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AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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AGRICULTURAL AND NATURAL RESOURCE POLICY ANALYSIS COURSE

Outline and Lecture Notes

September 1993

APAP II
Methods and Guidelines
No. 412

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PREFACE

This volume presents the outline and lecture notes of the APAP 2 Agriculture and Natural Resource Policy Course that has been given every summer at Stanford's Food Research Institute. The course is accompanied by a series of books and manuals that have been listed at the end of the outline. Instructors should be sure they have the latest versions of these manuals (September 1993) as there has been considerable revision since the first versions were published several years ago.

The first page of the present volume gives the outline of the month-long course at the daily level. The next four pages provide a more disaggregated look at course organization by adding a period by period view. The final 40-odd pages provide a topic outline with notes about what the lecturer might say to in his/her presentation to the class.[1]

The main objective of the course has been to train students from developing countries to improve their ability to do quantitative policy analysis. Each half-day block begins with a lecture on the topic relevant to policy analysis modeling. The lecture is followed by a computer session in which students use a series of previously prepared manuals to implement the procedures that have been discussed. The computer sessions may also contain lectures and discussions as the need arises.

Carl Gotsch
September 1993

[1] (The different "views" of the same document are made possible by software package called Grandview.)

OUTLINE OF POLICY ANALYSIS COURSE

I. WEEK I:

A. DAY 1: INTRODUCTION TO POLICY ANALYSIS

B. DAY 2: INTRODUCTION TO THE POLICY ANALYSIS MATRIX

C. DAY 3: COMMODITY BUDGETS AT SOCIAL PRICES

D. DAY 4: THE POLICY ANALYSIS MATRIX (PAM)

E. it

II. WEEK II:

A. DAY 1: THEORY IN NATURAL RESOURCE POLICY ANALYSIS

B. DAY 2: MODELING NATURAL RESOURCE AND ENVIRONMENTAL POLICY

C. DAY 3: EXPANDING PAMS TO INCORPORATE NATURAL RESOURCE ISSUES

D. DAY 4: MARKET LEVEL MODELING

E. DAY 5: INDIVIDUAL CASE STUDY EXERCISES

III. WEEK III:

A. DAY 1: MULTI-MARKET MODELS

B. DAY 2: EXTENDED MULTI-MARKET MODELS

C. DAY 3: MARKET LEVEL ANALYSIS OF ENVIRONMENTAL POLICES

D. DAY 4: MARKET LEVEL MODELS AND PRICES DISTORTIONS

E. DAY 5: INTRODUCTION TO OPTIMIZATION

IV. WEEK IV:

A. DAY 1: USING OPTIMIZATION METHODS FOR POLICY ANALYSIS

B. DAY 2: AGRICULTURAL SECTOR MODELS AND AGRICULTURAL POLICY

C. DAY 3: AGRICULTURAL POLICY AND CGE MODELS

D. DAY 4: REVIEW OF AGRICULTURAL AND NR POLICY ANALYSIS

E. DAY 5: COURSE WRAP UP AND COURSE CRITIQUE

V. BIBLIOGRAPHY

A. BOOKS

B. MANUALS

OUTLINE OF POLICY ANALYSIS COURSE

I. WEEK I:

A. DAY 1: INTRODUCTION TO POLICY ANALYSIS

1. Morning (Period 1): Lecture--Overview of the Course
2. Morning (Period 2): Intro of Participants & Placement Questionnaire
3. Afternoon (Period 3): Computer--Vol.1: Introduction to Spreadsheets
4. Afternoon (Period 4): FREE

B. DAY 2: INTRODUCTION TO THE POLICY ANALYSIS MATRIX

1. Morning (Period 1): Lecture: Neo-classical theory and the PAM
2. Morning (Period 2): Computer--Private Budgets: (Vol. 2, Ch. 1)
3. Afternoon (Period 3): Lecture--Commodity Budgets at Private Prices
4. Afternoon (Period 4): Computer--Private Budgets: (Vol. 2, Ch. 2-3)

C. DAY 3: COMMODITY BUDGETS AT SOCIAL PRICES

1. Morning (Period 1): Lecture--The Price of Tradables
2. Morning (Period 2): Computer--Social Budgets (Vol. 2, Ch. 4)
3. Afternoon (Period 3) Lecture: The Price of Non-Tradables
4. Afternoon (Period 4): Computer--Work on budgets (Vol. 2, Ch. 1-4)

D. DAY 4: THE POLICY ANALYSIS MATRIX (PAM)

1. Morning (Period 1): Lecture--The Policy Analysis Matrix
2. Morning (Period 2): Computer--PAMs (Vol. 2, Ch. 5)
3. Afternoon (Period 3): Lecture--Extending PAMs
4. Afternoon (Period 4): Computer--Parity Prices (Vol. 2, Ch. 6-7)

E. it

1. Morning (Period 1): Lecture--Decomposing Nontradables
2. Morning (Period 2): Computer: Work on PAM manual
3. Afternoon (Period 3): FREE
4. Afternoon (Period 4): FREE

II. WEEK II:

A. DAY 1: THEORY IN NATURAL RESOURCE POLICY ANALYSIS

1. Morning (Period 1): Lecture--Analytics of NR&E Policy Analysis
2. Morning (Period 2): Computer--NR manual (Vol. 3, Ch. 1)
3. Afternoon (Period 3): Lecture--Sustainability as a "Standard"
4. Afternoon (Period 4): Computer--NR manual (Vol. 3, Ch 2)

B. DAY 2: MODELING NATURAL RESOURCE AND ENVIRONMENTAL POLICY

1. Morning (Period 1): Lecture--Static PAMs and NR Analysis
2. Morning (Period 2): Computer--Extending PAMS (Vol.3, Ch. 3)

3. Afternoon (Period 3): Lecture--Discussion of case study results
4. Afternoon (Period 4): Computer--Static PAMs (Vol.3, Ch. 4)

C. DAY 3: EXPANDING PAMS TO INCORPORATE NATURAL RESOURCE ISSUES

1. Morning (Period 1): Lecture--Dynamic PAMs: a C-B Approach
2. Morning (Period 2): Computer--Returns to Conservation (Vol 3, Ch 5)
3. Afternoon (Period 3): Lecture--Farming systems PAMs
4. Afternoon (Period 4): Computer--Whole farm PAMs (Vol.3, Ch. 4)

D. DAY 4: MARKET LEVEL MODELING

1. Morning (Period 1): Lecture--Static Supply and Demand Analysis
2. Morning (Period 2): Computer--Market Level Analysis (Vol 4, Ch. 2)
3. Afternoon (Period 3): Lecture--Computing Effects of Interventions
4. Afternoon (Period 4): Computer--Market Level Analysis (Vol 4, Ch 2)

E. DAY 5: INDIVIDUAL CASE STUDY EXERCISES

1. Morning (Period 1): Lecture--Introduction to Exercises
2. Morning (Period 2): Computer--Participant Analysis

III. WEEK III:

A. DAY 1: MULTI-MARKET MODELS

1. Morning (Period 1): Lecture--Multi-Market Models
2. Morning (Period 2): Computer--Market Level Analysis (Vol 4, Ch 3)
3. Afternoon (Period 3): Lecture--Computing with Non-Tradables
4. Afternoon (Period 4): Computer--Market level manual (Vol 4, Ch 3)

B. DAY 2: EXTENDED MULTI-MARKET MODELS

1. Morning (Period 1): Lecture--Adding Commodities and Regions
2. Morning (Period 2): Computer--Market-level manual (Vol.4, Ch.4)
3. Afternoon (Period 3) Lecture--Writing and Presenting Results
4. Afternoon (Period 4): Market level manual (Vol 4, Ch. 5)

C. DAY 3: MARKET LEVEL ANALYSIS OF ENVIRONMENTAL POLICES

1. Morning (Period 1): Lecture--Externalities in Market Level Models
2. Morning (Period 2): Computer--Market level NR model (Vol 5, Ch 1)
3. ***Determining corrective measures to internalize externalities***
4. Afternoon (Period 3): Lecture--Externalities and Trade
5. Afternoon (Period 4): Computer--Market level NR model (Vol 5, Ch 2)

D. DAY 4: MARKET LEVEL MODELS AND PRICES DISTORTIONS

1. Morning (Period 1): World price distortions
2. Morning (Period 2: Computer--Environmental policy (Vol 5, Ch 3)
3. Afternoon (Period 3): Distorted world prices and externalties

4. Afternoon (Period 4): Computer--Environmental policy (Vol 5, Ch 3)

E. DAY 5: INTRODUCTION TO OPTIMIZATION

1. Morning (Period 1): Lecture:--Introduction to optimization
2. Morning (Period 2): Computer:--Work on Individual Case Study
3. Afternoon (Period 3): FREE
4. Afternoon (Period 4): FREE

IV. WEEK IV:

A. DAY 1: USING OPTIMIZATION METHODS FOR POLICY ANALYSIS

1. Morning (Period 1): Lecture--Optimization Models
2. Morning (Period 2): Computer--Optimizaton manual (Vol 6, Ch 1)
3. Afternoon (Period 3): Lecture--Policy Experiments with LP Models
4. Afternoon (Period 4): Computer--Optimization manual (Vol 6, Ch 2)

B. DAY 2: AGRICULTURAL SECTOR MODELS AND AGRICULTURAL POLICY

1. Morning (Period 1): Lecture--Description of Sector Models
2. Morning (Period 2): Computer--Complete Previous Exercises
3. Afternoon (Period 3): Lecture--Computation of Sector Models
4. Afternoon (Period 4): Computer--Complete Previous Exercises

C. DAY 3: AGRICULTURAL POLICY AND CGE MODELS

1. Morning (Period 1): Lecture--Description of CGE Models
2. Morning (Period 2): Computer--Complete Previous Exercises
3. Afternoon (Period 3): Lecture--Computing CGE Models
4. Afternoon (Period 4): Computer--CGE Demo Using Hercules Solver

D. DAY 4: REVIEW OF AGRICULTURAL AND NR POLICY ANALYSIS

1. Morning (Period 1): Lecture--Approaching Policy Analysis Modeling
2. Morning (Period 2): Computer--Own Projects
3. Afternoon (Period 3): Computer--Own Projects
4. Afternoon (Period 4): Computer--Own Projects

E. DAY 5: COURSE WRAP UP AND COURSE CRITIQUE

1. Presentation of certificates
2. Verbal discussion of course improvements
3. Written evaluations

V. BIBLIOGRAPHY

A. BOOKS

1. Monke, Eric and Scott Pearson, *The Policy Analysis Matrix for Agricultural Development*, Cornell University Press, 1989.
2. Tsakok, Isabelle, *Agricultural Price Policy-A Practitioner's Guide*, Cornell University Press, 1990.

3. Hazell, Peter and Norton, *Mathematical Programming for the Economic Analysis in Agriculture*,MacMillian Press, 1986.

B. MANUALS

1. Volume 1: Learning Spreadsheets
2. Volume 2: The Policy Analysis Matrix (PAM)
3. Volume 3: Natural Resourse in a PAM Framework
4. Volume 4: Market Level Analysis of Agricultural Policy
5. Volume 5: Social Equilibrium Analysis with Market Level Models
6. Volume 6: Optimization Methods for Agricultural Policy Analyis

OUTLINE OF POLICY ANALYSIS COURSE

I. WEEK I:

A. DAY 1: INTRODUCTION TO POLICY ANALYSIS

1. Morning (Period 1): Lecture--Overview of the Course

a. ***Welcoming comments***

i. Welcome to course site

ii. Daily schedule

Use Handout 1.1 (should be made up by course organizers: not enclosed) to describe scheduled times and rooms for each activity. Day broken into 4 sessions: two lecture sessions and two computer sessions. Stress that the lecture sessions will also be discussion sessions and the computer sessions will involve a good bit of lecturing.

Handout 1.2 provides an overall picture of what is to be accomplished during the month. Used only in first lecture. Provide a more detailed outline each morning so that when course is completed, students will have a detailed syllabus.

Traditionally, the detailed syllabus is given out at the beginning of the course. However, experience suggests that, if given out in advance, it will disappear. Will not be brought to class each day. Overall schedule will provide students an idea of what to expect.

Course spends a lot of time in what might called a "hands-on" mode. Exercises try to simulate as much as possible to work that a policy analyst does.

- Morning: 9:00-10:00 Lecture
- Morning: 10:00-10:15 Coffee Break
- Morning: 10:15-12:00 Computer Exercises
- Noon: 12:00-1:30 Lunch
- Afternoon 1:30-2:30 Lecture
- Afternoon 2:30-2:45 Coffee Break
- Afternoon 2:45-4:30 Computer Exercises

b. ***Conventional formulation of policy analysis***

Refer to Chapter 1, Monke-Pearson for a discussion of material to be covered. Place for a brief commentary on the role of efficiency vs. other types of objectives. Notning intrinsically "bad," from a analyst's point of view, in government policies that seek non-efficiency objectives. Matter for social decision making, usually done through the political process. Forward reference point that efficiency and sustainability have to do with allocation of resources when inputs and outputs are valued at social prices. Equity and security, on the other hand, are derived by evaluating the input-output relationships at private prices.

i. Objectives: efficiency, equity, security, sustainability

ii. Activities: programs and policies

iii. Constraints: resources, markets, security, sustainability

c. ***Common agricultural policy problems***

i. Major agricultural policy issues

Begin by eliciting list of issues that are likely to come up in most ag. policy situations. This is a good chance on the first day to get a dialog going with students. Try to get everyone to say something based on their own experience. Spend time eliciting suggestions from people, not in providing a detailed critique of each issues raised. Develop rapport with students.

Some obvious suggestions that should come up are those given below. Those that don't come up can be mentioned when students have given up. Use Socratic method to raise questions that will lead students to answers. When list is complete, organize into objective categories of efficiency, equity, security, sustainability.

- Agricultural prices (levels and stability)
- Food security (prices and quantity)
- Insuring adequate farm income
- Creating a knowledge base to sustain growth
- Making the necessary investments in infrastructure
- Insuring that agriculture will be sustainable

d. ***Methods and models for analyzing policy issues***

Discussion based on Handout#1.3. Handout organizes the modeling approaches that will be used in the course to each other. In developing a quantitative analysis of objectives, activities, and constraints, will begin with the simplest possible approach and move toward more complex models in response to increasing complex policy issues. At each stage, must pay a price in data and computational difficulty for ability to provide more comprehensive answers to policy issues. Emphasize trade-offs.

Budgeting methods require the least data and are the simplest to use and communicate. Problem is that everything (input-output relationships and prices)in the model is exogeneous. Hence can't say much about the result of moving from one government policy to another. Must move in one of two directions to incorporate response to policy: market level models or optimization models

Market level models are familar from economics textbooks. Feature familar supply and demand curves. Virtue: incorporate supply response by utilizing past relationships between prices and quantities. Incorporate demand relationships based on time series data also. Several problems: data, lack of free markets to produce the necessary variation, structural change, etc.(May want to expand single commodity models to more than one commodity if significant cross-price elasticities exist. Gives rise to multi-market models.)

Optimization methods provide another method of building in response to policy changes. Set up models of farming systems or agricultural sector; simulate

what farmers are likely to do by assuming that they maximize profits. Obtain an idea of what they will do by simulating what they should do. Problem: additional computational complexity.(Data problem no more significant that budgeting methods because both use the same farm management data.)

General equilibrium analysis is more useful conceptually than practically. Need to be thinking at every stage about ramifications of policy proposals. Feedback from prices onto factor incomes can be important if agricultural commodity being studied is large component of gross domestic product, e.g., rice in the Philippines. (Objective in this discussion is to de-mystify and motivate rather than to provide a rigorous analysis. Problems: data, aggregation required makes it difficult to understand policy implications, high level of computational skills required.

i. Budgeting methods

ii. Partial equilibrium using supply and demand curves

iii. Multi-market simulation using supply and demand

iv. Optimization at farming systems level

v. Optimization at sector level (prices endogenous)

vi. General equilibrium tools (income endogenous)

e. ***Data and computing tools***

Students invariable have questions following the models discussions about how these approaches are to be implemented. Good point to offer some reassuring comments about the fact that the approaches outlined do not require a large investment in computer skills.

i. Electronic spreadsheets ideal for budgeting

ii. Spreadsheets can also deal with market level models

iii. Optimization and CGE models will require learning GAMS

f. ***Policy memo as a way of integrating the workshop***

Use Handout 1.4. This handout is drawn from pp. 242-252 of the Monke-Pearson book. Briefly note the significance of communication in policy related work. Need to pay attention to the structure of the memo. Also need to be sure that the memo is attractive. Should know how to introduce graphs and tables in an interesting way. Refer briefly to the structure of the policy memo as shown in the Handout.

i. Importance of communication

ii. Structure is significant

iii. Presentation must be attractive

2. Morning (Period 2): Intro of Participants & Placement Questionnaire

a. ***Introduce individual course participants***

Have students and instructors introduce themselves and say a few words about where they come from, their home towns, jobs, and policy interests.

i. Home country, institutional affiliation, etc.

ii. Personal: job, major policy concerns, etc.

b. ***Fill out questionnaire on economic and computing skills***

Use Handout 1.5. Questionnaire is intended to provide instructors with information that will help (a) gauge the level of the lectures and (b) place the individual with the appropriate group based on computer skills. Instructors can go over the questionnaire at lunch in order to make the placements for the afternoon's computer session.

i. Economics quizz

ii. Computer quizz

3. Afternoon (Period 3): Computer--Vol.1: Introduction to Spreadsheets

a. ***Instructions for working with manual***

i. Read through assignments before starting

ii. Skip familar parts of manual

iii. Try to follow instructions before asking for help

b. ***Review of some important spreadsheet concepts***

i. Organizing data in rows and columns

ii. Copying

iii. Formating

iv. Graphing

4. Afternoon (Period 4): FREE

B. DAY 2: INTRODUCTION TO THE POLICY ANALYSIS MATRIX

1. Morning (Period 1): Lecture: Neo-classical theory and the PAM

a. ***The general model of gains from trade***

i. Gains from trade model

Handout 2.1. This is one of the most famous graphs in all of economic theory. It illustrates the idea that the most efficient allocation of resources--and hence the highest level of welfare--can be obtained when markets exist in which goods can be exchanged. Any introductory economic textbook can supply the logic.

Argument holds for both the household and for the economy as a whole. Much of modern economic theory makes little distinction between the theory of the household and its exchange of goods and services in the domestic market and the country and its exchange in international markets.

For all of its shortcomings, the idea that a market economy is the "best" way to develop has much to support it. Build up the model a piece at a time on the blackboard

.

ii. Production possibility frontier

Use maize and cotton as the example. The production possibility frontier describes the trade-offs between producing maize and cotton. It describes the technical relationships that exist in the production process.

Discuss why the curve has the shape does? Explain how the curvature of the production possibility frontier refelcts diminishing returns. Assume that these two commodities compete for some resources. Could there be a trade-off if there was no competition for resources? No. These two commodities must be using some resources that are in fixed supply. Must be that as more and more variable resources are committed to the production of a particular commodity, they encounter diminishing returns. Add more purchased inputs such as fertilizer and pesticides, then marginal returns, i.e., the returns to the last unit, decline.

iii. Utility function describing consumer preferences and tastes

What determines the position of the utility function that describes people's consumption preferences?

The shape indicates the marginal utility that people get from consuming maize and cotton. This is relative--describes the rate at which people would give up maize to get more cotton. How would such a trade-off come about? Ask students for a plausible story that would explain the shape of this curve?

Story: People can only eat so much maize before they begin to worry about whether they have enough clothes or not. At some point, would prefer to have clothes made from cotton rather than another kilo of maize. That is what gives the utility function its shape.

iv. Comparative advantage vs. autuarchy

What would happen if no exchange was possible? Would have to resort to barter. What is that called? Autarchy. Absence of trade; absence of exchange.

v. International prices-social prices-terms of exchange (line SS)

Consider that the country or the household finds itself in a position to undertake trade. Doesn't necessary have to do with boats and airplanes; could be from one neighboer to another. People going to grocery stories.

Prices are exogeneous. Determined in international markets for the economy. May actually be established in national markets for households. Focus on the economy wide situation. Suppose these prices exist and they have a ratio shown by the line SS.

vi. Domestic prices--private prices--policy prices PP

Domestic prices are those observed in the market place. Incentives that face private individuals. The are also the product of government policy--or lack thereof. Label this line PP for private prices.

vii. Inefficiency introduced--consumption locus below free trade

Show that policy prices and the absence of trade result in a loss of welfare, i.e., the highest utility curve that can be reached as a result of the policy wedge is below the free trade solution.

b. ***PAMs and the general trade model***

i. PAMs are based on budgets constructed at one point on the PPF.

Physical coefficients reflect the input-output relationships for a particular commodity at one point on the production possiblitity frontier. Numbers not visible on the diagram. PAM permits highly disaggregated approach to policy analysis

PAM measured at the point where private prices line is tangent to the PPF. This is the point currently observed.

ii. PAMs contain no adjustment for changes in relative prices

Based on trade model, changes in relative prices reflected by market liberalization should result in changes to the optimal enterprise. No mechanism for endogeneous adjustments in budget based approaches.

Private and social PAMs reflect alternative slopes to the relative prices line. Physical input-output relationships remain the same. Policy is the wedge between the private and social prices line. Can't capture adjustments with this mechanism, but can capture the direction that liberalization would imply.

c. ***Translating theory into practice: commodity budgets***

i. Commodity budgets are first step in producing PAMs

PAMs are simply a way of reorganizing data in commodity budgets. May not seem like much but organizing data is an important analytical step. Strength of budgets is that they can be obtained from survey data. Also highly disaggregated so that analysis can be fine-tuned to reflect specific policy, e.g., can examine fertilizer policy, water policy, etc. More aggregate analysis often lump all inputs together as "costs." Most agricultural policy issues require more disaggregation.

2. Morning (Period 2): Computer--Private Budgets: (Vol. 2, Ch. 1)
3. Afternoon (Period 3): Lecture--Commodity Budgets at Private Prices

a. ***Components of commodity budgets: revenues and costs***

i. Input-output block

The input-output block reflects the physical parameters of the PAM analysis. Ordinarily standardized on land because land is the single truly fixed factor. Data also come naturally in this form, i.e., output per acre or hectare, fertilizer per hectare, etc.

Some of most sensitive data in PAM analysis are to be found in yield estimates. Gross revenues are prices times yields. Multiplication means incorrect yield estimates will have a much larger impact that, say, getting fertilizer or pesticide applications wrong.

Engage students in a discussion of where physical input-output data are likely to be found. Many are likely to have experience with collecting this type of information.

ii. Prices block

Private prices are those observed in the market place. Possible, in situations where the crop has never been grown in the country before, to work back from international prices. But ordinarily use prices that are reported by farmers or found from interviews at wholesale markets.

Price series that are kept by ministries and agencies are also useful checks on prices reported from surveys. These data are important to governments and are probably the most accurate statistics they gather.

Elicit comments from students about sources of price data. This is again the type of information with which people in the Ministry of Agriculture are likely to have experience. This kind of discussion enables students to talk about something on which they are "experts."

b. ***Cost components: variable (tradable) and fixed (non-tradable)***

i. Tradable inputs

Tradable inputs tend to be variable costs. As production increases, variable costs increase. Examples are: fertilizer, pesticides, etc.

ii. Domestic factors

Domestic factors are more in the nature of fixed costs. They can be broken down into two parts.

- Mobile-- capital and labor

  Capital and labor are called mobile because they can move between sectors. Hence, <u>at the level of the sector</u>, they are variable costs to agriculture. Their prices are determined by their opportunity costs in non-agricultural uses.

- Fixed--land

  Land is the only truly fixed factor. (In some cases, water would qualify also.) Means that, at the sector level, does not have a cost.

  Important to repeat warning that the problem of pricing land is connected to the level of the analysis. If question is about the efficiency of resources used in the agricultural sector versus the non-agricultural sector, land has no price, i.e., it is assumed to have no opportunity cost.

However, if analysis is done at the commodity level, i.e., the issue is comparative advantage within the agricultural sector, then will have to determine a value for land. Forward reference discussion that will take place under the heading of the shadow prices of domestic factors.

c. ***Choosing commodity systems***

i. Agro-climatic conditions

Successful PAM analysis requires a good deal of disaggregation by type of farming system. Can't compare apples and oranges. Most significant differences occur around the availability and timing of moisture and temperature.

Ask students to enumerate features of the agro-climatic environment that they think are likely to be important. Discuss reasons for wanting to distinguish between different ecological situations.

- Irrigated

Irrigated areas can ordinarily grow wide variety of crops. Means that there will be complex farming systems. Creates difficult in determining comparative advantage because seasonal land constraints can be quite complicated.

- High rainfall

High rainfall areas vary from monsoon rice to temperate climates. However, with exception of rice, the higher the rainfall area, the more complex the cropping system. More complex cropping system require more data collection as costs and returns data required for competing crops as well as for the crop under study.

- Low rainfall

PAMs may not be of much interest in really low rainfall areas. Options may be extremely limited. Farmers are doing the only thing they can do. For example, in many low rainfall areas, livestock is the only way in which land can be made productive. Means that the opportunity cost of land--even at the firm level--is practically zero. (Interest in environmental policy (conservation) may assign a positive value--result in negative social profits for the current livestock enterprises.

ii. Production technology

Separate PAMs (commodity budgets) are required is production systems are dramatically different. As in climatic case, comparisons of systems that have very different technical coefficients can't yield correct insights into comparative advantage for a particular commodities.

Some obvious distinctions that researchers have found important in the past are determined by the type of power used. This shows up in the PAM because of the substantial divergence that may occur between the private and social costs of the source of power. Unemployed labor, for example, has a high private

costs relative to its social cost. Tractors purchased on international markets may have a high social cost relative to their private costs.

Ask students about reasons for wanting to distinguish between various technologies for producing a commodity. Elicit their suggestions about what the most important categories should might be.

- Manual cultivation
- Animal traction
- Mechanical traction

iii. Institutional structure (farm size)

Question of whether PAMs should be done for different farm sizes is, like the examples above, an empirical question. If the technical coefficients for the different farms are roughly the same, then this distinction need not be made.

Differences between farms may have already been captured above, e.g., small farms use manual cultivation while large farms use tractors.

Want to keep number of different PAMs for a particular commodity to a minimum. But if important distinctions exist that would result in different conclusions about competitiveness and comparative advantage, must do the required disaggregation.

Elicit suggestions about the most important distinctions having to do with institutional characteristics of different farming systems.

- Subsistence agriculture
- Sharecropping
- Small commercial farms
- Large commercial farms

d. ***Defining the "representative" commodity budget***

i. Factors that produce variation in farm performance

Even within the framework discussed above in which important sources of heterogeniety are controlled for, will have a good deal of variation. PAMs based on budgets, not on statistical estimation, hence need to determine what a "representative" budget is for the particular category being investigated. Some of the dimensions along which "representativeness" can be measured include the following:

Ask students about the factors that might account for variation among farmers after climate, technology, and institutional characteristics have been accounted for. Is there likely to be considerable unexplained variation? How should the policy analyst deal with this type of variation.

- Managerial decision capacity
- Willingness to accept risk

ii. Pros and cons of budgeting approach to farmer decisions

Budgets have as their strengths their simplicity and the ability to organize data collection efforts regardless of the data that have been collected historically. Means that this type of approach can always be implemented provided resources are made available. By comparing budgets computed at private and social prices, can get a sense of the direction of policy changes, i.e., would the commodity under study become more or less profitable if markets were reformed.

Weakness is that they provide no information on what decisions farmers would make if the situation changed. Show only what farmers are doing, not what they would do in the presence of reforms. Lack of adjustment limits what policy analysts can say to decision makers who want to know what the consequences of their actions would be.

e. ***Organizing data on the spreadsheet***

i. The diamond back method

Want to create a flexible, re-usable template. Maximum freedom is obtained when the user can insert and delete rows without fear of disturbing other tables. Most complete way of doing this is to locate table along a diagonal with each new table below and to the right of the predeeding one. Sometimes called the diamondback method

Diamondback provides maximum flexibility. However, in case of PAM analysis, may want to line up tables that have same structure one below the other. For example, the I-O table, the prices table, and the budget table all have the same columns. These columns consist of the crops in the cropping system. (Alternatively, the table may contain a range of technologies or different types of farming systems. Output and input prices tend to be similar across regions and hence there is considerale efficiency in organizing several budgets into a single table.

ii. Elements of the I-O table

The I-O table occupies the upper left hand corner of the spreadsheet. See figures in Vol. 2. Data are organized into tradable inputs, labor, capital, and output.

iii. Elements of the prices table

The prices table should be copied below and to the right of the I-O table. Prices are also organized into categories of tradable inputs, labor, capital, and output. Each cell occupies the same relative position in the table as in the corresponding I-O table

iv. Elements of the budget

The budget table is computed from the I-O table and the prices table. First copy the I-O table or the prices table below and to the right of the prices table. Select the cell in the upper left hand corner of the newly created budget table and write in a formula that multiplies the same cell in the I-O table by the same

cell in the prices table. Then use the COPY command to compute quantities times prices in the remaining budget cells.

Additional computations will be required for the PAMs. However, at this point, simply compute the profits (revenues-costs) as shown in the manual.

4. Afternoon (Period 4): Computer--Private Budgets: (Vol. 2, Ch. 2-3)

C. DAY 3: COMMODITY BUDGETS AT SOCIAL PRICES

1. Morning (Period 1): Lecture--The Price of Tradables

a. ***Social prices reflect opportunity cost of inputs and outputs***

i. Tradables: Commodities that have an international market.

Previous discussion focused on private prices, i.e, prices that included the effects of government policies. Evaluation of efficiency requires that the true opportunity cost of tradables be used in the computing commodity budgets.

International prices reflect opportunity costs and returns--and hence social costs and returns--because they are prices at which the country might have traded for inputs and output. Use of these prices implies that there is no government intervention in commodity markets, either in the form of taxes and subsidies or in the form of quantitative restrictions.

ii. Non-tradables: Commodities have alternative domestic uses.

Non-tradables must also be valued at their true cost to the economy. In the case of domestic factors that do not have international prices, this is the opportunity cost of using the factors in some other way within the economy. The price of labor, for example, should reflect the opportunity cost of labor used in non-agricultural production if the analysis is at the sector level.

The returns to non-tradable outputs should reflect the willingness of consumers to pay.

b. ***Computation of international prices for tradables***

i. Determination of export and import parity prices.

Want to determine the farm gate equivalent of the international prices. Parity in this case means "the same as." Need social prices (parity prices) at the same level of the distribution and marketing system as domestic prices.

The basis of the PAM is a comparison of cost and returns under two sets of prices. Obviously need to make the comparison at the same place. Can't have one price refer to the farm gate and the other refer to the price of the commodity at the port.

ii. Definitions: f.o.b. and c.i.f.

- f.o.b.: Free on board (on boat in harbor of exporter)
- c.i.f.: Cost,insurance, freight (in harbor of importer)

iii. Determination of appropriate international market price

- Local information and statistics

  Works if the commodity is being actively traded. Problem is to get a clear picture of the actual international value because the published data may be confusing. May have been shipped on concessionary terms. May have been of a particular quality that is hard to verify. Moreover, want to see how macro policy, namely exchange rate policy, affects commodity incentives. To see components of parity price, need to disaggregate beginning with its actual price in an international market.

- International market statistics

  Use statistics from markets where substantial amount of trade takes place. Prices for grains are frequently reported as being f.o.b. Gulf ports. Price of oil is quoted as c.i.f. Rotterdam, cotton c.i.f. Liverpool, sugar c.i.f. New York.

- Determination of comparable quality

  Perhaps most difficult problem is to be sure that the commodity whose price you are trying to determine is comparable to the commodity whose export or import parity price you are trying to determine.

iv. Computation of import parity price (use table in manual)

- Determine f.o.b price in harbor of exporter
- Add freight and insurance
- Result: c.i.f. price in harbor of importer
- Convert from foreign to domestic currency
- Add price of moving commodity to farm gate

  Movement from the border to the farm gate may also involve a transformation of the commodity. E.g., cotton lint must be converted to raw cotton.

v. Computation of export parity price (use table in manual)

- Determine c.i.f. price in the harbor of importer
- Subtract freight and insurance
- F.o.b. in harbor of the exporter
- Convert foreign to domestic currency
- Subtract cost of moving from border to farm gate

  Moving from international prices to farm gate prices often involves the transformation of the commodity. For example, polished rice on international prices must be converted to paddy or unmilled rice at the farm gate.

2. Morning (Period 2): Computer--Social Budgets (Vol. 2, Ch. 4)
3. Afternoon (Period 3) Lecture: The Price of Non-Tradables
   a. ***Shadow prices for labor***
      i. Markets function

Draw supply and demand diagram. If markets function reasonably well, the equilibrium price is a measure of the social price of the domestic resource. Signal that this is so will be the absence of widespread unemployment. Demonstrate that if the private wage rate was higher than the equilibrium rate, supply would exceed demand. Evidence of this condition would be extensive overt or disguised unemployment.

ii. Markets do not function

In developing countries, often evidence of considerable unemployment. If so, opportunity cost of labor as evidenced by the equilibrium wage rate, may be considerably below the wage rate actually observed. Could be the result of government minimum wage legislation.

In agriculture, difficult to measure the opportunity cost of labor because of seasonality. During planting and harvesting, little unemployed labor. Wages reflect marginal product of labor. If persuaded that the private price of labor is not a good measure of the social price, try weighted average of different seasons.

b. ***Shadow prices for capital***

i. Function markets

Capital markets rarely function "freely." Government intervention heaviest and hardest to trace. Not clear how policy analyst can develop quantitative estimates of the price of capital without extensive macro modeling.

ii. Rules of thumb

Rule of thumb frequently used is 5 percent for developed countries, 10 percent for middle income countries, and 15 percent for the poorest countries.

There are two countervailing forces at work. Countries that have low levels of capital stocks have a high marginal productivity for additional capital on scarcity grounds. However, these same countries usually have poor infrastructure, an untrained work force, and often chaotic institutions. All these mitigate against a high rate of return on capital.

c. ***Shadow prices for land***

i. Commodity analysis at economy-wide level

Determining the price of fixed factor depends upon the level of analysis. If commodity PAMs are being constructed at the economy-wide level, usually assumed that land has no opportunity costs. Could be misleading if the commodity was being grown in an environment that has other uses for land. Examples: soil for use in making brickes; land for urban housing. However, looking at intersectoral uses leads to the general conclusion that land has no opportunity cost because it cannot be used for anything but agriculture.

ii. Commodity analysis at sector level

If analysis is being used to determine comparative advantage within the agricultural sector, opportunity cost of land must be incorporated. Its opportunity cost in growing one commodity is the revenue that it could have earned if used for some other enterprise in agriculture.

The opportunity cost of land at the sector level is the net return of the the next best alternative. Computed by determining the profits to a commodity minus the net returns of the commodity that provides the best alternative. (Forward reference the discussion of this topic under the PAM heading.)

4. Afternoon (Period 4): Computer--Work on budgets (Vol. 2, Ch. 1-4)

D. DAY 4: THE POLICY ANALYSIS MATRIX (PAM)

1. Morning (Period 1): Lecture--The Policy Analysis Matrix

a. ***Structure of a PAM*** (Use illustration in manual.)

i. Private profits row

The private profits row is obtained from the private commodity budget. Tradable inputs, labor, and capital are subtracted from gross revenues.Result is D, a measure that, at the economy wide level, reflects private incentives to produce. Land is included in this calculation as a residual along with management skills and willingness to take risks.

Positive value for D means that the system is not competitive. Factors are not being paid their marginal products. If they were, wouldn't have anything left over.

ii. Social profits row

Social profits row is obtained from the social commodity budget. Tradable inputs, labor, and capital are subtracted from gross revenues. Result is H, a measure that, at the economy wide level, reflects the countries comparative advantage.

Positive social profits mean that country's value-added at international prices is greater than its domestic factor costs when these are measured at their opportunity cost to other sectors in the economy.

b. ***Divergences in tradable outputs***

i. Source of figures for private profits row

Gross revenues at private prices come from multiplying yields times the private price for outputs.

ii. Source of data for social profits row

Gross revenues at social prices come from multiplying yields times the social (international) price for outputs.

iii. Interpretation of divergences

Divergences are found by subtracting social revenues from private revenues. A positive value means that producers are being subsidized, i.e., their financial returns are greater than they would be they had been paid export or import parity prices for their commodity.

A negative divergence means that producer are being taxed. They are receiving less for their commodity in private terms than they would have received had output prices reflected international prices.

c. ***Divergences in tradable inputs***

i. Source of figures for private profits row

The data for the tradable inputs cell come from summing over the tradable input category in the private commodity budget.

ii. Source of figures for social profits row

The data for the tradable inputs cell come from summing over the tradable input category in the social commodity budget

iii. Interpretation of divergences

A negative number in the tradable inputs divergence row means that input costs at private prices are greater than inputs valued at international prices. This means that producer are being subsdized in their purchase of tradable inputs. (The interpretation is the opposite of the output interpretation where a negative number mean they are being taxed.)

A positive divergence means that tradable inputs cost more at domestic prices then they would if valued at international prices. Producers are being taxed.

d. ***Divergences in domestic resource costs***

i. Sources of private profits row

Data in the cells for labor and capital are obtained from the private commodity budget. (Separate summations are required for each category.)

ii. Sources of data for social profits row

Data in the cells for labor and capital are obtained from the social commodity budget. (Separate summations are required for each category.)

iii. Including or excluding land

Land is not included in a PAM that looks at the opportunity cost of resources at an economy-wide level

Land is included in the PAM if the analysis is attempting to determine the comparative advantage of producing a commodity within the agricultural sector, e.g., would resources be used more efficiently in the production of maize or cotton if both crops can be grown on the same land in the same season.

e. ***Divergences and policy instruments***

i. Tradables

Policy instruments are much more accessible. Trade polcies involve tariffs and duties. Commodities may also be the beneficiaries of direct taxes and subsidies. Quotas and quantitative restrictions may also be in the policy mix. But these are all policies in which reforms are reasonably straightforward.

Divergences in tradables also affected by exchange rate policy and that, as far as an individual commodity is concerned, will be much more difficult to change.

ii. Non-tradable domestic factors

Imperfections in markets are much more difficult to deal with than trade policies. Rooted in the lack of information, limited competition, externalities, infrastructure limitations, etc. Capital market constraints imposed on financial institutions would be easier to deal with as would outright subsidies, e.g., rural credit programs that subsidize interest rates.

2. Morning (Period 2): Computer--PAMs (Vol. 2, Ch. 5)
3. Afternoon (Period 3): Lecture--Extending PAMs

a. ***Summary coefficients***

PAM results are given in absolute terms. Makes it difficult to compare protection and comparative advantage across regions, technologies, farm size, and types of commodities. Problem can be alleviated by computing dimensionless ratios.

i. Nominal protection coefficient

NPC is defined as A/E or output at private prices divided by output at social prices. A ratio greater than 1 means that producers are receiving a subsidy; less than one means they are being taxed.

ii. Effective protection coefficient

EPC is defined as (A-B)/(E-F) or value-added at private prices divided by value-added at social prices. A ratio greater than one means that, when both outputs and inputs are taken in to account, producers are being subsidized. Less than one means they are being taxed.

Common development strategy has been to tax output and subsidize inputs in an effort to get an EPC that was relatively neutral. Idea was to stimulate the introduction of new technology.

iii. Domestic resource coefficient

DRC is defined as G/(E-F) or the cost of domestic factors divided by value added at international prices. A ratio of less than one means that the country uses its domestic resources efficiently in the production of the commodity for which the PAM has been calculated. (Costs of domestic resources are less than value-added by them when both are measured at social prices.) Country has a comparative advantage in producing commodity.

Note that if the DRC is less than one, social profits (H) are positive.

b. ***Capital Recovery Factors***

i. Adding durable capital costs to PAM calculations

Need to account for depreciation of fixed capital assets used in production. Assumption is that agricultural sector will continue to stay in business. But to do so, will need to replace capital. (Note: not a problem with other fixed asset, land.) Need to compute a value that reflects both decline in the value of the asset but the opportunity cost of having tied up capital as well. (See formula in the manual for computing the capital cost recovery factor.)

ii. Additions to the I-O table

Implementing the annual capital cost factor requires an addition to the I-O table that reflects the physical parameters of the asset. Requires a somewhat difficult decision about how much of the fixed factor is being devoted to the particular commodity being grown. For example, what portion of the total tractor hours available during the year should be allocated to growing maize? If machine is used only for particular crops, e.g., maize sheller, then not a problem. Otherwise need to look at entire farming system to make a judgment about portion to allocate to crop for which the PAM is being computed.

iii. Computing a value for the prices table

Annual cost per unit (hour, day, week). Determined by the physical units in which the use is measured in I-O table. Recovery factor formula in manual. When added to the prices table, quantity times price is the basis for the annualized cost of fixed capital in the budget table. It is included under the heading of capital in the PAM.

4. Afternoon (Period 4): Computer--Parity Prices (Vol. 2, Ch. 6-7)

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DAY 5: EXTENDING THE POLICY ANALYSIS MATRIX (PAM)

1. Morning (Period 1): Lecture--Decomposing Nontradables

a. ***Definition of non-tradable goods and services***

Use a supply demand graph to show the characteristics of a non-tradable. c.i.f. price above the equilibrium prices; f.o.b. price below the equilibrium price. The width of the fob-cif increases the range over which the good is a nontradable.

i. f.o.b. < domestic cost of production

When the f.o.b. price is less than the cost of production, means that the country cannot produce a good cheaply enough to export.

ii. c.i.f. > domestic cost of production

When the c.i.f. price is greater than the cost of production, means that the country can produce the good more cheaply than it can be imported.

b. ***Review framework for computing non-tradable prices***

i. Input prices

- Fully employed, reasonably function markets, use market price
- Unemployed or imperfect markets, estimate opportunity cost

ii. Output prices

- Willingness to pay; prices determined domestically

c. ***Decomposing non-tradables***

i. Social cost decomposition procedure

May encounter non-tradables--usually services--that have no international prices (marketing, transportation, storage) but that are a mixture of tradables and non-tradables. For example, transportation is a non-tradable. It has no

international price. However, the truck chassis and fuel may be imported while the the truck body and the labor of the driver are domestic nontadables. PAM methods require that this type of non-tradable be decomposed into its tradable and nontradable components so that each can be assigned to its proper cell in the PAM.

- Tradable inputs for each non-tradable activity

  Identify the tradable inputs and compute the export or import parity price for the commodity. Will usually be an import parity prices. Good example would be fuel.

- Labor costs of each non-traded activity

  Determine labor costs and add to the nontradable domestic factor portion of the budget. Do this by adding the physical component to the I-O table and the price to the prices table.

- Capital costs of each non-traded activity

  Determine capital costs and add to the nontradable domestic factor portion of the budget.Do this by adding the physical component to the I-O table and the price to the prices table

ii. Rules of thumb

Decomposing nontradable services can be very time consuming and it is often impossible, without a great deal of investment in data collection, to disaggregate nontradables. Researchers often use a 1/3, 1/3, 1/3 rule, i.e., they assign 1/3 of the cost to tradables, labor, and capital.

Under any circumstances, should do a preliminary sensitivity analysis to see whether signficant divergences from the market price would make any difference. For example, if the social price of the nontradable were to decline by 50 percent from the market price as a result of decomposition, would it alter the results. If not, some kind of rough and ready rule of thumb should probably be applied.

2. Morning (Period 2): Computer: Work on PAM manual
3. Afternoon (Period 3): FREE
4. Afternoon (Period 4): FREE

II. WEEK II:

A. DAY 1: THEORY IN NATURAL RESOURCE POLICY ANALYSIS

1. Morning (Period 1): Lecture--Analytics of NR&E Policy Analysis

a. ***General analytical approach: maximize social good***

i. Problem: find social optimum

Approach is same as previous neo-classical argument. Want to equate marginal costs and marginal benefits. However, want to be sure that all costs and benefits, including those that occur when markets are imperfect or missing.

- Maintain distinction between private and social prices

- Incorporate explicitly dynamic market failures

ii. Costs: direct costs, externalities, user costs.

Determining marginal costs of producing a commodity begins with the usual direct costs. Form the firm's supply curve when measured at private prices. When considering natural resource use, two other important components: externaltities and user costs

- Direct costs
- Externalities

Externalities:physical interaction of systems

One individual's production activity includes activities whose magnitude is chosen by other individuals. Systems in which physical production systems interact. Examples: rice farmer and fishermen. Farmer chooses level of pesticide application without considering effects on fisherman.

Markets may be too thin or too costly to operate

It may be too costly to set up and maintain the market. Market in which the transactions costs, i.e., the costs of setting up the market exceed the negative effects of the externality.

People may not understand cause and effect

Market may also fail because of assymetric information. Fisherman didn't know they were catching fewer and fewer fish because of pesticide that the farmers using. Whether the farmers knew what was happening is immaterial. Fishermen didn't know and consequence, were not in a position to initiate a claim on the farmers. Might have been willing to give up fish if they had known who the culprit was...but that information was essential.

The resource being polluted may be common property

Fishermen have difficulty in telling farmers that they (fishermen) own the river and farmers can dump pesticides in it. Without property rights comes, fishermen can't make claim. River is a public good.

- User costs

Future income foregone as result of using resourses now

Many resources used as though they had value only in the period in which they are used. If they could be used in the future, means they have an opportunity cost. Returns foregone by future users called users cost--the cost to future users of using the resources in the present.

Markets that incorporate future use missing or imperfect

iii.Policies for dealing with externalities and user costs

Requires institutional invervention--by definition. Private agents will not voluntarily reliquish rights to polute. Number of ways in which those responsible for externalties can be induced to alter their production system.

- Regulation of production

  Pesticide use by farmers is banned, either by specific product or generally.

- Taxes and subsidies to influence production incentives

  Farmers can be taxed on output, i.e., on rice, to persuade them to reduce the production of the commodity that uses the pesticide.

  The input can be taxed so that its use becomes less profitable.

  Can also compensate fisherman for the loss of fish if the loss is small compared to the gains realized by farmers. (Government would tax farmers and transfer funds to fishermen.)

b. ***Marginal analysis of social optimum***

i. Difficult to measure marginal costs and benefits

Argument for doing PAMs that begins with observation that it is difficult to determine marginal costs, i.e., a supply curve, is even more obvious in case where market prices do not reflect marginal products. Extremely difficult to find the kind of data required to employ a marginalist approach.

ii. A "standards" approach to determining social optima

A possible way out of the marginalist impasse is to focus on what might be called "socially acceptable" or "socially desirable" behavior. Standards, e.g., chemical parts per million, can be implemented for pesticide residues. But standards can also be implemented for other "desirable" outcomes. Sustainability--by whatever definition is chosen--is such a standard.

c. ***Extending PAMs to incorporate environmental issues***

i. Begin with the traditional PAM

The first step in constructing an extended PAM that incorporates socially desirable standards is to construct a traditional PAM that makes the distinction between what is privately and socially profitable.

ii. Develop a second PAM that incorporates a desirable "standard."

A second PAM is then constructed using a new I-O table that incorporates the physical dimensions of a sustainable (standard) by whatever definition the analyst desires. In commodity specific analysis, sustainability could refer to yields. At the farm level, could refer to improved cropping systems or rotations, etc. The key is to work with agriculturalists and ecologists to put together a system that meets the criteria of sustainability that have been set forth in the project.

iii. Compare PAMs along both economic and environmental dimensions

The third step will be to compute private and social profitability using the new PAM and comparing those numbers with the values found in the old PAM. From this comparative vantage point, interplay of economic and environmental issues will become apparent.

2. Morning (Period 2): Computer--NR manual (Vol. 3, Ch. 1)

3. Afternoon (Period 3): Lecture--Sustainability as a "Standard"

a. ***Definitions of sustainability***

i. Maintanence of physical resources

Number of authors have argued that the maintenance of natural resource "capital" is only way to insure that future generations will have access to same resources enjoyed by present generations. By this standard, withdrawal from aquifers should equal "safe-yields," soil depth should be maintained, forests should not be logged beyond replacement, fish should not be taken beyond growth, etc. Stringent condition that assumes that future generations will want resources in the same form as present generations.

ii. Maintanence of yields

Yield maintenance also popular candidate for sustainability standard. Somewhat greater flexiblity than maintenance of physical resources. Would permit improved technology to play a role in production. Could use pesticides and herbicides in a cautious way. Might be some reduction in physical capital but no more than could be replaced without becoming dependent upon other sectors. (E.g., yield maintenance that depended heavily on fertilizers created from fossil fuels would not be regarded as fitting the standard.)

iii. Maintanence of incomes at the local level

Policy analysts concerned about developing countries have pointed out that the problem is not one of commodity level sustainability but sustaining the incomes of farmers at the micro level. Unless the problem of income maintenance is addressed, effect of incentives will not be understood properly. E.g. conservation measures might be acceptable if there were emerging possibilities for off-farm employment.

iv. Maintanence of incomes at regional or national level

Some authors have argued that micro approaches to sustainability miss too much. E.g., as noted earlier, yields can be maintained but at the expense of depletion of resources in other sectors. Means that some sort of macro framework is required to keep problems of "sustainability" from being pushed from one place to another. Must look at the entire system--the universe?

b. ***Sustainability as a "standard"***

i. Definition of sustainability

Need a definition that can be used as a "standard." Don't know whether the practices are socially optimal. But can make an argument that they possess certain desirable social characteristics based on technical grounds.

Yield sustainability lends itself to a micro argument. Can avoid some of the problems of measuring resource capital by saying that it will be captured or manifested in declining yields. Any benefit analysis of maintaining resources would require this approach. (Alternative would be to set as a standard, maintenance of physical capital at minimum cost. Would not require a cost-benefit analysis.)

ii. The degredation function (physical relationships)

Technical analysis of sustainability proceeds by first defining a physical function that describes how yields behave over time. Set of relationships that have to do with agro-ecological interactions: soil chemistry, hydrological behavior, plant physiology, etc.

iii. The cost function (economic relationships)

Prices of inputs and outputs are added to the technical relationships and profits computed.

c. ***Weak sustainability***

A production system that is weakly sustainability is on in which profits are positive over the normal range of production practices. That is, farmers could practice sustainable agiculture and earn a profit.

d. ***Strong sustainability***

A system that is strongly sustainable is one in which sustainability is consistent with profit maximization. Difference between weakly sustainable systems and strongly sustainable system can be seen in the rates of return to farming. In a weakly sustainable system, the returns are positive but may not reflect the returns that could be obtained from the resources at the farmers disposal. In a strongly sustainable system, returns are maximized at a point which is consistent with resource preservation, i.e., with sustainability as defined by long-term yield maintenance.

4. Afternoon (Period 4): Computer--NR manual (Vol. 3, Ch 2)

B. DAY 2: MODELING NATURAL RESOURCE AND ENVIRONMENTAL POLICY

1. Morning (Period 1): Lecture--Static PAMs and NR Analysis

a. ***Review***

i. Externalties reflect missing or incomplete markets

- Thin markets
- Asymmetric information
- Public goods

ii. Sustainability as a "standard"

- May reflect externalities: market failures
- May reflect policy failures: distorted incentives

b. ***Static Extended PAMS***

i. Comparision of sustainable and unstainable budgets

- Existing situation

The point of departure for NR and environmental PAMs is the existing situation and the traditional budget calculations. Need I-O table and private and social prices.

- Sustainable scenario

The second PAM, defined to represent a sustainable agriculture--by whatever definition--requires the specification of a second I-O table. Table

must incorporate practices that are sustainable. May involve getting rid of certain pesticides and herbicides; could mean different types of tillage; could mean different cropping patterns.

Repeated: don't know if it is optimal. For example. don't know if banning a certain pesticide is socially optimal. Perhaps there are ways of using that pesticide that would do relatively little damage to the enviroment. But since we don't know how to compute the benefits of removing the health and other externalties, will simply ban.

Same kind of reasoning follows for lot of other types of environmental problems. Don't have the data to compute benefits so will define a system that has desirable environmental properties: no externalities. minimal user costs, protection against catastrophes, etc. Then, using the technical coefficients that define that system, computation of budgets and PAMs show the private and social returns to implementing it.

2. Morning (Period 2): Computer--Extending PAMS (Vol.3, Ch. 3)
3. Afternoon (Period 3): Lecture--Discussion of case study results
   a. ***Interpretation of private profitablity***
   b. ***Interpretation of social profitability***
   c. ***Interpretation of divergences***
   d. ***Policy recommendations***
4. Afternoon (Period 4): Computer--Static PAMs (Vol.3, Ch. 4)

C. DAY 3: EXPANDING PAMS TO INCORPORATE NATURAL RESOURCE ISSUES

1. Morning (Period 1): Lecture--Dynamic PAMs: a C-B Approach
   a. ***The general cost benefit model***

The internal rate of return on "investments" in environmental policies can be captured by treating the unsustainable or observed situation as the "without project" case of standard benefit cost analysis. The sustainable technology then becomes the "with project" case and the entire computation proceeds along the lines of a standard C-B analysis

i. Computing the "without project" case (unsustainable)

Compute as a traditional PAM. Use same input-output coefficients and same distinction between private and social prices. Calculate parity prices as described in earlier explanations of the PAM framework.

ii. Computing the "with project" case (sustainable)

Difference between the unsustainable PAM and the sustainable PAM is in the technical coefficients. Latter represent a system of production that has an "acceptable" level of externalities. It also has a long-run perspective that insures that user costs have been considered in determining the present level of resource use.

iii. Computing the stream of net benefits

Net benefit stream for the private IRR is obtained by subtracting the private profits of the unsustainable system from the private profits of the sustainable

system. Typically, would expect that the unsustainable system has higher profits in the present and hence the initial numbers would be negative. Subsequently, the degradation process becomes important enough so that the difference between sustainable and unsustainable becomes positive.

iv. Computing IRR's and NPV's.

IRRs and NPVs are computed using the spreadsheet's IRR and NPV functions. (See spreadsheet manual for directions.)

b. ***Merging cost-benefit analysis and PAMs***

i.

c. ***NVP PAMS***

i. Computing NPVs for PAM cells

NPV computation uses spreadsheet functions. Select an interest rate, select the ranges of the cash flow stream, computer will do the rest.

ii. NPV interpretation

The cells of the PAM can be interpreted in the same way that the traditional PAM is interpreted. Profits now reflect discounted profits over the lifetime of the policy. Divergences represent taxes and subsidies in the same way they do in the original PAM.

2. Morning (Period 2): Computer--Returns to Conservation (Vol 3, Ch 5)

3. Afternoon (Period 3): Lecture--Farming systems PAMs

a. ***Linking technical coefficients to unit of standardization***

i. Shortcoming of single commodity analysis

Single commodity PAMs are based on assumption that only one constraint--usually land--is binding. Farming systems emerge because numerous constraints, many of them seasonal, determine the optimal allocation of resources

ii. Multiple commodity budgets

Using a spreadsheet makes it possible to organize whole farm budgets simulate the total farming system. Standardize technical coefficients on land, then link them to the amount of land that is available. Standard PAMs can be computed by setting land availability equal to one. Farming systems PAM's can be constructed by providing an estimate of farm size.

b. ***Finding acceptable rotations***

Rotations in a budgeting approach to farming systems require an input from an experienced agriculturalist who has some idea of what non-land constraints might determine the most appropriate rotations. The time dimension of rotations can also be considered, e.g., the farming system PAM can be based on three or four year rotations rather than using the results of only one year.

c. ***Computing and interpreting whole-farm PAMS***

The interpretation of the PAM's cells follows the interpretation outlined earlier. Difference is that the numbers now reflect the entire farm. Some crops may be highly protected, others may have a mandatory procurement. By including all commodities, can get a better picture of how the entire sector is being protected or taxed. Goes to the question of the impact of government policy on the farming sector as a whole.

4. Afternoon (Period 4): Computer--Whole farm PAMs (Vol.3, Ch. 4)

D. DAY 4: MARKET LEVEL MODELING

1. Morning (Period 1): Lecture--Static Supply and Demand Analysis

a. ***Shortcomings of budgeting approach***

i. No adjustments on supply side to changes in quantities

A major shortcoming of our budgeting approach is that, although we could figure out the direction of policy reforms that would improve efficiency, our ability to answer the question of what would happen in the economy if we undertook them was quite limited. The adjustments that one would expect, first in the commodity quantities themselves--and subsequently in the markets for the inputs and factors used to produce the commodity--were very limited.

ii. No effects of interventions on the demand side

Budgeting approaches do not take into account the effect of policies on consumer demand. Important to consider because, in case of tradables, is an important determinant of the effect on trade, i.e., on the level of imports or exports. Taxes on producers mean low prices to consumers. Will lower amount produced while increasing amount that will be demand.

iii. Improvements made by using market level methods

Using market level methods permits an analysis of adjustments to changes in prices. Adjustments incorporate both supply and demand sides of the market clearing equations.

If prices are exogeneous (determined by policy or world markets) trade provides the mechanism by which supply and demand are balanced.

If good is a non-tradable, must solve set of simultaneous equations. Need supply equations, demand equation, and market clearing equation.

b. ***Theoretical background of supply curves***

i. What do supply curves show?

Supply curves are the aggregated marginal cost curves of firms. Show quantities that producers would be willing to supply at various prices. (Draw a supply curve.)

ii. Why do supply curves slope up?

Supply curve slope up because the costs of inputs increase as producers bid them up.

Additional firms entering the market are less efficient. Such firms will only produce if prices increase.

iii. Producer surplus

Profits that are obtained by firms who are relatively efficient and who, at a particular price, have costs that are lower than the marginal firm that is determining the market price. Producer surplus is a measure of producer welfare. It is the additional profits that they earn because there is a single price in the market place.

c. ***Theoretical background of demand curves***

i. What do demand curves show?

Demand curves describe the quantities that consumers would purchase at different prices.

ii. Why do demand curves slope down?

Demand curves slope down because consumers obtain a decreasing utility from each unit consumed. Hence they are willing to pay less for it.

iii. Consumer surplus

Consumer surplus arises because, in a competitive market, there is only a single price in the marketplace. Consumers who would have been willing to pay a higher price have a "surplus" consisting of the difference between the market price and the price that they would have been willing to pay.

d. ***Concept of a market equilibrium***

i. Determination of equilibirum prices

In a competitive market for nontradables, supply and demand interact to bring about a market equilibrium. Equilibrium represents a single value for prices and quantities that represent a simultaneous willingness of producers to produce and consumer interest in consumption. Prices are endogeneous to the market level model.

ii. Exogeneous international prices

Export and import parity prices are exogenous to the country when they reflect values determined in international markets. Unless a country is a large producer or large consumer of a particular commodity, they will be unable to influence world markets. Usual small country assumption is valid in most cases.

iii. Exogeneous policy determined prices

Commodity prices are also exogenous to a market level model when they are determined by government policy. The equilibriating mechanism in this case is still international trade, but government policy is an important determinant of quantities supplied and demanded.

iv. Endogeneous price determination: nontradables

Nontradables are commodities whose c.i.f. price exceeds the local costs of production and whose f.o.b. price is less than the local costs of production. The commodity is too expensive on world market to import and to cheap to permit exports. Prices will then be determined in domestic markets.

In the case of domestic factors, there is no question of using international prices; hence the focus on domestic factor markets.

e. ***Example of a policy interventions in a market level model***

i. Government's perspective

Government's perspective on price reforms depends on how policies are implemented. For example, if policy is a tariff, domestic prices will rise but government collects the revenues. If policies are based on quantity restrictions, producers rather than the government will get the revenues.

Governments use tariff to increase amount of commodity produced. Food security measures, for example, call for protecting domestic producers and therefore to increase output.

At the same time, increasing the cost of staple commodities is not popular with consumers. This may lead to consumer subsidies. Worst of all worlds: government subsidies producers and consumers with its food and agricultural policy. Budgetary effects of such policies are substantial.

ii. Producer's perspective

Producer surplus increases with increased prices. Producers like any form of protection. However, they obviously like quantity restrictions best.Means they receive the benefits from the higher prices rather than having the revenue go to the government

iii. Consumer's perspective

Consumer surplus goes up when the price goes down. They oppose producer interests regarding quantity restrictions.

2. Morning (Period 2): Computer--Market Level Analysis (Vol 4, Ch. 2)

3. Afternoon (Period 3): Lecture--Computing Effects of Interventions

a. ***Definition of supply and demand elasticities***

i. Derivation of the elasticity concept

Begin with the equations of the supply and demand curves

$$S = a + bP$$
$$D + c - dP$$

Not concerned, in looking at the effect of policy reforms, in what happens to the constant. Only interested in what happens to the changes in quantities as a result of changes in prices.

Delta S = b Delta P

b (slope) = delta s over delta P

Want to evaluate the change at a particular point. Incorporate base year prices and quantitites to make clear where the change is being measured.

Interested in the percentage changes rather than the absolute changes in delta S and delta P. That leads to the formula for an elastictity. Defined as the percentage change in quantity over the percentage change in price.

b. ***Using elasticities in computations***

delta S = elasticity times initial S times % price change

Write out and show that this reduces to previous formula for determining the change in S.

i. Assume that prices are exogeneous

ii. Objective is to compute change in quantities

If we have change in price, say, the proposed price reform, we can, with the original price for the percentage change in price. Since we also have the original quantity, we now need to solve for the change in quantitity.

We also have the value for the elasticity as determined by econometric estimates.

With these data, can determine the change in quantity that results from a change in price.

Delta S = E x S x (Delta P/P)

c. ***Sources of elasticities***

i. Econometrics estimation

Elasticities are usually estimated from time series data that describe prices and quantities over time. Can use these to obtain an estimate of price-quantity relationships.

ii. Compendiums of elasticities

Several books available that have put together extensive collections of elasticities by crop, country, etc. In absence of data to do own calculation--or lack of econometric skills--can use some of these.

d. ***Limitations of the approach***

i. Reliance on elasticities

Econometrically estimated elasticities require data that reflect the response to policy. If prices have been tightly controlled by the government, there may be little "untainted" information.

ii. Structural change

The underlying statistical model is violated if the economy is undergoing

rapid change. Not estimating movement along a supply curve by jumps from one supply curve to another

iii. Linearity of the model

Kind of geometric calculations done in model require linear curves. Only way on can compute areas without integrating.

iv. No measure of comparative advantage

Comparative advantage becomes much more complex. Movement along the supply curve indicates that some firms will have a comparative advantage in growing a commodity but other firms will not. Much more insight than what one finds in PAMs about adjustments in resource use to policy initiatives.

v. No multi-market effects

Single commodity models do not capture what is going on elsewhere in the farming system

vi. Difficult to introduct input price distortions

Most analysis using market level models has to do with distorted output prices. Means that the discussion is about movements along the supply curve. But input prices may be distorted also--causing shifts in the supply curve as the analysis moves from private to social prices.

4. Afternoon (Period 4): Computer--Market Level Analysis (Vol 4, Ch 2)

E. DAY 5: INDIVIDUAL CASE STUDY EXERCISES

1. Morning (Period 1): Lecture--Introduction to Exercises

a. Hand out data for individual exercises

(Participants have selected substantive and geographical areas on which they would like to work. Should be encouraged to choose problems with which they are likely to have some familiarity. Data drawn from FRI database on agriculture in developing countries.)

b. Review the requirements of a policy memo

See the section in the Monke-Pearson book discussed on first day of the course.

2. Morning (Period 2): Computer--Participant Analysis

III. WEEK III:

A. DAY 1: MULTI-MARKET MODELS

1. Morning (Period 1): Lecture--Multi-Market Models

a. ***Motivation for the approach***

i. Interest in market linkages
Why should we think that there are linkages between different commodity markets?

- Supply side: complements and substitutes

Commodities are said to be complements when the production of one enhances to production of another. They are substitutes when the production

of one precludes production of the other. E.g., crops that could be grown in the same season on the same land are substitutes.

- Demand side: complements and substitutes

  Commodities are said to be complements in demand when the consumption of one causes increased consumption of the other. Condiments on foods are complementary. Rice and wheat are substitutes in consumption.

ii. Cross-price effects

- Definition of a cross-price elasticity

  The percentage change in quantity as a result of the percentage change in price of a complement or substitute.

- Total elasticity vs. partial elasticities

  Partial elasticities distinguish between own price and cross price elasticities.

  Total elasticities are own price elasticities that include the effects of cross price elasticities.

  Type of elasticity is determined by the estimation technique. If simple own price-own quantity relationships are used, elasticity will be total elasticity. If, in addition to own price changes, cross-price elasticities are estimated, then the own price elasticity is a partial elasticity.

- Estimation of elasticities

b. ***Multimarkets and exogeneous prices***

i. Grapics of indirect (spillover) effect

Use the multimarket graph in Volume 4 to illustrate the indirect effects of an exogeneous price change. Change in price of commodity A causes a move along its own supply curve but a shift in the supply curve of the linked market.

So long as the price of commodity B is also an exogeneous price, will not have a feedback effect on the market for commodity A.

ii. Multi-market effects in policy models

Important to determine whether prices can be treated as exogenous or endogenous. Examples of the former are models in which the relevant prices are policy determined or internationally determined tradables prices.

iii. Writing down the price exogeneous model

Use equations in Volume 4 to discuss the multimarket model with exogenous prices. Model now contains both own and cross price elasticities. But formula is a simple extensions of the previous formula for determining a change in quantity as a function of its own price.

Delta S = own elasticity x initial quantity x percent change in price. Now add cross price elasticity times initial quantity times percent change in price of competing or substituting commodity.

iv. Solving the multi-market model

Virtue of models in which prices are exogenous is that they can continue to be solved on a spreadsheet with same techniques used earlier. Because of exogenous prices, can form the percentage change in prices without difficulty. When coupled with the original quantity and the elasticities, can compute the change in the quantity being analyzed.

2. Morning (Period 2): Computer--Market Level Analysis (Vol 4, Ch 3)
3. Afternoon (Period 3): Lecture--Computing with Non-Tradables

a. ***Multimarkets and edogeneous prices***

i. Review definition of a non-tradable

A nontradable commodity is one for which the cost of production is (1) greater than its f.o.b. value and hence it cannot be exported, and (2) less then the c.i.f. cost so that it will not be imported.

ii. Graphics of feedback effects

Use graph in Volume 4 to illustrate model in which there is feedback from one market onto the other. Starts out like a price exogenous mode. But, instead of stopping with a shift in the supply curve of the competing or substituting commodity, the price is endogenous and changes as a result of the supply curve shift.

With the change in price of commodity B, the supply or demand curve in the original market shifts. Process stops there is the market for commodity A has an exogenously determined price. If that is true, the adjustment to the shifting curves will be the quantities of commodity A that are exported or imported.

iii. Writing down the price endogenous model

Refer to Volume 4 for the price endogenous model. Show how there are now several equations and several unknowns because the percent change in price is not given from outside the model.

iv. Solving simultaneous equations using matrix inversion

Solving the supply and demand equations with endogenous prices involves two equations and two unknowns. Need to solve simultaneously for prices and quantitites. In simple two equation--or even three equation--models, can do by substitution. But for more than two markets, need a better tool. Use matrix inversion techniques to solve simultaneous equation model

v. Formulating the multi-market model matrix

Lead students through relevant section of Volume 4. The matrix inversion routine in spreadsheets quite powerful and can handle substantial problems. Need the inverse of the coefficients matrix to solve the equations. Show steps in the spreadsheet tutorial included in Volume 4 to invert matrix.

vi. Solving the price endogeneous model

Once the inverse has been obtained, use to compute values for prices and quantities. See Volume 4 for details.

b. ***Working through the multimarket spreadsheet***

4. Afternoon (Period 4): Computer--Market level manual (Vol 4, Ch 3)

B. DAY 2: EXTENDED MULTI-MARKET MODELS

1. Morning (Period 1): Lecture--Adding Commodities and Regions

a. *Adding additional commodities*

Adding more commodities means expanding the size of the matrix. Use Volume 4 to show how this is done. Add new headings for commodities. Need own price elasticities and cross-price elasticities. Then need to add initial quantities and initial prices.

Beware that adding too many commodities makes a model difficult to interpret. Model becomes a black box. Need to be selective in the number of commodities that you try to include in this type of exercise. Not only becomes difficult to interpret, becomes even more difficult to explain.

b. *Adding additional regions*

Regions can be added in the same way as commodities. Indeed, so can inputs. Additional markets are continum from single market to a general equilibrium model. To include an additional market, need only know its cross-price elasticity to at least one other markets. (If there are no significant cross price elasticities, then don't need to worry about including commodity or region in the matrix.

Use Volume 4 to discuss illustrative multi-commodity multi-regional markets.

2. Morning (Period 2): Computer--Market-level manual (Vol.4, Ch.4)

3. Afternoon (Period 3) Lecture--Writing and Presenting Results

a. *Outline of a policy memo*

4. Afternoon (Period 4): Market level manual (Vol 4, Ch. 5)

C. DAY 3: MARKET LEVEL ANALYSIS OF ENVIRONMENTAL POLICES

1. Morning (Period 1): Lecture--Externalities in Market Level Models

a. ***Modeling externalities in market level models***

i. Conventional supply and demand models as a point of departure

Supply curves are marginal cost curves. Call these curves MPC for the supply curve. MPV (marginal private value) is the demand curve. Illustrate with equations and graphs in Volume 5.

ii. Correct for production and consumption externalities

Assume MPC curve do not contain costs that are generated by the production system. Assume these costs are being borne by other production systems. Examples are pollution, silting of reservoirs, health hazards, etc.

iii. Correct supply curves for production externalties

Forcing private producers to pay for externalities would shift the supply curve up. At constant output prices, would mean that optimal production was lower than it was before the externality was included.

iv. Correct supply curve for distorted input prices

Similar correction of supply curve also required for distorted inputs. If input prices are being subsidized, removing the subsidy would shift the supply curve upward also. The result would be to reduce the optimal level of production.

b. ***Computing optima with externalities assuming nontradables***

Use same techniques that were used in the multimarket framework. If prices are not exogenous, need to solve by setting up a matrix of coefficients and inverting. Use the inverse to compute optimal prices and quantities.

2. Morning (Period 2): Computer--Market level NR model (Vol 5, Ch 1)

3. ***Determining corrective measures to internalize externalities***

a. Variety of ways in which externalities might be corrected

i. Government could take over production

Until the actual truth was revealed, assumption was that centrally planned economies would have better environmental records. Demise of Soviet Union and Eastern Europe revealed that although the government with it ubiquitous presence countrolled everything, it had other priorities than the environment. Result: environmental disaster. But in theory could minimize environmental costs.

ii. Government could set quantitative controls

Imposing standards has been a traditional way of forcing producers to internalize the costs of externalities. This was basis of the extended PAM analysis.

iii. Government could impose taxes and subsidies

Government could create incentives for firms to move from what is privately profitable to what is socially desirable. (Note: two are not equivalent. Taxes bring costs into line while discouraging output. Subsidies for implementing conserving into line while encouraging output.

b. Use graphs in Volume 5 to show optimal taxation.

Optimal tax brings private quantities into line with what have been determined to be the optimal social quantities.

4. Afternoon (Period 3): Lecture--Externalities and Trade

a. ***Incorporating exogeneous world market prices***

i. Marginal cost of imports

Represented by the world price of the commodity. Price is now exogenous; not a policy determined price. Consumption and production at private prices will determine the level of necessary imports.

ii. Marginal cost of exports

Represented by the world price of the commodity. Same argument as above except now talking about exporting the commodity rather than importing.

b. ***Effects on producer and consumer welfare through trade policy***

General finding: if domestic policies have been implemented to deal with the presence of externalties, trade will have no effect on the country's environmental situation. Gains from trade will exceed losses from market failures, e.g., increases in exports of cotton will off-set environmental effects of pesticides. However, for this to be correct, must be willing to implement corrective measures domestically.

There are certain special problems associated with diseases and pathogens. E.g., European ban on beef imports from East Africa are intended to contain foot and mouth disease.

c. ***Interaction of economic and environmental policy***

i. Increasing output as a result of removing price distortions

Most common policy in developing countries has been to tax agriculture by taxing agriculture's output. Result is that production has been retarded. If output has a degrading effect on the environment, means that misguided growth policy have actually protective of the environment, e.g., increasing price of beef in Zimbabwe results in greater demand for pasture and more intensive use of a resource that is already in a state of degradation.

ii. Decreasing inputs supports sustainability

The same macro policies that dampened the demand for outputs subsidized tradable inputs, especially fertilizer. Reducing the profitability of purchased inputs that have a negative effect on the environment is a win-win situation. The amount used of a degrading input is decreased.

iii. Eeconomic-environmental interaction is often ambigious

Can't tell easily which effects dominate without going into the specifics of a particular situation. Do need to understand the ecological system in which the policy analyst is working. But cannot lose sight of the economic incentives that are operative both today and in the future.

5. Afternoon (Period 4): Computer--Market level NR model (Vol 5, Ch 2)

D. DAY 4: MARKET LEVEL MODELS AND PRICES DISTORTIONS

1. Morning (Period 1): World price distortions

a. ***Health hazards (diseases)***

i. Protection of consumers from unsafe food

ii. Protection of workers from unhealthy working situations

iii. Protection of environment from pathogens

iv. Prevention of animal abuse

v. Protection of plants and animals from disease

2. Morning (Period 2: Computer--Environmental policy (Vol 5, Ch 3)

3. Afternoon (Period 3): Distorted world prices and externalties

4. Afternoon (Period 4): Computer--Environmental policy (Vol 5, Ch 3)

E. DAY 5: INTRODUCTION TO OPTIMIZATION

1. Morning (Period 1): Lecture:--Introduction to optimization

a. *Purpose of the module*

This module is not designed to make students in linear programming experts. Rather it is provide a conceptual framework that can be contrasted with the PAM and market level approaches.

Weakness of the PAMs is that it was designed to look at single commodity model. It has difficult in examining that commodity when it is simply one of many that compete for a scarce resource.

No mechanism for the adjustment that one would expect to take place when markets are liberalized.

Need same data set. Only addition is the need for quantity data on at least one domestic factor. Usually taken to be land. Need data on seasonal crop use. If only a single land constraint, then back in the PAM world.

b. ***Optimal resource use in output space***

i. Identify Commodity A and B along the axis (Volume 6)

Using the two dimensions available for graphing, create a space defined an "outputs" space. (See Volume 6 for graph.)

ii. Define production possiblity frontier to reflect trade-offs

Use technical coefficients and resource (constraint)s to determine maximum output of each commodity.

iii. Assumptions of a linear model

Proportional factors use in all activities

Additivity of all activities

Static, deterministic

c. ***Optimal use in input space***

i. Represent problem by putting inputs on axis

Put capital and labor on the axes as shown in Volume 6.

ii. Rays embody technical assumptions

Use rays to depict activities. Slopes of the rays are determined by the technical coefficients. Rays can represent different commodities or different ways of producing the same commodity.

d. ***Factor substitutions based on technology changes***

Rays can show different product using different combinations of capital and labor or the same commodity using different factor proportions. Factor substitution takes place by shifting from one technology to another.

All the problems of linearity apparent here also. Easy to see how corner

solutions occur. Show how solutions involving only one activity occur. Two activities.

2. Morning (Period 2): Computer:--Work on Individual Case Study
3. Afternoon (Period 3): FREE
4. Afternoon (Period 4): FREE

IV. WEEK IV:

A. DAY 1: USING OPTIMIZATION METHODS FOR POLICY ANALYSIS

1. Morning (Period 1): Lecture--Optimization Models

a. ***Review of relationship between budgeting and optimization***

i. Focus on factor or domestic resource markets

Important difference between PAMs and GAMS is that the quantities of domestic factors become important. Land clearly belongs in this category where factor should be modeled as fixed. If there is significant seasonality, seasonal constraints will produce optimal solutions that contain a number of commodities. If water is also a constrained commodity, will add to the possibility of multiple crop solutions.

ii. Factors as quantity constrained rather than freely traded

Need to consider whether quantity constraints on mobile factors such as capital and labor make sense. May be better to model them as being domestic factors that can be moved for a price. All modeled as being hired in PAMs. In optimization models have the opportunity to incorporate different types of mobile market structures.

b. ***Organization of an optimzation model***

i. Objective function

Outputs have positive prices and positive entries; inputs have negative prices and enter function as negative numbers. Variable costs reflect summations of purchased inputs costs. But can create activities that deliver inputs. They would also have negative elements in the objective function.

ii. Technical coefficients

Input-output coefficients. Show the physical amounts of inputs and factors that are required to produce crop.

iii. Factor constraints

Show the amount of factors that are available.

c. ***The optimization tutorial on GAMS***

i. GAMS as a language

GAMS is a programming language that permits the user to write programs similar to the textbook version of the model.

Was designed to make it possible to "read" models and share then with other users. Want to organize the equations in such a way that the structural equations of the model are readily apparent.

ii. Organization of the problem in GAMS (See Volume 6 tutorial)

- Sets
- Parameters and tables for data organization
- Variable designation
- Equations
- Model statements

iii. Writing a GAMS model

GAMS is written with a programming editor. Popular editors include Norton editor, Brief, VEDIT, etc. Could use a wordprocessor but have to be very careful that file is saved as a DOS textfile.

iv. Interpreting GAMS output

If problem is a primal, values of the duals (shadow prices) is shown first. The levels of the primal (Use GAMS tutorial in Volume 6 to lead students through results.)

2. Morning (Period 2): Computer--Optimizaton manual (Vol 6, Ch 1)
3. Afternoon (Period 3): Lecture--Policy Experiments with LP Models

a. ***Computing supply curves***

i. Parametric programming

Change price parameter systematically and record results. Effect will be to create a supply curve. i.e., a marginal cost curve.

ii. Discontinuity

Supply curves reflect linearity of the model. Supply curve will not be the smooth curve usually seen in textbooks. Need rich technical matrix (lots of activities and constraints) in order to get smooth supply curve.

b. ***Computing at private and social prices***

i. Private prices

Initial model assumed that prices were exogneous and that they reflected government policies. Same assumptions as the private prices row of the PAM

ii. Social prices

Social prices computed in the same way as the export and import parity prices calculated in the PAM. Re-run the model with social prices and record the results. Can all be done in the GAMS model in one run. (See the appropriate chapter in Volume 6 to see how this is done.)

c. ***Computing summary protection coefficients***

With the availability of social prices, can compute summary coefficients that make it possible to compare protection and efficiency across commodities and regions.

i. Nominal protection coefficients

Shows protection on the value of output

ii. Effective protection coefficients

Value added at social prices/ value added at private prices. Adds information on the protection of input prices to the previous analysis of output prices. Number provides a total estimate of protection.

d. ***Computing PAMs***

i. GAMS report generator can compute PAMs

Value added is computed using statments similar to those computed for the summary coefficients exercise. Values for the fixed assets can also be obtained from the GAMS reports. Done by identifying "attributes." These include .l for levels of activities and .m for values of marginals (See Chapter in volume 6 that describes syntax.)

Difference between GAMS generated PAMs is that the former use the computed values for shadow prices instead of trying to adjust private prices empirically.

Leads to an anomoly. Social prices of domestic factors differ between PAM and l.p. models. In l.p. model, product exhaustion theorm always holds. Value added always imputed to factors. When output prices change, shadow prices of domestic factors change. When incorporated in the PAM framework, will always show a divergence between private and social costs. This suggest market imperfections. Actually, it is just the opposite. Factor prices are changing <u>because</u>of the reponsiveness of factor markets.

4. Afternoon (Period 4): Computer--Optimization manual (Vol 6, Ch 2)

B. DAY 2: AGRICULTURAL SECTOR MODELS AND AGRICULTURAL POLICY

1. Morning (Period 1): Lecture--Description of Sector Models

a. ***Comparison: sector models and multimarket models***

i. Sector models as a response to PAM weakness

Optimization element of sector models makes it possible to talk about supply response in a more sophisticated way than can be done using PAMs

Demand schedules are a part of sector models and hence the effect of consumer preferences can be included

ii. Sector models as a response to market model weaknesses

Incorporate demand curves--the same demand curves--as market level models

Sector models substitute normative supply curves based on the optimization algorithm rather than using elasticies computed econometrically.

b. ***Disaggregation by region, technology, farm size***

PAM policy comparisons require a detailed data collection program. Once data has been collected, can be organized efficiently in form of a sector model.

Difficulty with sector models is not the data requirements. These are the same data as one would need doing PAMs. Problems is that considerable skills are needed to organize the data in the form of a sector model and to interpret the results of a more complex model.

Sector model and its results are also sufficiently complex so that the entire enterprise is difficult to explain to policy makers

c. ***Policy analysis using an agriculture sector model***

i. Supply analysis

ii. Trade analysis

2. Morning (Period 2): Computer--Complete Previous Exercises

3. Afternoon (Period 3): Lecture--Computation of Sector Models

a. ***Maximizing producer-consumer surplus***

i. Simulating a competitive equilibrium

Maximizing competitive equilibrium occurs at the point where supply and demand intersect. (Demonstrate using graph of market level model.

ii. Non-linear objective function

Producer-consumer surplus is an area. Hence the objective function is quadratic. So long as constraints are linear, no problem in solving this kind of model with MINOS, the non-linear solver.

b. ***Incorporating international trade***

i. Exports

Add exports by adding an export activity. In the small country case, the demand curve is assumed to be perfectly elastic. Hence there will be no price-quantity interaction. However, there are surely limits to the amount that can be exported. Add a constraint that limits exports.

ii. Imports

Imports also simply an activity. Small country assumption is that the supply of imports is perfectly elastic.

c. ***Characteristics of a competitive equilibrium***

Model solution should not be interpreted as maximizing welfare. That would require the assumption of cardinal utility maximization. Better to assume that the model simulates competitive equilibrium. It permits the investigation of policy effects of price reforms.

4. Afternoon (Period 4): Computer--Complete Previous Exercises

C. DAY 3: AGRICULTURAL POLICY AND CGE MODELS

1. Morning (Period 1): Lecture--Description of CGE Models

a. ***Contribution of CGE models to policy analysis***

i. CGE models permit investigation of indirect effects

Sector models make prices endogenous. But there is no income effects from changes in factor prices. Incorporation of households who own factors make the link. Now have the circular flow that characterizes general equilibrium models.

ii. Commodity policy

Useful in countries where single commodity plays a very large role in the economy. Rice in Philippines or Indonesia would be a good example. Also cotton in Egypt or Sudan. Problem is that it is difficult to develop GE models that are sufficiently disaggregated so that individual commodity effects can be identified.

iii. Macro policy

Structural adjustment policies, especially their income effects, benefit from a GE analysis. Market liberalization almost always have negative distributive effects if the indirect effect of growth are not included.

b. ***Structure of a CGE model***

i. Firms

ii. Households

iii. Circular flow

CGE model captures the circular flow that characterizes a GE model. Production is sold by firms; firms use receipts to pay for factors; factors are apportioned to households; households use incomes from factors to purchase the output of firms.

c. ***Data requirements***

i. Inter-industry table

Need substantial amount of information to build the traditional input-output table. Columns represent outputs of industries; rows inputs of industries

ii. SAM

Expansion of I-O table called a social accounting matrix. Includes households and factor endowments. Again substantial data requirements. Need disaggregation by household types: urban-rural, high income-low income, etc.

d. ***Strengths and weaknesses of CGE analysis***

i. Captures both direct and indirect effects

ii. Too aggregated for policy purposes

2. Morning (Period 2): Computer--Complete Previous Exercises

3. Afternoon (Period 3): Lecture--Computing CGE Models

a. ***Transaction value approach to constructing CGE models***

Fill out SAM by accounting for all transactions between sectors in the economy

b. ***Using Hercules as a GAMS solver***

Hercules is designed to work with GAMS, not only to solve the simultaneous equations of the model, but to provide production and consumption relationships. This is all built into the solver.

Hercules also checks for consistency. In the TV approach, transactions must all add up. Must account for everything. Hercules insures that the balances all balance, i.e., that the circular flow is completed.

c. ***Interpreting CGE model results***

Use the Hercules demo to run a simple problem. Show how a change in capital availability would have an effect on growth

4. Afternoon (Period 4): Computer--CGE Demo Using Hercules Solver

D. DAY 4: REVIEW OF AGRICULTURAL AND NR POLICY ANALYSIS

1. Morning (Period 1): Lecture--Approaching Policy Analysis Modeling

a. ***Budgets and PAMS***

i. Strengths

Conceptually rigorous; easy to compute and to explain; data requirements can be substantial but, because they are cross-sectional field survey data, they can be obtained

ii. Weaknesses

Limited analytical flexibility; difficult to discuss supply response

b. ***Multi-market Models***

i. Strengths

Incorporate demand analysis so that consumer preferences also play a role in response to price changes; use of elasticities incorporate great deal of information about supply response

ii. Weaknesses

Elasticity calculations are suspect given the data situations in most developing countries. Time series with sufficient market-based variation not readily available.

c. ***Optimization Models***

i. Strengths

Provide endogenous supply response; gets more from farm management budget data than can be obtained from the PAM analysis

ii. Weaknesses

When only budget data available, linear models tend to overspecialize.

d. ***Sector and CGE Models***

i. Strengths

Make more variables endogenous and hence enrich the analysis. Get a better feeling for the indirect effects of policy proposals.

ii. Weaknesses

Level of aggregation makes it difficult to relate results from model solutions to individual commodity analysis. Requires substantial data manipulation and computational skills.

e. *Summary*

No free lunch. Isn't any one way to do policy modeling. Need to consider (a) the problem, (b) the resources available to solve it, (c) the ability to use the information to persuade policy makers.

2. Morning (Period 2): Computer--Own Projects
3. Afternoon (Period 3): Computer--Own Projects
4. Afternoon (Period 4): Computer--Own Projects

E. DAY 5: COURSE WRAP UP AND COURSE CRITIQUE

1. Presentation of certificates
2. Verbal discussion of course improvements
3. Written evaluations

V. BIBLIOGRAPHY

A. BOOKS

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4. Volume 4: Market Level Analysis of Agricultural Policy
5. Volume 5: Social Equilibrium Analysis with Market Level Models
6. Volume 6: Optimization Methods for Agricultural Policy Analyis

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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AGRICULTURAL AND NATURAL RESOURCE POLICY ANALYSIS COURSE

Learning Spreadsheets and
Analyzing Aggregate Data

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PREFACE

The computer exercises in this volume have two objectives. First, they serve as an introduction to the use of electronic spreadsheets. The treatment is brief and it is not intended to be a reference for Lotus 1-2-3 or any of the other spreadsheets that can emulate 1-2-3. Books such as Lotus Development Corporation's *Learning Lotus 1-2-3* or Que's *Using Lotus 1-2-3* serve that purpose. Rather, the initial exercises focus on a sub-set of concepts and commands that will be especially useful in the subsequent policy analysis series. Thus, if students find themsevles doing more "moving" and "copying" than the initial simple problems seem to call for, it is all part of an effort to practice the tools and techniques that will be helpful later on.

This manual also has a substantive agenda. Subsequent volumes in this series take up more sophisticated analytical tools such as the policy analysis matrix (PAM), market-level analysis, and mathematical programming. However, for anyone interested in policy, there is much to recommend an examination of aggregate data as an initial step. It is highly desirable, for example, to establish what has happened over time to aggregate output, yields, the compostion of output, input use, prices, etc. Often much that is of relevance to the policy environment can be seen from the calculation of percentages and simple trends. These analyses are quite straightforward and involve simple arithemetic that can be carried out easily on spreadsheets. The substantive work therefore complements the first objective of acquiring a familiarity with spreadsheets on microcomputers.

The manual begins with a brief introduction to Lotus 1-2-3 on microcomputers. It is designed to be led by an instructor and to provide students with an overview of the computations and presentations that will be developed in subsequent hands-on work. In the absence of the instructor, students may wish simply to read the material and go on to the introductory exercises in Chapter 2. The material in Chapters 3-5 progresses from the development of a small database to the computation of the components of agricultural growth for particular time periods. To reiterate, this manual is not a substitute for the detailed tutorials that are supplied with most spreadsheet software. It is also not a substitute for having a Lotus manual nearby to consult when something goes awry.

The exercises can be carried out on a wide variety of microcomputers. Lotus 1-2-3 (Version 2.2) is the point of departure and it is assumed that students will be working on IBM or IBM compatible machines. Spreadsheets such as Borland's QuattroPro and Computer Associates' SuperCalc contain Lotus emulation modes that make it possible to utilize the manual's instructions without change. Spreadsheets such as Excel or Wingz running on the Apple Macintosh work equally well as far as the calculations are concerned, but some translation of specific instructions will be required.

For those unfamiliar with Lotus 1-2-3 commands, the Quick Reference section of the Lotus manual has been bound as a part of this volume. It can be found at the back of the manual.

Thanks are due to the Agricultural Policy Analysis Project (APAP), funded by U.S.A.I.D., for providing the resources to prepare this manual and to carry out the training exercise. Further information about this project, its newsletter and its published output in the agricultural policy field can be obtained from Abt Associates, Inc., Hamden Square, 4800 Montgomery Lane, Suite 600, Bethesda, MD 20814.

Carl H. Gotsch

July, 1991

CHAPTER 1: LOTUS 1-2-3: A DEMONSTRATION

The following exercise provides an overview of some of the most important features of Lotus 1-2-3.[1]

Like all spreadsheets, columns and rows identify the **cell address** of each data entry. A repeating alphabet (e.g., A, B, C...IV) goes up to 256 columns horizontally; the vertical scale has 8192 rows. A1 refers to Column A, Row 1; AB2 refers to Column AB, Row 2. In subsequent exercises, you will be asked to enter data yourselves. However, in the following introductory sequence, the contents of the data file have been stored on a diskette under the file name "**INTRO**" and the file need only be retrieved in order to follow the demonstration. Insert the "Intro" diskette into drive A if you have not already done so.

At the DOS prompt C:\, type **Lotus**. In its command structure, Lotus 1-2-3 does not distinguish between upper and lower case fonts. You could also have typed LOTUS or lotus.

After you have typed LOTUS, the computer will work for a few seconds and then produce a menu of choices. Choose 1-2-3.

THE LOTUS MENU

Lotus is a menu driven program. The menu contains a series of commands which appear at the top of the screen. The first step in retrieving the data file is to retrieve the menu.

Press: / {slash}

Below the main menu is a sub-menu showing options at a lower level. For example, if the cursor is on ***Worksheet***, the menu will appear as it does on Screen 1.1:

Notice that the word MENU is shown in the top right hand corner of the screen. This indicates that the only action that can be taken is to select from the menu. If data are to be entered, the word READY must show in the upper right hand corner.

RETRIEVING A DATA FILE

The data file can be retrieved in one of two ways:

(1) Move the cursor to the word ***File*** with the arrow keys and press **[Enter]**,

or

[1] Chapter 1 is not intended to be a self-teaching tutorial. It will ordinarily be carried out with the instructor as an interactive demonstration of the capabilities of electronic spreadsheets. If self-taught, it requires a diskette containing the file INTRO.WK1. This diskette should be inserted in Drive A: after the DOS prompt has appeared and before Lotus 1-2-3 is started.

Screen 1.1

```
A1                                                                  MENU
Worksheet  Range  Copy   Move   File   Print   Graph  Data  System  Quit
Global, Insert,  Delete,  Column,  Erase, Titles,  Window,  Status,  Page

        A      B       C        D         E         F         G         H
=========================================================================
1 |
2 |
3 |
4 |
5 |
6 |
7 |
```

(2) Type the first letter of the command, ***F.***

When the file sub-menu appears, retrieve the file. Again, there are two choices:

(1) Move the cursor to ***Retrieve*** with the arrow keys and press **[Enter]**,

or

(2) Type the first letter of the command, ***R.***

The computer will then display a list of file names. Select **INTRO.WK1** by highlighting with the arrow keys and press **[Enter]**. (Note that all Lotus 1-2-3 spreadsheet files end in **.WK1**.)

Screen 1.2

```
A1                                                                  MENU
Worksheet  Range  Copy  Move   File   Print   Graph   Data   System  Quit
Global, Insert,  Delete,  Column,  Erase,  Titles,  Window,  Status, Page

        A         B         C         D         E         F         G     H
=========================================================================
1 |
2 |
3 |
4 |
5 |
6 |
```

MOVING AROUND THE SPREADSHEET

There are several ways to move the cursor around the spreadsheet. Practice using the following commands. (If the arrow keys are on the numerical keypad, make sure that the **[Num Lock]** switch is off.)

(1) The **[Home]** key returns the cursor to the cell, A1.

(2) The **[End]** key followed by the **[Home]** key moves the cursor to the lower right corner of the last table.

(3) The **[PgUp]** and **[PgDn]** keys move the cursor up and down the spreadsheet in lengths of screen.

(4) **[F5]**, the {GOTO} function key, moves the cursor to a specified cell. (This key will become important later when there are a number of tables on a single spreadsheet and the analysis requires moving quickly from one to another.)

Press: **[F5]**
Type: ***D3***
Press: **[Enter]**

The cursor will move to the word "Production" in cell D3 of **INTRO.WK1**.

(5) The cursor can be moved rapidly around the spreadsheet by using it in conjunction with the **[Ctrl]** key. Hold down the **[Ctrl]** key and press the left or right arrow key. The cursor moves a screen at a time.

It is important to develop the habit of moving the cursor in the most efficient way possible. Your productivity will be much enhanced if you are able to locate tables and cell entries quickly.

LABELS AND NUMBERS

Three types of data may be entered in a Lotus 1-2-3 spreadsheet.

(1) **Labels** are words or symbols that are not used for calculations. All labels have prefixes that determine their position in a cell. The prefixes are ', ", or ^.

(a) The ' prefix aligns the label on the left hand side of the cell. It is the default that Lotus uses if no other command is given.

(b) The " prefix aligns the label on the right hand side of the cell.

(c) The ^ prefix aligns the label in the center of the cell.

Press: **[Home]** Notice the label prefix (') in cell A1 at the top of the screen where the cell contents are displayed.

Press: **[F5]** {GOTO} and type **A6**. Notice the numbers entered here as dates also have a label prefix. This is because they are not going to be used for calculations.

(2) **Values** are numerical entries that will be used in computations. They do not have

prefixes. Move the cursor to a numerical entry with the arrow key and verify that the cells containing numbers do not have a prefix.

(3) **Formulas** are cell entries whose values are obtained by computation from other values in the spreadsheet. Move the cursor to the column under the heading: "Production." The formula used to calculate the values in the column will appear in the upper left hand corner of the screen. The formulas need only be entered in the first cell of the column. The ***Copy*** command can be used to copy them into other cells, making it possible to construct spreadsheets rapidly.

Formulas must be written with a mathematical sign before the first value, such as +, -, (or @. The @ sign indicates that a specific Lotus 1-2-3 function for computing numerical values is to follow.

USING FORMULAS

The power of a spreadsheet results from the ability to insert formulas that compute cell values from data stored in other cells of the worksheet. For example, move the cursor to numbers in the column labeled "Production" and note the formulas displayed in the upper left hand corner of the screen. Row and column designations that have a dollar sign prefix ($) are called "**absolute**" addresses. This means that when they are copied, they will continue to reference the cell address given in the formula without automatically adjusting to the changes in "relative" cell position. If there are no $ signs in front of row and column indentifiers, the computer will automatically change the cell addresses to reflect the changes in the "**relative**" position of the target cells.

Understanding the ***Copy*** command is crucial to building policy analysis models quickly and accurately. To see its power:

Press: **[F5]** {GOTO}
Type: F6
Press: **[Enter]**
Type: +D6*E6/1000
Press: **[Enter]**

The result of the multiplication will appear in Cell F6. Now:

Press: /
Select: ***Copy***
"Range to copy FROM: F6..F6" [2]
Press: **[Enter]**
"Range to copy TO: F6"
Press down arrow once to move to F7
Press: . (anchor the range)
Press: **[Down Arrow]** (highlight to the bottom of the column)

[2] Thoughout the manual, quotes indicate Lotus 1-2-3 prompts.

Press: **[Enter]**

Notice that the copied cell addresses have changed to reflect the formula's position **relative** to the cells in the original formula.

LOTUS GRAPHICS

To see a graph of the data in the spreadsheet, call the main menu:

Press: /
Select: ***Graph***
View

A graph of the data from the spreadsheet will appear on your screen. The data for this graph have been entered previously. The graph presents, not only the data on aggregate production and acreage shown earlier, but a graph of the trend line through the data. The trend values have been estimated from the coefficients of the equation [Y = a + bX] computed using Lotus 1-2-3's regression capability. The calculated Y values of the trend line are shown under the column "Trend" in the "INTRO.WK1" worksheet.

Graphs may be saved in two ways:

(1) As part of the worksheet when the worksheet is saved. (If there is more than one graph, each must have been saved as a "named" graph.)

(2) As a **.PIC** file that can be printed with the Lotus module, **PrintGraph.** (**.PIC** is a standard data format that can be read by many other packages including word processors such as WordPerfect or Microsoft Word. This makes it possible to import graphs into reports and research papers.)

Remember that saving the graph as a file to be printed (.PIC) does not mean the graph has been saved in its worksheet form. Similarly, saving the graph in the worksheet does not mean it can be printed. Much work can be lost by failing to save properly.[3]

PRINTING A TABLE IN LOTUS 1-2-3

Tables may be sent either directly to the printer or to a file for subsequent incorporation in text documents. To print,

Press: /
Select: ***Print***
Printer

The sub-menu offers several different output formats. Once the range, i.e., the rows and

[3] Newer spreadsheets such as Quattro, Excel and SuperCalc5 allow graphs to printed directly from the spreadsheet.

columns to be included in the printout, has been set, such parameters as margins, headers and footers, length of page, size of type, etc., may be chosen. The printer is activated by selecting: ***Go***. (Printers may be stop by pressing the **[Control]** key and the **[Break]** key simultaneously.)

Worksheets may also be printed as a file that can subsequently be read by a wordprocessor. The command sequence is **/Print File** instead of **/Print Printer** . The result will be an ASCII file with the extension **.PRN** that can be retrieved by such programs as WordStar, WordPerfect and Microsoft Word.

PRINTING A GRAPH IN LOTUS 1-2-3

To print a graph you must exit the Lotus 1-2-3 program and enter the **PrintGraph** program. Before leaving 1-2-3, remember to save your work.

Select: ***File***
Save

The full path name of the file is **A: \INTRO.WK1**. When asked whether to **Cancel** or **Replace**, anwer "Replace" if new work has been added and the old file should be overwritten. (Note: Accidentaliy replacing a file with a blank spreadsheet will wipe out previous work.)

Now exit Lotus 1-2-3.

Select: ***Quit***
Yes

From the Lotus program menu,

Select: ***PrintGraph***

The Printgraph menu will appear on the screen.

Select: ***Image-Select***

A list of files will appear on the screen

Screen 1.3

```
                                                                    MENU
Select Graphs for Printing
Image-Select      Settings        Go        Align        Page       Exit
=========================================================================
=
INTRO
```

Move the cursor to **INTRO** and press **[Enter]**.

Select: ***Align***
Go

The graph from Lotus 1-2-3 will be printed. (Printing graphs is quite slow. To stop the printer, press **[Ctrl]-[Break]**.)

To leave the Printgraph program,

Select: ***Exit***
Yes

LOTUS ADD-IN PROGRAMS

Lotus 1-2-3 (Version 2.2) is an upgrade to what is sometimes called a "second generation" spreadsheet. It is an improvment over first generation spreadsheets such as VisiCalc, but does not have many of the features contained in such third generation spreadsheets such as Excel and Lotus 1-2-3 Version 3. However, because of modest hardware requirements, Version 2 is still the most popular spreadsheet currently in use on microcomputers.

In an effort to improve its printing performance, a number of third-party software vendors have written programs that can be used in conjunction with Lotus 1-2-3. They are called "add-in" programs because they can be invoked from within Lotus by the use of a "hot key." One of the most popular of such packages is AllWays.

To run Allways:

Press: **[Alt]-[F7]**

AllWays uses the same type of menu system as Lotus 1-2-3. It permits a wide range of fonts and formatting commands to be used with the spreadsheet currently on the screen and in memory.

Print ranges, margins, etc., are set in the same way that they are set in Lotus. Control is returned to the spreadsheet by pressing **[Esc]**.

Print the **INTRO** file using Allways. Use the commands described earlier in the directions on how to print a Lotus table.

SUMMARY

Chapter 1 highlights some of the most important attributes of Lotus 1-2-3. Experienced spreadsheet users will, of course, already be aware of the power of the Copy command, the need to distinguish between relative and absolute cell addresses, the importance of saving graphs in both the spreadsheet and **.PIC** formats, etc. For new users, the demonstration serves to create an awareness of the capabilities of spreadsheets and the skills that participants will acquire in carrying out the exercises in this and other workbooks in the series.

CHAPTER 2: LEARNING LOTUS 1-2-3

The exercises in Chapter 1, carried out with the help of the instructor, displayed some of the features of Lotus 1-2-3. In Chapter 2, you will be asked to type in data and execute the commands yourself.

ENTERING NUMBERS

Enter the number 2800 into the cell A1. As the number is typed, the word **VALUE** will appear in the top right hand corner of the spreadsheet and the number will appear in the top left corner. When the number as been typed in, press **[Enter]** and the number will be entered in cell A1 of the spreadsheet. The indicator will return to **READY**.

Screen 2.1

```
A1   2800                                                                  VALUE
       A         B         C         D         E         F         G         H
==================================================================================
1 |
2 |
3 |
4 |
```

Data can also be entered into a cell by pressing the **Arrow Keys** after typing in the values. For example, move the curser to the cell A2. Enter the value 3000. Press the **[Down Arrow]** The number will be entered in the spreadsheet and the cursor will jump down one cell in preparation for entering the next value.

Screen 2.2

```
A2   3000                                                                  READY

       A         B         C         D         E         F         G         H
==================================================================================
1 |   2800
2 |   3000
3 |
4 |
```

Practice typing numbers and moving around the spreadsheet.

ENTERING LABELS

Remember that labels are always identified with a **label prefix**, e.g, ' (apostrophe), "

(quote), or ^ (caret). If the cell entry begins with an ', the label will be left justified; if it begins with a ", it will be right justified. If it begins with ^, it will be centered. Unless told otherwise, Lotus 1-2-3 assumes that any entry beginning with a letter is a label and will place it on the left hand side of the cell because the default label prefix is an apostrophe (').

If the cell entry begins with a number or an arithmetical operator such as +, -, *, (, and is intended to be a label rather than a value or a function, a label prefix must be typed in preceding the number.

Move the cursor to cell A3.

Type: **Area**
Press: **[Enter]**

Notice that the word is identified as a **LABEL** when it is being typed. When the **[Enter]** key is pressed, the status indicator on the right returns to **READY** indicating that another operation can be performed.

Screen 2.3

```
A1   'Area                                                          READY

       A         B         C         D         E         F         G         H
=================================================================================
1 |   2800
2 |   3000
3 |Area
4 |
5 |
```

Move the cursor to cell A4.

Type: **Yield**
Press: **[Down Arrow]**

Numerical dates can be entered as labels by adding a "label prefix" before the number.

Type: **'1970**
Press: **[Down Arrow]**

Type: **'1971**
Press: **[Enter]**

Notice that the numbers preceded by an apostrophe (') are aligned on the left-hand side of the cell just as the word **Area** is.

To see why the use of labels prefixes is important, move to cell A7 and enter a date

separated by a / (slash). For example:

Type: **'7/4/89**
Press: **[Down Arrow]**

Type: **7/4/89** (no prefix)
Press: **[Enter]**

The result in the A7 cell will be a data label. The result in the A8 cell will be a number: .019662. The machine divided 4 into 7 and 89 into the answer to the first division.

Screen 2.4

```
A1 '1971                                                                MENU

     A         B         C         D         E         F         G         H
==========================================================================
1 |    2800
2 |    3000
3 |Area
4 |Yield
5 |1970
6 |7/4/89
7 |.019662
8 |
```

There are a number of commands in Lotus 1-2-3 that can be used to change the appearance of a spreadsheet. Data can be moved around the spreadsheet, edited, and re-aligned. Rows and columns can be inserted and deleted. The following section provides some practice in using these commands.

INSERTING ROWS AND COLUMNS

Move the cursor to the top of the spreadsheet (cell A1) by pressing **[Home]**.
Press: / (slash)
The main menu will appear.

Select: ***Worksheet***
Insert
Row
Press: **[Enter]**

The row below the cursor will be shifted down by one row, placing a new empty row at the cursor. More than one row can be inserted at a time. With the cursor at A1:

Press: /
Select: ***Worksheet***

Insert
Row

The command "Enter row insert range: A1 . . A1" will appear above the spreadsheet:

The current range starts and ends with row 1. Move the cursor to row 2. The range will now be **A1 . . A2**, rows 1 and 2.

Screen 2.5

```
A2:  2800                                                          POINT
Enter row insert range:  A1 . . A2

          A         B         C         D         E         F         G         H
=================================================================================
 1|
 2|  2800
 3|  3000
 4|Area
 5|Yield
 6|1970
 7|1971
 8|
```

Now press **[Enter]** and Lotus will insert two rows instead of one. The same procedure is used to delete rows with the ***/Worksheet Delete Row*** command. Delete one of the two inserted rows.

MOVING DATA

Numbers and labels can be moved around the spreadsheet as individual cells or as blocks of cells described by "ranges." Begin by moving the word **Area** from cell A4 to cell B1.

Move the cursor to **Area**.
Press: /
The main menu will appear.
Select: ***Move***
Press: **[Enter]**
"Enter range to move from: A4..A4"
Press: **[Enter]**
"Enter range to move to: A4."

When asked for the target cell, move the cursor to cell B1 and press **[Enter]**. Now move the cursor to the word **Yield**.

Type: /
Select: *Move*
[Enter]

Move the cursor to cell C1 and press **[Enter]**.

Screen 2.6

```
C1:                                                                    READY

        A         B         C         D         E         F         G         H
=========================================================================================
 1|              Area      Yield
 2|
 3|
```

Moving a Block of Cells with the Range Command

A range is a cell or rectangular group of contigious cells located side-by-side in the spreadsheet. A range can be one cell, a single row or column of cells, or a block of cells consisting of many rows and columns. However, a range must be a **rectangular block**.

To define a range within a command, move the cursor to the beginning of the range, type a period (.) to **anchor** the range, and move the cursor over the other cells that you want included in the range until it is completely highlighted. To see how this works,

Select: *Move*

The computer will respond by asking, "Enter range to move from: A1 . . A1"

Press: **[Escape]**
Move the cursor to 2800
Type a period: .
Move the cursor down until both 2800 and 3000 are highlighted.
Press: **[Enter]**

The computer prompt will ask "Move To"
Move the cursor to cell B3. This identifies the beginning of the range.
Press: **[Enter]**
The numbers will be moved into column B under **Area**.

Now move the dates 1970 and 1971 to cell A3 and A4 respectively so they will be aligned with the area figures. Use the same move commands that you just used to move the area figures.

You spreadsheet should now look like the one in Screen 2.7.

Screen 2.7

```
A1 '1971                                                                MENU

       A        B        C        D        E        F        G        H
=================================================================================
1 |           Area     Yield
2 |
3 |1970        2800
4 |1971        3000
5 |
6 |
7 |
8 |
```

Note: If data are moved into a cell which already has data in it, *the data in the receiving cell will be overwritten*. This makes ***Move*** one of the more dangerous commands in Lotus 1-2-3.

ERASING DATA

Labels, numbers, and formulas can be erased in a spreadsheet by using the ***Range Erase*** command. Practice by erasing the cells that contain 7/4/89 and .019662.

Move To: **7/4/89**
Select: ***Range***
Erase

Now highlight the range (block) that is to be erased.
Type a period: .
Move to: **.019662**
Both numbers will now be highlighted.

Press: **[Enter]**

REALIGNING LABELS AND EDITING CELLS

Labels can be re-aligned from the left-hand side of the cell to the right-hand side of the cell by using the **Edit** command [F2].

Move to: **B1 (Area)**
Press: **[F2]**

[F2] is an important key; it puts you in the **Edit** mode. The word **EDIT** will appear in the top right-hand corner of the screen.

Use the Home key to move the cursor to the label prefix (') in the top left-corner of your screen.

Press: **[Del]**
Type: "
Press: **[Enter]**
The label will now be aligned to the right-hand side of the cell. Do the same for **Yield.**

EDIT COMMAND KEYS

The following keys can be used when editing entries:

1) **[F2]**	Start editing. The word edit appers in the top of the screen.
2) **[Enter]**	Ends editing. Replaces the original entry with the edited one.
3) **[Esc]**	Ends editing and leaves the original entry intact.
4) **[Backspace]**	Erases the character to the left and moves left.
5) **[Del]**	Erases the character above the cursor.
6) **[Home]**	Moves to the first character of the entry.
7) **[End]**	Moves to the last character of the entry.
8) **[Arrows]**	Move one space at a time: left, right, up, down.

Setting the Column Width

The width of each column in the Lotus 1-2-3 worksheet is set by default to 9 characters. This setting can be changed to make the width of the column smaller or larger. To see how this is done, change the width of column A to 6 characters. Move the cursor to column A.

Press: /
The main menu will appear.
Select: ***Worksheet***
Column
Set-Width

Screen 2.8

```
A1 [W9]                                                                MENU
Enter column width (1..240): 9

      A      B         C         D         E         F         G         H
=========================================================================
1 |         Area      Yield
2 |
3 |1970
4 |
5 |
```

Type: **6**
Press: **[Enter]**

The width of column A is now set at 6 characters.

Alternatively, instead of entering a number, the arrow keys can be used to set the column width. This method makes it easy to judge how wide the column needs to be in order to accommodate the proposed entry.

Drawing lines under headings

The appearence of a spreadsheet can be improved by drawing lines under headings to separate the headings from the data. Lotus 1-2-3 does not have a special underline command, so additional cells below the headings must be used to draw the lines. Single or double lines can be drawn, using the hyphen or equal-sign character.

Move to:	A2	
Type:	\-	(a backslash followed by a hyphen). Note this backslash key is different from the slash key used to call up the menu.
Press:	**[Enter]**	

A line will appear across the entire width of the cell. The backslash is a special label prefix that repeats the character following it across the entire cell.

Screen 2.9

```
A1  /-                                                                    ENTER

        A         B         C         D         E         F         G         H
==========================================================================
1 |            Area      Yield
2 |----------
3 |Area
4 |Yield
5 |1970
6 |7/4/89
7 |.019662
8 |
```

The line can be entered into cells to the right using the *Copy* command. With the cursor in cell A2,

Press:	/
From the main menu,	
Select:	*Copy*
Press:	**[Enter]**

"Enter the Range to Copy TO: A2...A2"

Press:	**[Enter]**
Move to:	**B2**

Type a period:
Move to: **C2**
Press: **[Enter]**

Double lines can be drawn in the same way by entering \=, i.e. a backslash followed by an equal sign, in the cell. Any characters entered after the backslash will be repeated across the cell.

FORMATING DATA

Before learning how to format data, add the following data on yields.

Move to: **C3**
Type: **3**
Move to: **C4**
Type: **3.2**

Screen 2.10

```
C4  3.2                                                                ENTER

       A         B         C         D         E         F         G         H
==================================================================================
1 |             Area      Yield
2 |----------------------------
3 |1970         2800       3
4 |1971         3000       3.2
5 |
6 |
```

Format the data on yields such that both numbers have one decimal place.

Move to: **C3**
Press:: /
From the main menu,
Select: ***Range***
Format
General

The **Range Format** menu will appear. Press **[Enter]** to select a fixed number of decimal places.

The following command will appear:

"Enter number of decimal places (0 . . 15): 2"
Type: **1**
Press: **[Enter]**
"Enter range to format C3 . . C3"

Screen 2.11

```
C3: 3                                                                  MENU
Fixed  Scientific  Currency  ,  General  +/-  Percent  Date  Text  Hidden
Fixed number of decimal places (x.xx)

       A        B        C        D        E        F        G        H
=================================================================================
1 |    2800
2 |    3000
```

Move to: **C4**
Press: **[Enter]**

The yield numbers will now display one decimal place. (The default value is two decimal places.) Data can also be formatted by ranges or for the entire worksheet. To format all of the numbers in the worksheet, the following commands are used:

Type: /
Select: ***Worksheet***
Global
Format

The same sub-menu will appear as above. The following list contains some of the options available with the **Format** command.

Fixed	Rounds to a fixed number of decimal places: 89.09
Scientific	Exponential notation: 2.45E+04
Currency	Dollars and cents: $4.35
,	Adds commas to long numbers: 3,456,898 and places negative values in parentheses
General	No fixed number of decimal places (the initial setting format)
Percent	Multiplies by 100 and adds a % sign: .36 = 36%
Date	Formats into one of several date formats: DD-MMM-YY
Reset	Returns to global default format

SAVING A FILE AND EXITING

When work on the spreadsheet is complete, or as a precautionary measure to prevent accidental loss of work, the worksheet must be saved. Alternative "Save" choices are under the **FILE** heading on the menu tree. Chosing SAVE will bring up a sub-menu with three choices: Cancel, Replace and Backup. Choosing Cancel will void the save command. The spreadsheet will remain on the screen and no work will be lost. If Lotus 1-2-3 has previously saved a file under the suggested name, it will first ask whether it should write over the old file with the new material in the machine's memory. If this is desired, the choice should be Replace with a following Yes. If a second copy of the file is desired, the choice is Backup. The file will be saved with the extension, <Filename.BAK>. It can be retrived and used by renaming it to <Filename.WK1>.

SUMMARY

This chapter introduced a number of commands that are useful for editing data and changing the appearence of a spreadsheet. These include inserting and deleting rows and columns, moving data around the spreadsheet, erasing data from a cell, realigning data within cells, underlining headings, and formatting numbers. The need for tools that permit flexibility in worksheet construction will become more apparent in the following chapters.

CHAPTER 3: CREATING AN AGGREGATE DATABASE

This section consists of a series of spreadsheet exercises using agricultural sector data from Indonesia. The data include area, yields, and prices for the following crops: palay, maize, and mungbeans. All of the crops can be grown in lowland rainfed or irrigated fields and therefore act as substitutes in production during certain seasons. The data in this chapter are aggregated across all agro-climatic zones and seasons. This provides an overall picture of national trends but it obscures the dynamics of the agricultural sector at the regional and farm level. Various methods of disaggregating national data are discussed in subsequent chapters.

CREATING A TABLE

The following steps create the column headings for a table called Philippine Food Crops Sector.

Screen 3.1

```
D8                                                                    READY

        A         B         C         D         E         F         G         H
=========================================================================
1 |Philippine Food Crops Sector
2 |
3 |Wetseason Palay
4 |
5 |Year         Area      Yield     Production
6 |             ('000 ha) (kg/ha)   ('000 mt)
7 |_____________________________________________________________________
8 |
```

Press:	**[Home]**
Type:	**Philippine Food Crops Sector**
Press:	**[Down Arrow] [Down]**
At:	**A3**
Type:	**Wetseason Palay**
Press:	**[Down Arrow] [Down]**
At:	**A5**
Type:	**Year**
Press:	**[Right Arrow]**
At:	**B5**
Type:	**Area**
Press:	**[Right Arrow]**
At:	**C5**
Type:	**Yield**

Press: **[Right Arrow]**

At: **D5**
Type: **Production**
Press: **[Enter]**
Setting Column-Widths:

Notice that **Production** has more than 9 characters and thus exceeds the limit of the column. Expand the column to 13 characters.

Press: /
Select ***Worksheet***
Column
Set-width
Type: **13**
[Enter]

The column will now be 13 characters in width.

Fill in the measurement units for Area, ('000 ha); Yield, (kg/ha); and Production, ('000 mt) in row 6. (Remember, in order to have numbers or arithematical operators such as +, -, (, etc., appear as labels, they must be preceeded by an apostrophe.)

Lines under headings

Move to: **A7**
Type: \- (backslash followed by a hyphen)
Press: **[Enter]**

Copy across to each column using the copy command.
Press: /
Select: ***Copy***
Press: **[Enter]**

"Enter range to copy TO: A7"
Move to: **B7**
Type a period .

Move cursor along row until columns B through D are highlighted (range B7..D7)
Press: **[Enter]**

Entering Dates

Enter the dates in column A. Dates can be entered either as labels (as in the previous chapter) or as values. To enter dates as labels, type ' before the year in each row. To enter dates as values, which this exercise requires, use the ***Data Fill*** command as follows:

Move to:	**A8**
Press:	/
Select:	***Data***
	Fill
Press:	**[Enter]**

The following prompts will appear in the top panel:

"Enter fill range: A8"

Complete the range by typing a period (.) and moving the cursor down until 11 cells are highlighted (i.e., enough room for the years 1976 to 1986).

"Start: 0"	Type:	**1979**
"Step: 1"	Press:	**[Enter]**
"Stop: 8191"	Type:	**1989**
	Press:	**[Enter]**

The dates, when entered as values, will be aligned on the right hand side of the cell and may appear with decimal places. To eliminate the decimal places, use the ***Range Format Fixed*** command.

Press:	/
Select:	***Range***
	Format
	Fixed

"Enter number of decimal places (0 .. 15): 2"

Type:	**0**

"Enter range to format: A8 . . A8"

Move the cursor to the bottom of the column so that the years are highlighted and press **[Enter]**.

Once the table format for Wetseason Palay is complete, save the spreadsheet.

Press:	/
Select:	***File***
	Save
Type:	**Phil**
	[Enter]

It is important that the worksheet be saved periodically. Because the worksheet is held in RAM memory, all previous work will be lost if the power fails or if you hit the wrong key sequence.

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Copying Tables

Once the table format has been created for the first crop, it can be copied easily for other crops. Copy the table formats before entering the data. Once the table format has been copied, the name of the table can be changed and the data altered. *Be sure you understand the Copy command.* It is one of the most powerful features of spreadsheets. Its mastery adds greatly to the speed with which worksheets can be constructed. (Figure 3.1 shows how the partially completed worksheet will look.)

Move to: **Wetseason Palay**
Press: /
Select: *Copy*
"Enter range to copy from: A3 . . A3"

Move the cursor down the rows until the last data item is highlighted, then move it to the right until the column entitled **Production** is highlighted (A3 . . D18).

Press: **[Enter]**
"Enter range to copy to: A3"
Press: **[PgDn]**
[Enter]

The table format will now be copied one screen length below the first table.

Move to the second table by pressing **[PgDn]**.

Type: **Dryseason Palay** in place of **Wetseason Palay**.
Press: **[Enter]**

Copy this table one page length down for Maize. Do the same for Mungbeans using the instructions above. Be sure to type in the correct titles for each table. A good time to **save the worksheet** is after the tables have been copied. It is also a good time to make a second copy of the spreadsheet. To make a copy, save it again under another name.

ENTERING DATA

Use the data in **Data Table 3.1** at the end of the Chapter to enter the figures for area and yield of the three crops into the tables that have been created. Note that Table 3.1 is a data table containing numbers; it is not intended to represent a screen. For each table, it is easiest to enter the data by column, using the **Down Arrow** to move from one number to the next. The data will be entered automatically as numbers (as opposed to labels or formulas). Another good time to save your work is after the data have been entered.

CALCULATING PRODUCTION

Move to the first table, Wetseason Palay, using the **[Home]** key. Move the cursor to the

Figure 3.1: Partial Worksheet Showing Food Sector Tables

```
        A          B          C          D          E          F          G          H
==========================================================================================
1  |Philippine Food Crop Sector
2  |
3  |Wetseason Palay
4  |
5  |Year        Area        Yield     Production
6  |            (000 ha)    (kg/ha)   (000 mt)
7  |------------------------------------------------------------------------------------
8  |    1979
9  |    1980
10 |    1981
11 |    1982


23 |Dryseason Palay
24 |
25 |Year        Area        Yield     Production
26 |            (000 ha)    (kg/ha)   (000 mt)
27 |------------------------------------------------------------------------------------
28 |    1979
29 |    1980
30 |    1981
31 |    1982


43 |Maize
44 |
45 |Year        Area        Yield     Production
46 |            (000 ha)    (kg/ha)   (000 mt)
47 |------------------------------------------------------------------------------------
48 |    1979
49 |    1980
50 |    1981
51 |    1982
52 |    1983
```

first row under the Production column (D8). Create a formula that shows area times yield. This number must be divided by 1,000 in order to convert kg. to thousand metric tons ('000 mt). If the production data remain in kg., the numbers are too large to comprehend easily. Policy-makers in the Philippines usually discuss palay production in terms of thousands of tons or millions of tons.

For cell D8,

Type:	+
Move to:	**B8** (area)
Type:	*
Move to:	**C8** (yield)
Type:	**/1000**
Press:	**[Enter]**

Production is now calculated as area times yield, converted to thousands of tons. The formula will be displayed above the worksheet on the screen.

Screen 3.2

```
D8: [W13] +B8*C8/1000000                                                    READY

            A      B         C         D         E         F         G         H
==========================================================================
 1|Philippine Food Crops Sector
 2|
 3|Wetseason Palay
 4|
 5|Year          Area      Yield     Production
 6|              (000 ha) (kg/ha)   (000 mt)
 7|-------------------------------------------------------------------------
 8|   1979       3561      1615      5751.015
 9|   1980       3470      1629
10|   1981       3419      1674
11|   1982       351       1769
12|   1983       3054      1599
```

Copying a formula to another cell

Formulas that are entered with **relative cell addresses** can be copied easily to other cells. In the example above, the formula tells the cursor to move two cells to the left (area) and multiply that number by the number that is one cell to the left (yield). This can be copied for all of the cells in the production column. Unless directed otherwise by $ signs, the computer will adjust cell addresses so that their "relationship" on the worksheet is preserved.

Move to: **D8** (the formula under the production column for 1976)
Press: /
Select: *Copy*
"Enter Range to Copy From: D8..D8"
Press: **[Enter]**

"Enter range to copy to: D8"
Move to: **D9**
Type a period: .
Move the cursor down to the end of the column.
Press: **[Enter]**

Production values for wetland palay will be calculated for all years.

Use the *Copy* command to copy the production formula in each of the other tables for each of the other crops.

FORMATING PRODUCTION DATA

Screen 3.3

```
D8: [W13] +B8*C8/1000000                                                    READY

        A          B          C          D          E          F          G     H
=================================================================================
 1 Philippine Food Crop Sector
 2
 3 Wetseason Palay
 4
 5 Year      Area       Yield      Production
 6           (000 ha)   (kg/ha)    (000 mt)
 7 ---------------------------------------------------------------------------
 8    1979      3561       1615       5751.015
 9    1980      3470       1629        5652.63
10    1981      3419       1674       5723.406
11    1982      3351       1769       5927.919
12    1983      3054       1599       4883.346
13    1984      3162       1783       5637.846
14    1985      3306       1885        6231.81
15    1986      3464       1913       6626.632
16    1987      3256       1777       5785.912
17    1988      3393       1878       6372.054
18    1989      3497       1901       6647.797
```

A previous exercise indicated how to format the numbers in the entire table using the ***/Worksheet Global Format*** command. Unless the spreadsheet was formatted previously, the values for the production calculations will have a large number of decimals. Format the production data so that the numbers have only two decimal places using the following steps.

Press:	**[F5]** {Goto}
Press:	**[Enter]**
Type:	**D8**
Press:	/
Select:	***Range***
	Format
	Fixed
	2
	[Enter]

"Enter range to format: D8 . . D8"

Move the cursor down until all of the numbers in the column are highlighted and press **[Enter]**. Format the production values for all crops. Once the tables are complete and formatted as desired, **save your file**.

CALCULATING GROSS REVENUE

Gross revenue for each crop and year is calculated by multiplying total production by the

price. Data on prices for each crop are contained in Data Table 3.2 at the end of the Chapter. Begin by extending the tables to include prices and gross revenue, then enter the data on prices.

Press:	**[F5]** {Goto}
Type:	**E5**
Press:	**[Enter]**
Type:	**Price**
Press:	**[Right arrow]**
Type:	**Gross Revenue**

Expand the width of column F to 15 characters using the ***Worksheet Column Set-Width*** command.

Move to:	**E6**
Type:	**'(P/kg.)**
Press:	**[Right Arrow]**
Type:	**P mil**
Press:	**[Enter]**

Extend the line under the headings using the ***Copy*** command. (If you have forgotten how to do this, consult previous exercises or consult your Lotus 1-2-3 reference book.)

Copy the new part of the table to the tables for the other crops using the ***Copy*** command. The "Range to copy From" will be E5 . . F7. The "Range to copy To" will be one screen length below (E25 . .F27). Once the tables have been extended, save your worksheet.

Now enter prices into the tables using the data at the end of the Chapter. As with the area and yield data, it is easiest to enter each number and use the **[Down Arrow]** to move to the next cell. While entering the data, be aware of any irregularities or surprises in the numbers. Careful attention to the data while entering helps to identify errors in the reported figures and to identify interesting stories that come out of the data.

Gross revenue is production times price.

Move to:	**F8**
Type:	**+**
Move to:	**D8**
Type:	*****
Move to:	**E8**
Press:	**[Enter]**

Copy the formula for the other years in the Wetseason palay table, then copy the formula for the other crops. Format the Gross Revenue data so that all of the numbers have 2 decimal places using the ***Range Format*** command.

CREATING RANGE NAMES

Screen 3.4

```
F8: +D8*E8                                                                READY

        A          B         C         D         E         F         G         H
=================================================================================
 1|Philippine Food Crops Sector
 2|
 3|Wetseason Palay
 4|
 5|Year      Area      Yield Production  Price Gross Revenue
 6|         ('000 ha) (kg/ha)  (000 mt) (P/kg)    (P mil)
 7|---------------------------------------------------------------------------
 8|1979      3561      1615      5751        1.01       5809
 9|1980      3470      1629      5653        1.15       6495
10|1981      3419      1674      5723        1.32       7554
11|1982      3351      1769      5929        1.39       8232
12|1983      3054      1599      4883        1.55       7552
13|1984      3162      1784      5638        2.51      14164
14|1985      3306      1885      6232        3.26      20325
15|1986      3464      1913      6627        2.85      18912
16|1987      3256      1777      5786        3.06      17698
17|1988      3393      1878      6372        3.41      21744
18|1989      3497      1901      6648        4.19      27880
```

The ***Range Names*** command is a useful tool in organizing spreadsheets. After creating a range name, the table can be located by simply choosing that name. It is also useful in commands such as **Copying**, **Printing**, **Formatting**, **Moving**, and **Graphing**. Each of these requires a range specification. By naming the range of the table beforehand, it may then be used simply by invoking the name.

Begin by naming ranges to identify certain regions of the worksheet so that it becomes easy to move to specific tables.

Move to: **A3** (Wetseason Palay)

Press: /
Select: ***Range***
Name
Create
"Enter name:"
Type: **Wet-Palay**
[Enter]
"Enter range: A3 . . A3"

Move the cursor over the entire table for wetland palay so that it is fully highlighted and press **[Enter]**.

Create range names for the other crops.

Press: **[PgDn]** to move the cursor to Dryseason Palay.

Press: /
Select: ***Range***
Name
Create

Screen 3.5

```
A23:  'Dryseason Palay                                                FILES
Enter name:
WET-Palay
        A         B        C        D        E        F        G       H
=================================================================================
23 |Dryseason Palay
24 |
25 |Year           Area     Yield    Production
26 |               (000 ha) kg/ha       (000 mt)
27 |---------------------------------------------------------------------------
```

Look at the third line of the panel below the worksheet. Below the prompt **Enter name:** you will see **WET-PALAY**. Each range name you create will now be listed when you select the **Range Name Create** command. When there are more names than fit the width of the panel, use the left and right arrow keys to see the complete list. The names will disappear when you type in a range name.

Type: **Dry-Palay**

Set the range to cover the entire table for Dryseason Palay and press **[Enter]**.

Follow the same directions to create range names for the tables on maize, and mungbeans. Once the range names have been completed, **save your worksheet.**

To see how the range names work, press **[Home]** to go to the top of the worksheet.

Press:	**[F5]** (GoTo)
"Enter address to go to:	A1"
Press:	**[F3]** (name) Note: Try pressing [F3] twice.
Select:	**Dry-Palay**
	[Enter]

The cursor will immediately jump to the table on dryland palay.

PRINTING TABLES

The ***Print*** command in Lotus 1-2-3 allows you to make hard copies of the spreadsheet.

Because the spreadsheet on the Philippine Food Crops Sector data is much larger than a single page of paper, you must print individual sections of the worksheet at a time. The **Range Names** are useful in identifying sections of the worksheet (by crop) for printing. Before you start, make sure the printer is turned on and ready. Call up the Print menu.

Press: /
Print
Printer

The Printer sub-menu will appear in the panel above the spreadsheet.

Screen 3.6

```
A1: [W6] Philippine Food Crop Sector                                    MENU

Range    Line    Page    Options  Clear    Align    Go    Quit
Specify a range to print
        A         B         C         D         E         F         G         H
=================================================================================
 1 Philippine Food Crop Sector
 2
 3 Wetseason Palay
 4
```

The print menu offers a number of choices about the appearance and format of the printout. The only option that **must** be specified is the **range** to be printed.

Range	Specifies the range of the worksheet that will be printed. This **must** be specified even if you want to print the entire worksheet	
Line, page	Advances the paper one line or one page	
Options	Contains a number of choices about the appearance of the printout	
Header, Footer	Specifies header or footer to be printed on each page	
Margins	Sets left, right, top, and bottom margins	
Borders	Specifies border columns and/or rows	
Setup	Establishes printer setup string	
Page-length	Specifies number of lines per page	
Other	Print formulas on a worksheet or	Ignore print settings
Clear	Resets some or all of the print settings	
Align	Resets the alignment of the paper to the top of the page	
Go	Begins the printing process	
Quit	Returns 1-2-3 to the READY mode	

Specify the range of the worksheet you want to print using range names. From the menu,

Select: ***Range***
Press: **[F3]**
Select: **Wet-Palay**

[Enter]

If the paper in your printer is properly aligned, and the printer is "on-line"

Select: ***Align***
Go

The Wetseason Palay table will be printed out. Print the other tables using the respective range names. Between each table select ***Page*** from the menu in order to have each table printed on a separate page.

Data Table 3.1: Philippine Area and Yield Data

Philippine Food Crops Sector

AREA ('000 ha)

Year	Wetseason Palay	Dryseason Palay	Maize	Mungbeans
1979	3561	490	3090	31.5
1980	3470	532	3199	33.5
1981	3419	568	3295	34.0
1982	3351	602	3383	35.4
1983	3054	618	3132	33.6
1984	3162	576	3227	33.8
1985	3306	643	3511	35.5
1986	3464	680	3595	36.0
1987	3256	689	3683	34.7
1988	3393	658	3745	36.7
1989	3497	702	3689	35.7

YIELD (kg/ha)

Year	Wetseason Palay	Dryseason Palay	Maize	Mungbeans
1979	1615	3600	950	696
1980	1629	3750	954	737
1981	1674	3850	1000	744
1982	1759	4000	1006	740
1983	1599	3900	1001	741
1984	1783	3800	1007	743
1985	1885	4000	1100	713
1986	1913	3850	1138	719
1987	1777	4000	1162	729
1988	1878	3950	1182	725
1989	1901	4000	1226	703

Data Table 3.2: Philippine Price Data

Philippine Food Crops Sector

PRICE (P/kg)

Year	Wetseason Palay	Dryseason Palay	Maize	Soybeans
1979	1.01	1.01	0.92	7.84
1980	1.15	1.15	1.06	8.06
1981	1.32	1.32	1.21	9.96
1982	1.39	1.39	1.28	6.47
1983	1.55	1.55	1.38	6.36
1984	2.51	2.51	2.37	10.73
1985	3.26	3.26	2.79	11.98
1986	2.85	2.85	2.51	12.41
1987	3.06	3.06	2.85	10.69
1988	3.41	3.41	2.84	11.91
1989	4.19	4.19	3.84	15.01

CHAPTER 4: DISAGGREGATING AGRICULTURAL SECTOR DATA

Chapter 3 was devoted to the creation of a database. The estimates in that chapter are aggregated to the national level. Such aggregation obscures differences due to seasonality, agroclimatic zones, and production technologies. Understanding the regional impact of national policies on income and production requires a greater degree of disaggregation. Chapter 4 contains exercises that disaggregate wetland palay production in the Philippines by land type. The data are classified into 4 land types, defined by soil conditions, fertility, and water control. Each land type has a different cropping intensity (number of crops per year), input use, and level of profitability. The 4 land types are:

1) high productivity irrigated land,
2) medium productivity irrigated land,
3) low productivity irrigated land, and
4) rainfed land

The main substantive objective of the exercise is to calculate the contribution of each land type to total production of wetland palay and to show how the relative contributions have changed over a 13 year period. The results will then be graphed using stacked bar graphs. These results provide further insight into the characteristics of the food crops sector by demonstrating the source of output growth by land type.

The exercise offers an opportunity to practice a variety of Lotus commands, especially those used to copy formulas and tables.

COMPUTING REGIONAL PRODUCTION ESTIMATES

The figures in Data Table 4.1 (p. 35) describe the area and yield of wetland palay in each of the four land type systems for 4 observation years: 1976, 1980, 1986, and 1989. The data in this table will be used to calculate the total area in each land system and the contribution of each system to total production over time.

Begin by creating a Lotus 1-2-3 table that resembles Data Table 4.1. Enter the dates as labels using a label prefix. Enter the production systems based on land types as rows. Enter the estimates of area and yield and columns.

Calculating Production and Production Shares in Each System

Once the table has been created, area and yield can be multipled to give an estimate of production. This could easily be done on the existing worksheet. However, for practice, **copy** the initial table to a position one screen **[PgDn]** below and compute aggregate regional production and regional shares in the second table.

To copy the data table format from the first table to the second (calculations) table:

Move to the top of the first table.

Data Table 4.1. Area and Yield of Wetseason Palay by Land Type

Wetseason Palay	Area by Land Type ('000 ha)				Yield (ton/ha)			
Land Type	1976	1980	1986	1989	1976	1979	1983	1989
High Productivity (Irrigated)	246	283	316	340	3.75	4.25	4.50	5.05
Medium Productivity (Irrigated)	278	320	356	384	2.75	3.40	3.75	3.95
Low Productivity (Irrigated)	313	360	402	433	1.95	2.75	3.15	3.10
Rainfed	2813	2508	2390	2340	0.90	0.95	1.10	0.90
Total Wetseason								

Press: ***/Copy***

Enter a range which highlights the entire table.

Press: **[Enter]**
Move one page down using the **[PgDn]** key.
Press: **[Enter]**

Move to the new table and erase the contents of the table using the ***Range Erase*** command.[4]

In the new table, type new headings: **Wetseason Palay Production By Land Type.**

Calculating Wetseasons Production

Move to the row and column in the new table reserved for *high productivity irrigated agriculture*. Enter the formula in that cell to calculate production by multiplying acreage times yield using the cell addresses in the first table. Using the ***Copy*** command, copy the formula into the cells for the entire "Production" block. That is, instead of copying each column independently, simply **highlight the columns for all three years at once**. All cell relationships will be preserved

[4] It is not actually necessary to erase numerical values if these are to be replaced with other numerical values. Lotus will simply write over the existing data.

and the entire "Production" block can be copied at one time.

Using the ***Copy*** command in this fashion will produce 0's where blanks occur in the table. Suppress the 0's with the */Worksheet Global Zero Yes* command (/WGZY)

/WGZY

(Note that this command does not actually remove the 0's; they will reappear each time the worksheet is retrieved. If the formulas that generate the 0's are to be removed compietely, use the ***Range Erase*** command.)

Once production has been calculated for the individual land types for each year, you can add the production figures using the ***@SUM*** command to arrive at the total production of wetland palay by year. (See Box 4.1.)

Move to the last row, "Total "
Move to the column for 1976.
Type: **@SUM(**
Move to the top of the column, "High Productivity Irrigated".
Anchor the range by typing a period: **.**
Move to the last row, "Rainfed."
Type:)
Press: **[Enter].**
Copy to remaining columns.

Calculating the Share of Production (Percentage) by Land Type.

In order to calculate the share of production by land type, replace the original table's "Yield" block with a "Share" block in the new table.

Replace the word "Yield" with "Share of Production." (Erase the (ton/ha) cell.)

Move to the row and column describing "High Productivity" and "1976" under the "Share" section

Lotus Functions

An @ function is made up of three parts:

(1) The @ symbol, which must appear as the first character.
(2) The name of the function
(3) The data to which the function is to be applied. The data can be a single cell or a range of cells.

The data can be addressed by *relative cell addresses* or by *range names*. Example:

@SUM(B20 . . B28) indicates that the values in rows 20 through 28 in column B should be added together. Other functions include:

@IRR()internal rate of return
@NPV() net present value
@AVG() average
@MAX() maximum value

(The Lotus manual or any Lotus book will display and define all of the function commands. They will be described in this manual when they are used.)

Box 4.1

Enter the formula to calculate the share of production. The basic formula is: **production in 1976 divided by total production**. Use an **absolute** cell address (a dollar sign) to compute the production row so that, when the ***Copy*** command is used, the columns will change but the row will remain the same. For example, the formula in the upper left hand corner of the table's data block might look as follows:

Screen 4.2

Wetseason Palay Production by Land Type

Land Type	Production '000 mt 1976	1980	1986	1989	Share of Production 1976	1980	1986	1989
High Productivity (Irrigated)	923	1202	1421	1718	18.9%	21.2%	21.4%	25.9%
Medium Productivity (Irrigated)	764	1086	1337	1517	15.7%	19.2%	20.2%	22.8%
Low Productivity (Irrigated)	615	983	1269	1335	12.6%	17.4%	19.1%	20.1%
Rainfed	2572	2385	2607	2075	52.8	42.2%	39.3%	31.2%
Total Wetseason	4873	5657	6634	6645	100%	100%	100%	100%

+B27/B$37 [5]

The formulas for all of the other data cells in the block can be computed with a single step. When the ***Copy*** command prompts with "COPY TO", move the cursor to the lower right hand corner of the table's data section. When the entire data block has been highlighted, press **[Enter]**.

The original calculation will produce values with a large number of decimals. These can be altered and percent signs can be introduced by formatting with the ***Range Format*** command. Decimal places can be set with the same command.

GRAPHING REGIONAL PRODUCTION STATISTICS

Move to the previous table on production of wetland palay production by land type. Graph the changes in production shares and total production over time with a stacked bar graph.

Select ***Graph*** from the main menu. Use the cursor and highlights to enter the type of graph, i.e., stacked bar. Select X for the range of the independent variable. (Use the ESC key to erase previous ranges should these show up in a block on the screen) Position the cursor on the first cell in the range, "anchor" with a period, and highlight the entire range. Press **[Enter]**.

Choose A for the range or row that describes the value of production in each year from high productivity irrigated land. Position the cursor on the first cell in the range, anchor with a period,

[5] Your row and column addresses may, of course, be slightly different. In this example, cell B27 contains a formula that multiplies yield times acreage under high productivity palay for 1976. Cell B37 totals the rice produced in all systems during that year.

and highlight the entire range. Press **[Enter]**.

Follow the same procedure for the remaining data series. When the data entry is complete, select **View** for a screen rendition of the graphed data without any titles or legends. The choices associated with each range are indicated below.

Type	stacked bar
X	range containing dates, 1976, 1980, 1986, 1989.
A	row of values for high productivity irrigated land.
B	row of values for medium productivity irrigated land.
C	row of values for low productivity irrigated land.
D	row of values for rainfed land.

When the data have been entered and verified, add titles and legends to the graph.

Select:	***Options***
Select	***Titles***
First:	**Wetseason Palay Production**
Second:	**By Land Type**
X:	**Year**
Y:	**Metric tons**
Select:	***Quit***
Select:	***View***

The graph should look approximately like the one in Figure 4.1. (Legends can be created using the **Options** menu.) If the appearance of the graph is satisfactory, **save the graph file**. Lotus then prepares a file for printing. Note: to avoid confusion in the titling of units of measure along the Y-axis, you may convert the rows of production values into metric ton units (i.e., multiply by 1000) to have Lotus print "(millions)" instead of "(thousands)" along the Y-axis and beneath your Y-axis title.

Save the worksheet containing the graph with /File Save Replace. (Failure to save the **worksheet** as well as the **graph** will result in losing the graph that is viewed from the worksheet. The work of assigning ranges, titles and legends will be lost.)

Exit 1-2-3 with /Worksheet Quit Yes (/WQY) to move to the menu displaying the PrintGraph program. Enter the PrintGraph program by pressing **[Enter]**. When in the PrintGraph part of Lotus:

Select:	***Image-select***
Move the cursor to the name of the file saved before exiting Lotus 1-2-3.	
Press:	**[Enter]**
Select:	***Go***

A second, equally interesting stacked bar chart can be developed using the share

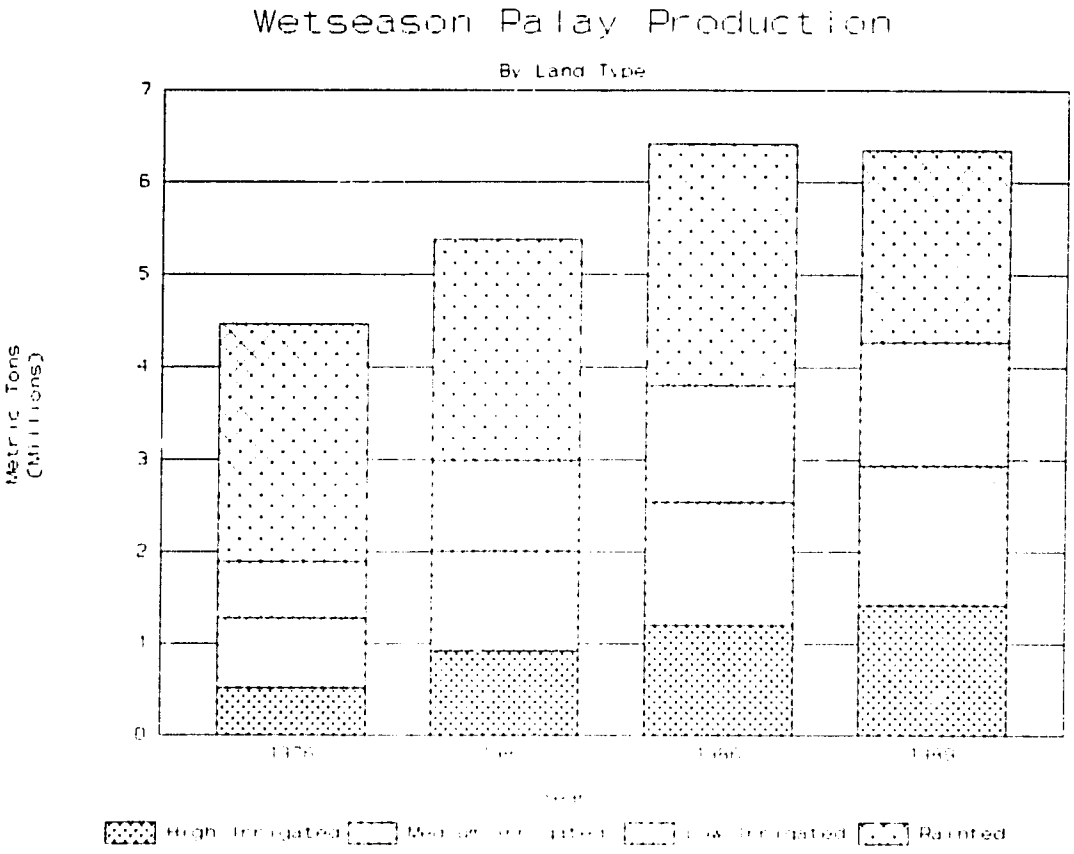

Figure 4.1

calculations. The resulting stacks sum to 100; they provide evidence on what has happened to the distribution of production across types of production systems. Such graphs are a good first step in identifying the sources of growth and the incidence of technical change.

CHAPTER 5: COMPUTING STATISTICAL MEASURES AND TRENDS

Data on the production of various food crops, calculated in the previous exercise, provide important information on the food crops sector in Philippines. But time series data, to be really helpful, need to be summarized. For example, information about a particular year increases in value if it can be related to the **average** over the recent past. The **highest** and the **lowest** values in the series also provide additional points of reference. Still more information can be obtained from a particular annual figure if it can be related to **trends** in the data over time.

The following exercise begins by demonstrating how Lotus functions can be used to compute parameters such as the mean, variance, maximum and minimum of a time series. The spreadsheet's built-in regression capability is then used to compute a trend. Subsequently, the data and the trend are plotted on the same graph, a procedure that allows the analyst to add a visual assessment of the goodness of fit to the standard errors report by the regression program.

COMPUTING SUMMARY MEASURES

Call up the worksheet containing data on the Philippine Food Crop sector, ***/FR.***

Screen 5.1

Wetseason Palay Trends

Year	Area 000 ha	Yield kg/ha	Production 000 mt	Price P/kg	Revenue P mil	ProTrend
79	3561	1615	5751	1.01	5809	5463
80	3470	1629	5653	1.15	6495	5557
81	3419	1674	5723	1.32	7554	5650
82	3351	1769	5928	1.39	8232	5744
83	3054	1599	4883	1.55	7552	5837
84	3162	1783	5638	2.51	14164	5931
85	3306	1885	6232	3.26	20325	6025
86	3464	1913	6627	2.85	18912	6118
87	3256	1777	5786	3.06	17698	6212
88	3393	1878	6372	3.41	21744	6305
89	3497	1901	6648	4.19	27880	6399
Average	3358	1766	5931	2.34	14215	
Variance	21182	13175	240157	1.09	51796898	
Maximum	3561	1913	6648	4.19	27880	
Minimum	3054	1599	4883	1.01	5809	

Screen 5.1 shows a table containing data on production and gross revenues for wetland rice palay. The summary measures have been computed using Lotus functions.
The extended statistical functions are used in exactly the same way as the @SUM function. The mean or average is calculated using @AVG; the variance is computed with @VAR. Maximum and minimum are obtained by using @MAX and @MIN.

After typing in the function name, set the range over which the analysis is to be carried out. For example: @AVG(D8..D18)

REGRESSION ANALYSIS FOR TREND CALCULATIONS

A **trend** shows the estimated least squares relationship between the observed data and time. It is calculated by ordinary least squares regression with time as the independent variable (x-axis) and production or revenue as the dependent variable (y-axis). The following illustration shows production trends for wetland palay in thhe Philippines from 1979 to 1989.

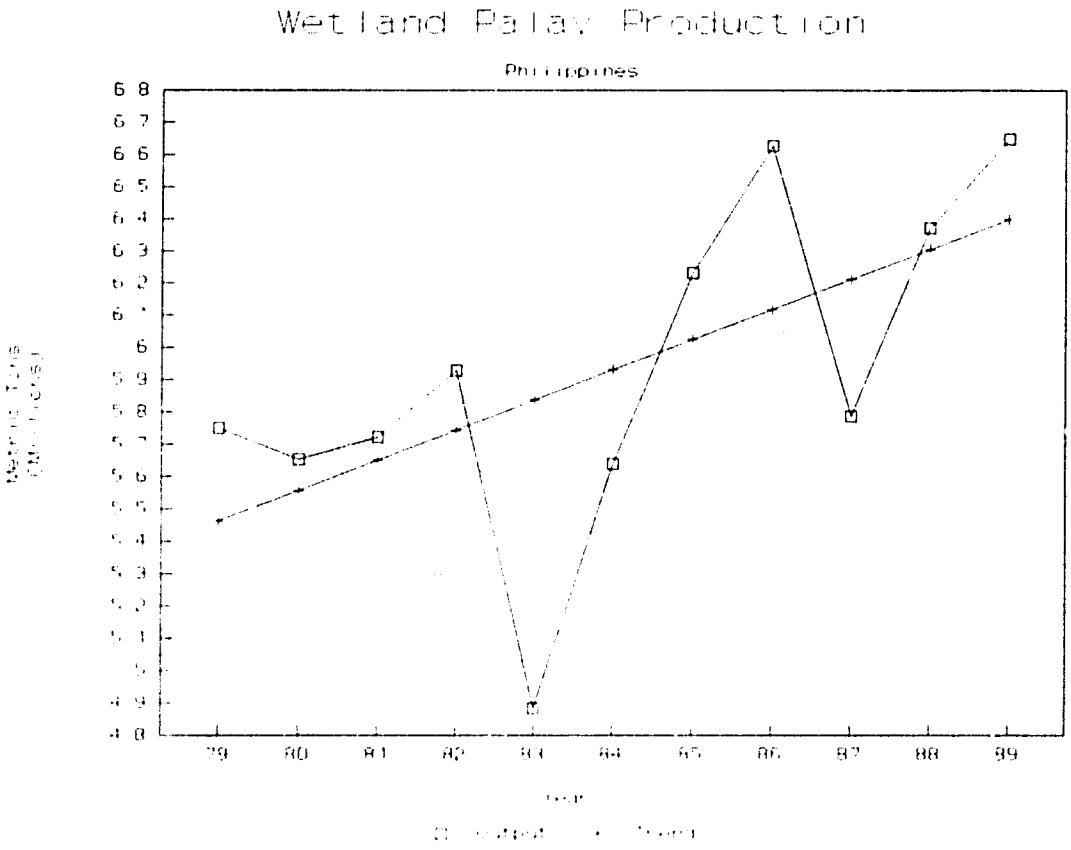

Figure 5.1

The following exercise describes the steps needed to produce such a graph.

Regression Command in Lotus

Regressions are performed in Lotus with the **Data Regression** command. In order to run a

regression the following must be specified:

X-Range	The data range containing the independent variable. When calculating trends, the series consists of years. (If a substantial number of data points exist, it is usually a good idea to use only two numbers to indicate years, e.g., 1980 becomes simply 80, in order to avoid overlapping labels on the X-axis.) The entries for dates in a regression must be values not labels.
Y-Range	The data range containing the dependent variable. In the following exercise, the dependent variable will be **production** for each crop. (When specifying the Y-range, the column of data must contain the same number of rows specified for the X-range.)
Output-Range	Specifies the range of cells that will receive the output of the regression. The output range must be at least nine rows deep and two columns wider than the number of independent variables but not less than four columns. In calculating trends, the range must be 9 rows deep and 4 columns wide.
Intercept	Two choices are possible: Compute or Zero. Zero forces the y-intercept to be zero. Compute (the default) permits a non-zero intercept.

A regression is performed by using the command **Go** from the regression menu. Lotus 1-2-3 will perform the analysis and display the following information in the output range:

Constant	The Y-intercept
Std Err of Y Estimate	Standard error of the estimated Y values
R-Squared	One measure of "goodness of fit"
No. of Observations	Number of values for the X and Y variables
Degrees of freedom	Number of observations relative to the number of dependent variables
X Coefficient(s)	Slope for each of the independent variables
Std Err of Coef.	Standard error for each of the X Coefficients

Running a Regression

Before specifying the parameters for the regression, change the dates in the table so that each year has 2 characters (e.g., change 1979 to 79). This will permit the data to be used as labels on the x-axis without overcrowding.

The quickest way to produce a series in Lotus 1-2-3 is to use the ***/Data Fill*** command. The menu asks for a starting value. Use 79 for 1979. Highlight 11 rows in the same column in response to the question: Data range. End the series with 89 and tell Lotus to use a step value of 1. **The years must be specified as values** in order to run a regression with years as the independent variable. Then:

Press:	/
Select:	***Data***

A sub-menu will appear.

Screen 5.2

```
A1:                                                                    MENU
Fill  Table Sort  Query Distribution      Matrix      Regression  Parse
Calculate Linear Regression
        A         B         C         D         E         F         G         H
==========================================================================
 1|
 2|
 3|
 4|
 5|
```

Select: ***Regression***
Select: ***X-range***

The initial element of the range is the first year, i.e., 79. The last year is 89.

Screen 5.3

```
A1:                                                                    MENU
   X-range  Y-range  Output-Range   Intercept      Reset Go    Quit
Set independent variable(s), or X, range
           A         B         C         D         E         F         G         H
==========================================================================
 1|
 2|
 3|
 4|
 5|
```

Press: **[Enter]**
Select: ***Y-range***

Production is the dependent variable over the same vertical range.
Select: ***Output-range***

Put the output range (regression results) to the right of the data table.

Select: ***Intercept***
Compute
Select: ***Go***

The regression will be performed and the output will appear beginning with the cell selected to receive the results. The important values for the trend calculation are (1) the **constant**, and (2) the **coefficient** associated with the independent variable. These numbers will be required in computing the trend values for each year. Lotus will display the following output block:

```
              Regression Output:
Constant                      -1932.16
Std Err of Y Est              431.7701
R Squared                     0.364872
No. of Observations                 11
Degrees of Freedom                   9
X Coefficient(s)              93.60909
Std Err of Coef.              41.16766
```

COMPUTING TREND VALUES FOR AGRICULTURAL PRODUCTION

The results of the regression analysis can be used to calculate trends with the formula $Y = a + bX$ where:

Y = production or revenue
a = constant (intercept)
b = x coefficient (for years)
X = years

To compute the values that will be needed to plot the trend on the same graph as the production data, both **relative** and **absolute** cell addresses will be needed.
Remember that in order to copy a formula in which the same cell is to be addressed for all rows and columns, a $ sign must be inserted in front of the row and column address. In the trend calculation, you will want to fix both the row and the column for the **constant** (e.g., $R$9) and for the **coefficient** of the independent variable, time (e.g., $Q$15). The F4 function key can be used to create an absolute cell address. The necessary steps are shown below.

To compute: $Y = a + bX$

Move to:	**ProTrend**	(First blank cell of the ProTrend column)
Type:	+	
Move to address for:	**Constant**	(Value in the regression output block)
Press:	**[F4]**	(Absolute cell address. You will see the dollar sign added to the cell address in the panel above the worksheet.)
Type:	+	
Move to address for:	**Year**	Year will be a **relative** cell address
Type:	*	
Move to address for:	**X-coefficient**	(Coefficient value in the regression output block)
Press:	**[F4]**	Absolute cell address
Press:	**[Enter]**	

The calculation will appear in the first row of the production trend column. Since you have

done the calculation using **absolute** cell addresses, you can copy the formula to the remaining cells in the production column using the ***Copy*** command.

GRAPHING PRODUCTION TRENDS

In order to graph production trends, begin by creating the graph in Lotus 1-2-3. For clarity in the presentation of production numbers along the Y-axis, convert first the production values into metric ton units by multiplying each of the numbers in the cells D8..D18 by 1000. Do the same for the numbers under the column **production trend**. These two new data series should now be in cells H8..H18 and I8..I18, respectively. After these conversions, proceed with the following steps.

Press: /
Select ***Graph***
Type
Line
X

The X range indicates the values on the X-axis of the graph. In this exercise, production numbers and the trend will be graphed against time, so **Years** will be on the X-axis.
Enter the range corresponding to the years in the table.

Select: ***A***
"Enter first data range:"
The first data range contains the production **numbers** in cells: H8..H18.

Select: ***B***
"Enter second data range:"

The second data range contains the computed values for the **production trend** in the column **ProTrend** (Cells I8..I18)

Select: ***Options***
Legend
A
"Enter legend for first data:"
Type: **Output**

Select: ***Legend***
B

Type: **Trend**

Select: ***Titles***
Enter the following titles:

First: Wetseason Palay Production
Second: Philippines

X-axis: Year
Y-axis: MMT
Select: *Quit*

Once you have specified the graph, you can view it by selecting ***View***. Press **[Esc]** to return to the graph menu.

Before you leave the graph command, save it for printing.

Select: *Save*
Type: **Wet-Pal**

The graph will be saved as WET-PAL.PIC.

PRINTING THE GRAPH

Select: *Quit*
The program menu of Lotus will appear on the screen.
Select: ***PrintGraph***
The graphics menu will appear.

Screen 5.4

```
Copyright 1986. Lotus Development Corp. All Rights Reserved. Release
2.01.
-----------------------------------------------------------------------
Select graphs for printing

Image-Select    Settings    Go    Align    Page    Exit
=======================================================================
```

Select: ***Image-Select***

A list of existing graphics files will appear on the screen. Select the graph to be printed.

Move the cursor to **Wet-Pal** and press **[Enter]**.

Make sure that your printer is turned on and that the paper is aligned.

Select: ***Go***

The graph of wetland palay production and the trend shown in Figure 5.1 will be printed.

Use the same series of commands to calculate and graph price and revenue trends. What conclusions can you draw from these graphs? Would you be confident in making predictions about

the general health of the rice production sector on the basis of these data?

COMPUTING A GROWTH RATE

Having the trend line appear on the same graph as the original time series helps interpret the results of the regression equation. It can also be used to provide an estimate of the growth rate that provides a more reliable indicator of performance than if growth was computed from the end points of the series.

Growth rates are conventionally calculated at the mean or average of the series. The formula therefore is simply the slope (the coefficient of the independent variable, X, computed by the regression) divided by the mean of the dependent variable, Y.

To estimate the growth rate of production for wetland palay, enter the following formula in a convenient empty cell:

Cell address of coefficient of X / cell address of @AVG (production)

As noted above, the coefficient of X is the slope coefficient displayed in the regression output. The Lotus @AVG function automatically finds the mean of the dependent variable Y, in this case PRODUCTION. The result of this calculation may be formatted as a percent by using the **Range Format Percent** command.

CHAPTER 6: ANALYZING AGGREGATE OUTPUT

In Chapter 5, trend analysis was used to gain insights into the behavior of a single commodity over time. In the following exercise, it is extended to compute a measure for growth in the agricultural sector as a whole. The data required are the annual estimates of gross revenues that have already been calculated for individual crops in Chapter 3.

TRENDS IN THE VALUE OF AGRICULTURAL OUTPUT

To compute the graph shown in Figure 6.1, retrieve the worksheet containing the data for the Philippine Food Sector. Find an area below the last crop table and create the following table:

Year	Gross Revenue
76	(f8 + f28 + f48 + f68)
...	...
86	(f18 + f38 + f58 + f78)

Use the ***Data Fill*** command to create the series: 1976 - 1986. Use the ***Copy*** command to copy the formula for gross revenue at current prices down the column. (Note: Your cell addresses may be slightly different as a result of differences in the number of lines that separate the individual commodity tables.)

Compute the trend line of gross revenue at current prices using the methods described in Chapter 5. Calculate the growth rate also. Your answer should be roughly 16 percent per annum. Note that both the graph and the growth rate bear a good deal of similarity to the graph of wetland palay shown in Chapter 5. This is because wetland palay has such a large weight in the output of Philippines's agricultural sector. Note also that a growth rate computed as the difference between the first year and the last divided by the mean is 15.5 percent per year.

For most purposes, graphs based on current prices are less useful than graphs using constant price weights. The physical performance of the agricultural sector is of primary interest, not the extent of commodity price inflation.

The values for constant prices shown in Figure 6.1 were computed using 1989 weights. (Ordinarily, growth rates in constant prices are not terribly sensitive to the choice of base year weights. But if there have been substantial changes in relative prices as a result of significant policy interventions, care needs to be taken in drawing conclusions based on a particular period.) Using the same prices for all years and thus restricting increases in the value of output to increases in physical output obviously has a significant impact on estimates of growth in the value of agricultural output. For example, the growth rate declines from roughly 16 percent per annum to 3 percent per annum.

Still another improvement in aggregate data analysis could be obtained if costs were subtracted from revenues. The figures shown in the table clearly give an inflated picture of

agriculture's contribution to the economy since they do not account for the inputs required to produce the crops. The tables computed earlier could be extended horizontally and values entered for such inputs as fertilizer, pesticide, seeds, etc. The result would be a measure of agriculture's value-added, i.e., its contribution to gross domestic product. Trends in value-added could then be computed using the methods used above.

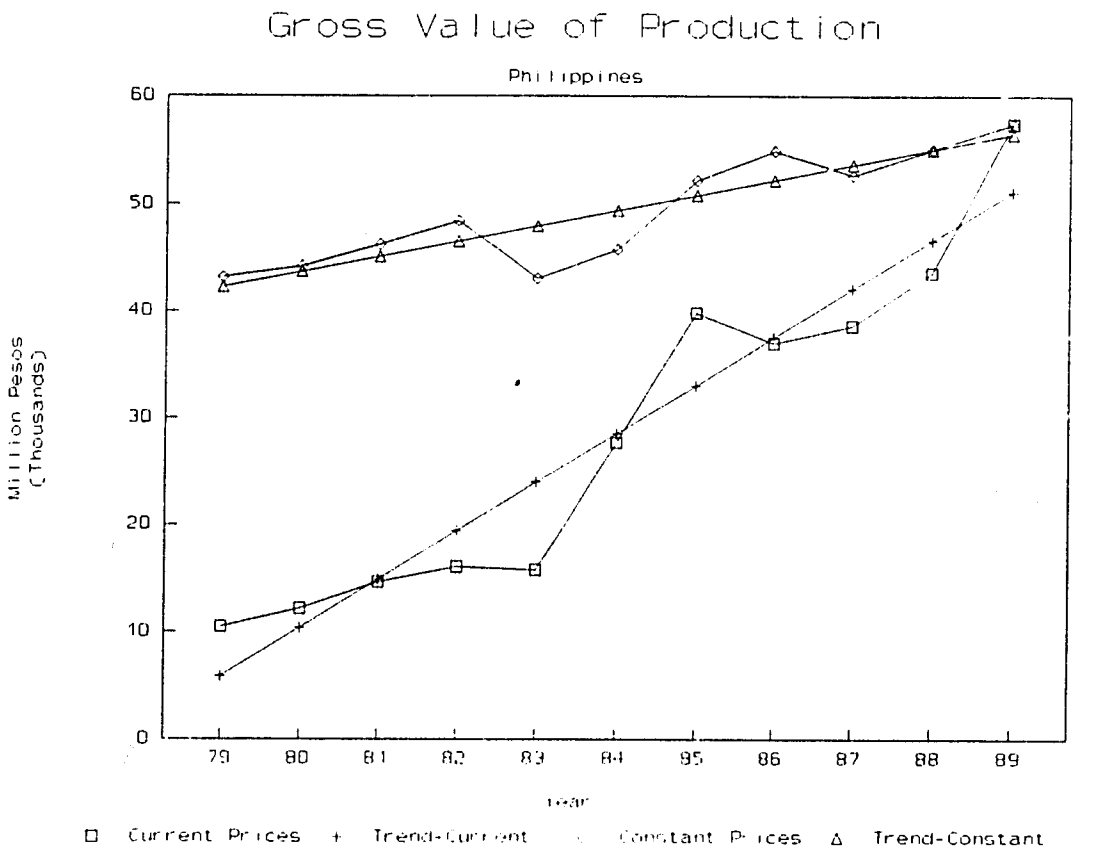

Figure 6.1

DECOMPOSING AGGREGATE OUTPUT

Computing trends in aggregate output provides important insights into the overall performance of the agricultural sector. However, it is equally interesting to decompose the sector's performance into changes in area, cropping patterns, and yields. Trend values cannot be used for this purpose; there is nothing to insure that independently measured values for acreage, yields and crop share would result in the trend value for gross revenue. Decomposition must therefore be done using the actual end periods of the series. (If the first and last periods lie far from the trend line, it may be desirable to take an average of the last several periods at each end so that the decomposition is not biased by extreme end points.)

The identity used to decompose changes in gross revenue from the beginning to the end of the period is given below. The first term on the right hand side captures the effect of increasing area if yields and the compostion of the cropping pattern had remained the same. The second term reflects the changes in yields over the period, other things being held constant. The third term captures the effects of changes in crop compostion, and the last term computes the interactions between changes in the various components of growth.

$$
\begin{aligned}
(R_t - R_o) \equiv\ & (A_t - A_o) \sum_{i=1}^{n} p_i Y_{io} C_{io} \\
& + A_o \sum_{i=1}^{n} p_i (Y_{it} - Y_{ot}) C_{io} \\
& + A_o \sum_{i=1}^{n} p_i Y_{io} (C_{it} - C_{io}) \\
& + \sum_{i=1}^{n} p_i (A_t - A_o)\ (Y_t - Y_o)\ (C_t - C_o)
\end{aligned}
$$

where R = Revenue, A = acres, Y = yields, C = percent of cropped acreage, and p = constant price weights.

The values needed for the decompositon exercise can be computed from the tables that were created in the previous exercises. Start the exercise by retrieving the Philippine Food Sector worksheet containing the various commodity tables. (This worksheet was also used in the preceding exercise.) Find a blank spot below the last table on the worksheet and lay out the table shown below:

Decompostion of Output

	Wetseason	Dryseason	Maize	Mungbeans	Total
Area					
1979	3561	490	3090	31.5	7172.5
1989	3497	702	3689	35.7	7923.7
Change	-64	212	599	4.2	751.2
Yields					
1979	1615	3600	950	696	
1989	1901	4000	1226	703	
Change	286	400	276	7	

Shares

1979	0.496	0.068	0.431	0.004	1.000
1989	0.441	0.089	0.466	0.004	1.000
Change	-0.055	0.020	0.035	0.000	0
1989 Prices	4.19	4.19	3.84	15.01	

Values fo· area and yields can be obtained either by typing in the data directly or by referencing the appropriate cell addresses of the commodity tables. The entries in the section entitled **Shares** are obtained by dividing the commodity acreage shown in the **Area** section by the total acreage of all commodities shown under the **Total** column.

The table below shows values for the various terms of the decomposition identity. For example, as the first term of the identity shows, the contribution of **area changes** to the increase in the value of wetland rice output is:

(change in area) x (base year yield) x (base year share) x (1989 price)

	Wetseason	Dryseason	Maize	Mungbeans	Total	Percent
Area	-215226	218664	942119	193	945750	25.0%
Yield	2121595	56156	1410909	14	3588675	94.9%
Pattern	-1330128	150019	392053	37	-788019	-20.8%
Interaction	4235	7212	22063	0	33511	0.9%
Value	580477	432051	2767145	245	3779916	100.0%

The results of the decomposition exercise suggest that roughly 79 percent of the resultant increase (94.9% / (25.0% + 94.9% + 0.9%)) in the value of agricultural revenues came from yield effects. These effects are due, in large measure, to the adoption of the high-yielding production technology for rice, i.e., modern seeds, fertilizer, irrigation, pesticides. Another 21 percent was due to an area effect that mostly worked through an expansion of corn areas and irrigated palay in the dry season. From a policy perspective, sustaining this type of growth means that attention needs to be paid to input prices, agricultural research, irrigation, etc.

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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PREFACE

The computer exercises in this volume serve two purposes. The most important is substantive. They provide an introduction to the policy analysis matrix (PAM) approach to analyzing government policy interventions in the agricultural sector. The analytical framework for the analysis draws upon the seminal work by Monke and Pearson, *The Policy Analysis Matrix in Agricultural Development.* The Monke-Pearson text should be used in conjunction with the exercises developed here.

The workbook also seeks to develop microcomputer skills. Particular attention is given to the efficient arrangement of computations on the spreadsheet which simplifies the expansion from a single commodity PAM to a PAM that simulates a farming system. Moreover, careful application of a few simple rules allows PAM's from one country or region to be copied for reuse in other situations. They become, in spreadsheet jargon, "templates" for further work.

Students who find they have difficulty in following this manual's spreadsheet commands may find it helpful to work through the first few chapters of one of the many beginning books on learning Lotus. An excellent introduction is contained in *Learning Lotus 1-2-3* from Lotus Development Corporation. A more helpful reference volume is *The Best Book of Lotus 1-2-3, Rel. 2.2* by Alan Simpson. It can be obtained from Macmillian Publishing Company.

This volume begins by developing a single commodity farm budget using private or market prices. Chapters 2 and 3 extend the budgeting exercise to encompass increasingly more complex multiple commodity systems. Chapter 4 illustrates the creation of commodity budgets using social prices, without actually describing how to calculate such prices. Chapter 5 introduces the Policy Analysis Matrix (PAM) and links the PAM to previously completed budgeting exercises. Chapters 6 and 7 explain the process for calculating export and import parity (social) prices for tradable inputs and outputs. Decomposition of non-tradable services used in production, such as tractors, is covered in Chapter 8. Chapter 9 suggests a method for including capital recovery costs in the overall analysis. Finally, Chapter 10 gives an example of sensitivity analysis on macroeconomic variables.

A number of people have contributed to the development of this manual. Much of the first draft, based on Indonesian data, was written by Rosamund Naylor. This material was subsequently revised in the light of Scott Pearson's "beta testing." Brigit Helms extended the final chapters to include material on alternative macro policy assumptions. Manny Gaspay was responsible for converting the earlier Indonesian examples to the Philippine data on which the present version is based. Bugs undoubtedly remain and comments on the manual are welcome.

Thanks are due to the Agricultural Policy Analysis Project (APAP), funded by U.S.A.I.D., for providing the resources to prepare this manual. Further information about this project, its newsletter and its published output in the agricultural policy field can be obtained from Abt Associates, Inc., Hamden Square, 4800 Montgomery Lane, Suite 600, Bethesda, MD 20814.

Carl H. Gotsch

CHAPTER 1: DEVELOPING SINGLE COMMODITY FARM BUDGETS

Farm level commodity budgets are the building blocks of the PAM approach to agricultural policy analysis. This chapter reviews the basic components of farm budgets and shows how to calculate private profitability for a single commodity. Data on high yielding paddy in the Philippines are used to illustrate the computations.

COMPONENTS OF THE BUDGET

Chapters 8 and 9 of the Monke and Pearson text contain a detailed discussion of the intricacies of developing farm budgets.[1] This exercise covers the basic ingredients of M-P's farm budgets, i.e., tradable inputs, domestic factors, outputs, and prices. The discussion in Chapter 9 ("Farm Level Budgets and Analysis") is essential reading before undertaking the data collection that precedes the construction of actual budgets.

The main data components of a commodity budget are:

(1) Tradable intermediate inputs -- (fertilizer, seeds, pesticides)
(2) Factor inputs -- (land, labor, and capital) [2]
(3) Outputs -- (crops and by-products)
(4) Prices of inputs and outputs

Quantities are standardized on land area, e.g., man-hours/ha for labor, kg/ha for fertilizer, and kg/ha for yields. Prices are specified in corresponding measurements, e.g., P/hour for labor, P/kg for fertilizer, and P/kg for output. Profits are calculated by subtracting the costs of tradable inputs and factor inputs from total revenue.

ORGANIZING THE SPREADSHEET--THE DIAMONDBACK METHOD

Spreadsheets for farm budgets may be organized in a variety of ways. The method used here begins with an input-output data table of physical quantities, adds a data table of prices, and produces a third (budget) table with computations that draw on the first two tables.

Complicated worksheets such as the ones developed in this manual often utilize the so-called "**diamondback**" method which arranges tables along the spreadsheet's diagonal. This procedure facilitates organizational flexibility. So long as the table rows and columns do not overlap, it is possible to alter the table structure while leaving the basic relationships of the spreadsheet intact. **Formulas, functions and range names continue to be valid if rows and columns are "inserted" and "deleted" rather than added or erased.**

This chapter applies the diamondback method for organizing the spreadsheet by placing the

---

[1] Monke and Pearson text will be referred to in the manual as M-P.

[2] Factor inputs are often called "domestic resources." The two terms will be used interchangeably in the exercises that follow.

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Input-Output table in the top left-hand corner, the Price table below and to the right of the Input-Output table, and the Budget table below and to the right of the Price table. Figure 1.1 illustrates this format. The tables are identical except for the measurements (e.g., labor quantity equals Hr/ha, labor price equals P/ha). Using identical formats makes it easy to develop a third table that contains the commodity budget. Once the formula (price times quantity) for the first cell has been entered, the ***Copy*** command can be used to calculate all of the remaining cells in the budget table. Individual input costs can be summed to calculate total cost.

With a diamond array it is highly desirable to use the ***Range Name*** command to identify the tables. By using table names, along with the **GoTo** [F5] and **Names** [F3] function keys, tables located anywhere on the spreadsheet can be found quickly and easily.

COMPUTING A SINGLE COMMODITY BUDGET

The first step in creating a spreadsheet is to specify the labels and column headings. After the table structure has been designed, it can be copied to other tables. If this sequence is followed, changes can be made in the spreadsheet's structure without having to re-type the data.

Input-Output Table

Move to the top of the spreadsheet and type a name (I-O) in Column A. Begin typing the list of input quantities in column B as illustrated in Screen 1.1. The level of disaggregation will depend on the type of data that are available. It is usually best to disaggregate as much as possible to facilitate sensitivity analysis. Remember to specify carefully units of measurement, e.g., kg/ha for fertilizer, hours/ha for labor, etc. Make sure to expand the width of column B to accommodate all labels by using the ***/Worksheet Column Set-Width*** command. Put a double at line at the bottom of the table to show clearly where the table ends.

Assign a name to the Input-Output table with the ***Range Name*** command. To do this,

Move to:	the top left corner of the table, i.e., the "I-O" cell address.
Press:	/
Select:	***Range***
	Name
	Create
Type:	***I-O***
	[Enter]

Select the entire table range to facilitate subsequent spreadsheet manipulation and printing.

Figure 1.1

Input-Output
Block

Tradable Inputs

Domestic Resources

Output

(Quantities)

Private Prices
Block

Tradable Inputs

Domestic Resources

Output

(Prices)

Commodity Budget

Tradable Inputs

Domestic Resources

Revenue

Total Costs

Profits

Screen 1.1: Physical Input-Output Table

	A	B	C	D
1	I-O		High Yielding Paddy	
2		Quantities	Wet	Dry
3				
4	Tradables:	Fertilizer (kg/ha)		
5		Urea	162	192
6		0-18-0	165	196
7		Chemicals (kg/ha)	8	8
8		Seed (kg/ha)	115	115
9		Fuel (liters/ha)	64	256
10				
11	Factors:	Labor		
12		Seedbed preparation	87	104
13		Crop care	250	240
14		Harvesting	116	125
15		Threshing	12	14
16		Drying	54	49
17				
18		Capital		
19		Working capital (P/ha)	5,519	7,365
20		Tractor services (hr/ha)	140	180
21		Thresher (hr/ha)	95	112
22				
23		Land (ha)	1	1
24				
25	Output:	(Kg/ha)	5,500	6,500
26				
27				

H 05

Price Table

After creating the Input-Output table, build the Prices table below and to the right of the I-O table. The Prices table should be placed so that at least a column and a row separate it from the Input-Output table. The Price table can be created by copying the structure of the Input-Output table and by editing the unit measurements, e.g., by changing kg/ha to P/kg.

Move to the top of the Input-Output table.
Press: /
Select: *Copy*

"Enter range to copy from A1 . . A1"
Move the cursor down and across the table, including the double dotted line at the bottom of the table and press **[Enter]**.

"Enter range to copy to A1 . .

Move down and to the right of the Input-Output table's bottom line, leaving one empty column and one empty row. Press **[Enter]**.

A copy of the I-O table will be inserted along the diagonal.

Move to the copied I-O table and edit it so that it becomes the Price table. First, put the cursor on the copied cell containing term: "I-O" and type "P-Prices" for *private prices*. Enter a return. Use the */Range/Name/Create* command (see the instructions for the I-O table above) and create a range called "P-Prices."

Edit the remainder of the Price table so that the prices of the inputs and output are shown instead of physical quantities (Screen 1.2.)[3] Even in the case when input and output prices for wet and dry season paddy are identical (in our example they are not, land rent and paddy price are higher in the dry season), two price columns should be used in order to retain the symmetry of construction between the I-O and Price tables. The reasons for this redundancy will become apparent in the following section.

Use the edit key **[F2]** to change the measurements, e.g., kg/ha to P/kg for fertilizers. After editing each measurement, press **[Enter]**.

Type **Private Prices** over the word **Quantities** at the top of the table.
In the "**Output**" row, convert **(kg/ha)** to **(P/kg)**.

---

[3] Caution: The price of working capital (percentage) is entered in the price table in decimal format instead of percentage format for uniformity, since all the rest of the prices are in decimals. Lotus 1-2-3, however, offers the option of percentage formatting for individual cells or ranges.

Screen 1.2: Private (Domestic) Prices Table

	F	G	H	I
28	P-Prices		High Yielding Paddy	
29		Private Prices	Wet	Dry
30				
31	Tradables:	Fertilizer (P/kg)		
32		Urea	3.8	3.8
33		0-18-0	2.3	2.3
34		Chemicals (P/kg)	120.0	120.0
35		Seed (P/kg)	6.0	6.0
36		Fuel (P/liters)	6.7	6.7
37				
38	Factors:	Labor (P/man hour)		
39		Seedbed preparation	7.5	7.5
40		Crop care	6.2	6.2
41		Harvesting	6.2	6.2
42		Threshing	7.0	7.0
43		Drying	6.2	6.2
44				
45		Capital		
46		Working capital	.14	.14
47		Tractor services (P/hr)	6.50	6.50
48		Thresher (P/hr)	12.50	12.50
49				
50		Land (P/ha)	3,500.00	7,100.00
51				
52	Output:	(P/kg)	4.5	4.8
53				
54				

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Enter the data shown in Screen 1.2 by typing over the entries in the copied I-O screen.

Budget Table

Create a third table to calculate costs, revenue, and profits. This table has the same table format as the previous tables, and can be built by using the ***Copy*** command. The calculations in the budget table are obtained by multiplying quantities and prices.

Copy the table format from the P-Price table, including the double dotted line at the bottom, to a position below and to the right. Type "P-Budget" over the term "P-Price" and use the ***/Range Name Create*** command to create a range called "P-Budget." Compute the entries in the budget table with the following steps:

Step 1.

Input costs, domestic factor costs and revenue for one hectare are computed by multiplying quantities in the I-O table by prices in the price table. Remember to start the formula with a + sign. The formula can be written using **relative** cell addresses.[4] For example, to calculate the cost of urea in the wet season,

Type:	+
Move to:	**Urea** in the wet season in the Input-Output table
Type:	*
Move to:	**Urea** in the wet season in the Price table
Press:	**[Enter]** [5]

The cells for urea price and quantity can be identified quickly within the spreadsheet by using the **[F5]** and **[F3]** keys and choosing the appropriate table.

Step 2.

The formula can now be copied from the urea cell to all of the other input cells as well as the Total Revenue cell in the budget table with the ***Copy*** command. To suppress the zeros that appear in this process, use the ***/Worksheet Global Zero Yes*** command.

---

[4] Recall that when a *relative* cell address is copied, the *relationship* between the cells positions that make up the original formula are preserved. The *absolute* cell address sign ($) fixes the relationship so that the formulas, when copied, continue to refer to the original cells. *Absolute* address can be fixed by row (A$1), by column ($A1) or both ($A$1). Copying a cell with a fixed row address, for example, means that the relationship between columns will change, but the row portion of the formula will remain that same.

[5] An alternative to the "pointing" approach is simply to note the appropriate cells for urea price and quantity on a piece of paper before calculating the cost, then write the formula directly into the spreadsheet. For example, if the urea quantity is in cell C7 and the urea price is in cell G35, the formula to be typed into the budget cell for urea is +C7*G35/1000.

Screen 1.3: Private Prices Budget

	K	L	M	N
55	P-Budget		High Yielding Paddy	
56		Cost and Returns (P/ha)	Wet	Dry
57				
58	Tradables:	Fertilizer (P/kg)		
59		Urea	616	730
60		0-18-0	379	451
61		Chemicals (P/kg)	960	960
62		Seed (P/kg)	690	690
63		Fuel (P/liters)	429	1,715
64				
65	Factors:	Labor (P/man hour)		
66		Seedbed preparation	653	780
67		Crop care	1,550	1,488
68		Harvesting	719	775
69		Threshing	84	98
70		Drying	335	304
71				
72		Capital		
73		Working capital (P/ha)	773	1,031
74		Tractor services (P/hr)	910	1,170
75		Thresher (P/hr)	1,188	1,400
76				
77		Land (P/ha)	3,500	7,100
78				
79	Output:	Total Revenue	24,750	31,200
80		Total Costs (excluding land)	9,285	11,592
81		Profit (excluding land)	15,465	19,609
82		Net Profit (including land)	11,965	12,509
83				

Type: **/WGZY**

Care must be taken to be sure that the row structure is the same for all tables. Lotus does not recognize row labels when multiplying. When relative cell addresses have been specified, it simply matches rows by their position.

Step 3.

Move to the new budget table and use the edit key **[F2]** to edit the table labels as shown in Screen 1.3. Then add the total cost, profit, and net profit rows in the following manner:

Step 3.1. Insert a row below **Total Revenue** and label it **Total Costs (Excluding Land)**. This entry sums all individual costs except for land. Compute total Costs with @SUM(..). The appropriate range, in this case, is all costs above the total land costs line.

Step 3.2. Insert a row below Land Cost and label it **Profit (Excluding Land Costs)**. This cell is calculated by subtracting the previously computed Total Costs row from Total Revenue.

Step 3.3. Insert a row below Profit and label it **Net Profit (Including Land)**. This cell is calculated by subtracting the Land Cost row from the Profit Excluding Land Cost row.

The distinction between profits that include or exclude returns to land is important. Whereas rental values can be observed and included in a private budget, the same is not true for social budgets. As M-P (pp. 207-209) make clear, social prices of factors uniquely fixed to agriculture are not observable, and consequently other methods must be used to find a social value for them.

You may wish to present the results of the calculations in a format other than the default format, which in this case may lead to some numbers with more than 2 decimal places. To achieve the format seen in Screen 1.3, do the following:

Press:	/
Select:	**Range, Format, Fixed**
Type:	**1** (when prompted for the number of decimal places)
Move to:	Urea in the wet season in the Budget table (Cell address M71)
Move to:	Land Cost in the dry season (Cell address N92)
Press:	**[Enter]**

These steps will format the costs as a number with one decimal place. To present the rest of the results in a "comma" format with no decimals, select , instead of **Fixed** and enter **0** when prompted for the number of decimal places.

Save the just completed exercise under the name CHAPT1. Use ***/File Save***, then type CHAPT1. If you have saved the chapter previously under this name, you will be asked: "Cancel, Replace,

Backup"). Choose "Replace." This will cause Lotus 1-2-3 to write the current contents of the spreadsheet over the previous file. Lotus will automatically add the .WK1 suffix to the file name, calling it CHAPT1.WK1.

Then save the worksheet a second time. This time choose "Backup" instead of "Replace." This will create a duplicate of CHAPT1.WK1 called CHAPT1.BAK. Use CHAPT1.WK1 to continue the exercise in Chapter 2. If a serious error is made, return to the original by retrieving CHAPT1.BAK. Using a backup copy of the original may save redoing a substantial amount of work.

SUMMARY

Chapter 1 organizes the ingredients of a simple commodity budget. The exercise demonstrates how to arrange the computations and take advantage of the power of the ***Copy*** command. The ***Copy*** command replicates the structure of the input-output table to produce the price and budget tables. Only a minor editing of measurement units is needed to produce the new tables. The ***Copy*** command is then used to reproduce the formulas that compute the values in the individual commodity budget table. The addition of several rows to the commodity budget permits the calculation of profits excluding land costs by subtracting total costs excluding land costs from total revenue. Subtraction of the land costs from this figure yields net profits.

The values obtained in the private budget calculation translate into the first row of the PAM, which describe private profitability. In Chapter 4, this row of the PAM will be juxtaposed with the calculation of profits at social prices. The two rows form the basis of further calculations that yield various protection coefficients and estimates of the incidence and degree of policy interventions and market imperfections.

CHAPTER 2: MULTIPLE RICE PRODUCTION SYSTEMS

Chapter 1 calculated a single commodity budget for high productivity paddy production in the Philippines. This chapter includes additional paddy production systems in the spreadsheet and calculates private profits for each system. Sensitivity analyses also are carried out on several input-output and price coefficients.

The most important objective of the chapter is to demonstrate how to expand commodity budgets within the diamondback method. This approach to worksheet design encourages an analytical strategy that begins simply but becomes progressively more complex as the policy analyst acquires more information.

ADDING PRODUCTION SYSTEMS TO THE WORKSHEET

Retrieve the copy of the worksheet completed in Chapter 1 using the ***File Retrieve*** command. GoTo the input-output table (I-O) by pressing **[F5]** and **[F3]** and selecting **I-O**. (Pressing **[F3]** a second time produces a *table* of range names from which to choose.)

If you have not created names for your tables, return to Chapter 1 and complete that part of the exercise. All subsequent directions assume that the tables have been named correctly.

Adding Production Systems to the I-O Table

Expand the I-O table by inserting columns to the right of the existing dry season high-productivity crop. Use the ***Worksheet Insert Column*** command and insert three columns after the last column in this table. Title the first two columns: Average Yield Paddy with sub-titles of Wet and Dry (seasons). Title the third new column: Rainfed Paddy. When completed, the table should look like Screen 2.1.

Physical data for average-productivity and rainfed paddy are shown in Table 2.1. Note that rainfed paddy does not utilize any gasoline input. Gasoline or diesel fuel is required to operate the irrigation pump, tractor, and power thresher. Fuel used by the tractor and thresher, however, are supplied by the rental operators of these farm machineries and its cost is included in their rental rates. Fuel for the farmer-owned irrigation pump, on the other hand, must be accounted for as a tradable input in irrigated paddy production. The data represent rice growing environments distinguished by different soil types, water control methods and drainage regimes. They are **not** assumed to be different technologies for growing rice under the same environmental conditions. The data should be typed into the columns inserted in the expanded I-O table.

Adding Production Systems to the Prices Table

Add 3 columns to the Prices table using the same procedure followed for the I-O table. Tradable input prices and the prices of labor and capital are assumed to be the same for all paddy systems, so these prices should be copied into the columns for the new production systems. Wet and Dry season season paddy prices are the same as prices for the high yielding systems. Rainfed varieties are the same as the paddy grown in the wet season.

Screen 2.1: Physical Input-Output Table

	A	B	C	D	E	F	G
1	I-O		High Yield Paddy		Average Yield Paddy		Rainfed
2		Quantities	Wet	Dry	Wet	Dry	Paddy
3	----------						
4	Tradables:	Fertilizer (kg/ha)					
5		Urea	162	192			
6		0-18-0	165	196			
7		Chemicals (kg/ha)	8	8			

Although private prices for the new paddy systems are the same as for the original high yielding systems, it would be reasonable to expect the rental prices of land to vary with the profits obtained from rice production. The land price for the wet season and the dry season in the average productivity paddy equals P2,380 and P5,000, respectively. The land price for rainfed paddy is P1,500.

Adding Production Systems to the Budgets Table

The budget calculations table, "P-Budget," must also be expanded to include the new columns that have been inserted in the I-O and Price tables.

CALCULATING COSTS AND REVENUES

The formulas for calculating costs in the expanded budget table have been adjusted automatically by Lotus for the changes made in the number of columns in the I-O table. Copy the formula for urea costs to the entire budget table down to and including the **Total Revenue** row with a single *Copy* command.

After copying formulas you may want to clear zeros once again: /WGZY.

Total Costs and Profits

All formulas have been automatically adjusted for the columns inserted in the I-O and Budget tables. They can simply be copied from the high yielding systems to the new systems that have been added to the spreadsheet. A completed Lotus budget table is shown in Screen 2.4.

GRAPHING REVENUES, COSTS AND PROFITS

One way to illustrate profits for a number of different technologies is to use a **stacked-bar** graph with land on the bottom, variable costs on the next level, and profits on the highest level.

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This graph is useful because it shows all of the technologies side by side (Figure 2.1) and makes it possible for decision makers to grasp quickly relative profitability.

Screen 2.2: Graphing Relative Profits

	Q	R	S	T	U	V	W
78	----------						
79	Output:	Total Revenue	24,750	31,200	16,200	23,520	10,800
80		Total Costs (excluding land)	9,285	11,592	9,280	11,879	6,251
81		Profits (excluding land)	15,465	19,609	6,920	11,641	4,549
82		Net Profit (including land)	11,965	12,509	4,540	6,641	3,049
83			High-W	High-D	Avg-W	Avg-D	Rain
84	==========						

Before creating the graph, make a new row below **Net Profits** in the Budget table for the X-axis labels as shown in Screen 2.2. These labels will be an abbreviated version of the headings at the top of the table, for instance, **High-W** for High-Yielding Wet Season Paddy, **High-D** for High-Yielding Dry Season Paddy, **Avg-W**, etc. Short headings are required so that they all fit on the graph.

Now make the graph.

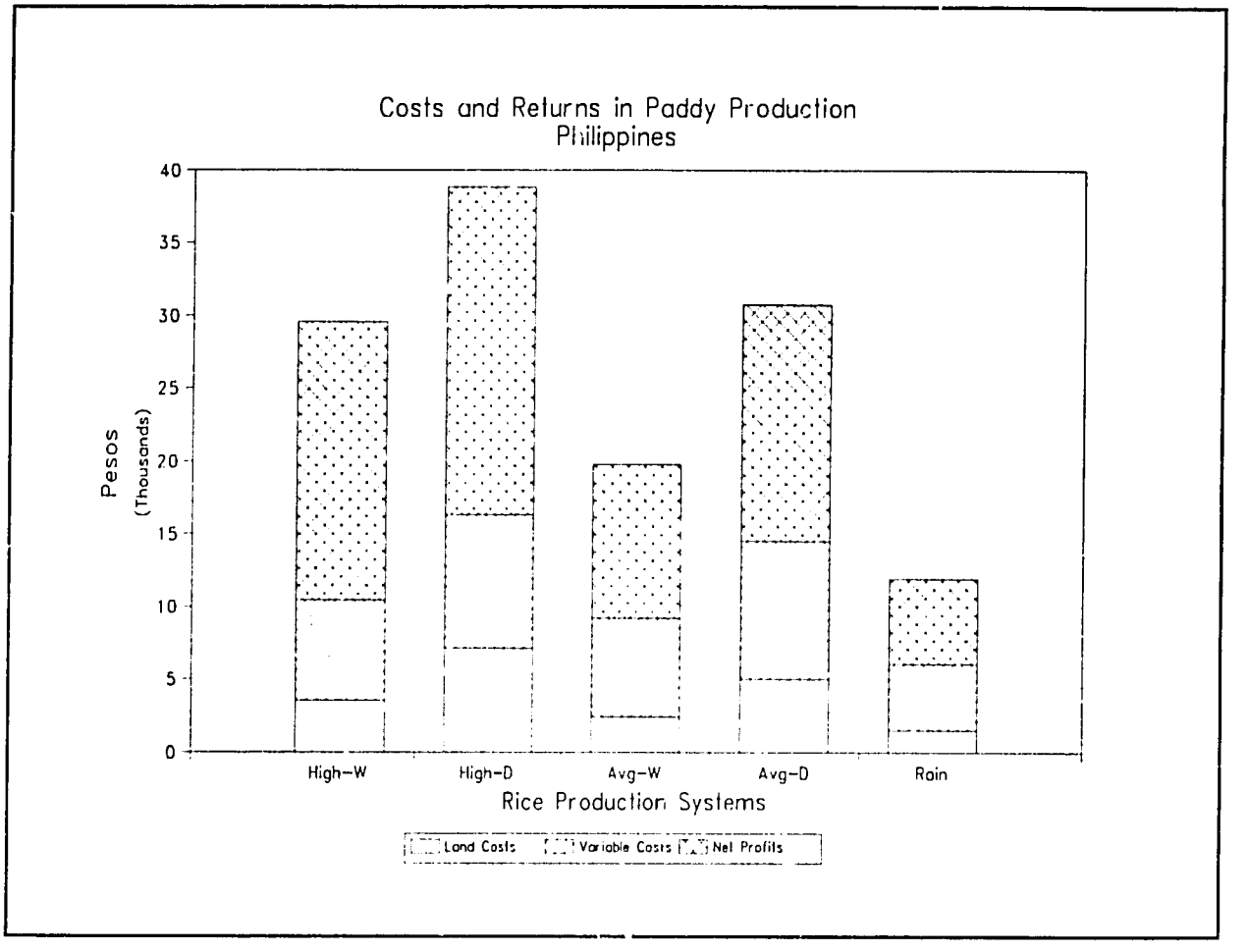
Press: /
Select: ***Graph***
Type
Stacked-Bar
X

Specify the row of labels, e.g., S110 . . W110
Press: **[Enter].**
Select: ***A***
Specify the row of Total Costs Excluding Land, S105 . . W105
Press: **[Enter]**

Select: ***B***
Specify the row of Land Costs, S101 . . W101
Press: **[Enter]**
Select: ***C***
Specify the row of Net Profits, S109 . . W109
Press: **[Enter]**

Name each of these ranges:
Select: ***Options***
Legend
Specify:
A: Cost Excluding Land
B: Land Costs

Figure 2.1: Costs and Returns in Paddy Production



C: Net Profit
Give the graph titles:
Select: ***Options***
Titles
Specify:
First: Costs and Returns in Paddy Production
Second: Philippines
X-axis: Rice Production Systems
Y-axis: Pesos

Select: ***Quit*** (move back to the main menu)

The graph can be viewed with the **View** command. If the graph is correct, save the graph file. Call the graph "Profit"; it will be saved as "PROFIT.PIC."

Before printing the graph, save the **worksheet file** containing the data on which the graph is based. Call it CHAPT2. Save it a second time and choose "Backup." After saving the file, exit 1-2-3. Enter the Print-graph program and print the graph using the **Image-Select** command.

SENSITIVITY ANALYSIS

Once data and formulas are entered into a worksheet, sensitivity analysis can be conducted with minimal effort. This exercise compares relative profitability across different paddy systems (technologies and seasons) under different pricing scenarios. This type of exercise helps policy-makers understand how input and output prices affect farm incomes and, hence, farmers' potential production responses.

One approach to performing a sensitivity analysis of price policies makes extensive use of named ranges. For example:

1) Move to the price table using the **[F5]** and **[F3]** keys.
2) Change the price(s) that are to be tested for sensitivity.
3) Move to the budget table using the **[F5]** and **[F3]** keys.
4) Move the cursor to the bottom of the table and look at the effects on Total Costs, Total Revenues, and Profits.

A more efficient way of doing interactive sensitivity analysis entails the use of spreadsheet *windows*. Put the cursor in the middle of the screen and type ***/ Worksheet Windows Horizontal (/WWH)***. A bar will appear across the middle of the screen. Repeat the process, except this time select ***Unsynchronized***. Type: ***/WWU***. The diamondback structure requires unsynchronized movement in order to view two tables simultaneously in the windows.

Use the **[F6]** key to move back and forth between the tables. Use **[F5]** and **[F3]** to select the Budget table in the bottom window and scroll until the rows for Total Costs, Total Revenues and Profits are in view. Then press **[F6]** to jump to the upper screen. Use **[F5]** and **[F3]** to go to the price table, P-Price. Scroll to the prices on which the sensitivity analysis is to be performed. Change the prices as desired, then press the recalculation key, **[F9]** and note the results in the lower window.

Print the results of the sensitivity analysis to facilitate comparisons between price assumptions. Compare with the original results in Screen 2.4.

Compare the <u>relative profits</u> for the different systems under the following conditions and make some notes in the space provided below regarding the results:

1) All fertilizer prices are doubled; eg., urea is raised from P3.20/kg to P6.40/kg.

Screen 2.3: Horizontal Windows

B7 READY

Horizontal Vertical Synch Unsynch Clear

Split the screen horizontally at the current row

	A	B	C	D	E	F	G	H
1								
2								
3								
4								
5								
6								
	A	B	C	D	E	F	G	H
1								
2								
3								
4								
5								
6								

2) Fertilizer prices do not change but paddy price rises to P7.50/kg.

3) Same as above with paddy prices at:

a) P10.00/kg

b) P3.75/kg

4) Fertilizer and output prices remain at their original values, but all labor costs double.

What are the policy implications of these results for farmer incentives? In many countries, different government agencies administer output and input prices. Note that the sum total of different prices policies determines farmer incentives to grow the crop--the farmer responds to changes in profitability, regardless of the source of these changes.

What can be said about the competitiveness of the various production systems? Significant private profits in a system means that rents accrue to the owners of domestic resources such as land. Recall that in a perfectly competitive system, there are no profits, i.e., in equilibrium, factors are paid the value of their marginal product. Consequently, positive profits imply low levels of competition.

Table 2.1: Input-Output Data for Alternative Paddy Systems

	High Yield Paddy		Avg. Yield Paddy		Rainfed
Quantity	Wet	Dry	Wet	Dry	Wet
Fertilizer					
Urea	162	192	224	230	167
0-18-0	165	196	100	120	20
Chemicals	8	8	8	7	2
Seed	115	115	100	115	115
Fuel	64	256	96	320	
Labor					
Seedbed	87	104	64	75	65
Crop care	250	240	152	175	100
Harvesting	116	125	196	210	200
Threshing	12	14	8	11	5
Drying	54	49	36	38	60
Capital					
Working capital	5,519	7,365	5,136	7,166	3,398
Tractor	140	180	240	260	140
Thresher	95	112	64	88	40
Land	1	1	1	1	1
Output	5,500	6,500	3,600	4,900	2,400

Screen 2.4: Paddy Budgets at Private Prices

	Q	R	S	T	U	V	W
55	P-Budget		High Yield Paddy		Avg. Yield Paddy		Rainfed
56		Cost and Returns (P/ha)	Wet	Dry	Wet	Dry	Wet
57							
58	Tradables:	Fertilizer					
59		Urea	616	730	851	874	635
60		0-18-0	379	451	230	276	46
61		Chemicals	960	960	960	840	240
62		Seed	690	690	600	690	690
63		Fuel	429	1,715	643	2,144	0
64							
65	Factors:	Labor					
66		Seedbed preparation	653	780	480	563	488
67		Crop care	1,550	1,488	942	1,085	620
68		Harvesting	719	775	1,215	1,302	1,240
69		Threshing	84	98	56	77	35
70		Drying	335	304	223	236	372
71							
72		Capital					
73		Working capital	773	1,031	719	1,003	476
74		Tractor services	910	1,170	1,560	1,690	910
75		Thresher	1,188	1,400	800	1,100	500
76							
77		Land	3,500	7,100	2,380	5,000	1,500
78							
79	Output:	Total Revenue	24,750	31,200	16,200	23,520	10,800
80		Total Costs (excluding land)	9,285	11,592	9,280	11,879	6,251
81		Profits (excluding land)	15,465	19,609	6,920	11,641	4,549
82		Net Profit (including land)	11,965	12,509	4,540	6,641	3,049
83			High-W	High-W	Avg-W	Avg-D	Rain
84							

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CHAPTER 3: MULTIPLE COMMODITY BUDGETS

Farmers' decisions concern both input use and crop choice in each season. These decisions depend on the agroclimatic production zones and the technologies, including irrigation facilities, available to farmers. Within each season, differences in expected profitability influence the crop choice for a given production system.

Chapter 3 introduces several non-paddy crop alternatives. The issue of comparative advantage **within** a production environment becomes important in determining what commodities farmers will find profitable to produce. As a result, response to price changes, i.e., supply response, becomes more complex. A detailed discussion of the problems associated with modeling more complex commodity systems can be found on pp. 161-169 of the Monke and Pearson book.

Once the budgets for the non-paddy crops are constructed, sensitivity analysis can be performed to gauge the potential impact of policy prices on profitability **within** farming *systems*.

ADDING MORE COMMODITIES TO THE WORKSHEET

This section adds irrigated mungbeans, irrigated maize, and rainfed maize to the analysis. **The two irrigated crops are assumed to be grown in an average productivity agro-climatic environment during the dry season. Rainfed maize competes with rainfed rice.**

The diamond pattern of the worksheet permits the addition of new quantities and prices without interfering with existing tables and range name locators. If care is taken to insert rows and columns, existing range names do **not** have to be re-specified nor do most formulas have to be rewritten.

REMEMBER! New columns and rows must be inserted--not added--in order to insure that the existing tables do not overlap. Use */WIC* and */WIR* to insert columns and rows.

The first step is to call up the worksheet on paddy production systems from the previous exercise (CHAPT2.WK1).

Table 3.1 contains budget data for mungbeans and maize. This table is <u>not</u> a spreadsheet, so <u>do not</u> simply type it into your worksheet. The headings shown in the data table may be used as a guide to headings in the worksheet. The data can be added to the existing I-O and Prices tables by (1) expanding the size of the tables with the ***Worksheet Insert*** command, and (2) typing the data into the tables. Use the **[F5]** and **[F3]** keys to move from one table to the next.

Adding Data to Tables Using "Titles"

One problem in filling out the existing tables is that the input labels (fertilizer, labor, etc.) can not be seen from the new columns. This makes the process of data entry more difficult. The ***Titles*** command always displays the column of labels on the left regardless of which data columns appear

on the right.[6]

Begin by moving into the I-O table. Then,

Press: /
Select: ***Worksheet***
Titles
Vertical

Move the cursor to the right until the new headings, "Irrigated Mungbeans" and "Irrigated Maize", appear on the right hand side of the screen, as shown in Screen 3.1.

Screen 3.1: Physical Input-Output Table

	A	B	H	I
1	I-O		Irrigated	Irrigated
2		Quantities	Mungbean	Maize
3	----------	----------	----------	----------
4	Tradables:	Fertilizer (kg/ha)		
5		Urea	162	192
6		0-18-0	165	196

Budget data can now be entered into the I-O table easily because the labels for the inputs are in view. Enter the budget data shown in Table 3.1. After the data have been entered, clear the title:

Press: /
Select: ***Worksheet***
Titles
Clear

Follow the same procedure to modify the P-Price table.

CALCULATING RELATIVE PROFITS

Move to the budget calculation table. Notice that this table moved automatically as a result of additions to the I-O and price tables. All of the calculations moved to new columns, but the

[6] Alternatively, the ***Windows*** command learned in Chapter 2 could also be used. However, the ***Titles*** command is simpler for data entry tasks.

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formulas changed automatically to reflect the insertions.

Insert three columns to the right of the "Rainfed Rice" column for "Irrigated Mungbeans", "Irrigated Maize", and "Rainfed Maize".

Sufficient space already exists to accommodate the headings for mungbeans and maize. These may either be copied from the I-O or Prices tables--or typed in.

The new budget values can now be copied for each of the production systems and commodities.

Step 1

Place the cursor on the urea cost cell in the first column of data. Use the ***Copy*** command to copy the formula contained in this cell to the entire data area down to and including **Total Revenue**.

Step 2

Copy the formulas for **Total Costs Excluding Land**, **Profits Excluding Land Costs**, and **Net Profits** into the new commodity columns. (Try copying all three rows in a single step.)

Compare your results to the completed budget table shown in Screen 3.3.

Update the graph produced in Chapter 2 to reflect the new commodities by simply adding additional labels, say, "Soy," "Maize," and "RMaize," and extending the ranges of the various rows to include the new commodities. See Figure 3.1.

Save the worksheet at this point. Call it CHAPT3. Save it a second time as CHAPT3.BAK by choosing "Backup." Do not exit Lotus 1-2-3.

SENSITIVITY ANALYSIS

As noted in a previous exercise, sensitivity analyses are best done using the *Windows* command. Remember to use the *Unsynchronized* command to get the relevant portions of both the price and budget tables on the screen at the same time. The effects of changes in assumptions on revenues, costs and profits can then be ascertained immediately.

Perform sensitivity analysis on all or some of the following parameters and make a note of any interesting results in the space provided:

a) fertilizer prices double

b) labor costs double

c) yields for mungbeans double

d) yields for corn double

e) paddy prices drop by 50%

Questions: Note that changes in the costs of inputs have much smaller effects on profits than changes in the prices of outputs? Why? What are the implications of this kind of sensitivity analysis for data collection efforts? If human resources to do research on agricultural policy are scarce, do these results suggest what types of empirical work a Ministry or planning unit ought to focus on?

Answers: Profits are much less sensitive to individual input prices than to individual output prices because each input makes up only a fraction of the cost. This strongly suggests that the highest priority in doing research is to obtain the best possible data on output prices and yields. The next highest priority would be the largest item in costs, say, labor. Only after the larger cost items have been determined should minor costs be investigated. The "what-if" feature of spreadsheets makes it possible to determine quickly exactly how much impact a particular price has on the overall results. Efforts to improve the database can be organized accordingly.

Screen 3.2: Data for Mungbean and Maize

Quantities	Irrigated Mungbeans	Irrigated Maize	Rainfed Maize	Units	Prices
Fertilizer					
Urea	25	100	85	P/kg	3.8
0-18-0					2.3
Chemicals	1	1.5	0.5		120
Seed					
Mungbeans	30				18
Irrigated Maize		40			4.8
Rainfed Maize			40		4.8
Fuel	16	16	0	P/l	
Labor					
Seedbed	42	50	50	P/hr	7.5
Crop care	80	120	100		6.2
Harvesting	200	200	180		6.2
Threshing	35	0	0		7.0
Shelling	0	85	60		6.2
Drying	8	12	20		6.2
Capital					
Working capital	1,815	2,331	1,630	%	.14
Tractor	126	150	120	P/hr	6.5
Thresher	65			P/hr	12.5
Land	1	1	1		
Wet season (rainfed)				P/ha	1,500
Dry season (irrigated)					5,000
Mungbean (kg/ha)	750			P/kg	14
Maize (kg/ha)		2,500			4.6
Rainfed maize (kg/ha)			1,270		4.6

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Screen 3.3: Multi-Commodity Budgets at Private Prices

	High Yield		Avg. Yield		Rainfed	Irrigated	Irrigated	Rainfed
	Wet	Dry	Wet	Dry	Paddy	Mung	Maize	Maize
Fertilizer:								
Urea	616	730	851	874	635	95	380	247
0-18-0	379	451	230	276	46	0	0	0
Chemicals	960	960	960	840	240	120	180	60
Seed	690	690	600	690	690	540	192	192
Fuel	429	1,715	643	2,144	0	107	107	
Labor:								
Seedbed	653	780	480	563	488	315	450	375
Crop care	1,550	1,488	942	1,085	620	496	744	620
Harvest	719	775	1,215	1,302	1,240	1,240	1,240	1,116
Threshing	84	98	56	77	35	245	0	0
Shelling	0	0	0	0	0	0	527	372
Drying	335	304	223	236	372	50	74	124
Capital								
Working	773	1,031	719	1,003	476	254	326	228
Tractor	910	1,170	1,560	1,690	910	819	975	780
Thresher	1,188	1,400	800	1,100	500	813	0	0
Land	3,500	7,100	2,380	5,000	1,500	5,000	5,000	1,500
Revenue	24,750	31,200	16,200	23,520	10,800	10,500	11,500	5,842
Costs	9,285	11,592	9,280	11,879	6,251	5,093	5,196	4,114
Profits	15,465	19,609	6,920	11,641	4,549	5,407	6,304	1,728
Net profit	11,965	12,509	4,540	6,641	3,049	407	1,304	228

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CHAPTER 4: FARM BUDGETS AT SOCIAL PRICES

Information regarding private and social costs and returns allow the policy analyst to calculate:

(1) Private profits = returns to the willingness of an entrepreneur to manage resources and accept risk

(2) Social profits = returns to the economy when products and factors are valued at their opportunity costs

(3) Divergences = the effects of policy interventions and market failures, which are reflected in the difference between private and social costs, returns and profits.

This chapter takes an important step toward developing this information by adding a computation for social profits to the worksheet.

In order to simplify the initial calculations, Screen 4.1 provides social prices for tradables and nontradables. Monke and Pearson discuss the empirical estimation of social prices their Chapter 11. In preparation for the exercises in this manual the material in M-P's Chapter 6 ("Social Valuation of Commodities") and Chapter 7 ("Social Valuation of Factors") should be regarded as "required reading".

EXPANDING THE EXISTING WORKSHEET

The following major steps are required to calculate social profits in the existing worksheet:

(1) Retrieve the worksheet CHAPT3.WK1 created in the previous chapter.

(2) Copy the **P-Prices** table to the diagonal below and to the right of the private budget. Change the name of the new table to S-**Prices** and, using the ***Range Name Create*** command, add the new table to the list of named tables. Expand the column containing the table's labels so that they are all legible. The easiest way to do this is to use ***/WCS*** and the **[Right Arrow]** key.

(3) Copy the P-Budget table to a position on the diagonal to the right and below the "S-Prices" table. Rename this table S-Budget and add it to the list of named tables. Expand the column containing the table's labels so that they are all legible.

(4) Add data to the social prices table by typing over the existing private prices. Use the *Copy* command to add data to all cells for which the numbers are the same.

(5) Change the formulas in the urea cost cell in the first column of the social budget table to reflect the appropriate addresses in the social prices table. Follow the method used in computing values in the private budget to copy the formulas into the entire data area including **Total Revenues**. (If you have forgotten how to do this, refer to p. 20.)

SOCIAL PROFITABILITY CALCULATIONS

The cost and revenue data for the social budget have already been calculated! Lotus 1-2-3 keeps track of relative cell addresses, so all of the cost and profit calculations are still valid and need not be changed. There is, however, one crucial distinction in the social budget table:

In the absence of clearly specified cropping alternatives, imputing opportunity costs to fixed factors within a single commodity budgeting framework is essentially arbitrary. Consequently, the land price, and thus cost, equals 0 and all returns to land are included in the Profits residual, i.e., Profits and Net Profits are the same. Social profits thus measure the returns to land and management when all commodities are priced at their efficiency prices. The rationale for this approach will be examined in greater detail in Chapter 5.

The results of the social profitability calculations are shown in Screens 4.1 and 4.2.

After the social budget table has been constructed, save the worksheet as CHAPT4.WK1. Save another backup copy.

Screen 4.1: Social Prices for All Commodities

	High Yield		Avg. Yield		Rainfed	Irrigated	Irrigated	Rainfed
	Wet	Dry	Wet	Dry	Paddy	Mung	Maize	Maize
Fertilizer:								
Urea	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
0-18-0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Chemicals	105	105	105	105	105	105	105	105
Seed	6.0	6.0	6.0	6.0	6.0	14.0	4.8	4.8
Fuel	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Labor:								
Seedbed	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Crop care	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Harvest	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Threshing	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Shelling	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Drying	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Capital								
Working	.14	.14	.14	.14	.14	.14	.14	.14
Tractor	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Thresher	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Output	4.0	4.5	4.0	4.5	4.0	11.0	4.0	4.0

Screen 4.2: Multi-Commodity Budgets at Social Prices

	High Yield		Avg. Yield		Rainfed	Irrigated	Irrigated	Rainfed
	Wet	Dry	Wet	Dry	Paddy	Mung	Maize	Maize
Fertilizer:								
Urea	778	922	1,075	1,104	802	120	480	312
0-18-0	545	647	330	396	66	0	0	0
Chemicals	840	840	840	735	210	105	158	53
Seed	690	690	600	690	690	420	192	192
Fuel	429	1,715	643	2,144	0	107	107	0
Labor:								
Seedbed	653	780	480	563	488	315	450	375
Crop care	1,550	1,488	942	1,085	620	496	744	620
Harvest	719	775	1,215	1,302	1,240	1,240	1,240	1,116
Threshing	84	98	56	77	35	245	0	0
Shelling	0	0	0	0	0	0	527	372
Drying	335	304	223	236	372	50	74	124
Capital								
Working	773	1,031	719	1,003	476	254	326	228
Tractor	910	1,170	1,560	1,690	910	819	975	780
Thresher	1,188	1,400	800	1,100	500	813	0	0
Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Revenue	22,000	29,250	14,400	22,050	9,600	8,250	10,000	5,080
Costs	9,492	11,860	9,484	12,124	6,408	4,983	5,273	4,172
Profits	12,508	17,391	4,916	9,926	3,192	3,267	4,727	908
Net profit	12,508	17,391	4,916	9,926	3,192	3,267	4,727	908

CHAPTER 5: THE POLICY ANALYSIS MATRIX

A BRIEF INTRODUCTION TO PAMS

The calculation of private profitability provides information on the competitiveness of commodity systems at actual market prices.[7] The same computations using social prices provide information on profitability when commodities and factors are priced at their social or opportunity costs. When the two are juxtaposed, the divergences--the differences between private and social valuations--provide insights into the extent of policy interventions in the form of taxes, subsidies, trade restrictions and exchange rate distortions. The comparisons also points to imperfections in the functioning of commodity and factor markets.

The **Policy Analysis Matrix (PAM)** reorganizes the data from the private and social budgets to facilitate the evaluation of policy effects and market failures on tradable inputs, domestic resources, and outputs.[8] The PAM format, shown in Figure 5.1 below, contains data on revenues, costs, and profits for an individual crop at private and social prices.

The policy analysis matrix is made up of two accounting identities; one defines profitability and the other measures policy effects and market failures, i.e., divergences.

Profits, shown by D and H in the right column, are calculated by subtracting all costs from revenues, in private and social terms for each respective row. The calculation of private profitability provides information on the competitiveness of commodity systems at actual market prices. The same computations using social prices provide information on profitability when commodities and factors are priced at their social or opportunity costs.

Policy effects and market failures, shown in the bottom row, constitute the difference between private and social values of outputs and inputs. These divergences provide insights into the extent of policy interventions in the form of taxes, subsidies, trade restrictions and exchange rate distortions. They also point to imperfections in the functioning of commodity and factor markets. The sum of the policy effects constitutes net transfers for a particular crop. Net transfers also indicate the difference between private and social profits for the commodity system.

Data collection represents the most difficult aspect of creating PAMs. The construction of I-O and price tables is far more challenging than the calculations of policy effects, market failures, and profits. For example, Monke and Pearson comment at length (p. 137-138) on the difficulty of classifying inputs and outputs due to wide variations in prices depending upon quality, timing, standardization, etc. The earlier sensitivity analysis indicated that budgets are very sensitive to output prices; therefore PAM results will be sensitive to output prices. The treatment of data sources for farm budget analysis contained in Chapter 6 in M-P should be read by everyone who

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[7] In a perfectly competitive economy, there would be no private profits. Positive private profits indicate that some domestic factors are receiving rents.

[8] Chapter 2 of Monke and Pearson provides the authoritative introduction to the logic of the Policy Analysis Matrix.

Figure 5.1. The Policy Analysis Matrix

	Revenues	Costs		Profits
		Tradable Inputs	Domestic Factors	
Private prices	A	B	C	D
Social prices	E	F	G	H
Divergence	I	J	K	L

Private profits: D = A - B - C
Social profits: H = E - F - G
Output transfers: I = A - E
Input transfers: J = B - F
Factor transfers: K = C - G
Net transfers: L = D - H
L = I - J - K

intends to construct their own PAM's.

Figure 5.2 illustrates schematically the relationship between the PAM approach and the diamondback method used in this manual. Once the tables have been arranged in this way and the appropriate linking formulas established, the same "template" can be used for other PAM problems. The labels and data can be changed by simply typing in the new entries. Additional columns and rows can be inserted and deleted without affecting the formulas in the tables.

The final PAM table is constructed from the private and social budget tables. The top or private profits row is obtained from Figure III, the private budget. The middle or social profits row is obtained from Figure V, the social budget. The last row, divergences, is obtained by subtracting numbers computed in Table V from Figure III.

Most of the work required to create PAMs for the Philippine food crops sector has already been done in previous exercises. The facilities of Lotus 1-2-3 make the final computations nothing more than the assignment of cell addresses.

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Figure 5.2: Diamondback Display of PAM Calculations

Figure I

I-O Data
Quantities

Tradable Inputs
Domestic Factors
Yields

Figure II

Private Prices
Prices

Tradable Inputs
Domestic Factors
Output

Figure III

Private Budget
Costs

Tradable Inputs
Domestic Factors
Revenue
Total Cost
Profit

Figure IV

Social Prices
Prices

Tradable Inputs
Domestic Factors
Output

Figure V

Social Budget
Costs

Tradable Inputs
Domestic Factors
Revenue
Total Cost
Profit

Fig I x Fig II = Fig III
Fig I x Fig IV = Fig V
Fig III + Fig V + (Fig III-Fig V) = Fig VI

Figure VI

P A M

	Tradables		Domestic	
	Rev	Cost	Resource	Profit
Private	A	B	C	D
Social	E	F	G	H
Diverge	I	J	K	L

CREATING A PAM FOR HIGH PRODUCTIVITY, WET SEASON PADDY

The first PAM exercise focuses on a single commodity PAM for which complete information on competing alternatives is not available. In such cases, private land costs can be obtained from the private rental market. But in the absence of information on the social profits of competing commodities, social returns to land are difficult to define. Consequently, in both the private and social computations, **Profits** in this PAM equal **Profits Excluding Land Costs**. Domestic resource costs include only labor and capital.

Retrieve CHAPT4.WK1 into the spreadsheet. Create a new table for the first PAM (high productivity, wet season paddy) on the diagonal to the right and below the S-Budget table. Use the table shown in Figure 5.3 as a guide. Label the table "Policy Analysis Matrix: High Yielding Wet Season Paddy" and give the table a name using the ***Range Name Create*** command. (For example, you might call this first PAM, "PAMHPP" for high productivity paddy.)

Figure 5.3. Single Commodity PAM

Policy Analysis Matrix
High Yielding, Wet Season Paddy

	Tradables		Domestic Resources		
	Output	Input	Labor	Capital	Profits
Private					
Social					
Divergences					

Additional PAMS for other commodities can be obtained by copying "PAMHPP" further down on the diagonal, changing the labels and editing the data cell addresses. **Note that only the column addresses change for each PAM**. The *row addresses* of the private and social budgets from which the PAM data are obtained remain the same. Consequently, it will save time to make the row addresses of the first PAM absolute addresses, for example, use K$55 instead of K55. When copied to the new PAM, the row address will remain the same regardless of where the PAM is located and only the column addresses will require adjustment.

Values for the "profits" column and the "divergences" row should be computed in the PAM and should not be transferred from the private and social budgets. This method allows for more straightforward movement from the original to subsequent PAMs. The necessary relative cell adjustments in the new PAM's will be made by the *COPY* command

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Entering Data Into the PAM

The necessary PAM cell entries that reference the private and social budgets can be obtained most easily with the judicious use of **Windows.**

Step 1

Create a horizontal, unsynchronized window that divides the screen in half, following the instructions introduced in Chapter 2. (Hint: use ***/WWH*** followed by ***/WWU***).

Using the **[F5]** and **[F3]** functions, position the PAM table in the lower window and the appropriate budget table in the upper window. Use **[F6]** to jump back and forth between windows.

Step 2

Position the cursor in the appropriate PAM cell. Begin to create the necessary formula with a + for a single cell or @SUM(..) for a range such as the cost of tradable inputs.

Step 3

Use **[F6]** to jump back to the upper window and locate the cell address(es) that should enter the formula. When the appropriate cell has been highlighted, press **[Enter]**. Lotus will write the cell address of the budget into the PAM. (Note: in the case of the @SUM function, you will have to complete the process of identifying a range by typing in a closing parenthesis. Otherwise, Lotus will beep to let you know the formula is incomplete.) **Don't forget to make all rows in the cell addresses absolute!**

Step 4

Calculate the **Profits** cell by writing a formula that subtracts cells in the PAM containing tradable inputs and domestic costs from the PAM cell containing the value of output. Using the numbers in the PAM verifies the profit calculations in the budget and minimizes the use of absolute addresses.

Step 5

Complete the third row of the PAM by writing in the formula that subtracts the social value of output from the private value of output. Copy this formula into the other cells in the **Divergences** row.

The completed PAM for high productivity, wet season paddy is shown in Screen 5.1. The accuracy of most of the values in the table can be checked by direct comparison with the private and social budgets shown in Screens 3.3 and 4.2.

Interpret the results of the high productivity, wet season paddy PAM. What does it say about the extent of rice subsidies? What about input subsidies? (Chapter 12, pp. 226-236, of M-P provides detailed interpretations of a number of PAM's that can serve as models for interpreting the high

productivity paddy PAM.)

CREATING MUNGBEAN PAMS

A Single Commodity Mungbean PAM

Computing a single commodity soybean PAM, i.e., a PAM without full information about competing crops, can be accomplished quickly by copying the already completed paddy PAM further along the diagonal. **Remember to change the row addresses of the first PAM to absolute addresses if you did not enter them in this format.** Change the name and title of the PAM to indicate that it refers to the mungbean column of the private and social budgets. Name the PAM and add the name to the list of table names.

Use *Windows* or a piece of paper to edit the column names of the copied PAM to reflect the mungbean column in the private and social commodity budgets.

A Farming Systems PAM

The two previous PAMS were created under the assumption that the opportunity cost of land could not be identified. However, mungbeans is an irrigated crop which competes for the same land as average productivity dry season rice. Examination of both the **Profit** figures for rice clearly indicate that it is a superior alternative to mungbeans. This point can be demonstrated more dramatically by creating a mungbean PAM that includes a social cost for land in the form of the "**next best alternative.**" To compute such a PAM, first copy the original mungbean PAM to its appropriate place on the diagonal.

Then:

Step 1

Insert a column in the mungbean PAM to extend the domestic resource (non-tradable) category to include land. include land in the domestic resource category. */WIC*

Step 2

Use *Windows* to note the cell address for the cost of land for mungbeans in the private budget. Insert that cell address in the private cost cell for land in the new mungbean PAM. Go to the social budget and locate the cell that represents the highest value "**Profits Excluding Land Costs**" of the crops that compete directly for agricultural resources with mungbeans. In this case, the crop is average productivity dry season paddy. Insert the paddy cell address in the social profits row of the PAM under Land. **This value represents the opportunity cost of land to mungbean growers because it describes what the returns to land would have been had the land been used in the next best alternative.**

Examine the resulting farm systems mungbean PAM. Interpret the results from the perspective of private incentives. Is it possible for farmers to grow mungbeans? Where are the incentives for mungbean production coming from?

Is mungbean production socially profitable if **within** agriculture efficiency is considered, i.e., the opportunity cost of land is included as a domestic resource cost? What inferences can be drawn about the functioning of land markets on the basis of the evidence from the PAM?

ADDING A PAM FOR MAIZE

To create a maize PAM, repeat the steps used to develop the mungbean PAM.

(1) Copy the high yielding paddy PAM to a point on the diagonal below the mungbean system PAM.

(2) Edit the column portion of cell addresses of the private and social budget tables so that they refer to the maize column.

COMPUTING SUMMARY RATIOS

To compare the profitability and efficiency of different crops, a common numeraire must be used throughout the analysis. Ratios are one convenient method of avoiding the problem of a common numeraire, particularly when the production processes and outputs are very dissimilar. Several useful ratios that provide information on private and social profitability can be derived directly from the data in the policy analysis matrix. These ratios can then be used to rank crops according to different policy objectives. [9]

In this part of the exercise, the results from the previous PAMs will be used to calculate the **nominal protection coefficient**, the **effective protection coefficient**, and the **domestic resource cost coefficient**. The ratios will be calculated in a summary table so that the results can be compared easily between crops. The summary table is also convenient for conducting sensitivity analysis on the results.

Before calculating the ratios, create a new table for the summary table on the diagonal to the right and below the last PAM table. Use the **Range Name** command to call this table **Ratio**. The table consists of four rows, one for high productivity paddy, two for mungbeans, and one for maize. Three columns are shown, one for each of the three ratios. See Figure 5.4 for a suggested format.

Nominal Protection Coefficient (NPC)

The bottom row of the PAM indicates the extent of commodity and factor market distortions in the production of each crop. Without market failures, this row measures the effects of distorting policy on inputs and outputs. The nominal protection coefficient, defined by the ratio of private commodity prices and social commodity prices, compares the impact of government policy (or of

[9] For a more detailed discussion of various summary ratios including the DRC, see pp. 25-29 in Monke and Pearson.

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Figure 5.4. Summary Ratios

Ratios of Efficiency and Protection

	Nominal Protection Coefficient		Effective Protection Coefficient	Domestic Resource Cost
	Output	Input		
High Yielding Paddy				
Mungbeans (alone)				
Mungbeans (rice as next best alternative)				

market failures that are not corrected by efficient policy) between different crops. [10]

The formula for the NPC on tradable outputs (i.e., crop output) is:

+ revenue in private prices / revenue in social prices

This ratio indicates the policy effect on the output. For example, an NPC greater than 1 shows that the market price of the output exceeds the social price. The farmer receives an output subsidy.

The formula for the NPC on tradable inputs is:

+ cost of tradable inputs in private prices / cost of tradable inputs in social prices

An NPC on tradable inputs of less than 1 indicates that market prices of inputs fall below the price that would result in the absence of policy. This ratio reveals the presence of input subsidies, taxes, trade restrictions raising or lowering prices or an inappropriate exchange rate.

Effective Protection Coefficient (EPC)

The effective protection coefficient, defined by the ratio of value added in private prices to value added in social prices, more completely measures incentives to farmers. The EPC indicates the

[10] "Efficient" policies are interventions deliberately introduced to off-set distortions caused by market failures. For a discussion of policies that promote food security in developing countries where imperfect capital and insurance markets make it difficult to obtain a desired protection against risk, see M-P, pp.53-54.

combined effects of policies in the tradable commodities markets. This is a useful measure because input and output policies, such as commodity price supports and fertilizer subsidies, often constitute part of a comprehensive policy package. For example, governments frequently reduce the price of outputs and then subsidize inputs in an effort to encourage the adoption of new technology.

The formula for the EPC is:

+ (revenue - cost of tradable inputs / (revenue - cost of tradable inputs in private prices) in social prices)

An EPC greater than 1 indicates positive incentive effects of commodity policy (a subsidy to farmers) whereas an EPC less than 1 shows negative incentive effects (a tax on farmers).

Note: Both the EPC and the NPC ignore the effects of transfers in the factor market and therefore do not reflect the full extent of incentives to farmers.

Domestic Resource Cost Coefficient (DRC)

The domestic resource cost coefficient measures the efficiency, or comparative advantage, of crop production.

If the social returns to land cannot be identified clearly because full information about alternatives is lacking, the DRC may be calculated with respect to labor and capital only. It is calculated by dividing the cost of labor and capital by value-added at social prices.

The DRC will be positive unless the social value added in crop production is negative. However, DRCs greater than one indicate that the value of domestic resources used to produce the commodity exceeds its value added at social prices. Production of the commodity, therefore, does not represent an efficient use of the country's domestic resources. DRC's less than one imply that a country has a comparative advantage in producing the commodity. Values less than 1 mean that the denominator (net revenues of tradables measured at world prices) exceeds the numerator (the cost of the domestic resources measured at their shadow prices).

Where the opportunity cost of land can be clearly identified with another alternative, the DRC is calculated by including the cost of land in the form of the next best alternative. The resulting DRC reflects the country's comparative advantage, not only with respect to capital and labor, but **within** agriculture as well.

The formula for the single commodity DRCs is:

+ (labor cost + capital) / (revenue - costs of tradable inputs)

The formula for farming system PAMs in which the cost of land can be clearly identified is:

+ (labor cost + capital + land cost) / (revenue - costs of tradable inputs)

The costs and revenue must be in **social** prices and hence the source of the cell addresses is the

social price row in the PAMs.

SENSITIVITY ANALYSIS

The stage has now been set to examine the sensitivity of the commodities for which PAM's have been computed to alternative assumptions about output, input and domestic factor prices. (Remember to create a horizontal, unsynchronized *window* to facilitate the interactive investigation of changes in the data tables.)

Examine the impact of the effects among crops if:

(a) Market fertilizer prices are raised to P5/kg

(b) The market price for mungbeans is lowered to P10/kg

(c) The market price for maize is doubled

(d) The yield for maize is doubled

(e) Social prices (reflected by changes in international markets) for paddy and mungbeans double.

Determine the "breakeven" world price that either gives or removes each crop's comparative advantage. If, by using a window, both the data table and the ratio table are in view on the screen, the breakeven price can easily be found by trial and error.

Screen 5.1: High Yielding, Wet Season Paddy PAM

Policy Analysis Matrix

High yielding, wet season paddy

	Tradables		Domestic Resources		
	Output	Inputs	Labor	Capital	Profits
Private	24,750	3,074	3,341	2,870	15,465
Social	22,000	3,281	3,341	2,670	12,508
Divergences	2,750	(207)	0	0	2,957

Screen 5.2: Irrigated Mungbean PAM

Policy Analysis Matrix

Mungbeans, irrigated

	Tradables		Domestic Resources		
	Output	Inputs	Labor	Capital	Profits
Private	10,500	862	2,346	1,886	5,407
Social	8,250	752	2,346	1,886	3,267
Divergences	2,250	110	0	0	2,140

Screen 5.3: Mungbean PAM (Including Land as a Cost)

Policy Analysis Matrix

Mungbeans, dry season paddy (farming system)

	Tradables		Domestic Resources			
	Output	Inputs	Labor	Capital	Land	Profits
Private	10,500	862	2,346	1,886	11,641	(6,234)
Social	8,250	752	2,346	1,886	9,926	(6,659)
Divergences	2,250	110	0	0	1,715	425

Screen 5.4: Summary Ratios

Ratios of Protection and Efficiency

	Nominal Protection Coefficient	Effective Protection Coefficient	Domestic Resource Cost
High Yielding Paddy	1.13	1.16	0.33
Mungbeans (alone)	1.27	1.29	0.56
Mungbeans (system)	1.27	1.29	1.89

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CHAPTER 6: ESTIMATING SOCIAL PRICES

Previous chapters provided the social prices required to implement PAM computations as part of a prepared data set. This chapter shows how to calculate the import and export parity prices that measure social prices for tradable inputs and outputs. In most cases, analysts will be required to compute these prices as part of the PAM exercise.

Social prices are calculated on the basis of the opportunity cost ("most profitable alternative") of inputs and outputs. For tradable inputs and outputs, social prices are derived from prices in international markets. Estimation of social values for nontradable goods and domestic factors is more difficult and requires detailed knowledge of individual factor markets.

This chapter gives the details of computing social prices for only two commodities, paddy and maize. The purpose of the chapter is to provide an illustration of how import and export parity (equivalent) price calculations are made and to show how the results of these calculations should be linked by cell addresses into the social prices table. Like all elaborations of the PAM model, the tables for computing export and import parity prices are located along the diagonal and given names to facilitate quick access.

Important references for the computations made in this chapter are contained in Chapter 11 of the M-P text. Pages 188-199 deal with the calculation of domestic import and export parity prices when starting with the prices in international markets. That section also contains a discussion of the implications of over- or undervalued exchange rates for establishing the prices of tradables in domestic currency. Pages 199-209 address the difficult question of how to estimate social prices of factors, i.e., of domestic resources.

SOCIAL PRICES FOR TRADABLE GOODS

The social price of a tradable output (rice) or a tradable input (fertilizer) at the farm gate equals the international or border price adjusted for domestic transportation, processing and marketing costs. The resulting farm gate prices are called *import and export parity prices* or sometimes *border price equivalents*. They are computed in the following steps:

Step 1

The first step is to find an international price for the commodity. There are several ways in which this can be done. If the data are available, the simplest and most straightforward way is to consult the country's trade statistics. For imports, the appropriate measures are the so-called c.i.f. prices.[11] They can often be obtained by dividing the value of the imported commodity by the quantity imported. For exports, the appropriate value are f.o.b. prices and they can be computed in

[11] C.i.f. prices include the *cost* of the commodity in the exporting country plus the *insurance*, and *freight* required to move it from the point of export to the harbor of the importing country. Consequently, "border" prices have traditionally meant "at the border," and do not include the handling cost required to move goods from the boat to the dock of the importing country. The latter distinction is rendered meaningless in the case of truck, rail and air transport.

the same way.[12]

Using local sources may be misleading, however, when only limited amounts have been traded or trade has taken place under special concessional circumstances. In this case, the alternative to using country data is to use quotes from a major international market in which a large volume of the good is traded, and to make an adjustment for insurance and freight. Data on insurance and freight can be obtained from shipping companies or freight forwarders.

The computation of import parity prices using international market sources begins with the f.o.b. price at the border of the reference country, usually a major exporter. Insurance and freight are added to obtain the c.i.f. price in the importing country. Export parity prices can be obtained in a similar fashion. In this case, however, the reference is the border of major importers. Insurance and freight are subtracted to arrive at f.o.b. prices at the local border.

Step 2

The second step in computing parity prices is to find an appropriate **exchange rate** at which to convert prices expressed in international currency to prices expressed in domestic currency. The official exchange rate can be used in the calculations only if it accurately reflects the true scarcity value of foreign exchange. In many developing countries, the official foreign exchange rate is overvalued and its availability is rationed through a system of exchange controls. Hence it must be adjusted to reflect the true "willingness of the economy to pay" for tradable goods and services.

When the **equilibrium foreign exchange rate (EER)**--the social price that reflects the true value of foreign exchange--differs from the official exchange rate, the difference can be expressed as a **foreign exchange premium**. For example, if the official exchange rate is overvalued by 10 percent, then the shadow exchange rate equals the official rate times (1 + .1).[13]

Once an EER is selected, international prices can be converted to local currency by multiplying the international price times the equilibrium exchange rate.

Step 3

The third step in computing the value of a commodity at the farm gate requires costing the marketing, transportation, storage and processing activities that link the border to the farm. The computation can be broken into two parts. For imports, the first part consists of *adding* the costs of activities between the border and the wholesale market where the farmer sells or purchases the commodity; imports cost more as they move from the border inland. For exports, the reverse is true. Marketing, transportation and processing costs between the wholesale market and the border

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[12] F.o.b. (free on board) prices are measured on the boat in the harbor of the exporting country.

[13] The discussion on the top of page 197 in M-P regarding the need to adjust for exchange rate overvaluation is misleading. Their suggestion that no such adjustments are required because factor markets will eventually adjust is a long run view that is inconsistent with the short and medium run analysis on which the PAM approach is based. A more complete discussion of equilibrium exchange rate computation when partial equilibrium methods are being used is contained in Isabelle Tsakok, *Agricultural Price Policy*, Cornell University Press, 1991.

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are *subtracted*; exports are worth less at the wholesale market than they are at the border.

The second part of the computation involves the link between the wholesale market and the farm gate. In the case of imports, the calculation depends upon whether the commodity is an output or an input. For outputs, the c.i.f. plus value of the commodity at the wholesale market is too high because it does not take into account the cost to the farmer of bringing his goods to market. Hence the farm to wholesale distribution costs must be subtracted. For inputs, the opposite is true. Inputs must be transported to the farm to be used and hence distribution costs must be added to the wholesale price to obtain a farm gate price.

For exports, farmers must incur the cost of taking the commodity to market thereby reducing the value of the commodity at the farm gate relative to its price in the wholesale market.

Because post-farm goods and services are non-traded, the costs of transportation, marketing and processing are locally determined. It might be assumed therefore that, except in the case of underemployed facilities, private prices and social prices were the same. However, even in the absence of direct government trade policies or market imperfections, private costs may not equal social costs. Transportation and processing facilities in particular may have a high import content in the form of equipment, fuel, parts, etc. If the country is attempting to maintain an overvalued exchange rate, these imports have cost less than they would have had an equilibrium exchange rate prevailed. Theoretically therefore, the cost of non-traded goods and services must be decomposed into their traded input and non-traded domestic factor components. Chapter 8 illustrates the decomposition computations for non-traded goods that the theory requires. However, in this chapter, it is assumed that the private costs of non-traded goods and services such as transportation and marketing provides an estimate of their social costs. The more complete calculations will subsequently be linked by cell addresses to the data initially provided without explanation.[14]

DETERMINING IMPORT PARITY PRICES

The following steps are used in the calculation of import parity prices for farm outputs:

Steps for Calculating Import Parity Prices for Farm Output

Start	f.o.b. price at point of export
Add	freight to point of import
Add	insurance

[14] In Chapter 8, "Constructing PAM's for Commodity Systems," Monke and Pearson point out that focusing the PAM analysis entirely on the farming system may be quite misleading. When assessing the competitiveness and efficiency of a commodity system, it may be equally or even more important to investigate the policy interventions and market imperfections associated with transportation, processing and marketing. If there are significant divergences between private and social profits in these elements of the commodity system, then estimates for private and social profits at the farm gate will be biased.

Equals c.i.f. at point of import

Convert world price in foreign currency to border price in domestic currency at EER

Add local transport and marketing costs to wholesale market, valued in social prices

Equals social value at wholesale market

Apply the processing conversion factor which adjusts the social value of the imported commodity for any processing it requires

Equals import parity value at regional market before processing

Deduct transport, marketing, and storage costs to farm, valued at social prices

Equals import parity value at farm gate

For a farm input, i.e., fertilizer, the costs of distribution (i.e., transport, marketing costs) from the wholesale or regional market to the farm should be added instead of subtracted from the import parity value at the wholesale or regional market, to arrive at the equivalent import parity value for the input at the farm gate level. The same commodity could be treated differently, depending upon its origin. For example, distribution costs of maize grown on the farm and sold in the wholesale market would be subtracted. However, the distribution costs between the farm gate and the wholesale market of maize purchased for livestock feed would be added to obtain its import parity price.

Calculating the Import Parity Price for Paddy in Nueva Ecija

Follow the steps shown above to calculate the import parity price (social price) of paddy at a major regional wholesale center for rice like Nueva Ecija in the Philippines. Begin by creating a new table in the existing worksheet along the diagonal called "Import". Remember to copy the existing worksheet under a new name (e.g.,"Chapt6") before adding the new tables. The new table (Import) will consist of two columns: one for the labels and one for the calculations. Expand the label column to 30 characters using the */WCS* command.

Table 6.1 shows a sample format for the table. Use the following assumptions in the computations:

(1) f.o.b. Bangkok price of rice (35% brokens) equals $260/ton

(2) insurance and freight costs from Bangkok to Manila equal $15.57/ton.

(3) official exchange rate $1 = P22

(4) foreign exchange premium = 20%

(5) conversion from tons to kg: 1000 kg = 1 ton

(6) transportation costs from port to wholesale market equal P0.50/kg

(7) marketing costs from port to wholesale market equal P0.35/kg

(8) processing conversion factor from paddy to rice: 1 kg. paddy = .64 kg. rice

(9) wholesale to farm distribution margin = P0.51/kg

Assume for the purposes of this table that there are no distortions in the transportation and marketing sectors so that private and social prices are equal.

All of the calculations involve simple arithmetic as shown in the steps above. However, pay attention to three important **conversions** required for transforming the international price ($/ton) into a comparable domestic market price (Pesos/kg).

Conversion 1: Converting international prices in $ to local currency (Pesos).

Conversion 2: Converting tons, the usual international price unit, to kilograms.

Conversion 3: Converting a finished products (e.g., rice) to its raw (paddy) equivalent

DETERMINING EXPORT PARITY PRICES

The export parity price is the border price of an exportable good adjusted for transport and marketing costs and revalued by the EER. The calculations for the export parity price resemble those for the import parity price, but generally work in the opposite direction. The following steps are used in the calculations:

Steps for Calculating Export Parity Prices

Start	c.i.f. price at point of import
Deduct	freight to point of export
Deduct	insurance
Equals	f.o.b at point of export
Convert	world price in foreign currency to border price in domestic currency at EER
Deduct	local transport and marketing costs to wholesale market, valued in social prices
Equals	social value at wholesale market
Apply	the processing conversion factor which adjusts the social value of the exported commodity for any processing

Equals export parity value at regional market

Deduct farm to wholesale distribution costs

Equals export parity value at farm gate

Calculating the Export Parity Price for Maize in Mindoro

Follow the steps above to calculate the social price of maize in Mindoro, assuming that maize is an exportable good. (Note: Philippines occasionally exports maize and at other times imports maize.) Create the table for the export parity price along the diagonal in the existing worksheet. Remember to assign a range name to the table with the **Range Name Create** command. Call the new table "Export".

As in the import parity table, the export parity table consists of a column of labels and a column of data and calculations. The labels can be copied directly from the import parity table using the **Copy** command. Use the edit command [F2] to change "add" to "deduct" in the new table. Table 6.2 illustrates the export parity calculations.

Use the following assumptions in the calculations:

(1) c.i.f. Taiwan price for no. 2 yellow maize equals $216/ton

(2) costs of insurance and freight between Taiwan and Manila equal $14.86/ton

(3) official exchange rate: $1 = P22

(4) foreign exchange premium = 20%

(5) transportation costs from port of Manila to Mindoro wholesale market equal P0.60/kg.

(6) marketing costs from port to wholesale market equal P0.25/kg.

(7) conversion of weights: 1000 kg = 1 ton

(8) farm to wholesale distribution costs: P0.42/kg

A conversion factor is not necessary for the processing of maize, a commodity sold on international markets in an unprocessed form.

LINKING TABLES IN THE WORKSHEET

Link the results of the import and export parity calculations directly into the social price table using **cell addresses**. Make a note of the cell addresses for the import parity price of rice and the export parity price of maize. Move to the social price table using the **[F5]** and **[F3]** keys and type the appropriate cell addresses into the rows for rice and maize. Remember to begin the formula with a +. For rice, type an **absolute cell address** (e.g., +$A$1) and copy the formula to the

remaining rice columns. A single address also can be used for maize grown in high productivity and rainfed areas.

The worksheet is now fully integrated so that sensitivity analysis on international prices and

Table 6.1: Import Parity Calculations

	Rice
F.O.B. Bangkok, 35% brokens ($/ton)	260
Add	
Freight and insurance ($/ton)	15.57
Equals	
C.I.F. price in the Philippines ($/ton)	275.57
Exchange rate (P/$)	22
Exchange rate premium	0.20
Equilibrium exchange rate (P/$)	26.40
C.I.F. in domestic currency (P/ton)	7275
Weight conversion (kg/ton)	1000
C.I.F. price (P/kg)	7.28
Add	
Transportation (P/kg)	0.50
Marketing (P/kg)	0.35
Equals	
Value before conversion (Rp/kg) (processing)	8.13
Processing conversion factor	0.64
Equals	
Import parity value at wholesale (P/kg)	5.20
Total distribution costs to farm (P/kg)	0.51
Equals	
Import parity value at farm gate (P/kg)	4.69

exchange rates can be reflected in the social budgets. Use the Windows command to keep the social budget in view. How does the social profitability for the paddy and maize systems change when:

(1) the exchange rate premium equals 30%

(2) the international price of rice rises to $320/ton

(3) the international price of maize falls to $150/ton

The Import and Export Parity Price Tables assume an exchange rate premium of 20 percent, which means that the exchange rate is overvalued by 20 percent. Although many developing countries experience overvalued exchange rates, it is often difficult to ascertain the exact amount of the premium. Hence it is desirable to test the results of different ERR assumptions. However, as Chapter 10 indicates, making changes in the exchange rate premium to test the influence of different assumptions regarding the equilibrium exchange rates is not the same as simulating exchange rate policy. The latter has its affect on private and not social prices.

SUMMARY

This chapter demonstrated the necessary steps for calculating the social prices of tradable commodities. Although the computations are simple and straightforward, data requirements are often formidable. For example, in identifying the f.o.b. and c.i.f. prices in international markets, it is usually difficult to ensure equivalence in specifications (e.g., quality) between the traded product the domestically available product. Even small comparability mistakes can swamp large errors in input-output coefficients.

Table 6.2: Export Parity Calculations

	Maize
C.I.F. price, Taiwan, No.2 yellow maize ($/ton)	216
Deduct	
Freight and insurance	14.86
Equals	
F.O.B. price at Philippine port ($/ton)	201.14
Exchange rate (P/$)	22
Exchange rate premium	0.20
EER	26.40
F.O.B. in domestic currency (P/ton)	5310
Weight conversion (kg/ton)	1000
F.O.B. price (P/kg)	5.31
Deduct	
Transportation (P/kg)	0.60
Marketing (P/kg)	0.25
Equals	
Value before conversion (processing) (P/kg)	4.46
Processing conversion factor	1
Equals	
Export parity value at wholesale (P/kg)	4.46
Distribution costs from farm to wholesale (P/kg)	0.42
Equals	
Export parity value at farm gate (P/kg)	4.04

CHAPTER 7: COMPUTING ADDITIONAL PARITY PRICES

Chapter 7 expands the import parity table to include mungbeans and most tradable inputs in the budget. Upon expanding the structure of the tables, parity prices for each commodity can be computed. For the most part, these import parity prices will link into the social price table using **relative cell addresses.** (The exceptions are prices that are computed in the export parity price table.)

Calculations for import and export parity prices in this chapter follow directly from the previous chapter.

IMPORT PARITY PRICES

Begin by copying the file from the previous chapter ("Chapt6") into a new file called "Chapt7." Retrieve this file onto the screen.

Move to the import parity table using the **[F5]** and **[F3]** keys. Insert 10 columns to the right of "Rice" by typing **/WIC** and highlighting the appropriate area. Import parity prices for mungbeans, urea, 0-18-0, Chemicals, seeds (for paddy, mungbean, and maize), and fuel (gasoline) will be calculated in the additional columns.[15]

Type headings for these commodities as shown in Table 7.1.

Use the assumptions shown in this table to compute import parity prices for the additional commodities.

EXPORT PARITY PRICES

Move to the export parity table and insert 2 columns to the right of "Maize" for Maizeseed and Urea. Urea is used domestically in agricultural production, but is also exported to other countries in the region. Use the same price assumptions for freight, insurance, and marketing as used for 0-18-0 in the previous section. The numbers in the transportation row are again provisional.

The C.I.F. prices in the importing countries (i.e., Philippines's export markets) for the additional commodities are:

(1)	Maizeseed:	$240/ton
(2)	Urea:	$159/ton

[15] While corn is an export commodity, corn seed is neither exported nor imported in this example. This is because its export parity price is lower than its private price while its import parity price is higher than its private price. Its import parity value and export parity value at the farm level are both calculated and shown to demonstrate this case. In such circumstances, the private price becomes equivalent to its social price.

Table 7.1: Data for Computing Import Parity at Social Prices

Import Parity Prices	Output			Inputs					
	Paddy (wet)	Paddy (dry)	Mung	0-18-0	Chemical	PaddySeed	Mungseed	Maizeseed	Fuel
F.O.B. prices ($/ton)	260	265	396	70	3750	165	440	225	182
Freight and Insurance	15.57	15.57	22.56	6.89	162.88	10.00	25.91	14.88	10.42
C.I.F. (Philippines)	275.57	300.57	418.56	76.89	3912.88	175.00	465.91	239.86	192.42
Exchange rate (P/$)	22	22	22	22	22	22	22	22	22
Exchange rate premium	.20	.20	.2	.20	.20	.20	.20	.20	.20
Equilibrium rate	26.40	26.40	26.40	26.40	26.40	26.40	26.40	26.40	26.40
C.I.F. (local currency)	7,275	7,935	11,049	2,030	103,300	4,620	12,300	6,332	5,079
Conversion (kg/t)	1000	1000	1000	1000	1000	1000	1000	1000	1000
C.I.F. price (P/kg)	7.28	7.94	11.05	2.03	103.30	4.62	12.30	6.33	5.08
Transport	.50	.50	.50	.50	.50	.50	.50	.50	.50
Marketing	.35	.35	.69	.34	.80	.38	.70	.35	.82
Processed value (P/kg)	8.13	8.79	12.24	2.87	104.80	5.50	13.50	7.16	6.40
Processing conversion	.64	.64	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Import parity (wholesale)	5.20	5.62	12.24	12.87	104.60	5.50	13.50	7.18	6.40
Distribution (farm)	.51	.51	.49	.36	.54	.50	.50	.42	.50
Import parity (farm gate)	4.69	5.11	11.75	3.23	105.14	6.00	14.00	7.60	6.90

Table 6.2: Export Parity Calculations

	Maize	MaizeSeed	Urea
C.I.F. price, Taiwan, No.2 yellow maize ($/ton)	216	240	159
Deduct			
Freight and insurance	14.86	14.86	6.89
Equals			
F.O.B. price at Philippine port ($/ton)	201.14	201.14	152.11
Exchange rate (P/$)	22	22	22
Exchange rate premium	0.20	0.20	0.20
EER	26.40	26.40	26.40
F.O.B. in domestic currency (P/ton)	5310	5944	4016
Weight conversion (kg/ton)	1000	1000	1000
F.O.B. price (P/kg)	5.94	5.31	4.02
Deduct			
Transportation (P/kg)	0.60	0.60	0.50
Marketing (P/kg)	0.25	0.25	0.34
Equals			
Value before conversion (processing) (P/kg)	4.46	5.09	3.18
Processing conversion factor	1	1	1
Equals			
Export parity value at wholesale (P/kg)	4.46	5.09	3.18
Distribution costs from farm to wholesale (P/kg)	0.42	0.42	0.36
Equals			
Export parity value at farm gate (P/kg)	4.04	4.67	2.82

Copy the formulas for the export parity calculations from the "Maize" column to the additional columns after entering the appropriate data. An illustration of the expanded export parity price table is shown in Table 7.2.

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NON-TRADED GOOD PRICES

In this exercise, the seed for maize is assumed to be non-traded, though it has international prices. The reason for this is made clear by comparing its computed import and export parity prices (Tables 7.1 and 7.2) at the farm gate level. Transport and marketing costs differentials account for the spread between the P7.60 import parity price and the P4.67 export parity price. Hence, even under a free trade policy regime, this commodity will not be traded if its domestic production cost falls in-between this price spread. For maize seed, the private price of P4.80/kg (below the import but above the export parity prices) reflects a willingness to pay and hence reflects both its private and social prices.

CHAPTER 8: ANALYSIS OF NONTRADABLE SERVICES

Previous chapters have ignored the issue of nontradable services such as machine rentals, transportation, processing, and marketing. Collecting data for these nontradable services is one of the most challenging, and often frustrating, exercises in agricultural policy analysis. Because the information is difficult to collect and, once gathered, may only have a marginal impact on the results, analysts frequently resort to broad assumptions about the data, using sensitivity analysis to verify that these assumptions would not do violence to their conclusions.

But as Monke and Pearson point out in their Chapter 10 ("Postfarm Budgets and Analysis"), market imperfections or policy divergences in nontradable goods and services should not be treated in a cavalier fashion. Chapter 8 in this manual focuses on policy divergences in the tradable component of tractor services and illustrates how these divergences affect private and social budgets. In theory, the costs of all nontradable inputs (goods and services) should be decomposed into their tradable inputs and domestic factor cost components. These costs, standardized on units such hours or measures of volume or weight, can then be substituted into the appropriate cells of the private and social prices tables.

DECOMPOSING TRACTOR COSTS

In Chapter 1, the labor associated with tractor and thresher services (i.e., tractor driver and thresher operator) were included as labor in various cultural operations and labor in threshing. The rent of capital associated with these services was included in the capital account. Rental services, however, may contain a significant tradable component in the form of machine depreciation, fuel, and grease and oil. Of course, they also include labor in the form of organization administration and capital in the form of working capital and investment costs.

This exercise decomposes tractor services and assigns tradables, labor and capital to their respective accounts in the budgets. Assume that the tradable component of the tractor service budget consists of the depreciation of the tractor itself, fuel, and grease and oil. The nontradable component consists of the use of labor for maintenance and administration of the tractor rental operations, and capital to pay for operational expenses (working capital).

Table 8.1 contains the input-output table and prices (private and social) for the tractor decomposition. The unit of standardization is the tractor service hour. Tradable prices will be multiplied times hours of tractor use given in the commodity input-output table. Adjustments will also have to be made in the labor and capital sections of the table to account for the use of domestic factors in running the tractor rental service.

Create the new table along the diagonal to the right and below the export parity price table. Assign the table a name ("Tractor") with the **Range Name** command.

The costs of tradable tractor services are constructed along the same lines as the commodity import parity prices. F.O.B. prices obtained from exporting countries are the point of departure if local estimates of the C.I.F. prices in foreign currency are unavailable. The likelihood that the latter can be found is substantially greater that would be the case for commodities since local importers will know what their landed costs are.

Table 8.1: Data for Tractor Budget

I-O	Units per tractor service hour
Tradables	
Service (hours/hr)	1
Fuel (liters/hr)	0.135
Grease and Oil (liters/hr)	0.0052
Non-Tradables	
R&M Labor (man-hr/hr)	0.015
Working capital	5.20

PRICES	Private			Social		
	Tractor	Fuel	Grease	Tractor	Fuel	Grease
F.O.B. ($/unit)	5,000.00	0.50	3.40	5,000.00	0.50	3.40
Freight and insurance	400.00	0.15	0.15	400.00	0.15	0.15
C.I.F.	5,400.00	0.65	3.55	5,400.00	0.65	3.55
Official exchange rate	22	22	22	22	22	22
Exchange rate premium	0	0	0	0	0	0
Equilibirum exchange rate	22	22	22	22	22	22
C.I.F. (Domestic)	118,800	14.30	78.10	142,560	17.16	93.72
Domestic duties (%)	0.4	0.4	0.3	0	0	0
Domestic subsidies	0.0	0.0	0.0	0	0	0
Domestic cost	166,320	20.02	101.53	142,560	17.16	93.72
Tractor life (hours)	25,000			25,000		
Cost per hour	6.65			5.70		
Transportation	.10	1.00	3.00	.10	1.0	3.00
Farm gate cost per unit	6.75	21.02	104.53	5.80	18.16	96.72

PRICE PER SERVICE HOUR	Private	Social
Tradables		
Tractor depreciation (P/hr)	6.75	5.80
Fuel (P/hr)	2.84	2.45
Grease and oil (P/hr)	0.54	0.50
Total cost per hour of tradables	10.13	8.76

The results of the calculations give total costs per hour of tractor services in private and social prices. The difference between private and social costs in tractor services originate from the same sources as the divergences in the agricultural sector. For example, in the tradable category, many governments subsidize tractor services by permitting tractor dealers to import tractors and spare parts and pay for them with hard currency obtained at an overvalued exchange rate. Gasoline and diesel fuel are also frequently subsidized. Interestingly, in the Philippines imports of machines are heavily taxed in order to encourage and protect the domestic production especially of smaller machineries like two-wheeled tractors. Imports of oil is also significantly taxed instead of

subsidized, though the degree of taxation is somewhat offset by granting foreign exchange allocations at a cost below the equilibrium exchange rate for imports of machinery and production inputs. The off-setting effects of an overvalued currency and import duties can be seen from the private and social price calculations in Table 8.1.

LINKING TABLES IN THE WORKSHEET

The most time consuming part of this exercise is linking the results back to earlier calculations. Several steps are involved.

Step 1: (Modifiying the tradables section)

(a) Add a new row in the tradables section of the (1) the I-O table, (2) the prices tables, and (3) the budget tables. (The partial I-O table shown in Screen 8.2 indicates where the entries should be inserted to insure that they will be included in the formulas used to compute the PAMs.)

(b) Copy the hours from the "Tractor services" row currently in the Capital section to the newly created tradables row in the I-O table. These coefficients describe the number of tractors hours used by each commodity. They will be multiplied times the cost per hour computed in Table 8.1 to obtained the total cost of tradable tractor services.

(c) Insert the cell address of the hourly cost of tradable tractor services computed in Table 8.1 into the first cell of the tractor services row in the Private Prices table. Make this an absolute cell address (**F4**) and copy it into all cells in the tractor services row. Do the same for the hourly social cost of tractor services.

(d) In the tradables section of the Private and Social Prices budgets, copy the formula that multiplies quantities times prices from the row above the newly inserted tractor services row. This should compute the total cost of the tradable component of tractor services for each budget.

Step 2: (Modifying the labor section)

(a) Add a new row in the labor section of the (1) the I-O table, (2) the prices tables, and (3) the budget tables. (The partial I-O table shown in Screen 8.2 indicates how the entries should be inserted to insure that they will be included in the formulas used to compute the PAMs.)

(b) To obtain the coefficients in the tractor service row of the labor section in the I-O table, multiply the hours in the "Tractor services" row currently in the tradables section by the coefficient of the Tractor Service decomposition table labeled: "R&M labor". The coefficient in the decomposition table describes the amount of repair, maintenance, and administrative labor used by the vendor to deliver one hour of tractor services. Make the decomposition table address an absolute address and copy into all columns in the tractor services row.

(c) In the Private and Social Prices tables, copy the wages from the preceding row into the newly created tractor services row.

(d) In the labor section of the Private and Social Prices budgets, copy the formula that

multiplies quantity (I-O table) times prices (Prices table) from the row above the newly inserted tractor services row. This should compute the total cost of the labor component of tractor services.

Step 3: (Modifying the capital section)

(a) Add a new row in the capital section of the (1) the I-O table, (2) the prices tables, and (3) the budget tables. (The partial I-O table shown in Screen 8.2 indicates how the entries should be inserted to insure that they will be included in the formulas used to compute the PAMs.)

(b) To obtain the coefficients in the tractor service row of the capital section in the I-O table, multiply the hours in the "Tractor services" row currently in the tradables section by the coefficient of the Tractor Service decomposition table labeled: "Working capital". The coefficient in the decomposition table describes the amount of working capital used by the vendor to deliver one hour of tractor services. Make the decomposition table address an absolute address and copy into all columns in the tractor services row.

(c) In the Private and Social Prices tables, copy the season interest rate from the preceding row into the newly created tractor services row.

(d) In the capital section of the Private and Social Prices budgets, copy the formula that multiplies quantity (I-O table) times prices (Prices table) from the row above the newly inserted tractor services row. This should compute the total cost of the capital component of tractor services.

As noted above, integrating the results of the decomposition into the existing tables is the most time consuming part of the exercise. However, such integration is highly desirable because it simplifies the sensitivity analysis of various types of policy proposals. For example, once the template has been properly implemented, it will be easy to see if significant changes in the international price of tractors has an impact on commodity PAMs.

Adjusting the PAMs

If the PAMs have been done correctly in the earlier exercises, changes in the Tractor Decomposition table should be automatically reflected in the PAMs. In order to gain a better understanding of the relative importance of nontradable service decomposition, perform the following sensitivity analysis. As usual, space is provided for comments.

1) Tractor prices increase by 100%

2) Fuel prices triple

Do the PAM results change much? What do the results of this sensitivity analysis suggest in terms of data collection priorities?

SUMMARY

This chapter has shown how to decompose nontradable services into their tradable and nontradable components. The illustration was simplified for ease of presentation, but the difficulty in computing costs of nontradable services should not be underestimated. Due to the inherent problems of estimating the social costs of services, it is often useful to assess their importance in the budget of individual commodities before embarking on a complete analysis. This can be done by computing the value of nontradable services as a share of total costs and by performing sensitivity analyses. The diamondback method makes it possible to incorporate a more comprehensive analysis at a later date if the nontradable services are thought to play an important role.

CHAPTER 9: INCLUDING CAPITAL RECOVERY COSTS

Chapter 9 includes the opportunity costs of fixed capital in the PAM analysis. Including such costs is somewhat awkward in a budgeting framework where the focus is on annual variable costs and not on fixed costs. However, over the usual lifetime of policies being analyzed, farmers make decisions about investment items whose costs are fixed annually. Failure to include annualized fixed input costs in some form would lead to distortions, not only in decisions about durable capital goods, but also the selection of crops and technologies.

As Monke and Pearson note in the text (pp. 139-141), one simplified but incomplete way to deal with the problem of finding the annual cost of a fixed input would be to divide its initial cost by the life of the input. This same method can be used to apportion the annual cost between different commodities, i.e., each crop could be debited in proportion to the time the fixed inputs were used in its cultivation. However, this approach ignores the opportunity cost of the capital tied up in the fixed input. The farmer could have put the money in the bank rather than investing it in a fixed production asset. Therefore, the fixed input charge against a particular crop should include both the appropriate portion of the total cost and the interest on the embodied capital.

ADJUSTING THE I-O TABLE

The first step in including a capital recovery cost is to account for the use of fixed inputs in the Input-Output table. This requires inserting a row for each item to be included. In the interest of simplicity, this example only accounts for capital recovery for the irrigation pump. In practice, the farmer may own other implements which may need to be fully accounted for in the budgeting process.

Go to the I-O table in a copy of the CHAPT8.wk1 spreadsheet. *Insert* a row just above the Thresher Capital row. Enter data given in Table 9.1 on the number of pump hours per hectare used by each crop.

Table 9.1: Pump Hours/Hectare

	Rice Systems					Irrigated		Rainfed
	High Productivity		Avrg Productivity		Rainfed	Mung	Maize	Maize
	Wet	Dry	Wet	Dry	Wet	Dry	Dry	Wet
Pump (hp-hr)	640	2560	960	3200		160	160	

THE CAPITAL RECOVERY COST TABLE

The second task is to develop an intermediate table for calculating the annual capital recovery cost per hour of use. The table to be entered on the diagonal in the worksheet is shown in Screen 9.1. The contents of the various cells are also given below.

Screen 9.1: Capital Recovery Cost Table

Capital Recovery Cost
(Pesos per hp-hr)

	Private Prices	Social Prices
	Water Pump	Water Pump
Initial cost (P/15 hp-unit)	15000	9000
Useful life (years)	10	10
Salvage value (P)	1500	900
Interest rate (%/year)	28%	28%
PV salvage	127.05	76.23
Net cost	14872.95	8923.77
Recovery ratio	0.31	0.31
Annual recovery	4549.[illegible]	2740.25
Total hp-hours	7200	7200
Recovery/hp-hour (P/hp-hr)	0.632	0.381

(1) The initial cost and useful life of the machine represent the two most important parameters of the capital cost recovery calculations. After its useful life has expired, the machine may still have a salvage value as scrap and a source of parts and this value should be included as part of the computation.

(2) Fill in the interest rate cell by writing a formula which references the interest rate in the first column of the Private Prices interest rate. Follow the same procedure for the Social Prices table. These steps integrate the spreadsheet so that subsequent sensitivity analysis on the interest rate will require the alteration of only one parameter, i.e., the number corresponding to the interest rate row in the first column of the relevant Prices table.

(3) The salvage value is received 10 years in the future, therefore the present value of the salvage value must be computed. The formula for calculating the value of the cell is shown below where i = the interest rate and n = the number of time periods (in this case, years of useful life).

$$\frac{SALVAGE\ VALUE}{(1+i)^n}$$

Cell address of salvage value/ (1 + cell for interest rate) ^ cell address for useful life

where ^ is the arithmetic operator for exponentiation.

(4) Net cost is initial cost minus PV of salvage.

(5) Monke and Pearson derive the formula used to compute the capital recovery cost factor on p. 140 of their text. It is defined "as the annual payment sufficient to repay the cost of the fixed input at the end of its useful life." The formula used to compute the capital recovery cost rate is:

$$\frac{(1+i)^n i}{(1+i)^n - 1}$$

The spreadsheet implementation of the formula is shown below.

*((1 + i) ^ useful life * i)/ (((1 + i)^ useful life) -1)*

(6) Annual recovery cost is the recovery factor computed in (5) times the net cost figure reported in (4).

(6) Total hours is annual machine *capacity* in hours. [16]

(7) Recovery per hour is the annual recovery costs (6) divided by total hours (7). It will be multiplied by the hours shown in the input-output table.

Screen 9.2 shows the initial private and social prices of the machine. In many developing countries manufactured equipment is often wholly or partially imported. It must then be treated like any other input. The tradable components must be valued at international prices which are in turn converted to domestic prices using the equilibrium exchange rate. The nontradable factors used in its domestic manufacture or assembly must be valued at their shadow prices using the methods described in Chapter 8.

ADJUSTING THE PRIVATE AND SOCIAL BUDGETS

Step 1:

Use **[F5]** and **[F3]** to go to the Range Names menu. Select P-Prices and go to the private prices budget table. Add a line for water pump under the capital section in the same way that it was added in the input-output table. In the first (leftmost) pump cell, enter the **absolute address** of the recovery rate per hour shown at the bottom of the pump column in Screen 9.2.

Step 2: Make the same change in the Private Budgets table, i.e., insert a row above the

[16] Using the *capacity* of the machine as the denominator seems preferable to the practice of computing percentage of use on the basis of total hours actually used. The latter depends upon the choice of a cropping pattern and thus is a function of the entire cropping system. By using capacity, the denominator becomes exogenous. The assumption that there is no surplus machine capacity in the sector also seems more consistent with the long run concerns of the PAM analysis than using total actual hours.

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thresher row. Copy the cell addresses that multiply the I-O table times the prices table from the line above. (Copying the formula into the cells of non-irrigated crops will not hurt; the result will simply be zero.)

Step 3: Repeat the procedure for the social prices table and the social prices budget. The cell address in the capital recovery table should be the social prices capital recovery factor.

ADJUSTING THE PAMS

If the preceding steps have been done correctly, the ranges in the @SUM command should have been expanded and there should be no further steps necessary for the effect of the capital recovery calculations to take effect on the PAMs.

CHAPTER 10: SENSITIVITY TO MACROECONOMIC ASSUMPTIONS

Macroeconomic disequilibria, such as overvalued exchange rates, can swamp commodity policies that attempt to provide positive incentives to production. Policy makers often want to see the results of sensitivity analysis regarding such macro variables as interest rates, exchange rates, and wage rates. This chapter explains how to construct import and export parity prices for *private prices*. integrate macroeconomic assumptions table into the spreadsheet, and evaluate the impact of overvalued exchange rates on the PAMs.

PRIVATE PRICES AND POLICY ANALYSIS

In order to simulate the impact of specific policies on private prices, it is necessary to decompose *observed* private prices into "parity prices" similar to those calculated for social prices in Chapters 6 and 7. These private "parity prices," are based on (a) international prices, (b) official exchange rates, and (c) taxes and subsidies that reflect the effects of agricultural policy. In the absence of quantity restrictions, they should approximate prices observed in the market place.

Steps:

(1) Copy the Social Import Parity Table created earlier to the next place on the diagonal and call it the Private Import Parity Prices table.

(2) Use the Range/Names/Create command to add this table to the list of named tables. Call if PIMPORT.

(3) Change the Exchange Rate Premium label to Percent Devaluation. Change the EER label to Post Devaluation Rate.

(4) Insert four lines under CIF Price (P/kg) and label them:

Percent Net Trade Tax
Percent Domestic Subsidy
Percent Domestic Tax
Domestic (P/kg)

(5) Enter exogenously the net trade, domestic subsidy and tax *rates* shown in Screen 10.1. (These numbers may subsequently be replaced with the cell addresses of foreign trade taxes, and local subsidies and taxes drawn from assumptions table if commodity policies (i.e., trade protection policy, domestic taxation policy) are to be analyzed.)

Table 10.1: Data for Computing Import Parity at Private Prices

Import Parity Prices	Outputs			Inputs					
	Paddy (wet)	Paddy (dry)	Mung	0-18-0	Chemical	PaddySeed	Mungseed	Maizeseed	Fuel
F.O.B. prices ($/ton)	260	265	396	70	3750	165	440	225	182
Freight and Insurance	15.57	15.57	22.56	6.89	162.88	10.00	25.91	14.88	10.42
C.I.F. (Philippines)	275.57	300.57	418.56	76.89	3912.88	175.00	465.91	239.86	192.42
Exchange rate (P/$)	22	22	22	22	22	22	22	22	22
Devaluation (%)	.00	.00	.00	.00	.00	.00	.00	.00	.00
Post devalutation rate	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
C.I.F. (local currency)	6,062.54	6,612.54	9,208.32	1,691.58	86,083.36	3,850.00	10,250.02	5,276.92	4,233.24
Conversion (kg/t)	1000	1000	1000	1000	1000	1000	1000	1000	1000
C.I.F. price (P/kg)	6.06	6.61	9.21	1.69	86.08	3.85	10.25	5.28	4.23
Net trade taxes (%)	.15	.15	.45		.38	.20	.60		.15
Domestic subsidies (%)	0	0	0	.35	0	0	0	.35	0
Domestic taxes (%)	0	.02	0	0	0	0	0	0	.10
Domestic price (P/kg)	6.97	7.47	13.35	1.10	118.80	4.62	16.40	3.43	5.29
Transport	.50	.50	.50	.50	.50	.50	.50	.50	.50
Marketing	.35	.35	.69	.34	.80	.38	.70	.35	.35
Processed value (P/kg)	7.82	8.32	14.54	1.94	120.10	5.50	17.25	4.28	6.14
Processing conversion	.64	.64	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Import parity (wholesale)	5.01	5.33	14.54	1.94	120.10	5.50	17.25	4.28	6.14
Distribution (farm)	.51	.51	.49	.36	.54	.51	.51	.51	.51
Import parity (farm gate)	4.50	4.82	14.05	2.30	120.64	6.01	17.76	4.79	6.65

(6) Call the fourth row Domestic Price (P/kg) and calculate by multiplying the CIF price (P/kg) by (1 + (net trade tax + local subsidy - local tax)). (Note in developing the cell formulas that net trade taxes are positive, subsidies are positive, and local taxes are negative for the case of import-competing outputs. In the case of imported inputs, the local subsidy and local tax signs are reversed. For example, local taxes must be *added* to the CIF price as they increase the price of the imported input.) In order to account for the possibility that several programs may affect the same commodity, write the formula so that the effective policy rate is the difference between the subsidy rate and the tax rate.

4 The formula for the domestic price of output is: **C.I.F. Price * (1 + (net trade tax + subsidy rate - tax rate))**. For inputs, the signs on the subsidy rate and the local tax rate are reversed.

(8) Add the transportation and marketing costs to get the Private Import Parity Price at the farm gate.

The Private Export Parity Prices table is constructed in the same way. The domestic price is calculated by adding subsidies and deducting taxes, i.e.local and foreign trade taxes, the cell formula is: **F.O.B. Price * (1 + (subsidy rate - local tax rate - net trade tax rate))**. The objective is to choose a combination of trade taxes and domestic price policies that will reproduce the private prices for export commodities such as maize, maize seed and urea. Remember, as in the case of the original social parity prices table, transportation and marketing costs are *deducted* rather than added.

LINKING TABLES IN THE WORKSHEET

Using the **/WWH** and **/WWU** commands, create a window with the Private Import Parity Prices table in one window and the original Private Prices table in the other. Begin with the inputs. In the first commodity column for 0-18-0, reference the Private Import Parity Price for 0-18-0, then press **[F4]** to make the cell address absolute. Next, copy the formula into the remaining commodity columns. Repeat this procedure for 0-18-0 and the other fertilizers and chemicals. For seeds, repeat the same steps, but be sure to copy the rice seed price formula **only** into the rice columns. In the rest of the commodity columns, reference the appropriate seed price.

For output prices, move to the last row of the Private Prices table, Output (P/kg). Reference the Private Import Parity Price for rice in the first rice column, make the formula absolute, and copy it to the remaining rice columns. Use the same procedure to reference the Private Import Parity Price of mungbeans in the Private Prices table.

Repeat the entire procedure for the Private Export Parity Price table.

CREATING AND INTEGRATING THE ASSUMPTIONS TABLE

The assumptions can be either very elaborate or very simple depending on the extent of the desired sensitivity analysis. Table 10.2 suggests only a few obvious candidates for such a table:

(1) The *nominal interest rate*. The nominal interest rate is the return to capital in private markets. Markets for capital are often highly distorted in developing countries. Sensitivity analysis of the private interest rate helps determine whether special agricultural credit programs have a significant impact on the sector's competitiveness.

(2) The *social interest rate*. The social interest rate reflects the long-run opportunity cost of capital. A very difficult indicator to measure, the World Bank and other international agencies estimate social interest rates and periodically publish their results.

(3) The *official exchange rate*. The government sets this rate and uses it for government transactions. This policy parameter enters in the translation of international output and input prices into domestic currency.

(4) The *exchange premium* measures the extent to which the official exchange rate is over or undervalued. (See Monke and Pearson, pp. 197-198, 261.)

(5) The *devaluation percent*. Changing this figure simulates a devaluation policy.

Once the measures in the macroeconomic assumptions table have been developed, they need to be linked to the private and social budgets created earlier. For example:

(1) Link the nominal interest rate to the private prices table. The link to the capital recovery table has already been made and the changes to the capital recovery factor and subsequently to the private budgets will be made automatically.

(2) Link the social return to capital to the social prices table. As in the private budget case, the link from the prices table to the capital recovery factor and to the social budget will be automatic.

(3) Link the exchange rate and the exchange rate premium to the export and import parity price calculations. **Do not** link the official exchange rate to these tables, because social prices should not move with devaluation. Sensitivity analysis can be performed on the exchange rate premium to test the responsiveness of PAMs to alternative assumptions about the equilibrium exchange rate.

(4) Link the official exchange rate and the devaluation percent to the new **private** import and export parity price tables. This connection will make it possible to simulate changes in exchange rate policy.

(5) (Optional) Create new rows in the assumptions table for taxes and subsidies on commodities and/or inputs. Link these tax and subsidy entries into the appropriate cells in the private import and export parity tables.

ASSESSING THE IMPACT OF A DEVALUATION ON MAIZE

Now that the spreadsheet is fully integrated, a number of sensitivity analyses on macroeconomic

Screen 10.2: Assumptions Table

```
    Assumptions Table
-----------------------------------
    Nominal interest rate       28%
    Social interest rate        28%
    Official exchange rate      22
    Exchange Premium            20%
    Percent Devaluation          0%
    Rice Tariff                  5%
    Mungbean Tariff             80%
    Maize Export Tax             5%
```

indicators can be performed. This section illustrates the effect of devaluation on the maize PAM.

First, create a window and put the assumptions table on one side and the maize PAM on the other. Assume the government has decided to devalue the currency by 20 percent in order to eliminate the degree of overvaluation assumed to exist. Change the official exchange rate from 22 to 26.40 in the assumptions table. Try and answer the following questions:

(1) What is the overall effect of the devaluation on the results of the PAM?

(2) Is the percentage change in the level of divergences between private and social prices exactly equal to the 20 percent devaluation? Why and why not?

(3) How can the farming system register an apparent "subsidy" overall when the output appears to remain "taxed?"

(4) Why does devaluation only affect the price of tradables and not the price of factors? Can factor prices be expected to increase with adjustment to the new devaluation?

(5) What implications for policy analysis can be drawn from the devaluation experiment?

Repeat the devaluation experiment for other commodities. Try to answer Questions 1-5 using other PAMs.

FINAL COMMENTS REGARDING THE DIAMONDBACK METHOD

At this point there are more than a dozen tables along the diagonal of the worksheet. The early tables are arranged according to a series of tasks. For example, the I-O table is first, then comes the private prices table, then comes the private budget table. The placement of subsequent table entries, however, is the result of adding complexity to the PAM analysis in the form of a more complete analysis of nontradable inputs and fixed inputs. If the /Range Name Create command has been used conscientiously to name each table, their precise location on the spreadsheet makes little difference. Use of the **[F3]** and **[F5]** keys, along with the **Windows** command, provides a means of moving about the spreadsheet quickly and efficiently.

After becoming more familiar with the PAM approach and the diamondback method, users may wish to rearrange sequence of the tables. For example, private and social prices could be entered side-by-side under different headings in the same table, thereby minimizing the need for table copying. The same might be done for private and social budgets. Indeed, experienced users may wish to complete the international price tables and the capital recovery cost table before the private and social prices tables since the former tables feed into the latter. But these are all matters of taste for the individual researcher. So long as the diamondback approach is preserved and tables are identified with Range Names, the flexibility to proceed in any order will be maintained. The spreadsheet software, using a "natural" order of recalculation, will decide which cells should be computed prior to other cells and the order in which the formulas are entered will have little discernable effect on the speed with which the final results are computed.

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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CHAPTER 1: WHOLE-FARM PAMS

The study of natural resource economics requires greater flexibility in the description of farming systems than is found in a single commodity PAM analysis. In the case of soil erosion, for example, it is often the mix of crops that is grown--with an undue emphasis on high yielding, soil depleting crops--that is a major culprit of soil degradation. Similarly, in the case of fertilizers and pesticides, it is one particular crop that produces both on- and off-farm damage to the agricultural environment. Budgets that seek to incorporate cropping pattern effects must necessarily be based on a whole-farm model.

The model that follows is, of course, still not an optimization model. However, the ability to combine crops into acceptable rotations is easily accomplished and provides a useful tool in examining a variety of farming system problems.

CREATING A WHOLE-FARM PAM

The whole-farm PAM in this chapter consists of only two crops: rainfed paddy and rainfed maize. The number of crops can easily be expanded with the usual column insertions.

The Whole-Farm Input-Output Table

The input-output table for paddy and maize is given below. Each of the technical coefficients in the table, including outputs, is linked to the cell address containing the amount of land that is to be devoted to each crop. For example, the formula for the cell C5 (urea) is 167*C24. Output is also obtained by multiplying yield times area. (If the I-O table was obtained from Chapter 4 of the original PAM manual, use the Edit key (F2) to add the cell address of the land row.) Changes in output and income from changes in the cropping pattern or farm size can now be produced by simply typing in new values for the area under a particular crop.

Total resources used are given by summing over the quantities shown in columns C and D. The size of the farm is given by the summation of the land row. In the base case for Table 1.1, the farm contains two hectares.

Private Prices and Private Budget Tables

For convenience, the private prices and private budget tables are shown below. Create the tables by copying the I-O table along the diagonal. Enter the data as shown.

Table 1.1: Input-Output Table: Whole Farm PAM

	A	B	C	D	E
1	I-O	Input-Output Table	Rainfed	Rainfed	Total
2		Quantities	Paddy	Maize	
3					
4	Tradables:	Fertilizer (kg/ha)			
5		Urea	167	85	252
6		u-18-0	20		20
7		Chemicals (kg/ha)	2	.5	2.5
8		Seed (kg/ha)	115	40	155
9		Fuel (liter/ha)	0	0	0
10					
11	Factors:	Labor (man hours/ha)			
12		Seedbed preparation	65	50	115
13		Crops care	100	100	200
14		Harvesting	200	180	380
15		Threshing	5	0	5
16		Shelling		60	60
17		Drying	60	20	80
18					
19		Capital			
20		Working capital (P/ha)	3398	1630	5028
21		Tractor services (hr/ha)	140	120	260
22		Thresher (hr/ha)	40		40
23					
24		Land (ha)	1	1	2
25					
26		Output (total kgs)	2400	1270	
27		Yields (kgs/ha)	2400	1270	
28					

Table 1.2: Private Prices for a Whole Farm PAM

	G	H	I	J
30	P-Prices	Private Prices	Rainfed	Rainfed
31			Paddy	Maize
32				
33	Tradables:	Fertilizer (P/kg)		
34		Urea	3.8	3.8
35		0-18-0	2.3	2.3
36		Chemicals (P/kg)	120	120
37		Seed (P/kg)	6.0	4.8
38		Fuel (P/liter	6.7	6.7
39				
40	Factors:	Labor (P/man-hour)		
41		Seedbed preparation	7.5	7.5
42		Crop care	6.2	6.2
43		Harvesting	6.2	6.2
44		Threshing	7.0	7.0
45		Shelling	6.2	6.2
46		Drying	6.2	6.2
47				
48		Capital		
49		Working capital (%)	.14	.14
50		Tractor services (P/hr)	6.5	6.5
51		Thresher (P/hr)	12.5	12.5
52				
53		Land (ha)	1,500	1,500
54				
55		Output (kg/ha)	4.5	4.2
56				
57				

Table 1.3: Private Prices Budget for a Whole-Farm PAM

	L	M	N	O	P
82					
83		Total Revenue	10,800	5,334	16,13[illegible]
84					
85		Total Costs (excluding Land)	6,251	4,190	10,441
86					
87		Profit (excluding land costs)	4,549	1,144	5,693
88					
89		Net Profit (including land costs)	3,049	(356)	2,693
90					

Social Prices and Social Budgets

Social prices and social budgets are identical to those created for single commodity PAMs except that they now contain an additional column that sums up the results for the entire farm. Totals shown for most items are not particularly noteworthy. However, the final results, in which the costs and expenditures for the whole farm are presented, is of concern to agricultural policy makers. It describes the overall cost and returns--and hence income--of a particular size farm.

Tables 1.4 and 1.5 show the social prices table and the portion of the social budgets table that is not a replica of the I-O table labels. As in the private budget case, the table should be created by first copying the I-O table along the diagonal. The I-O table already contains the additional "Total" column that will be needed to sum up the individual commodities into the whole-farm aggregates. The total revenue line is derived by the multiplication of the "Yield" cell in the I-O table times the output prices in the social prices table. The total cost (excluding land) row is obtained by summing over all costs except for the cost of land. Net profits (excluding land) are obtained by subtracting costs from revenues.

Computing a Whole-Farm PAM

The steps in creating a whole-farm PAM are identical to creating the PAM for a single commodity. The only difference is that the "Totals" column in the budget is used instead of the individual commodity columns.

Step 1:

Use the cell address of the total revenue row in the "Totals" column of the two budgets in order to obtain the PAM values for the cells A and E.

Table 1.4: Social Prices for a Whole Farm PAM

	R	S	T	U
92	S-Prices	Social Prices	Rainfed	Rainfed
93			Paddy	Maize
94				
95	Tradables:	Fertilizer (P/kg)		
96		Urea	4.8	4.8
97		0-18-0	3.3	3.3
98		Chemicals (P/kg)	105.0	105.0
99		Seed (P/kg)	6.0	4.8
100		Fuel (P/liter)	6.7	6.7
101				
102	Factors:	Labor (P/hr)		
103		Seedbed preparation	7.5	7.5
104		Crop care	6.2	6.2
105		Harvesting	6.2	6.2
106		Threshing	7.0	7.0
107		Shelling	6.2	6.2
108		Drying	6.2	6.2
109				
110		Capital		
111		Working capital (%)	.14	.14
112		Tractor services (P/hr)	6.5	6.5
113		Thresher (P/hr)	12.5	12.5
114				
115		Land (ha)	0.0	0.0
116				
117		Output (P/kg)	4.7	4.0
118				
119				

Step 2:

Use the @SUM function to sum over the tradable input costs in each budget to obtain the values for the PAM cells B and F. (Remember to use the Windows (unsynchronized) command to create a horizontal line on the screen so that you can see both the budgets and the PAM on the same screen.

Step 3:

Table 1.5: Social Prices Budget for a Whole-Farm PAM

	W	X	Y	Z	AA
144					
145		Total Revenue	11,280	5,080	16,360
146					
147		Total Costs (Excluding Land)	6,408	4,268	10,676
148					
149		Profit (Excluding land costs)	4,872	812	5,684
150					
151		Net Profit (Including land costs)	4,872	812	5,684
152					

Sum over the labor costs in both budgets to obtain the values for the PAM cells showing the private and social costs of labor.

Step 4:

Sum over the capital costs in both budgets to obtain the values for the PAM cells showing the private and social costs of capital.

Step 5:

Compute private and social profits by subtracting costs from revenues. Compute policy and market divergences by subtracting the bottom line of the PAM from the top line. Create a summary ratios table from the PAM results showing the NPC, EPC and DRC for the whole-farm budget.

INTERPRETING THE WHOLE-FARM PAM

The basic interpretation of the whole-farm PAM follows that of single commodity PAMs. Divergences in the output column, for example, refer to distortions created by under or over valued exchange rates and by direct taxes and subsidies. Since the social prices row has been obtained from the calculation of export or import parity prices, it is also possible that the divergences reflect the effects of nontraded goods and services such as transportation, marketing and processing. The whole-farm PAM is interesting because it provides an *aggregate* picture of the incidence of agricultural policy. Just as the effects of taxes on output may be off-set by subsidies on inputs, taxes on one crop may be off-set by subsidies in another.[1]

[1] In Egypt, for example, the government has historically taxed cotton; farmers refer to it as the "government's crop." At the same time, the government has placed import quotas on livestock products so that farmers who maintain livestock benefit from an implicit subsidy, i.e., they receive more than the world prices for their meat and milk. What the government apparently failed to appreciate was that fodder for animals competes directly with cotton for scarce

The same is true of inputs. The whole-farm PAM provides an aggregate picture of the extent to which the price of tradables used in the agricultural sector diverge from efficiency prices. It may be that some inputs are actually taxed in order to maintain inefficient domestic machinery and fertilizer industries. These taxes may be off-set by subsidies on the pesticides that farmers purchase. Cells B and F in the PAM sum up the total input divergences.

The domestic factor cost cells are now aggregates that sum across all crops. Note that only the opportunity costs of labor and capital are included. Land costs are irrelevant in the whole-farm PAM. The issue of comparative advantage *within agriculture* does not arise because the cropping pattern has been determined in the I-O table. (Analysts will surely want to consult the private and social budgets to look at relative profitability in determining the amount of land to be devoted to each crop.)

On the basis of these results, a cropping pattern can be determined that appears to yield a high return to agricultural resources. But with a whole-farm model, a variety of other determinants of the cropping pattern can also be taken into account. For example, some crops may be considerably riskier than others and hence farmers would deem it unwise to put all their eggs in one basket, even if the expected or average value of the crop is quite high. Rotational considerations reflecting a concern with sustainability can also be incorporated by choosing a crop mix that minimizes erosion or the possibility of soil borne diseases.

FarmPAM	Whole-Farm PAM				
	Outputs	Inputs	Labor	Capital	Profit
Private	16,134	2,186	5,362	2,894	5,693
Social	16,360	2,420	5,362	2,894	5,684
Divergence	(226)	(235)	0	0	9

land and water resources. The result has been a continued decline in cotton acreage over time.

CHAPTER 2: THE ECONOMICS OF SUSTAINABILITY: PRIVATE PRICES[2]

With a whole-farm model it place, it is now possible to use the results to investigate various aspects of the sustainability problem. Sustainability in this instance is defined as a continuation of present crop yields over a planning horizon of 20 years. Constant yields are shown as a horizontal line in Figure 2.1 and represents at least one definition of sustainability.

The "degradation" case is also shown. Initially, yields are assumed to decline slowly in presence of environmental degradation such as waterlogging, soil salinity, water erosion, and wind erosion. Midway in the planning horizon, a decline in productivity is assumed to occur rather rapidly followed by another distinct period in which yield declines occur gradually over time.

There is broad scientific evidence that environmental degradation in agriculture has the characteristics shown in Figure 1.1. In the case of soil erosion, for example, deep soils may go for years with substantial amounts of erosion and only modest declines in yields. In such cases, it is chiefly nutrients that are being lost and these can be replaced by applying fertilizer. Similarly, in irrigation systems, waterlogging and soil salinity may increase over decades with only a slight effect on yields. These effects an be overcome for a considerable period of time by improved water management and micro-drainage practices.

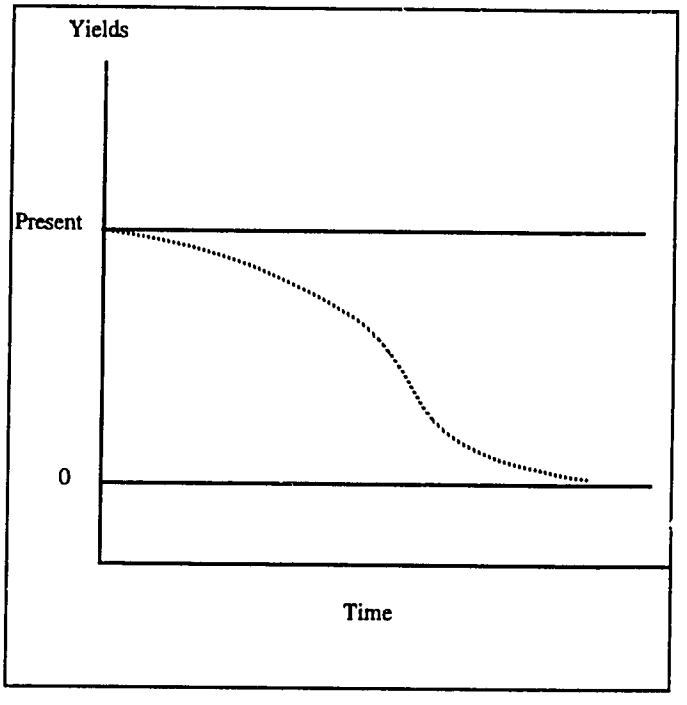

Figure 2.1: Yields Over Time

In both situations, however, at some point rapidly declining yields may set in. In the case of soils, it occurs when the favorable structure of the topsoil is replaced by underlying soil strata that have poor moisture and nutrient holding capacities. In the case of waterlogging, rapid yield declines occur once the water table reaches the root zone of plants.

The impact of different time profiles of yield degradation on returns to investment is significant. If conservation measures are implemented in the present in an effort to sustain yields at current

[2] The analysis in this and the following sections is based on several papers by Stefano Pagiola culminating in *The Cost Benefit Analysis of Soil Conservation*, Food Research Institute, August, 1991.

levels, the rewards may, for a number of years, be minimal. However, the costs are to a considerable extent incurred in the present. The combination of large costs in the early periods and significant benefits in the distant future to produce projects with very low internal rates of return on investment.

Figure 2.2 juxtaposes the yield degradation assumptions implicit in the typical "with" and "without" project appraisal with a stylized, linearly declining yield curve. In the conventional appraisal method, the decline in yields is assumed to occur immediately and uniformly throughout the project's lifetime.

It is easy to see that adjusting the without project case by the actual time stream of yield declines would yield a less favorable stream of benefits. Project returns are defined by the *difference* between the with and without cases and this difference would be less if actual yields were used in the early part of the project.

The impact of alternative assumptions about the path of environmental degradation and its implication for the economics of sustainability are the subject of calculations in the following section. The analysis in this chapter concentrates on computing a private internal rate of return for various yield paths. Chapter 3 adds computations for social rates of return and a sensitivity analysis table in which a variety of policy issues and their impact on private and social IRRs can be explored.

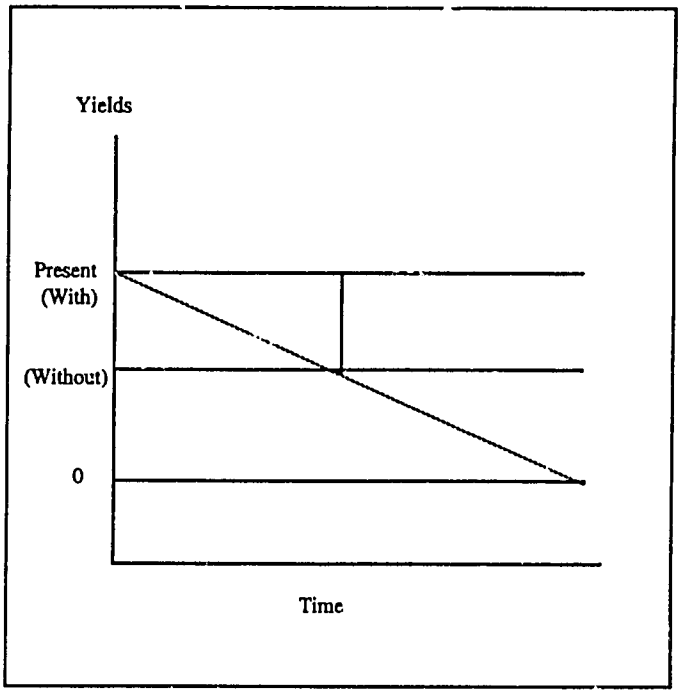

Figure 2.2: Alternative Yield Assumptions

COMPUTING A PRIVATE IRR FOR CONSERVATION MEASURES

Begin by copying the whole-farm PAM model (Chapt1.wk1) to a second file (Chapt2.wk1) that will become the base model for the private IRR calculation. The calculations involve three further tables.

Creating an "Investments" Table

Following the by now standard practice, create a table along the diamondback down and to the right of the Summary Ratios table. Although only the private values will be used in this chapter, it is efficient to create both the private and social investment components at this time. Assume, until altered by further analysis, that the numbers in the table are the same although values in the social prices table technically should be decomposed into tradables, labor, and capital, and the rules for determining the prices of each should be applied. For example, the presence of an overvalued

exchange rate in situations where machines and fuel are imported would result in a divergence between private and social investment costs.

Table 2.1 is highly simplified and can be modified later to provide more detail on costs.

Table 2.1: Conservation Investment and Maintenance Costs

	AR	AS	AT	AU
172	Invest	Investment Costs		
173			Private	Social
174		---	---	---
175		Tradable Inputs (P/ha)	500	500
176		Labor (P/ha)	2,000	2,000
177	Year	---	---	---
178	1	Total investment (P/ha)	2,500	2,500
179	2	Maintenance	100	100
180	3		100	100
181	4		100	100
182	5		100	100
183	6		100	100
184	7		100	100
185	8		100	100
186	9		100	100
187	11		100	100
188	13		100	100
189	14		100	100
190	15		100	100
191	16		100	100
192	17		100	100
193	18		100	100
194	19		100	100
195	20		100	100
196				

Creating a Yield Degradation Table

The analysis of alternative yield patterns requires the creation of a flexible table with which the impact on conservation IRRs of various yield paths can be explored. Table 2.2 provides such a tool. It assumes that the original technical coefficients in the input-output table are valid and do not change. The only effect of failing to make the necessary investment in conservation shown in Table

2.1 is for yields of paddy and maize to decline over time. (A more elaborate cost-benefit model is introduced in Chapter 4 in which both the with and without project input-output tables can be modified to take on alternative cropping patterns and technical coefficients.)

Table 2.2: Yield Degradation

	AW	AX	AY	AZ	BA	BB	BC
198	Yields	Yield Degradation					
199		% Yield Decline		Yields of System 1		Yields of System 2	
200		First year decline	2.0	(Without Investment)		(With Investment)	
201		Annual (%)	2.0	Paddy	Maize	Beans	Maize
202		Year					
203		1	2	2,352	1,245	2,400	1,270
204		2	4	2,304	1,219	2,400	1,270
205		3	6	2,256	1,194	2,400	1,270
206		4	8	2,208	1,168	2,400	1,270
207		5	10	2,160	1,143	2,400	1,270
208		6	12	2,112	1,118	2,400	1,270
209		7	14	2,064	1,092	2,400	1,270
210		8	16	2,016	1,067	2,400	1,270
211		9	18	1,968	1,041	2,400	1,270
212		10	20	1,920	1,016	2,400	1,270
213		11	22	1,872	991	2,400	1,270
214		12	24	1,824	695	2,400	1,270
215		13	26	1,776	940	2,400	1,270
216		14	28	1,728	914	2,400	1,270
217		15	30	1,680	889	2,400	1,270
218		16	32	1,632	864	2,400	1.270
219		17	34	1,584	838	2,400	1,270
220		18	36	1,536	813	2,400	1,270
221		19	38	1,488	787	2,400	1,270
222		20	40	1,440	762	2,400	1,270
223							

Flexibility is built into the table by making it possible to set both the initial percentage yield decline in the first year and the increment in each subsequent year. The percent degradation in Year 1 is therefore simply the cell address of the number associated with "First year" decline. For Year 2, the formula is the cell address of Year 1 plus the cell address of the number associated with the "Annual" label.

The formula for Year 2 is copied in all of the remaining cells of the time period, i.e., until Year 20. (Be sure to make the cell address for the "Annual" increment an *absolute* address before copying. The cell address for each succeeding year should reference the year that precedes ' something that is accomplished with a *relative* cell address. The formula for each year should reference the same "Increment" address and hence this term requires an *absolute* value.

The with project yields for each of the commodities are obtained by simply referencing the appropriate cell address in the I-O table. Remember to make this an *absolute* address before copying it to all time periods. This is because every period references the same cell in the I-O table.

The without yields are obtained by multiplying the with yields by one minus the cell address of the percent yield decline in each year. Thus, the without project yield in the first year is 98 percent of the with project yield. In the second year, the yield declines to 96 percent of the with project yield, etc. The formulas may be copied into all time periods using *relative* cell addresses. (Each cell is obtained by multiplying a term in its own row, e.g., 1 - the percentage yield decline times the with project yield in that same row.)

Table 2.2 can be used to simulate a wide variety of "degradation" scenarios. For example, the conventional with and without project approach referred to earlier is obtained by setting the initial percentage decline to the difference assumed in the cost-benefit analysis, e.g., 40 percent, and setting the increment equal to 0. The result will be that all without project yields will be reduced by 40 percent from Year 1 onward. (Verify that this is indeed the case.)

Creating the IRR Calculation Table

The IRR calculations shown in Table 2.3 are carried out using information from (a) the whole-farm budgets, (b) the conservation investment table, and (c) the yield degradation table. The computations can be organized in several steps:

Step 1:

The private investment cost column is obtained by referencing the appropriate cell address in the investment table and multiplying that times the total farm size obtained from the I-O table. Remeber to make the farm size address and absolute address. Only the first cell need be entered. The remaining cells in the column can be obtained by copying the first cell into each time period using the normal relative cell address for the investment table.

Step 2:

The without project revenues are obtained by using the without project yields in the yield degradation table. For private prices, the formula for each crop should reference the private prices table. Revenues for paddy would be:

Yield x Price x Hectares = Revenue from paddy

The same formula should be used to compute the revenues from maize. Total revenues shown in the without project case are the sum of the two. Before copying the formula into the remaining

Table 2.3: Private IRR Calculation

	BE	BF	BG	BH	BI	BJ	BK
230	IRR	IRR at Private Prices					
231		Investment		System 1	System 2		
232			(Without Investment)		(With Investment)		Net
233		Cost	Revenues	Costs	Revenues	Costs	Benefits
234	Year	----------					
235	1	5,000	15,811	13,441	16,134	13,441	-4,677
236	2	200	15,489	13,441	16,134	13,441	445
237	3	200	15,166	13,441	16,134	13,441	768
238	4	200	14,843	13,441	16,134	13,441	1,091
239	5	200	14,521	13,441	16,134	13,441	1,413
240	6	200	14,198	13,441	16,134	13,441	1,736
241	7	200	13,875	13,441	16,134	13,441	2,059
242	8	200	13,553	13,441	16,134	13,441	2,318
243	9	200	13,230	13,441	16,134	13,441	2,704
244	10	200	12,907	13,441	16,134	13,441	3,027
245	11	200	12,585	13,441	16,134	13,441	3,349
246	12	200	12,262	13,441	16,134	13,441	3,672
247	13	200	11,939	13,441	16,134	13,441	3,995
248	14	200	11,616	13,441	16,134	13,441	4,318
249	15	200	11,294	13,441	16,134	13,441	4,640
250	16	200	10,971	13,441	16,134	13,441	4,963
251	17	200	10,648	13,441	16,134	13,441	5,286
252	18	200	10,326	13,441	16,134	13,441	5,608
253	19	200	10,003	13,441	16,134	13,441	5,931
254	20	200	9,680	13,441	16,134	13,441	6,254
255						Guess	.4
256						IRR	0.31
257							

time periods, be sure to make the price and hectare addresses into *absolute* cell addresses. By fixing the row and column identification, the same address in the private prices table and the I-O table will be used in computing revenues. Only the address of the yield table will change when the formula is copied.

Step 3:

The with project revenues are computed with the same formula as the with project revenues. The only difference is that instead of referencing the without project yields in the yield degradation table, the with project revenues reference the cell address containing the with project yields.

Step 4:

The with and without cost columns are obtained from the total cost (excluding land) entry for the farming system.

Step 5:

Incremental net benefits in the final column are computed in one step with a formula that:

(a) computes net benefits in the with project case by subtracting costs from revenues,

(b) computes net benefits in the without project case by subtracting costs from revenues,

(c) subtracts without project net benefits from with project net benefits, and

(c) subtracts investment costs from with project net benefits.

The formula for the first cell can be copied into the remaining time periods using relative cell addresses because all of the entries in the formula occur on the same row. The result is a time stream of incremental net benefits.

Step 6:

The internal rate of return function in Lotus 1-2-3 is:

@IRR(interest rate, range of incremental net benefit stream)

The interest rate should be entered into a cell and its cell address entered as the first argument in the function. This is the cell address to the right of "GUESS" at the bottom of the IRR spreadsheet. The cell address in the formula is followed by a comma, after which the cell addresses of the range in the incremental net benefits column is entered. The range is set in the same way that the @SUM( ) function range is set. It can be done by moving the cursor to the first cell of the range, "anchoring" it, and then highlighting the entire column to be included in the range. Alternatively, the cell addresses can be typed in directly.

SENSITIVITY ANALYSIS

The effect of adding a time dimension to the calculation of conservation IRR's can be seen by comparing the declining yield scenario with the with and without project methodology. Under the assumption that yields decline to 60 percent of the present level, i.e., decline by 40 percent over a 20 year period, conservation expenditures shown in the investment table (Table 2.1) yield a 50

percent IRR. This is compared to a 200 percent rate of return to conservation expenditures when only a flat 10 percent level of degradation is assumed. The former is obtained in the yield degradation table by setting the starting or initial value equal to 10 percent and setting the incremental value equal to 0. (Remember to use the Windows Unsynchronized command in order to see the yield degradation table and the IRR calculation simultaneously.) The effects of different rates of decline can be obtained by varying the incremental value.

Also of interest is the impact of alternative cropping patterns on the returns to conservation. Rice is clearly the more profitably crop and hence assuming a greater area under rice increases the IRR of conservation.

CHAPTER 3: THE ECONOMICS OF SUSTAINABILITY: SOCIAL PRICES

The computations needed to find the IRR at social prices are straightforward. The following steps are involved in creating such a table and an accompanying "analysis" table:

Step 1:

Copy the IRR table along the diagonal down and to the right of the private prices table.

Step 2:

Edit the cell addresses of the investment costs so that they reference the social investment costs in the investment table. Edit the addresses of the revenue columns so that they reference the social prices table. (Note that if *absolute* cell addresses have been used for area in the private IRR table, these same addresses will appear in the copied table. These are correct and should not be changed. The only changes that are required are the cell addresses of yields and prices. The former are taken from the Yield Degradation table. They should not be absolute addresses because they must be copied into each time period. The cell addresses for private prices need to be changed to the appropriate values in the social prices table. The cell addresses in the incremental net benefit column should not require adjustment as they refer to rows in the newly created table.

Step 3:

Table 3.1 shows a suggested analysis table that can be used to explore alternative assumptions about the effect of yields, the rate of degradation, prices, and cropping patterns on private and social IRR's. Cell addresses from the sensitivity analysis table should be inserted at the appropriate points in the spreadsheet. For example, the cell addresses for the area under paddy and maize should be inserted in cells C33 and D33 of the I-O table.

Many of the results of varying the parameters of the model will be obvious. Nevertheless, it is useful to trace through the logic of the effects. For example, tilting the cropping pattern away from the high value crop clearly decreases the benefits of conservation. This points to the fact that any long term sustainability effort that involves moving to crops that are less demanding of the environment at the expense of net revenue will have little private support.

Increasing farm size has the predictable effect in increasing the returns to conservation because of the way in which investment costs have been entered into the model. Currently, the investment cost table is fixed to the farming system and is not given on a per hectare basis. Consequently, increasing farm size has the effect of decreasing the cost per acre of conservation and reclamation measures.

From a policy point of view, taxes on outputs clearly have the effect of decreasing the private IRR relative to the social IRR. This means that where agriculture continues to be taxed by overvalued exchange rates and the sale of concessionally purchased commodities from abroad, the incentive to invest in activities that sustain agriculture yields is diminished.

Table 3.1: Sensitivity Analysis

Analysis	Sensitivity Analysis Table			
		First year	Annual	
	Degradation rate	.02	.02	
		Paddy	Maize	Size
	Area	1	1	2
	Yields	2400	1270	
		Prices		
	Private	4.5	4.2	
	Social	4.7	4	
		IRR	Guess	
	Private	30.9%	0.4	
	Social	31.2%	0.4	

Undertaking conservation activities when there is a divergence between private and social IRR's e.g., private IRR's are lower than social IRR's, would require that the opportunity cost of capital with which the IRR is compared should also differ. If the social opportunity cost of capital was below the private rate, for example, it would be correct to undertake conservation measures in cases where the social IRR was below the private IRR. However, to the extent that private individuals are expected to implement these methods, a mechanism must be found to deliver to incentive in the form of a subsidy to the private sector. In the accompanying PAM, this would show up as a subsidy on capital.

CHAPTER 4: SUSTAINABILITY AND ALTERNATIVE FARMING SYSTEMS

The previous exercises in the economics of conservation focused on a farming system in which the commodities grown did not change and only the yields responded to conservation investments. The result showed that a variety of policy issues--along with assumptions about the path of yield degradation--had a significant effect on the economics of conservation investments.

True "sustainability," however, often requires more than erosion control or drainage measures. With the additional constraint of sustainability, optimal cropping patterns are affected and new crop new combinations of crops are likely to emerge in response to changes in private incentives. The following exercise simulates the use of a second farming system in the sustainability analysis. In it beans replace paddy. The new beans-maize system is designated as the with project case.

ADDING A SECOND FARMING SYSTEM

There are a variety of ways in which a second farming system might be added including creating a new I-O table and the associated private and social budgets along the diagonal. However, there are substantial efficiencies to be gained if the second farming system is incorporated in the existing tables by *inserting* additional columns. Many of the formulas can then simply be copied from the existing columns to new columns that have been relabeled to indicate that they belong to a second farming system.

Creating the I-O Table

Table 4.1 shows how the I-O table would look after a second farming system has been added. To create the table, move the cursor into the column to the right of the last column in the original table. *Insert* three columns. Copy the three existing columns into the space created by the blank columns just inserted. Relabel the "paddy" column and call it "beans." (Note: Data in the area column copies over as a zero. Insert 1's in the cell addresses for land and the columns will compute their correct values. Also, type in yields from the previous columns in order to obtain values for commodity output. For starters, keep the data in the paddy column intact. This will make it possible to check the accuracy of the entire spreadsheet before turning to the question of how the new farming system differs from the old.

Creating the Private and Social Prices Tables

Create the new private and social prices tables with a similar procedure. Move the cursor to the column to the right of the last column in the table. *Insert* two additional columns in each table and copy the existing columns into the newly created columns.

Creating Private and Social Budgets

Creating the budget tables also follows the procedure outlined above. Move the cursor to the right of the last column of the table and *insert* three columns. Copy the existing columns into the newly created columns.

Table 4.1: Input-Output Table: Whole Farm PAM

	A	B	C	D	E	F	G	H
1	I-O	Input-Output Table	W/O Investment		Farming	With Investment		Farming
2			Paddy	Maize	System1	Beans	Maize	System2
3								
4	Tradables:	Fertilizer (kg/ha)						
5		Urea	167	85	252	167	85	252
6		0-18-0	20		20	20		20
7		Chemicals (kg/ha)	2	.5	2.5	2	.5	2.5
8		Seed (kg/ha)	115	40	155	115	40	155
9		Fuel (liter/ha)						
10								
11	Factors:	Labor (P/man-hr)						
12		Seedbed preparation	65	50	115	65	50	115
13		Crop care	100	100	200	100	100	200
14		Harvesting	200	180	380	200	180	380
15		Threshing	5	0	5	5	0	5
16		Shelling	0	60	60	0	60	60
17		Drying	60	20	80	60	20	80
18								
19		Capital						
20		Working capital	3398	1630	5028	3398	1630	5028
21		Tractor services	140	120	260	140	120	260
22		Thresher (P/hr)	40	0	40	40	0	40
23								
24		Land (ha)	1	1	2	1	1	2
25								
26		Yields (kg/ha)	2405	1270		2405	1	
27		Output (total kgs)	2405	1270		2405	1270	
28								
29								

Recall that values in the cells of the budget tables are obtained by multiplying prices times the quantities in the prices tables. Because of the intervening "Totals" column in the I-O table, the cell addresses in the newly created section of the budget tables must be edited. Specifically, the column addresses shown in the newly created columns need to be advanced by one letter. If the column address in the total revenues cell of beans, for example, reads E, it should be advanced to F. The adjacent maize budget column should be edited to reflect the maize output column, G.

The total commodity cost calculations should be computed properly without adjustment. They refer to the rows in the column of the calculations and the normal relative cell address adjustments should have been made. The total farm revenues and costs also require some editing.

Revising the Yield Degradation Table

Adding the new farming system to the yield degradation table is straightforward. Two new columns are required to hold the with and without data on bean yields. The old cell addresses for the without case can be retained; they refer to Farming System 1 which is the without project case.

Since there is no paddy in the new with project case, paddy yields should be set to 0. Similarly, because beans do not appear in the without project case, their yields should be set to 0. The with project bean yields should reference the yields in the I-O table. (Setting these yields to 0 is not significant since these cell addresses do not appear in the IRR table. However, when set to 0, they serve as a reminder that the two farming systems do not contain the same crops.)

The with project maize yields should be adjusted to reflect maize yields in Farming System 2; in the without case, the reference continues to be Farming System 1 and need not be adjusted.

Revising the IRR Tables

The revisions in the IRR table are two-fold. First, the cell addresses that describe the with project case need to be changed so that the area, yields and prices of the with project case reflect bean yields instead of paddy yields. Second, the cost figures for beans need to be substituted in place of the cost figures for paddy in the with project case. The without project revenues do not require adjustment.

Step 1:

In the with project case, substitute the area, yield and price of beans. Also, change the cell address of area and yield in the maize revenue calculation to reflect maize in Farming System 2.

Step 2:

Adjust the with project cost cells to reflect the area under beans and maize in Farming System 2 and the costs of beans and maize in the Farming System 2 section of the private and social budgets.

Edit the with project cell address for revenues so that the elements refer to the area, yield and price of beans instead of paddy. (The maize cell addresses should also be changed to reflect maize grown in Farming System 2 rather than maize in Farming System 1.

Expanding the Analysis Table

The final step in creating a more flexible "sustainability" template is to include the second farming system in the analysis table. Table 4.3 shows the revised table. The new cell addresses for beans and maize under Farming System 2 should be added at the appropriate places in the I-O table

Table 4.2: Yield Degradation

Yields	% Yield Degredation		Yields of System 1 (Without Investment)		Yields of System 2 (With Investment)	
	First year (%)	2.0				
	Annual (%)	2.0	Paddy	Maize	Beans	Maize
	Year					
	1	2	2,352	1,245	2,400	1,270
	2	4	2,304	1,219	2,400	1,270
	3	6	2,256	1.194	2,400	1,270
	4	8	2,208	1,168	2,400	1,270
	5	10	2,160	1,143	2,400	1,270
	6	12	2,112	1,118	2,400	1,270
	7	14	2,064	1,092	2,400	1,270
	8	16	2,016	1,067	2,400	1,270
	9	18	1,969	1,041	2,400	1,270
	10	20	1,920	1,016	2,400	1,270
	11	22	1,872	991	2,400	1,270
	12	24	1,824	965	2,400	1,270
	13	26	1,776	940	2,400	1,270
	14	28	1,728	914	2,400	1,270
	15	30	1,680	889	2,400	1,270
	16	32	1,632	864	2,400	1,270
	17	34	1,584	838	2,400	1,270
	18	36	1,536	813	2,400	1,270
	19	38	1,488	787	2,400	1,270
	20	40	1,440	762	2,400	1,270

Table 4.3: Sensitivity Analysis of Conservation Returns

Analysis	Sensitivity Analysis Table				
		First year	Annual		
	Degradation rate	.02	.02		
		Farming System 1		Farming System 2	
		Paddy	Maize	Beans	Maize
	Area	1	1	1	1
	Yields	2400	1270	2400	1270
		Prices			
	Private	4.5	4.2	4.5	4.2
	Social	4.7	4	4.7	4
		IRR	Guess		
	Private	31.9%	.4		
	Social	31.2%	.4		

and the calculated IRRs should be inserted in the analysis table so that the effects of changing data in the upper part of the table on the IRR's can be seen immediately.

ANALYZING SUSTAINABILITY SCENARIOS

When beans are given the same input-output values and prices as paddy, the new template reproduces the results of the template developed in the previous chapter. Using the same values provides a useful check on the accuracy of the template's construction. However, adding an additional farming system has, as it purpose, the investigation of more complex issues of sustainability than could be done with the template developed in Chapter 3. Examples include the following:

(1) Separating the with and without project farming systems makes it possible to examine the economics of radical changes in the way in which commodities are produced. Crops grown under the new regimes may have a distinction different set of I-O coefficients. Minimum tillage practices, for example, often generally result in somewhat lower yields, but costs are also reduced significantly leading to an overall increase in net revenues.

(2) With a second farming system table, it is also possible to capture the effects of yield enhancing investments. Terracing, for example, is often a poor investment if the objective is simply to maintain existing yields. However, if terracing can open the way toward a better utilization of water and even the use of chemical fertilizers, the result may be an IRR that would be of interest to private entrepreneurs.

CHAPTER 5: COMBINING DEVELOPMENT AND SUSTAINABILITY

In the previous appraisal, the economics of maintaining productivity were explored. Benefits from the project or policy were due to the difference between the continuation of current yields and the decline in yields that would have occurred had the project or policy not been implemented. While some of the conclusions drawn from these calculations are rather pessimistic in the sense that use of more realistic time-related deterioration of the resource base reduces the returns to conservation, there is also a potential benefit from incorporating sustainability considerations in all project appraisal efforts.

Figure 5.1 suggests a situation in which the benefits from the project flow, not only from arresting resource degradation, but from enhancing productivity as well. One could imagine a number of projects that fit this type of model. Terracing, for example, may be important in arresting water erosion. However, as noted in Chapter 4, it also makes possible greater control over moisture and hence the use of purchased inputs that would otherwise be very risky. Use of vertical drainage is another example. In this type of project, tubewells are put down to pump groundwater for use in irrigation, a practice that lowers the water table at the same time that it provides additional water for irrigation.

INCORPORATING YIELD ENHANCEMENT

The possiblities for yield enhancement can be incorporated in the same way that yield degradation was incorporated (Table 5.1) The only difference is a change in sign. In the enhancement mechanism, the with project yields are measured by one plus the enhancement percentage rather than one minus the enhancement rate.

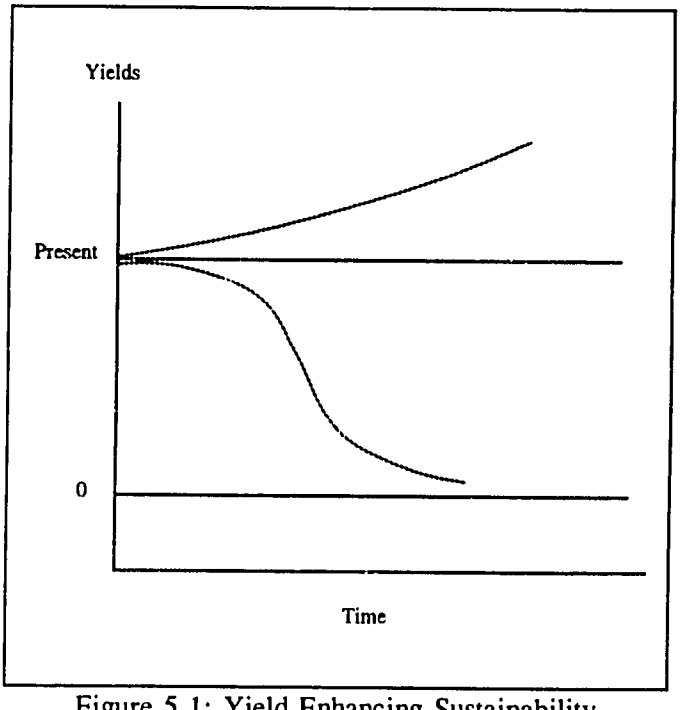

Figure 5.1: Yield Enhancing Sustainability

The enhancement rate is also incorporated in the analysis table. It is always important to remember that, from a benefit-cost point of view, the project IRR is determined by the difference between the with and without cases. It matters not whether the increment is secured by an increase of one percent per annum in yields in the with case or by a one percent decrease in yields in the without case. The all important number is the difference between the two. Hence, any project that simultaneously increases output while minimizing the deterioration of the resource base need not be delayed until severe degradation sets in to be economically viable. In the long run, the effort to create a sustainable agriculture will benefit from the search for projects and policies that have the characteristics shown in Figure 5.1

Table 5.1: Yield Degradation

Yields	Degredation	Enhancement	Yields of System 1 (Without Investment)		Yields of System 2 (With Investment)	
First year change (%)	2.0	0				
Increments (%)	2.0	0	Paddy	Maize	Beans	Maize
Year						
1	2	0	2,352	1,245	2,400	1,270
2	4	0	2,304	1,219	2,400	1,270
3	6	0	2,256	1,194	2,400	1,270
4	8	0	2,208	1,168	2,400	1,270
5	10	0	2,160	1,143	2,400	1,270
6	12	0	2,112	1,118	2,400	1,270
7	14	0	2,064	1,092	2,400	1,270
8	16	0	2,016	1,067	2,400	1,270
9	18	0	1,969	1,041	2,400	1,270
10	20	0	1,920	1,016	2,400	1,270
11	22	0	1,872	991	2,400	1,270
12	24	0	1,824	965	2,400	1,270
13	26	0	1,776	940	2,400	1,270
14	28	0	1,728	914	2,400	1,270
15	30	0	1,680	889	2,400	1,270
16	32	0	1,632	864	2,400	1,270
17	34	0	1,584	838	2,400	1,270
18	36	0	1,536	813	2,400	1,270
19	38	0	1,488	787	2,400	1,270
20	40	0	1,440	762	2,400	1,270

Table 5.2: Sensitivity Analysis of Conservation Returns

	Sensitivity Analysis Table				
	Investment (P/ha)	Initial	Maintenance		
	Private prices	100%	100%		
	Social prices	100%	100%		
		First year	Annual		
	Degredation rate	.02	.02		
	Enhancement rate	.00	.00		
		Farming System 1 (without)		Farming System 2(with)	
		Paddy	Maize	Beans	Maize
	Area	1	1	1	1
	Yields	2400	1270	2400	1270
		Prices			
	Private	4.5	4.2	4.5	4.2
	Social	4.7	4	4.7	4
		IRR	Guess		
	Private	30.9%	.4		
	Social	31.2%	.4		

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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AGRICULTURAL AND NATURAL
RESOURCE POLICY ANALYSIS
COURSE

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Using Market Level Models

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PREFACE

The simpliest approach to agricultural policy analysis for individual commodities relies on farm level budgets. This technique is particularly helpful in examining the effects of interventions in markets for outputs and inputs that are traded in international markets. It also leads to the identification of imperfections in factor markets where these imperfections can be detected by divergences between the market price of domestic resources and their opportunity cost.

Budgeting methods focus on the supply side of policy interventions and prices are taken to be exogeneous. In the initial exercises in this volume, the focus is also on situations in which prices are determined exogenously, either by government policy or by international markets. However, the market level analysis takes the policy discussion further in at least two ways: (1) the demand side is taken into account, and (2) adjustments to price changes are permitted on the supply side. This is accomplished, in the first instance, using the traditional supply and demand curves of neo-classical analysis in a single commodity world. Subsequently, price exogeneous methods are extended to more than one market under the assumption that significant cross-price effects exist. In the final chapters, the assumption that prices are exogeneous is relaxed to include markets in which the prices of non-traded commodities are determined by the interaction of domestic supply and demand.

Chapter 1 reviews the theoretical background of the neo-classical market model giving particular attention to the concepts of elasticities and producer/consumer surplus. As in the case of single commodity budgeting models, much that is of importance in understanding the impact and incidence of agricultural policy becomes apparent using some very simple tools. In Chapter 2, Philippine rice policy serves as a vehicle for doing spreadsheet calculations that move policy analysis from the theoretical to the practical.

Chapter 3 extends the single commodity analysis and examines agricultural policy in a multi-market framework. Initially, the focus remains on exogenous policy or trade determined prices. However, the multi-market framework makes it possible to develop a more complete picture of the indirect effects of policy reform.

Models in which prices are exogenous give way in Chapter 4 to a simple model containing a nontradable commodity whose price is determined entirely in domestic markets. This requires more advanced computational methods and matrix inversion techniques are used to find the values of the simultaneous equations that are generated by the problem. A final chapter extends the multi-market analysis further by incorporating additional commodities, differential taxes and subsidies, and by showing how multi-market models can examine regional comparative advantage.

The limitations of these types of models are well known. Although the data requirements are relatively modest, finding estimates of supply and demand elasticities can be particularly difficult. This is especially true of the cross-elasticities that are the basis of the interactions between commodities in a multi-commodity, i.e., multi-market framework. Moreover, the models depend upon point elasticities and hence are technically valid only in the immediate vicinity of the estimate. Policy reforms often involve drastic changes, however, and hence any set of elasticities needs to be treated with caution. Fortunately, the ease with which sensitivity analysis can be carried out permits

the effects of alternative elasticity estimates to be explored in detail.

Numerous individuals have served as "beta testers" for these exercises; their efforts to reduce the number of "bugs" have been much appreciated. Particular thanks are due to Timothy Josling, not only for his role as a tester, but for his willingness to share his enormous experience in implementing multi-market models on spreadsheets

Thanks are also due to the Agricultural Policy Analysis Project (APAP), funded by the U.S. Agency for International Development, for providing the resources to prepare this manual. Futher information about this project, its newsletter and its published material in the agricultural policy field, can be obtained from Abt Associates, Inc., Hamden Square, 4800 Montgomery Lane, Suite 600, Bethesda, MD 20814.

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CHAPTER 1: THEORETICAL BACKGROUND OF MARKET ANALYSES

Chapter 1 reviews the most important concepts employed in the traditional supply-demand market equilibrium model. Limited space and the many available textbook treatments of the topic dictate that the exposition be brief. However, the chapter provides a refresher for participants who have had previous training in economics and is a a ready reference for the spreadsheet exercises that follow.

The chapter is divided into four sections. The first reviews the derivation of the supply curve from the marginal cost curves of the firms in an industry. Because the concept of the price elasticity of supply figures so prominently in the market level analysis, it is also reviewed in some detail. Lastly, the notes on supply response discuss the derivation and significance of producer surplus for policy analysis.

The second section treats the demand curve in an analogous manner. First, the neo-classical derivation of the demand curve from an aggregation of consumer preferences is discussed. Then the concept of demand elasticities is reviewed. The last part of the section deals with the notion of the consumer surplus and its implications for policy analysis.

The third section brings together the supply and demand curves for an illustration of market level policy analysis. Some discussion is devoted to the difference between the modeling of tradable and nontradable commodities. In the former case, prices are assumed to be exogenous to the determination of a market equilibrium when the country's share of the world market is small. Adjustments to price changes result in changes in the net import variable. Subsequently, nontradables whose prices are domestically determined, are introduced into the discussion. [1]

The final section in Chapter 1 relates the market level analysis to the concepts of the policy analysis matrix presented (PAM) in Volume II and provides a brief comparison between the two approaches.

THE COMMODITY SUPPLY CURVE

The Firm's Supply Curve

In Figure 1.1, the SMC_1 curve represents the individual firm's short-run marginal cost curve. Underlying the shape and position of the curve are considerations such as the state of technical knowledge, the prices of commodities closely related to commodity X in production, and the supply curves of the factors of production employed in producing commodity X. Given the prices of the factors, there will be some optimum combination of factors for producing any given output, and some minimum marginal cost of producing that output. If, for any given output, that marginal cost

[1] The analysis of the large country case whose tradable commodity prices are also endogenous is not treated in this volume.

is less than the output price but greater than the average cost of producing that output, the firm has an incentive to expand. Accordingly, the portion of the marginal cost curve above the minimum point on the firm's average total cost curve, ATC_1, for a given set of factor prices, will be the firm's short-run supply curve for X. The portion of the marginal cost curve below the minimum point of the firm's ATC_1 curve does not establish supply points, because the firm's profit will be negative for any price less than minimum average costs.

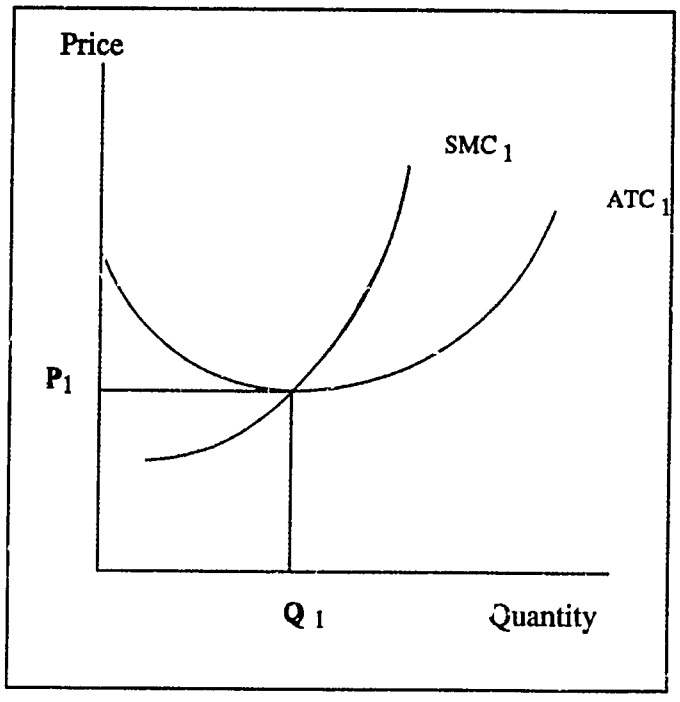

Figure 1.1: The Firm's Short Run Supply Curve

The Industry's Supply Curve

It has been shown that the firm's short-run supply curve is the portion of its short-run marginal cost curve above its minimum ATC curve. The industry short-run supply curve might be thought of as the horizontal sum of such firm supply curves, S, shown in Fig. 1.2. However, in a competitive industry, in response to a price increase to P_2, all firms will try to expand along their SMC_1 curves. The combined expansion of all firms may increase the prices of the variable factors of production. If so, each firm's average and marginal cost curves will shift upward to SMC_2 and ATC_2, and each firm will expand output to Q_2, less than the amount Q_3 suggested by the original marginal cost curve.

These smaller increases in each firm's output sum to a smaller amount of output at the industry level. Thus the actual supply curve of the industry, S^*, is the horizontal summation of firms' SMC curves corrected for factor price changes as industry output expands or contracts. Factor price effects normally operate to reduce the magnitude of the supply response to changes in output prices, that is, they steepen the industry supply curve.

The Elasticity of Supply

Attention has already been directed to the role of factor markets in determining the position and shape of the commodity supply curve. These relationships are made explicit in farm and sector level optimization models where the decision about modeling factor markets such as land and labor is an important determinant of the model's response to prices. Market equilibrium methods, however, while acknowledging the underlying determinants of supply response, use an empirically derived estimate that implicitly incorporates these influences. In this type of analysis, the value that

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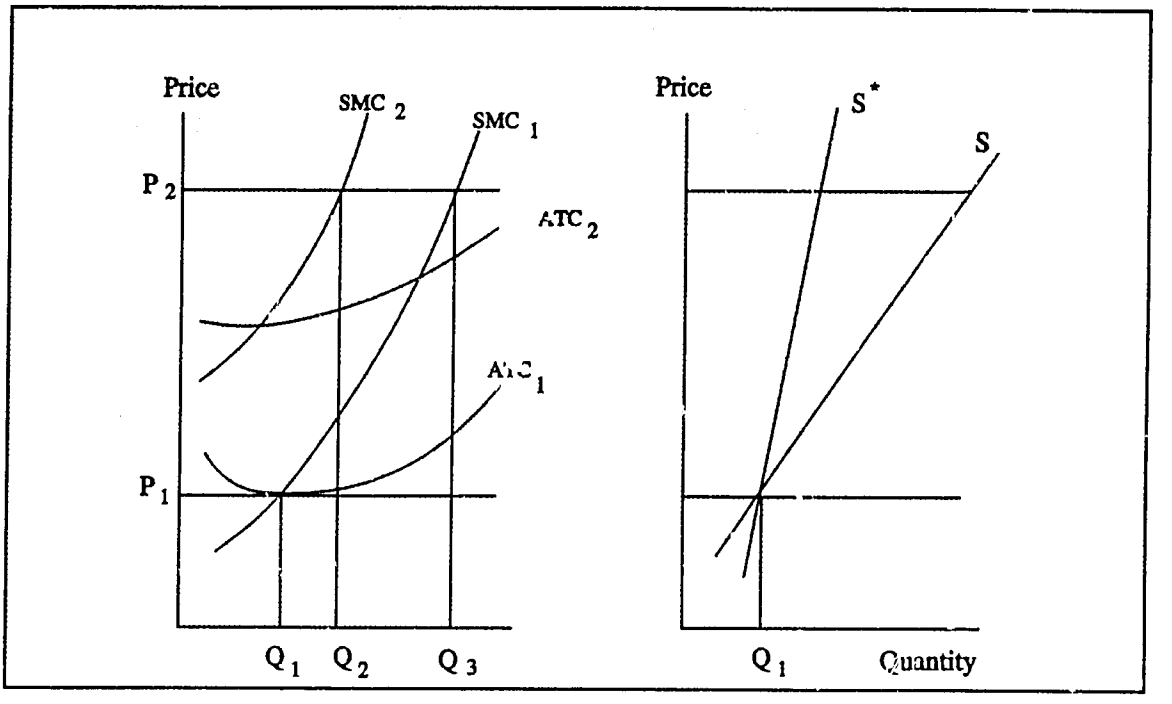

Figure 1.2: The Short Run Industry Supply Curve

captures the *total* change in supply in response to a change in the output price is known as the *total price elasticity of supply*.

The total price elasticity of supply, denoted by the upper case Greek letter *epsilon*, is defined as:

$$E_s = \frac{\textit{corresponding relative change in quantity supplied}}{\textit{relative change in output price}} \tag{1.1}$$

where all factor and other relevant commodity prices are allowed to adjust to the output price change. In symbols,

$$E_S = \frac{(\Delta S/S)}{(\Delta P/P)} = \frac{\Delta S}{\Delta P} \cdot \frac{P}{S} = \frac{\%\Delta S}{\%\Delta P} \tag{1.2}$$

where S = supply, ΔS = change in supply, P = price, and ΔP = change in price.

Price elasticities of supply are statistically estimated parameters which relate a proportional change in price to a proportional change in quantity. For example, suppose the elasticity of supply for rice in Indonesia is 0.2. This elasticity indicates than for every 10% change in the price of rice,

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the quantity produced will change by 2%. The changes in quantity and price are normally defined as infinitesimal changes although in practice they may be substantial. P and S are the price and quantity at the point at which the elasticity is measured. In calculations, these are often referred to as *initial* or *base year* P's and S's. (It is important to keep in mind that the definition refers to percentage changes in prices and quantities. By making the changes percentage changes, i.e., by introducing the initial or base year P and S into the definition, elasticities are independent of the units in which quantities and prices are quoted.)

A virtual industry has grown up around the estimation of supply response elasticities. The results of several decades of work in developing countries on supply response in agriculture is summarized in Askari and Cummings (1976).[2] The results have been further summarized in Timmer, Falcon and Pearson (1983) and Isabelle Tsakok (1990).[3]

The definition of the elasticity given above applies to a point on the supply curve. A similar expression can be derived that makes it possible to compute an elasticity in the absence of continuous curves and statistically estimated mathematical functions. This is done by defining an *arc elasticity* as being the elasticity mid-way between two sets of price-quantity observations, P_0, S_0 and P_1 and S_1. In the absence of sufficient data for econometric estimation--such rough and ready methods may be required.

$$E_S = \frac{(S_0 - S_1)/(S_0 + S_1)}{(P_0 - P_1)/(P_0 + P_1)} = \frac{S_0 - S_1}{S_0 + S_1} \cdot \frac{P_0 + P_1}{P_0 - P_1} \tag{1.3}$$

Producer Surplus

The notion of producer surplus follows from the analysis of supply presented earlier. Figure 1.1 showed how each point on the supply curve represents the marginal cost of producing that unit of output. Summing firm specific curves (Figure 1.2) gives the industry supply curve or the industry marginal cost curve. Under the assumption that the area under the curve is made up entirely of variable costs, this amount represents a payment to factors purchased in the market. Since all producers receive the same price in the market, firms other than the marginal firm (one whose revenue is exactly equal to its costs), will be receiving a rent over and above the returns needed to cover the payments to variable factors. The sum of the rent received by all inframarginal firms is called the *producer surplus* shown by the shaded area A in Figure 1.3. In other words, the

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[2] Hossein Askari and John T. Cummings, *Agricultural Supply Response: A Survey of Econometric Evidence*, New York, Praeger, 1976.

[3] For a survey of the results by commodity, see p. 108 of Timmer, Falcon and Pearson, *Food Policy Analysis*, Johns Hopkins University Press, Baltimore, MD, 1983. (The entire chapter on "Understanding Farming Systems" is highly recommended.) An even more comprehensive review of empirical estimates can be found in Isabelle Tsakok, *Agricultural Price Policy: A Guide to Partial Equilibrium Analysis*, Cornell University Press, 1990.

producer surplus is the return to fixed factors such as land and/or management. If the price rises to P_2, production will increase from Q_1 to Q_2 and the rent earned by the inframarginal firms will increase by the striped area B in Fig 1.3. Because the supply curve is based on payments to factors, producer surplus is a net concept that takes the additional costs of responding to the increase in the commodity price into account.

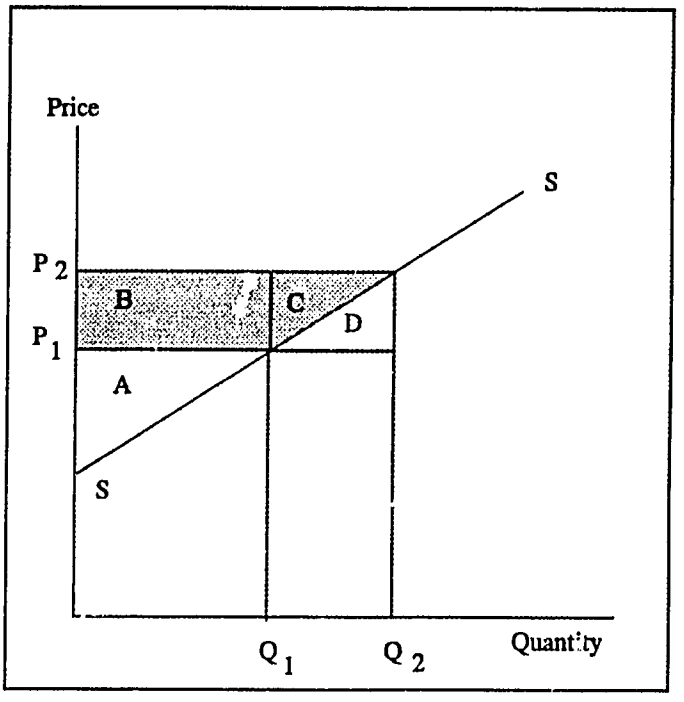

Figure 1.3: Producer Surplus

The concept of producer surplus is only one component of measuring the welfare implications of policy changes. Although producers benefit from the increase in the price of commodity X, consumers of the commodity suffer. Their consumer surplus declines. In general, policies that claim to improve overall welfare must benefit one group more than they hurt another.

Surplus concepts measure the change in welfare in moving from one allocation of resources to another. As explained above, the concept of producer surplus indicates the change in income (profits) accruing to owners of factors of production resulting from changes in policy or market conditions. As will be seen, the concept of consumer surplus indicates the changes in *real* income accruing to consumers also resulting from changes in policy or market conditions.

THE COMMODITY DEMAND CURVE

A demand curve for a particular commodity can be defined as a locus of points, each of which shows the maximum quantity of the commodity that will be purchased at a particular price. It is often useful to conceive of a demand curve as a boundary line separating two spaces, the space to the left of the demand curve representing the points that are attainable under the given conditions of demand, in the sense that the consumers would be willing to buy the indicated quantity at the indicated price, and the space to the right of the demand curve consists of points that are unattainable, i.e., consumers would not be willing to buy the indicated quantity at the indicated price.

Consumer Optimization

The derivation of an individual's demand curve begins with the set of indifference curves that describe the consumer's utility for two commodities. Figure 1.4 displays such an indifference

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map in which the curves I_1 through I_3 describe the points at which a consumer is indifferent between the quantities of X and Y at different levels of income. Figure 1.4 also indicates the line describing the consumer's budget constraint that limits the consumer's ability to purchase commodities, line BB. In a simple two-good world, these limitations on purchasing power may be expressed in the form of a budget constraint equation:

$$XP_x + YP_y = R = Income$$

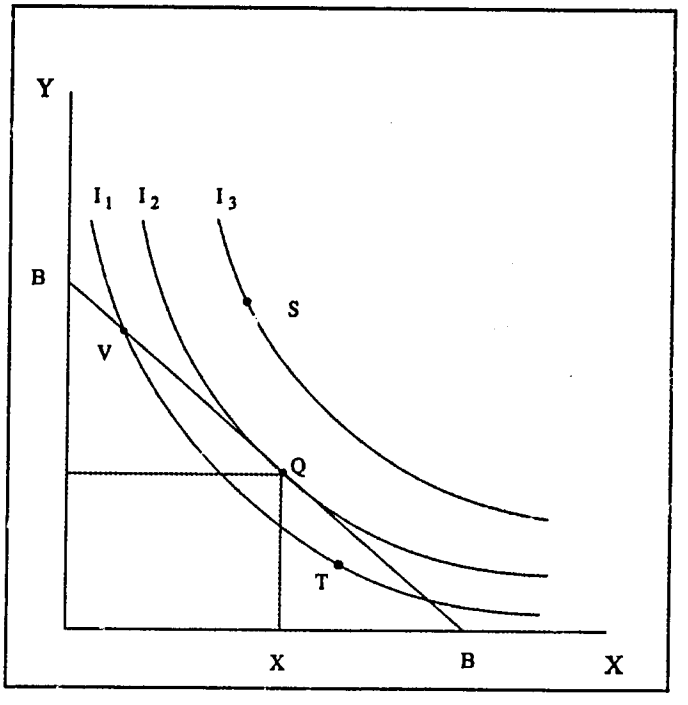

Figure 1.4: Consumer Indifference Map

When the consumer purchases all Y and no X, the maximum number of units of Y obtainable is R/Py. This is the vertical intercept in Figure 1.4. Similarly, if the consumer purchases all X and no Y, R/Px represents the maximum units of X obtainable, which is the intercept of the horizontal axis of BB in Figure 1.4. A consumer ordinarily will choose to buy some combination of goods rather than only one good; the alternative combinations available to the consumer may be visualized by connecting the two intercepts with a straight line, the slope of which is -Px/Py.

At point Q in Figure 1.4, the budget constraint is tangent to the indifference curve I_2. Choosing the combination of X and Y described by the commodity bundle Q yields the highest utility the consumer can attain, given income and prices. Notice that the consumer is also able to purchase commodity bundles V and T, but these bundles represent lower levels of utility. Commodity bundle S is not available since it costs more than the available income.

The slopes of the indifference curves are defined as the marginal rate of substitution of Y for X. It is the rate at which consumers are willing to trade Y and X at a constant level of income. Maximum utility is reached at the point where the budget line is tangent to the highest possible indifference curve. At this point, the price line and the indifference curve have the same slope, so the condition of maximum utility can be written as follows:

$$MRS_{xy} = \frac{P_x}{P_y}$$

The economic interpretation of this condition is that maximum utility is attained when the rate at

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which the consumer is just willing to trade Y in order to obtain a unit of X (MRS_{xy}) is equal to the rate at which the consumer is able to trade Y for X (the price ratio).

Derivation of Consumer Demand

With a statement of the equilibrium conditions of consumer choice in hand, it is now possible to derive a consumer's reactions to changes in prices. This analysis leads, in turn, to the derivation of a consumer demand curve.

Figure 1.5a shows the impact of changes in the price of the commodity on consumer demand. Let the price of commodity X be the price that is changing. The budget line can then be written:

$$Y = \frac{R}{P_y} - X\frac{P_x}{P_y}$$

As P_x rises, the slope of the price line ($-P_x/P_y$) becomes a larger negative number--the price line becomes steeper. An array of price lines are drawn in Figure 1.5a. Again, the tangencies with indifference curves can be read off, and are connected by a curve called the price-consumption curve (PCC) or offer curve. The PCC curve records the different combinations of X and Y that the consumer will buy at different prices of X, holding income and the price of Y constant. The PCC curve has a negative slope indicating that the quantity of X purchased declines as its price rises (the basic "law of demand").

Using the above analysis, the demand curve, which records the maximum quantity of X that consumers will buy at different prices of X, holding the price of Y and income constant, can now be derived. When the price of X is equal to 2, point A′ is the consumer optimum and the consumer will purchase X_3 units of X. This point is plotted in Figure 1.5b. When the price of X is equal to 3, point B′ is the consumer optimum and the consumer will purchase X_2 units of X. Thus points A′ B′ C′, and all others not shown are quantities of X demanded at different prices, where all other significant impacts on demand, such as income, the price of Y, and consumer preferences, are held constant. The collection of such points forms the *income compensated* demand curve, labeled D in Figure 1.5b.

Unfortunately, the demand curve just derived is not the one obtained by recording a consumer's *observed* purchases of a commodity as prices change. The problem is that while *nominal* income R can be held constant when the price of a commodity declines, the amount of income available for purchasing all commodities increases as a direct consequence of the price change. In other words, any relative price decrease causes a consumer's purchasing power or *real* income to increase. The demand curve derived in Figure 1.5b has ignored this last effect since the income effect of a price change cannot be easily separated from the price change that brought it about. The *ordinary* demand curve used in empirical analysis therefore includes both the relative price effects and the real income effects. However, unless the expenditures on the good, and the price variations in question are large relative to the consumer's income, the error in using a directly observed ordinary demand curve in empirical analysis will be small. For this reason, in policy analysis and in applied welfare analysis, the use of ordinary rather than income compensated demand curves is widely accepted.

The Market Demand Curve

The slope and position of the industry demand curve, can, like the industry supply curve, be derived from an aggregation of individual consumer choices. Once the individual demand curves are derived from the indifference maps of each consumer, the market demand curve is obtained by horizontally summing over the individual demand curves.

In Figure 1.6 the demand curves d_1 and d_2 represent demand for the only two households in a particular market. Each point on the market demand curve D is the result of a horizontal sum of individual quantities demanded at a given price. Thus, added horizontally, $A = a_1 + a_2$ at price P_1 and $B = b_1 + b_2$ at price P_2. Plotting all points such as A and B defined the market demand curve, labeled $D = \Sigma_h d$.

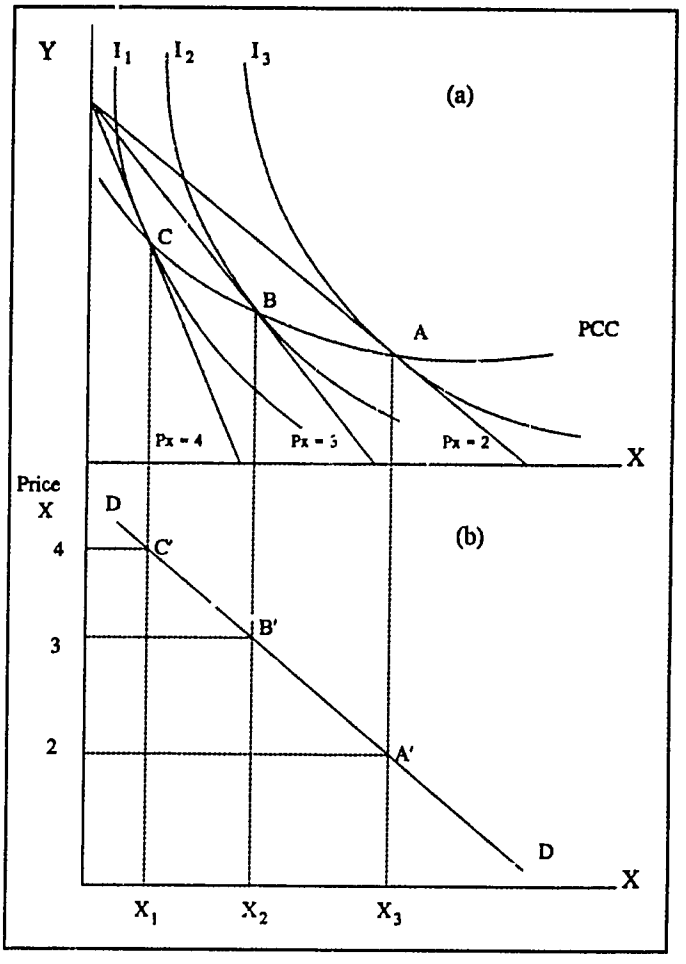

Figure 1.5: Derivation of Individual Demand Curves

Demand Elasticities

Demand elasticities are similar to the supply elasticities discussed earlier in that they are a ratio of relative changes in price to the corresponding ratio of relative changes in quantity consumed. The price elasticity of demand depends primarily on consumption substitutes. Consequently, the more narrowly the commodity in question is defined, the more substitutes will be available and the greater will be the price elasticity of demand for the commodity. It is usually assumed that, in the course of changing a policy, the quantity of resources owned by different individuals is fixed and so a particular set of factor prices is taken as determining the income and wealth of the individual consumers. Similarly, tastes and preferences are regarded as fixed. Thus, formulas for computing the elasticity of demand are the same as those shown in the previous section on supply elasticities. However, it must be remembered that there is a difference in the sign of the coefficient. When price increases, quantity decreases. The price elasticity of demand is therefore negative. If the elasticity is -1, it is called a *unitary* elasticity. (Such a curve--a rectangular hyperbola--will produce a 10 percent decline in quantity for a 10 percent increase in price.) If the elasticity is numerically greater than a -1, for instance, -2, the demand is called *elastic*. This means that for a 10 percent change in price, there will be a greater than 10 percent change in quantity. If the elasticity is numerically less than -

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1, for instance, -0.5, the demand is *inelastic* and a 10 percent change in price will bring about a smaller percentage change in quantity.

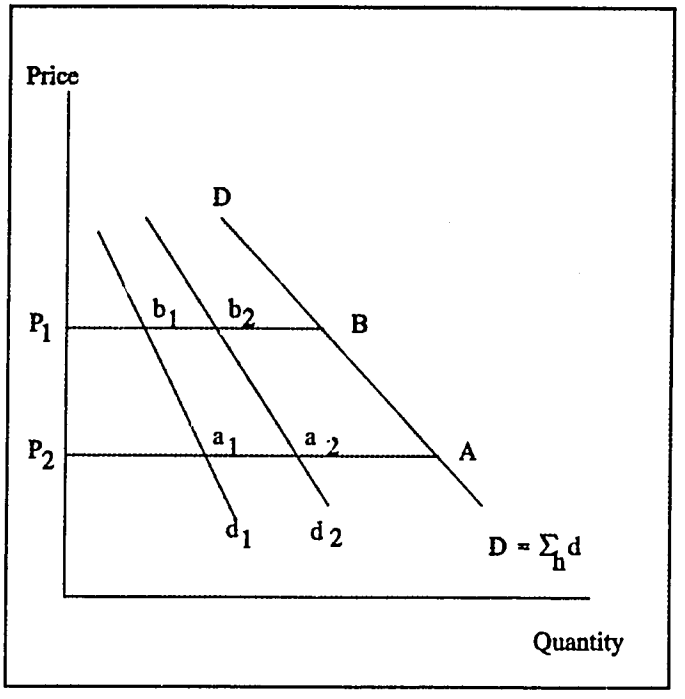

Figure 1.6: The Market Demand Curve

Consumer Surplus

The notion of consumer surplus is straight forward. The demand function shown in Figure 1.7 represents the various quantities that consumers are willing to buy at different prices. A perfectly discriminating monopolist, by definition, would extract as revenue the whole area under the demand curve by selling to individual customers at sequentially lower prices. But in a competitive market producers must sell all units of the commodity at the same price. Therefore, the area under the demand curve and above the price line is "surplus" (unspent income) of consumers; consumers are able to obtain a unit of the commodity at a price which is less than their marginal willingness to pay for it. In Figure 1.7, at price P_2, consumer surplus is the shaded area A. If the price falls to P_1 and consumption increases from Q_2 to Q_1, consumers gain an additional surplus equal to area B + C. Consumers, therefore, gain from a price fall provided that the demand function slopes downward.

LIMITATIONS OF SURPLUS MEASURES

While the use of surplus measures in policy analysis is quite common, their use requires acceptance of several restrictive assumptions. For example, imlicit in all surplus measures is the assumption that a person's money or real income is a reasonable index of individual well-being. Surplus measures cannot account for the fact that an individual may derive satisfaction from such things as leisure as an alternative to maximizing income. Surplus measures should therefore be thought of as only approximate indices of a individual's well-being.

A more serious limitation of surplus measures is that they are technically only suitable in a perfectly functioning environment, i.e. one in which there are no further distortions in the economy preventing individuals from exploiting all opportunities for mutual gain. If this assumption does not hold, analyses of *n*th best worlds in which numerous distortions exist have shown that no unequivocal welfare conclusions can be drawn.

A final important limitation of surplus measures is that while economic theory demonstrates that

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the maximization of producer and consumer surplus will lead to the most efficient outcome in a perfectly competitive environment, such an outcome *may not* be the most equitable one in a normative sense.[4] The problem is that the outcome actually achieved depends upon the initial pattern of ownership of society's primary factors of production among the households of the economy. If these factors of production are initially distributed unequally, the efficient outcome may be even more inequitable. If income distribution is a policy goal, the analyst may want to disaggregate the gains and losses due to a policy change by income group. There are potentially a large number of efficient allocations of resources in the economy, each associated with different patterns of factor ownership and different levels of well-being in the economy's various households. Maximizing surplus measures only finds the efficient outcome for a given pattern of ownership of factors of production. It does not indicate how society's resources should be allocated among households initially.[5]

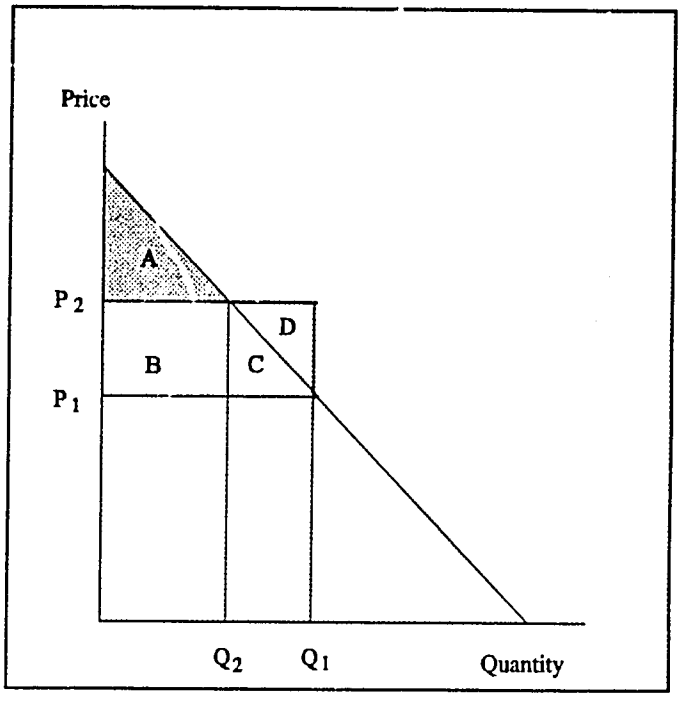

Figure 1.7: Consumer Surplus

Despite these limitations, surplus measures are widely used in policy analysis because they are relatively easy to calculate and easy to interpret. Most importantly, they do provide a broad indication of which groups benefit and which groups are made worse off as a result of changes in world market conditions or changes in government policy.

ANALYZING MARKET INTERVENTIONS

The definition of supply and demand curves for a commodity opens the way for a discussion of market equilibrium. The graph in Figure 1.8 shows the traditional intersection of supply and demand curves for a commodity in which the equilibrium price is determined in a market *without*

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[4] This statement assumes that the feasibility of costless lump-sum payments to make the efficient outcome also more equitable, is limited.

[5] For a thorough treatment of the theory and assumptions underlying applied welfare economics see, Robin W. Boadway and Neil Bruce, *Welfare Economics*, Basil Blackwell Publisher Limited, Oxford, England, 1984. See also Isabelle Tsakok, *op. cit.* pp. 137-138.

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reference to trade.

Suppose the supply and demand model is given by the following three equations:

$S = D$ *Market clearing*
$S = a + bP$ *Supply equation*
$D = c - dP$ *Demand equation*

Finding the point of intersection between these two lines can be done in several ways. In the single commodity model, simple graphing techniques can be used. For example, by using a spreadsheet or a calculator, values for S and D can be computed for a range of prices, and the equilibrium price that equates the marginal utility of consumers with the marginal costs of producers can be read from the graph. The solution can also be found algebraically by simple substitution or, as Chapter 4 demonstrates, a spreadsheet's matrix inversion capabilities can be used in the multi-market case.

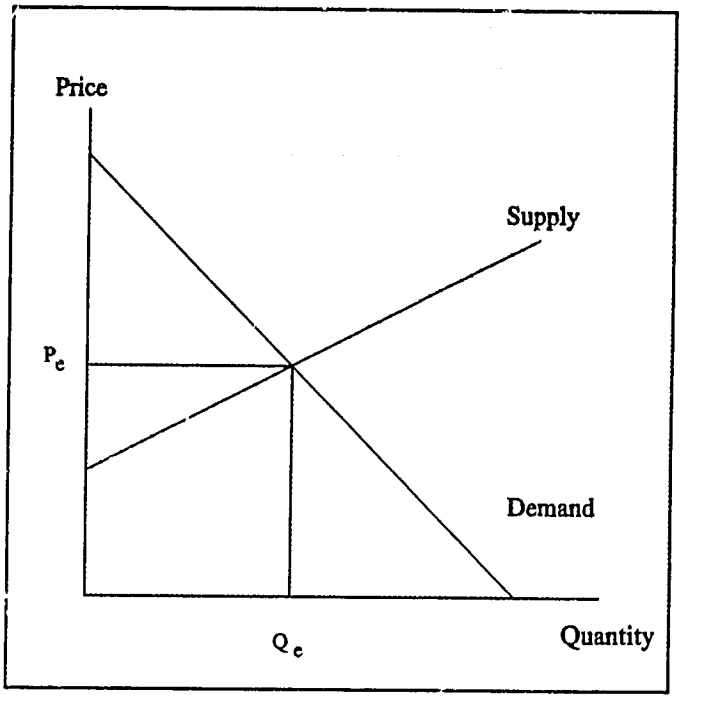

Figure 1.8: Supply-Demand Equilibrium

Although endogenously determined agricultural commodity prices can be found in most economies, commodities whose prices are determined exogenously by government policy or by trade on international markets are likely to be even more important. Price exogeneity actually stimulates rather than dampens the need for multi-market analysis because it means that, in the presence of significant cross price elasticities, the impact of trade or policy related price changes in one market must be absorbed to a greater extent by quantity adjustments in that market. Such a result will be demonstrated in Chapter 3.

The initial exercises in Chapters 2-3 illustrate the welfare implications of price policy interventions when the adjusting variables are the quantities produced, consumed, and traded. An example of this type of approach is presented in Timmer, Falcon and Pearson (p.191-193) in which the authors analyze the impact of a subsidy on Indonesian rice.

Figure 1.9 illustrates the effect of a consumer subsidy (cum producer tax) on rice from the perspective of the government. In the example, the government is setting the domestic price of rice to both producers and consumers below the border price, causing domestic rice consumption to increase, and domestic production to decline. The deficit (Q_4 - Q_2) must be purchased by the government at world prices and then resold to consumers at the lower domestic price. In order to

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do so, it incurs a budgetary cost shown by the shaded area in the diagram. The area is equal to the subsidy on each unit (P_w - P_d) times the number of units imported (Q_4 - Q_2).

Figure 1.10 examines the policy from the producers' point of view. Obviously, due to the lower price received by producers, producer surplus has been reduced. Without the tax, producers would be earning total rents (profits) equal to the area ACJ. At the lower domestic price, however, producers only earn rents equal to the area FGJ. The difference - the shaded area ACGF - represents the loss in producer surplus due to the tax. From the economy's point of view, the reduction in production from Q_1 to Q_2 is inefficient. In the absence of the tax, producers could produce the (Q_1-Q_2) amount of rice at a cost equal to the area Q_1Q_2GC; yet with the policy the government is having to import this amount of rice at the world price at a total cost equal to Q_1Q_2BC. The difference, the triangular area BCG, is the additional cost to the economy of importing rice at a higher opportunity cost than domestic production. This triangle is commonly labeled the "production efficiency loss" of the rice subsidy.

Figure 1.11 shows the effects of a consumer subsidy on rice. Consumers are clearly better off; consumer surplus has increased by the area under the demand curve between P_w and P_d, i.e., the striped area ADHF. However, to generate this increase, the government was required to expend an amount equal to the area DEQ_3Q_4--the cost of importing this rice at world prices. This amount is larger than the consumers marginal willingness to pay

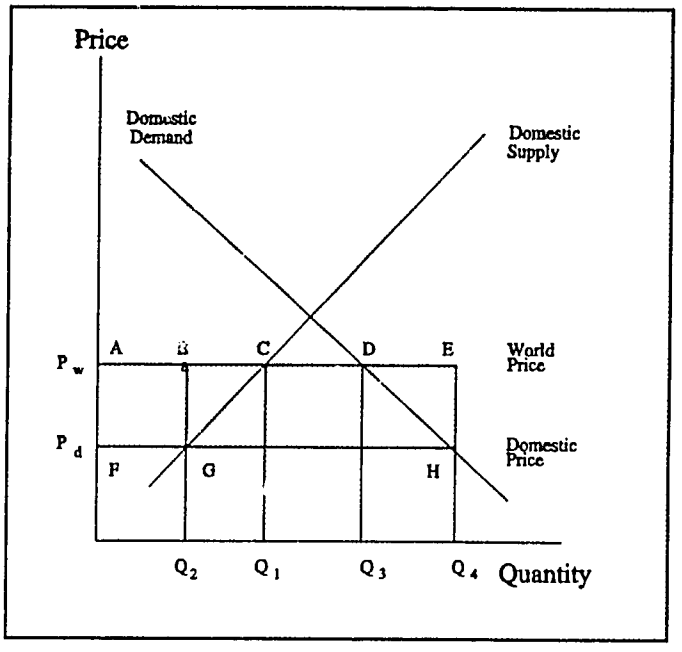

Figure 1.9: Government's Perspective

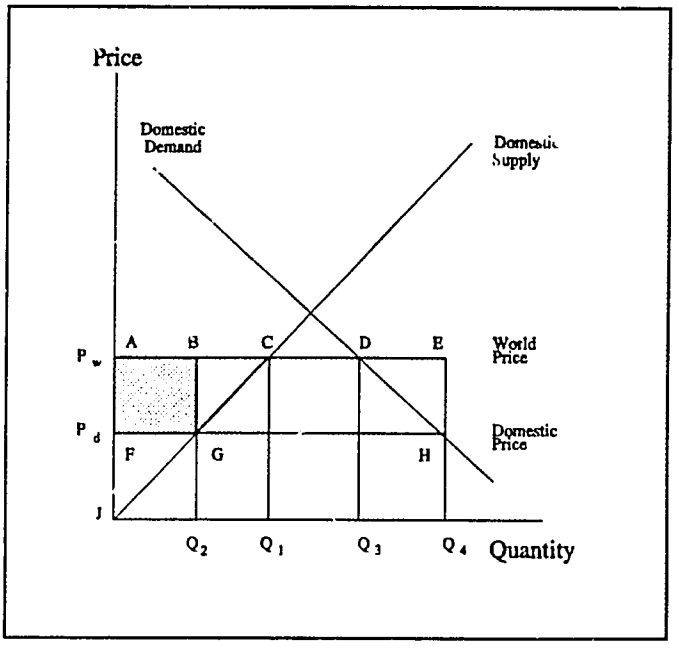

Figure 1.10: Producer's Perspective

for the additional consumption equal to area Q_4Q_3DH. The difference--the triangle DEH--illustrates the excess the economy had to pay for the extra consumption over and above what consumers were willing to pay. This triangle is often labeled the "consumption efficiency loss" of the rice subsidy.

Figure 1.11 also makes it clear that only a portion of the subsidy to imported rice is coming from the government. The remainder, i.e., the area ACGF, is a transfer from producers to consumers. This aspect of maintaining low food prices, often supported by concessional sales from developed countries in their foreign aid programs, has had profound negative effects on agricultural output in many developing countries.

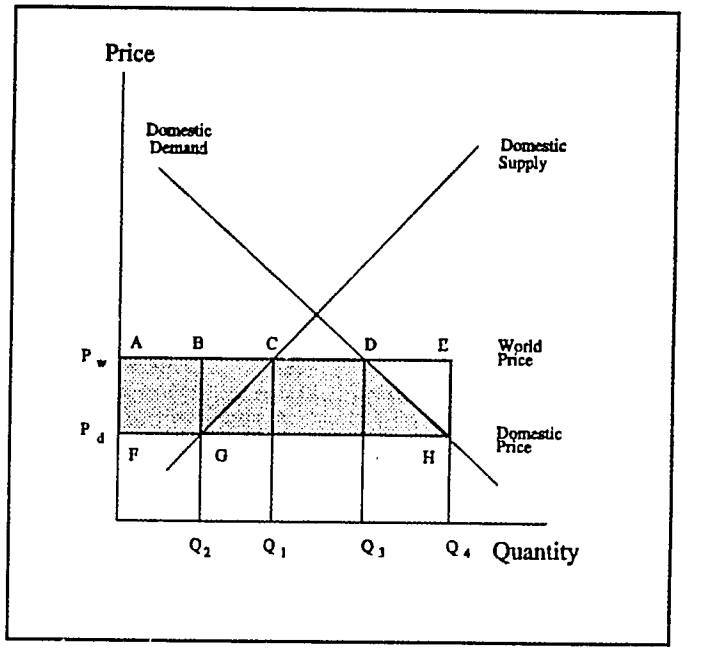

Figure 1.11: Consumer's Perspective

The above example illustrates the power of simple market level models in which, because prices are exogenous, adjustments to policy take place entirely through adjustments in commodity trade.

PAMS vs. MARKET LEVEL ANALYSIS

Another volume in this series provides an example of the PAM (Policy Analysis Matrix) approach developed in the text by Monke and Pearson.[6] The following section provides a brief comparison between the PAM and market level approaches and discusses the strengths and weaknesses of each.

As demonstrated, the market level model in the previous section calculates the impact of output price policy on the quantities produced, consumed and traded of a single commodity, and the impact on the government budget. Moreover, the model addresses the distributional impact of price policy between consumers, producers and taxpayers, and the deadweight efficiency losses that arise from distorting price policies.

In contrast, the PAM approach to policy analysis examines the impact of price policies on the

[6] Eric Monke and Scott Pearson, *The Policy Analysis Matrix in Agricultural Development*, Cornell University Press, 1989.

costs and returns of agricultural production and how per unit profits change as input and output prices are altered. The strength of a PAM stems from its use of disaggregated crop budget data which allow the straightforward identification of the sources of policy distortions affecting profitability.

Yet by focusing on profits rather than supply response directly, PAMs provide little indication as to how quantities produced may adjust to price changes. Furthermore, because a PAM framework does not incorporate the demand side, it does not provide information on the impact of price polices on consumption, and therefore trade. Of course, without the demand side, the distributional impact between producers and consumers of price policy also cannot be addressed.

The market level approach is also subject to several limitations. One problem associated with this class of models is their heavy reliance on elasticities which, at best, are only guides as to how producers and consumers respond to prices. For example, because elasticities are often measured using historical data, they reflect past behavior and may therefore be inadequate for predicting behavior under new and different policies. Moreover, the information required to determine whether the elasticity is a partial or a total estimate may not be readily available. Finally, market level approaches depend upon *point* elasticities which provide no information on the true shape of the supply or demand curve. Hence, market level models are technically a legitimate guide only for *small* changes in policies (points near which the elasticity was measured).

A second important limitation of single commodity market models that employ partial elasticity estimates is their failure to account for multi-market effects. Multi-market effects are the *indirect* effects of policy and the *feedback* effects from other markets which arise because of the linkages of the commodity being analyzed with other commodities and with factor markets. For example, when two commodities are substitutes in production (i e., they compete for the same resources), a single market analysis of either of the two commodities will overstate the impacts of any price change on the market being analyzed and will not provide any information on the impact of the policy on the other market.[7] Chapters 3-5 focus specifically on incorporating multi-market effects

There are strengths and weaknesses to both the PAM and market-level approaches to agricultural policy analysis. The decision as to which framework to use ultimately depends on data availability and the questions being addressed.

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[7] Note, however, that the impacts on the commodity market under investigation will *not* be overestimated if total elasticities are used in the analysis. This result is demonstrated in Chapter 4.

CHAPTER 2: ANALYSIS OF A SINGLE COMMODITY MARKET

The preceding chapter dealt with the conceptual framework of market level analysis. This chapter develops examples of a variety of single commodity interventions in the Philippine rice market. It shows how the impact of policy on efficiency, the government budget and the welfare of producers and consumers can be measured. Before turning to the computations, however, the following section suggests ways in which the exercises can be organized on a spreadsheet.

ORGANIZING MARKET LEVEL MODELS ON A SPREADSHEET

Table 2.1 illustrates the principal table used in this Chapter. As the instructions in the next section indicate, tables are identified by the use of the *Range/Name/Create* command which names each table, and by the use of the *GoTo* command (F5) which permits users to go directly to the table of interest. When these two commands are used together, it no longer matters where the table is located on the spreadsheet since finding it is simple.

Maximum flexibility in spreadsheet applications can be maintained by organizing tables on a diagonal. Each successive table is placed below and to the right of the preceding tables. This arrangement, sometimes called the "diamondback" method, makes it possible to make alterations to the computations of any one table by simply inserting or deleting rows and columns. So long as these spreadsheet commands are used (they are virtually the same for all vendors), the computer will adjust cell addresses used to calculate various cell formulas to reflect the change of the table's dimensions. It is important that the addition or deletion of rows and columns be done in this way. If row and columns are simply added or subtracted, tables will quickly overlap and changes cannot be made in one table without interfering with other tables.

Typically, a spreadsheet model contains separate blocks for *assumptions and data, computation, and reports*. In the following exercises, the organization will be somewhat different. Each model begins with an Assumptions and Data block, but then continues with a series of blocks that illustrate a particular type of agricultural policy intervention. For example, the first exercise investigates the impact of a production tax on production, consumption, welfare and the government budget. Following that, the effects of a consumer subsidy are modeled. Subsequently, a combination subsidy intervention on both producers and consumers is considered together. Finally, the model is used to investigate the impact of a tariff, and the equivalency between a tariff and a quota is discussed.

Each exercise contains both the instructions required to implement the model on the spreadsheet and a figure that shows graphically the arithmetic computations being made. Being able to move easily between two-dimensional graphs and the arithmetic on the spreadsheet is one of the attractive features of single commodity market level models. These tools are obviously no longer available when multi-commodity computations are employed, but the graphic approach is important in developing an intuition about how market level modeling works.

Table 2.1: Single Commodity Simulation

	A	B	C	D	E
1)	Exercise 2.1	Producer	Consumer	Combined	Tariff
2)	Comparison of policy instruments	Tax	Subsidy	Policy	Policy
3)	==========	==========	==========	==========	==========
4)	ASSUMPTIONS AND DATA				
5)	Supply elasticity	0.70	0.70	0.70	0.70
6)	Demand elasticity	-0.60	-0.60	-0.60	-0.60
7)	Initial Production ('000 mt)	22.00	22.00	22.00	22.00
8)	Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
9)	Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
10)	World price ($US/mt)	55.00	55.00	55.00	55.00
11)	Exchange rate (P/$US)	3.80	3.80	3.80	3.80
12)	Foreign exchange premium (%)	0.00	0.00	0.00	0.00
13)	Equilibrium price of exchange	3.80	3.80	3.80	3.80
14)	Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
15)	Border price-market rate-(p/mt)	231.80	231.80	231.80	231.80
16)	Border price-equib. rate-(p/mt)	231.80	231.80	231.80	231.80
17)	POLICIES				
18)	Producer Subsidy Equivalent (%)	-10.00	0.00	10.00	10.00
19)	Consumer Subsidy Equivalent (%)	0.00	10.00	10.00	-10.00
20)	PRICES (pesos/mt)				
21)	Producer Price	208.62	231.80	254.98	254.98
22)	Consumer price	231.80	208.62	208.62	254.98
23)	Producer price change	-23.18	0.00	23.18	23.18
24)	Consumer price change	0.00	-23.18	-23.18	23.18
25)	QUANTITY EFFECTS ('000 mt)				
26)	Change in production	-1.54	0.00	1.54	1.54
27)	Change in consumption	0.00	2.10	2.10	-2.10
28)	New production level	20.46	22.00	23.54	23.54
29)	New consumption level	35.00	37.10	37.10	32.90
30)	Net imports	14.54	15.10	13.56	9.36
31)	Change in net imports	1.54	2.10	0.56	-3.64
32)	FINANCIAL ('000 pesos)				
33)	Change in prod. receipts	-831.23	0.00	902.63	902.63
34)	Change in con. expenditures	0.00	-373.20	-373.20	275.84
35)	Change in forex. costs	356.97	486.78	129.81	-843.75
36)	Budget costs (revenues)	-474.26	859.98	1405.64	-216.96
37)	WELFARE EFFECTS ('000 pesos)				
38)	Producer gain (loss)	-492.11	0.00	527.81	527.81
39)	Consumer gain (loss)	0.00	835.64	835.64	-786.96
40)	Efficiency loss in production	17.85	0.00	17.85	17.85
41)	Efficiency loss in consumption	0.00	24.34	24.34	24.34
42)	Total deadweight loss	17.85	24.34	42.19	42.19
43)	CHECK	0.00	0.00	0.00	0.00

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ORGANIZING THE WORKSHEET

Enter Table 2.1 in the upper left hand corner of the spreadsheet. Put the table name, Exercise 2.1 at the top of Column A and identify it with *Range/Name/Create* command (e.g., EXER1). Save the worksheet and call it CHAPT2 before proceeding.

The ASSUMPTIONS AND DATA block describes a situation in which the market for rice in the Philippines is in equilibrium. World market prices prevail, i.e., producer, consumer and border prices are all the same. The result is that the country imports approximately 35 percent of its total consumption.

For the most part, the entries in the ASSUMPTIONS AND DATA block of the table are data; the exceptions are the entries for consumption, the equilibrium price of foreign exchange and the border prices. These data entries should be obtained by using the proper formulas. For example, if the worksheet has been set up identically to the one shown in Table 2.1, the formula to calculate consumption is +B7+B9 (production plus net imports); likewise, the formula for the shadow price of foreign exchange is +B11*(1+B12) (the exchange rate times 1 plus the foreign exchange premium). Finally, +B11*(B10+B14) (the exchange rate times the world price plus unloading costs) gives the border price at the market exchange rate, and +B13*(B10+B14) computes the border price at the equilibrium exchange rate.

$$
\begin{aligned}
M &= D - S && \textit{Market clearing equation} \\
S &= a + bP^p && \textit{Supply schedule} \\
D &= c - dP^c && \textit{Demand schedule}
\end{aligned}
\tag{2.1}
$$

The basic single commodity model where the market clears through changes in exports or imports, consists of three equations. The coefficient of P, b, is the slope of the supply curve:

$$b = \frac{\Delta S}{\Delta P_r^p} = \frac{\partial S}{\partial P_r^p} \quad as \quad \Delta P \rightarrow 0 \tag{2.2}$$

and d is the slope of the demand curve:

$$d = -\frac{\Delta D}{\Delta P_r^c} = -\frac{\partial D}{\partial P_r^c} \quad as \quad \Delta P \rightarrow 0 \tag{2.3}$$

Because the analysis proceeds by examining *changes* in policy, the constants a and c can be ignored. The relevant equations for computing the impact of changes in prices on changes in quantities are therefore:

$$\Delta S = b\,\Delta P_r^p$$

$$\textit{and} \tag{2.4}$$

$$\Delta D = d\,\Delta P_r^c$$

Very often, the numerical values of the slopes of the curves are not directly available. What are more commonly available are the elasticities which are the products of the supply or demand slopes times some "base year" or "initial" conditions, i.e.:[8]

$$E_s = \frac{\partial S}{\partial P_{ro}^p} \times \frac{P_{ro}^p}{S_{ro}} \tag{2.5}$$

$$E_d = \frac{\partial D}{\partial P_{ro}^c} \times \frac{P_{ro}^c}{D_{ro}} \tag{2.6}$$

where P^p_{ro} is the initial producer price for rice, P^c_{ro} is the initial consumer price for rice ($P^p_{ro} = P^c_{ro}$ = world price P^w_r), S_{ro} is initial production, and D_{ro} is initial consumption.

In order to calculate ΔS and ΔD corresponding to a given change in price, the elasticity is multiplied by the base year conditions prevailing before the price change occurs. The results are given below.

[8] In time-series econometric estimation of elasticities, the "base-year" conditions are usually the average of the actual series used in the estimation.

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$$\Delta S = E_s \times S_{ro} \times \frac{\Delta P^p_{ro}}{P^p_{ro}}$$

and (2.7)

$$\Delta D = E_d \times D_{ro} \times \frac{\Delta P^c_{ro}}{P^c_{ro}}$$

On the left hand side are the quantities to be determined, namely, the changes in supply and demand. The first term on the right hand side is the supply or demand *elasticity*. The second term is the initial quantity listed in the ASSUMPTIONS AND DATA block, and the third term is the percentage change in the base year price. Since the "new" prices are policy prices and so are exogenous, the change in quantity supplied and demanded can be calculated with knowledge only about the relevant elasticities and the initial prices and quantities.[9]

The final part of the computation, i.e., the determination of trade adjustments, is obtained from the market-clearing condition by substitution. The change in net imports is the difference between the change in quantity demanded and the change in the quantity supplied.

A PRODUCER TAX

Figure 2.1 illustrates a tax on rice producers. The government is assumed to implement this policy by procuring all domestically produced rice at a price lower than the world price, and by prohibiting all exports. The price that producers receive for the commodity is then assumed to decline by 10% as a result of the procurement scheme. By using the appropriate formula in 2.7, the decline in production can be determined. This amount must be made up with additional imports. It is assumed that the government is the sole purchaser of imports and sells these imports--plus what it has acquired from producers--to consumers at the old higher initial price P^w_r (the world price). The difference between the cost at which the product is acquired by the government from domestic producers, and the price at which it sells the commodity to domestic consumers, goes into the government's coffers.

The remaining blocks in Table 2.1 contain the necessary cells to investigate the impact of the price change. It is a generic table that is set up so that it can be used for a variety of computations. (To make subsequent instructions easier to understand, set up this first worksheet exactly as shown in Table 2.1.)

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[9] Of course, it is highly unlikely that initial prices and quantities will be equal to the original values used to measure the elasticity. This is one limitation of borrowing elasticities from previous work, rather than estimating them directly. Nevertheless, since elasticities are, at best, only approximate indicators of how individuals respond to price changes, this problem is often thought relatively unimportant.

Step 1: Enter the policy prices.

The first cells under the POLICIES heading are data cells and their entries represent the impact of the policy intervention, in percentage terms, on the prices received by consumers and producers. For example, an entry of -10 next to the Producer Subsidy Equivalent heading indicates that the government is levying a 10% tax on producer prices.[10] These values should be entered directly by typing in the appropriate numbers. Enter the value -10 next to the Producer Subsidy Equivalent heading, and 0 next to the Consumer Subsidy heading.

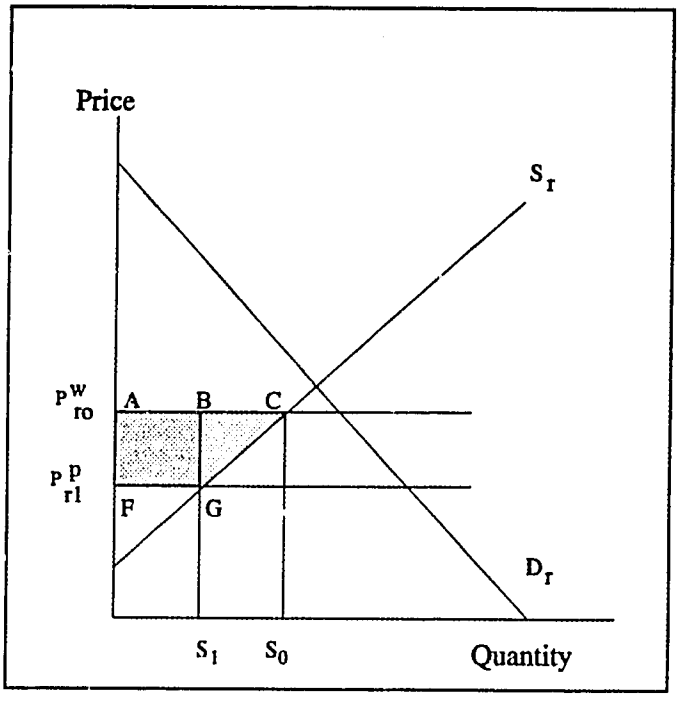

Figure 2.1: Base Case and Producer Tax

Step 2: Compute absolute price changes.

The second block, PRICES, calculates the absolute changes in prices due to the policy intervention. Using cell addresses, enter the formula for calculating the price farmers now receive as a result of the 10% tax. The correct formula is +B15*(1+B18/100). Although consumers are neither taxed nor subsidized in this example, the appropriate formula, +B15*(1-B19/100), also should be entered at this time. (Note the negative sign in the formula for consumers.) In so doing, the worksheet can be used later to analyze price policies that affect consumers. Then proceed by entering the formulas to compute the absolute change in both producer and consumer prices due to the tax. The formula to calculate the producer price change is +B21-B15; for consumers the formula is +B22-B15.

Step 3: Compute quantity changes.

As indicated above, the change in S is given by:

[10] The Producer Subsidy Equivalent attempts to capture in a single measure the total tax or subsidy levied on a commodity. This includes explicit output and input subsidies as well as indirect taxes and implicit subsidies. The Consumer Subsidy Equivalent is a similar inclusive measure applied to the demand side. For a discussion of the calculation of PSE's and CSE's, see Tsakok, *Agricultural Price Policy*, pp 96-101.

$$\Delta S = E_s \times S_{ro} \times \frac{\Delta P_{ro}}{P_{ro}} \tag{2.8}$$

In words, the change in supply is equal to the elasticity of supply times the initial quantity supply times the percentage change in the initial price. Using the cell addresses given in the above table, the value of the cell indicating the change in production due to the tax is +B5*B7*B23/B15. Production declines by 1,540 mt since farmers reduce their output in response to the tax. The same basic formula applies for calculating the change in consumption, +B6*B8*B24/B15. Note that consumers continue to purchase the same amount; they are unaffected by the production tax.

Step 4: Compute new values for production, consumption and net imports.

The new level of production after the policy intervention is given by adding the change in production to the initial production level given in the ASSUMPTIONS AND DATA block. Using the cell addresses given in Table 2.1, the formula for "new" production level is +B7+B26. Consumption remains the same because the government continues to sell rice to consumers at the old border price. Do not, however, simply type the number 35 for consumption or copy the cell address for this amount from the ASSUMPTIONS AND DATA block. Remember, the idea behind building a good spreadsheet model is to make it as flexible as possible so that various types of policy interventions can be subsequently analyzed with *few or no adjustments* to the original table. The correct formula for the new level of consumption is therefore +B8+B27.

The new level of imports is obtained from the market-clearing equation M = D - S. Total net imports are given by the formula +B29-B28. As expected, the value for net imports is equal to the decline in production since consumer prices have not changed. The change in net imports is +B30-B9.

Step 5: Compute the financial implications of the producer tax.

The following block of financial calculations provides a variety of information of interest to policymakers.

a) Change in producer receipts.

The change in producer receipts is the difference between the gross revenue producers earned in the absence of intervention, and what they earn after the tax is imposed. A positive computation indicates that the policy increases producer gross revenue and a negative value indicates a decline in producer receipts. Since gross revenue is defined as the producer price times the amount produced, the formula to calculate the *change* in producer receipts is +(B28*B21)-(B7*B15). In this example, the producer tax results in a decline in producer receipts since both the price farmers receive, and the amount they produce decline.

b) Change in consumer expenditures.

An analogous computation can be done for consumers. The change in consumer expenditures is the difference between their total expenditures in the absence of policy, and what they spend in the presence of policy. A positive computation indicates an increase in consumer expenditures and a negative value indicates a reduction in total expenditures. Since consumer expenditures are defined as the price consumers pay times the amount they consume, the formula to calculate the *change* in consumer expenditure is +(B29*B22)-(B8*B15). The formula should return a value of zero in this example because consumers are unaffected by the production tax.

c) Change in foreign exchange (Forex.) costs.

Of special interest to finance ministries is the impact of the policy on foreign exchange expenditures. Since foreign exchange is used to purchase imports, the cost of the policy in terms of foreign exchange is equal to the change in imports times the border price at the market exchange rate. A positive entry indicates an increase in foreign exchange requirements due to the policy; conversely, a negative value indicates that the policy saves foreign exchange.[11] The correct formula is +B31*B15. (Note that formula reports the foreign exchange costs (savings) in terms of domestic currency. Since imports have increased because of the producer tax, so do foreign exchange expenditures. To report the change in terms of foreign currency, simply divide the formula by the exchange rate, B11.)

d) Budget costs (revenues)

Up to now, the government's rationale for implementing a producer tax has not been discussed. One possible motivation is the need to raise revenue, particularly since the income raised from the tax is not passed on to consumers. The amount raised is equal to the product of the per unit tax on production and the amount produced at the lower price level.

The same type of calculation is repeated to compute any impact on the government's budget due to changes in consumer prices. In this case, consumers are neither taxed nor subsidized. However, in the interest of building a flexible worksheet, the appropriate formula should be included. The portion of government revenue originating from consumers is the product of the change in the consumer price and the amount consumed at the new price level.

With these two elements in hand, the correct formula to calculate the impact of the production tax on the budget is +(B23*B28)-(B24*B29).

---

[11] Notice that the accounting convention where savings would be represented as a positive number and costs as a negative number is not employed in this instance (nor in the subsequent calculations of budgetary impact and efficiency losses). By not adhering to this convention, the formulas used to calculate the impact of a producer tax can also be used to compute the impact of other policies - no changes will be required.

Step 6: Compute the welfare effects of the producer tax.

a) Producer gain/loss.

As Fig. 2.1 illustrates, a tax on production lead to a loss of producer surplus (profits) equal to the area ACGF. This loss can be broken down into two parts:

(a) the loss of profits on the amount of crop that continues to be grown, area ABGF;

(b) plus the loss of profits on the amount of the crop that was previously grown, area BCG;

One way to compute the loss in producer surplus is to use the appropriate cell addresses to compute the areas indicated in (a) and (b) above. The problem with this method is that it will lead to the correct result (both in magnitude and in sign) only if the order of subtraction of the prices and quantities is correctly specified. In other words, one has to be very careful to ensure the formulas yield the right signs.

Fortunately, by simple algebraic manipulation, the sum of the above formulas can be shown to be equal to $(P^p_{r1}-P^w_r)*(S_0+S_1)/2$. (Check for yourself.) Using this formula eliminates any potential sign problems because it returns a negative value if producer surplus declines and a positive value if producer surplus increases. This is the way producer losses and gains are designed to be reported on the worksheet. For this reason, the use of the above formula, +B23*(B7+B28)/2, is highly recommended. (Note that the formula using cell addresses takes advantage of the previous calculation of the producer price change reported under the PRICES block.)

b) Consumer gain/loss.

The producer tax on rice does not lead to a change in consumer surplus because the "new" price and quantity estimates for consumers are also the "old" values. Nevertheless, the appropriate formula should be added at this time in anticipation of future exercises. Using the same logic as in (a) above, the change in consumer surplus can be calculated as -B24*(B8+B29)/2. **(Do not forget the negative sign!)**

c) Efficiency loss in production.

As Figure 2.1 shows, domestic production has declined. In the absence of the tax, producers could have produced S_0-S_1 at a total cost equal to the area S_0S_1GC. With the policy, the government has to import rice at the world price at a total cost equal to S_0S_1BC. The difference, the triangular area GBC, is the additional cost to the economy of importing rice at a higher opportunity cost than domestic production. Using the cell addresses given in Table 2.1, 0.5*@ABS(B21-B15)*@ABS(B28-B7) gives the value of the triangle. (The use of absolute values ensures that losses will always be reported as positive numbers - see footnote 10.)

d) Efficiency loss in consumption.

In this example, the producer tax on rice does not lead to an efficiency loss in consumption because consumers continue to purchase rice at the world price. Again, in the interest of constructing a flexible spreadsheet, the appropriate formula, 0.5*@ABS(B22-B15)*@ABS(B29-B8) should be entered. The formula should return a value of zero.

c) Total deadweight loss.

The total deadweight loss is the sum of the production efficiency loss and the consumption efficiency loss. This amount represents how much society as a whole is losing, in monetary terms, from implementing a distorting policy. As we shall see, the total efficiency loss can also be viewed as the portion of the producer tax revenue that is not transferred either to the government or to consumers. The correct formula for the total deadweight loss when producer and consumer welfare gains and losses are reported as positive numbers is +B40+B41.

Step 7: Check the results

A quick glance at the calculations made thus far indicates that the loss in producer surplus (profits) is not entirely transferred to the government. The difference between what producers lose and what is transferred to the government *is* the total efficiency loss to the economy of implementing the policy. Although certain groups gain and certain groups lose as a result of a move away from free markets, society as a whole is made worse off since resources are being allocated inefficiently. The total deadweight loss provides an indication, in monetary terms, of how much worse off the country is because of the distorting policy. If the formulas have been entered correctly thus far, the loss in producer and consumer surplus should be equal to the total deadweight loss of the policy plus the tax revenue the government collects. The results can be checked by entering the formula @ABS(B38+B39)-@ABS(B42-B36). The result should equal zero. (Incidentally, this would be a good time to save your spreadsheet!)

A CONSUMER SUBSIDY

The market level analysis continues with the investigation of a subsidy on consumption. Figure 2.2 describes the situation graphically. In this exercise, the government is assumed to purchase all domestic production and imports at the world price and sell the total amount to consumers at 10% below the purchase price. The consumer subsidy is represented graphically in Fig. 2.2 by the gap between P^w_r and P^c_r. The government budget bears the cost of the total subsidy on the amount consumed, since producers continue to receive the border price.

The consumer subsidy problem can be implemented by copying both the data in the Assumptions and Data block, and the formulas used in the previous problem, to the column next to itself. As shown in Table 2.1, label this column "Consumer Subsidy".

The first step requires entering the 10% percentage decrease in the consumer price under the POLICIES block. Enter a *positive* value of 10 next to the Consumer Subsidy Equivalent heading since a price decrease to consumers represents a subsidy, not a tax. Also enter the value zero next

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to the Producer Subsidy equivalent heading since producers are neither taxed nor subsidized in this example.

All subsequent computations will be automatic as soon as these new price changes are entered. Because the formulas are flexible, the worksheet correctly reports the impact of a consumer subsidy on the volumes produced, consumed and imported, in addition to the impact on the budget and welfare, without any further alterations.

As anticipated, a consumer subsidy increases the amount consumed and therefore imported. The policy also costs the government 860,000 pesos to implement, an amount that is not transferred entirely to consumers. The difference is the total deadweight loss of the policy, area DEH in Figure 2.2.

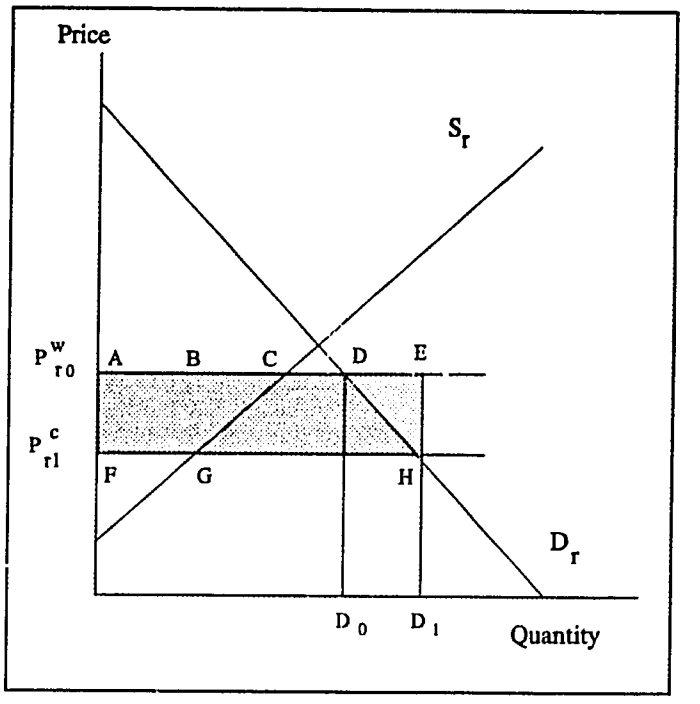

Figure 2.2: Base Case and Consumer Subsidy

COMBINED PRODUCER-CONSUMER INTERVENTIONS

Thus far interventions in a single commodity market have been taken isolation. In reality, there are often multiple interventions resulting from policies administered by different organizations in the government. For example, the Ministry of Agriculture, with its focus on production problems, imposes taxes, subsidies or regulations on producers. The Ministry of Commerce, on the other hand, is primarily oriented toward consumers and hence its policies are directed at their welfare.

Figure 2.3 suggests such a problem. In this diagram, the government is subsidizing domestic production by procuring all output at a price higher than world market price equivalents. At the same time, the government is providing a subsidy to consumers so that they will not bear the burden of the higher domestic price. Of course, the government must also restrict private imports in this case; otherwise importers could profit from importing at the world price and selling to the government at the subsidized price. Such a combined subsidy program is an example of an extreme preoccupation with food security. When the government subsidizes the producer in order to obtain increased output and then subsidizes the consumer in order to provide cheap access to the commodity, the impact on the government budget is substantial. These types of policies are generally feasible only in the presence of substantial non-agricultural sources of government revenues.

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Step 1: Enter the price changes

The first step should now be familiar. Copy the entire Consumer Subsidy column to the right of itself. Label this new column "Combined Policy" as shown in Table 2.1. Then enter a positive value of 10 next to the Producer Subsidy Equivalent heading to indicate that producers are now also receiving a 10% subsidy.

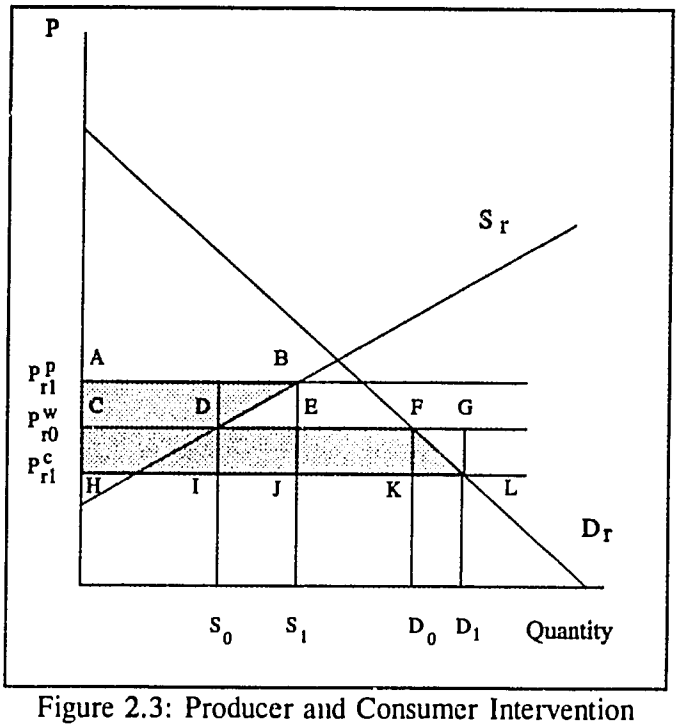

Figure 2.3: Producer and Consumer Intervention

Once again, due to the flexibility of the worksheet, the values in the column correctly represent the impact of a combined subsidy program on production, consumption, and imports as well as on the budget and welfare. Not surprisingly, the combined subsidy program has a substantial negative impact on the government budget. The total budgetary cost of this combined subsidy is shown in Figure 2.3 and is equal to ABEC + CEJH + EGLJ. Note that very little additional foreign exchange is required since the subsidy to producers increases production, thus offsetting most of the increase in demand due to the consumption subsidy.

TARIFF POLICY

Thus far the analysis of policy interventions has focused on the use of domestic taxes and subsidies to cause prices to diverge from their undistorted levels. Yet in order for the policies to have their intended effects, the government must control trade in the commodity. The above Combined Policy exercise is an example where the government would have to be restricting imports to prevent importers from purchasing at the world price and selling to the government at the higher subsidized price.

In some circumstances, governments prefer to not intervene in the market directly with procurement programs, but rather rely on trade policy exclusively. Two common trade policy instruments are tariffs and quotas. A tariff is nothing other than a border tax levied on imports. A tariff can be computed on an ad valorem basis whereby the tariff is calculated as a percentage of the border price. Alternatively, it can be computed as a flat tax - a rate quoted in absolute dollars per physical unit. This latter type of tariff is called a specific tariff.

Figure 2.4 describes the impact of a tariff policy. The tariff raises the domestic price to both consumers and producers above the world price; producers are subsidized and consumers taxed. At

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the world price, (D_0 - S_0) would have been imported. At the new higher price only (D_1 - S_1) is imported, since the higher price causes consumers to purchase less and suppliers to produce more.

An alternative way for the government to achieve these results is through the use of a quota. A quota is a quantitative restriction on imports to some specified amount. A quota restricting imports to (D_1 - S_1) would raise domestic prices by the same amount as the tariff. Hence, the two instruments are said to be "equivalent." The only significant difference between them is who receives the revenue generated from the policy. With a tariff, the government receives the tax revenue. With a quota, imports can be restricted either by prohibiting the private sector from importing the commodity with the government then assuming that role, or by issuing quota permits to the private sector for the amount (D_1 - S_1). If the government does the importing, it receives the rent. This is the profit from being able to import (D_1 - S_1) at the world price and selling that amount to consumers at the higher domestic price. If the government chooses to issue quota permits to the private sector, then the recipients of the permits receive the rent.

As before, copy the data and results of the previous exercise to the right of itself. Label this new column "Tariff Policy' as shown in Table 2.1. In this exercise, the government is imposing an ad valorem tariff of 10%. Enter 10 next to the Producer Subsidy Equivalent heading and -10 next to the Consumer Subsidy Equivalent heading.

Once again, the impact of the tariff policy on consumption, production, imports, the budget and welfare are all correctly reported. Imports decline as expected and the government earns the tariff revenue. Producers are better off since they receive a higher price; consumers are worse off for the same reason.

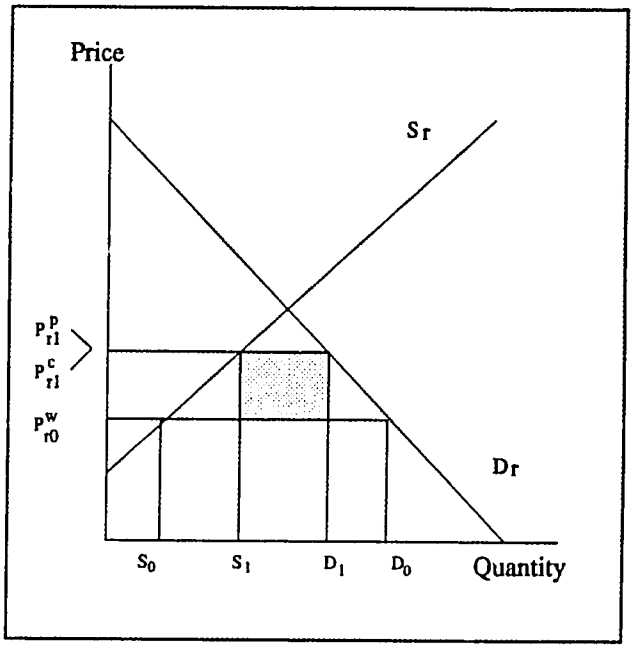

Figure 2.4: Tariff Policy

SENSITIVITY ANALYSIS

Elasticities

The effects of changes in assumptions about any of the parameters in the Assumptions and Data block can be easily examined with the "what if" capabilities of the spreadsheet. Two areas of particular interest are assumptions about the elasticities that were used and the assumption about the equilibrium exchange rate.

Table 2.2 presents the results of changing the assumption about the elasticity of supply on the Tariff Policy Intervention analysis. To perform this exercise, copy the entire table just completed

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down and to the right of itself so that it is separated by at least a column and a row. Label this new table "Exercise 2.2 - Sensitivity to Elasticity Values." On the new worksheet, copy the tariff policy column over the other policy exercises so that all four columns are identical.

To examine the sensitivity of the results to changes in the elasticity values, reduce the supply elasticity by .1 in each of the columns after the first. The supply elasticity in the second column will now be .6, and will be .5 in the third column, etc. One interesting result that emerges is the

relationship between the total deadweight loss of a tariff and the size of the supply elasticity. As the results indicate, the higher the supply elasticity, the greater are the deadweight losses from a tariff policy. Why?

Tariff Height

One can think of many types of "what if" analyses to perform and the design of the worksheet makes the task quite easy. The following exercise suggests a perhaps less obvious sensitivity test - one that examines the relationship between the size of the tariff and the total deadweight loss.

To perform this analysis, proceed as before by copying Exercise 2.2 (the heading and the four tariff columns) down and to the right of itself on the diagonal. Label this new exercise "Exercise 2.3 - Tariff Height and Economic Cost". Be sure to return all supply elasticities to their original value of .7. Table 2.3 shows the impact of raising the tariff by 5% successively. Why does the deadweight loss increase at a much faster rate?

TRACING SUPPLY AND DEMAND CURVES

Note that the facilities of the spreadsheet also make it possible to trace out supply and demand curves. To draw Figure 2.5, first copy Exercise 2.1 down and to the right of Exercise 2.3 - "Tariff Height and Economic Policy". Name it Exercise 2.4 - "Tracing Demand and Supply Curves." Under the POLICIES block, enter four Producer Subsidy Equivalents: 1, 5, 10, and 15. Enter Consumer Subsidy Equivalents -15, -10, -5 and -1. These amounts represent different combined policy exercises. The combined policy exercise is used because in order to trace supply and demand curves, both supply and demand must be reacting to price changes.

Table 2.2: Sensitivity Analysis of Elasticity Values

Exercise 2.2 Sensitivity to Elasticities	Tariff Policy	Tariff Policy	Tariff Policy	Tariff Policy
ASSUMPTIONS AND DATA				
Supply elasticity	0.70	0.60	0.50	0.40
Demand elasticity	-0.60	-0.60	-0.60	-0.60
Initial Production ('000 mt)	22.00	22.00	22.00	22.00
Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
World price ($US/mt)	55.00	55.00	55.00	55.00
Exchange rate (P/$US)		3.80	3.80	3.80
Foreign exchange premium (%)	0.00	0.00	0.00	0.00
Shadow price of foreign exchange	3.80	3.80	3.80	3.80
Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
Border price at Market rate (p/mt)	231.80	231.80	231.80	231.80
Border price at Shadow rate (p/mt)	231.80	231.80	231.80	231.80
POLICIES				
Producer Subsidy Equivalent (%)	10.00	10.00	10.00	10.00
Consumer Subsidy Equivalent (%)	-10.00	-10.00	-10.00	-10.00
PRICES (pesos/mt)				
Producer Price	254.98	254.98	254.98	254.98
Consumer price	254.98	254.98	254.98	254.98
Producer price change	23.18	23.18	23.18	23.18
Consumer price change	23.18	23.18	23.18	23.18
QUANTITY EFFECTS ('000 mt)				
Change in production	1.54	1.32	1.10	0.88
Change in consumption	-2.10	-2.10	-2.10	-2.10
New production level	23.54	23.32	23.10	22.88
New consumption level	32.90	32.90	32.90	32.90
Net imports	9.36	9.58	9.80	10.02
Change in net imports	-3.64	-3.42	-3.20	-2.98
FINANCIAL IMPLICATIONS ('000 pesos)				
Change in producer receipts	902.63	846.53	790.44	734.34
Change in consumer expenditures	275.84	275.84	275.84	275.84
Change in Forex. costs (savings)	-843.75	-792.76	-741.76	-690.76
Budget costs (revenues)	-216.96	-222.06	-227.16	-232.26
WELFARE EFFECTS ('000 pesos)				
Producer gain (loss)	527.81	525.26	522.71	520.16
Consumer gain (loss)	-786.96	-786.96	-786.96	-786.96
Efficiency loss in production	17.85	15.30	12.75	10.20
Efficiency loss in consumption	24.34	24.34	24.34	24.34
Total deadweight loss	42.19	39.64	37.09	34.54
CHECK	0.00	0.00	0.00	0.00

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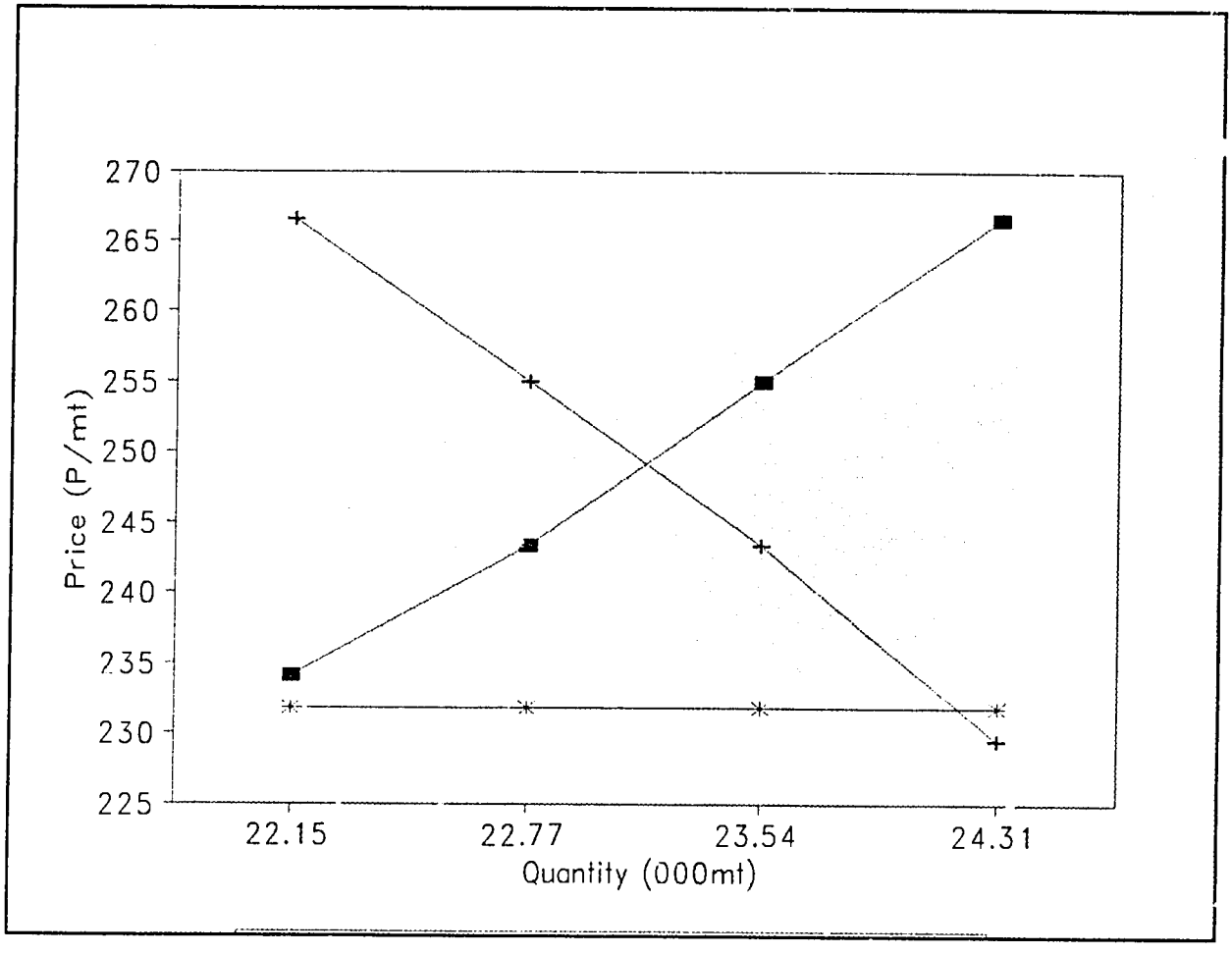

Figure 2.5: Market Diagram

To plot the results, use the Lotus graph option and select a line graph. Note that the X axis of this graph is quantity. The correct quantity to use for the X axis is the "New Production Level." Then select the "Producer Price", "Consumer Price" and the "Border Price" series for lines A, B and C. Be sure to give a title to the graph and label both axes. When viewed, the final graph should look like the one shown in Figure 2.5. What is the autarky equilibrium in the rice market?

Table 2.3: Tariff Height and Economic Cost

Exercise 2.3 Tariff Height and Economic Cost	Tariff Policy	Tariff Policy	Tariff Policy	Tariff Policy
ASSUMPTIONS AND DATA				
Supply elasticity	0.70	0.70	0.70	0.70
Demand elasticity	-0.60	-0.60	-0.60	-0.60
Initial Production ('000 mt)	22.00	22.00	22.00	22.00
Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
World price ($US/mt)	55.00	55.00	55.00	55.00
Exchange rate (P/$US)	3.80	3.80	3.80	3.80
Foreign exchange premium (%)	0.00	0.00	0.00	0.00
Shadow price of foreign exchange	3.80	3.80	3.80	3.80
Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
Border price at Market rate (p/mt)	231.80	231.80	231.80	231.80
Border price at Shadow rate (p/mt)	231.80	231.80	231.80	231.80
POLICIES				
Producer Subsidy Equivalent (%)	10.00	15.00	20.00	25.00
Consumer Subsidy Equivalent (%)	-10.00	-15.00	-20.00	-25.00
PRICES (pesos/mt)				
Producer Price	254.98	266.57	278.16	289.75
Consumer price	254.98	266.57	278.16	289.75
Producer price change	23.18	34.77	46.36	57.95
Consumer price change	23.18	34.77	46.36	57.95
QUANTITY EFFECTS ('000 mt)				
Change in production	1.54	2.31	3.08	3.85
Change in consumption	-2.10	-3.15	-4.20	-5.25
New production level	23.54	24.31	25.08	25.85
New consumption level	32.90	31.85	30.80	29.75
Net imports	9.36	7.54	5.72	3.90
Change in net imports	-3.64	-5.46	-7.28	-9.10
FINANCIAL IMPLICATIONS ('000 pesos)				
Change in producer receipts	902.63	1380.72	1876.65	2390.44
Change in consumer expenditures	275.84	377.25	454.33	507.06
Change in Forex. costs (savings)	-843.75	-1265.63	-1687.50	-2109.38
Budget costs (revenues)	-216.96	-262.17	-265.18	-226.01
WELFARE EFFECTS ('000 pesos)				
Producer gain (loss)	527.81	805.10	1091.31	1386.45
Consumer gain (loss)	-786.96	-1162.19	-1525.24	-1876.13
Efficiency loss in production	17.85	40.16	71.39	111.55
Efficiency loss in consumption	24.34	54.76	97.36	152.12
Total deadweight loss	42.19	94.92	168.75	263.67
CHECK	0.00	0.00	0.00	0.00

Table 2.4: Tracing Supply and Demand Curves

Exercise 2.4 Tracing Supply and Demand Curves	Combined Policy	Combined Policy	Combined Policy	Combined Policy
ASSUMPTIONS AND DATA				
Supply elasticity	0.70	0.70	0.70	0.70
Demand elasticity	-0.60	-0.60	-0.60	-0.60
Initial Production ('000 mt)	22.00	22.00	22.00	22.00
Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
World price ($US/mt)	55.00	55.00	55.00	55.00
Exchange rate (P/$US)	3.80	3.80	3.80	3.80
Foreign exchange premium (%)	0.00	0.00	0.00	0.00
Shadow price of foreign exchange	3.80	3.80	3.80	3.80
Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
Border price at Market rate (p/mt)	231.80	231.80	231.80	231.80
Border price at Shadow rate (p/mt)	231.80	231.80	231.80	231.80
POLICIES				
Producer Subsidy Equivalent (%)	1.00	5.00	10.00	15.00
Consumer Subsidy Equivalent (%)	-15.00	-10.00	-5.00	1.00
PRICES (pesos/mt)				
Producer Price	234.12	243.39	254.98	266.57
Consumer price	266.57	254.98	243.39	229.48
Producer price change	2.32	11.59	23.18	34.77
Consumer price change	34.77	23.18	11.59	-2.32
QUANTITY EFFECTS ('000 mt)				
Change in production	0.15	0.77	1.54	2.31
Change in consumption	-3.15	-2.10	-1.05	0.21
New production level	22.15	22.77	23.54	24.31
New consumption level	31.85	32.90	33.95	35.21
Net imports	9.70	10.13	10.41	10.90
Change in net imports	-3.30	-2.87	-2.59	-2.10
FINANCIAL IMPLICATIONS ('000 pesos)				
Change in producer receipts	87.05	442.39	902.63	1380.72
Change in consumer expenditures	377.25	275.84	150.09	-32.94
Change in Forex. costs (savings)	-765.87	-665.27	-600.36	-486.78
Budget costs (revenues)	-1056.07	-498.72	152.18	926.88
WELFARE EFFECTS ('000 pesos)				
Producer gain (loss)	51.17	239.44	527.81	805.10
Consumer gain (loss)	-1162.19	-786.96	-399.57	81.37
Efficiency loss in production	0.18	4.46	17.85	40.16
Efficiency loss in consumption	54.76	24.34	6.08	0.24
Total deadweight loss	54.94	28.80	23.93	40.40
CHECK	0.00	0.00	0.00	0.00

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CHAPTER 3: INTRODUCTION TO MULTI-MARKET MODELING

Chapter 2 focused on market level modeling with a single commodity. By using the concept of a *total elasticity*, it was possible to compute the corresponding changes in quantities that a price policy intervention elicited. This single commodity approach is perfectly valid where no significant *cross price effects* exist. However, cross price effects occur when the supply and/or demand for a particular commodity are affected by the changes in the price of another commodity or the price of an input.

Chapters 3 and 4 extend the single commodity analysis of the previous chapter to explore cases in which significant cross-price effects exist but have not been adequately captured in the own-price elasticity estimates. Such cases occur when the prices of other commodities are held constant in the statistical procedure used to estimate the elasticity. More importantly, they occur when relative agricultural prices have been fixed by the government over a long period of time and therefore statistical procedures cannot estimate the potential cross price effects. Therefore, throughout the discussion of multi-market models, the use of *partial elasticities* is assumed. (Recall from Chapter 1 that a partial elasticity of supply relates a relative change in the quantity supplied to a relative change in its price, *holding the prices of all other commodities constant.*)

The analysis proceeds in stages. In Chapter 3, the related concepts *indirect policy effect* and *feedback effect* are introduced. A single exercise is developed in which an additional commodity, maize, is added to the exercises of the previous chapter. The exercise is limited to the case where both commodity markets clear through quantity adjustments and specifically illustrates an *indirect* policy effect. Analysis of the case where one or more of the commodity markets clear endogenously, (i.e., adjustments of both quantities and prices take place within the domestic market with no government intervention) is reserved for Chapter 4. As will be seen, endogenous prices lead to *feedback* effects.

THE CONCEPT OF MULTI-MARKET EFFECTS

Multi-market effects is the term used to describe both the indirect effects of commodity policy on other markets, and the feedback effects from other markets, Each arises because of the linkages of the commodity being analyzed with other commodities and with factor markets. The basic idea behind multi-market effects is best explained by an example.

Figure 3.1 describes the case in which two commodities, maize and rice, are linked because they are substitutes in both production and consumption. Two commodities are considered to be production (consumption) substitutes when an increase in the production (consumption) of one commodity leads to a reduction in production (consumption) of the other. In Figure 3.1 the markets for rice and maize are in equilibrium and there is no government intervention. World market prices prevail, i.e. producer, consumer and border prices are all the same.

Suppose that the government decides to tax rice producers by setting the producer price of rice (but not the consumer price) below the border price. As Figure 3.1 illustrates, the total effect of

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this policy intervention in both markets is the sum of (a) that affecting the rice market directly due to the change in its own price (the "direct" or "own" effect); and, (b) that affecting the maize market through the impact of the price of rice on the supply of maize (the "indirect" or "cross-price" effect). At constant factor prices, the rice price decrease raises the relative profitability of producing maize. Hence, profit maximizing producers, at the margin, shift resources out of the production of rice and into the production of maize. This movement of resources into maize is represented by a rightward shift of the maize supply curve increasing production to S_{m1}.

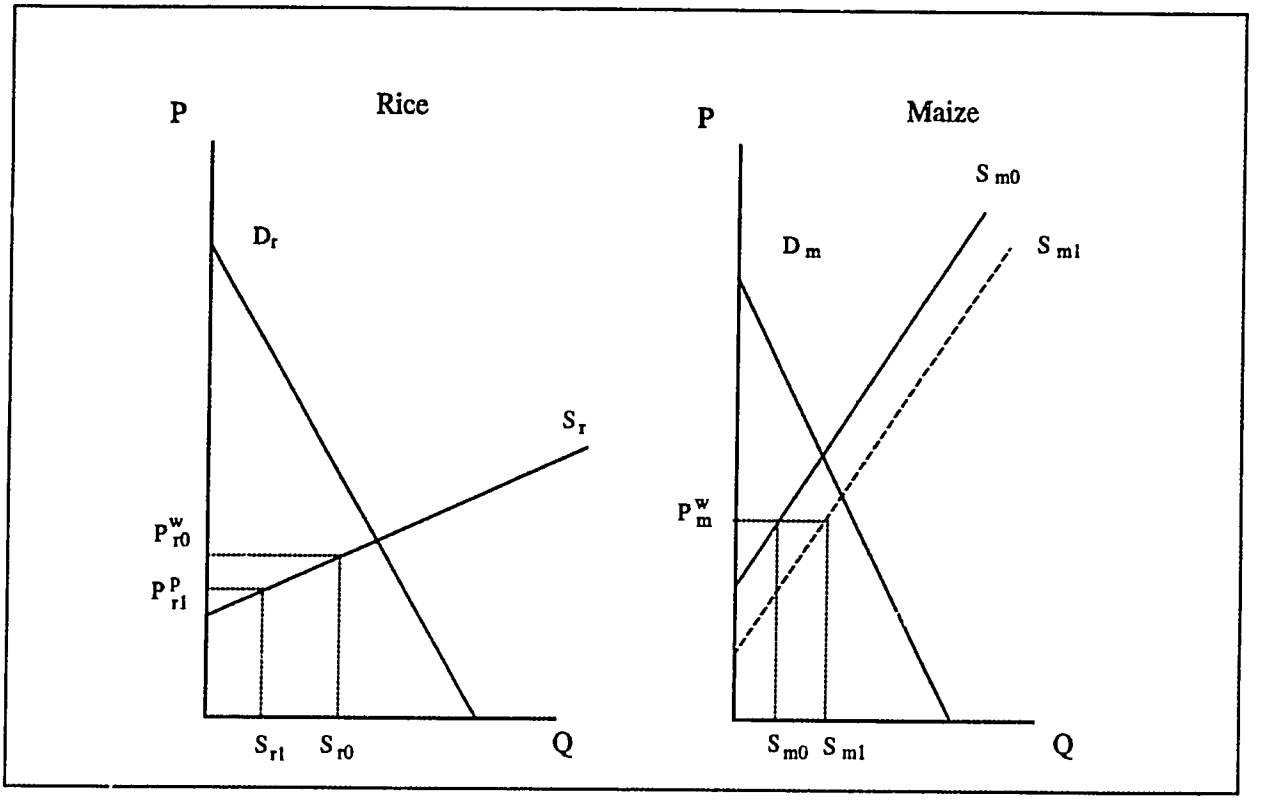

Figure 3.1: Illustration of an Indirect Effect

If the price of maize were allowed to change in response to the shift in its supply curve, a *feedback* process would follow. The increase in the supply of maize would cause a decline in its price. This, in turn, would produce a rightward shift in the rice supply curve. (Chapter 4 will explain this effect in detail.) However, since both commodity prices are exogenous, all feedback effects are eliminated.

CALCULATING MULTI-MARKET EFFECTS

The 6 equations (3.1) shown below define the simplest multi-market model when all prices are exogenous.

$$
\begin{aligned}
S_r &= a + bP_r^p + cP_m^p && \textit{Supply of rice} \\
D_r &= d + eP_r^c + fP_m^c && \textit{Demand for rice} \\
S_m &= g + hP_m^p + iP_r^p && \textit{Supply of maize} \\
D_m &= j + kP_m^c + lP_r^c && \textit{Demand for maize} \\
S_r + M_r &= D_r && \textit{Market clearing for rice} \\
S_m + M_m &= D_m && \textit{Market clearing for maize}
\end{aligned}
\tag{3.1}
$$

where P_r^p is the producer price of rice and P_r^c is the consumer price of rice.

Again, because the interest is in analyzing changes in policy, the constants (intercepts) are unnecessary and the relevant equations for examining the impact of a change in price on quantities supplied and demanded are the slope coefficients multiplied by the percentage change in the exogenous prices.[12]

$$
\begin{aligned}
\Delta S_r &= b\Delta P_r^p + c\Delta P_m^p && \textit{Change in the supply of rice} \\
\Delta D_r &= e\Delta P_r^c + f\Delta P_m^c && \textit{Change in the demand for rice} \\
\Delta S_m &= h\Delta P_m^p + i\Delta P_r^p && \textit{Change in the supply of maize} \\
\Delta D_m &= k\Delta P_m^c + l\Delta P_r^c && \textit{Change in the demand for maize}
\end{aligned}
\tag{3.2}
$$

Multiplying through by initial or base year quantities and prices and converting to *elasticities* results in equations that are very similar to the single commodity equations except that a *cross price elasticity* term is now included. The cross price elasticity is defined in Equation 3.3

Cross price elasticities relate a proportional change in the quantity of one commodity to a

[12] It is not necessary to assume that the supply and demand curves are linear throughout as implied in the previous equations. The crucial assumption is that the portion of the curve in the vicinity of the changes being estimated is linear.

$$\epsilon_{rm} = \frac{\textit{relative change in quantity supplied of rice}}{\textit{corresponding relative change in the producer price of maize}} \tag{3.3}$$

proportional change in the price of a different commodity. Suppose the cross price elasticity of the supply of rice and the price of maize (ϵ_{rm}) is -.1. This indicates that for every 10% increase in the price of maize, the quantity of rice produced will decline by 1%. Commodities whose cross-price elasticities of supply are negative are called *production substitutes*. If the cross price elasticities of supply are positive, the two commodities are called *production complements*.[13]

For the total change in the quantity supplied (demanded) of rice, the incorporation of cross-commodity effects leads to the inclusion of an additional term in the supply (demand) equation that captures how the supply (demand) of rice is affected by a change in the price of maize. The results are shown below for the change in the supply of rice where ϵ_{rr} refers to the partial own price elasticity of supply of rice , i.e., it does not now include the *sum* total of changes in the supply of rice due to a change in its own price since the impact of the change in the price of maize has been excluded.

$$\Delta S_r = \left[\epsilon_{rr} \times S_r \times \frac{\Delta P_r^p}{P_r^p}\right] + \left[\epsilon_{rm} \times S_r \times \frac{\Delta P_m^p}{P_m^p}\right] \tag{3.4}$$

Analogous calculations are required to compute the demand for rice and for the supply and demand for maize. If prices are endogenous, the resulting *feedback* from one commodity to another requires the solution of a set of simultaneous equations. However, when both the price of rice and maize are exogenous, the multi-market model can be solved in the same way as the single commodity model is solved. Each equation is evaluated for the effect of price changes using the equations indicated above and the results are substituted in the market-clearing equations to obtain the net impact on trade.

A PRODUCER TAX

To compute the impact of a producer tax on rice on the supply of maize, begin by copying the Lotus 1-2-3 file containing the work of the previous chapter. (If instructions have been followed, it is called CHAPT2.WK1) Using the DOS copy command, at the command prompt, type: COPY A:CHAPT2.WK1 A:CHAPT3.WK1. Retrieve the CHAPT3 file and make the following modifications.

Step 1:

[13] The reverse holds for cross price elasticities of demand, i.e. commodities whose cross price elasticities of demand are positive are called substitutes, etc.

Using Exercise 2.1, (now 3.1) revise the spreadsheet labels as shown in Table 3.1. Add the label rice to the first column and relabel the second column "Maize Impact." Replace the rice data with the appropriate data for maize as shown in the Assumptions and Data block of Table 3.1. (For the moment, ignore the final two columns in this table.) Finally, erase the previous financial and welfare effects calculations including the headings.[14]

Step 2:

Add two rows to the ASSUMPTIONS AND DATA block of the table called "Supply cross elasticity" and "Demand cross elasticity." Place these two rows just below those for the own price elasticities as indicated in Table 3.1. In the supply cross elasticity row, enter -.2 for both crops. Use .1 for the cross price elasticity of demand. (Be sure to insert the rows.) Recall that a positive cross price elasticity of demand indicates that users of maize will consider the price of rice in their consumption decisions. This is particularly true of livestock producers for whom the two commodities are easily substitutable.

Step 3:

Since the government is not adjusting the price of maize, enter the value zero next to the producer and consumer subsidy equivalent headings for maize.

Step 4:

Insert four new rows to the QUANTITY EFFECTS block called "Cross price change in production", "Cross price change in consumption", "Total change in production" and "Total change in consumption." Table 3.1 indicates the appropriate location for these rows and shows the minor changes required to the other subheadings in this block. Compute the impact on rice supply due to a change in the price of maize by entering the following formula into the cross price change in production cell for rice.

$$\Delta S_{rice\ /\ maize} = \epsilon_{rm} \times S_{ro} \times \frac{\Delta P^{p}_{mo}}{P^{p}_{mo}} \tag{3.5}$$

Using cell addresses, the correct formula is +B6*B9*C25/C17. The formula to calculate the impact of a change in the price of rice on maize supply is analogous.

[14] Analyzing the welfare impacts in multi-market exercises with several distortions is conceptually complicated. Therefore it has not been attempted here.

Table 3.1: Producer Policy Intervention: Two-Commodity Market

A	B	C	D	E
1) Exercise 3.1: Two commodity market	Rice	Maize	Rice	Maize
2) Comparison of policy instruments	Prod. tax	Impact	Combined	Impact
3)				
4) ASSUMPTIONS AND DATA				
5) Supply elasticity	0.70	0.70	0.70	0.70
6) Supply cross elasticity	-0.2	-0.2	-0.2	-0.2
7) Demand elasticity	-0.60	-0.60	-0.60	-0.60
8) Demand cross elasticity	0.1	0.1	0.1	0.1
9) Initial Production ('000 mt)	22.00	29.00	22.00	29.00
10) Initial Consumption ('000 mt)	35.00	32.00	35.00	32.00
11) Initial net imports ('000 mt)	13.00	3.00	13.00	3.00
12) World price ($US/mt)	55.00	64.00	55.00	64.00
13) Exchange rate (P/$US)	3.80	3.80	3.80	3.80
14) Foreign exchange premium (%)	0.00	0.00	0.00	0.00
15) Shadow price of foreign exchange	3.80	3.80	3.80	3.80
16) Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
17) Border price at Market rate (p/mt)	231.80	266.00	231.80	266.00
18) Border price at Shadow rate (p/mt)	231.80	266.00	231.80	266.00
19) POLICIES				
20) Producer Subsidy Equivalent (%)	-10.00	0.00	10.00	0.00
21) Consumer Subsidy Equivalent (%)	0.00	0.00	10.00	0.00
22) PRICES (pesos/mt)				
23) Producer Price	208.62	266.00	254.98	266.00
24) Consumer price	231.80	266.00	208.62	266.00
25) Producer price change	-23.18	0.00	23.18	0.00
26) Consumer price change	0.00	0.00	-23.18	0.00
27) QUANTITY EFFECTS ('000 mt)				
28) Direct change in production	-1.54	0.00	1.54	0.00
29) Cross price change in production	0.00	0.58	0.00	-0.58
30) Direct change in consumption	0.00	0.00	2.10	0.00
31) Cross price change in consumption	0.00	0.00	0.00	-0.32
32) Total change in production	-1.54	0.58	1.54	-0.58
33) Total change in consumption	0.00	0.00	2.10	-0.32
34) New production level	20.46	29.58	23.54	28.42
35) New consumption level	35.00	32.00	37.10	31.68
36) Net imports	14.54	2.42	13.56	3.26
37) Change in net imports	1.54	-0.58	0.56	0.26

Step 5:

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$$\Delta S_{maize\ /rice} = \varepsilon_{mr} \times S_{mo} \times \frac{\Delta P^{p}_{ro}}{P^{p}_{ro}} \tag{3.6}$$

Enter the appropriate formulas to calculate the impact of changing maize prices have on the demand for rice. For example, the formula for rice is:

$$\Delta D_{rice} = \eta_{rm} \times D_{ro} \times \frac{\Delta P^{c}_{mo}}{P^{c}_{mo}} \tag{3.7}$$

Step 6

Add the quantity changes resulting from both the direct and indirect changes to the rows that summarize total changes in quantities produced and consumed. Then edit the formulas that calculate the new level of production and consumption to reflect the additional quantity changes due to the cross price effects. For example, the new rice production level should now be calculated as the initial production level plus the **total** change in production.

Simulating a decrease in rice prices resulting from a producer tax now gives the expected result. Rice output declines as determined by its own supply elasticity. Maize output, on the other hand, increases because it is a production substitute for rice. This exercise demonstrates that in the presence of multi-market effects, a single commodity analysis will fail to capture any impacts on related commodity markets.

Table 3.1 also shows the result of repeating this exercise for the Combined Rice Subsidy exercise. This exercise can be accomplished by copying the first two columns over the original third and fourth column of the worksheet, and then changing the producer and consumer subsidy equivalents for rice to reflect the Combined Policy exercise (i.e., type +10 next to the Producer and Consumer Subsidy Equivalent headings). The correct results are reported immediately. Notice that there is now a decrease in both the production and consumption of maize. Why?

CHAPTER 4: MULTI-MARKET MODELS WITH PRICE ENDOGENEITY [15]

Chapter 4 introduces a new element into multi-market modeling, namely, the presence of a commodity for which the adjustments of quantities and prices are assumed to take place entirely within domestic markets. As previous comments have indicated, this produces a significant change, not only in the characterization of the market, but in the complexity of the computations required to determine the effects of a change on price.

As explained in Chapter 1, once one or more prices are endogenous to the system, the solution of the system to a price policy change in one of the markets cannot be found by the simple substitution of prices in to the commodity demand and supply curves, with the market clearing through changes in net trade. With price endogeneity, the system must be solved as a set of simultaneous equations.

ILLUSTRATING A FEEDBACK EFFECT

Again, market adjustment in the presence of price endogeneity is best illustrated by an example. Figure 4.1 describes the case in which rice and maize are again both production and consumption substitutes. The two markets are initially in equilibrium and there is no government intervention. Producers and consumers in the rice market face an exogenous world price with net imports equal to (D_0 - S_0). Maize, however, is assumed to be a nontradable. Equilibrium is achieved in this market at the point (Q_e,P_e) where domestic supply is equal to domestic demand.[16]

Suppose the government decides to impose a tariff that raises the price in the rice market to P_{s1} to both consumers and producers, increasing domestic production to S_1 and decreasing domestic consumption to D_1. As explained in Chapter 3, a rice price policy change causes a series of indirect effects in the maize market. Specifically, a rice price rise increases the profitability of producing rice relative to maize. Hence profit maximizing producers will, at the margin, shift resources out of the production of maize and into the production of rice. This movement of resources out of maize production is represented by a leftward shift in the maize supply curve to S_{m1}.

A similar indirect effect occurs on the demand side. At a higher relative price for rice, consumers will maximize their utility by increasing the consumption of the substitute commodity - maize.[17] The increase in the consumption of maize is illustrated by a rightward shift in the maize

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[15] Chapters 4-6 are based on an unpublished paper written for the Agricultural Policy Analysis Project by Stefano Pagiola entitled *Notes on the Implementation of Multi-Market Analysis* (Food Research Institute, September, 1989). This paper is in turn based on a series of multi-market models by Braverman and Hammer of the World Bank.

[16] Recall, however, that price endogeneity can also occur with traded commodities; i.e., the "large country" case.

[17] Review the discussion in Chapter 1 (pp. 6-8) regarding the derivation of consumer demand if this idea is not clear.

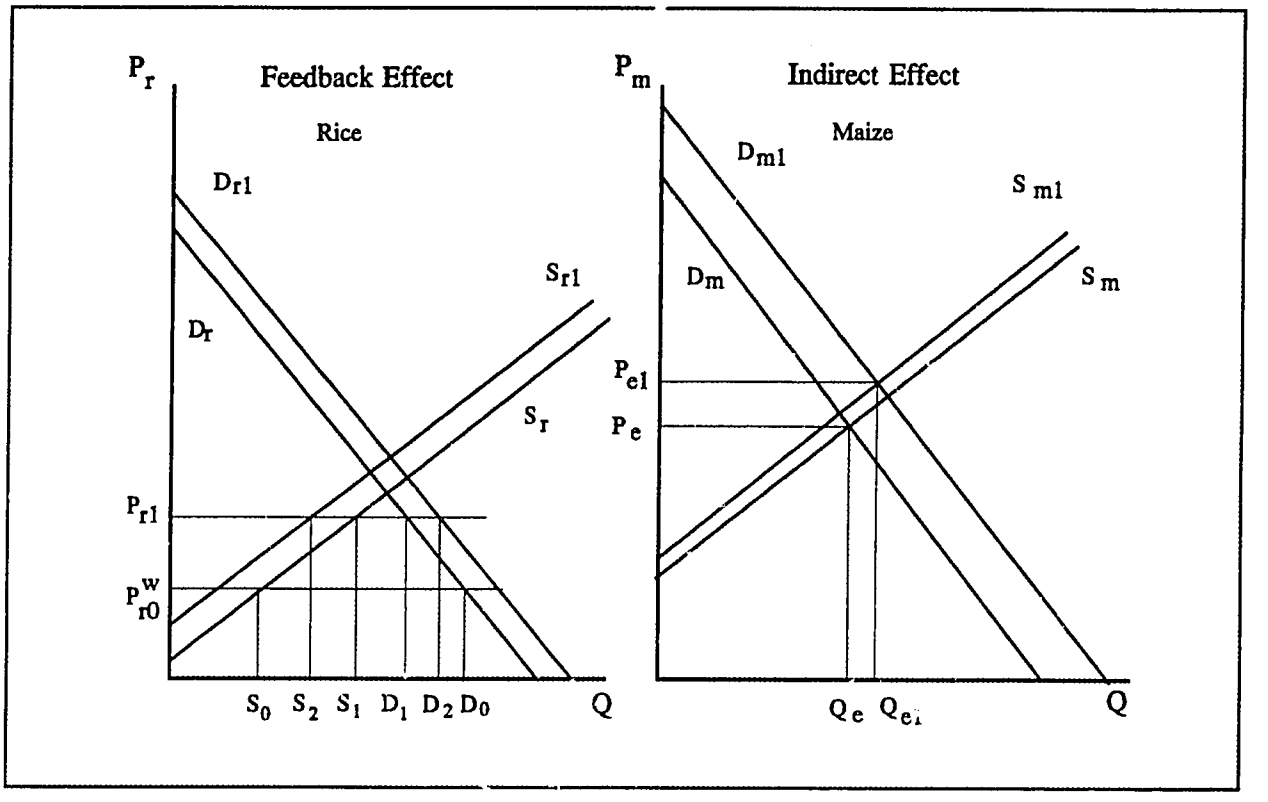

Figure 4.1: Illustration of an Indirect and Feedback Effect

demand curve to D_{m1}.

Yet, unlike the example in Chapter 3, the quantity changes in maize are not reflected in a change in net trade, but rather the market equilibrates through price adjustment. The shifts in the maize demand and supply curves induce an increase in the price of maize, and an increase *or* decrease in the quantities demanded and supplied. (The direction of the change in quantities depends on the slopes of the supply and demand curves - the own price elasticities, and the magnitude of the shifts in the curves - the cross-price elasticities.)

The increase in the maize price, in turn, sets in motion a *feedback* effect on the rice market. The new higher price of maize increases the relative profitability of producing maize and consequently, producers will shift back into maize production and away from rice.[18] This feedback effect is represented by a leftward shift in the rice supply curve from S_s to S_{s1}, decreasing

[18] The magnitude of a single feedback effect will be always less than the magnitude of the original direct effect that brought it about; otherwise the system will never reach a new equilibrium.

supply to S_2. Because the two commodities are also consumption substitutes, a similar feedback effect occurs in the consumption side, represented in Figure 4.1 by a rightward shift in the rice demand curve from D_s to D_{s1}, increasing consumption to D_2. This process continues until both markets reach a new equilibrium.

From this discussion it should now be clear that the key difference between an indirect effect and a feedback effect is that the former occurs in the market for the alternative commodity, and latter occurs in the original commodity market facing the exogenous price change. Both effects, however, result from the cross price linkages between the two commodities.

MATHEMATICAL REPRESENTATION OF A MULTI-MARKET MODEL

To illustrate these ideas mathematically, consider the familiar set of commodity equations derived in 3.1-3.2. They are reproduced in Equation 4.1 with one exception: the possibility for trade adjustment has been removed from the market clearing equation for maize. Imports and exports are not a way in which the maize market can adjust to changes in either price or quantity.[19]

$$
\begin{aligned}
S_r &= a + bP_r^p + cP_m^p && \textit{Supply of rice} \\
D_r &= d + eP_r^c + fP_m^c && \textit{Demand for rice} \\
S_m &= g + hP_m^p + iP_r^p && \textit{Supply of maize} \\
D_m &= j + kP_m^c + lP_r^c && \textit{Demand for maize} \\
S_r + M_r &= D_r && \textit{Market clearing for rice} \\
S_m &= D_m && \textit{Market clearing for maize}
\end{aligned}
\tag{4.1}
$$

Using the difference quotient notation, the relevant equations for examining the impact of a change in the price of rice are:

$$
\begin{aligned}
\Delta S_{rr} + \Delta S_{rm} + \Delta M_r &= \Delta D_{rr} + \Delta D_{rm} && \textit{Market clearing for rice} \\
\Delta S_{rm} + \Delta S_{mr} &= \Delta D_{mm} + \Delta D_{mr} && \textit{Market clearing for maize}
\end{aligned}
\tag{4.2}
$$

where ΔS_{rr} denotes the ΔS_r due to a change in P_r, ΔS_{rm} is the ΔS_r due to a change in P_m, etc.

Equation 4.3 shows the equilibrium conditions in the *change* form of the supply and demand

[19]See also footnote 12, Chapter 3.

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schedules for rice.[20] Note that the change form for each element of a market-clearing condition is *always* comprised of three elements: 1) the elasticity for the initial quantity and price variables; 2) the initial quantity corresponding to the element in the market-clearing condition; and 3) a relative change in an exogenous or endogenous price variable. The first equation in brackets is equal to ΔS_{rr}, the second element is equal to ΔS_{rm} and so on.

$$\left[\epsilon_{rr} \times S_{ro} \times \frac{\Delta P_{ro}}{P_{ro}}\right] + \left[\epsilon_{rm} \times S_{ro} \times \frac{\Delta P_{mo}}{P_{mo}}\right] + M_{ro} \times \frac{\Delta M_{ro}}{M_{ro}} \tag{4.3}$$

$$= \left[\eta_{rr} \times D_{ro} \times \frac{\Delta P_{ro}}{P_{ro}}\right] + \left[\eta_{rm} \times D_{ro} \times \frac{\Delta P_{mo}}{P_{mo}}\right]$$

Rearranging (4.3) so that the endogenous variables P_m and M_r (and the terms related to them) are on the left, and the exogenous variable P_r and its terms is on the right gives:

$$(S_{ro}\,\epsilon_{rm} - D_{ro}\,\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} = (D_{ro}\,\eta_{rr} - S_{ro}\,\epsilon_{rr})\frac{\Delta P_{ro}}{P_{ro}} \tag{4.4}$$

The market equilibrium equation for maize (Equation 4.5) is slightly different from rice. As noted above, it has been defined as a nontradable and hence it does not include the variable M, net imports. Arranging the equation so that the exogenous variables are on the right and endogenous variables on the left gives:

$$(S_{mo}\,\epsilon_{mm} - D_{mo}\,\eta_{mm})\frac{\Delta P_{mo}}{P_{mo}} = (D_{mo}\,\eta_{mr} - S_{mo}\,\epsilon_{mr})\frac{\Delta P_{ro}}{P_{ro}} \tag{4.5}$$

To solve this simultaneous equation system, arrange equations 4.4 and 4.5 in matrix form as follows:

---

[20] Equation 4.3 is derived by totally differentiating the market-clearing condition for rice and converting the result to elasticities. See Pagiola, op. cit., p. 4, for an example of how this is done. Knowledge of calculus is not required to complete the exercises in this volume.

$$\begin{bmatrix} (S_{ro}\epsilon_{rm} - D_{ro}\eta_{rm}) & M_{ro} \\ (S_{mo}\ \epsilon_{mm} - D_{mo}\ \eta_{mm}) & 0 \end{bmatrix} \begin{bmatrix} \Delta P_{mo}/P_{mo} \\ \Delta M_{ro}/M_{ro} \end{bmatrix} = \begin{bmatrix} (D_{ro}\eta_{rr} - S_{ro}\epsilon_{rr}) \\ (D_{mo}\eta_{mr} - S_{mo}\epsilon_{mr}) \end{bmatrix} \frac{\Delta P_{ro}}{P_{ro}} \quad (4.6)$$

The next step is to solve this set of equations for the unknowns, $\Delta M_{ro}/M_{ro}$ and $\Delta P_{mo}/P_{mo}$. The solution method takes advantage of the ability of all spreadsheets to invert and multiply matrices. The next section provides a step-by-step example using Lotus 1-2-3.

SOLVING SIMULTANEOUS EQUATIONS BY MATRIX INVERSION

The use of the matrix inversion capabilities of spreadsheet programs is illustrated below using a simple example. The problem is to find the values of x and y that are a solution to the following equations:

$$\begin{aligned} 2x + 3y &= 31 \\ x + 2y &= 19 \end{aligned} \quad (4.7)$$

Step 1:

Open a *new* spreadsheet and call it CHAPT4.WK1. Write the equations in matrix form in the upper left had corner of this new spreadsheet. This is done by separating the coefficients from the variables and writing them as a matrix product. The product of the *coefficient* (G) matrix times the *variable* matrix is equal to the matrix (U) of exogenous *constants*.

$$\begin{bmatrix} 2 & 3 \\ 1 & 2 \end{bmatrix} \times \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 31 \\ 19 \end{bmatrix} \quad (4.8)$$

The Lotus screen showing the coefficient matrix is shown in Table 4.1. Type in the coefficient matrix on the spreadsheet.

Step 2:

Invert the coefficient matrix.

1. Select /Data Matrix Invert
2. Specify the range of the coefficient matrix

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Table 4.1: Matrix Inversion Using Lotus 1-2-3

	A	B	C	D
1)	Simultaneous Equation Solution			
2)	----------			
3)	Coef. Matrix (G):		2	3
4)			1	2
5)				
7)	Constants Matrix (U):			31
8)				19
9)	Inverse (G) Matrix:			
10)			2	-3
11)			-1	2
12)	Solution Matrix:			
13)				5
14)				7

3. Specify the output range, i.e., the range in which you want Lotus to put the output. In Table 4.1, this is the range shown next to the "Inverse (G) Matrix".

Step 3:

Once the inverse of the G matrix has been obtained, it remains only to multiply the inverse by the vector of exogenous constants to obtain the values of x and y that are solutions to the two equations given earlier. To multiply matrices in Lotus:

1. Select /Data Matrix Multiply

2. Specify the first range to be multiplied. The first range is the inverse G matrix.

3. Specify the second range to be multiplied. The second range is the "Constants" U vector .

4. Specify the output range (the range where 1-2-3 is to enter the results of the multiplication). In this problem, the range is the "Solution Matrix" block. The solution can be checked by inserting the values of the solution matrix in Equations 4.7.

This simple three step process will be used to solve the multi-market problem described earlier.

SOLVING THE MULTI-MARKET PROBLEM

The exercises in this section continue with the analysis of rice and maize. The only new assumption is that maize is now considered a nontradable.

Step 1:

Set up a new worksheet identical to the one shown in Table 4.2. (Be sure that the position of the worksheet is as shown in Table 4.2; otherwise the cell addresses of the formulas given below will not correspond to the worksheet.) The data are the initial quantities, prices and elasticities. Enter these data directly.

Table 4.2: Basic Two-Commodity Multi-Market Model

	F	G	H	I	J	K
16)	Basic Two-Commodity Multi-Market Model					
17)	==========					
18)	INITIAL QUANTITIES:			ELASTICITIES:		
19)	Commodity:	Rice	Maize		Rice	Maize
20)	Supply	22	29	Supply		
21)	Demand	35	29	Pr	0.74615	-0.2
22)	Imports	13	0	Pm	-0.2	0.7
23)						
24)	INITIAL PRICES:			Demand		
25)		Rice	Maize	Pr	-0.62308	0.1
26)	Domestic	231.80	266.00	Pm	0.1	-0.6
27)	Border	231.80	266.00			
28)						
29)	MATRICES:					
30)		G Matrix		U Matrix		Inverse G Matrix
31)	-7.9	13		-38.2	0.00	0.03
32)	37.7	0		8.7	0.08	0.02
33)						
34)	Solution Matrix					
35)	0.23					
36)	-2.80					
37)						
38)	POLICY CHANGE:	% Change in Exogenous Variables				
39)						
40)	Pr	10.00				
41)						
42)	OUTCOME:					
43)	% Change in Endogenous Variables			New Levels of Endogenous Variables		
44)	Pm	2.31		Pm	272.14	
45)	Sr	7.00		Sr	23.54	
46)	Sm	-0.38		Sm	28.89	
47)	Dr	-6.00		Dr	32.90	
48)	Dm	-0.38		Dm	28.89	
49)	Mr	-28.00		Mr	9.36	

Step 2:

Produce the matrices of coefficients and constants with formulas which use the cell addresses of the initial data. The coefficient matrix is the "G" matrix. It consists of the coefficients of the variables associated with the left hand side of the matrix equation 4.6. Table 4.3 gives the elements

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of the matrix and the cell addresses from which they were derived. (The cell addresses shown in Table 4.3 may differ significantly if the worksheet has not been organized identically to the one shown in Table 4.2.) The construction of the exogenous constants matrix U is shown in Table 4.4.

Table 4.3: The Coefficient Matrix

G Matrix			
Elements:		Formulas:	
-7.9	13	(G20*J22) - (G21*J26)	G22
37.7	0	(H20*K22) - (H21*K26)	0

Step 3:

Invert the G matrix and display the output in the area below the Inverse G Matrix subheading.

Step 4:

Multiply Inverse G times U to obtain the percentage changes in P_m and M_r that are consistent with a given percentage change in P_r. The result should be placed below the Solution Matrix subheading. Table 4.5 explains that the first element of the solution matrix is the % change in P_m divided by the % change in P_r and the second element is the % change in M_r divided by the % change in P_r.

Table 4.4: Constants Matrix

U Matrix	
Elements:	Formulas:
-38.2	(G21*J25) - (G20*J21)
8.7	(H21*K25) - (H20*K21)

Table 4.5: Solution Matrix

Solution Matrix:	
Elements:	Definition
0.23	$\%\Delta P_m$ / $\%\Delta P_r$
-2.80	$\%\Delta M_s$ / $\%\Delta P_r$

Step 5:

The policy under consideration is a 10% tariff on the price of rice to both consumers and producers. Type in 10 below the POLICY CHANGE heading.

Step 6:

Under the OUTCOME heading, create the appropriate formulas in the "% Change in Endogenous Variables" portion of the table to relate the percentage change in P_{ro} to the endogenous variables. An explanation of some of the calculations is given below and the necessary formulas to make these calculations are given in Table 4.6.

1. The formula for the percentage change in P_{mo} is the first element in the Solution matrix times the percentage change in P_{ro}.

$$\frac{\Delta S_{ro}}{S_{ro}} = \left[\varepsilon_{rr} \times \frac{\Delta P_{ro}}{P_{ro}}\right] + \left[\varepsilon_{rm} \times \frac{\Delta P_{mo}}{P_{mo}}\right] \tag{4.9}$$

2. The formula for the percentage change in S_{ro} is given by Equation 4.9 shown below. This equation is nothing more than the first two elements of equation 4.3 divided by S_{ro} so that the result calculates percentage changes. Equation 4.9 states that the percentage change in S_{ro} is equal to the own partial price elasticity of supply of rice times the percentage change in P_{ro}, plus the cross price elasticity of the supply of rice with respect to the price of maize times the percentage change in P_{mo}. The percentage change in the other supply and demand variables is derived in exactly the same way.

Table 4.6: Calculating Policy Effects

EFFECTS:	% Change in Endogenous Variables	
Pm	2.31	+F35*G40
Sr	7.00	(J21*G40) + (J22*G44)
Sm	-0.38	(K22*G44) + (K21*G40)
Dr	-6.00	(J25*G40) + (J26*G44)
Dm	-0.38	(K26*G44) + (K25*G40)
Mr	-28.00	+F36*G40

3. The value for the percentage change in net imports is computed by multiplying the second element of the Solution matrix times the percentage change in P_{ro}.

Step 7:

The final step that completes the multi-market solution is to update all of the original initial

variables to reflect the changes that have occured. This computation is exactly like the computation done for the single commodity case when the values of the initial conditions are multiplied by (1 + (percentage change/100)) to arrive at the new levels for the endogenous variables. Once these steps have been completed, the worksheet should now contain the results found in Table 4.2.

ANALYZING THE RESULTS

The exercise just completed is similar to the tariff policy intervention exercise performed in Chapter 2 since the quantity changes in the rice market are identical in both cases. (Compare the results of Table 4.2 with the last column of Table 2.1.) This may appear paradoxical given that the above exercise now includes maize. Yet, in this case, both the the single and multi-market models return the same results precisely because the single commodity exercise in Chapter 2 employs *total* price elasticities of supply and demand for rice which, by construction, already capture the feedback effects from the maize market.

To see this more clearly, consider equation 4.10 which is Equation 4.9 after dividing by the percentage change in P_{ro}. The term on the left hand side of the equation *is* the total price elasticity of supply of rice. Equation 4.10 says that this total elasticity is equal to the partial price elasticity of supply of rice plus a term incorporating the cross price elasticity of supply between rice and maize and the relative percentage change in the two prices. Of course, if P_m is held constant (i.e. is equal to zero in the equation), then the total supply elasticity is equal to the own partial elasticity. Likewise, if there are no cross price interactions between maize and rice, the total elasticity will again be equal to the partial elasticity.

$$\frac{\dfrac{\Delta S_{ro}}{S_{ro}}}{\dfrac{\Delta P_{ro}}{P_{ro}}} = \varepsilon_{rr} + \left[\varepsilon_{rm} \times \frac{\dfrac{\Delta P_{mo}}{P_{mo}}}{\dfrac{\Delta P_{ro}}{P_{ro}}} \right] \tag{4.10}$$

The total price elasticities of supply and demand for rice used in Chapter 2 were derived using Equation 4.10 Hence, the use of a single total elasticity in a one commodity exercise is equivalent to the joint use of the partial and cross price elasticities in a multi-market exercise. By construction, the total elasticities aggregate the information contained in the set of own and cross price elasticities. The only additional information obtained from a multi-market model is the impact of changes in the rice market on the supply, demand and price of maize. The importance of this additional information should not be overlooked. Decision-makers are likely to be equally interested in the multi-market effects of commodity policy, especially if the linked markets are basic staple crops or important foreign exchange earners.

Suppose only the partial own price elasticities of supply and demand for rice are available. This problem occurs frequently due to the fact that many governments have traditionally intervened in

agricultural markets to hold relative prices constant. If so, then reliable statistically estimated cross price elasticity estimates will not be available.[21] A good example is Mexican maize and rice policy. Out of a concern for food security, the Mexican government has traditionally held the relative price between maize (the country's main food staple) and sorghum (used exclusively as a feedgrain) roughly constant to balance production and therefore imports of the two commodities.

The magnitude of the error in using only the partial own-price supply and demand elasticities can be seen by returning to the basic two commodity model developed above. Set all cross price elasticities to zero and repeat the matrix inversion and multiplication steps.[22] Comparison of these results with those which include the cross price elasticities demonstrates the following: if two commodities are production and consumption substitutes, then failure to incorporate multi-market effects will lead to an *overestimation* of the impact a price increase has on the quantities produced of the commodity under analysis, and an underestimation of the quantities consumed. The degree of bias depends, of course, on the size of the own and cross price elasticities.

GENERATING MULTIPLE SOLUTIONS

One form of sensitivity analysis is to vary P_r. Varying the percentage change in the exogenous variable does not require reinverting the matrix because an exogenous parameter is not a matrix element. It is therefore possible to display multiple solutions generated by different values of this parameter. This is achieved through the use of absolute cell addresses.

To proceed, first *reset the cross price elasticities to their original values and repeat the matrix inversion routine*. Then copy the exercise just completed down and to the right of itself. Using the Range/Name/Create command, name this new model "Multiple". Then change the name of the table to "Multiple Solutions to the Basic Two Commodity Multi-Market Model" as shown in Table 4.7.

Recall the series of formulas used to calculate the *percentage changes* in the endogenous variables resulting from the exogenous price change. Each of these formulas references initial data, the parameter being changed, P_{ro}, and the endogenous price parameter, P_{mo}. Return to the first of these formulas in the multi-market exercise and press the F2 *edit* key. Then use the F4 key to change all the cell addresses which reference *initial data* from relative addresses to absolute addresses. For example, the modified formula to calculate the percentage change in P_{mo} should be +$N$73*078. The percentage change in S_{ro} should now be ($R$59*078)+($R$60*083). Note that both of the prices remain relative cell addresses. Continue with this process for the remaining

[21] In this case, the only way to generate cross price elasticity estimates is via mathematical programming models similar to those developed in Volume III of this series.

[22] See the section on Lotus macros and sensitivity analysis on how to automate the matrix inversion routine.

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Table 4.7: Generating Multiple Solutions

N	O	P	Q	R	S
54) Multiple Solutions to the Basic Two Commodity Multi-Market Model					
55) ==========					
56) INITIAL QUANTITIES:				ELASTICITIES:	
57) Commodity:	Rice	Maize		Rice	Maize
58) Supply	22	29	Supply		
59) Demand	35	29	Pr	0.74615	-0.2
60) Imports	13	0	Pm	-0.2	0.7
61)					
62) INITIAL PRICES:			Demand		
63)	Rice	Maize	Pr	-0.62308	0.1
64) Domestic	231.80	266.00	Pm	0.1	-0.6
65) Border	231.80	266.00			
66)					
67) MATRICES:					
68) G Matrix			U Matrix	Inverse G Matrix	
69) -7.9	13		-38.2	0.00	0.03
70) 37.7	0		8.7	0.08	0.02
71)					
72) Solution Matrix					
73) 0.23					
74) -2.80					
75)					
76) POLICY CHANGE:	% Change in Exogenous Variables				
77)					
78) Pr	10.00	8.00			
79)					
80) OUTCOME:					
81) % Change in Endogenous Variables			New Levels of Endogeneous Variables		
82)					
83) Pm	2.31	1.85	Pm	272.14	270.91
84) Sr	7.00	5.60	Sr	23.54	23.23
85) Sm	-0.38	-0.31	Sm	28.89	28.91
86) Dr	-6.00	-4.80	Dr	32.90	33.32
87) Dm	-0.38	-0.31	Dm	28.89	28.91
88) Mr	-28.00	-22.40	Mr	9.36	10.09

formulas in the section. Then repeat the process in the following section which calculates the *new levels* of the endogenous variables by making all of the *initial* prices and quantities absolute addresses.

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Return to the section indicating the percentage change in the exogenous variables. Type in a different value for this parameter next to the original. (The value 8 is used in Table 4.7.) Then copy all of the modified formulas under the "% change" and "new level" subheadings to the column directly to the right. The new formulas will automatically make the correct calculations. The worksheet should now be identical to the one shown in Table 4.7.

LOTUS MACROS AND SENSITIVITY ANALYSIS

As noted earlier, once any of the original quantity and elasticity assumptions are changed, the coefficient matrix must be reinverted. In some spreadsheets, notably Microsoft's *Excel*, the invert command is a function and hence any time new data are entered, the matrix is reinverted automatically. However, in spreadsheets such as Lotus 1-2-3 (all versions), Quattro Pro and Supercalc, this computation cannot be automated except by creating a macro which can be run after the data are changed to produce the new solution. Because all other values have been created by formulas, the values for the percentage changes in endogenous variables and the new levels of endogenous variables will be calculated automatically.

A macro is a group of cells constaining a series of Lotus commands. The commands recorded in these cells are performed by Lotus whenever the macro is invoked by pressing the Alt key and a one-letter name assigned to the macro. With a macro, repetitive tasks that would otherwise require several keystrokes can be performed by pressing a simple two-key combination.

Creating an "Invert/Multiply" Macro

A macro that automates the matrix inversion and multiplication routine in the multi-market exercise is shown in Table 4.8. To create this macro, move the cursor to an empty cell to the right of the Multiple Solution exercise just completed. Type in the entire contents of Table 4.8. The "Invert Matrix Macro" heading is a descriptor of the macro to be written. \I is the macro identifier and the one letter name assigned to the macro.

Table 4.8: Matrix Inversion Macro

MACRO DESCRIPTION	KEY	COMMAND
Invert Matrix Macro	'\I	'/DMIN69..O70~ R69..S70~ '/DMMR69..S70~ Q69..Q70~ N73..N74~

The command lines are merely the sequence of keystrokes one would manually type to invert and multiply the matrices of the multi-market model. Thus the first command line contains the Lotus keystrokes */Data/Matrix /Invert* and then a range identifying the cell addresses of the coefficient matrix in the multi-market model table. The apostrophe keeps the command */Data/Matrix/Invert* from actually being executed as it is entered into the cell. The tilde is a special macro symbol that

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stands for the *enter* key on the keyboard and should be used in a Macro each time one would have manually pressed the enter key.

The second line is the range identifying the cell addresses where the inverted matrix is to be placed. The third line contains the keystrokes */Data/Matrix/Multiply* and the range of the first matrix to be multiplied. The final two lines indicate the range of the second matrix to be multiplied and the range where the final solution matrix result should be placed.

Once the macro is written, use the /Range/Name/Create command to assign the name "/I" to the first cell of the range where the macro keystrokes are located. To invoke the macro, move the cursor to any empty cell of the worksheet, hold down the Alt key and then press the letter corresponding to the name given the macro.

With a macro, it is now very simple to perform sensitivity analyses on parameters such as elasticities that form part of the G matrix. Return to the "Multiple Solutions" exercise just completed and increase the own price elasticity of supply to 1.2. How do the new results differ from the original?

CHAPTER 5: EXTENDING THE MULTI-MARKET MODEL

Chapter 5 builds on the multi-market model developed in Chapter 4 by demonstrating how the basic framework can be adapted to a variety of situations and policy choices.

The chapter is divided into five sections, the first four illustrating a basic extension to the two commodity model. The exercises are organized in an order of increasing difficulty. The first illustrates how the model can be adapted to explicitly analyze alternative policy instruments such as import quotas. The following two exercises show how to enlarge the model to include additional commodities and to reflect regional differences. A fourth exercise returns to the issue of policy instruments and explains how to incorporate a differential price policy between producers and consumers. The final exercise combines all of the above extensions to form a three commodity, two-region multi-market model with differential taxes.

These exercises illustrate only a few of the extensions that can be made to multi-market models, yet a solid understanding of the above extensions should enable the user to proceed directly to constructing small models reflecting real world situations.[23] The only difficulty lies in writing down the equilibrium market conditions correctly and in such a way that the G and U matrices can be constructed. Before proceeding, the mathematical representation of the basic model in Chapter 4 should be reviewed and understood.

QUANTITATIVE RESTRICTIONS

In the basic model in Chapter 4, the price of rice is considered to be exogenous. Such a formulation is appropriate when a government taxes producers of the commodity and controls imports to meet domestic demand. In other situations, a government may be more directly concerned about the foreign exchange costs of importing, or wish to subsidize producers by restricting imports to a fixed level, allowing the domestic price to increase to equate supply with demand. The appropriate way to model import restrictions is to consider imports the policy variable, and allow prices to vary endogenously.

The basic two commodity model is easily adapted to analyze quantitative restrictions by rearranging the market-clearing condition for rice and entering the new G and U matrices in the appropriate blocks. The new G matrix is then reinverted and multiplied by the new U matrix to provide the final solution matrix. Indeed, this is the basic pattern behind almost every kind of extension to a multi-market model.

Each of the four basic exercises in this chapter begins with the basic model constructed in Chapter 4. For convenience, the market-clearing conditions in the change form of the supply and demand schedules for both commodities are repeated below.

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[23] Additional extensions are detailed in Pagiola, op. cit., pp.8-13.

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$$(S_{ro}\varepsilon_{rm} - D_{ro}\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} = (D_{ro}\eta_{rr} - S_{ro}\varepsilon_{rr})\frac{\Delta P_{ro}}{P_{ro}} \tag{5.1}$$

$$(S_{mo}\ \varepsilon_{mm} - D_{mo}\ \eta_{mm})\frac{\Delta P_{mo}}{P_{mo}} = (D_{mo}\eta_{mr} - S_{mo}\ \varepsilon_{mr})\frac{\Delta P_{ro}}{P_{ro}} \tag{5.2}$$

Step 1:

Copy the contents of the file entitled CHAPT4.WK1 to a new file. Call this new file Chapt5.WK1. Copy the basic market model down and to the right of itself. (This will overwrite table 4.7 that displays multiple solutions to the basic model.) Using the Range/Name/Create command, call this new model "Quantity" and change the name of the table to "Quantity Constrained Two Commodity Model"

Step 2:

On a separate piece of paper, write down the market-clearing equation for rice (equation 5.1). Since M_r is now the policy parameter, rearrange this equation so that both price variables (and their related terms) are on the left-hand side, and the import variable M_{ro} and its related terms are on the right-hand side.

Step 3:

Combine this new equation with the market-clearing equation for maize (equation 5.2 rearranged so that P_{ro} is also on the left-hand side) in matrix form. (Refer to Equation 4.6 if this procedure is not clear.) The first element in the G matrix should be the coefficient of$\Delta P_{mo}/P_{mo}$ from the rice market-clearing equation. (This is not necessary in order to solve the model correctly, but by keeping to this order, the remaining instructions will be easier to follow.) Enter the formulas to calculate the elements of both the G and U matrices using the cell addresses of the initial data. If this step has been followed correctly, the formula for the bottom right-hand element of the G matrix should be:

$$S_{mo}\varepsilon_{mr} - D_{mo}\eta_{mr} \tag{5.3}$$

Step 4:

Replace M_r for P_r under the POLICY CHANGE subheading. The policy under consideration is a 28.00% *reduction* in rice imports from 13,000 mt. per year to 9,360 mt. per year. (The

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Table 5.1: Quantity Constrained Two-Commodity Model

	N	O	P	Q	R	S
54)	Quantity Constrained Two-Commodity Model					
55)	==========					
56)	INITIAL QUANTITIES:				ELASTICITIES:	
57)	Commodity:	Rice	Maize		Rice	Maize
58)	Supply	22	29	Supply		
59)	Demand	35	29	Pr	0.74615	-0.2
60)	Imports	13	0	Pm	-0.2	0.7
61)						
62)	INITIAL PRICES:			Demand		
63)		Rice	Maize	Pr	-0.62308	0.1
64)	Domestic	231.80	266.00	Pm	0.1	-0.6
65)	Border	231.80	266.00			
66)						
67)	MATRICES:					
68)	G Matrix			U Matrix	Inverse G Matrix	
69)	-7.9	38.2		-13.0	0.0063	0.03
70)	37.7	-8.7		0.0	0.0275	0.01
71)						
72)	Solution Matrix					
73)	-0.08					
74)	-0.36					
75)						
76)	POLICY CHANGE: % Change in Exogenous Variables					
77)						
78)	Mr	-28.00				
79)						
80)	OUTCOME:					
81)	% Change in Endogenous Variables			New Levels of Endogeneous Variables		
82)						
83)	Pm	2.31		Pm	272.14	
84)	Pr	10.00		Pr	254.98	
85)	Sr	7.00		Sr	23.54	
86)	Sm	-0.38		Sm	28.89	
87)	Dr	-6.00		Dr	32.90	
88)	Dm	-0.38		Dm	28.89	

percentage change in imports should be typed in directly.)

Step 5:

Insert a row just after P_m under the "% Change" block. Type in P_r. Also type in P_r in the

following block that calculates the new levels of the endogenous variables. Then eliminate M_r from both columns

Step 6:

Enter the appropriate formula to calculate the percentage change in P_{ro}. This formula is the second element of the Solution Matrix multiplied by the percentage change in the exogenous variable. Also enter the formula to calculate the new level of P_r. (Recall that a new level of a variable is always calculated as the initial value multiplied by [1 + (percentage change/100)].) Then modify all remaining formulas under the "% Change" subheading so that each formula references the new location for P_r.

Step 7:

The remaining step is, of course, to reinvert the new G matrix. One way to do so is to return to the macro located near the upper left-hand corner of the spreadsheet. Edit the macro by entering the ranges which reference the matrices in the *current* table. Then simply invoke the macro. Alternatively, the macro can be inverted manually.

If the above steps have been followed correctly, the results should be identical to those calculated in Chapter 4 and listed in Table 4.2. An import quota that reduces rice imports by 28.00%, raises the domestic price of rice by 10%. Because maize and rice are both production and consumption substitutes, the rice price increase induces an increase in the price of maize and a slight decrease in maize consumption and production.

ENLARGING THE TWO-COMMODITY MODEL

Additional Commodities

In most countries, farmers grow several crops on the same type of land, and even during the same season, in order to diversify their risk. On the demand side, empirical analysis has shown that consumers prefer a varied diet and respond rapidly to changes in relative food prices. In short, there are potentially a large number of multi-market interactions in agriculture, the skill of the analyst is to select those interactions thought to be most relevant to the policy change under consideration. Incorporating several livestock markets in an analysis of feedgrain price changes is an example of a case where it might be important to include these additional markets.

The following exercise shows how the two commodity model can be enlarged to incorporate a third commodity, beans. In this exercise, maize and beans are modeled as production complements because they are often intercropped. They are also modeled as consumption complements since they are often consumed together. While rice and beans are substitutes in production, they are neither consumption complements or substitutes since livestock users would not consider the price of beans in formulating their livestock rations.

Step 1:

Copy the *original* two commodity model (not the exercise just completed) down and to the right of the exercise just completed. Using the Range/Name/Create command, name this new model "Three". Then change the name of the table to "Three Commodity Multi-Market Model".

Step 2:

Insert a new column just after the initial quantity data and a new row after the supply elasticities block. Then enter the initial data for beans as shown in Table 5.1. Beans is a nontradable commodity and so, like maize, its price is endogenous to the system.

Step 3:

The market-clearing equation for beans is given in equation 5.4. shown below. Note that P_{ro} does not appear on the demand side since rice and beans are neither consumption complements

$$S_{bo}\varepsilon_{bb}\frac{\Delta P_{bo}}{P_{bo}} + S_{bo}\varepsilon_{bm}\frac{\Delta P_{mo}}{P_{mo}} + S_{bo}\varepsilon_{br}\frac{\Delta P_{ro}}{P_{ro}} = D_{bo}\eta_{bb}\frac{\Delta P_{bo}}{P_{bo}} + D_{bo}\eta_{bm}\frac{\Delta P_{mo}}{P_{mo}} \qquad (5.4)$$

nor substitutes. On a separate piece of paper, arrange this equation so that the endogenous variables and their related terms are on the left-hand side and the exogenous variable, P_{ro} and its related terms, is on the right-hand side, and then collect terms.

Step 4:

A term which incorporates the impact of a change in the price of beans on the supply and demand for maize, and the supply for rice, must be added to the rice and maize market-clearing equations. The new market-clearing equation for rice is given in equation 5.5.

$$\begin{aligned}(S_{ro}\varepsilon_{rm} - D_{ro}\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + S_{ro}\varepsilon_{rb}\frac{\Delta P_{bo}}{P_{bo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} \\ = (D_{ro}\eta_{rr} - S_{ro}\varepsilon_{rr})\frac{\Delta P_{ro}}{P_{ro}}\end{aligned} \qquad (5.5)$$

Write down the market-clearing equation for maize and then add the appropriate cross-price terms for beans to *both* the supply and demand sides, i.e., add ($S_{mo}\varepsilon_{mb}\Delta P_{bo}/P_{bo}$) to the supply side of the market-clearing equation of maize and ($D_{mo}\eta_{mb}\Delta P_{bo}/P_{bo}$) to the demand side. Finally, collect terms

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and arrange this equation so that the endogenous variables are on the left-hand side and the exogenous variable, P_{so}, is on the right-hand side.

Table 5.2: Three-Commodity Model

	U	V	W	X	Y	Z	AA	AB	AC
90)	Basic Three-Commodity Multi-Market Model								
91)	==========								
92)	INITIAL QUANTITIES:						ELASTICITIES:		
93)	Commodity:	Rice	Maize	Beans			Rice	Maize	Beans
94)	Supply	22	29	10		Supply			
95)	Demand	35	29	10		Pr	0.746	-0.2	-0.3
96)	Imports	13	0	0		Pm	-0.2	0.7	0.2
97)						Pb	-0.3	0.2	0.4
98)									
99)	INITIAL PRICES:					Demand			
100)		Rice	Maize	Beans		Pr	-0.623	0.1	0
101)	Domestic	231.80	266.00	400		Pm	0.1	-0.6	-0.2
102)	Border	231.80	266.00	400		Pb	0	-0.2	-0.3
103)									
104)	MATRICES:								
105)		G Matrix			U Matrix		Inverse G Matrix		
106)									
107)	-7.9	13	-6.6		-38.22		0.00	0.03	-0.05
108)	37.7	0	11.6		8.70		0.08	0.01	0.07
109)	4	0	7		3.00		0.00	-0.02	0.17
110)	Solution Matrix								
111)	0.12								
112)	-2.68								
113)	0.36								
114)	POLICY CHANGE: % Change in Exogenous Variables								
115)									
116)	Pr	10.00							
117)									
118)	OUTCOME:								
119)	% Change in Endogenous Variables				New Levels of Endogenous Variables				
120)	Pm		1.20		Pm		269.19		
121)	Pb		3.60		Pb		414.40		
122)	Sr		6.14		Sr		23.35		
123)	Sm		-0.44		Sm		28.87		
124)	Dr		-6.11		Dr		32.86		
125)	Dm		-0.44		Dm		28.87		
126)	Mr		-26.85		Mr		9.51		
127)	Sb		-1.32		Sb		9.87		
128)	Db		-1.32		Db		9.87		

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Step 5:

Arrange the three market clearing equations in matrix form. The first equation in the G matrix should be rice, the second, maize, and the third, beans. The resulting G matrix is now a (3x3) matrix and the U matrix is a (3x1) matrix. Enter the formulas to calculate the additional elements of the G and U matrices using the cell addresses of the original data. (It may be necessary to insert a new row just below the G matrix to accommodate the additional elements.)

Step 6:

The policy change under consideration remains a 10% increase in the price of rice to both consumers and producers so no changes are required to the POLICY CHANGE block. Move to the "% Change" block of the table and insert three rows, one just below P_m, the other two just below the last entry, M_r. Type P_b in the first blank row, and S_b and D_b in the remaining two new rows for both the "% Change" and "New Levels" blocks. (See Table 5.1.)

Step 7:

Enter the formulas that calculate the percentage changes in P_{bo}, S_{bo} and D_{bo}. For example, the new equation to calculate the percentage change in S_{bo} is given in equation 5.6. Also, P_{bo} is calculated as the third element of the solution matrix times the percentage change in P_{ro}. Then edit the remaining formulas in this block so that they also include the impact of a change in the price of beans.

$$\frac{\Delta S_{bo}}{S_{bo}} = \varepsilon_{bb}\frac{\Delta P_{bo}}{P_{bo}} + \varepsilon_{br}\frac{\Delta P_{ro}}{P_{ro}} + \varepsilon_{bm}\frac{\Delta P_{mo}}{P_{mo}} \tag{5.6}$$

Step 8:

Enter the formulas to calculate the new levels of P_b, S_b, and D_b. Then edit the remaining formulas as required so that they reference the appropriate initial quantities and percentage change values.

Step 9:

Invert the new G matrix either manually or by editing the Invert Matrix macro. (Do not forget to multiply the inverted matrix by the new U matrix if the G matrix is inverted manually.) The correct answers to this exercise are shown in Table 5.1. (In the absence of answers, the model can be checked by setting all cross-price elasticities between beans and the other two commodities to zero and reinverting the matrix. The result should be identical to the basic model.)

The results indicate that incorporating beans into the model reduces the supply response of rice

to the price change and increases the demand response. As a result, rice imports decline only by 26.85%, rather than 28.0% as calculated in the model without beans. The addition of beans to the model also slightly increases the impact of the rice price increase on the maize market.

These results are due to the complex linkages between the three commodities and their competition for factors of production and consumers preferences. Even a simple three commodity model illustrates that these interactions are often impossible to predict without a formal framework, since they depend on the relative magnitudes of all of the elasticities as well as on their signs. Multi-market analysis provides a framework for estimating these endogenous changes in a consistent manner.

ADDITIONAL REGIONS

Very often, decision-makers are concerned with the regional implications of policy change. Regional distinctions are also important if the commodity is grown under a wide range of agroclimatic conditions and so the response to policy may differ significantly by region. In this case, a sound approach is to divide the country into regions and estimate the impact of changes in policy by region.

The following exercise shows how to adapt a multi-market model to analyze the regional impacts of policy. In the exercise, the country is divided into two regions, both of which produce and consume rice and maize. Thus, there is a supply and demand curve for both commodities in both regions. The total amount supplied and demanded for a particular commodity is the sum of the amount supplied and demanded in each of the regions. The market-clearing equation for rice is therefore $S_r^1 + S_r^2 + M_r = D_r^1 + D_r^2$. Regional demand does not have to equal regional supply either before or after the policy change. In other words, the two regions can trade.

An important assumption of this exercise is that there are no costs associated with transporting a commodity from one region to another. Consequently, there is only one price for each commodity and each region produces, consumes and trades at that price. Figure 5.1 illustrates the market for rice *before* the policy change.

Step 1:

Copy the *original* two commodity model down and to the right of the three commodity model just completed. Using the Range/Name/Create command, name this new table "Regional". Then change the name of the table to "Regional Two Commodity Multi-Market Model".

Step 2:

Insert one new column just after the final column of the table and several new rows to

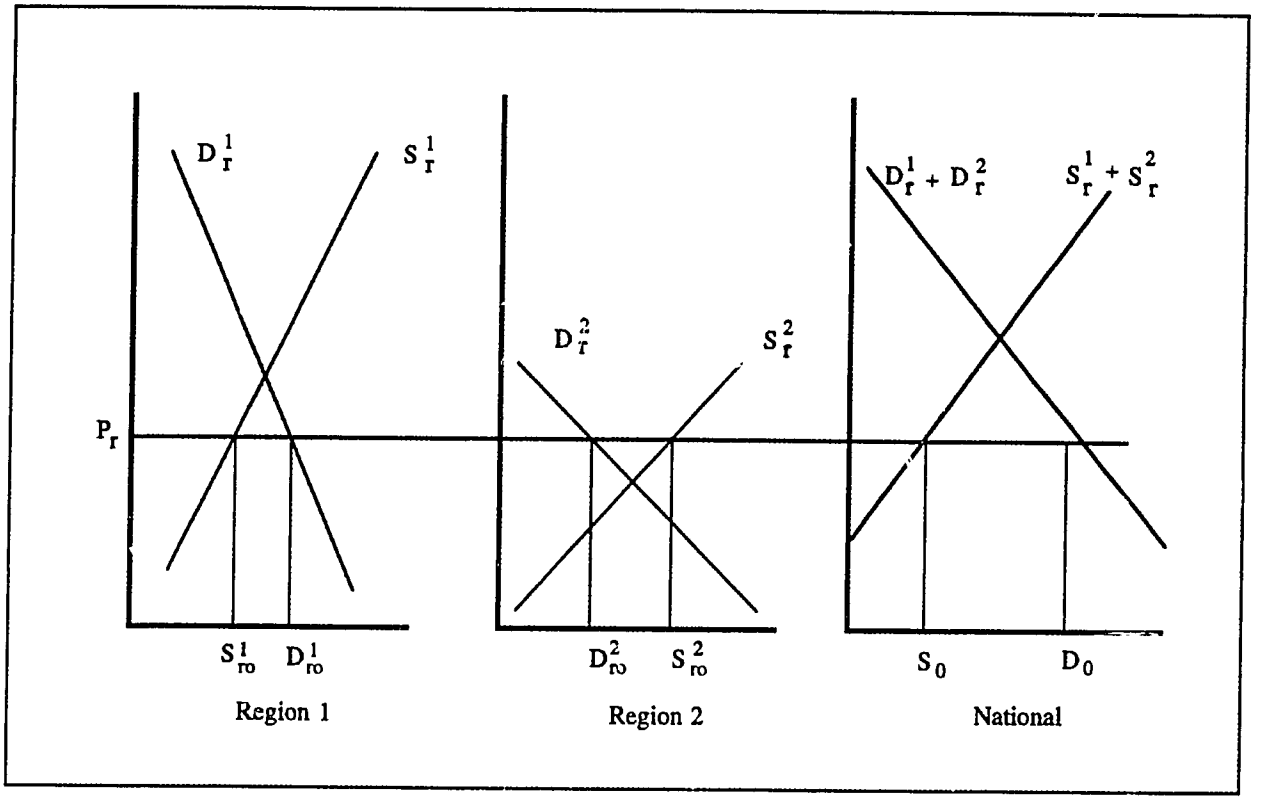

Figure 5.1: Rice Market

accommodate the additional initial data. Enter the new data as shown in Table 5.2.

Step 3:

The new market-clearing equation for rice in the change form of the supply and demand schedules is shown in equation 5.7.

$$\left(S_{ro}^1\varepsilon_{rm}^1 + S_{ro}^2\varepsilon_{rm}^2 - D_{ro}^1\eta_{rm}^1 - D_{ro}^2\eta_{rm}^2\right)\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}}$$
$$= \left(D_{ro}^1\eta_{rr}^1 + D_{ro}^2\eta_{rr}^2 - S_{ro}^1\varepsilon_{rr}^1 - S_{ro}^2\varepsilon_{rr}^2\right)\frac{\Delta P_{ro}}{P_{ro}} \qquad (5.7)$$

where ϵ_{rr}^1 refers to the own price elasticity of rice supply in region 1 and ϵ_{rr}^2 is the own price elasticity of supply in region 2. Note that the disaggregation of commodity supply and demand

curves by regions expands the formulas for calculating the elements of the G and U matrices, but does not expand the size of the matrices themselves. Write down the new market-clearing equation for maize ($S_m^1 + S_m^2 = D_m^1 + D_m^2$) in the change form of the variables and then rearrange the equation so that the endogenous variables are on the left-hand side, and the exogenous variable, P_r, is on the right-hand side.

If this step has been performed correctly, the new market-clearing equation for maize should be as shown in equation 5.8.

$$\left(S_{mo}^1\varepsilon_{mm}^1 + S_{mo}^2\varepsilon_{mm}^2 - D_{mo}^1\eta_{mm}^1 - D_{mo}^2\eta_{mm}^2\right)\frac{\Delta P_{mo}}{P_{mo}} = \left(D_{mo}^1\eta_{mr}^1 + D_{mo}^2\eta_{mr}^2 - S_{mo}^1\varepsilon_{mr}^1 - S_{mo}^2\varepsilon_{mr}^2\right)\frac{\Delta P_{ro}}{P_{ro}} \tag{5.8}$$

Step 4:

Combine the rice and maize market-clearing equations in matrix form. Enter the formulas to calculate the elements of the G and U matrices using the cell addresses of the initial data.

Step 5:

Insert sufficient rows under the "% change" subheading to disaggregate the supply and demand calculations by regions. For example, use the [F2] edit key to add the number 1 next to S_r. Then in a new inserted row below S_r^1, type in S_r^2. Continue this step for the remaining supply and demand entries. (See Table 5.2 if this is not clear.) Then enter the appropriate formulas to calculate the percentage change in the endogenous variables due to the 10.0% tariff on rice. For example, the percentage change in S_r^1 is:

$$\frac{\Delta S_{ro}^1}{S_{ro}^1} = \varepsilon_{rr}^1\frac{\Delta P_{ro}}{P_{ro}} + \varepsilon_{rm}^1\frac{\Delta P_{mo}}{P_{mo}} \tag{5.9}$$

Table 5.3: Two-Commodity Regional Model

	AF	AG	AH	AI	AJ	AK
135)	Two-Commodity Regional Model					
136)	==========					
137)	INITIAL QUANTITIES:			ELASTICITIES:		
138)	Commodity:	Rice	Maize		Rice	Maize
139)						
140)	Supply: R1	7	15	Supply: R1		
141)	R2	15	14	Pr	0.74615	-0.2
142)				Pm	-0.2	0.7
143)	Demand: R1	15	11	Supply: R2		
144)	R2	20	18	Pr	0.3	-0.1
145)				Pm	-0.1	0.2
146)						
147)	Imports:	13	0	Demand: R1		
148)				Pr	-0.62308	0.1
149)				Pm	0.1	-0.6
150)	INITIAL PRICES:			Demand: R2		
151)		Rice	Maize	Pr	-0.3	0.2
152)	Domestic	231.80	266.00	Pm	0.2	-0.3
153)	Border	231.80	266.00			
154)						
155)	MATRICES:					
156)	G Matrix		U Matrix		Inverse G Matrix	
157)	-8.4	13	-25.07		0.00	0.040
158)	25.3	0	9.10		0.077	0.026
159)						
160)	Solution Matrix					
161)	0.36					
162)	-1.70					
163)						
164)	POLICY CHANGE:	% Change in Exogenous Variables				
165)						
166)	Pr 10.00					
167)	OUTCOME:					
168)	% Change in Variables		New Variable Level		National Totals	
169)	Pm	3.60	Pm	275.57		
170)	Sr1	6.74	Sr1	7.47	Sr	22.87
171)	Sr2	2.64	Sr2	15.40		
172)	Sm1	0.52	Sm1	15.08	Sm	27.92
173)	Sm2	-0.28	Sm2	13.96		
174)	Dr1	-5.87	Dr1	14.12	Dr	33.66
175)	Dr2	-2.28	Dr2	19.54		
176)	Dm1	-1.16	Dm1	10.87	Dm	29.04
177)	Dm2	0.92	Dm2	18.17		

Step 6:

Repeat the first part of Step 5 for the block that calculates the new levels of the endogenous variables, and then enter the correct formulas for each of the variables.

Step 7:

Insert seven rows at the end of the spreadsheet to calculate the new level of maize and rice supply and demand at the national level. Type the subheading "National Totals" below the last entry in the % change" block. Then enter the appropriate formulas to calculate the new quantities of rice and maize demand and supply at the national level. The first entry is S_r and its formula is simply the sum of S_{ro}^1 and S_{ro}^2.

Step 8:

Invert the new G matrix and multiply this new inverted matrix by the U matrix.

Step 9:

Before analyzing the results, it is crucial to be sure that the model is working properly. One way to do so is to recall that, by construction, the sum of the regional demand and supply for both commodities is equal to national demand and supply, plus imports for rice. If the elasticities of each of the regional curves are identical to the aggregate elasticities used in the basic two commodity one region model, and the sum of the initial quantities supplied and demanded in each region equals the initial quantities used in the basic model, then the results of the regional model will be identical to those of the basic model. The only difference, of course, is that the regional model will disaggregate the quantity changes by region.

To demonstrate this result, change the elasticity estimates for region 2 so that they are identical to the estimates used for region 1. (Region 1's estimates are already the estimates used in Chapter 4.) Then reinvert the matrix (or invoke the matrix inversion macro if it has been edited for this exercise.). If the regional model has been constructed correctly, the new levels of the endogenous variables at the national level should be identical to those calculated in the basic two commodity model. Make the necessary corrections to the table until the model is working correctly, and then re-enter the true elasticities for region 2 and reinvert the matrix. The results should now be those listed in Table 5.2.

An interesting result that emerges from this model is that the impact of a price change on quantities supplied and demanded can vary significantly between regions. In this example, the impact of a price increase in rice induces a larger rice supply *and* demand response in region 1 than in region 2. This is due to the fact that the own price elasticities of supply and demand for rice are smaller (in absolute value) in region 2. In words, the demand and supply for rice are more *inelastic* in region 2.

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It is also worth noting the differential regional response of the maize market. In region 1 the quantities consumed and produced increase as a result of the price change in the rice market; yet in region 2, the quantities consumed and produced actually decrease. In the absence of a full-blown mathematical model, it is practically impossible to isolate the most important factor causing this result since the magnitude and sign of several elasticities are involved. The power of the multi-market model is in providing a way to calculate these results simply and rapidly.

COMBINED POLICY INTERVENTION (ADVANCED)

Up to now, the endogenous price multi-market models have only considered situations in which a government raises (or lowers) a price to *both* consumers and producers. Yet, as was demonstrated in the earlier chapters, a price policy, especially for a basic staple crop, may often involve setting a higher price to producers than to consumers.

Incorporating differential prices into the multi-market framework is made possible by defining one price in terms of another. For example, in the following exercise it is assumed that the government wants to subsidize rice producers but also wants consumers to be able to purchase rice at the lower pre-subsidy price. One way to formulate the problem is to define the producer price of rice as: $P^p_r = P^c_r(1 + s)$ where s is the subsidy rate to producers.

Let $(1 + s) = r$. The supply curve of rice in the change form is now:

$$\Delta S_{ro} = S_{ro}\varepsilon_{rr}\frac{\Delta r}{r} + S_{ro}\varepsilon_{rr}\frac{\Delta P^c_{ro}}{P^c_{ro}} + S_{ro}\varepsilon_{rm}\frac{\Delta P_{mo}}{P_{mo}} \qquad (5.10)$$

This equation states that the supply of rice is a function of the price of maize, the consumer price of rice and the subsidy rate the government sets. In short, the government now has two policy variables: the consumer price of rice and the subsidy rate and can induce an increase in the supply of rice either by increasing the consumer price of rice or by increasing the subsidy rate (or both).

Step 1:

Once again, copy the *original* two commodity model down and to the right of the regional model just completed. Using the Range/Name/Create command, name this new table "Dual". Then change the name of the table to "Dual Price Two Commodity Multi-Market Model".

Step 2:

The new policy variable, r, must be included on the supply side of the market-clearing equation of rice as shown in equation 5.11.

$$(S_{ro}\varepsilon_{rm} - D_{ro}\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} = (D_{ro}\eta_{rr} - S_{ro}\varepsilon_{rr})\frac{\Delta P^{c}_{ro}}{P^{c}_{ro}} - S_{ro}\varepsilon_{rr}\frac{\Delta r}{r} \qquad (5.11)$$

Note that the coefficients on the subsidy rate are the same as those for P_r^c. Why? By construction, the producer price of rice has simply been disaggregated into two components: the consumer price and the subsidy rate, and farmers can be expected to respond in the same way to an increase in either component.

Step 3:

The new policy variable must also be added to the *supply* side of the market-clearing equation for maize. To do this, write down equation 5.2 on a piece of paper and then decompose the price of maize (on the supply side) into its new components. Then collect terms and rearrange the equation so that all endogenous variables are on the left-hand side and all exogenous variables are on the right-hand side. The result is given in Equation 5.12.

$$(S_{mo}\varepsilon_{mm} - D_{mo}\eta_{mm})\frac{\Delta P_{mo}}{P_{mo}} = (D_{mo}\eta_{mr} - S_{mo}\varepsilon_{mr})\frac{\Delta P^{c}_{ro}}{P^{c}_{ro}} - S_{mo}\varepsilon_{mr}\frac{\Delta r}{r} \qquad (5.12)$$

Step 4:

Combine the two market-clearing equations in matrix form. Enter the formulas to calculate the elements of the G and U matrices using the cell addresses of the initial data. (The resulting U matrix should be (2x2).)

Step 5:

Insert a row under the POLICY CHANGE heading and type the letter r. The policy is a 10% subsidy to rice producers. (Be sure to set P_r^c to zero.)

Step 6:

Edit the appropriate formulas under the "% change" subheading to include the additional component of the price of rice, i.e., the subsidy rate, and then invert the G matrix.

To check the results, set r = 0 and P_r^c = to 10%. The outcome should be identical to the basic model developed in Chapter 4. Why?

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COMBINING THE EXTENSIONS (ADVANCED)

The final exercise of this chapter combines the last three extensions into a single three commodity, two region differential price market model. Since no instructions will be given, this exercise should not be attempted until the above exercises are fully understood. Nevertheless, by following the same sequence of steps given for the above exercises, the only additional challenge of this exercise will be to correctly specify the G and U matrices. (The most efficient way to proceed is to begin with the completed regional model and then add beans and the differential price policy.)

The data for this exercise are located in Table 5.3. Due to the size of the model, a suggested format is to place the data and assumptions in one table and the subsequent calculations and outcomes in another.

The results of this exercise are reported in Table 5.4. The model can be checked by setting region 2's demand and supply elasticities identical to those in region 1 (which are same estimates used in the three commodity exercise) *and* $r = 0$ and $P_r^c = 10\%$. With these data, a correctly specified model will return the same results as those calculated in the three commodity exercise, the results of which are found in Table 5.1. (Consistency checks to be sure that the model is working properly after changes have been made are highly recommended.)

Table 5.4: Combined Regional and Three Commodity Model

DATA BLOCK (Combined Regional and Three-Commodity Multi-Market Model)

INITIAL QUANTITIES:

Commodity:		Rice	Maize	Beans
Supply:	R1	7	15	6
	R2	15	14	4
Demand:	R1	15	11	3
	R2	20	18	7
Imports		13	0	0

ELASTICITIES:

		Rice	Maize	Beans
Supply: R1	Pr	0.74615	-0.2	0.3
	Pm	-0.2	0.7	0.2
	Pb	-0.3	0.2	0.4
Supply: R2	Pr	0.3	-0.1	-0.1
	Pm	-0.1	0.2	0.3
	Pb	-0.1	0.3	0.2
Demand: R1	Pr	-0.62308	0.1	0.0
	Pm	0.1	-0.6	-0.2
	Pb	0.0	-0.2	-0.5
Demand: R2	Pr	-0.3	0.2	0.0
	Pm	0.2	-0.3	-0.3
	Pb	0.0	-0.3	-0.3

INITIAL PRICES:	Rice	Maize	Beans
Domestic	231.80	266.00	400.0
Border	231.80	266.00	400.0

Table 5.5: Combined Regional and Three-Commodity Model

CALCULATIONS BLOCK (Combined Regional and Three-Commodity Model)

MATRICES:

G Matrix			U Matrix		Inverse G Matrix		
-8.4	-3.6	13	-25.07	-9.7	0.0	0.1	-0.2
25.3	14.8	0	9.1	4.4	0.0	-0.1	0.3
5.1	6.8	0	2.2	2.2	0.1	0.0	-0.0

Solution Matrix

0.3	-0.0
0.1	0.3
-1.7	-0.7

POLICY CHANGE: % Change in Exogenous Variables

Rice	Pr	10
Subsidy	S	0

OUTCOME:

% Change in Endogenous Variables		New Levels of Endogenous Variables		National Totals	
Pm	3.04	Pm	274.08	Sr	22.85
Pb	0.96	Pb	403.83	Sm	29.03
Sr1	6.57	Sr1	7.46	Sb	9.88
Sr2	2.60	Sr2	15.39	Dr	33.63
Sm1	0.32	Sm1	15.05	Dm	29.03
Sm2	-0.11	Sm2	13.99	Db	9.88
Sb1	-2.01	Sb1	5.88	Mr	10.78
Sb2	0.10	Sb2	4.00		
Dr1	-5.93	Dr1	14.11		
Dr2	-2.39	Dr2	19.52		
Dm1	-1.01	Dm1	10.89		
Dm2	0.80	Dm2	18.14		
Db1	-1.09	Db1	2.97		
Db2	-1.20	Db2	6.82		
Mr	-17.06	Mr	10.78		

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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AGRICULTURAL AND NATURAL RESOURCES POLICY ANALYSIS COURSE

Social Equilibrium Analysis
Using Market Level Analysis

Computer Exercises: Manual V

September 1993

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Methods and Guidelines
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Social Equilibrium Analysis with Market Models: Introduction

This manual contains a set of computer-based exercises designed to explore social (as opposed to private) costs, benefits and optimum quantities of production and consumption in commodity and goods markets. This type of analysis can be used for a variety of circumstances where the private decisions of individuals do not in themselves lead to an optimum situation from the point of view of society. Such situations are referred to as "market failures", and are characterized by differences between social and private costs and benefits, leading to over- or under-production and consumption of the good in question.

The concept of social prices and costs at the level of the individual enterprise was introduced in the second manual of this series. The focus at that time was on the influence of government policy in distorting factor and product prices, to give the wrong production signals to farmers. The second manual introduced the notion of sustainability by comparing two sets of budgets: one using a production technology that could not be sustained without significant environmental damage and decreasing yield, and the other based on sound practices that preserved fertility and avoided negative environmental impacts. These were evaluated at private and social prices to assess the social benefits from sustainable practices. This approach still has the drawback that it focusses on the behavior of individual farmers, and does not indicate the aggregate market situation. The third manual made this step from the individual farm or firm level to look at market level behavior. But, although government policies were introduced, to alter prices, there was no explicit discussion of why governments might wish to alter signals to the private sector. This present manual focusses on the "market" level, the aggregated costs and benefits, and looks at how governments might influence private actions to attain the highest level of satisfaction to society (subject to issues of income distribution, not explicitly considered in a commodity-based analysis).

The method used is to assume that we know the schedule of both the social and private costs and benefits, or can deduce the social schedules from a knowledge of the private schedules and the extent of the externalities. Thus, just as moving from the individual budget to the market level required more information, on how farmers and consumers react to different prices, so to introduce social schedules of costs and benefits presupposes information on how these costs and benefits are related to output levels. These data needs may well prove restrictive, and limit analysis to the individual budget level, but the reward for venturing into the market level is to be able to explore the role of policy in making the actions of private firms and individuals conform with the public good. In other words, we can devise optimal policy interventions that will exactly offset the divergence between social and private costs and benefits.

As with other parts of this series, this manual describes the construction of a set of Lotus 1-2-3 spreadsheets, each building on the one before, as a way of illustrating the analytical points being made and providing experience which can be useful in dealing with actual policy situations. Adequate knowledge of Lotus commands is assumed, and it is recommended that users follow closely the layout of the spreadsheets to avoid confusion. Once the spreadsheets have been constructed following the manual, they can of course be adapted and modified according to the interest of the analyst. You should, however, save each completed spreadsheet for use in subsequent steps in the manual.

The procedure followed in this manual is to present in each chapter the basic theoretical underpinning to the model used, to construct the actual model, and then to use the model to illustrate the theoretical points. A series of questions is included for self-testing of one's understanding of the points being made. The manual exercises are simple numerical examples which generate results. These results can be seen on graphs based on the spreadsheets.[1]

The first chapter (Chapter 1) of the manual discusses directly the issue of maximizing social profits on the basis of schedules linking benefits and costs to quantities produced and consumed. This is the social analogy to the private market, where consumers and producers interact to arrive at output and consumption levels. This private market is introduced at the next stage (Chapter 2), to see the conditions under which private decisions lead to the social optimum. The issue of corrective subsidies and taxes, designed to achieve the social optimum through influencing private decisions, is then explored. In Chapter 3, the model is opened up to world trade, by allowing imports or exports at a world price. The way in which such trading opportunities affect the social situation is discussed, along with the conditions under which domestic interventions enhance or conflict with gains from trade. The case where world prices are themselves not the true social cost of imports (or value of exports) is also discussed. A final chapter (Chapter 4) gives a set of examples to relate the analysis to actual policy issues, and emphasizes the data problems associated with making such an approach practically useful.

[1] The spreadsheets were constructed using Lotus 1-2-3, release 2.2. More advanced versions of Lotus, as well as other modern spreadsheets, can show the graphs and the numbers simultaneously.

Chapter 1: The Social Equilibrium

It will be recalled from the exercises based on the Policy Analysis Matrix (PAM) that commodities can have both a private and a social cost of production. The social cost of production is the cost of the inputs and factors used, where each is priced at their true cost to society (their social opportunity cost). This cost may be different from the cost faced by producers. Similarly, output has a value to society which can differ from the price people are prepared to pay in the market. In the absence of government intervention, the differences between such social and private costs and values are known as "externalities" or "divergences".

Government policies can themselves introduce differences between private and social costs and benefits, which are then known as "distortions". In the first PAM manual, the difference between private and social profits is attributed to the combined effect of divergences and policy distortions, arising from factor, input or product markets. In the second PAM manual one type of externality is specifically introduced, that of unsustainable farming practices which reduce yields.

To the extent that farmers themselves will switch to sustainable practices when given adequate information, no direct policy intervention is required. This will not always be the case. More often than not, the externality is not just a result of a lack of information. The presumption is then that it takes some public policy action to encourage the correct private decision. On the other hand, government intervention in markets, when not carefully targeted at the source of a "market failure" can lead to serious distortions in the sector involved. The focus of this manual is on correcting for divergences, or "internalizing" the externalities, without the introduction of distortions. At that point, government policy is guiding the private market toward a social optimum.

The simplest place to start is to assume that one knows the underlying social costs and benefit relationships, or at least the relationship between these and the corresponding private schedules. One would assume that social costs at the margin rise with the output of a good, just as marginal private costs will tend to rise. Figure 1.1 shows an upward rising schedule for the *marginal social cost* (MSC), with respect to the output of the product (Q). How can this be related to the private cost curves used in the earlier manuals? One can imagine the social cost schedule as containing the private costs, adjusted for

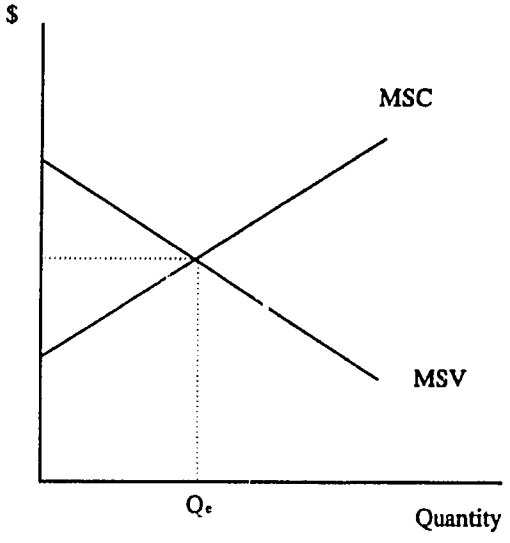

Figure 1.1: Marginal Social Costs and Benefits

three types of externality. The first is the element of higher production costs associated with need to use sustainable processes; the second is the possible negative impact that the production of the commodity has on the environment; and the third is the adjustment required to reflect true social cost of inputs and factors. In Figure 1.1, it is assumed that each of these adjustments raises the costs at the margin, though there is no reason why this should always be the case.

For simplicity , assume that this curve is linear described by the equation:

$$MSC = a + bQ \qquad \text{where } b > 0 \tag{1.1}$$

The *marginal social benefit* (or value) function can also be shown graphically. The assumption behind a downward sloping MSV is that successive units of product yield a little less benefit to society (as to individuals). This curve can also be thought of as related to the private demand schedule, reflecting the marginal value put on the good by consumers, adjusted for externalities associated with consumption (not production) of the good. These externalities might arise as a result of health or other factors which are not fully taken into account by individual consumers. In the figure, it is assumed that these externalities are negative: in the models used in this manual the externalities can also be positive.

Assume that the equation for this function is also linear, and represented by the following equation:

$$MSV = c + dQ \qquad \text{where } d < 0 \tag{1.2}$$

Placing the two schedules on the same axes is a convenient way of finding which quantity of the good will generate costs equal at the margin to benefits: MSC = MSV at quantity Qe. This is a necessary (though not sufficient) condition for maximum net social profit.[2] This is equivalent to solving equations (1) and (2) for the "optimum" condition that MSC = MSV.

$$\begin{aligned} a + bQ_e &= c + dQ_e \\ Q_e &= (c - a)/(b - d) \\ MSC\ (=MSV_e) &= a + bQ_e \end{aligned} \tag{1.3}$$

To see intuitively why this is an optimum quantity for society, imagine discrete units of Q starting from the first. Each unit will contribute to both value and cost, as shown by the schedule. The difference between the value and cost is the contribution of that unit to the

[2] With linear curves, rising costs and declining benefits, the point of intersection is always the maximum social profit point. Without linearity, minima and "local" maxima may give other results.

surplus. Adding up these surpluses gives the area bounded by the MSC, the MSV and the dollar axis, as shown by the shaded area in Figure 1.2. Quantities less than Q_e leave some potential surplus or profit unexploited: quantities greater than Q_e incur losses at the margin as social costs exceed benefits for additional units.

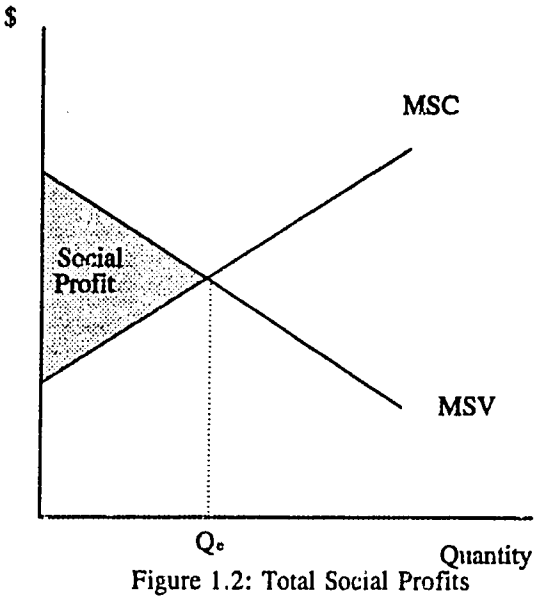

Figure 1.2: Total Social Profits

Model 1: Optimal Quantity

The first model consists of a numerical example of the social cost and benefit curves and illustrates the conditions for the optimal quantity. Start a new spreadsheet and follow these steps:

(i) Create a range named "model", defined as A1.E8 and a range named "graphdat", defined as F9.K116. These ranges will be used in all the spreadsheets, and facilitate navigation. (Use/RNC)

(ii) Set column widths to contain labels. The default width is 9: set other columns as below (using/WCS).

Column	Width
A	27
B	18
F	5

(iii) Enter the labels as shown in Table 1, starting in cell A1. Type the "formulae" in B4.B5 as labels: they are just there as a reminder. Add the parameter values in D4.E5. The formulae in E6 and E7 are added later, in step (v).

(iv) Enter the column headings shown in Table 2, starting in cell F9, including the dashes in F14.J14 which are produced with the \- keys. In cell F15 put "0" (zero) and fill from F15 to F115 with the integers up to 100 (use/DF). Copy the row of dashes in F14.J14 to F116, to underline the table.

(v) Enter the formulae to compute the "optimal" values of the variables in the model.

These include the optimal quantity, at which MSC=MSV, and the common level of the MSC and MSV at that quantity. The formulae are from equations 3 and 4.

Variable	Expression	Cell	Formula
Qe	(c-a)/(b-d)	E6	(D5-D4)/(E4-E5)
MSVe	c + dQe	E7	+D4+(E4*E6)

The other formulae display the variables for creating a graph. These include the MSC, the MSV, the Social Profit (ie. MSV-MSC) and the accumulation of that profit from output unit 0 (ie. the area under the social profit curve).

Variable	Expression	Cell	Formula
MSC	a + bQ	G15	+D$4+(E$4*F15)
MSV	c + dQ	H15	+D$5+(E$5*F15)
SocProf	MSV-MSC	I15	+H15-G15
Cumulat		J15	+J14+I15

Table 1.1: Social Equilibrium Analysis

EQUILIBRIUM ANALYSIS	EXERCISE 1			
Social Optimum, Closed Economy			Constant	Slope
Social Cost Curve	MSC = a + bQ	MSC	4	0.5
Social Benefit Curve	MSV = c + dQ	MSV	50	-0.2
Socially Optimal Quantity		Q (equilib) =		65.7
Equilibrium Costs and Benefits		MSC=MSV (equil) =		36.9

Copy G15.J15 to G15.G115 to complete the table. (Note that J14 is a label and enters as zero: this avoids having to have a separate formula for the first entry in the cumulative column.) Be sure to understand the meaning of a formula before entering it into the spreadsheet.

(vi) Create two graphs using the information in the GRAPHDAT range. Table 1.2 shows the screen for creating a graph named "Social Curves", which graphs the MSC and MSV schedules over the range of output levels chosen. (Follow the graph menu, /G, to enter ranges, legends and titles, and choose

Table 1.2: Graphic Analysis of Social Equilibrium

Graphical Representation of Social Optimum				
	Social Curves		Social Profit	
Quantity	MSC	MSV	MSV-MSC	Cumulative
0	4.0	50.0	46.0	46.0
5	6.5	49.0	42.5	88.5
10	9.0	48.0	39.0	127.5
15	11.5	47.0	35.5	163.0
20	14.0	46.0	32.0	195.0
25	16.5	45.0	28.5	223.5
30	19.0	44.0	25.0	248.5
35	21.5	43.0	21.5	270.0
40	24.0	42.0	18.0	288.0
45	26.5	41.0	14.5	302.5
50	29.0	40.0	11.0	313.5
55	31.5	39.0	7.5	321.0
60	34.0	38.0	4.0	325.0
65	36.5	37.0	0.5	325.5
70	39.0	36.0	-3.0	322.5
75	41.5	35.0	-6.5	316.0
80	44.0	34.0	-10.0	306.0
85	46.5	33.0	-13.5	292.5
90	49.0	32.0	-17.0	275.5
95	51.5	31.0	-20.5	255.0
100	54.0	30.0	-24.0	231.0

Options/Scale/Skip to simplify the x-axis labels.) Be sure to name the graph (Name/Create) to be able to recall it later. Create the graph named "Social Profit" being sure to name it when created. [Note: In Lotus Ver 2.3, "saving" a graph saves it to a PIC file, for printing: "naming" a graph allows one to recall it on the screen.]

(vii) Save the spreadsheet as SOCIAL1.WK1 before making any further modifications.

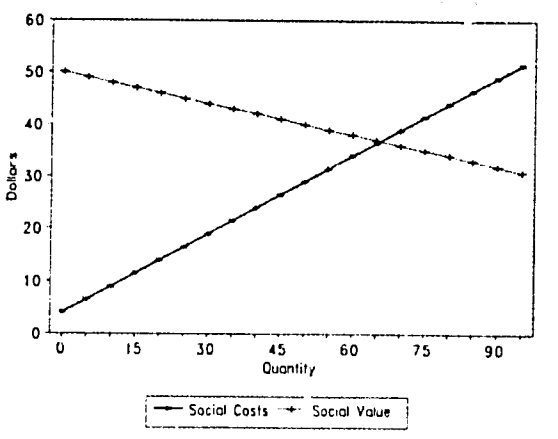

Figure 1.3: Social Equilibrium Analysis

The model in SOCIAL1 represents the situation in a closed economy. The quantity of production and consumption are the same, implying no trade (or stocks). The quantity at which MSC = MSV is shown in cell E6, and the common cost/value is in cell E7. If the coefficients have been entered as in Table 1.1 and 1.2, the maximum social profit should be at a quantity of 65.7 units (produced and consumed), where both the cost and benefit of the last unit was $36.9. Look at the schedules in the "social curves" graph and check the point of intersection. Then refer to the "social profits" graph to see the total social profitability.

Exercise 1

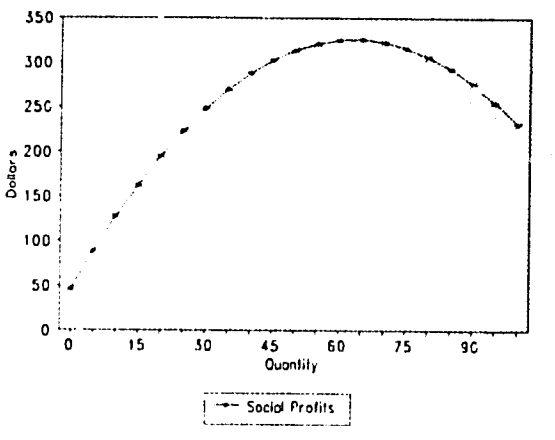

Figure 1.4: Social Profits Analysis

Before extending this model, it is useful to get some feel for the effect of changing parameter values.

The parameter values that can be varied are in cells D4.E5. Try some different parameter values, remembering that the graph is set up to cover only the range of quantities 1 to 100 at intervals of 5. The exercise below illustrates the impact on the "social profit" curve of a flatter MSC schedule and what happens to social profits as the MSV curve gets flatter.

Assume that the marginal cost and value schedules for corn production in Italy are known to be as follows:

$$MSC = 5 + 0.2Q$$
$$MSV = 20 - 0.1Q$$

What is the socially optimal quantity of production? What is the level of social profit at this optimal quantity? (Read from the graph or look at the "graphdat" table.) What would happen to the optimal quantity if the slope parameter of the MSC curve doubled to 0.4 (from 0.2)? What would happen if the slope of the MSV curve doubled to -0.2? Can you provide and intuitive explanation of these results?provide an intuitive explanation for these results?

Chapter 2: Private and Social Optima

There is no guarantee that normal market forces will lead to output and consumption levels consistent with the point of maximum social profit, as defined above. This is the basic policy problem to which we now turn. The private market (assuming the good is produced and consumed in the private sector) will follow market signals, notably the price of the good. Under competitive conditions, as assumed in this exercise, producers will expand until their marginal (private) cost reaches the price, at which point any further expansion will be unprofitable. Consumers will expand purchases until the marginal unit adds no more to their satisfaction than the price of that unit (representing the satisfaction that can be had from alternative purchases). This competitive market equilibrium can be thought of in two ways: as the quantity at which marginal private costs (MPC) is equal to marginal private value (MPV), or as the market clearing price at which the quantity supplied of the product is equal to the quantity demanded.

If we assume linear equations, these can be written as:

$$
\begin{aligned}
MPC &= e + fQ \qquad \text{where } f > 0 \\
MPV &= g + hQ \qquad \text{where } h < 0 \\
Qp &= (g - e)/(f - h) \\
MPC_p\ (=MPV_p) &= e + fQ_p
\end{aligned}
\tag{2.1}
$$

The same situation can also be represented by means of the supply and demand curves, as follows:

$$
\begin{aligned}
S &= w + xP \qquad \text{where } x > 0 \\
D &= y + zP \qquad \text{where } z < 0 \\
S &= D \\
S\ (=D) &= w + xP_e
\end{aligned}
$$

Note that the parameters in the foregoing equations are simply related to each other:

e = -(w/x)	w = -(e/f)
f = 1/x	x = 1/f
g = -(y/z)	y = -(g/h)
h = 1/z	z = 1/h

Either formulation can be used in the model, but it is helpful to distinguish between their economic interpretations. The "private" market equilibrium given by the equality of MPC and MPV curves indicates a maximum level of joint profits to producers and consumers. Producers receive a "surplus" profit, or rent to fixed factors, of the difference between the price and the

marginal cost.[3] This producer surplus will be at a maximum when the price is equal to the MPC.[4] Consumers also receive a "consumer surplus" when marginal private value exceeds the price, and this will be at a maximum where the price is equal to the MPV, and hence to the MPC as well. This gives a formulation for the private analog to the social profit function introduced earlier: there will be a quantity which maximizes the joint benefits to producers and consumers where MPC = MPV.

The second formulation emphasizes the market clearing process rather than the profit function *per se*: the supply curve captures the behavior of suppliers as observed by others in the marketplace (i.e. the consumers); the demand curve incorporates the information about consumer purchase intentions as relayed to suppliers. At price Pe purchase intentions are consistent with willing supply and the market clears. At prices either side of Pe, there will be unsold supply or unsatisfied demand.

It is useful to think of the private market searching for a price which then determines the quantity produced and consumed, which in turn defines both private and social profit. Which algebraic formulation is used for the private market is not crucial. In these exercises we show both formulations together to avoid confusion. This also allows the calculation of elasticities of supply and demand, the most common "summary" statistic of market behavior.

The private market equilibrium is shown in Figure 2.1, superimposed on the social cost and value schedules. The private equilibrium quantity, Qp, is greater than the socially desirable quantity, Qs, in this example. Both production and consumption decisions, in this case, fail to reflect social impacts. There are costs associated with production that are not taken into account by producers (such as pollution of groundwater by fertilizer), and social valuations are less than private valuations (perhaps because of health hazards no reflected in market demand). In this case the two "externalities" reinforce one another: Qp is greater than Qs both from the production and the consumption

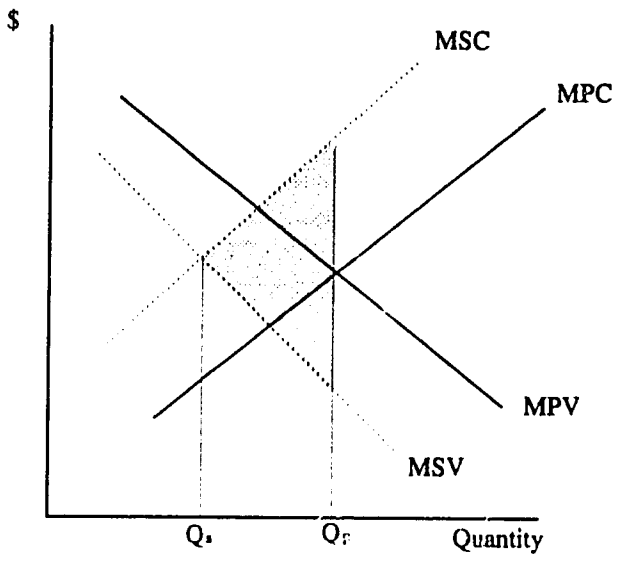

Figure 2.1: Private and Social Equilibra

[3] Producer and consumer surplus were introduced in Volume 2, The Policy Analysis Matrix (PAM).

[4] See footnote 2 for the qualifications about non-linear schedules.

divergence. The loss in potential social profit is shown in Figure 5 by the shaded area between the MSV and MSC schedules over the range Qs to Qp. The over-production and over-consumption together cause this loss to society.

The social and private profit functions are illustrated in Figure 2.2. Private profit (producer surplus plus consumer surplus) peaks at Qp, and social profit is maximized at Qs. (The loss in social profit seen in Figure 5 is also shown in Figure 6, as the height of the vertical line from Qp between the two profit curves). Moving to Qs increases social profit, though at the expense of private profit. Before looking at how to impose the socially beneficial solution on a reluctant private sector, we can introduce the private equilibrium into the model developed in Chapter 1.

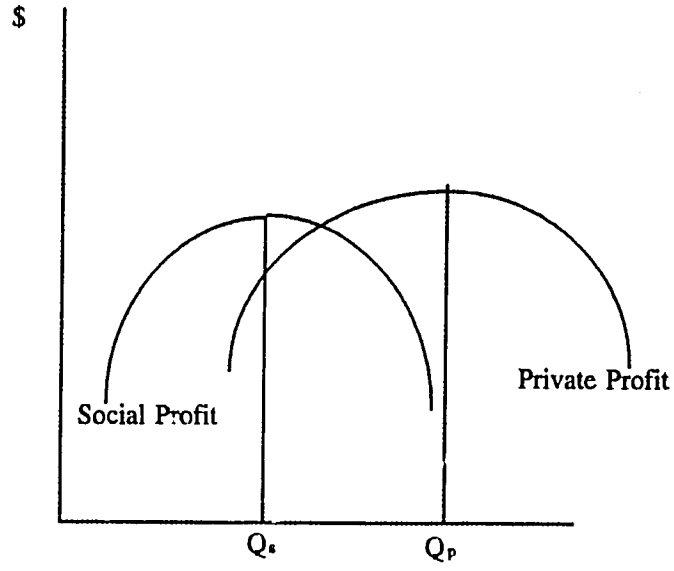

Figure 2.2: Private and Social Profit Functions

Model 2

The introduction of the private sector into the existing spreadsheet is accomplished with the following steps.

(i) Insert 15 rows after row 8 (i.e. /WIR A8.A22) to make room for the private sector equations.

(ii) Type in the labels indicated in Table 2.1, where they differ from the existing spreadsheet. Note that E12, E13, D16, D17, and E16.E22 are formulae that will be added below.

(iii) Type in the labels indicated in Table 2.2 for the new column headings (i.e. cells K26.Q29)

Table 2.1: Private and Social Equilibrium Analysis

EQUILIBRIUM ANALYSIS	EXERCISE 2			
Private and Social Curves, Closed Economy				
			Constant	Slope
Social Cost Curve	MSC = a + bQ	MSC	12	0.25
Social Benefit Curve	MSV = c + dQ	MSV	45	-0.15
Socially Optimal Quantity		Q (equilib) =		82.5
Equilib Costs and Benefits		MSC=MSV		32.6
			Constant	Slope
Private Cost Curve	MPC = e + fQ	MPC	10	0.25
Private Benefit Curve	MPV =g + hQ	MPV	50	-0.15
Equilibrium Quantity		Q (equilib) =		100.0
Equilibrium Price		P (equilib) =		35.0
			Constant	Slope
Supply Curve	S = w + xP	Supply	-40	4
Demand Curve	D = y + zP	Demand	333.3	-6.7
Equilibrium Quantity		Q (equilib) =		100.0
Equilibrium Price		P (equilib) =		35.0
Parameter Check		Supply Elasticity		1.4
		Demand Elasticity		-2.3

(iv) Enter the new formulae for the private sector equilibrium:

Variable	Expression	Cell	Formula
Qp	(g-e)/(f-h)	E12	(D11-D10)/(E10-E11)
MPCe	e + fQp	E13	+D10+(E10*E12)
w	-e/f	D16	-D10/E10
x	1/f	D17	-D11/E11
y	-g/h	E16	1/E10
z	1/h	E17	1/E11
Qp	w + xPe	E18	+D16+(E16*E19)
Pe	(y-w)/(x-z)	E19	(D17-D16)/(E16-E17)
SE	y*Pe/Qp	E21	+E16*E19/E18
DE	z*Pe/Qp	E22	+E17*E19/E18

Enter the new formulae for creating the graph data, as shown below

Variable	Expression	Cell	Formula
MPC	e+fQ	K30	+D$10+(E$10*F30)
MPV	g+hQ	L30	+D$11+(E$11*F30)
PS	Pe-MPC	M30	+E$19-K30
Cumulative		N30	+N29+M30
CS	MPV-Pe	O30	+L30-E$19
Cumulative		P30	+P29+O30
Total Surplus	PS+CS	Q30	+N30+P30

Copy down K30.Q30 to K30.K130, and copy K29.Q29 to K131, to complete the table of data for the graph.

(v) Adjust the graph settings to match those shown in Tables 7 and 8. This involves adding ranges and legends for the C and D variables in the first graph and for the B variable in the second.

(vii) Save the spreadsheet as SOCIAL2.WK1 before making any further modifications.

The model is now ready to be used to examine the impact of alternative parameters on social and private profits. To alter the private parameters, enter new values in D10, D11, E10 and E11. ("Unprotect" this range with /RU, to highlight the entries.) The private and social quantities will change with the parameter values, as shown in the "curves" graph. The "profit" curves will indicate how different are the private and social optima for each set of parameters values.

Table 2.2: Graphical Representation of Social and Private Optima

			Social Profit					PS		CS	Surplus
Q	MSC	MSV	MSV-MSC	Cumulative	MPC	MPV	Prod Sur	Cumulat	Cons Sur	Cumulat	Total
0	12.0	45.0	33.0	33.0	10.0	50.0	25.0	25.0	15.0	15.0	40.0
5	13.3	44.3	31.0	64.0	11.3	49.3	23.8	48.8	14.3	29.3	78.0
10	14.5	43.5	29.0	93.0	12.5	48.5	22.5	71.3	13.5	42.8	114.0
15	15.8	42.8	27.0	120.0	13.8	47.8	21.3	92.5	12.8	55.5	148.0
20	17.0	42.0	25.0	145.0	15.0	47.0	20.0	112.5	12.0	67.5	180.0
25	18.3	41.3	23.0	168.0	16.3	46.3	18.8	131.3	11.3	78.8	210.0
30	19.5	40.5	21.0	189.0	17.5	45.5	17.5	148.8	10.5	89.3	238.0
35	20.8	39.8	19.0	208.0	18.8	44.8	16.3	165.0	9.8	99.0	264.0
40	22.0	39.0	17.0	225.0	20.0	44.0	15.0	180.0	9.0	108.0	288.0
45	23.3	38.3	15.0	240.0	21.3	43.3	13.8	193.8	8.3	116.3	310.0
50	24.5	37.5	13.0	253.0	22.5	42.5	12.5	206.3	7.5	123.8	330.0
55	25.8	36.8	11.0	264.0	23.8	41.8	11.3	217.5	6.8	130.5	348.0
60	27.0	36.0	9.0	273.0	25.0	41.0	10.0	227.5	6.0	136.5	364.0
65	28.3	35.3	7.0	280.0	26.3	40.3	8.8	236.3	5.3	141.8	378.0
70	29.5	34.5	5.0	285.0	27.5	39.5	7.5	243.8	4.5	146.3	390.0
75	30.8	33.8	3.0	288.0	28.8	38.8	6.3	250.0	3.8	150.0	400.0
80	32.0	33.0	1.0	289.0	30.0	38.0	5.0	255.0	3.0	153.0	408.0
85	33.3	32.3	-1.0	288.0	31.3	37.3	3.8	258.8	2.3	155.3	414.0
90	34.5	31.5	-3.0	285.0	32.5	36.5	2.5	261.3	1.5	156.8	418.0
95	35.8	30.8	-5.0	280.0	33.8	35.8	1.3	262.5	0.8	157.5	420.0
100	37.0	30.0	-7.0	273.0	35.0	35.0	0.0	262.5	0.0	157.5	420.0

Exercise 2

Assume that intensive research has turned up the following parameter values for the production of corn in Italy:

$$MSC = 5 + 0.2Q$$
$$MSV = 20 - 0.1Q$$
$$MPC = 2 + 0.15Q$$
$$MPV = 25 - 0.08Q$$

What is the quantity which ensures the maximum social profit? What is the quantity that maximizes private profit? Explain the results in non-technical terms. Is private profit more or less than social profit? Do these functions represent positive or negative externalities?

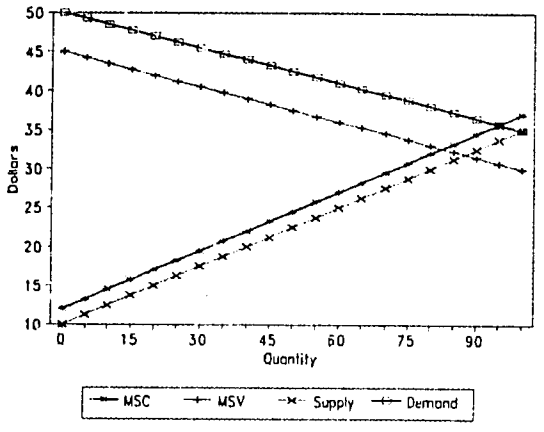

Figure 2.3: Private and Social Supply and Demand Curves

Try another example of an externality, and find the quantity and the levels of profit in this case as well. Keeping the social curves as above, change the private curves as follows:

$$MPC = 6 + 0.21Q$$
$$MPV = 15 - 0.12Q$$

Imagine now that the private value schedule is as follows:

$$MPV = 21 - 0.09Q$$

What is the new market quantity, and how does it relate to the social optimum? Explain this result.

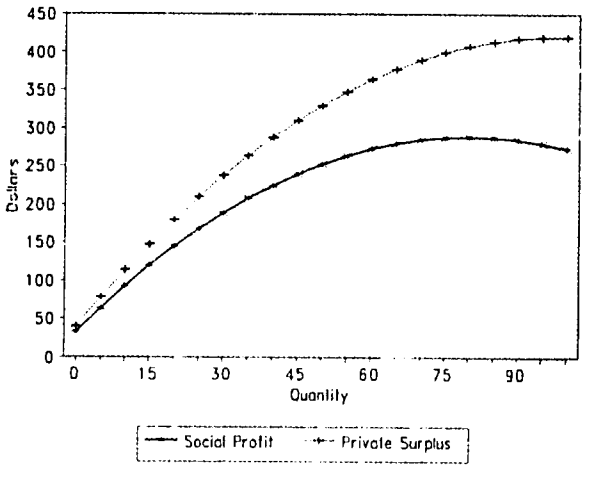

Figure 2.4: Private and Social Surpluses

Chapter 3: Corrective Taxes and Subsidies

The classic role for government in a situation where the private market does not fully reflect social benefits and costs is to intervene to induce a convergence. This can be done essentially in four different ways:

(i) government can take over the production and/or purchasing of the product in question to replace the private market,

(ii) government can set quantitative controls on the market by imposing mandatory levels of production and consumption (including zero levels),

(iii) government can create additional instruments such as pollution rights, and oblige producers to obtain such rights. If a market is set up for such rights, private costs will then reflect the cost of pollution rights and the value put on non-pollution will govern the quantity of rights issued.

In this chapter we will concentrate on the third of these mechanisms, the use of taxes and subsidies. Public provision of commodities is out of political favor, and quantitative controls can be treated as a special case of taxes and subsidies. The creation of marketable instruments is in early days, but the analysis of such markets has much in common with the operation of taxes and subsidies considered here.

The aim of tax/subsidy schemes is to "correct" for divergences between private and social costs and benefits in order to make private decisions conform with social optima. In Figure 3.1, the private output can be made equal to the social equilibrium, Qs, by a producer price of Pp and a consumer price of Pc. This can be achieved by a combination of producer and consumer taxes equal to Pc-Pp. The "market" price is no longer relevant to the situation, except to separate consumer taxes (Pc-Pm) from producer taxes (Pm-Pp), and is not shown in Figure 7.

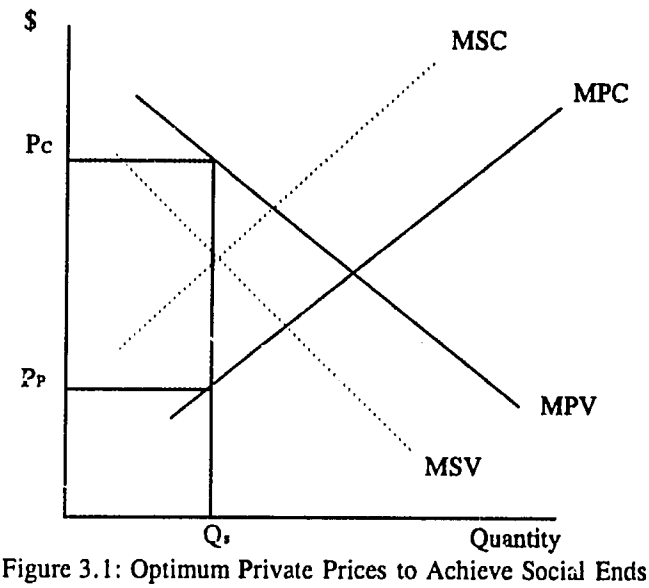

Figure 3.1: Optimum Private Prices to Achieve Social Ends

The quantity that both clears the market and ensures the highest level of social surplus can be derived algebraically, using a straightforward modification of the earlier analysis. Assume that taxes and subsidies can come in two varieties, specific (per unit) or percentage (ad valorem). Four taxes/subsidies are therefore possible:

tp1 specific producer taxes
tp2 percentage producer taxes
tc1 specific consumer taxes
tc2 percentage consumer taxes

We can now define tax-inclusive marginal private costs and benefits schedules, MPC' and MPV' (and the corresponding tax-ridden supply and demand curves, S' and D') and hence define the market clearing output.

$$MPC' = e' + f'Q$$
$$MPV' = g' + h'Q$$
$$Qe = (g'-e')/(f'-h')$$

The parameters of this model are linked to those of the no-taxes model:

$$e' = e(1+tp2) + tp1$$
$$f' = f(1+tp2)$$
$$g' = g(1-tc2) - tc1$$
$$h' = h(1-tc2)$$

The success of the combined producer/consumer tax in terms of social and private profits is shown in Figure 3.2. Social profit and private profit now peak at the same quantity, as a result of the tax. (Private profit is measured after the tax has been paid.) The corrective policies have ensured coincidence between public and private aims. In this closed economy, one instrument, a tax, has been sufficient. Before introducing the complexity of international trade, it is useful to explore the properties of this closed economy case. This is done in Model 3.

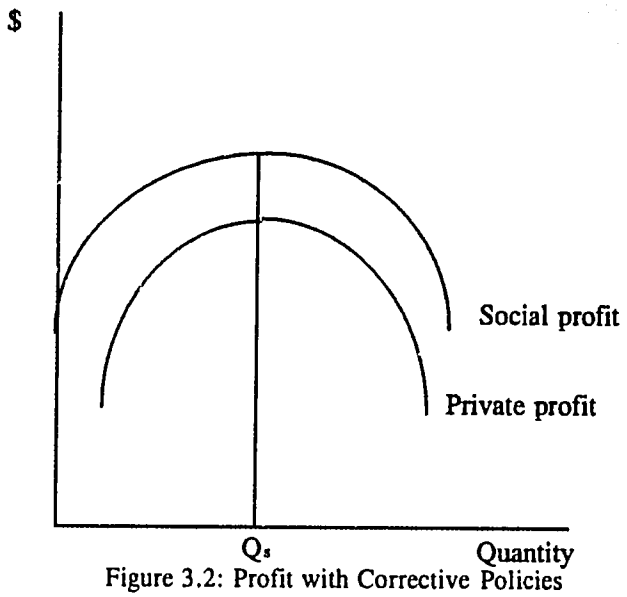

Figure 3.2: Profit with Corrective Policies

Model 3: Optimal Policies

Starting with the spreadsheet used for Chapter 2, (SOCIAL2.WK1) perform the following steps:

(i) Insert 6 rows at A14 (/WIR A14.A19) and insert 13 rows at A.29 (/WIR A29.A41) to make room for the new headings.

(ii) Type in the new labels in A15.E19 and A30.C41 from Table 9. Note that ranges C36.D37 and C39.C41 contain formula, as indicated below. Type in the column headings for the new columns R to T, as shown on table 10.

(iii) Enter the following formulae which compute the equilibrium quantity in the presence of taxes and subsidies, first using marginal costs and benefits and then supply and demand curves:

Variable	Expression	Cell	Formula
e'	e(1+tp2)+tp1	D16	+D10*(1+D32/100)+C32
g'	g(1-tc2)-tc1	D17	+D11*(1-D33/100)-C33
f'	f(1+tp2)	E16	+E10*(1+D32/100)
h'	h(1-tc2)	E17	+E11*(1-D33/100)
Qe	(g'-e')/(f'-h')	E18	(D17-D16)/(E16-E17)
MPC'e	e'+f'Qe	E19	+D16+(E16*E18)

To help with interpretation of the results, it is useful to add some derived calculations, including the "remaining" difference between parameters of the social curves and those of the tax-inclusive private schedules, and the maximum level of both private and social profits. This facilitates the choice of optimal policies.

SOCIAL EQUILIBRIUM ANALYSIS	EXERCISE 3			
Corrective Policies and Social Optima				
			Constant	Slope
Social Cost Curve	MSC = a + bQ	MSC	5	0.2
Social Benefit Curve	MSV = c + dQ	MSV	20	-0.1
Socially Optimal Quantity		Q (equilib) =		50.0
Equilib Costs and Benefits		MSC=MSV		15.0
Before taxes and subsidies			Constant	Slope
Private Cost Curve	MPC = e + fQ	MPC	6	0.21
Private Benefit Curve	MPV = g + hQ	MPV	25	-0.08
Equilibrium Quantity		Q (equilib) =		65.5
Equilibrium Price		P (equilib) =		19.8
adjusted for taxes and subsidies			Constant	Slope
Private Cost Curve	MPC' = e' + f'Q	MPC + tax	6	0.22
Private Benefit Curve	MPV' = g' + h'Q	MPV - tax	21	-0.07

Equilibrium Quantity		Q (equilib) =		50.0
Equilibrium Price		P (equilib) =		17.3
adjusted for taxes and subsidies			Constant	Slope
Supply Curve	S = w + xP	Supply	-29	4.54
Demand Curve	D = y + zP	Demand	313	-15.15
Equilibrium Quantity		Q (equilib) =		50.0
Equilibrium Price		P (equilib) =		17.3
Parameter Check		Supply Elasticity		1.6
		Demand Elasticity		-5.3
Corrective Policies				
		specific	ad valorum	
Production tax (+) or subsidy (-)		0	5.0	percent
Consumption tax (+) or subsidy (-)		0	17.5	percent
Remaining Divergences				
Necessary producer tax or subsidy		-1.30	-9.30	
Necessary consumer tax or subsidy		0.63	-51.52	
Maximum Social Profit		82.5		
Maximum Private Profit		79.8		
Difference		2.8		

Variable	Cell	Formula
a-e'	C36	+D4-D16
c-g'	C37	+D17-D5
(b-f')/f'	D36	100*((E4-E16)/E16))
(d-h')/h'	D37	100*((E17-E5)/E17))
Soc Profit (max)	C39	@max(J49.J149)
Priv Profit (max)	C40	@max(Q49.Q149)
Difference	C41	@abs(C39-C40)

In addition, more formulae are needed in the graph-data section of the spreadsheet, to reflect the new variables. These include modifying the formulae for producer and consumer surplus to reflect the incidence of the taxes, and the computation of the prices net of tax that producers and consumers face. These prices are calculated by applying the quantity produced to the marginal private cost and value curves before taxes (ie using the parameters e,f,g and h). It is also useful to create a column for the market price so that it can be included in a graph.

Variable	Expression	Cell	Formula
PS	Pp-MPC	M49	+R49-K49

```
CS          MPV-Pc        O49        +L49-S49
Pp          e+fQe         R49        +D$10+(E$10*E$24)
Pc          g+hQe         S49        +D$11+(E$11*E$24)
Pe                        T49        +E$25
-----------------------------------------------------------
```

and then copy M49.T49 down to M49.M149 to complete the table.

(iv) Check that the graph settings for Table 3.2 (not shown). There should have been no change from SOCIAL2.WK1, except that the addresses will have been modified. Add the range and legends for the producer and consumer price series.

(v) Save the spreadsheet as SOCIAL3.WK1 before making any modifications.

The levels of producer tax and subsidy (negative tax) are entered in cells C32 and D32. They can be specific (per unit) taxes which raise or lower the constant term in the equation (i.e., shift the supply curve up or down vertically), or ad valorem (percentage) taxes which alter both the constant and the slope. Enter specific taxes in C32 and ad valorem taxes in D32. Similarly, consumer taxes (+) and subsidies (-) can be entered into C33 and D33. These taxes and subsidies show up in the formulae for the constant and slope of the adjusted MPC' and MPV' curves, and hence alter the equilibrium. The underlying divergences, as defined in the last chapter, are reflected in the difference between the parameters in D4.E5 and in D10.E11.

To make it easy to choose the correct policies, the "remaining" divergences are calculated in C36.D37. When these are zero, the set of policies chosen in C32.D33 are "correct." At this point, maximum social profit and maximum private profit should coincide.

Exercise 3: Computing Optimal Policies

To demonstrate the concept of optimal policies, recall the example from the previous chapter, which assumed the following parameter values for the hypothetical Italian corn market.

$$MSC = 5 + 0.2Q$$
$$MSV = 20 - 0.1Q$$
$$MPC = 2 + 0.15Q$$
$$MPV = 25 - 0.08Q$$

What is the tax and subsidy set which ensures the maximum social profit? Use the guide in cells C36.D37 to enter the initial levels of subsidy and tax. Check that the quantity which clears the market is also that which ensures maximum social profit. If this is not the case, modify the taxes and subsidies. A few minutes practice will enable you to enter the "ideal" policies with no difficulty.

As a variation, try the following marginal curves:

$$MPC=6+0.21Q$$
$$MPV=21-0.09Q$$

What is the optimum set of taxes? How different would the situation be if there were no taxes or subsidies? Explain this result.

As a final exercise, try to offset all the divergences with just percentage taxes, putting tax levels in D32 and D33 but not in C32 and C33. Assume that the marginal private value curve is

$$MPV=25-0.08Q$$

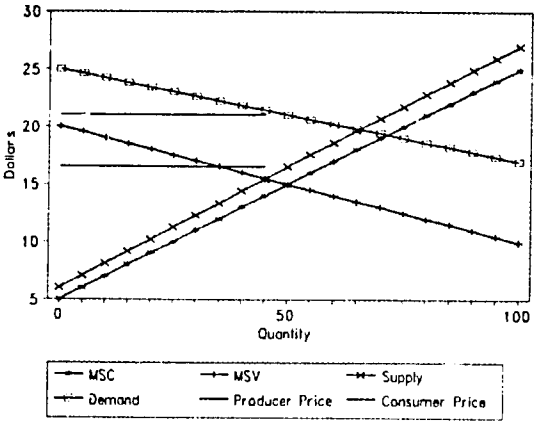

Figure 3.3: Graphing Optimal Policies

and impose a 5 percent tax on production.
What percentage consumption tax will give the socially optimal level of output and consumption? Will private and social profit be the same under these conditions? Explain the result.

Chapter 4: Introduction of International Trade

The analysis so far has been relevant to a closed economy, or to a commodity for which transportation costs were such as to render it non-tradable. Such situations are rare in practice, and should be treated as special cases of the more general "open" economy model.

Let us drop the restricting assumption of autarchy (no trade), but assume initially that the country is a price taker on world markets (the "small-country" assumption). Figure 4.1 shows the situation for both an importer and an exporter with production and consumption diseconomies. The opportunity to trade introduces a further two variables:

MCM = marginal cost of imports
MRX = marginal value of exports

Under the small-country assumption with no externalities associated with trade, these both are represented by the world price, P_W.

Private profit in the importing country will be at a maximum at the level of output and consumption where MPC = P_W = MPV. Free trade will lead toward this outcome under appropriate assumptions about competition and complete markets. Consumption at D_P and production at S_P will determine the level of imports (Figure 4.1). The corresponding social optimum is where MSC = MCM (=P_W) = MSV. This implies less production and less consumption, as shown by S_S and D_S in Figure 4.1. Analogous private and social situations are shown for the exporter in Figure 4.2. The distortion (loss of social benefits) implied in the private optimum is shown in both cases as the shaded areas between the world price and the social curves over the quantities overproduced and overconsumed. In the presence of externalities, trade may or may not be beneficial. It may, for instance, encourage production of a commodity with negative externalities, or reduce consumption of a good with positive externalities. In such cases, the losses may exceed the normal gains from specialization.

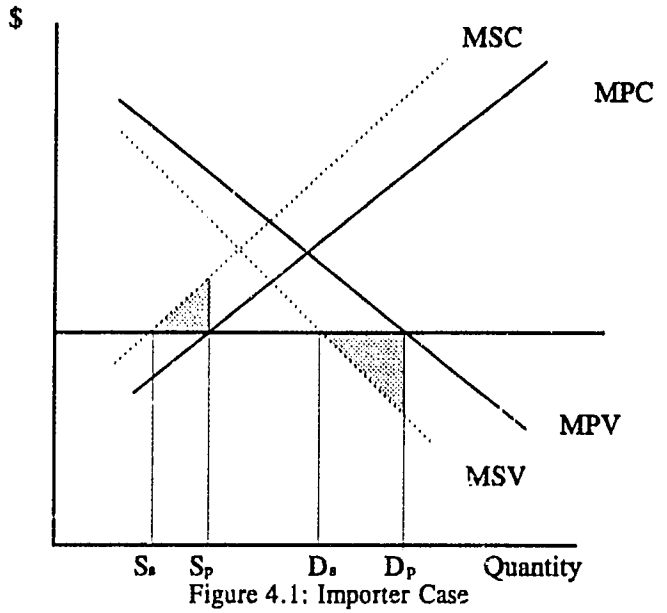

Figure 4.1: Importer Case

Assume now that the country institutes policies to constrain the domestic economy to the "correct" levels of consumption and production. The situation is shown in Figure 4.3. Optimum Pigouvian policies require both producer and consumer taxes and subsidies, in whatever

combinations (and by whatever means) will give prices of P_C for consumers and P_P for producers. Command-and-control schemes, or marketable pollution rights, will also need to bring output and demand to S_s and D_s respectively. It is important to note that the gains from trade survive the presence of externalities. In Figure 4.3, the potential social welfare is enhanced by the shaded areas. The integral of the social net benefit (value less cost) function (represented on the graph by the area between the MSV and MSC curves) is expanded by the possibility of trading at the world price. The earlier conclusion that trade can make a situation worse assumes critically *that the domestic divergence has not been corrected*: if domestic optimum policies are pursued, then the full potential gains from trade are nevertheless realized.

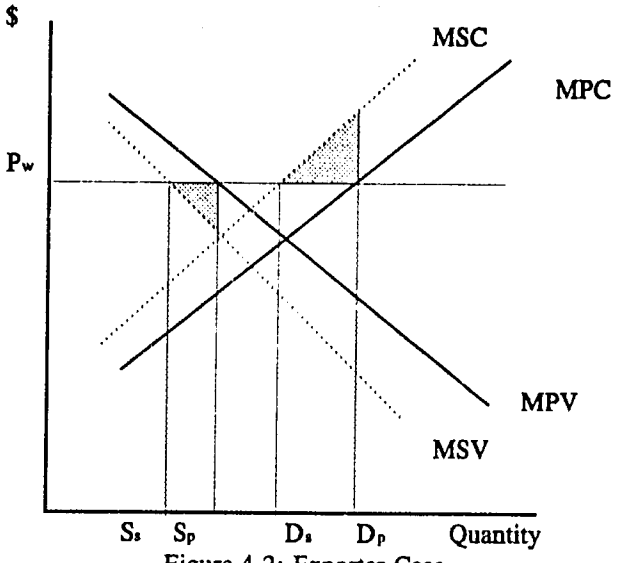

Figure 4.2: Exporter Case

Model 4: Incorporating International Trade

To introduce trade into the model, take the following steps:

(i) Insert 5 rows at A42 (/WIR A42.A46)
Insert 3 columns at I (/WIC I49.K49)
Insert 1 column at V49 (/WIR V49.V49)
Erase cells A27.E28 (closed-economy elasticity formulae no longer relevant)

(ii) Type the new labels for the "model" range in C8, C14, C20, A43, A46. Enter 30 in cell C46. Type the new labels for the "graphdat" range, as in Table 14. This involves new headings in columns I, J, K, L, and M, along with T and U.

(iii) Enter new formulae to change the price level used in the market equilibrium and surplus calculations from the "autarchy" price, where supply and demand meet, to the world price, as follows:

Variable	Expression	Cell	Formula
Qss	(Pw/b) - (a/b)	E6	(C46/E4) - (D4/E4)
Qds	(Pw/d) - (c/d)	E7	(C46/E5) - (D5/E5)
Qxs	Qss-Qds	E8	+E6-E7

Qsp	(Pw/f)-(e/f)	E12	(C46/E10)-(D10/E10)
Qdp	(Pw/h)-(g/h)	E13	(C46/E11)-(D11/E11)
Qxp	Qsp-Qdp	E14	+E12-E13
Qst	(Pw/f')-(e'/f')	E18	(C46/E16)-(D16/E16)
Qdt	(Pw/h')-(g'/h')	E19	(C46/E17)-(D17/E17)
Qxt	Qst-Qdt	E20	+E18-E19
Qst	w'+x'Pw	E24	+D22+(E22*C46)
Qdt	y'+z'Pw	E25	+D23+(E23*C46)
Qxt	Qst-Qdt	E26	+E24-E25

The interpretive statistics also have to be modified to take into account the possibility of trade at the world price. Trade makes it possible to choose production and consumption quantities independently of one another, and hence allow social and private profits from production and consumption to be increased. Gains from trade can therefore be calculated by subtracting the "autarchy" profit (ie when production and consumption are the same) from the profit in the presence of trade.

Variable	Cell	Formula
Social Profit	C39	@max(R54.K154)+@max(L54.L154)
Private Profit	C40	@max(Q54.Q154)+@max(S54.S154)
Social Gain from Trade	C43	+C33-@max(M54.M154)
Private Gain from Trade	C44	+C34-@max(T54.T154)

In addition the graph data have to be modified, both to take into account the world price in the calculation of social and private surpluses and also to calculate separate "autarchy" surpluses to allow calculation of the gains from trade.

SOCIAL EQUILIBRIUM ANALYSIS	EXERCISE 4			
Corrective Policies and Social Optima				
Social Cost Curve	MSC = a + bQ	MSC	5	0.2
Social Benefit Curve	MSV = c + dQ	MSV	20	-0.1
Socially Optimal Quantities		Q for production		25.0
		Q for consumption		100.0
		Trade		-75.0
Before taxes and subsidies			constant	slope
Private Cost Curve	MPC = e + fQ	MPC	2	0.15
Private Benefit Curve	MPV = g + hQ	MPV	25	-0.08
Equilibrium Quantities		Q (production) =		53.3

		Q (consumption) =		187.5
		Trade		-134.2
adjusted for taxes and subsidies			constant	slope
Private Cost Curve	MPC' = e' + f'Q	MPC + tax	3	0.26
Private Benefit Curve	MPV' = g' + h'Q	MPV - tax	15	-0.05
Equilibrium Quantities		Q (production) =		25.0
		Q (consumption) =		100.0
		Trade		-75.0
			constant	slope
Supply Curve	S = w + xP	Supply	-13	3.83
Demand Curve	D = y + zP	Demand	313	-21.25
Equilibrium Quantity		Q (production) =		25.0
Equilibrium Price		Q (consumption) =		100.0
		Trade		-75.0
Corrective Policies			ad	
		specific	valorum %	
Production tax (+) or subsidy (-)		0	74.0	
Consumption tax (+) or subsidy (-)		0	41.2	
Remaining Divergences				
Necessary producer tax or subsidy		1.52	-23.37	
Necessary consumer tax or subsidy		-5.29	-112.48	
Maximum Social Profit		120.0		
Maximum Private Profit		277.8		
Difference		157.8		
Social Gains from trade and policies		37.5		
Private Gains from trade and policies		228.5		
World Price Level		10		

Variable	Cell	Formula
Pw-MSC	I54	+U54-G54
MSV-Pw	J54	+H54-U54
Cumulative	K54	+K53+J54

Cumulative	L54	+L53+J54
Soc Prof (Aut)	M54	+K54+L54
PS	P54	+U54-N54
CS	R54	+O54-U54
Priv Prof (Aut)	T54	+Q54+S54
Pw	U54	+C$46

and copy down I54.V54 to I54.I154.

(iv) Adjust the graph settings by adding the address and legend for variable E. Adjust the graph setting for the other graph by changing the addresses and legends for variables A, B, C, and D.

(v) Save the spreadsheet as SOCIAL4.WK1, before making further modifications.

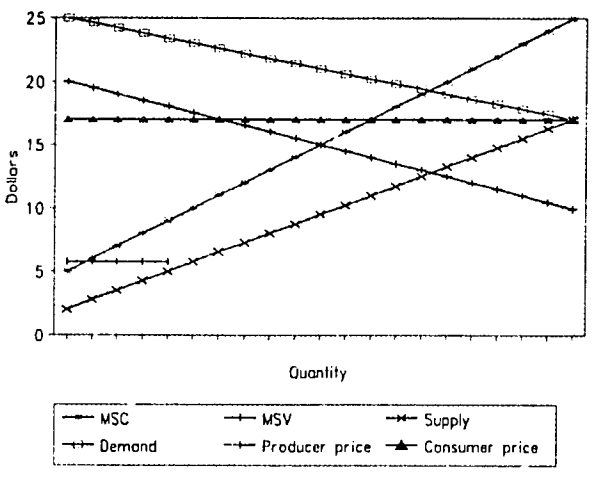

Figure 4.3: Incorporating International Prices

In addition to changing parameters on the social and private curves, and adding different taxes and subsidies, the model can now show the impact of different world prices. Enter the world price at cell C46. How do different levels of world price alter the trade balance, and the level of social and private profit? The following exercise gives some practice at running this trade model.

Exercise 4: Computing a Trade Model

Assume that the social and private curves for Italian corn are as follows:

MSC=5+0.2Q
MSV=20-0.1Q
MPC=2+0.15Q
MPV=25-0.08Q

The world price is 10. How much would be imported if there were no corrective policies (ie no taxes and subsidies)? What would be the level of trade to maximize social profits? What producer and consumer taxes and subsidies are needed to make the market clearing output and

consumption equal to the socially desirable levels? What are the social gains from introducing the corrective policies? What are the gains from trade? What do private individuals gain from trade? Why are private and social gains from trade different? Impose a tax of 74 percent on production and 41.2 percent on consumption. Now compare the trade quantities with the socially optimal level.

Chapter 5: World Price Distortions

The previous exercise made the assumption that world prices were a true reflection of the social cost of imports and the value of exports. This is not necessarily the case. Three factors might cause a "trade divergence":[5]

- trade involves a risk or other hazard deemed to reduce its value in social terms, or a non-pecuniary benefit which is over and above private valuations,
- trade introduces disease organisms (plant, human or animal) which cross with traded goods, and
- exchange rates may be out of line, not reflecting the true cost and value of foreign exchange.

If any of these were to be significant, then one can define a private and social world price level.

The situation for the open economy and trade divergences is shown in Figures 5.1 and 5.2. The social world price, adjusted for risks, pathogens and exchange rates, is labeled Pws, in contrast to Pwp the market (private) world price. Output and consumption respond to the private signals, with the losses (shaded) representing the social costs of overproduction and overconsumption in the presence of trade, which could even outweigh the gains from trade. These losses are measured relative to the social price of trade goods.

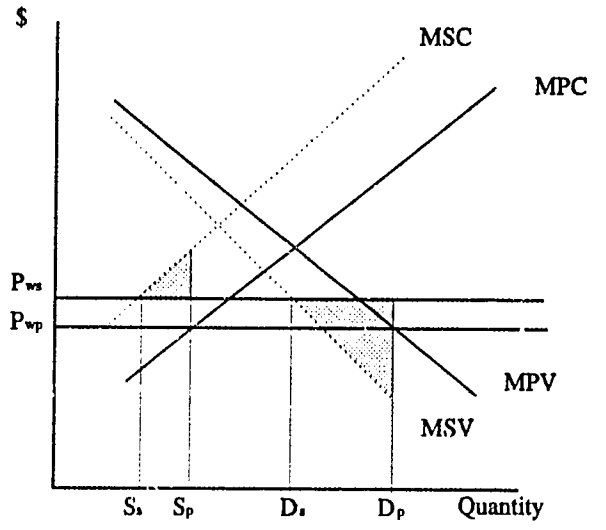

Figure 5.1: Private and Social Equilibria in the Presence of Trade: Importer Case

Once again, corrective policy can rescue the situation, by influencing producer and consumer prices. Consumer prices at Pc and producer prices at Pp will give consumption and production at Ds and Ss, respectively, and thus ensure a social optimum. The shaded areas represent the gains from trade, in the presence of corrective policies, which shows again that trade is beneficial if domestic divergences have been offset by policies.

[5] This chapter still keeps the "small country" assumption, that world prices are given. The ability of a large trader to influence world prices leads to similar conclusions but is not treated here.

The algebraic model can be modified simply by recognizing that the trade tax (tariff, import subsidy, export tax or export subsidy) changes the market price, and hence the price received by producers and that paid by consumers. The market clearing equilibrium is given by the intersection of these tariff-and-tax ridden supply and demand curves (or the equivalent cost and benefit curves), and the social surplus is measured from the social level of world price.

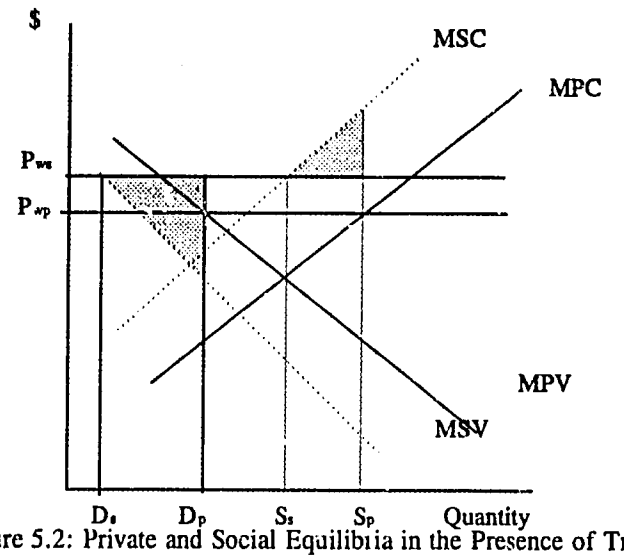

Figure 5.2: Private and Social Equilibria in the Presence of Trade: Exporter Case

Model 5: Adding World Market Price Distortions

The previous version of the model can be adapted to take into account trade divergences by making the following addition:

(i) Add labels to the model range as shown in Table 5.1, specifically in A34, A38, A42 and A47.A49. Enter a value, such as 3, in C47 and 10 in C48.

(ii) Insert 2 columns at V50 (/WIC V50.W50) and add labels to the "graphdat" range, as shown in Table 19, in column V and W.

(iii) Enter new formulas to change the world price in the social optimum calculations to correspond to the social world price and to make the market price reflect the presence of a trade tax as follows:

Variable	Cell	Formulae
Qss	E6	(C49/E4)-(D4/E4)
Qds	E7	(C49/E5)-(D5/E5)
Qsp	E12	(C46/E10)-(D10/E10)
Qdp	E13	(C46/E11)-(D11/E11))
Qst	E18	((C46*(1+D34/100)+C34)/E16-(D16/E16))
Qdt	E19	((C46*(1+D34/100)+C34)/E17-(D17/E17))
S'	E24	+D22+(E22*(C46*(1+D34/100)+C34))
D'	E25	+D23+)E23*(C46*(1+D34/100)+C34))

(As you make these changes, be sure to understand why the modifications are appropriate) The interpretive statistics need modification, by adding variables to pick up

the remaining difference between the trade taxes imposed and to define the social world price, as follows:

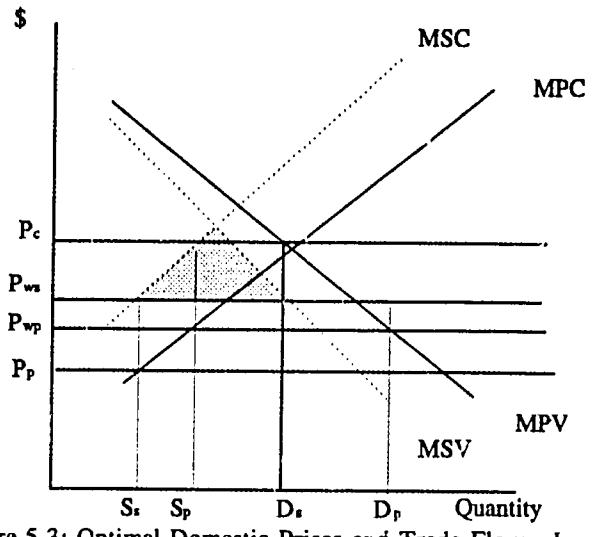

Figure 5.3: Optimal Domestic Prices and Trade Flows: Importer Case

Variable	Cell	Formulae
Necessary trade tax (spec)	C38	+C47-C34
Necessary trade tax %	D38	+C48-D34
Tariff Revenue	C42	+E26*((C46*D34/100)+C34))
World Price (Soc)	C49	+C46*(1+C48/100)+C47

The information for the graphs needs to be changed to reflect the incidence of the tariff, as follows:

Variable	Cell	Formulae
PW(Soc)-MSC	I54	+V54-G54
MSV-PW(Soc)	J54	+M54-V54
PS	P54	+V54+W54-N54
CS	R54	+O54-V54-W54
PW(Soc)	V54	+C$49
Tariff	W54	+V49*(D$34/100)+C$34

SOCIAL EQUILIBRIUM ANALYSIS	EXERCISE 5			
Corrective Policies and Social Optima				
			Constant	Slope
Social Cost Curve	MSC = a + bQ	MSC	5	0.2
Social Benefit Curve	MSV = c + dQ	MSV	20	-0.1
Socially Optimal Quantities		Q for production		50.0
		Q for consumption		50.0
		Trade		0.0
Before taxes and subsidies			Constant	Slope
Private Cost Curve	MPC = e + fQ	MPC	2	0.15
Private Benefit Curve	MPV = g + hQ	MPV	25	-0.08
Equilibrium Quantities		Q (production) =		86.7
		Q (consumption)=		125.0
		Trade		-38.3
adjusted for taxes and subsidies			Constant	Slope
Private Cost Curve	MPC' = e' + f'Q	MPC + tax	2	0.15
Private Benefit Curve	MPV' = g' + h'Q	MPV - tax	25	-0.08
Equilibrium Quantities		Q (production) =		86.7
		Q (consumption)=		125.0
		Trade		-38.3
adjusted for taxes and subsidies			Constant	Slope
Supply Curve	S = w + xP	Supply	-13	6.67
Demand Curve	D = y + zP	Demand	313	-12.50
Equilibrium Quantities		Q (production) =		86.7
		Q (consumption)=		125.0
		Trade		-38.3
Corrective Policies			Ad	
		Specific	valorum %	
Production tax (+) or subsidy (-)		0	0.0	
Consumption tax (+) or subsidy (-)		0	0.0	

Trade tax (+) or subsidy (-)		0	0.0	
Remaining Divergences				
Necessary producer tax or subsidy		3.00	33.33	
Necessary consumer tax or subsidy		5.00	-25.00	
Necessary trade tax or subsidy %		0.00	0.00	
Maximum Social Profit (Optimum Policies)		83		
Maximum Private Profit (No Policies)		245		
Difference		163		
Tariff revenue		0		
Social Gains from trade and policies		0		
Private Gains from trade and policies		4		
World Price Level		15		
Fixed Divergence		0		
Proportional Divergence (%)		0.0		
Social World Price		15		
Social Profit from Production		27		
Social Profit from Consumption		0		
Total Social Surplus		27		
Producer Surplus		119		
Consumer Surplus		0		
Total Private Surplus		119		

Copy down I54.W54 to I54.I154 to complete the table.

(iv) Modify the graph settings by adding the address and legends for series F. The other graph should require no changes.

(v) Save spreadsheet as SOCIAL5.WK1.

The assumed divergence between the market price of imports and their social cost (or the market returns from exports and their social value) can be entered in cells C47 and C48. A percentage divergence could represent a misaligned exchange rate, and a per unit divergence might imply a commodity-specific externality. The level of trade taxes can be varied by imposing both specific taxes and also percentage taxes, in C34 and D34. Try to offset the trade divergence, ie the difference between the actual world market price and the social cost of

importing (or value from exporting).

Exercise 5: The Effect of Price Distortions

Start with the parameter values used in the previous exercise, ie:

$$MSC = 5 + 0.2Q$$
$$MSV = 20 - 0.1Q$$
$$MPC = 2 + 0.15Q$$
$$MPV = 25 - 0.08Q$$

assume that the world market price is 10. Further assume a 10 percent overvaluation of the exchange rate (ie foreign exchange is too cheap by ten percent). What would be the level of trade to maximize social profits? What producer, consumer and trade taxes and subsidies are needed to make the market clearing output and consumption equal to the socially desirable levels? What are the social gains from introducing the corrective policies? What are the gains from trade if all corrective policies are applied? Impose a tax of 54 percent on production and 43.8 percent on consumption, and note the level of trade and the gains from trade. Now compare these trade quantities and social gains with the result of a 69.4 percent production tax, a 38.2 percent consumption tax, and a 10 percent trade tax. Explain your results.

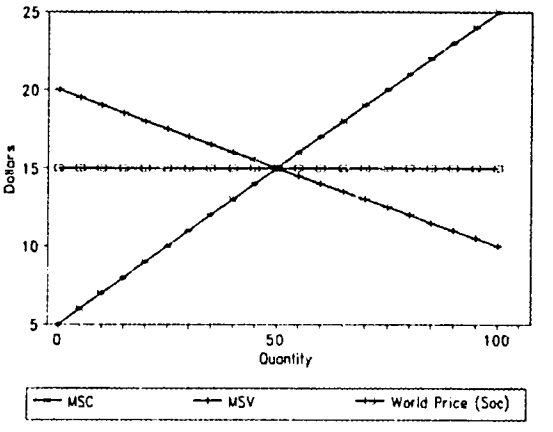

Figure 5.4: World Price Equilibrium

Chapter 6: Analyzing Agricultural Policy Issues

The models just described have the merit of being able to contribute to the understanding of a number of different policy issues. This chapter is an attempt to show the way in which it might be used in a small sample of "new" policy issues: the regulation of public health and food standards in open agricultural markets; the question of how to define "sustainable" agriculture; and the issue of trade and the environment. The issues chosen have all arisen in policy discussions in recent years and many involve a clash between domestic and international policies.

Trade and regulation of public health

There has been considerable interest in recent years in the impact on trade of domestic policy in the area of health and safety standards, including as a subcategory the range of sanitary and phytosanitary regulations (SPR). Some argue that such policies can represent undesirable trade impediments, posing a challenge for trade relations between countries, as well as for multilateral trade rules. This has led to an attempt to harmonize such policies among countries. Others have suggested that the existence of trade itself poses a threat to the working of these national policies, and freer trade, whether on a regional or global basis will expand that threat. The antagonism of many environmental and consumer groups to the Uruguay Round of GATT negotiations and to the prospect of a North American Free Trade Area stems from this view.

These issues can be treated analytically, employing the model described above. The first step is to identify the objectives deemed to be the rationale for public policy action, and then to consider the regulatory instruments available for use. In terms of the model this implies identifying the set of divergences presumed in the market and specifying a choice of ways in which government can intervene in the market.

At the risk of oversimplification, government health and safety regulations in the agricultural area can be thought of as meeting five needs: a) protection of consumers from unsafe food; b) protection of workers from unhealthy working conditions; c) protection of the environment from contamination as a result of farming practices; d) prevention of animal abuse; and e) protection of plants and animals from disease.[6]

The first of these types of concerns can be conveniently modeled as an example of a negative consumer externality associated with the consumption of the unhealthful product; the second, third and fourth as a negative externalities in the different aspects of production process for domestic agriculture; the fifth as a negative trade externality, occasioned by the unwitting import of pathogens along with the desired goods.

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[6] Until recently, regulating the treatment of farm animals so as to prevent hardship and suffering was not a major policy issue: authorities had statutes that governed such matters, but they did not have much public visibility nor did they impinge on other areas of farm policy. Destruction of species and habitats in the act of forestry, and the accidental injury to marine mammals while fishing have of course been the focus of much attention, but this is considered as a broader "environmental" issue below.

The range of policy responses to these issues open to the government in the closed economy is relatively limited. The consumer externality can be countered with education and labeling, allowing the consumer to identify and avoid those goods considered risky; or the government can set standards for products sold on the market, in effect usurping or prejudging the consumer decision; or it can regulate the production process so that the undesired food product is never produced. Direct taxation of the "undesirable" good is not often tried for foodstuffs, though it is widely used for tobacco and alcohol. The producer externalities can be offset by worker education and training, farmer education, regulations on farming practices, and taxes to discourage the use of environmentally damaging inputs (or subsidies to encourage better practices).

Many of the most politically contentious issues that have arisen in the area of farm policy in recent years have come along with the increased exposure of agricultural sectors to international trade. The above policy choice changes somewhat under such open economy conditions. Trade will change the policy issue in two ways. First, in so far as government regulations differ among countries, the existence of trade raises demands for border inspection to keep out substandard imports. This can be both to protect domestic consumers from the "lower-quality" imported product and to protect domestic producers from competition from foreign producers who face less stringent standards. Secondly, as environmental conditions and the assessment of risks will tend to differ in different countries, there will be an additional incentive to trade: trade takes advantages of these national differences and tends to lower the cost of providing such protection. But trade also can cause changes in the political economy of farm policy. Such changes underlie much of the new farm policy agenda.

These points can be illustrated with respect to the optimum intervention model described above. In the closed economy model with multiple domestic divergences, the balance chosen between producer and consumer corrective policies does not greatly matter. The price spread can be maintained by raising consumer prices or by lowering consumer prices, or by any appropriate combination of the two. The same is not true of the open economy models, where to correct for the full range of divergences one needs a consumer tax/subsidy, a producer tax/subsidy, and a trade tax/subsidy. This result can be directly applied to the issue of the impact on the farm policy agenda of the expansion of trade. Consumer policies in a closed economy can be run as a branch of producer policy, mainly by regulating production methods. Such policies are commonly under the control of agriculture ministries. Food policy in an open economy, by contrast, raises different issues. Consumers will still demand that their food supply, from whatever source, meet certain standards of quality and safety. But it is no longer possible to satisfy this demand only by regulating domestic production. And if one regulates at the border, then the risk is incurred of rent-seeking by domestic producer groups, offering the twin package of consumer protection against lower quality foods and producer protection against lower market prices.

The same conclusion is apparent in the case of production externalities, both those that arise from the cost to workers of using hazardous materials and those that have to do with soil, air and water pollution. In the closed economy, such matters can be regulated at a variety of stages in the production and marketing chain. Banning the sale of a herbicide, for instance, effectively prevents any ill-effects to farm workers from applying it to fields. Banning any

residue in foodstuffs of the same chemical might have the same effect, though as indicated above the regulations were more often at the farm level. Partly because of this, environmental legislation has been tied into land-use regulation. In an open economy, things look very different. The need for separate instruments to regulate farming practices, environmental policies and consumer concerns calls for a change in policies. Consumers are not well-served by policies which prevent them from consuming goods which meet local consumption standards but were produced abroad, where environmental and labor conditions are different.

The model developed above suggests that each country should put its own house in order, in terms of correcting for domestic divergences, and not attempt to use trade policy for that purpose. Trade policy, the model suggests, is only for correcting the trade-dependent externalities, such as the transmission of disease across borders. Under such a regime of national optimum policies, countries and states can legislate the method of production of agricultural goods within their jurisdiction. Taking advantage of the opportunity to trade does not imply any loss of control over the regulation of worker health or of soil, water, or air pollution. Indeed, it opens up possibilities for lower-cost controls over domestic production externalities, as domestic consumers do not have to foot the bill. The converse is also true: the benefits of trade are not hampered by the appropriate use of corrective domestic policies. The fact that a nation's legitimate policy corrections has an impact on the pattern of trade, and may in certain cases lower the volume of trade, does not mean that trade is thereby distorted. Indeed, it would be a distortion to deny consumers or farm workers their desired health protection, merely for the sake of expanding trade.

Different consumer laws can only become trade barriers when they are administered as border restrictions. Rent-seeking activities are allowed to cloud the public policy picture. Economic motives for protection become linked with the operation of health standards. The objectives of public policy become confused and the instruments become abused. Mercantilist and xenophobic political arguments masquerade as sound common sense.

Assume that two trading partners differ on the issue of the acceptability of a particular chemical residue level in food. The country with the stricter standard will undoubtedly seek to institute controls over imports. If that country chooses to regulate its own producers, it will seem natural to test imports from abroad to ensure compliance with the same standards. But the act of inspecting goods at the border is the cause of most complaints arising from different national consumer standards. Producers in other countries feel that they have no say in the way in which the regulations are imposed. They fear discrimination with good cause: there are countless examples of the use of health standards to keep a little more of the domestic market for local producers. The consumer gets some protection, but pays in higher costs for the produce, to the net disadvantage of the economy as a whole.

Similarly, if two trading partners differ on the health hazards of particular farming practices, such as the use of pesticides, on farm workers. In this case the regulations may put the producers in the stricter country at a disadvantage in the marketplace. Their ability to compete on both domestic and international markets will be impaired. Similar effects may be felt from different policies on groundwater pollution and on animal welfare. Producers will often be tempted to argue for economic protection to counter their cost disadvantage. In this way a trade

barrier may arise as a result of different production standards. The producer protection from the economic implications of stricter production standards will again come at a cost to the consumer and to the economy as a whole.

The best hope for removing the temptation to use health standards as trade restrictions is to de-emphasize action at the border. Enforcement of any particular pesticide-residue limit should be carried out on all foodstuffs regardless of origin. In general, this would imply testing at the wholesale level, where imported and domestic goods merge. Control over method of production would no longer be an appropriate way of enforcing this consumer standard, though there might still be controls to comply with worker-health and environmental regulations. Production methods would in effect become self-regulated: all producers (domestic and foreign) would have an incentive to produce goods that would pass the test at the wholesale level. And domestic producers would be free to use different production methods for other, less regulated, consumer markets. Most importantly, the absence of any border controls would reduce the possibility of granting an economic advantage to domestic producers and remove the possibility of challenges from trading partners. The GATT principle of "national treatment" for imports (i.e., no discrimination within the country on the basis of origin) would be applied, and as no border intervention would be needed, these would be no need for recourse to the Article XX exemption.

Does the same hold true for different production standards, designed to protect worker-health or animal welfare, or different policies to control resource depletion? If no border restrictions apply, then it is much less likely that such policies will be viewed as trade issues. Other countries will reach their own decisions on the use of their resources and the standards they set for worker safety. The removal of the temptation to use trade policy instruments to influence such decisions will improve conditions in international trade.

Under what conditions might it be necessary to retain border controls? Some health problems arise directly from the transmission of goods across borders. In particular, plant and animal diseases are often spread through trade. In this case, intervention at the border is often the best way to prevent the spread of disease. Free trade will always be subject to the qualification that unwanted pathogens should not accompany the traded products. It may not be possible to avoid all cases of economic protectionism taking advantage of such sanitary and phytosanitary import restrictions. But the problem will be minimized if the regulations are clearly cast in terms of the objective of disease control. This will normally imply differentiation of the regulation by place of origin, as areas of endemic disease do not always correspond to national boundaries.

Sustainable agriculture

Among the most controversial of the new concepts that have emerged in the agricultural economics literature in recent years is that of "sustainable agriculture." The broader concept of sustainable development has been around since the mid-1960s and has now become a tenet of World Bank and USAID development assistance. It refers to the perception that "economic development must consider both protection of natural resources and maintenance of environmental quality" (Batie, 1989, p 1083). As such it has attracted the attention of

environmentalists, who see the "older" economic development strategies as ignoring such issues. Sustainable agriculture, by extension, implies the "management of resources (including soils, crops, water and fish, livestock and forestry) to maintain and improve their productive capacity over time." (Cusumano, 1991).

The concept in its purest form clearly poses problems for economic analysis, which is largely based on the notion that consumers obtain satisfaction from "consuming" commodities, not conserving resources. Societies can, of course, abstain from current consumption in order to consume more later, but the shift of emphasis from production to productive capacity is profound. Happily, there are interpretations of sustainability which allow economists to continue to view the economic process as consumption--and at the same time take into account the responsibilities of stewardship of resources for the next generation. Dasgupta, for instance, argues that the natural resource base of the economy (or planet) is an asset essential to the productive process: depreciation of that asset base should be calculated and included in economic measures of well-being (Dasgupta, 1991). Depleting the asset base is not irrational in itself, but the cost should be incorporated into the calculus. In this way, the more tricky ethical and philosophical issues related to the intergenerational distribution of income and the intrinsic value of natural objects can be ducked--or rather subsumed in the task of putting a value on changes in the natural resource base.

Armed with the knowledge that environmental degradation can be reduced to a "user cost", the analysis of sustainability can proceed. The model introduced above needs no modification if one can measure the externalities. Environmental benefits (costs) are merely the joint production of a private good and a public good (bad). Sustainability is therefore indicated by the time path of the externality: an increasing divergence between private and social evaluation of costs and benefits over time is unlikely to be sustainable. Fully correcting for such divergences must therefore be sustainable. Concern over sustainability should therefore focus on the correction of current production and consumption patterns.

Sustainability problems are not all global issues, nor do they all involve imponderable matters of species survival. Some are relatively easy to internalize into private decisions. Many are of specifically local interest, while others affect a region or country but have little impact outside those borders. A few examples can make this point clear. A farmer who is careless about maintaining the fertility of the land will suffer yield reductions or cost increases, and the market value of the land will reflect the lower level of productivity. In this case, there may be no externality present. Divergence problems exist where there is either imperfect information or inadequate markets in assets (or rental services). Under these circumstances a prima facie case exists for public intervention. By definition, few if any of these privatized sustainability issues have impacts across boundaries. It should be of no concern to one country if farmers in a trading-partner country knowingly depreciate their asset base.

Should the same farmer manage her resources in such a way as to cause true external costs, by progressive pollution of groundwater for instance, then measures can be applied appropriate to the situation. What would be unsustainable would be the absence of such corrective measures, for then the pollution would get worse. Sustainability, in this context,

appears to be no more than applying the right policy. But if traditional analysis can identify that correct policy, then no new apparatus is needed to study sustainability. Instead, the controversy may boil down to a clash of preconceived solutions (quantitative control at the federal level vs. local tax/subsidy schemes, for instance) and to doubts about the ability of technicians to calculate external costs with any accuracy.

Trade and the environment

Trade has also become entangled with that set of issues that have to do with global environmental problems. Trade negotiations are sometimes seen as reducing the willingness and ability of countries to prevent or offset such global environmental hazards. The GATT is already gearing up for a "green round" of trade negotiations, when (and if) the current Uruguay Round is completed (GATT, 1992). The Uruguay Round itself has become the focus of some attention by some environmentalists, who associate expanded trade with the destruction of the tropical rainforests. "Eradicating restrictions on the trade of tropical products and reducing the sovereignty that third world countries have over natural resources will undermine efforts to conserve tropical forests." (Menotti, 1989). The complaint is that the GATT agreement would prohibit export controls on timber, import bans on tropical hardwoods, and domestic subsidies on reforestation.

Our analytical model suggests a classification of problems in this area, to avoid some of the confusion that seems to have been created. Externalities that occur within a country and that have no spillover effects should be separated from those which either spill across borders or which affect people in other countries through less direct means. Externalities within a country should presumably be corrected by the appropriate authorities within that country. If these corrective policies are operated through internal regulation (whether command-and-control, Pigouvian taxes or tradable permits), then no trade impediment is created. Indeed, trade is distorted if the domestic corrections are not made. This calls into serious question the present trend toward eliminating national subsidies on the grounds that trade is distorted. The analytical issue is whether the size of the subsidy is excessive relative to the divergence it is intended to correct. Of course, such measurements are likely to be controversial, and in practical terms it may be difficult to negotiate on the issue as to whether one's subsidy on an environmentally-safe production process exceeds the social benefits of that process. But it would still seem appropriate for economists to state that the phasing out of domestic subsidies in order to obtain a socially undesirable ("free") trade pattern is not analytically supportable. Incorporating reasonable guesses on the size of externalities into trade models would give some indication of how important empirically is this objection.

Cross-border pollution is a special kind of international problem, having little to do with trade. It is possible that export expansion in border regions could add to air and water pollution, but the same pollution could occur if the expansion were to meet domestic consumption. Such cross-border externalities, unrelated to trade, present a classic case for bi-national or multi-national environmental coordination. The pollution problems of the Rhine River, which runs through four countries, is a notable example, as are Mediterranean water quality issues and those pertaining to salinity in the lower reaches of the Colorado River. To confuse these issues by addressing them through trade discussions is clearly unhelpful.

Externalities that are only indirectly linked to trade are more tricky. Suppose that one country's consumers object to the way in which another country produces a product. The product itself confers no negative consumption externality, but the production process itself causes offense. (There could also be similar positive externalities.) International production externalities clearly have led to trade frictions, of which the recent US-Mexico dispute on method of tuna fishing is a good example. The "open economy" divergence model would suggest that many US consumers would indeed overconsume tuna caught at the expense of dolphins in the absence of some action. One approach to the problem is to tackle it by labeling, as indeed happened, giving the presumably higher-cost dolphin-safe tuna (the same product produced with a different technology) a market niche.

Consumers can express their preferences in the market. In addition, US law could (as it does) mandate fishing practices to minimize the problem in the US tuna fleet. The question is to what extent should the US ban imports from countries not conforming to such fishing standards (or who might import tuna from those countries for reexport to the US). The externality is generated by the production process, and therefore should be tackled at the source, but the angst is felt by people outside the jurisdiction in which the fishing is taking place. This is a clear case of a global externality, where optimum national policies do not maximize global welfare. A global public bad is being produced along with the private good and any national public goods that might be associated with tuna fishing. International agreement, along with transfer payments if necessary, is the first-best solution. US trade sanctions should therefore be seen not as a rational policy response but as a statement of concern and a way of bringing pressure to bear on other countries to modify their domestic policies. The question for the GATT is whether such "embargo" statements are to be allowed.

These statements suggest that by correct policy targeting, clashes between trade and environmental objectives can be avoided. There will always be a set of "global" issues that cannot be resolved by independent national action. Using trade policy to coerce others into taking environmental action is a diplomatic rather than an economic issue. Rarely will the appropriate economic policy be to intervene at the border. But it is important to stress that the increasingly open environment can put more pressure on domestic policies. The new agenda for agricultural policy is in large part a reflection of this concern. Old policies are likely to be less appropriate in an open environment, and new policies must be carefully targeted. If this is done, the potentially positive effects of more open markets can be harnessed without compromising the objectives of health, resource stewardship, and concern for the environment.

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AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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AGRICULTURAL AND NATURAL
RESOURCE POLICY ANALYSIS
COURSE

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Policy Analysis: Micro-Level
Modeling Using GAMS

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PREFACE

Partial equilibrium budgeting methods continue to be the backbone of much of the analysis on agricultural policy. In their simplest form, budgets provide the evidence that policy makers use to make decisions about private profitability and hence the incentives that farmers have to grow particular commodities. In more sophisticated frameworks, such as the Policy Analysis Matrix (PAM) approach, the same partial methods are extended by using social prices along with private prices in the computations, to examine such issues as comparative advantage and the sources of policy intervention.

The results of programming and budgeting methods are identical if it can be assumed that the competition between crop activities can be reduced to a single resource. When all costs, including the costs of mobile domestic factors such as capital and labor, can be captured in the crop's net revenue calculation, comparative advantage in the use of the unique factor, say, land, is determined by the most profitable enterprise.

It is difficult in many agricultures, however, to characterize the competition for resources in such a straightforward way. In much of the arid and semi-arid tropics, for example, the presence of irrigation makes it possible to grow crops throughout the year, and the ways in which harvesting and planting overlap are important determinants of comparative advantage. Seasonal constraints are made even more complex if water is a scarce resource and its seasonal distribution is determined by precipitation and snow melt.

At a more general level, policy analysts may find it unrealistic to characterize domestic factors such as labor as being completely mobile between the agricultural and non-agricultural sectors. Family labor, for example, often sees working off the farm as fraught with high transaction costs. Analyses about policy response that do not take this and the presence of fixed durable production assets such as animals, tractors and pumps into account tend to overestimate the responsiveness of the sector to policy reforms.

Extending partial equilibrium budgeting methods to take additional fixed factors into account is relatively straightforward. A great deal of data is common to both approaches. Both require, for example, detailed information on production technologies in the form of yields, tradable inputs such as fertilizers, pesticides, seeds, etc. The description of production activities is also standardized in both on a single unit such as an acre, feddan or hectare. In both methods, information on the way in which domestic resources such as land, labor and capital are used and the extent to which markets for these factors exist is crucial to the analysis. However, the difference in assumptions about the extent of fixed factors requires analysts using l.p. methods to develop a more careful inventory of the physical quantities of resources available to the enterprise or the economy.

The following exercises seek to investigate the impact on policy analysis of the assumption that more than one fixed resource is potentially binding on agricultural output. Whether or not this is true is an empirical question and part of the modeling exercise. Additional constraints complicate the determination of comparative advantage, and hence policy recomendations, because of the increased complexity of the trade-offs in the use of resources. Some of this complexity could be reduced if specific binding constraints were known before hand. Optimal resource use could then be

determined by solving a set of simultaneous equations for the levels of various enterprises. However, in the absence of such knowledge, optimization algorithms such as the Simplex method or various "branch and bound" approaches must be employed.

The exercises contained in this manual begin with a simple tutorial developed from data presented in Hazell and Norton's *Mathematical Programming and the Economic Analysis of Agriculture*. This textbook serves not only as source of theory and ideas for the application of l.p. methods, but also as a guide to the sequence of the manual's exercises. For example, as in the book, the first step here is to develop a simple farming systems model based on data drawn from a mythical "Mayaland." This model is expanded to include factor substitution, seasonality, diminishing returns and factor markets. With the addition of demand curves for commodities and supply curves for inputs, the farm level model is used to simulate the behavior of the Mayaland agricultural sector.

The software package used in the course, GAMS, derives its name from its full description as a *G*eneralized *A*lgebraic *M*odeling *S*ystem. It is a computer language designed to facilitate a variety of simulation and optimization modeling activities. Its power is derived from the efficiency with which models that can be specified algebraically can be written down and computed.

The use of GAMS, although powerful and flexible, requires an investment by the user. In this regard, it is perhaps more demanding than other currently available l.p. codes such as Linus Schrage's LINDO or Sunset Software's XA. However, the resulting ability to write readable models and to apply non-linear methods where appropriate more than repays the additional effort required.

Access to GAMS has been made somewhat easier by the publication of Brooke, Kendrick, and Meeraus's *GAMS: A User's Guide* (Scientific Press). This book provides authoritative documentation on the program and should be a part of every analyst's library. Unfortunately, it is not a user friendly "Users Manual." A more readily accessible entry to GAMS is Jefferson and Boisvert, *A Guide to Using the General Algebraic Modelling System (GAMS) for Applications in Agricultural Economics*, Department of Agricultural Economics, Cornell University.

The manual also includes several references to Eric Monke and Scott Pearson, *The Policy Analysis Matrix for Agricultural Development*. In part, these references have been included because l.p. exercises are often best understood by contrasting them with the budgeting methods employed in the book. Perhaps more importantly, however, the book provides an excellent exposition of the general argument that policy interventions can be understood best by comparing private and social prices of outputs, inputs and domestic resources. The two approaches are joined in the manual when GAMS is used to derive individual commodity PAM's based on the optimal solution to an l.p. problem.

The present manual marks the first draft of a number of the GAMS exercises. Although they all have been run in the form presented, typos and discrepancies between the model that ran and the excerpts shown in the text may have occurred. Comments on the exercises are welcomed.

Carl H. Gotsch

CHAPTER 1: INTRODUCTION TO LP METHODS

Chapter 1 provides a brief introduction to l.p. in two dimensions. Although the models are extremely simple, much that prompts an interest in the use of optimization methods in policy analysis becomes apparent in comparing budgeting and programming approaches. (Hazell and Norton provide a similar analysis in their Chapter 2.)

MATHEMATICAL STATEMENT OF LP PROBLEM

When written mathematically, the conventional statement of l.p. models takes the following form:

$$Max \;\; Z = \sum_{j=1}^{n} c_j X_j$$

such that

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i, \qquad all \;\; i = 1 \; to \; m$$

and

$$X_j \geq 0, \qquad all \;\; j = 1 \; to \; n$$

where

X_j = is the level of the jth farm activity, such as the acreage of corn grown. Let n denote the number of possible activities; then j = 1 to n.

c_j = the forecasted gross margin (gross revenue minus variable costs) of a unit of the jth activity (e.g., dollars per acre).

a_{ij} = the quantity of the ith resource (e.g., acres of land or days of labor) required to produce one unit of the jth activity. Let m denote the number of resources; then i = 1 to m.

b_i = the amount of the ith resource available (e.g., acres of land or days of labor).

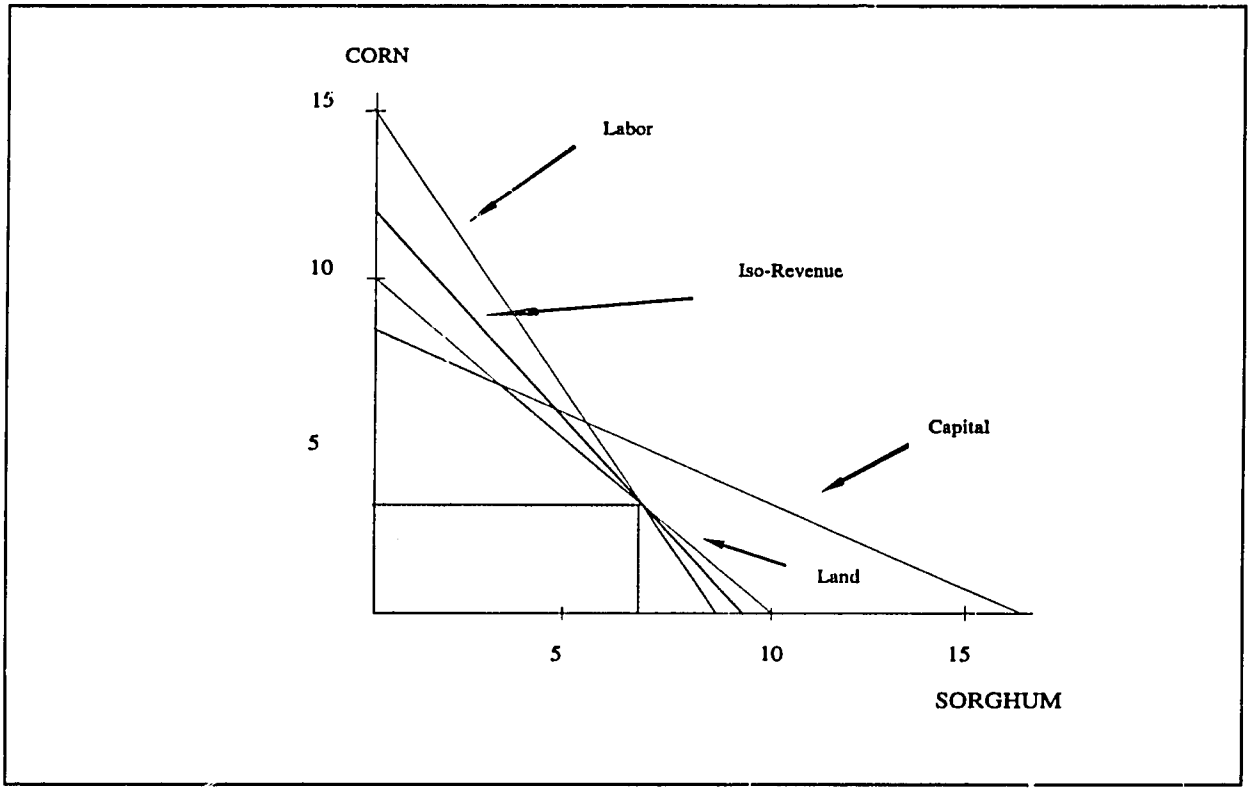
The task is then to find the cropping system (defined by a set of activity levels X_j, j = 1 to n) that has the highest possible total gross margin, Z, but does not violate any of the fixed resource constraints or involve any negative activity levels.

The above problem also is frequently set out in the form of a tableau which makes the data organization more intuitive. The data format is the same as that used in budgeting approaches. Crop and livestock enterprises are shown as columns and the inputs and resources used in their production are described in rows. Production in both methods are assumed to be linear. Any increase in output requires a proportional increase in all inputs and resources. (The generalized tableau is given specific form in a two dimensional graph shown below.)

NUMERICAL EXAMPLE: PROGRAMMING IN OUTPUT SPACE

Constraints/Activities	Corn	Sorghum	RHS
Objective Function ($/acre):	90	120	
Constraints:			
Land (acres)	1	1	<=10
Labor (man days/acre)	6	10	<=90
Capital ($/acre)	10	5	<=80

Figure 1.1: Graphic Solution in Output Space



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Algebraic Solution

Alternative 1: All Sorghum

Resource		Technical Coefficients	Max Sorghum Acreage
Land	10	1	10 acres
Labor	90	10	9 acres
Capital	80	5	16 acres

Objective function value of all sorghum = (9 x 120) = **1080**

Alternative 2: All Corn

Resource		Technical Coefficients	Max Corn Acreage
Land	10	1	10 acres
Labor	90	6	15 acres
Capital	80	10	8 acres

Objective function value of all corn = (8 x 90) = **720**

Alternative 3: Much sorghum, little corn

	Technical Coefficients		Resource
Equation 1 (land)	1 corn + 1 sorghum	=	10
Equation 2 (labor)	6 corn + 10 sorghum	=	90

Solve by substituting 1 corn = (10 - 1 sorghum) in Equation 2.

6 (10 - 1 sorghum) + 10 sorghum = 90
60 - 6 sorghum + 10 sorghum = 90
4 sorghum = 90 - 60
sorghum = 7.5
1 corn + 7.5 = 10
1 corn = 10 - 7.5
corn = 2.5

Objective function: 7.5 sorghum (120) + 2.5 corn (90) = **1125**

Alternative 4: Much corn, little sorghum

	Technical Coefficients		Resource
Equation 1 (land)	1 corn + 1 sorghum	=	10

7,25

Equation 2 (capital) 10 corn + 5 sorghum = 80

Solve by substituting 1 corn = (10 - 1 sorghum) in Equation 2.

10(10 - 1 sorghum) + 5 sorghum = 80
100 - 10 sorghum + 5 sorghum = 80
-5 sorghum = -2
sorghum = 4
1 corn + 4 = 10
corn = 6

Objective function: 4 sorghum (120) + 6 corn (90) = **1020**

The algebraic solution confirms the graphic solution, namely, that the optimal cropping pattern would be to grow much sorghum and little corn. Both commodities use equal amounts of the binding land constraint. However, given the ratio of net returns per acre, the bound imposed by the labor constraint is less restrictive than the bound imposed by the capital constraint. Consequently, the corner defined by land and labor yields a higher return than the corner defined by land and capital.

COMPARISON WITH BUDGETING (PAM) METHODS

The graphic solution of a multi-constraint problem in two-dimensional output space provides interesting insights into budgeting methods that assume that cropping enterprises compete for a single resource uniquely fixed to agriculture. Suppose that in the previous output space figure, land was the only binding constraint. In this case, comparative advantage would (1) dictate that all land would be planted to one crop or the other or (2) be indeterminant if the profits from the two enterprises were the same. Budgeting solutions thus represent what in l.p. methods are called "corner solutions". Any adjustments to policy reforms, according to this model, produce all or nothing results. Movements from an optimal solution that recommends much corn and little sorghum to one that recommends little corn and much sorghum, both possible combinations under the assumption that two or more factors are potential constraints, are never outcomes of the model.

The effect of the single constraint assumption can be seen if the fixed capital and labor constraints in the example above are transformed into variable costs. Suppose that the value of a unit of labor is determined by a labor market and is priced at 3. Similarly, assume a unit of capital can be obtained at 2. The net revenue per unit of land of corn then would become 52 (90-6x3-10x2) and the net revenue of sorghum would become 80 (120-10x3-5x2). Under these assumptions, profit would be maximized by growing all sorghum.

Adding more constraints makes the model behave differently when changes are made in relative prices. Indeed, with a large number of constraints, the trade-off between corn and sorghum becomes

NUMERICAL EXAMPLE: PROGRAMMING IN INPUT SPACE

Constraints/Activities	Corn	Sorghum	Beans	RHS
Objective Function:	90	120	50	
Constraints:				
Land	1	1	1	< = 10
Labor	6	10	3	< = 90

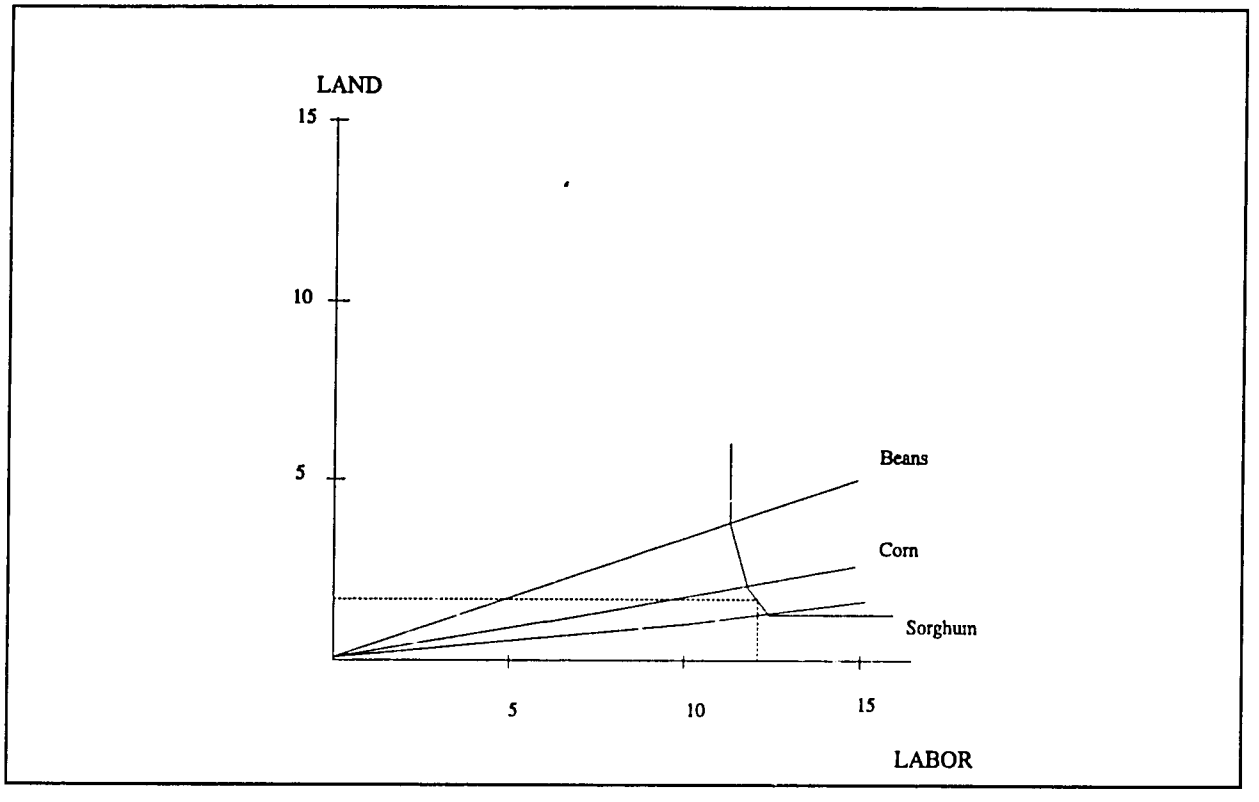

Figure 1.2: Graphic Solution in Input Space

more and more continuous and the adjustment of farmers to changes in relative prices less abrupt. In l.p. methods, this substitution takes place by shifting between technologies and enterprises as the two-dimensional "inputs space" model shown below indicates.

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The slopes of the rays emanating from the origin in Figure 1.2 describe the required combination of land and labor needed to produce beans, corn and sorghum. Beans, for example, require one unit of land for every three units of labor. The model can be solved graphically at any point by drawing in the 1:9 ratio of land and labor availability. The resulting intersection of the resource constraint lines with the line linking points of similar revenue on the corn and sorghum rays confirm the result of the previous exercise (Figure 1.1), namely, that with these technical coefficients and relative net revenues, the optimal solution will contain both corn and sorghum.

Figure 1.1 shows how adding constraints decreases the abruptness of the trade-offs between corn and sorghum. Figure 1.2 provides a similar example, namely, increasing the number of technogies can make the trade-off between land and labor less discontinuous. The lesson in both cases is that for l.p. models to behave "realistically," i.e., to avoid simplistic corner solutions, rich technical matrices containing a number technologies and constraints are required.

CHAPTER 2: GAMS TUTORIAL [1]

INTRODUCTION

The easiest way to learn a new computer language or system is by using an example. The exercise used below is taken from the "Mayaland" farm model shown on p. 12, Chapter 2 of the Hazell-Norton text. You will be asked to copy and run it in a GAMS tutorial session described below.

The recommended procedure for using GAMS is to create directories or sub-directories for your data sets and to call GAMS from these directories. For example, suppose there were some sample programs in a sub-directory called GAMSLIB. The first thing you would need to do is to get into the sub-directory called GAMSLIB. (From the DOS prompt: CD\GAMS205\GAMSLIB) GAMS should not be run from the directory containing the GAMS program files, i.e. from C:\GAMS205. Calling can be done from any other directory or, in this case, from a sub-directory under GAMS205.

GAMS programs and data files are written with the help of an external text editor. The Norton Editor (NE.COM) has been included in the GAMS sub-directory, and the exercises assume that it will be used to write the GAMS files. (Any text editor can be used to write GAMS files, e.g., BRIEF, VEDIT, KEDIT, etc. Word processors may also be used, but extreme care must be taken to insure that the DOS text mode is used. GAMS does not recognize non-standard characters--including TAB!--and will crash if these are encountered in the model files.)

The Norton Editor is invoked with the command: NE <Filename>. When started from a directory, NE automatically knows where it is and only the name of the file being retrieved or initiated need be entered. (NE also understands "paths" so it is possible to retrieve files from other directories.) A manual is unnecessary; a complete help file is available (F1) for all cursor and editing commands. The help facility should be consulted from the outset. Learning to use NE's ability to move to the ends of files, define and print blocks, find and replace, etc., will be rewarded amply in reducing the time required to write and examine GAMS programs.

---

[1] GAMS, largely a product of World Bank research efforts, comes on six diskettes that include (1) the GAMS matrix generator/compiler, (2) the BDLP version of the Simplex algorithm for solving linear programming problems, (3) Stanford's MINOS5, a solver for both linear and non-linear problems, (4) HERCULES, a solver for computable general equilibrium (CGE) models, and (5) a diskette, GAMSLIB, containing a number of examples.

Installation of GAMS should be done according to the instructions given in GAMS.DOC. This means basically that GAMS should be installed in a DOS sub-directory called GAMS205, the CONFIG.SYS file parameters should be enlarged, GAMS205 should be included in a path contained in the AUTOEXEC.BAT file, and separate work areas, e.g., sub-directories, should be set up to hold the files containing the actual models.

Hazell and Norton's Mayaland model is set out below, first in the form of a tableau, then in algebraic notation, and finally in an annotated GAMS program. The complete GAMS program to be copied and run is contained in the section entitled "GAMS Model".

MAYALAND MODEL

Tableau

	Corn (ha)	Beans (ha)	Sorghum (ha)	Peanuts (ha)	RHS
Objective Function (pesos)	1372	1219	1523	4874	
Land (ha)	1	1	1	1	<= 5.0
Labor (months)	1.42	1.87	1.92	2.64	<= 16.5
Mules (months)	1.45	1.27	1.16	1.45	<= 10.0
Market Constraint (tons)				.983	<= 0.5

Algebraic Notation

Max: $Z = 1372X_1 + 1219X_2 + 1523X_3 + 4874X_4$

Such that:

$$
\begin{aligned}
1.0X_1 + 1.0X_2 + 1.0X_3 + 1.0X_4 &<= 5.0 \\
1.42X_1 + 1.87X_2 + 1.92X_3 + 2.64X_4 &<= 16.5 \\
1.45X_1 + 1.27X_2 + 1.16X_3 + 1.45X_4 &<= 10.0 \\
0.983X_4 &<= 0.5
\end{aligned}
$$

$$X_1, \quad X_2, \quad X_3, \quad X_4, \quad >= \quad 0$$

GAMS PROGRAM REPRESENTATION

The basic syntax used to convert the algebraic notation described above into a GAMS program relies on the following definitions:

GAMS Expressions	Interpretation
SETS	A keyword that identifies a group of numbers or a set, e.g., j (crops) or i (resources) in the Mayaland model

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PARAMETERS	A keyword that indicates the beginning of the data for a vector or a scalar, e.g., the gross margin of peanuts (crop j) or the availability of land resource i).
TABLE	A keyword to indicate the beginning of a data array e.g., A_{ij} describing the amount of labor (resource i) required to produce sorghum (crop j).
VARIABLES	A keyword to specify a variable, e.g.,the level of crop activity j.
EQUATIONS	A keyword to specify the types of equations included in the model. For example, RESOURCES(I) denotes the constraints on resources available to produce crops.
*	Identifies a line of comments. All the following characters on this line are ignored.

GAMS uses =L=, =E=, =G= to denote the symbols $\leq$, = and $\geq$, respectively.

ANNOTATED GAMS MODEL

Consider first the crops and resources that are shown in the Mayaland model. These are described in GAMS input as follows:

```
SETS
        J  CROPS        / CORN, BEANS, SORGHUM, PEANUTS /
        I  RESOURCES    /LAND, LABOR, MULES, MARKETING/
```

As noted above, the word SETS is a keyword in GAMS that identifies a specific type of input. It can be typed anywhere in the line. The letter J is the name of a set and the word CROPS is the text that describes the set. The letter I is also the name of a set and the word RESOURCES describes the content of the set. The result, as the table -- Table A(I,J) --in the tutorial below indicates, is to emulate the standard mathematical notation for linear programming problems.

The elements of the set are indicated in lines set off by slashes, one at the beginning, one at the end. They are set off from each other by commas. (Elements are also referred to at times as "labels" because they play the role of row and column headings when data are organized in a table format.)

The structure of the SETS statement is common to many GAMS statements. The keyword in this case is SETS. The declaration consists of two parts: the name, which is a single word (an identifier) of ten characters or less; and the text, which may consist of several words. The definition

refers to the list of elements in the set. The element names (labels) can be ten characters long but cannot have embedded blanks.

After having defined the sets over which the computations are to be made, GAMS then requires that the data for the parameters be entered. This is done under the heading of the keyword: PARAMETERS.

Parameters that linear programming models require include the values for the elements in the objective function, the values describing resource availabilities (the "right hand side"), and the technical coefficients matrix. These values are given below for the Mayaland problem.

```
PARAMETERS

C(J)     GROSS MARGINS OF CROP ACTIVITIES (PESOS PER ACRE)
       / CORN 1372, BEANS  1219, SORGHUM  1523, PEANUTS 4874 /

B(I)     RESOURCE AVAILABILITY
       / LAND  5, LABOR  16.5, MULES  10, MARKET  .5 /;
```

A powerful GAMS facility that allows parameters to be calculated in the equations section will be introduced in Chapter 3. It is possible to disaggregate input-output data and to enter only coefficients such as prices, yields, and costs. Gross margins then can be calculated in a subsequent part of the program as Prices x Yields - Costs. This ability to transform raw data into coefficients required by the linear programming problem has caused some people to refer to GAMS as a "matrix generator." In subsequent exercises using parametric programming techniques, it also will become apparent that such disaggregation makes it possible to vary individual parameters such as prices and yields without having to go back to the aggregate gross margin figures. This capability can be expanded to include much of the data processing that ordinarily is done exogenously with other l.p. software packages.

The syntax of the parameter statement again is worth noting. First comes the keyword (PARAMETERS) that tells GAMS what kind of information is to follow. Then comes the name of the parameter. In this case there are two: C (the values of the objective function elements); and B (the values of constraints or the "right hand side "). After that there is a statement about the "domains" to which the parameters refer. In the case of C, the domain entry (J) tells GAMS that the ensuing entries refer to crops. Similarly, (I) tells GAMS that the B parameter refers to resources. The text that follows explains what the parameter refers to and is optional. Finally, the statement contains the "definition" part of the PARAMETERS entry specifying the actual element values.

A great time saver in creating l.p. models is software that can read technical coefficient tables rather than the line-by-line entry required by many l.p. packages. (See Linus Schrage's LINDO or Sunset Software's XA for examples of the latter.) Given the definition of sets above, i.e., J refers to

crops and I refers to resources, the technical coefficient matrix can be specified as a traditional "a_{ij}" matrix.

As in all virtually all computer languages, sub-scripts show up in parentheses. GAMS understands that the word TABLE refers to parameters unless told otherwise and, in this case, that the domains are I and J. The element a(i,j) defines the ith resource used in the production of the jth crop. (In the GAMS matrix notation, rows always come before columns.)

TABLE A(I,J) TECHNICAL COEFFICIENTS MATRIX

	CORN	BEANS	SORGHUM	PEANUTS
LAND	1	1	1	1
LABOR	1.42	1.87	1.92	2.64
MULES	1.45	1.27	1.16	1.45
MARKET				.983
+				
	OTHER CROPS		OTHER CROPS	
LAND				
LABOR				
MULES				
MARKET				

Tables can be extended simply by typing a + on the next line (see above) and continuing. (The GAMS technical manual contains more precise rules and regulations for table expansion.)

GAMS also requires a declaration of the variables in the problem. (The keyword is VARIABLES.) In this case, when written in set notation, there are two -the variable that represents the summation of the objective function and the variable that describes the levels of the different crop activities. In addition, GAMS must be informed at this point which variables must be positive, e.g., all the crop activities. (This latter condition is the familiar stipulation that $X_j \geq 0$)

```
VARIABLES
        Z        TOTAL GROSS MARGINS (DOLLARS)
        CROPS      LEVELS OF CROP ACTIVITIES (HECTARES)

        POSITIVE VARIABLE CROPS;
```

After the variables have been declared, i.e , the activities identified, it is necessary to declare the names of the equations and to spell out the relationships that hold in the model. This is also the point at which statements can be used to calculate parameters, e.g., gross margins can be calculated from yields, prices, and costs. Again, these elements can be written in set notation and do not require the laborious row-by-row entry of LINDO or XA.

```
EQUATIONS

    OBJFN          OBJECTIVE FUNCTION
    CONSTRNT(I)    RESOURCE CONSTRAINTS;


OBJFN..          Z =E= SUM(J, C(J)*CROP(J));
CONSTRNT(I)..    SUM(J, A(I,J)*CROP(J))        =L= B(I);
```

Remaining to be completed are the definition of the model, instructions regarding the appropriate solver to use, and the objective function to be maximized or minimized. ("All" means to use all the equations that have been defined earlier.) Each of the statments must be ended with a semi-colon.

```
MODEL  MAYALAND /ALL/;

SOLVE MAYALAND USING LP MAXIMIZING Z;
```

TUTORIAL TASKS

The complete GAMS model of the Mayaland example is shown below. This exercise should be done from a sub-directory that houses your data. Create the sub-directory using the DOS MD command. Enter it using DOS's Change Directory (CD) command. Once in the sub-directory, type NE to invoke the Norton Editor. When asked for the file name, type: MAYALAND. You should then have a blank screen and you can begin typing in the tutorial indicated below.

GAMS Model

Type the model shown below beginning with the line "$TITLE". Take care in typing in the model; it will save a good deal of time in debugging. Especially pesky is the need to put a semi-colon after many GAMS statements. Those separated by a keyword are not required to have a semi-colon, but GAMS will do strange things if the semi-colon is left out elsewhere. (A frequent trouble spot is at the end of the EQUATION definition command. You must put a semi-colon before going on to write out the equation detail because there is no intervening keyword. Subsequently, each equation must also have a semi-colon at the end.)

```
-----------------------------------------------------------------------------
$TITLE                                MAYALAND TUTORIAL

     SETS        J      ACTIVITIES          /CORN, BEANS, SORGHUM, PEANUTS/
                 I      CONSTRAINTS         /LAND, LABOR, MULES, MARKET/

     PARAMETERS
```

```
            C(J)   GROSS MARGINS OF CROP ACTIVITIES (PESOS PER HECTARES)
                  /CORN 1372, BEANS 1219, SORGHUM 1523, PEANUTS 4874/

            B(I)  RESOURCE CONSTRAINTS
                  /LAND 5, LABOR 16.5, MULES 10, MARKET .5/

TABLE A(I,J)      TECHNICAL COEFFICIENTS

                   CORN        BEANS       SORGHUM        PEANUTS
     LAND           1           1           1              1
     LABOR          1.42        1.87        1.92           2.64
     MULES          1.45        1.27        1.16           1.45
     MARKET                                                 .983

VARIABLES

                  Z       TOTAL GROSS MARGINS (PESOS)
                  CROPS   LEVELS OF CROP ACTIVITIES (HECTARES)
                  POSITIVE VARIABLES CROPS;

EQUATIONS

OBJFN          OBJECTIVE FUNCTION
CONSTRNT(I)    RESOURCE CONSTRAINTS;

* Note the two dots below that indicate that an equation follows:

OBJFN..            Z =E=  SUM(J, C(J)*CROPS(J));
CONSTRNT(I)..             SUM(J, A(I,J)*CROPS(J)) =L= B(I);

MODEL MAYALAND /ALL/;
SOLVE MAYALAND USING LP MAXIMIZING Z;
```

REMEMBER: GAMS DOES NOT UNDERSTAND NON-ASCII CHARACTERS. THEREFORE BE SURE NOT TO USE THE TAB KEY WHEN WRITING OUT THE MODEL OR CREATING THE TABLES.

When the model is complete, save it. (It will be saved automatically under the name MAYALAND. There are a number of ways to accomplish this in NE but they all begin by pressing Function Key 3 (F3). Save and exit is F3, E. (Use the help key (F1) if you forget what to use. Also, after pressing F3, a menu of commands appears at the bottom of the screen.)

Run the model by typing GAMS <filename> at the sub-directory's DOS prompt (C:\<DATA_SUB>). The statement is GAMS MAYALAND. If everything has been done correctly, the model will run and output will be written to a file called MAYALAND.LST. If you have used some other file name, the output file produced by GAMS will be called <FILE NAME>.LST. You can look at this file by typing NE <FILE NAME>.LST. To repeat: there are two files involved. One is the model, called MAYALAND. Another, produced by GAMS, is the output file called MAYALAND.LST.

If there are mistakes, the compilation will abort with an error message. In this case, you must also look at the output file to see where the mistakes are. They are identified by a series of ***** in the row number column and by error message codes at roughly the point of the error. These codes are defined at the end of the output file so you will need to look them up in order to find out what they mean. (Use ALT-F in the NE to find the **** string that identifies where the errors are located.). Remember: mistakes are found in the output (.LST) file, but corrections must be made in the input file. The former contains row numbers; the later does not.

GAMS Output

GAMS produces a great deal of output, much of which can be shut off as you get better acquainted with the model you are running. In the initial phase of creating a model, the symbol listing is helpful in debugging. Like many computer languages, GAMS symbols first must be declared and then defined. The symbol listing also indicates where symbols are referenced so that typos and other syntax mistakes are easier to locate.

The equation listing also is helpful because it transforms the set notation that is used in writing out the model into an equation-by-equation listing. If mistakes have been made in setting up the calculations--but internal domain checking has not been violated--the difficulty may show up here. The equation listing is the most important tool for diagnosing problems with GAMS models once syntax errors have been resolved.

The following output will be discussed in greater detail in lecture sessions. Those with prior l.p. experience will note that the primal and dual values of the optimal solution are at the end of the solution report. Methods of using the GAMS report writer to organize data in the form of tables suitable for inclusion in documents are discussed in Chapter 3.

The first output encountered in MAYALAND.LST is a repetition of the model typed in earlier--but adds line numbers. If mistakes were made, a description of the error codes will be found at the end of this listing. If the run has been successful, the SOLVE statement in the output is followed by a series of definitional and technical statements that can be passed over quickly. After that, GAMS writes out the individual rows and columns of the model. Lastly, GAMS presents a solution report that describes the optimal levels of activity use and the resulting shadow prices of the constraint set. The output shown below begins with the equation listing.

```
---------------------------------------------------------------------------
GAMS 2.05 PC AT/XT                                  89/03/15 14:29:49  PAGE  2
MAYALAND TUTORIAL
EQUATION LISTING     SOLVE TUTOR USING LP FROM LINE 38

   In this section, GAMS prints out the details of the equations it has
generated from the model definition section above. It is the best place to
check whether the model has been written correctly. Once everything checks out
properly, this section can be suppressed. (The default is to print out the
first three equations and skip the rest. This may also be changed to print
more than three.)
```

```
---- OBJFN        =E=  OBJECTIVE FUNCTION
OBJFN..  Z - 1372*CROPS(CORN) - 1219*CROPS(BEANS) - 1523*CROPS(SORGHUM)
      - 4874*CROPS(PEANUTS) =E= 0 ;

---- CONSTRNT     =L=  RESOURCE CONSTRAINTS
CONSTRNT(LAND)..  CROPS(CORN) + CROPS(BEANS) + CROPS(SORGHUM) + CROPS(PEANUTS)
     =L= 5 ;

CONSTRNT(LABOR)..  1.42*CROPS(CORN) + 1.87*CROPS(BEANS) + 1.92*CROPS(SORGHUM)
    + 2.64*CROPS(PEANUTS) =L= 16.5 ;

CONSTRNT(MULES)..  1.45*CROPS(CORN) + 1.27*CROPS(BEANS) + 1.16*CROPS(SORGHUM)
    + 1.45*CROPS(PEANUTS) =L= 10 ;
```

COLUMN LISTING SOLVE TUTOR USING LP FROM LINE 38

This section is the equivalent of the equation listing in that it prints out the details of the columns. It is the easiest way to check the technical coefficients that have been entered in the data tables. Like the equation section, the default is three columns although all may be printed out if desired.

```
---- Z            TOTAL GROSS MARGINS (PESOS)
Z
                  (.LO, .L, .UP =  -INF, 0,  +INF)
        1         OBJFN

---- CROPS        LEVELS OF CROP ACTIVITIES (HECTARES)
CROPS(CORN)          (.LO, .L, .UP = 0, 0,  +INF)
    -1372         OBJFN
        1         CONSTRNT(LAND)
        1.42      CONSTRNT(LABOR)
        1.45      CONSTRNT(MULES)

CROPS(BEANS)         (.LO, .L, .UP = 0, 0,  +INF)
    -1219         OBJFN
        1         CONSTRNT(LAND)
        1.87      CONSTRNT(LABOR)
        1.27      CONSTRNT(MULES)

CROPS(SORGHUM)       (.LO, .L, .UP = 0, 0,  +INF)
    -1523         OBJFN
        1         CONSTRNT(LAND)
        1.92      CONSTRNT(LABOR)
        1.16      CONSTRNT(MULES)
```

MAYALAND TUTORIAL
SOLUTION REPORT SOLVE TUTOR USING LP FROM LINE 38

This section prints out the primal and dual solutions. The dual is printed first and lists the levels of the fixed factors along with their upper bounds, i.e., their availability. It also lists their "marginals" or shadow prices. When the level of use is equal to the upper bound, it means that the resource has been exhausted and has a positive shadow price or marginal product. The extent to which the resource is surplus can be found by subtracting "level" from "upper".

```
EXIT -- OPTIMAL SOLUTION FOUND.


---- EQU CONSTRNT    RESOURCE CONSTRAINTS
          LOWER     LEVEL     UPPER    MARGINAL
LAND       -INF      5.000     5.000  1523.000
LABOR      -INF      9.966    16.500       .
MULES      -INF      5.948    10.000       .
MARKET     -INF      0.500     0.500  3408.052

   This section prints out the value of the objective function, Z.

--- VAR Z              -INF   9319.476     +INF

  Z           TOTAL GROSS MARGINS (PESOS)

   The final section gives the levels of the model's activities.
The associated "marginals' are often referred to in other l.p. codes as
"reduced costs." They indicate how much the objective function would
decrease if one unit of the crop were forced into the solution. Those
crops already in the optimal solution have reduced costs of zero.

---- VAR CROPS       LEVELS OF CROP ACTIVITIES (HECTARES)

           LOWER     LEVEL     UPPER    MARGINAL
CORN         .         .       +INF   -151.000
BEANS        .         .       +INF   -304.000
SORGHUM      .       4.491     +INF       .
PEANUTS      .       0.509     +INF       .

 **** REPORT SUMMARY :  0  NONOPT, 0 INFEASIBLE, 0  UNBOUNDED
```

MAYALAND'S DUAL

Test your understanding of GAMS by running the dual of the Mayaland model (Hazell and Norton, p. 16). As you will note from the reading, "if fixed resources are valued at their marginal value product (or shadow prices), opportunity costs, the total rental value assigned to the inputs of the farm must exactly exhaust total output or gross margin." Computing the values of the fixed resources that would lead to this result requires that (a) the levels of resources become the variables, (b) the activities become the constraints, (c) the direction of the inequalities is reversed, and (d) the objective function is minimized.

It is easy to convert the primal of the Mayaland into its dual. Do not type in the model from scratch. Just make a copy of the primal version (At the DOS prompt, type COPY MAYALAND MAYADUAL). Then, after calling the copied file into the Norton Editor, make the following adjustments (Don't worry about the primal headings):

```
VARIABLES

      Z  TOTAL COSTS (PESOS)
      RESOURCES   LEVELS OF RESOURCE USE
         POSITIVE VARIABLES RESOURCES;
```

```
EQUATIONS

   OBJFN     OBJECTIVE FUNCTION
   CONSTRNT(J)            GROSS MARGINS;

   OBJFN..   Z =E=  SUM(I, B(I)*RESOURCES(I));
   CONSTRNT(J)..  SUM(I, A(I,J)*RESOURCES(I)) =G= C(J);

MODEL MAYADUAL /ALL/;
SOLVE MAYADUAL USING LP MINIMIZING Z;
```

Compare the levels of the activities in the dual with the values of the constraints in the primal. Unless one of us has made a mistake, they ought to be the same. Refer to the Hazell and Norton explanation of the relationship between the primal and the dual and be prepared to explain why this is so.

o

CHAPTER 3: EXPANDING THE MAYALAND MODEL

The Mayaland model introduces a number of programming concepts. Chapter 3 expands the MAYALAND model in a number of ways. First, it is assigned a new name, i.e., MYPRIVT, to indicate that it is the original model at private prices. Then there is an exercise to demonstrate the power of GAMS as a matrix generator and report writer. Although it is not obvious because only very small models have been attempted, the output from GAMS can be voluminous. Hence, developing a capacity to organize the output into legible tables should be practiced from the start.

In subsequent sections, the H-N example on factor substitution is incorporated, diminishing returns to weeding included, and, lastly, seasonal resource use is simulated by adding monthly labor and land constraints.

As in all the examples in this manual, it is assumed that each new exercise takes a previous model as a point of departure. Prudence dictates that a copy of the original model should be used as a starting point rather than the original itself. Then, if something drastic happens, you can always revert to the original model to repair the damage. (In this case, at the DOS prompt of the sub-directory housing your data, type COPY MAYALAND MYPRIVT1.)

As noted earlier, the strategy of the chapter is to work through some of the examples for expanding the basic model discussed in Chapter 3 of Hazell and Norton. Each of the examples indicates how a richer and more varied set of activities and constraints might be developed. As the earlier two dimensional exercises made clear, if the number of trade-offs among crops and technologies is very limited, comparative advantage can be ascertained with straightforward budgeting methods. Because of the need to save time and keep the original models simple, many of the models presented here have budget-like "corner" solutions. But this is a function of the exercises and not a requirement of the methodology.

GAMS AS A MATRIX GENERATOR AND REPORT WRITER

Two aspects of GAMS are explored in the following exercise. The first is its ability to do the often sophisticated arithmetic needed to move from the raw data of statistical reports and field surveys to the data forms required by the programming model. The example in which values for the objective function are calculated endogenously is relatively simple. However, more complex calculations that compute the variance of a distribution or produce piece-wise linearization of non-linear curves will be introduced in subsequent chapters. (In GAMS jargon, these are called "assignment statements.") The versatility of the report generator also will be apparent in later chapters when it is used to compute summary statistics such as nominal protection, effective protection, and domestic resource cost coefficients.

Computing Elements of the Objective Function (MYPRIVT1)

```
$TITLE            MYPRIVT1: BASIC MAYALAND MODEL AT PRIVATE PRICES
$OFFSYMXREF OFFSYMLIST
```

(These two statements turn off cross-referencing and symbol listing in the output listing.)

In the MAYALAND tutorial, the gross margins of the objective function were calculated outside the model. In this version, these values are computed by GAMS before the l.p. solver is called. Most of the computation is straightforward. However, because each crop uses several different types of inputs, an input table must be designed. That, in turn, requires a set that can be used to describe the table's rows.

```
SETS   J      CROPS      /CORN, BEANS, SORGHUM, PEANUTS/
       I      INPUTS     /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/
```

The data below on yields and prices are the numbers that underlay the previous gross margin calculations. These values will be computed in the equations section.

```
PARAMETERS

      YIELDS(J)       YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
                    /CORN 750, BEANS 375, SORGHUM 775, PEANUTS 983/

      PROUTP(J)       PRICES OF CROP OUTPUT (PESOS PER KG)
                     /CORN  3, BEANS  6, SORGHUM 2.6, PEANUTS 7/

      PRINP(I)        PRICES OF INPUTS (PESOS PER KG)
                     /FERT 14, PEST  300, CORNSEED 5, BEANSEED 8,
                      SORGSEED 5, PEASEED 9/

      LAND(J)        LAND USE (HECTARES)
                     /CORN 1,  BEANS 1,  SORGHUM 1,  PEANUTS 1/

      LABOR(J)       LABOR USE (MAN MONTHS PER HECTARE)
                     /CORN 1.42, BEANS  1.67, SORGHUM  1.92, PEANUTS 2.64/

      MULES(J)        MULE USE (PESOS PER HECTARE)
                    /CORN 1.45, BEANS 1.27, SORGHUM  1.16, PEANUTS 1.45/

      MP(J)          PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS PER HA)
                     /PEANUTS 983/
```

The table below indicates how data may be entered in the form of an array. Arrays are always an efficient way of organizing information and can be exploited in the GAMS format. Note that <u>rows always come before columns</u> in writing down GAMS indices.

```
TABLE IN(I, J) INPUT USE (KGS PER HECTARE)

                      CORN        BEANS       SORGHUM       PEANUTS
     FERT              50          40           30            70
     PEST             .25         .25                        .6
     CORNSEED          20
```

```
     BEANSEED                          50
     SORGSEED                                        15
     PEASEED                                                          95

SCALARS

      AMTLAND            AMOUNT OF LAND AVAILABLE (HECTARES)            /5/

      AMTLAB             AMOUNT OF LABOR AVAILABLE (MONTHS)             /16.5/

      AMTMULE            MULE POWER AVAILABLE (MONTHS)                  /10/
   MARKET       MARKET CONSTRAINT ON PEANUTS(KGS)                     /500/
```

The quantity of resources available was previously entered with a parameter statement. When the structure of the model becomes more complex, it is convenient to be able to isolate individual resources and they are now entered as scalars.

```
VARIABLES
            REVENUE    GROSS REVENUE FROM CROP ACTIVITIES
            COST       INPUT COSTS
            CROPS      LEVELS OF THE CROP ACTIVITIES
            Z          TOTAL VALUE ADDED FROM CROP ACTIVITIES
                      POSITIVE VARIABLES CROPS

EQUATIONS

       REV            COMPUTATION OF GROSS REVENUES
       INCOST         COMPUTATION OF TRADABLE INPUT COSTS
       CONSTL         LAND CONSTRAINT
       CONSTLA        LABOR CONSTRAINT
       CONSTMUL       MULE CONSTRAINT
       MARKT          MARKET CONSTRAINT ON PEANUTS
       OBJFN          OBJECTIVE FUNCTION;
```

The calculations that produce gross margins for the objective function are performed in the following two equations. The calculations could have been performed in the objective function itself. However, some intermediate computations are sometimes advisable because they appear to be less complicated and therefore are easier to debug.

```
       REV..       REVENUE =E= SUM(J, YIELDS(J)*PROUTP(J)*CROPS(J));
       INCOST..    COST    =E= SUM((I, J), IN(I, J)*PRINP(I)*CROPS(J));
```

The following equations describe the constraints on the farm's fixed factors: land, labor and mules. The market limit on peanuts is also a "fixed asset."

```
       CONSTL..                  SUM(J, LAND(J)*CROPS(J)) =L= AMTLAND;
       CONSTLA..                 SUM(J, LABOR(J)*CROPS(J)) =L= AMTLAB;
       CONSTMUL..                SUM(J, MULES(J)*CROPS(J)) =L= AMTMULE;
       MARKT..                   SUM(J, MP(J)* CROPS(J)) =L= MARKET;
       OBJFN..                   Z =E= REVENUE-COST;

MODEL MYPRIVT1 /ALL/;
SOLVE MYPRIVT1 USING LP MAXIMIZING Z;
-----------------------------------------------------------------------------
```

Compare the solution of MYPRIVT1 with the solution in to MAYALAND in Chapter 2. The slight differences results from setting the peanut marketing constraint at 500 Kgs. per hectare instead of the 491 kgs that one-half hectare constraint would imply.

Writing a Report Generator

It takes only a few sessions with GAMS to discover that scrolling through large amounts of output in search of a relatively few numbers is frustrating. Fortunately, several steps can be taken to reduce the amount of output.

Step 1: Turn off the Symbol Reference command and the Symbol List command. (This has already been done. They are the two so-called "dollar" commands that appear immediately after the title statement).

Step 2: Turn off the row and column equation listings and the printout of the solution. These invaluable debugging aids are no longer necessary once the model is running properly. They require the following OPTION statement that may appear anywhere, but is usually put at the head of the model file below the title statment in order to make it easily accessible. These statements should only be used when you have complete confidence that the model is working properly.

OPTION LIMROW=0, LIMCOL=0, SOLPRINT=OFF

Step 3: The most important thing that can be done to gain control over GAMS output is to begin right from the start to produce report generators as a part of the model's specification. From the l.p. point of view, four elements of the solution are interesting. Each is accessed from the output by appending an "attribute" to the element requested. The four attributes that can be requested are:

.L = the level of an activity or resource in the optimal solution.

.M = the "marginal" of an activity or resource. For resources, the latter, the value is often referred to as the "shadow price." It is also a measure of the resource's marginal value product and reflects the decrease in the objective function if one unit of the resource were withdrawn.

For activities, the "marginal" refers to what in some l.p. codes are called "reduced costs." They describe the reduction in the value of the objective function that would occur if one unit of the activity were forced into the solution.

.LO = Lower bound of the activity or resource.

.UP = Upper bound of the activity or resource. For resources, the difference between the .UP of a resource and the .L of a resource is the slack or excess resource that has not been used.

In addition, other values of interest may be computed in the report generator. For example, in the following exercises, values have been calculated for gross revenues, input costs, and gross margins. These values will become the building blocks for later exercises that compute the impact of commodity specific policies.

The entire process of writing a report generator resembles writing a GAMS model. As in a GAMS model, once a satisfactory module has been written, it can be used repeatedly in other models and other situations. The report generator shown below should be appended immediately following the SOLVE statement in MYPRIVT1. (Ignore the explanatory text when typing in the statements that generate the report.)

```
$TITLE                    REPORT ON MYPRIVT1 SOLUTION

   In producing the summary tables of a GAMS report generator, the elements in
the sets can be thought of as identifying the rows and columns of the desired
tables whereas the parameters identify the names of the tables. NOTE THAT THE
DEFINITIONS USED FOR PARAMETER VALUES MUST NOT HAVE BEEN USED PREVIOUSLY IN
DEFINING THE MODEL.

     SETS      AREP      /GROSSREV, INPUTCO, NETREV, LEVEL/
               CREP      /LAND, LABOR, MULES/
               OBJ       /OBJECTIVE/

     PARAMETERS     ACTREP     VARIABLES SUMMARY
                    CONREP     DOMESTIC RESOURCE USE SUMMARY
                    CONMARG    SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUN     OBJECTIVE FUNCTION VALUE;

   The first three equations of the table ACTREP (activity report) provide a
report on the model's activities in the form of calculated revenues, input
costs, and gross margins. The fourth equation reports the levels of the
activities in the optimal solution using the .L "attribute" command (see
previous page). An activity not in the optimal solution will be left blank.

     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =   SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)- ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =   CROPS.L(J);

   The table reporting the value of the objective function contains only one
element. But because it contains a different dimension, i.e., it is not
reported by crop, it requires a special statement.

     OBJFUN("OBJECTIVE")          =     Z.L;

   The CONREP (constraint report) table reports the amounts used of each fixed
resource.

     CONREP("LAND")               =      SUM(J, CROPS.L(J)*LAND(J));
     CONREP("LABOR")              =      SUM(J, CROPS.L(J)*LABOR(J));
     CONREP("MULES")              =      SUM(J, CROPS.L(J)*MULES(J));
```

The CONMARG (constraint marginals) table reports the shadow prices of each of the fixed resources.

```
CONMARG("LAND")        =      CONSTL.M;
CONMARG("LABOR")       =      CONSTLA.M;
CONMARG("MULES")       =      CONSTMUL.M;
```

The display statements organize the output of the various parameter values. The results are at the end of the output file. Use NE's End-of-File cursor command (Control-End) to move rapidly to the last line in the output file; then back up until the desired output is found.

```
DISPLAY OBJFUN, ACTREP, CONREP, CONMARG;
```

The report produced by the report generator for MYPRIVT1 is shown below. The output includes one additional line that produces the "reduced cost" for each activity. The reduced cost is given in the original GAMS output report by the "marginal" for activities. Test your understanding of the report generator by adding the line to the report generator that produced the output. Hint: If CROPS.L(J) produced the level of the activity, what attribute would produce the marginal for the set CROPS? If you solve this one, try creating a line in the report generator that reports the surplus resources in the optimal solution rather than the amount used. Hint: Subtract the amount amount used (.L) from the amount available (.UP).

```
REPORT ON MYPRIVT1 SOLUTION
E X E C U T I N G

----     106 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE
OBJECTIVE 9301.933

----     106 PARAMETER ACTREP        VARIABLES SUMMARY

                 CORN       BEANS     SORGHUM     PEANUTS
GROSSREV     2250.000    2250.000    2015.000    6881.000
INPUTCO       875.000    1035.000     495.000    2015.000
NETREV       1375.000    1215.000    1520.000    4866.000
LEVEL                                    4.491       0.509
RCOSTS       -145.000    -305.000

----     106 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
LAND  5.000,     LABOR 9.966,     MULES 5.948

----     106 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES

LAND 1520.000

**** FILE SUMMARY
INPUT   C:\FR230\MYPRIVT1
OUTPUT  C:\FR230\MYPRIVT1.LST
EXECUTION TIME       =        1.870 SECONDS        VER: 386-EK-008
-------------------------------------------------------------------------------
```

FACTOR SUBSTITUTION IN L.P. MODELS

In his famous text, *Economic Theory and Operations Research*. Baumol discusses the relationship between linear programming and neo-classical analysis in the following way:

> In at least one sense, the programming analysis digs deeper than does neoclassical theory. As has already been stated, the neoclassical theory assumes that the optimal technical production processes have somehow already been determined before the economic theorist gets to work on the problem. This premise is an integral part of the very concept of a production function, for, by definition, that function tells us what is the *largest* possible output which can be obtained for every input combination. That is, it assumes that optimal processes are employed to make those inputs go as far as possible. However, the choice of the optimal technological arrangement is no trivial task. It is, however, one which can be handled by the methods of mathematical programming.

In the example below, Baumol's comment is given concrete form in the case of corn. The example is again taken from H-N, p. 34-35. There are two different ways of producing corn which use different combinations of labor and mule power. The choice of technology therefore will be influenced by relative factor endowments. Should one factor become dear relative to another, the model could be expected to move away from the technology that utilizes the expensive factor in the direction of the one that uses the less expensive resource. Similarly, the same can be said of different crop enterprises. GAMS, of course, does not know that CORNHAND and CORNMULE both refer to the same crop whereas CORN and BEANS refer to different commodities. Both offer opportunities for factor substitution by moving from one activity to another.

Factor Substitution Model (MYPRIVT2)

Add the factor substitution possibilities to the MYPRIVT1 model developed in the previous section. First make a copy of MYPRIVT1 with the command: COPY MYPRIVT1 MYPRIVT2. Then add the activity CORNMULE to create a technology that substitutes mule labor to be substituted for hand labor.

```
-----------------------------------------------------------------------------

$TITLE            MYPRIVT2: BASIC MAYALAND MODEL AT PRIVATE PRICES
$OFFSYMXREF OFFSYMLIST
OPTION LIMROW=0, LIMCOL=0, SOLPRINT=OFF

SETS   J      CROPS      /CORNHAND, CORNMULE, BEANS, SORGHUM, PEANUTS/
       I      INPUTS     /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/

PARAMETERS

  YIELDS(J)  YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
          /CORNHAND 750, CORNMULE 750, BEANS 375, SORGHUM 775, PEANUTS 983/

  PROUTP(J)  PRICES OF CROP OUTPUT (PESOS PER KG)
         /CORNHAND 3, CORNMULE 3, BEANS  6, SORGHUM 2.6, PEANUTS 7/

  PRINP(I)   PRICES OF INPUTS (PESOS PER KG)
         /FERT 14, PEST  300, CORNSEED 5, BEANSEED 8, SORGSEED 5, PEASEED 9/
```

```
LAND(J)     LAND USE (HECTARES)
       /CORNHAND 1, CORNMULE 1, BEANS 1,  SORGHUM 1,  PEANUTS 1/

LABOR(J)    LABOR USE (MAN MONTHS PER HECTARE)
       /CORNHAND 2.5, CORNMULE 1.42, BEANS 1.87, SORGHUM 1.92, PEANUTS 2.64/


MULES(J)    MULE USE (PESOS PER HECTARE)
       /CORNHAND 1, CORNMULE 1.45, BEANS 1.27, SORGHUM  1.16, PEANUTS 1.45/


MP(J)       PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS/HA)
            /PEANUTS 983/

TABLE IN(I, J) INPUT USE (KGS PER HECTARE)

              CORNHAND     CORNMULE       BEANS       SORGHUM       PEANUTS
FERT             50           50           40           30            70
PEST            .25          .25          .25                        .6
CORNSEED         20           20
BEANSEED                                   50
SORGSEED                                                15
PEASEED                                                               95

            -----Remainder of the model is the same as MYPRIVT1-----
-----------------------------------------------------------------------------
```

Model Report

The initial result of running MYPRIVT2 is the same as MYPRIVT1. Sorghum and peanuts continue to be the crops in the optimal solution; the inclusion of new possibility for growing corn has not affected the solution. To see the impact of factor substitution, reduce the amount of labor available. For example, setting the labor availability scalar to half its value, e.g. 8 man months produces the report shown below. Why does an increase in labor scarcity bring corn into the cropping pattern? Why has does the optimal cropping pattern continue to include some sorghum?

```
-----------------------------------------------------------------------------

REPORT ON MYPRIVT2 SOLUTION  (Labor availability set at 8 man months.)
E X E C U T I N G

----     107 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE
OBJECTIVE 8731.727

----     107 PARAMETER ACTREP        VARIABLES SUMMARY

            CORNHAND    CORNMULE       BEANS     SORGHUM     PEANUTS
GROSSREV    2250.000    2250.000    2250.000    2015.000    6881.000
INPUTCO      875.000     875.000    1035.000     495.000    2015.000
NETREV      1375.000    1375.000    1215.000    1520.000    4866.000
LEVEL                      3.932                   0.559       0.509
RCOSTS      -313.200                -290.500

----     107 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY

LAND  5.000,    LABOR 8.000,    MULES 7.088
```


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```
----     107 PARAMETER CONMARG        SHADOW PRICES OF DOMESTIC RESOURCES

LAND  963.200,    LABOR 290.000

-----------------------------------------------------------------------------
```

INCORPORATING DIMINISHING RETURNS

The assumption that the output of a crop is a linear function of the resources used in its production has long been a criticism of l.p. methods. Just as in the case where there are only a limited number of constraints or technologies, responses to relative price and factor endowment changes under these conditions are often abrupt and "unrealistic."

As H-N (pp. 37-41) note, however, where data are available, it is relatively easy to incorporate the phenomenon of diminishing returns to more intensive input use. Again, the mechanism is to treat different levels of input use as different activities. Unlike the pure technologies case discussed earlier, however, each of the corn activities now has associated with it a yield commensurate with the amount of the input that is being applied. Assume, for example, that the letters shown in H-N's Figure 3.6 are replaced with the numbers shown below. (The yields associated with various levels of weeding labor are also shown in Figure 3.1.)

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
YIELDS (KGS/HA)	450	750	825	860	750
WEEDING LABOR (MONTHS)	0	.7	1.4	2.1	.5
TOTAL LABOR (MONTHS)	1.1	1.8	2.5	3.2	1.4

Adding Diminishing Returns to the Model (MYPRIVT3)

Create a new model, MYPRIVT3, by making a copy of MYPRIVT2.

```
-----------------------------------------------------------------------------

$TITLE            MYPRIVT3 BASIC MAYALAND MODEL AT PRIVATE PRICES
$OFFSYMXREF OFFSYMLIST
OPTION LIMCOL=0, LIMROW=0, SOLPRINT=OFF

SETS   J      CROPS      /CORNNW, CORNL1, CORNL2, CORNL3, CORNMULE,
                          BEANS, SORGHUM, PEANUTS/
       I      INPUTS     /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/

PARAMETERS

  YIELDS(J)  YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
             /CORNNW 450, CORNL1 750, CORNL2 825, CORNL3 860, CORNMULE 750,
              BEANS 375, SORGHUM 775, PEANUTS 983/
```

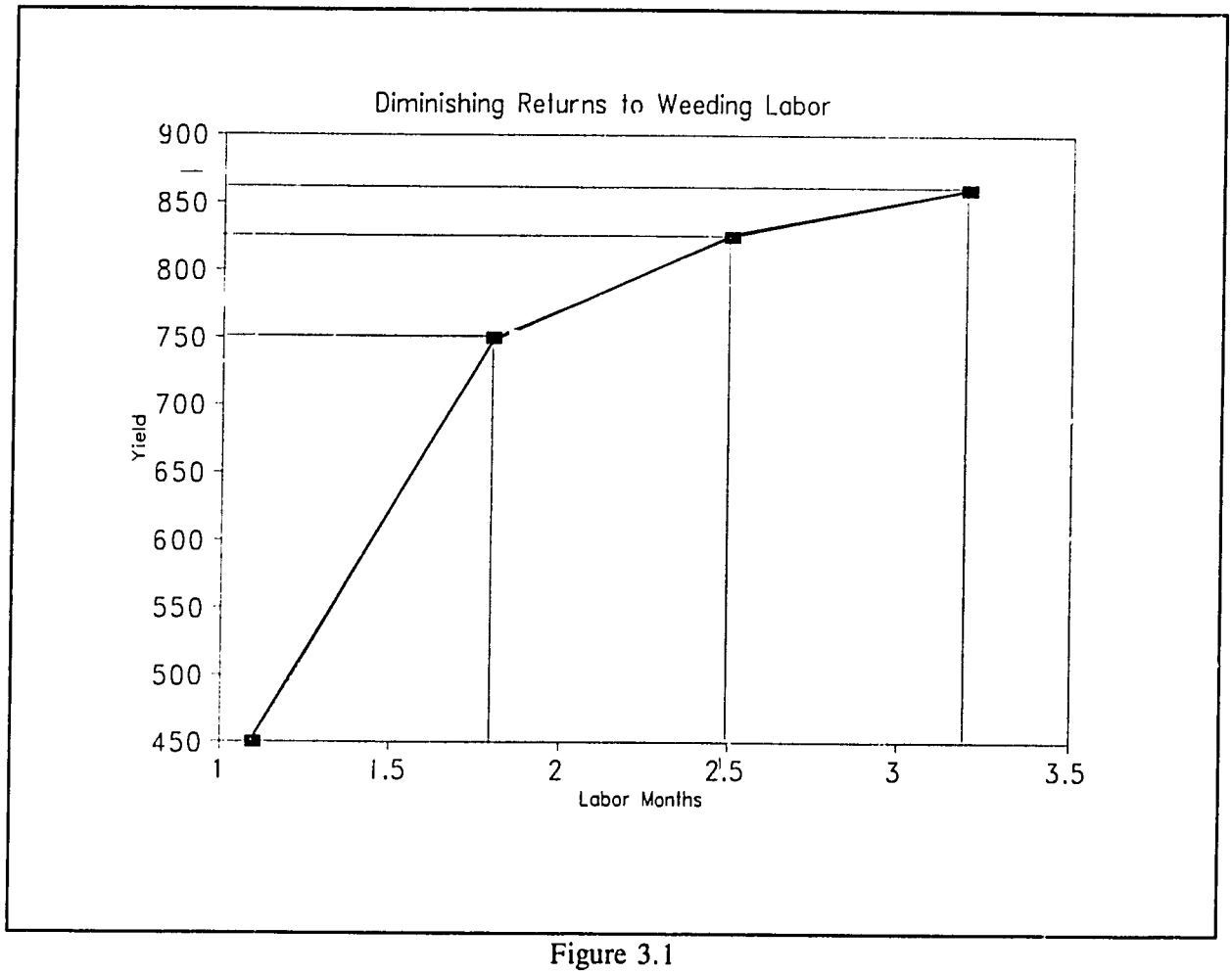

Figure 3.1

```
PROUTP(J)   PRICES OF CROP OUTPUT (PESOS PER KG)
            /CORNNW 3, CORNL1 3, CORNL2 3, CORNL3 3, CORNMULE 3,
             BEANS  6, SORGHUM 2.6, PEANUTS 7/

PRINP(I)    PRICES OF INPUTS (PESOS PER KG)
          /FERT 14, PEST 300,CORNSEED 5, BEANSEED 8, SORGSEED 5, PEASEED 9/

LAND(J)     LAND USE (HECTARES)
            /CORNNW 1, CORNL1 1, CORNL2 1, CORNL3 1, CORNMULE 1,
            BEANS 1,  SORGHUM 1,  PEANUTS 1/

LABOR(J)    LABOR USE (MAN MONTHS PER HECTARE)
           /CORNNW 1.1, CORNL1 1.8, CORNL2 2.5, CORNL3 3.2, CORNMULE 1.42,
           BEANS 1.87, SORGHUM 1.92, PEANUTS 2.64/

MULES(J)    MULE USE (PESOS PER HECTARE)
          /CORNNW 1, CORNL1 1, CORNL2 1, CORNL3 1, CORNMULE 1.45,
           BEANS 1.27, SORGHUM 1.16, PEANUTS 1.45/
```

```
  MP(J)        PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS PER HA)
               /PEANUTS 983/

TABLE IN(I, J) INPUT USE (KGS PER HECTARE)

           CORNNW  CORNL1  CORNL2  CORNL3  CORNMULE   BEANS  SORGHUM  PEANUTS
FERT          50      50      50      50       50      40       30       70
PEST         .25     .25     .25     .25      .25     .25               .6
CORNSEED     20      20      20      20       20
BEANSEED                                                50
SORGSEED                                                         15
PEASEED                                                                   95
              -----Remainder of model is the same as MYPRIVT2-------
-----------------------------------------------------------------------------
```

The initial value of the objective function for MYPRIVT3 is greater than the value for MYPRIVT1. This is because the single yield level for corn used in MYPRIVT1 is equal to CORNL2, i.e., corn at level or step 2, of the MYPRIVT3 model. As Figure 3.1 shows, the highest corn yields exceed the level 2 yields by 110 kgs/hectare. This increase in yield is sufficient to increase the gross margins of corn to the point where it replaces sorghum in the optimal cropping pattern.

The impact of diminishing returns to labor in this version of MYPRIVT can be observed if some modest changes are made in the model. In GAMS, both scalars and parameters can be changed although the notation is slightly different. As demonstrated in the example below, just type in the new value and repeat the SOLVE statement.

To get a complete report on the output at new parameter or scalar values, the statements that produced the desired information in the original report generator must be repeated. Use NE's block copying facility (F4,S to set the block, F4, C to copy it.) to reproduce the report generator as shown in the example. Do not repeat the sets and parameters definitions that were used to introduce the original report equations. (Parametric variation is dealt with in detail in Chapter 4.)

Immediately beneath the DISPLAY statement of the report generator, type (and copy) the following lines. (The output is shown below.)

```
*-----------------------------------------------------------------------------
   AMTLAB              =   12 ;
   PROUTP("SORGHUM")   =   2.4 ;
   SOLVE MYPRIVT3 USING LP MAXIMIZING Z;

     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =   SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)- ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =   CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);
```

The last statement produces the "reduced costs" for each crop and is the answer to the questions regarding extensions of the report writer posed earlier in the chapter. Reduced costs described the decline in the objective function that would occur if one unit of the enterprise was forced into the optimal solution.

```
OBJFUN("OBJECTIVE")          =      Z.L;

CONREP("LAND")               =      SUM(J, CROPS.L(J)*LAND(J));
CONREP("LABOR")              =      SUM(J, CROPS.L(J)*LABOR(J));
CONREP("MULES")              =      SUM(J, CROPS.L(J)*MULES(J));

CONMARG("LAND")              =      CONSTL.M;
CONMARG("LABOR")             =      CONSTLA.M;
CONMARG("MULES")             =      CONSTMUL.M;

DISPLAY OBJFUN, ACTREP, CONREP, CONMARG;
```

Output From The Diminishing Returns Model

The new solution when labor is set to 12 instead of 16.5 and the price of sorghum is set to 2.4 pesos per kilo instead of 2.6 is shown below. In addition to the information on costs and returns, the levels of the activities and the "marginals" for the resource constraints, the report also contains information on the "reduced cost" of the activities. This information is useful in assessing the distance that non-optimal activities are from being included in the optimal solution. For example, in the solution based on 12 man months of labor and a sorghum price of 2.4, it is clear from the reduced costs that the next candidate for inclusion in the optimal basis is sorghum.

Comparison of the revised MYPRIVT3 solution with the solution using the original parameters indicates that the selection by the model of steps on the production function below the maximum yield reflects not only the increasing scarcity of labor, but also the reduction in the comparative advantage of sorghum as a result of the decline in its price.

```
----     139 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE

OBJECTIVE  9542.239

----     139 PARAMETER ACTREP        VARIABLES SUMMARY

                CORNNW       CORNL1       CORNL2       CORNL3     CORNMULE

GROSSREV      1350.000     2250.000     2475.000     2580.000     2250.000
INPUTCO        875.000      875.000      875.000      875.000      875.000
NETREV         475.000     1375.000     1600.000     1705.000     -875.000
LEVEL                                      3.962                       .529
REDCOSTS      -833.333      -79.167                  - 40.833

        +        BEANS      SORGHUM      PEANUTS

GROSSREV      2250.000     1860.000     6881.000
INPUTCO       1035.000      495.000     2015.000
NETREV        1215.000     1365.000     4866.000
LEVEL                                      0.509
REDCOSTS      -253.750     -144.167

----     139 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
```

```
LAND   5.000,    LABOR 12.000,    MULES  5.467

----    139 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES

LAND  1079.167,    LABOR 208.33

-----------------------------------------------------------------------
```

Further disaggregation of cropping activities may be desirable along the lines suggested in the section in H-N dealing with differences in the quality of resources. In the case of irrigated vs. non-irrigated, if all crops could be grown on both types of land, new activities would have to be constructed for each. Each, however, would have common labor and mule rows indicating that, while they were grown in distinctly different environments, all continued to compete for a limited amount of human and animal power.

Disaggregation by labor type also can be important. More interesting than the H-N suggestion regarding a division of labor in crop production is the highly prevalent disaggregation of labor in livestock production. Livestock and livestock products are important in almost all developing country agricultures and, except in pastoral settings, animals usually are cared for by women and children.

SEASONALITY IN FARMING SYSTEMS MODELS

Seasonality is a major determinant of comparative advantage in most agricultural systems. It is particularly important in arid and semi-arid irrigated environments where year-around cropping is possible and planting and harvesting between seasons often creates extensive land, labor, and draught power bottlenecks.

Hazell and Norton provide coefficients on page 43 that make it possible to enrich the constraint set of the Mayaland model with data on the seasonal use of land, labor, and animal power. The previous extension to include diminishing returns of labor to corn weeding has been maintained, and labor coefficients for May and June have been adjusted accordingly. Lessor adjustments have been made to harvesting and corn shelling coefficients to reflect increased yields.

On page 44, H-N develop a further consideration of seasonality--the staggering of planting and harvesting dates. This is an important device that farmer's use to avoid seasonal bottlenecks. Note that seasonal information can be entered selectively, i.e., not all months need be represented nor do the time periods have to be the same for different constraints. If alternative planting dates were added to each of the already existing activities, it would produce 15 different ways of producing corn (5 technologies x 3 planting dates). Although additional activities add realism to the modeling of farmer decisions and columns are relatively inexpensive computationally, it is obvious that some care needs to be exercised so that the multiplication of technologies does not to make the model unwieldy.

The first step in developing a new model to carry out the seasonal exercise is to make a copy of MPRIVT3 with the command: COPY MYPRIVT3 MYPRIVT4, and add the information shown below to the model. Use the methods described in the following paragraph. Note also the places in which a seasonal index must be introduced in the model in order for the computations to be made correctly.

Adding seasonal information to a GAMS model can be facilitated by using block and copy commands. After adding the appropriate seasonal index to the model, one table showing crops as activities and months as constraints will need to be constructed. It probably is best to enter the data for land use in the table in order to provide a check on the accurate placement of data in the following labor table. Once the land table has been completed, use NE's block and copy commands (F4 S at both ends of the table, F4 C to copy it at the cursor) as described earlier. When entering data, first type F6 Insert in order to put the editor in "replace" or typeover mode. The new data then can be entered by typing over the existing data thus minimizing the number of deletions.)

GAMS Model with Seasons (MYPRIVT4)

```
-----------------------------------------------------------------------------

$TITLE              MYPRIVT4 BASIC MAYALAND MODEL AT PRIVATE PRICES
*                   (Adding seasonality to the MYPRIVT model)

$OFFSYMXREF OFFSYMLIST
OPTION LIMROW=0, LIMCOL=0, SOLPRINT=OFF

SETS   J      CROPS     /CORNNW, CORNL1, CORNL2, CORNL3, CORNMULE,
                         BEANS, SORGHUM, PEANUTS/
       I      INPUTS    /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/
       S      SEASONS   /JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG,
                         SEP, OCT, NOV, DEC/

PARAMETERS

  YIELDS(J)  YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
             /CORNNW 450, CORNL1 750, CORNL2 825, CORNL3 860, CORNMULE 750,
              BEANS 375, SORGHUM 775, PEANUTS 983/

  PROUTP(J)  PRICES OF CROP OUTPUT (PESOS PER KG)
             /CORNNW 3, CORNL1 3, CORNL2 3, CORNL3 3, CORNMULE 3,
              BEANS  6, SORGHUM 2.6, PEANUTS 7/

  PRINP(I)   PRICES OF INPUTS (PESOS PER KG)
            /FERT 14, PEST 300,CORNSEED 5, BEANSEED 8, SORGSEED 5, PEASEED 9/

  MULES(J)   MULE USE (PESOS PER HECTARE)
           /CORNNW 1, CORNL1 1, CORNL2 1, CORNL3 1, CORNMULE 1.45,
             BEANS 1.27, SORGHUM 1.16, PEANUTS 1.45/

  MP(J)      PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS PER HA)
             /PEANUTS 983/

TABLE IN(I, J) INPUT USE (KGS PER HECTARE)
```

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS	SORGHUM	PEANUTS
FERT	50	50	50	50	50	40	30	70
PEST	.25	.25	.25	.25	.25	.25		.6
CORNSEED	20	20	20	20	20			
BEANSEED						50		
SORGSEED							15	
PEASEED								95

TABLE LAND(S, J) LAND USE (HECTARES)

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS	SORGHUM	PEANUTS
JAN								
FEB						1		
MAR						1		
APR	1	1	1	1	1	1		1
MAY	1	1	1	1	1	1	1	1
JUN	1	1	1	1	1		1	1
JUL	1	1	1	1	1		1	1
AUG							1	1
SEP								
OCT								
NOV								
DEC								

TABLE LABOR(S, J) LABOR USE (MAN MONTHS PER HECTARE)

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS	SORGHUM	PEANUTS
JAN								
FEB						.27		
MAR						.36		
APR	.27	.27	.27	.27	.27	.50		.36
MAY	.16	.46	.76	1.06	.46	.50	.32	.36
JUN	.16	.46	.76	1.06	.46		.36	.27
JUL	.09	.09	.19	.19	.09		.50	.64
AUG							.50	.55
SEP	.08	.18	.18	.24	.18			
OCT	.26	.36	.36	.40	.36			
NOV							.24	.46
DEC								

* Labor used in September, October and November represent shelling and
*threshing hours.

SCALARS

```
      AMTLAND  AMOUNT OF LAND AVAILABLE (HECTARES)      /5/
      AMTLAB   AMOUNT OF LABOR AVAILABLE (BY MONTH)     /1.375/
      AMTMULE  MULE POWER AVAILABLE (MONTHS)            /10/
      MARKET   MARKET CONSTRAINT ON PEANUTS(KGS)        /500/
```

VARIABLES

```
             REVENUE    GROSS REVENUE FROM CROP ACTIVITIES
             COST       TRADABLE INPUT COSTS
             CROPS      LEVELS OF THE CROP ACTIVITIES
             Z          TOTAL VALUE ADDED FROM CROP ACTIVITIES
                       POSITIVE VARIABLES CROPS
```

EQUATIONS

```
REV              COMPUTATION OF GROSS REVENUES
INCOST           COMPUTATION OF TRADABLE INPUT COSTS
CONSTL(S)        LAND CONSTRAINT
CONSTLA(S)       LABOR CONSTRAINT
CONSTMUL         MULE CONSTRAINT
MARKT            MARKET CONSTRAINT ON PEANUTS
OBJFN            OBJECTIVE FUNCTION;

REV..        REVENUE =E= SUM(J,YIELDS(J)*PROUTP(J)*CROPS(J));
INCOST..     COST    =E= SUM((I, J), IN(I,J)*PRINP(I)*CROPS(J));
CONSTL(S)..                SUM(J, LAND(S,J)*CROPS(J)) =L=AMTLAND;
CONSTLA(S)..               SUM(J, LABOR(S,J)*CROPS(J)) =L=AMTLAB;
CONSTMUL..                 SUM(J, MULES(J)*CROPS(J)) =L=AMTMULE;
MARKT..                    SUM(J, MP(J)* CROPS(J)) =L=MARKET;
OBJFN..         Z =E= REVENUE-COST;

MODEL MYPRIVT4/ALL/;
SOLVE MYPRIVT4 USING LP MAXIMIZING Z;

$TITLE                    REPORT ON MYPRIVT4 SOLUTION

     SETS      AREP      /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
               CREP      /LAND, LABOR, MULES/
               OBJ       /OBJECTIVE/

     PARAMETERS     ACTREP     VARIABLES SUMMARY
                    CONREP     DOMESTIC RESOURCE USE SUMMARY
                    CONMARG    SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUN     OBJECTIVE FUNCTION VALUE;

     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =  CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")         =      Z.L;


     CONREP(S,"LAND")           =      SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")          =      SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")          =      SUM(J, CROPS.L(J)*MULES(J));
```

A seasonal dimension for mule resources is required if the results are to be reported in the same table as land and labor. The present statement reproduces the annual levels in each month. The same tactic has been used to report the shadow prices of mule labor below.

```
     CONMARG(S,"LAND")          =      CONSTL.M(S);
     CONMARG(S,"LABOR")         =      CONSTLA.M(S);
     CONMARG(S,"MULES")         =      CONSTMUL.M;

  DISPLAY OBJFUN, ACTREP, CONREP, CONMARG;
```

The tables represented by CONREP (Constraint Report) and CONMARG (Constraint Marginals) are currently inconsistent because the dimensions of the tables differ by type of constraint. For example, land and labor now have a seasonal dimension but mules do not. As GAMS error messages rightly note,

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this won't work. The best compromise, short of defining tables describing monthly mule use, is to tell GAMS to repeat the figure for the single annual constraint in each month. This has been done in the report generator shown above. The same value for mule power used will appear in each month although it represents the value of annual use. (The problem would be eliminated, of course, if you were to develop a seasonal mule labor table. If you do, be sure to add the seasonal index to the right hand side of the mule equations in the report generator.)

Results of Adding Seasonality

The impact of adding seasonal constraints is substantial. The cropping pattern is now determined by the monthly competition for labor rather than by the competition for land. For example, both corn and sorghum appear in the cropping pattern because, in the critical month of July when the high-valued peanuts use substantial amounts of labor, corn uses relatively less labor than sorghum. Including diminishing returns to weeding has a more focused impact when it is incorporated in a seasonal model than when weeding labor is part of a total labor aggregate. Virtually the entire effect of diminishing returns to labor has been implemented by adjusting the labor coefficients for May and June, the principal weeding months.

REPORT ON MYPRIVT4 SOLUTION (1.375 MAN MONTHS AVAILABLE PER MONTH)

---- 141 PARAMETER OBJFUN OBJECTIVE FUNCTION VALUE

OBJECTIVE 7080.332

---- 141 PARAMETER ACTREP VARIABLES SUMMARY

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
GROSSREV	1350.000	2250.000	2475.000	2580.000	2250.000
INPUTCO	875.000	875.000	875.000	875.000	875.000
NETREV	475.000	1375.000	1600.000	1705.000	1375.000
LEVEL		1.220			
REDCOSTS	-77.198		-723.769	-1441.571	

+	BEANS	SORGHUM	PEANUTS
GROSSREV	2250.000	2015.000	6881.000
INPUTCO	1035.000	495.000	2015.000
NETREV	1215.000	1520.000	4866.000
LEVEL	0.059	1.879	0.509

---- 141 PARAMETER CONREP DOMESTIC RESOURCE USE SUMMARY

	LAND	LABOR	MULES
JAN			4.212
FEB	0.059	0.016	4.212
MAR	0.059	0.021	4.212
APR	1.787	0.542	4.212
MAY	3.667	1.375	4.212
JUN	3.608	1.375	4.212
JUL	3.608	1.375	4.212
AUG	2.388	1.219	4.212

```
SEP                    0.220       4.212
OCT                    0.439       4.212
NOV                    0.685       4.212
DEC                                4.212

----     141 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES
           LABOR
MAY     2430.000
JUN      312.672
JUL     1259.676
-----------------------------------------------------------------------------
```

After you have copied the land and labor tables into the GAMS code and debugged the model, try adding a seasonal mule table on your own. You will have to make up the data, but you do have some guidance from the existing labor coefficients, i.e., mules can't work without drivers. However, you will have to make adjustments to account for the fact that the corn technologies have seasonally different labor and mule demands. Remember also that the "mule months" scalar will need to be adjusted to reflect monthly, not annual, availability

Try relaxing the labor constraint by typing in a higher value for the labor scalar. Does seasonality become more or less important as labor availability increases? How would the results of policy experiments differ in the seasonal vs. the non seasonal model? Inspect the technical coefficient tables and speculate on the effect of adding the alternative planting dates for corn given in H-N, p. 44. Without actually doing the exercise, try to imagine the likely impact of making these further adjustments in seasonality to the model.

CHAPTER 4: DERIVING NORMATIVE DEMAND AND SUPPLY CURVES

Even a casual acquaintance with l.p. modeling suggests that much of the benefit of constructing and running models is obtained by "playing" with the model. Often the lack of data, along with the limitations in model specifications, make specific answers to a farming systems problems suspect. However, considerable insight can be gained into the working of a farming system by parametrically altering various parameters and observing the behavior of the model. Along with systematic data organization, the sharpening of intuition about a particular agro-climatic area is one of the most important benefits of model construction.

Commercial optimization packages such as IBM's MPS series permit the systematic variation of parameters and the reporting of every basis changes that occurs. GAMS does not, and this is a limitation of the current versions of the software. However, something similar can be accomplished by using a sequence of assignment and SOLVE statements. Using this technique, the two examples that follow show how (1) demand curves for inputs or factors can be derived and (2) supply curves for outputs can be generated.

Begin at the DOS prompt with: COPY MYPRIVT4 MYDEM1. This produces a copy of the last model developed in Chapter 3. The new model will be used to produce a demand curve for labor. COPY MYPRIVT4 MYSUP1 will produce a version of MYPRIVT4 that will be used to generate a supply curve for sorghum.

DERIVING A DEMAND CURVE FOR RESOURCES

The techniques needed to derive a demand curve for resources have been indicated previously as a part of the discussion of sensitivity analysis. Producing the output required to plot a curve merely requires repeated application of the same methods. The sequence of commands shown below can be used to generate the data for a labor demand curve. It can be implemented immediately following the SOLVE statement in the original (MYDEM1) problem.

If only information on the parameters required to plot the graph is desired, the lines following the SOLVE statement might be confined to lines that displayed the amount of labor and the resulting sum of the resource marginals. However, much that is of interest, e.g., changes in the cropping pattern and changes in other resource marginals, would be lost. Hence, it is desirable to reproduce the report generator for each new value of the resource availability scalar.

The desired report generator is indicated below for the first two values of the scalar, AMTLAB. To produce the entire input file from the original MYDEM1 file, use the "block" and "copy" commands of the text editor (F4, S and F4, C) to produce the first step, modify it as indicated, then copy for each remaining step. Once the steps have been copied, edit them to produce different values for AMTLAB. (Remember to modify the name of the model definition statement to MYDEM1.)

Add SUMM to the list of the report generator's parameters. It should now read:

```
PARAMETERS    ACTREP    VARIABLES SUMMARY
              CONREP    DOMESTIC RESOURCE USE SUMMARY
              CONMARG   SHADOW PRICES OF DOMESTIC RESOURCES
              OBJFUN    OBJECTIVE FUNCTION VALUE
              SUMM      SUM OF LABOR MARGINALS;
```

The following sequence produces a series of scalar changes for monthly labor availability that will be used to chart out the labor demand curve. The first two steps, .5 and 1, are shown below. Continue at .5 step intervals to 3.0. (What do you already know about the demand curve for labor at 1.35?) Use of the block and copy facilities in NE make the seemingly formidable task of creating multiple solutions quite simple. The only things that needs to be changed in each version is the value of the scalar for labor.

```
AMTLAB = .5;
SOLVE MYDEM1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =  CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")          =      Z.L;

     CONREP(S,"LAND")             =      SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")            =      SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")            =      SUM(J, CROPS.L(J)*MULES(J));

     CONMARG(S,"LAND")            =      CONSTL.M(S);
     CONMARG(S,"LABOR")           =      CONSTLA.M(S);
     CONMARG(S,"MULES")           =      CONSTMUL.M;
```

The statements below sum over the shadow prices of the seasonal constraints. Be sure that SUMM has been added previously to the list of the report generator's parameters.

```
     SUMM("TOTALLA")              =      SUM(S, CONSTLA.M(S));
     SUMM("TOTALLN")              =      SUM(S, CONSTL.M(S));

DISPLAY AMTLAB,SUMM,OBJFUN, ACTREP, CONREP, CONMARG;

AMTLAB =  1;
SOLVE MYDEM1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =  CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")          =      Z.L;

     CONREP(S,"LAND")             =      SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")            =      SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")            =      SUM(J, CROPS.L(J)*MULES(J));
```

```
     CONMARG(S,"LAND")          =       CONSTL.M(S);
     CONMARG(S,"LABOR")         =       CONSTLA.M(S);
     CONMARG(S,"MULES")         =       CONSTMUL.M;

     SUMM("TOTALLA")              =       SUM(S, CONSTLA.M(S));
     SUMM("TOTALLN")              =       SUM(S, CONSTL.M(S));

DISPLAY AMTLAB,SUMM,OBJFUN, ACTREP, CONREP, CONMARG;
```

Results of the Sensitivity Analysis

Figure 4.1 is a plot of the amount of labor available each month against the seasonally summed shadow price of one unit of additional annual labor. The graph indicates clearly how sensitive the model is to assumptions about labor availability. The rapid decline in labor's shadow price is accompanied by an equally rapid increase in the value of the objective function.

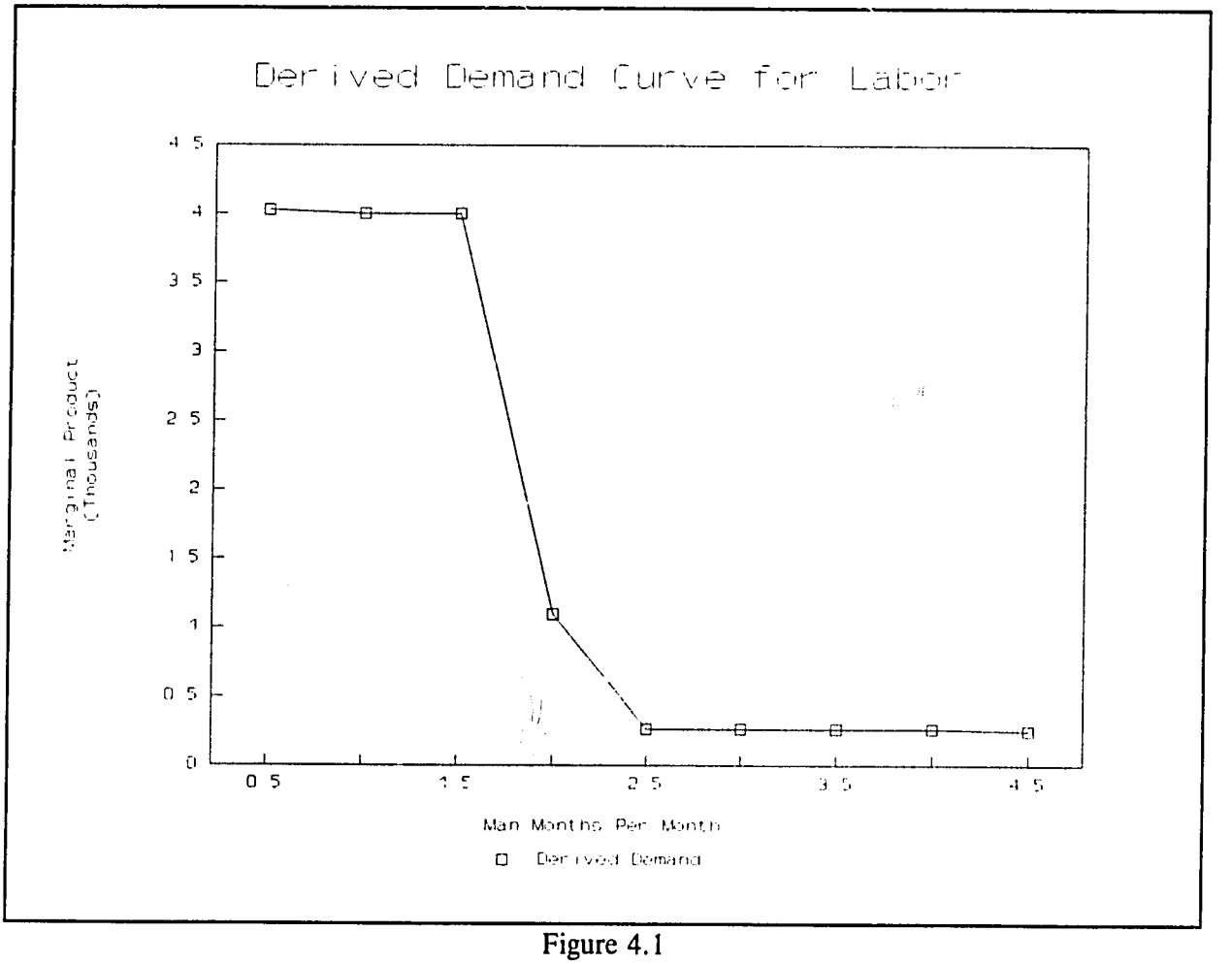

Figure 4.1

DERIVING A SUPPLY CURVE FOR OUTPUTS

Deriving a normative supply curve for sorghum proceeds in much the same way as deriving the demand curve for labor. In this case, however, the number to be varied is part of the parameter PROUTP and hence must be identified as such. The first two iterations are displayed below. Again, it would have been possible to isolate only the desired parameter by simplifying the report generator.

```
-----------------------------------------------------------------------------
PROUTP("SORGHUM") = 1;
SOLVE MYSUP1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
```

```
     ACTREP("LEVEL",J)          =  CROPS.L(J);
     ACTREP("REDCOSTS",J)       =   CROPS.M(J);

     OBJFUN("OBJECTIVE")          =      Z.L;
     CONREP(S,"LAND")             =      SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")            =      SUM(J, CROPS.L(J)*LABOR(S,J),;
     CONREP(S,"MULES")            =      SUM(J, CROPS.L(J)*MULES(J));

     CONMARG(S,"LAND")            =      CONSTL.M(S);
     CONMARG(S,"LABOR")           =      CONSTLA.M(S);
     CONMARG(S,"MULES")           =      CONSTMUL.M;

DISPLAY PROUTP,OBJFUN, ACTREP, CONREP, CONMARG;

PROUTP("SORGHUM") = 2;
SOLVE MYSUP1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)      =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)       =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)        =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)          =  CROPS.L(J);

     ACTREP("REDCOSTS",J)       =   CROPS.M(J);

     OBJFUN("OBJECTIVE")          =      Z.L;

     CONREP(S,"LAND")             =      SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")            =      SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")            =      SUM(J, CROPS.L(J)*MULES(J));
     CONMARG(S,"LAND")            =      CONSTL.M(S);
     CONMARG(S,"LABOR")           =      CONSTLA.M(S);
     CONMARG(S,"MULES")           =      CONSTMUL.M;

DISPLAY PROUTP,OBJFUN, ACTREP, CONREP, CONMARG;
-----------------------------------------------------------------------------
```

Results of the Sensitivity Analysis

Figure 4.2 shows the results of the parametric variation of sorghum prices. As would be expected with so few constraints, basis changes are relatively infrequent and the optimal solutions do not trace out a smooth curve. The result is a highly inelastic supply response over substantial sorghum prices ranges and extreme sensitivity at other points. It is reminiscent of the two dimension model described in Chapter 1. The need for a richer model with a more complete technical matrix and additional crop activities is obvious.

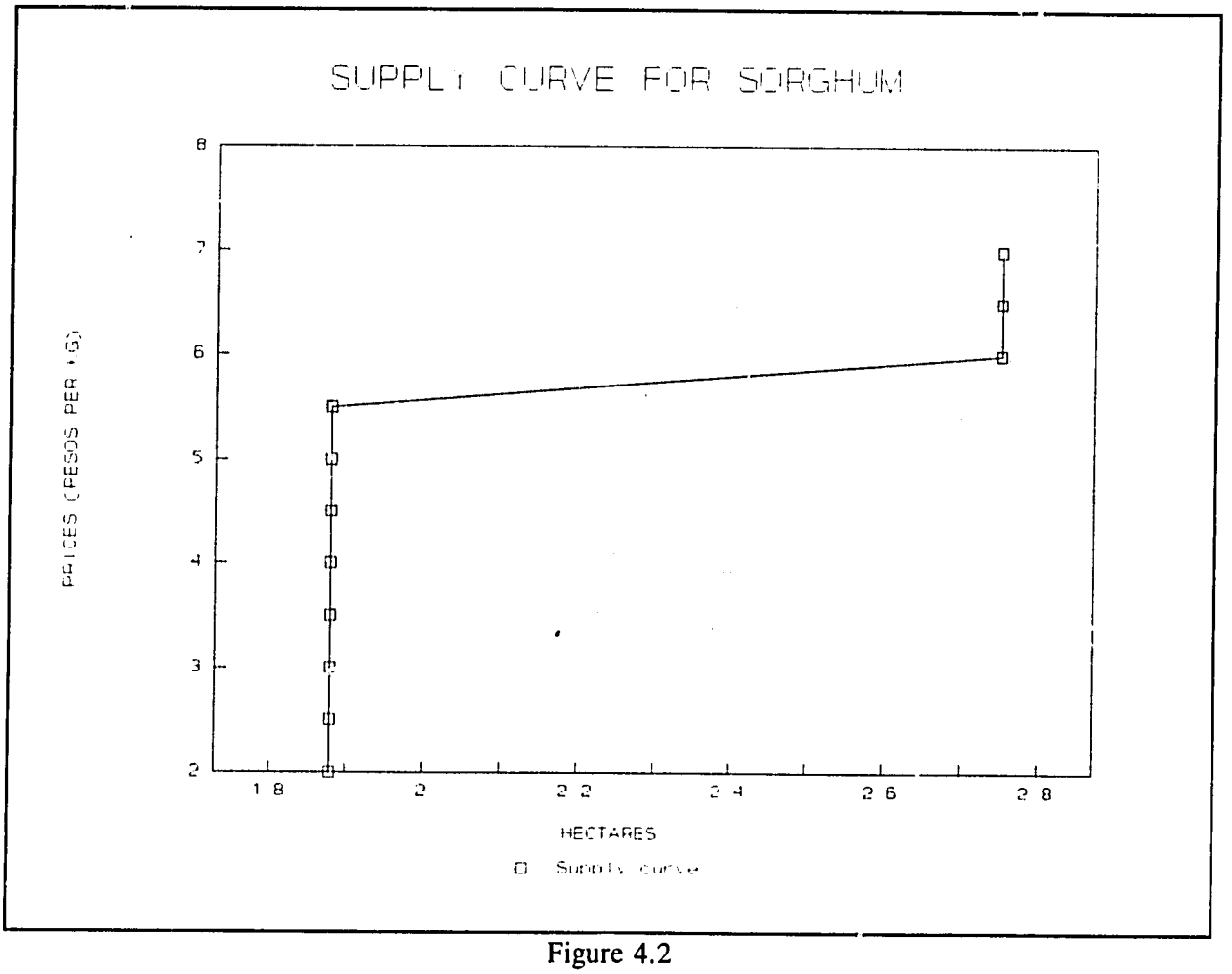
SUPPLY CURVE FOR SORGHUM
PRICES (PESOS PER KG)
8
7
6
5
4
3
2
1.8
2
2.2
2.4
2.6
2.8
HECTARES
Supply curve

Figure 4.2

CHAPTER 5: POLICY ANALYSIS: ADDING SOCIAL PRICES

In the Monke-Pearson PAM framework, policy interventions are associated primarily with divergences between the private and social prices of tradable outputs and inputs.[2] Private prices are those observed in domestic markets; social prices are the domestic equivalents of the international prices of tradable commodities. The latter represent the true opportunity cost of tradables to the economy. The significance of calculating optimal resource use when gross margins are computed using international prices is that the resulting cropping pattern contains those commodities in which the economy has a comparative advantage.

In the world of partial budgets, the impact of using social prices is often overstated because no adjustments of factor use to price changes is assumed. This assumption can be relaxed in the l.p. framework. The result is that judgments about the effects of policy reforms on farming systems tend to be less dramatic than when partial budgeting methods are employed.

The GAMS model below shows how a new set of (social) prices can be incorporated in the analysis with a minimum of effort. The strategy relies on reusing most of the constraints in the private prices model, namely, those relating to physical input-output constraints. Once the parameters describing output and input prices have been changed, only those equations that compute revenues and costs need be repeated. The model's definition statement, instead of specifying all constraints (/ALL/) as was the case in previous exercises, now ennumerates each constraint individually. *Both models are contained in the same MYPOLICY file and will be run consecutively by GAMS.*

COMPUTING AN OPTIMAL SOLUTION AT SOCIAL PRICES

To add social prices to the MYPRIVT4 model used in Chapter 3, first copy MYPRIVT4 to a file called MYPOLICY. Add the following section below the DISPLAY statement of the MYPRIVT4 report generator in the newly created MYPOLICY model.

```
-----------------------------------------------------------------------------
 $TITLE          OPTIMAL SOLUTION WITH SOCIAL PRICES

PARAMETERS

  SOOUTP(J)   PRICES OF CROP OUTPUT (PESOS PER KG)
              /CORNNW 2.5, CORNL1 2.5, CORNL2 2.5, CORNL3 2.5, CORNMULE 2.5,
               BEANS  12, SORGHUM 3.2, PEANUTS 5/

  SOINP(I)    PRICES OF INPUTS (PESOS PER KG)
             /FERT 28, PEST 450,CORNSEED 4, BEANSEED 14, SORGSEED 4, PEASEED 7/
```

The prices shown in the newly created parameter statements are assumed to reflect the domestic equivalents of international prices. Note that the names of the parameters have been changed.

---

[2] Chapter 1-2 are assigned reading.

```
EQUATIONS
            REVSO          REVENUE COMPUTATION AT SOCIAL PRICES
            INCOSTSO       COST COMPUTATION AT SOCIAL PRICES;

        REVSO..        REVENUE =E= SUM(J, YIELDS(J)*SOOUTP(J)*CROPS(J));
        INCOSTSO..     COST    =E= SUM((I,J), IN(I,J)*SOINP(I)*CROPS(J));
```

The above equations compute gross revenues and variable costs using parameters that describe social prices. The model definition statement shown below ennumerates each equation in the model. The new model has been called MYSOCIAL to distinguish it from the MYPRIVT4 model that makes up the first part of the MYPOLICY file.

```
MODEL MYSOCIAL /REVSO, INCOSTSO, CONSTL, CONSTLA, CONSTMUL, MARKT, OBJFN/;
SOLVE MYSOCIAL USING LP MAXIMIZING Z;
```

The report generator for the social prices model follows directly after the SOLVE statement. Again, remember to use NE's block and copy facility to convert the private prices report generator to the social prices report generator.

```
$TITLE                    REPORT ON MYSOCIAL SOLUTION
```

Note that the letter S has been added to the SET and PARAMETER names. The set <u>elements</u> need not be changed to distinguish between the results of the private and social solutions.

```
     SETS      AREPS      /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
               CREPS      /LAND, LABOR, MULES/
               OBJS       /OBJECTIVE/

     PARAMETERS     ACTREPS     VARIABLES SUMMARY
                    CONREPS     DOMESTIC RESOURCE USE SUMMARY
                    CONMARGS    SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUNS     OBJECTIVE FUNCTION VALUE;

  ACTREPS("GROSSREV", J)    =   YIELDS(J)*SOOUTP(J);
  ACTREPS("INPUTCO", J)     =  SUM(I, IN(I, J)*SOINP(I));
  ACTREPS("NETREV", J)      =   ACTREPS ("GROSSREV", J)-ACTREPS("INPUTCO", J);
  ACTREPS("LEVEL",J)        =  CROPS.L(J);
  ACTREPS("REDCOSTS",J)     =   CROPS.M(J);

  OBJFUNS("OBJECTIVE")          =      Z.L;

  CONREPS(S,"LAND")            =       SUM(J, CROPS.L(J)*LAND(S,J));
  CONREPS(S,"LABOR")           =       SUM(J, CROPS.L(J)*LABOR(S,J));
  CONREPS(S,"MULES")           =       SUM(J, CROPS.L(J)*MULES(J));


   CONMARGS(S,"LAND")           =       CONSTL.M(S);
   CONMARGS(S,"LABOR")          =       CONSTLA.M(S);
   CONMARGS(S,"MULES")          =       CONSTMUL.M;

  DISPLAY OBJFUNS, ACTREPS, CONREPS, CONMARGS;
*-----------------------------------------------------------------------
```

COMPARISON OF PRIVATE AND SOCIAL SOLUTIONS

The results of the private and social prices runs are reported below. They indicate clearly the significance of changes in relative prices of outputs and inputs in determining the optimal cropping pattern. Under social prices, beans are the dominant crop in the optimal cropping pattern. Note also, however, that neither the objective function nor the shadow prices of resources have changed much. A characteristic of farming systems models is that the primal tends to be more unstable and volatile than the dual. Why should this be so? Hint: When crops compete for the same resources, slight differences in relative profitability may produce a major change in the cropping pattern without affecting the marginal product of the scarce factors. The further implication, at least for the farming system being modeled, is that although price reforms might produce a significant change in the cropping pattern, there would be little impact on farmer's incomes.

Solution of MYPOLICY at Private Prices

```
--------------------------------------------------------------------------------
----     141 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE

OBJECTIVE 7080.332

----     141 PARAMETER ACTREP        VARIABLES SUMMARY
                CORNNW      CORNL1      CORNL2      CORNL3    CORNMULE
CROSSREV     1350.000    2250.000    2475.000    2580.000    2250.000
INPUTCO       875.000     875.000     875.000     875.000     875.000
NETREV        475.000    1375.000    1600.000    1705.000    1375.000
LEVEL                       1.220
REDCOSTS      -77.198                -723.769   -1441.571         EPS

       +        BEANS     SORGHUM     PEANUTS

GROSSREV     2250.000    2015.000    6881.000
INPUTCO      1035.000     495.000    2015.000
NETREV       1215.000    1520.000    4866.000
LEVEL           0.059       1.879       0.509

----     141 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
            LAND        LABOR       MULES
JAN                                 4.212
FEB        0.059        0.016       4.212
MAR        0.059        0.021       4.212
APR        1.787        0.542       4.212
MAY        3.667        1.375       4.212
JUN        3.608        1.375       4.212
JUL        3.608        1.375       4.212
AUG        2.388        1.219       4.212
SEP                     0.220       4.212
OCT                     0.439       4.212
NOV                     0.685       4.212
DEC                                 4.212

----     141 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES
          LABOR
MAY     2430.000
JUN      312.672
JUL     1259.676
------------------------------------ ----------------------------------
```

Solution to MYPOLICY at Social Prices

The change in relative prices is sufficient to drive all corn from the optimal cropping pattern under social prices. (Note that the net revenues of non-weeded corn are actually negative.) Does this suggest a rationale for the government subsidies? Hint: Suppose that the government, as a matter of national policy, wanted to maintain a certain amount of self-sufficiency in corn. What does the "reduced cost" report of the social prices solution say about the magnitude of the subsidies that would be required. Examine the distortions in the prices of other crops. What interpretation can be given to the motivation for government policies?

```
---------------------------------------------------------------------------
----     193 PARAMETER OBJFUNS        OBJECTIVE FUNCTION VALUE

OBJECTIVE 7147.807
            193 PARAMETER ACTREPS        VARIABLES SUMMARY

                CORNNW      CORNL1      CORNL2      CORNL3    CORNMULE
GROSSREV      1125.000    1875.000    2062.500    2150.000    1875.000
INPUTCO       1592.500    1592.500    1592.500    1592.500    1592.500
NETREV        -467.500     282.500     470.000     557.500     282.500
REDCOSTS     -1310.825   -2042.075   -3335.825   -4729.575   -2042.075

        +        BEANS     SORGHUM     PEANUTS
GROSSREV      4500.000    2480.000    4915.000
INPUTCO       1932.500     900.000    2895.000
NETREV        2567.500    1580.000    2020.000
LEVEL            2.384                   0.509

----     193 PARAMETER CONREPS        DOMESTIC RESOURCE USE SUMMARY
            LAND        LABOR       MULES
JAN                                 3.765
FEB          2.384      0.644       3.765
MAR          2.384      0.858       3.765
APR          2.892      1.375       3.765
MAY          2.892      1.375       3.765
JUN          0.509      0.137       3.765
JUL          0.509      0.326       3.765
AUG          0.509      0.280       3.765
SEP                                 3.765
OCT                                 3.765
NOV                     0.234       3.765
DEC                                 3.765

----     193 PARAMETER CONMARGS       SHADOW PRICES OF DOMESTIC RESOURCES

           LABOR

APR      197.500
MAY     4937.500
---------------------------------------------------------------------------
```

COMPUTING CROPWISE PROTECTION COEFFICIENTS

Now that the report generators have produced calculations of gross revenues and variable costs at both private and social prices, it is a simple matter to write a GAMS routine that computes the NOPC (nominal output protection coefficient), the NIPC (nominal input protection coefficient) and the EPC (effective protection coefficient). These ratios are important summary statements that capture the extent of government policy interventions in the markets for tradable commodities. Type in the following statements beginning below the DISPLAY statement of the social prices report generator.

```
---------------------------------------------------------------------------
$TITLE      PROTECTION COEFFICIENTS CALCULATED FROM MAYALAND DATA

   SET          COEFF    /NOPC, NIPC, EPC/
   PARAMETER    POLICY   SUMMARY OF CROPWISE PROTECTION COEFFICIENTS;

   POLICY("NOPC", J)   =   ACTREP("GROSSREV", J)/ACTREPS("GROSSREV", J);
   POLICY("NIPC", J)   =   ACTREP("INPUTCO", J)/ACTREPS("INPUTCO", J);
   POLICY("EPC", J)    =   ACTREP("NETREV", J)/ACTREPS("NETREV", J);

   DISPLAY POLICY;
*--------------------------------------------------------------------------
```

The protection coefficients generated by the equations shown above provide ample evidence of the Mayaland government's intervention in agricultural policy. Nominal protection coefficients for corn and peanuts show a subsidy while those for beans and sorghum show that a tax is being levied on farmers.

Input prices reflect subsidizes for all crops. Identifying the culprit requires reference to the more detailed I-O table and to the prices table. From these two data sets it is evident that the major source of the subsidies is fertilizer.

Corn receives the largest per hectare subsidy when both outputs and inputs are considered. Its EPC is substantially greater than its initial NPC for output and underscores the fact that both inputs and outputs need to be considered before the true extent of protection can be determined. In this case the Mayaland government presumably has a strong interest in increasing food security and hence is providing generous incentives for farmers to produce corn.

```
---------------------------------------------------------------------------

----    204 PARAMETER POLICY        SUMMARY OF CROPWISE PROTECTION
COEFFICIENTS
          CORNNW      CORNL1      CORNL2      CORNL3    CORNMULE       BEANS
NOPC       1.200       1.200       1.200       1.200       1.200       0.500
NIPC       0.549       0.549       0.549       0.549       0.549       0.536
EPC       -1.016       4.867       3.404       3.058       4.867       0.473

   +     SORGHUM     PEANUTS
NOPC       0.812       1.400
NIPC       0.550       0.696
EPC        0.962       2.409
```

CHAPTER 6: FACTOR MARKETS IN THE MAYALAND MODEL

Budgeting (PAM) models differ in orientation from the l.p. models described above principally by the way in which factor markets are modeled. In the partial equilibrium approach, only a single factor or bundle of factors is assumed to be uniquely fixed to agriculture. The opportunity costs of other factors, e.g., capital and labor, are assumed to be determined in national markets that include other segments of the economy as well.

The treatment in the Mayaland models thus far is the opposite extreme, namely, there are no markets for the factors at all. As Hazell and Norton note (pp. 45-46), adding markets for factors to l.p. models is straightforward. Including the possibility of hiring in labor, for example, requires only (1) some additional variables that "supply" labor to the right hand side of the factor using ("demand") rows, and (2) a negative term in the objective function that penalizes the model for hiring outside labor. The units will be those already specified in the model. The unit value subtracted in the objective function refers to pesos per man month.

To create the new model, follow earlier methods in which a copy of the previous model was used as the basis for the next step. In GAMS, debugging goes much faster this way and the amount of typing is reduced. To create the necessary copy of the model, at the DOS prompt, type following DOS command: COPY MYPRIVT4 MYMARKT1. Use MYMARKT1 to complete the following exercise. A full version of the labor market extension to the section of the model based on private prices has been appended. However, in the interest of learning GAMS, it would be wise to try to follow, as much as possible, the steps as outlined and to use the model that has been provided as confirmation.

ADDING A PRIVATE LABOR MARKET

Hiring In Labor

Adding a labor market to the private prices section of the MYMARKT1 model that permits farmers to hire in additional annual labor requires the following steps:

Step 1

Define a new variable called "HIREIN" and add it to the list of variables. Note that it must also be added to the list of positive variables. It must be separated from the other variable names by a comma, e.g., POSITIVE VARIABLES CROPS, HIREIN;

Step 2

Define a new scalar called "WAGEIN" and add it to the list of scalars. Hazell and Norton indicate that wage rates in Mayaland are 50 pesos per month. At this rate, the annual wage would be 600 pesos.

WAGEIN WAGES OF HIRED LABOR /600/

Step 3

Add the labor supplied by the labor hiring activity to the labor supply row, i.e., rewrite the labor equation as follows:

CONSTLA(S)..SUM(J, LABOR(S, J)*CROPS(J)) =L= AMTLAB + HIREIN;

Step 4

Compute a labor cost term to be added to the objective function. The term can be computed in the same way as the INCOST term. First, a variable called LABCOST under the VARIABLES section. Second, the equation LABORC must be defined in the EQUATIONS section. Finally, a new equation, shown below, must be written that can be included in the objective function.

LABORC.. LABCOST =E= WAGEIN * HIREIN

Step 5

Add the labor cost term to the objective function. The objective function will now read:

OBJFN.. Z =E= REVENUE-COST-LABCOST

Hiring Labor Out

Where possibilities exist for hiring in, possibilities for farmers with small holdings to hire out their excess labor will also surely exist. This aspect of the labor market can be modeled by reversing the signs on the steps followed above:

Step 1

Define a new variable called "HIREOUT" and add it to the list of variables. Note that it too must be added to the list of variables that are required to take on positive values.

Step 2

Define a new scalar called "WAGEOUT" and add it to the list of scalars. Assume that transaction costs involved in searching for a job, as well as its impact on social status, effectively discount the wage received to, say, 40 pesos per month. This would mean 480 pesos for the annual wage. The entry in the SCALAR section would then be:

WAGEOUT WAGES FOR HIRING OUT /480/

Step 3

Subtract the labor demanded by labor hiring out activity from the labor availability row. This means rewriting the labor equation as follows:

```
CONSTLA(S).. SUM(J, LABOR(S, J)*CROPS(J)) =L= AMTLABOR+ HIREIN-HIREOUT;
```

Step 4

Compute a labor revenue term to be added to the objective function. The term can be computed in the same way as the LABCOST term. First, it must be defined as a variable called LABREV under the VARIABLES section. Second, the equation LABORR must be defined in the EQUATIONS section. Finally, a new equation, shown below, must be written to compute a term that can be included in the objective function.

```
LABORR..      LABREV  =E=  WAGEOUT * HIREOUT
```

Step 5

Add the computed labor revenue term to the objective function. The objective function will now read:

```
OBJFN..          Z =E=  REVENUE-COST-LABCOST + LABREV
```

After the new model is running and the bugs from the SOLVE statement have been worked out, add statements to the report generator that report the labor market results. This requires the following additions:

(a) Add a set named HIRE with the elements LABORIN and LABOROUT

(b) Add a parameter called LABORH LABOR HIRING SUMMARY (If it is the last statement in the PARAMETER declaration, it must be followed by a semi-colon.)

(c) Add a series of statements that create the labor summary table:

```
LABORH ("LABORIN")      =    HIREIN.L;
LABORH ("LABOROUT")     =    HIREOUT.L;
```

(d) Add LABORH to the DISPLAY statement

COMPARISON OF MARKET RESULTS (PRIVATE PRICES)

The table below compares the results extracted from the output of the MYPRIVT4 and MYMARKT1 models reflecting the absence or presence of a private labor market. Both of these models contain the diminishing returns to corn weeding labor developed in Chapter 3.

Without a Labor Market (Private Prices)

```
---------------------------------------------------------------------------
REPORT ON MYPRIVT4 SOLUTION

----     141 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE
OBJECTIVE 7080.332

----     141 PARAMETER ACTREP        VARIABLES SUMMARY
                CORNNW      CORNL1      CORNL2      CORNL3    CORNMULE
GROSSREV      1350.000    2250.000    2475.000    2580.000    2250.000
INPUTCO        875.000     875.000     875.000     875.000     875.000
NETREV         475.000    1375.000    1600.000    1705.000    1375.000
LEVEL                        1.220
REDCOSTS       -77.198                -723.769   -1441.571         EPS

        +        BEANS     SORGHUM     PEANUTS
GROSSREV      2250.000    2015.000    6881.000
INPUTCO       1035.000     495.000    2015.000
NETREV        1215.000    1520.000    4866.000
LEVEL            0.059       1.879       0.509

----     141 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
            LAND        LABOR       MULES
JAN                                 4.212
FEB          0.059       0.016      4.212
MAR          0.059       0.021      4.212
APR          1.787       0.542      4.212
MAY          3.667       1.375      4.212
JUN          3.608       1.375      4.212
JUL          3.608       1.375      4.212
AUG          2.388       1.219      4.212
SEP                      0.220      4.212
OCT                      0.439      4.212
NOV                      0.685      4.212
DEC                                 4.212

----     141 PARAMETER COINMARG      SHADOW PRICES OF DOMESTIC RESOURCES
           LABOR
MAY     2430.000
JUN      312.672
JUL     1259.676
---------------------------------------------------------------------------
```

With a Labor Market (Private Prices)

```
---------------------------------------------------------------------------

REPORT ON MYMARKT1 SOLUTION
```

```
----     153 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE

OBJECTIVE 8890.290

----     153 PARAMETER ACTREP        VARIABLES SUMMARY
                CORNNW      CORNL1      CORNL2      CORNL3     CORNMULE
GROSSREV     1350.000    2250.000    2475.000    2580.000    2250.000
INPUTCO       875.000     875.000     875.000     875.000     875.000
NETREV        475.000    1375.000    1600.000    1705.000    1375.000
LEVEL                                   1.151
REDCOSTS     -877.676     -90.070                -7.394      -90.070

        +       BEANS     SORGHUM     PEANUTS
GROSSREV     2250.000    2015.000    6881.000
INPUTCO      1035.000     495.000    2015.000
NETREV       1215.000    1520.000    4866.000
LEVEL                       3.341       0.509
REDCOSTS      -57.451

----     153 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
            LAND        LABOR       MULES
JAN                                 5.763
FEB                                 5.763
MAR                                 5.763
APR        1.659        0.494       5.763
MAY        5.000        2.127       5.763
JUN        5.000        2.214       5.763
JUL        5.000        2.214       5.763
AUG        3.849        1.950       5.763
SEP                     0.207       5.763
OCT                     0.414       5.763
NOV                     1.036       5.763
DEC                                 5.763

----     153 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES
            LAND        LABOR
MAY     1272.451
JUN                   374.648
JUL                   225.352


----     154 PARAMETER LABORH        LABOR HIRING SUMMARY

         LABORIN
JAN        0.839
FEB        0.839
MAR        0.839
APR        0.839
MAY        0.839
JUN        0.839
JUL        0.839
AUG        0.839
SEP        0.839
OCT        0.839
NOV        0.839
DEC        0.839
```


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Labor was the only significant binding constraint in the without market case; it had a significant opportunity cost in May, June and July. After the addition of the labor market, its opportunity cost (shadow price) has been reduced considerably and now reflects the cost of hired labor. (Note that the 600 pesos representing the opportunity cost of hired labor are split between labor in June and labor in July.) The decline in labor scarcity results in a substantial increase in output, the emergence of land as a constraining factor of production, and a movement upward along the diminishing returns corn production function.

The figure for the monthly availability of annually hired labor, while capturing part of the "lumpiness" of assumption that labor will only work under a yearly contract, is still unsatisfactory in the sense that the LABOR HIRE decision variable should really be an integer. The present result is that .839 of a laborer could be hired annually; a mixed integer program of the sort discussed in Chapter 8 would have returned a 1.00 instead of .839 with the result that annual labor costs would have risen significantly. Question: Think about what making the labor hiring variable an integer would have done to monthly labor use? Would the higher annual labor costs increased or decreased labor use?

ALTERNATIVE ASSUMPTIONS ABOUT LABOR MARKETS

In the original Mayaland model, it was assumed that there was no market for labor. In MYMARKT1, this assumption was relaxed to some extent and it was assumed that labor could be hired annually. By implication, the skill level of hired labor was equal to the skills of the original family labor.

In agricultural sectors where there is a high degree of unemployment, or in situations where the model's specification distinguishes between different labor skills, it may be desirable to include a market for labor that can be hired in or hired out by the month. Changing MYMARKT1 to accommodate this interpretation of the existing market structure consists of (1) changing the wages scalar to reflect pesos per month and (2) adding a seasonal subscript to variables, HIREIN and HIREOUT. The correct statements for the monthly labor hiring scalars are shown below.

```
WAGEIN  WAGES OF LABOR HIRED IN (MONTHLY)      /50/
WAGEOUT WAGES OF LABOR HIRED OUT (MONTHLY)     /40/
```

An example of the addition of the seasonal subscript is shown in the labor cost equation given below:

```
LABCOST =E=SUM(S,.WAGEIN* HIREIN(S));
```

The same changes need to be made in other equations where the variables HIREIN and HIREOUT appear. Do not forget to change their values in the report generator as well.

The result of making labor a more divisible factor is to increase net revenues significantly. In part, the increase in revenues is generated by cost reductions that occur when labor is only hired in the month in which it is needed. In the present model, revenue is also generated by the off-farm employment of farmers during periods when they did not have remunerative employment on their own farms.

REPORT ON MYSOCIAL SOLUTION (MONTHLY LABOR HIRING ACTIVITIES)

---- 154 PARAMETER OBJFUN OBJECTIVE FUNCTION VALUE

OBJECTIVE 10085.289

---- 154 PARAMETER ACTREP VARIABLES SUMMARY

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
GROSSREV	1350.000	2250.000	2475.000	2580.000	2250.000
INPUTCO	875.000	875.000	875.000	875.000	875.000
NETREV	475.000	1375.000	1600.000	1705.000	1375.000
LEVEL				4.491	
RCOSTS	-1122.600	-261.600	-70.600		-261.600

+	BEANS	SORGHUM	PEANUTS
GROSSREV	2250.000	2015.000	6881.000
INPUTCO	1035.000	495.000	2015.000
NETREV	1215.000	1520.000	4866.000
LEVEL			0.509

---- 154 PARAMETER CONREP DOMESTIC RESOURCE USE SUMMARY

	LAND	LABOR	MULES
JAN			5.229
FEB			5.229
MAR			5.229
APR	5.000	1.396	5.229
MAY	5.000	4.944	5.229
JUN	5.000	4.898	5.229
JUL	5.000	1.179	5.229
AUG	0.509	0.280	5.229
SEP		1.078	5.229
OCT		1.797	5.229
NOV		0.234	5.229
DEC			5.229

---- 154 PARAMETER CONMARG SHADOW PRICES OF DOMESTIC RESOURCES

	LAND	LABOR
JAN		40.000
FEB		40.000
MAR		40.000
APR	111.900	50.000
MAY	1027.900	50.000
JUN	408.500	50.000
JUL		40.000
AUG		40.000
SEP		40.000
OCT		50.000
NOV		40.000

```
DEC                    40.000

----     154 PARAMETER LABORH        LABOR HIRING SUMMARY
         LABORIN    LABOROUT

JAN                     1.375      (All family labor hired out)
FEB                     1.375      (All family labor hired out)
MAR                     1.375      (All family labor hired out)
APR        0.021                   (Family labor used, additional labor hired in)
MAY        3.569                   (Family labor used, additional labor hired in)
JUN        3.523                   (Family labor used, additional labor hired in)
JUL                     0.196      (Some family labor used, remainder hired out)
AUG                     1.095      (Some family labor used, remainder hired out)
SEP                     0.297      (Some family labor used, remainder hired out)
OCT        0.422                   (Family labor used, additional labor hired in)
NOV                     1.141      (Some family labor used, remainder hired out)
DEC                     1.375      (Some family labor used, remainder hired out)
-------------------------------------------------------------------------------
```

As the comparison with the MYPRIVT4 "with labor market" solution given previously indicates, the shadow prices of labor differ significantly depending on the assumptions made about the divisibility of labor supplies. In both cases, the shadow prices reflect the market prices of labor. However, in the annual labor models, the annual wage of 600 pesos is inputed to two months, June and July. In the monthly market, the monthly wage is inputed in each month depending upon whether labor is being hired in or hired out. The bottom line: simply adding a factor market is not the end of the story. Care must be taken to get the institutional characteristics of the market right. This often means substantial disaggregation of tasks. For example, in many agricultural situations, family members may perform management functions, permanent hired labor may be employed to operate machines, and casual labor hired by the month or the day will be used for picking and harvesting.

ADDING A LABOR MARKET AT SOCIAL PRICES

As it stands, MYMARKT1, derived from MYPRIVT4, has no parallel social model. The focus in this exercise was to see how a market might be added and how it affects the choice of technique when diminishing returns to the factor are present.

Extending the social prices equations shown in the MYPOLICY model to a model called MYMARKT2 is straightforward. It can be done in one of two ways: (1) add the extensions that simulate a labor market as developed in MYMARKT1 to the MYPOLICY model or (2) add the social model contained in to MYMARKT1. The latter is probably the simplest and has been reported in the model described below.

As the social prices section of MYPOLICY shows, adding a social prices section is largely a matter of adding an "S" to the names of scalars, parameters and equations that are affected by the computation of social revenues. (The model's SOLVE statement must also be repeated.) For example, the scalars become WAGEINS and WAGEOUTS. The new definitions for computing labor cost and labor revenue become LABORCS and LABORREVS. (The latter must, of course, be

added to the definition statement that indicates the equations that are to be included in the social prices model.) The social prices solution is then generated by a second SOLVE statement.

Similar changes must be made in the report generator. The new SET element becomes HIRES and the new table (parameter) definition becomes LABORHS. Variables remain the same because the definitions of activities are not changed from the private prices model.

The values that should be given to the social prices data set are the subject of lengthy discussion in Monke and Pearson (Chapter 7, "The Social Valuation of Factors"). For the purpose of the comparisons shown below, 50 pesos per month (600 per year) are used for WAGEINS and 40 (480 per year) for WAGEOUTS. The implication of using these values is that the market for annual labor is functioning reasonably well and therefore private wages can be taken as a measure of labor's social marginal product. Alternative assumptions can easily be incorporate.

A DETAILED LABOR MARKET MODEL

The partial model shown below contains the details of the extensions required to simulate a labor market.

```
SCALARS

      AMTLAND  AMOUNT OF LAND AVAILABLE (HECTARES)       /5/
      AMTLAB   AMOUNT OF LABOR AVAILABLE (BY MONTH)      /1.375/
      AMTMULE  MULE POWER AVAILABLE (MONTHS)             /10/
      MARKET   MARKET CONSTRAINT ON PEANUTS(KGS)         /500/
      WAGEIN   WAGES OF LABOR HIRED IN (MONTHLY)         /50/
      WAGEOUT  WAGES OF LABOR HIRED OUT (MONTHLY)        /40/

   Note that wages have been changed from an annual value to a monthly wage
rate.

VARIABLES
             REVENUE    GROSS REVENUE FROM CROP ACTIVITIES
             COST       TRADABLE INPUT COSTS
             LABCOST    COST OF HIRING IN LABOR
             LABREV     REVENUE FROM HIRING OUT
             CROPS      LEVELS OF THE CROP ACTIVITIES
             HIREIN     LABOR HIRED IN
             HIREOUT    LABOR HIRED OUT
             Z          TOTAL VALUE ADDED FROM CROP ACTIVITIES
                       POSITIVE VARIABLES CROPS, HIREIN, HIREOUT

EQUATIONS

  REV            COMPUTATION OF GROSS REVENUES
  INCOST         COMPUTATION OF TRADABLE INPUT COSTS
  LABORC         COMPUTATION OF LABOR COST
  LABORR         COMPUTATION OF LABOR REVENUE
  CONSTL(S)      LAND CONSTRAINT
  CONSTLA(S)     LABOR CONSTRAINT
  CONSTMUL       MULE CONSTRAINT
  MARKT          MARKET CONSTRAINT ON PEANUTS
```

```
  OBJFN          OBJECTIVE FUNCTION;
```

Seasonal subscripts, i.e., S, have been added to the labor market computations in the equations cited below.

```
  REV..       REVENUE =E= SUM(J,YIELDS(J)*PROUTP(J)*CROPS(J));
  INCOST..    COST    =E= SUM((I, J), IN(I,J)*PRINP(I)*CROPS(J));
  LABORC..    LABCOST =E= SUM(S, WAGEIN*HIREIN(S));
  LABORR..    LABREV  =E= SUM(S, WAGEOUT*HIREOUT(S));
  CONSTL(S)..     SUM(J, LAND(S,J)*CROPS(J)) =L=AMTLAND;
  CONSTLA(S)..    SUM(J, LABOR(S,J)*CROPS(J)) =L=AMTLAB+HIREIN(S)-HIREOUT(S);
  CONSTMUL..      SUM(J, MULES(J)*CROPS(J)) =L=AMTMULE;
  MARKT..         SUM(J, MP(J)* CROPS(J)) =L=MARKET;
  OBJFN..         Z =E= REVENUE-COST-LABCOST+ LABREV;

MODEL MYMARKT2/ALL/;
SOLVE MYMARKT2 USING LP MAXIMIZING Z;

$TITLE                  REPORT ON MYMARKT2 SOLUTION

     SETS      AREP     /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
               CREP     /LAND, LABOR, MULES/
               OBJ      /OBJECTIVE/
               HIRE     /LABORIN, LABOROUT/

     PARAMETERS     ACTREP    VARIABLES SUMMARY
                    CONREP    DOMESTIC RESOURCE USE SUMMARY
                    CONMARG   SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUN    OBJECTIVE FUNCTION VALUE
                    LABORH    LABOR HIRING SUMMARY;

     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =  CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")          =      Z.L;

     CONREP(S,"LAND")             =      SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")            =      SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")            =      SUM(J, CROPS.L(J)*MULES(J));

     CONMARG(S,"LAND")            =      CONSTL.M(S);
     CONMARG(S,"LABOR")           =      CONSTLA.M(S);
     CONMARG(S,"MULES")           =      CONSTMUL.M;

     LABORH(S,"LABORIN")            =      HIREIN.L(S);
     LABORH(S,"LABOROUT")           =      HIREOUT.L(S);

  DISPLAY OBJFUN, ACTREP, CONREP, CONMARG, LABORH;

*-----------------------------------------------------------------------
$TITLE          OPTIMAL SOLUTION WITH SOCIAL PRICES

SCALARS         WAGEINS     SOCIAL WAGES OF HIRED IN LABOR       /50/
                WAGEOUTS    SOCIAL WAGES OF HIRED OUT LABOR      /40/
```

```
PARAMETERS

  SOOUTP(J)   PRICES OF CROP OUTPUT (PESOS PER KG)
              /CORNNW 2.5, CORNL1 2.5, CORNL2 2.5, CORNL3 2.5, CORNMULE 2.5,
               BEANS  12, SORGHUM 3.2, PEANUTS 5/

  SOINP(I)    PRICES OF INPUTS (PESOS PER KG)
            /FERT 28, PEST 450,CORNSEED 4, BEANSEED 14, SORGSEED 4, PEASEED 7/

EQUATIONS
              REVSO          REVENUE COMPUTATION AT SOCIAL PRICES
              INCOSTSO       COST COMPUTATION AT SOCIAL PRICES
              LABORCS         LABOR COST COMPUTATION
              LABORRS         LABOR REVENUE COMPUTATION;

         REVSO..        REVENUE =E= SUM(J, YIELDS(J)*SOOUTP(J)*CROPS(J));
         INCOSTSO..     COST    =E= SUM((I,J), IN(I,J)*SOINP(I)*CROPS(J));
         LABORCS..      LABCOST =E= SUM(S, WAGEINS*HIREIN(S));
         LABORRS..      LABREV  =E= SUM(S, WAGEOUTS*HIREOUT(S));

MODEL MYMARKT3 /REVSO, INCOSTSO, LABORCS, LABORR, CONSTL, CONSTLA,
                CONSTMUL, MARKT, OBJFN/;
SOLVE MYMARKT3 USING LP MAXIMIZING Z;

$TITLE                    REPORT ON MYSOCIAL SOLUTION

     SETS      AREPS      /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
               CREPS      /LAND, LABOR, MULES/
               OBJS       /OBJECTIVE/
               HIRES      /LABORIN, LABOROUT/

     PARAMETERS     ACTREPS     VARIABLES SUMMARY
                    CONREPS     DOMESTIC RESOURCE USE SUMMARY
                    CONMARGS    SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUNS     OBJECTIVE FUNCTION VALUE
                    LABORHS     HIRED LABOR SUMMARY;

   ACTREPS("GROSSREV", J)    =   YIELDS(J)*SOOUTP(J);
   ACTREPS("INPUTCO", J)     =  SUM(I, IN(I, J)*SOINP(I));
   ACTREPS("NETREV", J)      =   ACTREPS ("GROSSREV", J)-ACTREPS("INPUTCO", J);
   ACTREPS("LEVEL",J)        =  CROPS.L(J);
   ACTREPS("REDCOSTS",J)     =   CROPS.M(J);

   OBJFUNS("OBJECTIVE")          =      Z.L;

   CONREPS(S,"LAND")            =      SUM(J, CROPS.L(J)*LAND(S,J));
   CONREPS(S,"LABOR")           =      SUM(J, CROPS.L(J)*LABOR(S,J));
   CONREPS(S,"MULES")           =      SUM(J, CROPS.L(J)*MULES(J));


   CONMARGS(S,"LAND")           =      CONSTL.M(S);
   CONMARGS(S,"LABOR")          =      CONSTLA.M(S);
   CONMARGS(S,"MULES")          =      CONSTMUL.M;

   LABORHS(S,"LABORIN")           =      HIREIN.L(S);
   LABORHS(S,"LABOROUT")          =      HIREOUT.L(S);

  DISPLAY OBJFUNS, ACTREPS, CONREPS, CONMARGS, LABORHS;
```

*----------

As expected from the earlier computation, the output from the MYMARKT2 model at social prices differes significantly from private prices version shown in the previous output panel. Beans become the dominant crop and even peanuts no longer have a comparative advantage.

REPORT ON MYMARKT2 SOLUTION AT SOCIAL PRICES

```
----     219 PARAMETER OBJFUNS        OBJECTIVE FUNCTION VALUE

OBJECTIVE 13144.750

----     219 PARAMETER ACTREPS        VARIABLES SUMMARY
                CORNNW      CORNL1       CORNL2      CORNL3    CORNMULE
GROSSREV     1125.000    1875.000     2062.500    2150.000    1875.000
INPUTCO      1592.500    1592.500     1592.500    1592.500    1592.500
NETREV       -467.500     282.500      470.000     557.500     282.500
RECOSTS     -2419.800   -1704.800    -1548.300   -1491.800   -1704.800

       +        BEANS     SORGHUM      PEANUTS
GROSSREV     4500.000    2480.000     4915.000
INPUTCO      1932.500     900.000     2895.000
NETREV       2567.500    1580.000     2020.000
LEVEL           5.000

----     219 PARAMETER CONREPS        DOMESTIC RESOURCE USE SUMMARY
            LAND        LABOR        MULES
JAN                                  6.350
FEB        5.000        1.350        6.350
MAR        5.000        1.800        6.350
APR        5.000        2.500        6.350
MAY        5.000        2.500        6.350
JUN                                  6.350
JUL                                  6.350
AUG                                  6.350
SEP                                  6.350
OCT                                  6.350
NOV                                  6.350
DEC                                  6.350

----     219 PARAMETER CONMARGS       SHADOW PRICES OF DOMESTIC RESOURCES
            LAND        LABOR
JAN                    40.000
FEB      581.500       40.000
MAR                    50.000
APR      407.200       50.000
MAY     1500.000       50.000
JUN                    40.000
JUL                    40.000
AUG                    40.000
SEP                    40.000
OCT                    40.000
NOV                    40.000
DEC                    40.000


----     219 PARAMETER LABORHS        HIRED LABOR SUMMARY
```

	LABORIN	LABOROUT
JAN		1.375
FEB		0.025
MAR	0.425	
APR	1.125	
MAY	1.125	
JUN		1.375
JUL		1.375
AUG		1.375
SEP		1.375
OCT		1.375
NOV		1.375
DEC		1.375

CHAPTER 7: COMPUTING PAMS'S AND DRC'S WITH GAMS

It is clear from the Monke-Pearson text that a major impetus to the development of the policy analysis matrix (PAM) approach was the need for tools that could be explained and grasp by policy makers with very little training in economics. Coefficients are derived from simple budgets, a procedure that is also relatively easy to explain and implement. However, as noted earlier, there are inherent difficulties with such an approach when large numbers of fixed factors are present. In such situations, the optimal combination of resources ordinarily requires the production of more than one crop.

Chapter 6 added markets for previously fixed factors such as labor to the model. Treating these factors as variable costs opens the way for more direct comparisons between PAM's created with budgeting tools and PAM's created by l.p. models. In the market versions of the l.p. model, capital and labor still have shadow prices, but their values are now determined by considerations outside the model. For example, the scalars WAGEINS and SORATE are determined by reference to observed, economy-wide data rather than being generated internally by the model.

The only remaining fixed factor is land. However, because its seasonal dimension has been included in the model, the role of land differs in an optimization model from its role in budgeting exercises. Complex cropping systems in which a variety of crops can be grown in different time periods may lead to binding land constraints in more than one month. The resulting optimal solution is then likely to contain several crops in which the farming system has a comparative advantage.

The policy analysis matrix does not prescribe how the coefficients in the PAM are to be calculated. In the exercises that follow, the optimizing capability of GAMS is combined with its report writer to develop a series of individual commodity PAMS that can be used for policy discussion in situations where an exposition of the linear programming framework is considered too technical for policy makers to follow. Several examples are then used to show the impact of factor market assumptions on PAM calculations.

CREATING PAMS ON GAMS: SEASONAL LABOR MARKETS

The first step in producing a PAM generator is to copy MYMARKT2 to MYPAM. MYPAM should be set up so that it (1) contains models that produce solutions at both private and social prices, and (2) has markets for labor and capital that can be given different interpretations.

In the exercises that follow, quantities for capital will be generated by the need for working capital to cover the cost of purchased inputs. The appropriate values can be generated for the private prices model with the use of the following GAMS assignment statement. (It will need to be repeated for the social prices model as well. Note that the use of different prices for inputs will lead to a different value for capital required even when the interest rate is the same... a potentially misleading impression about the functioning of the capital market.)

The assignment statement that computes the amount of working capital needed is given below:

```
PARAMETER       CAPPRI       WORKING CAPITAL TO COVER VARIABLE COSTS;
CAPPRI(J)    =   SUM(I, PRINP(I)*IN(I,J));
-----------------------------------------------------------------------
```

The second step is (1) to add equations to the model to describe the relationship between the capital requirements ("demands") of various crops and capital availability, and (2) to add activities to simulate a capital market that "supplies" capital. Scalars that simulate private and social interest rates must also be added and the objective function changed to include the cost of capital. Examples of the necessary changes for the private prices model are given below. The interest rate definition and capital requirement computation will have to be repeated for the social model:

```
------- ---------------------------------------------------------------
SCALAR              PRRATE        PRIVATE INTEREST RATE     /.10/

VARIABLE            BORROW        CAPITAL BORROWING ACTIVITY
                    CAPCOST       COST OF BORROWING CAPITAL

EQUATIONS      CONSTCAP     CAPITAL CONSTRAINT
               CAPC         COMPUTATION OF CAPITAL COST;

       CONSTCAP..      SUM(J, CAPPRI(J)*CROPS(J)) =L=BORROW;
       CAPC..          CAPCOST =E= BOPROW*PRRATE;

       OBJFN..       Z = E=  REVENUE-COST-LABCOST+LABREV-CAPCOST;
-----------------------------------------------------------------------
```

The third step in developing a GAMS PAM generator is (1) to add capital to the report generator and (2) to use the report writer to access the output from the optimal solution. It is in many ways similar to the calculations that have already been done in the policy chapter when various trade-related policy ratios were calculated. However, the generator shown below organizes the PAM in what has come to be a conventional format for PAM presentation. The statements refer to PAM's for CORNL3 and BEANS. Other crops can be obtained by (1) copying the initial CORNL3 statements, and (2) using the "find and replace" capabilities of the text editor to change the name of the crop.

The report generator below has been modified to incorporate the capital variable.

```
-----------------------------------------------------------------------

$TITLE                    REPORT ON MYMARKT SOLUTION

     SETS      AREP      /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
               CREP      /LAND, LABOR, CAPITAL /
               OBJ       /OBJECTIVE/
               HIRE      /LABORIN, LABOROUT, BORROWING/

     PARAMETERS      ACTREP     VARIABLES SUMMARY
                     CONREP     DOMESTIC RESOURCE USE SUMMARY
                     CONMARG    SHADOW PRICES OF DOMESTIC RESOURCES
                     OBJFUN     OBJECTIVE FUNCTION VALUE
                     PFACTSUM    FACTOR MARKET SUMMARY;

     ACTREP("GROSSREV", J)    =    YIELDS(J)*PROUTP(J);
```

```
ACTREP("INPUTCO", J)      =  SUM(I, IN(I, J)*PRINP(I));
ACTREP("NETREV", J)       =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
ACTREP("LEVEL",J)         =  CROPS.L(J);
ACTREP("REDCOSTS",J)      =   CROPS.M(J);

OBJFUN("OBJECTIVE")          =      Z.L;

CONREP(S,"LAND")             =      SUM(J, CROPS.L(J)*LAND(S,J));
CONREP(S,"LABOR")            =      SUM(J, CROPS.L(J)*LABOR(S,J));
CONREP(S,"CAPITAL")          =      SUM(J, CROPS.L(J)*CAPPRI(J));

CONMARG(S,"LAND")            =      CONSTL.M(S);
CONMARG(S,"LABOR")           =      CONSTLA.M(S);
CONMARG(S,"CAPITAL")         =      CONSTCAP.M;

PFACTSUM(S,"LABORIN")           =      HIREIN.L(S);
PFACTSUM(S,"LABOROUT")          =      HIREOUT.L(S);
PFACTSUM(S,"BORROWING")            =   BORROW.L;

DISPLAY OBJFUN, ACTREP, CONREP, CONMARG, PFACTSUM;
```

*----------

The code shown below is somewhat intimidating at first sight. However, as noted above, by using the "Copy" and "Find and Replace" facilities of the text editor, individual commodity PAMS can be created for all crops in a matter of a few minutes. The formulas themselves simply follow the definitions of the PAM given in Monke and Pearson.

```
$TITLE        COMMODITY PAMS

      SET   PAM  /PRIVATE, SOCIAL, PROFIT, DIFFER/

      PARAMETERS CL3PAM, BEANSPAM;


CL3PAM("PRIVATE", "GROSSREV") = ACTREP("GROSSREV", "CORNL3");
CL3PAM("PRIVATE", "INPUTCO")  = ACTREP("INPUTCO", "CORNL3");
CL3PAM("PRIVATE", "LAND")     = SUM(S, CONMARG(S, "LAND")*LAND(S,"CORNL3"));
CL3PAM("PRIVATE", "LABOR")    =  SUM(S, CONMARG(S, "LABOR")*LABOR(S,"CORNL3"));
CL3PAM("PRIVATE", "CAPITAL") =  CONSTCAP.M*CAPPRI("CORNL3");
CL3PAM("PRIVATE", "PROFIT")  =      CL3PAM("PRIVATE","GROSSREV")
                                   -CL3PAM("PRIVATE", "INPUTCO")
                                   -CL3PAM("PRIVATE", "LABOR")
                                   -CL3PAM("PRIVATE", "CAPITAL")
                                   -CL3PAM("PRIVATE", "LAND");


CL3PAM("SOCIAL", "GROSSREV") = ACTREPS("GROSSREV", "CORNL3");
CL3PAM("SOCIAL", "INPUTCO")  = ACTREPS("INPUTCO", "CORNL3");
CL3PAM("SOCIAL", "LAND")   = SUM(S, CONMARGS(S,"LAND")*LAND(S,"CORNL3"));
CL3PAM("SOCIAL", "LABOR") =  SUM(S, CONMARGS(S, "LABOR")* LABOR(S,"CORNL3"));
CL3PAM("SOCIAL", "CAPITAL")  = CONSTCAPS.M*CAPSOC("CORNL3");
CL3PAM("SOCIAL", "PROFIT")  =     CL3PAM("SOCIAL","GROSSREV")
                                  -CL3PAM("SOCIAL", "INPUTCO")
                                  -CL3PAM("SOCIAL", "LABOR")
                                  -CL3PAM("SOCIAL", "CAPITAL")
                                  -CL3PAM("SOCIAL", "LAND");
```

```
CL3PAM("DIFFER", "GROSSREV") =   CL3PAM("PRIVATE", "GROSSREV")
                                  -CL3PAM("SOCIAL", "GROSSREV");

CL3PAM("DIFFER", "INPUTCO")  =   CL3PAM("PRIVATE", "INPUTCO")
                                   -CL3PAM("SOCIAL", "INPUTCO");

CL3PAM("DIFFER", "LABOR")    =   CL3PAM("PRIVATE", "LABOR")
                                   -CL3PAM("SOCIAL", "LABOR");

CL3PAM("DIFFER", "CAPITAL")  =   CL3PAM("PRIVATE", "CAPITAL")
                                   -CL3PAM("SOCIAL", "CAPITAL");

CL3PAM("DIFFER", "LAND")     =   CL3PAM("PRIVATE", "LAND")
                                 -CL3PAM("SOCIAL", "LAND");

CL3PAM("DIFFER", "PROFIT")   =   CL3PAM("PRIVATE", "PROFIT")
                                   -CL3PAM("SOCIAL", "PROFIT");


BEANSPAM("PRIVATE", "GROSSREV") = ACTREP("GROSSREV", "BEANS");
BEANSPAM("PRIVATE", "INPUTCO")  = ACTREP("INPUTCO", "BEANS");
BEANSPAM("PRIVATE", "LAND")     = SUM(S, CONMARG(S, "LAND")*LAND(S,"BEANS"));
BEANSPAM("PRIVATE", "LABOR")    = SUM(S, CONMARG(S,"LABOR")*LABOR(S,"BEANS"));
BEANSPAM("PRIVATE", "CAPITAL")  = CONSTCAP.M*CAPPRI("BEANS");
BEANSPAM("PRIVATE", "PROFIT")   =   BEANSPAM("PRIVATE","GROSSREV")
                                  -BEANSPAM("PRIVATE", "INPUTCO")
                                  -BEANSPAM("PRIVATE", "LABOR")
                                  -BEANSPAM("PRIVATE", "CAPITAL")
                                  -BEANSPAM("PRIVATE", "LAND");


BEANSPAM("SOCIAL", "GROSSREV") =   ACTREPS("GROSSREV", "BEANS");
BEANSPAM("SOCIAL", "INPUTCO")  =   ACTREPS("INPUTCO", "BEANS");
BEANSPAM("SOCIAL", "LAND")     =   SUM(S,CONMARGS(S,"LAND")*LAND(S,"BEANS"));
BEANSPAM("SOCIAL", "LABOR")    = SUM(S,CONMARGS(S,"LABOR")*LABOR(S,"BEANS"));
BEANSPAM("SOCIAL", "CAPITAL")  =   CONSTCAPS.M*CAPSOC("BEANS");
BEANSPAM("SOCIAL", "PROFIT")   =     BEANSPAM("SOCIAL","GROSSREV")
                                   -BEANSPAM("SOCIAL", "INPUTCO")
                                   -BEANSPAM("SOCIAL", "LABOR")
                                   -BEANSPAM("SOCIAL", "CAPITAL")
                                   -BEANSPAM("SOCIAL", "LAND");

BEANSPAM("DIFFER", "GROSSREV") =   BEANSPAM("PRIVATE", "GROSSREV")
                                  -BEANSPAM("SOCIAL", "GROSSREV");

BEANSPAM("DIFFER", "INPUTCO")  =   BEANSPAM("PRIVATE", "INPUTCO")
                                   -BEANSPAM("SOCIAL", "INPUTCO");

BEANSPAM("DIFFER", "LABOR")    =   BEANSPAM("PRIVATE", "LABOR")
                                   -BEANSPAM("SOCIAL", "LABOR");

BEANSPAM("DIFFER", "CAPITAL")  =   BEANSPAM("PRIVATE", "CAPITAL")
                                   -BEANSPAM("SOCIAL", "CAPITAL");

BEANSPAM("DIFFER", "LAND")     =   BEANSPAM("PRIVATE", "LAND")
                                 -BEANSPAM("SOCIAL", "LAND");
```

```
BEANSPAM("DIFFER", "PROFIT")  =    BEANSPAM("PRIVATE", "PROFIT")
                                   -BEANSPAM("SOCIAL", "PROFIT");

$TITLE          PAMS FOR INDIVIDUAL COMMODITIES
DISPLAY CL3PAM, BEANSPAM;
```

Individual Commodity PAMS: The Results

The table below shows the results of the PAM generator shown above under the assumption that farmers have access, without limit, to seasonal (monthly) labor markets and capital markets where capital is modeled with a single constraint.

Several points about these two commodities are immediately evident.

(1) The individual crop protection ratios computed in the policy chapter and repeated below are verified. For example, in the case of CORNL3, the positive difference between the gross revenue of corn shows that farmers have received policy incentives to grow CORNL3, i.e., the NPC is positive. Moreover, while positive differences in gross revenues indicate a subsidy, subsidies in input costs are signaled by negative differences. When negative input cost differences are subtracted from positive gross revenues, the results are increases in the subsidy to value added--as indicated by a large EPC.

Private profits for corn are zero. This is the PAM equivalent of the l.p. result that the "reduced costs" are zero. (There would be no penalty if a unit of corn was forced into the optimal basis.) This result will be obtained for any commodity that is in the l.p. model's optimal solution. The entire value added (GROSSREV - INPUTCO) has been exhausted by the "variable" costs of domestic LABOR and CAPITAL and the imputed value of the fixed factor, LAND. (Notice that in the zero profit case, the value of land has been determined by the crop shown to have a comparative advantage over other crops, not the next best alternative.)

The results of the BEANSPAM are somewhat different. The negative number for GROSSREV indicates that farmers growing beans are being taxed, i.e., that private output revenues are substantially below world market prices. However, like corn, bean farmers are the beneficiaries of subsidized inputs. Indeed, they receive a greater per acre subsidy on bean inputs than they do on corn inputs.

At private prices, beans show a negative profit and are not in the optimal solution. At social prices, however, the improvement of relative bean prices has been such that they have replaced corn in the optimal solution and show zero social profits, i.e., they have a DRC of 1.00.

(2) The interpretation of the PAM's generated by the programming model is, in many ways, the same as if they had been computed from budgets. One obvious difference arises in the case of capital where a difference between private and social costs arises because the amount of working capital changes as the price of inputs change. That is, because of the subsidies on inputs, less capital is required to finance the various enterprises and, even where the costs of capital are assumed to be the same under private and social prices, the PAM gives the impression that policy interventions or market imperfections exist.

What is more significant as far as interpretation goes, however, is the difference between private and social land costs. That amount of land required to produce one hectare remains, of course, the same. But because of the model's response to the change in relative prices that has accompanied the movement from private to social prices, the shadow prices for land have also changed. The difference between private and social land costs do not, therefore, reflect imperfections in the land market but merely the response of that market to changes in the prices of inputs and outputs.

The labor market continues to reflect the assumptions of budgeting solutions. If there is no difference between private and social wages, there will be no difference between private and social labor costs. In the presence of a monthly labor market, the fact that cropping patterns change has no effect on the shadow price of labor or on the amount of labor required to grow one hectare of the crop. (In a subsequent example where the labor market is modeled differently, and where more than one crop determines the shadow price of labor, it will become apparent that differences between the two estimates may emerge as a result of the adjustments that are taking place in the model as comparative advantage is determined under two sets of relative prices.)

---- 627 PARAMETER CL3PAM

	GROSSREV	INPUTCO	LAND	LABOR	CAPITAL	PROFIT
PRIVATE	2580.000	875.000	1456.500	161.000	87.500	0.000
SOCIAL	2150.000	1592.500	2292.750	161.000	159.250	-2055.500
DIFFER	430.000	-717.500	-836.250	0.000	-71.750	2055.500

---- 627 PARAMETER BEANSPAM

	GROSSREV	INPUTCO	LAND	LABOR	CAPITAL	PROFIT
PRIVATE	2250.000	1035.000	1456.500	81.500	103.500	-426.500
SOCIAL	4500.000	1932.500	2292.750	81.500	193.250	0.000
DIFFER	-2250.000	-897.500	-836.250	0.000	-89.750	-426.500

Summary Trade Coefficients

The table below shows the various trade coefficients computed from the individual commodity PAMs. Most have been presented previously but, with the LAND marginals (shadow prices) from the optimization results available, it is now also possible to compute the private profit coefficients (PPC) and domestic resource cost (DRC) coefficients for each enterprise. (PPC is the ratio of domestic resources valued at private prices to valued-added at private prices; DRC is the ratio of domestic resources valued at social prices to value-added at social prices.)

As expected, all coefficients for commodities not in the optimal solution are greater than one indicating that the cost of resources (land, labor and capital), when valued at their private or social shadow prices, exceed value added when measured at its opportunity cost.

(The unfavorable PFC's and DRC's of low yielding corn activities show how important yields are in the determining comparative advantage.)

---- 627 PARAMETER POLICY SUMMARY OF CROPWISE PROTECTION COEFFICIENTS

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS
NOPC	1.200	1.200	1.200	1.200	1.200	0.500
NIPC	0.549	0.549	0.549	0.549	0.549	0.536
EPC	-1.016	4.867	3.404	3.058	4.867	0.473
PPC	3.358	1.189	1.048	1.000	1.169	1.344
DRC	-5.367	8.983	5.474	4.676	8.983	1.000

+	SORGHUM	PEANUTS
NOPC	0.812	1.400
NIPC	0.550	0.696
EPC	0.962	2.409
PPC	1.000	0.368
DRC	1.569	1.344

CREATING PAMS WITH GAMS: ANNUAL LABOR MARKETS

Because of the assumption in the previous exercise that seasonal labor and capital markets existed, the impact of the shadow prices of labor on the optimal enterprise combination was muted. As a result, only a single commodity, determined by the shadow price of the factor for which there was not market (land) appeared in the optimal private and social solutions. It was the determining factor in comparative advantage.

As noted previously, somewhat different results would have been obtained using a budgeting approach because budgets do not allow for changes in enterprise combinations and factor shadow prices as a result of changes in relative output prices. Aside from this "supply response" factor that would be a part of any policy reform that moved from private prices to social prices, the computations would have been similar.

However, a slightly different assumption about labor markets, namely the assumption that labor could only be hired annually, produces rather different results. Changing the model involves a few simple steps:

(1) Change the wage scalars from the cost of hiring an individual for one month to the cost of hiring one man month annually.

(2) Remove the seasonal ("S") subscript's from the HIREIN and HIREOUT variables.

(3) Change the first stage of the report generator to reflect the change in the seasonal dimension of the variables.

(4) Change the PAM generator so that the labor cost line in the table no longer sums over the seasons but simply multiples the annual wage times the number of man months hired on a fixed annual contract.

The PAM's shown below for CORNL3, BEANS and SORGHUM were computed under the assumption that the labor market contains "imperfections" that limit hiring to annual labor. (Note: the effective monthly wage rate remained the same; the change in assumptions has to do with the way in which labor can be hired.)

---- 627 PARAMETER CL3PAM

	GROSSREV	INPUTCO	LAND	LABOR	CAPITAL	PROFIT
PRIVATE	2580.000	875.000	1216.658	400.842	87.500	0.000
SOCIAL	2150.000	1592.500	1514.500	162.000	159.250	-1278.000
DIFFER	430.000	-717.500	-297.842	238.840	-71.750	1278.000

---- 627 PARAMETER BEANSPAM

	GROSSREV	INPUTCO	LAND	LABOR	CAPITAL	PROFIT
PRIVATE	2250.000	1035.000	1216.658		103.500	-105.158
SOCIAL	4500.000	1932.500	2074.250	300.000	193.250	0.000
DIFFER	-2250.000	-897.500	-857.592	-300.000	-89.750	-105.158

---- 627 PARAMETER SORGPAM

	GROSSREV	INPUTCO	LAND	LABOR	CAPITAL	PROFIT
PRIVATE	2015.000	495.000	1216.658	253.842	49.500	0.000
SOCIAL	2480.000	900.000	2074.250		90.000	-584.250
DIFFER	-465.000	-405.000	-857.592	253.842	-40.500	584.250

A substantial number of PAM elements have, of course, remained the same. As noted previously, the interpretation of the columns showing distortions introduced through trade policies are unchanged. What has changed with the assumption of "imperfections" in the labor market introduced through hiring practices are the values for the shadow price of labor and, by the adding-up theorem, the shadow prices of other fixed factors. (The cost of capital changes because the change in the cropping pattern produces a new set of capital demands.) Values for the labor coefficients were computed by multiplying the seasonal shadow prices of labor times the monthly labor use. Annual hired labor is, however, a "lumpy" input; it is obviously possible in such cases for a crop to use labor in a month in which labor is generally in surplus. The resulting zero labor cost, when multiplied by the technical coefficient that describes labor use, still equal produces zero. This phenomenon accounts for the lack of labor costs in the private profit calculation for beans and the social profit calculation for sorghum.

The model hires 2.3 man months annually at private prices and 2.5 man months at social prices. An obvious extension of this exercise would be to model labor hiring as an integer variable, i.e., to insist that labor cannot be hired in fractions of a month. This further limits the flexibility of the labor market and introduces additional sources of divergence between private and social labor costs.

Summary Coefficients

The table below provides a summary of all of the PAM calculations. It reflects the requirements of equilibrium solutions in l.p. models. For example, at social prices, three crops (beans, sorghum and peanuts) display a DRC of 1 indicating that they are all in the optimal solution. The interesting divergence from this rule occurs in the case of peanuts under private prices. It has a DRC of < 1 because the penalty imposed by the binding marketing constraint has not been included as a cost. (The marketing constraint is not binding in the social prices solution although peanuts are in the optimal basis.)

---- 627 PARAMETER POLICY SUMMARY OF CROPWISE PROTECTION COEFFICIENTS

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS
NOPC	1.200	1.200	1.200	1.200	1.200	0.500
NIPC	0.549	0.549	0.549	0.549	0.549	0.536
EPC	-1.016	4.867	3.404	3.058	4.867	0.473
PPC	2.908	1.076	1.004	1.000	1.076	1.087
DRC	-3.927	6.498	3.906	3.293	6.498	1.000

627 PARAMETER POLICY SUMMARY OF CROPWISE PROTECTION COEFFICIENTS

+	SORGHUM	PEANUTS
NOPC	0.812	1.400
NIPC	0.550	0.696
EPC	0.962	2.409
PPC	1.000	0.345
DRC	1.000	1.000

The impact of assuming that labor markets do not function perfectly would become even more pronounced if the MAYALAND model introduced in Chapter 2, in which labor was entirely fixed, was the basis of the PAM calculations.

In the usual budgeting approach, imperfections in capital and labor markets are handled by adjusting private prices to reflect social opportunity costs. But it is clear from the foregoing exercise that if various types of quantity restrictions also apply, they too will be reflected in the PAM's computed with optimization models.