AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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Batch 80
ARDA

1. SUBJECT CLASSIFICATION	A. PRIMARY Food production and nutrition	AA00-0000-0000
	B. SECONDARY General	

2. TITLE AND SUBTITLE
Agricultural sector planning; Part IV: The Korean grain subsector models

3. AUTHOR(S)
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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1978	~~108p.~~ 109p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Mich.State

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(Complete work: Agricultural sector planning, a general system simulation approach, 246p.:PN-AAF-359)

9. ABSTRACT

Part IV of the Agricultural Sector Planning Report conveys a general understanding of the overall concept of the Grain Management Program (GMP) model, including the felt need for and objectives of the model's design; and what the model can do to assist researchers and decision makers in Korea. Equations are found in the discussion to aid in the description of key concepts and relationships. Food grains are by far the most important agricultural commodity group in Korea; therefore, more depth and detail are needed in studying problems related to these commodities than can be provided from the Korean Agricultural Sector Model alone. The GMP model focuses soley on the Korean food grain system and when used to supplement the broader KASM can provide insight into and analysis of food grain problems not otherwise possible. The model had two objectives: (1) to approximate the real world food grain system in Korea as it responds to various grain management programs, policies, and decisions and (2) to design control systems for the model that will enable its use as an on line grain management tool by government administrators in directing existing grain management programs to achieve prescribed objectives. The model is fully computerized and uses FORTRAN. It produces summary data at prespecified intervals that can be output in table format for the convenience of the model user.

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-AAF-363	

12. DESCRIPTORS		
Decision making	Planning	13. PROJECT NUMBER
Grain crops	Sector analysis	14. CONTRACT NUMBER CSD-2975 Res.
Korea Rep.	Simulation	15. TYPE OF DOCUMENT
Models	Technology transfer	

AID 590-1 (4-74)

AGRICULTURAL SECTOR PLANNING

A GENERAL SYSTEM SIMULATION APPROACH

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Published by
Agricultural Sector Analysis and Simulation Projects
Department of Agricultural Economics
Michigan State University, East Lansing, Michigan 48824
1978

Printed in the United States of America
Library of Congress Catalog Card Number: 77-092693

Composition by Capital Type, Lansing, Michigan
Printed by Braun-Brumfield, Inc., Ann Arbor, Michigan

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PREFACE

For as long as governments have existed, public sector decision makers have searched for better methods of planning and monitoring the performance of national economies and their subcomponents. In recent years, interest in many countries has focused on comprehensive and integrated sectoral planning and performance monitoring. Government officials in these countries are searching for better tools and techniques to assure more consistent and higher quality analytic input into their decisions. Some have turned to computer-based models as a partial answer to their needs. Many, however, are reluctant to make the sizable investment required for large and complex computer-based modeling efforts.

The arguments against computer-based modeling largely follow the line that the techniques and methodologies employed are generally not understood by decision makers, often do not include all the information necessary to a comprehensive analysis of the problem under consideration, and sometimes lead to unworkable prescriptions for action. Such arguments, in too many cases, have been justified.

The authors contributing to this book argue that it is possible, and in many cases highly desirable, to develop decision-making systems that include an investigative capacity to carry out analytical and monitoring functions with computer-based models as an integral part of the system. The authors, with widely varying backgrounds and experiences, through a series of fortuitous events became involved in working together on a project funded by the U.S. Agency for International Development (USAID) and carried out by Michigan State University in cooperation with the Ministry of Agriculture and Fisheries, Republic of Korea. This book is about the set of experiences and the lessons learned from this project. As such, it is as much about people and institutions as it is about models. The book should be useful to a wide range of scholars, students, administrators, policy analysts, planners, and decision makers interested in better approaches to more effective public sector decision making.

Although the work in Korea is depicted in some detail, the authors intend these descriptions to be viewed by the reader as a case example of the application of the general system simulation approach toward providing investigative input into the decision process. The Korea example focuses on national-level decision making with respect to agricultural sector development. But the lessons learned from this experience and the conceptual framework of the approach are applicable in a variety of decision-making contexts, subject matter foci, and geographic locations.

We wish to acknowledge the contributions and support provided by Francis C. Jones, both as project monitor during his tenure as Food and Agriculture Officer, USAID/Korea, and as one of the authors of this book after his retirement from USAID. His death in the spring of 1977 saddened us all.

It is impossible to individually acknowledge the contributions by the many people and institutions who have been a part of the projects upon which this book is based. To them the authors of this book owe a heartfelt debt of gratitude. Special acknowledgment and appreciation are due the institutions with which the authors are affiliated for providing them the opportunity to participate. We also specifically acknowledge the Government of the Republic of Korea for its contributions and cooperation, and the U.S. Agency for International Development for the funding which made both the projects and the book possible.

Particular thanks are due Michael H.B. Adler, Duck Young Rhee, Dong Hi Kim, and Man Jun Hahm for their interest, support, and participation. Appreciation is due Donnella Meadows whose excellent review and critique of the draft manuscript were extremely useful in developing this final version.

Finally special thanks go to Bert Pulaski, project administrative officer, who released us from untold logistic and administrative details and kept us solvent; to Kathleen Schoonmaker, who edited and managed the manuscript through the publication process; to Larry Senger, who assisted in the many steps from draft manuscript to published book; and to our secretarial staff — Judy (Pardee) Duncan, Edith Nosow, Kyong Soo Kim, and Sonia Brundage — for a difficult job well done.

George E. Rossmiller
Editor for the Team

Michigan State University
January 1978

INTRODUCTION

The purpose of this volume is to explain the general system simulation approach as a viable basis for providing input to planning and policy decision making in agricultural sector development. We do this through discussion of the philosophic orientation of the approach, its eclecticism with respect to modeling techniques and types and sources of data, its relationship to the decision-making process, and the establishment of its credibility with decision makers. We also discuss the prerequisites for institutionalization and use of the general system simulation approach for agricultural sector development planning and policy analysis within the agricultural decision structure of a national government. The development and institutionalization of the approach in Korea is detailed and conclusions are drawn about its transferability and preconditions for its use in other developing (or developed) countries.

A wide and varied audience for this volume is anticipated. It should be of particular interest to:

1. Agricultural sector development decision makers at the national level interested in improving the quality of their planning, policy formulation, program development, and project design, implementation, and evaluation
2. Agricultural sector development staff and policy analysts searching for more useful and comprehensive approaches to problem-solving analysis
3. Students of the systems approach interested in methodology and application of systems analysis to socioeconomic problem areas

4. Students of economic development within and outside the academic community who are interested in alternative methodological approaches to agricultural sector development problem solving
5. Students of political and institutional development interested in the problems, requirements, and process of integrating the use of quantitative analysis into the decision-making structure of developing (or developed) countries

In writing for such a diverse audience, we run the risk of probing too deeply in some areas and not deeply enough in others to satisfy any given reader. For those of you who are quantitatively oriented and are interested in a more in-depth mathematical treatment of the models, we can only refer you to the technical documentation by the project team [1, 2, 8, 30, 40, 115]. We urge those who find some of the concepts and the occasional mathematical exposition to be laborious simply to skip over those sections or equations. In doing so, most readers will find the general meaning still apparent.

The book is organized into five parts. Part I, "The Case Study Projects," consists of chapter 1 and covers the development of the projects and the experience upon which this book is based. Part II, "The General System Simulation Approach," consists of three chapters. The first, chapter 2, presents the conceptual framework of the general system simulation approach to improved decision making. The description focuses on a national decision structure concerned with agricultural sector development. The second, chapter 3, develops the public policy environment within which the agricultural sector operates and the policy choices available to the agricultural decision maker as influenced by the prevailing value system imposed by the socioeconomic, technical, and political environment. The third, chapter 4, covers a wide spectrum of model types and techniques, describes how they are used in decision analysis, and indicates their strengths and weaknesses.

Part III, "The Korean Agricultural Sector Models," consists of 9 chapters. The first, chapter 5, describes the process of sector model conceptualization in Korea. The next five, chapters 6 through 10, describe component models that constitute the Korean agricultural sector model system and give illustrations of their application for planning and policy analysis purposes. The five component models in the Korean agricultural sector model system are population, national economy, technology change, resource allocation and production, and demand-price-trade. The next, chapter 11, discusses data and parameter estimate requirements for the model and how they were obtained. The final two chapters in this part indicate the process by which the models can be used by decision makers (chapter 12) and a specific application of the models in long-term planning for land and water development (chapter 13).

Part IV, "The Korean Grain Subsector Models," illustrates the two subsector models built to focus specifically on short- and medium-term problems associated with the Korean government's grain management program. The first, chapter 14, discusses the grain management program model, developed for use as an on-line management tool for government decisions regarding the price, stock, storage, and trade of grain. The second, chapter 15, illustrates a small, static model used to analyze the consequences of grain pricing decisions on production, consumption, inflation, foreign exchange, and government grain management accounts.

Part V, "Technology Transfer," consists of four chapters that cover the problems, requirements, and process of integrating the use of quantitative analysis into the decision-making structure of developing countries. The first, chapter 16, discusses the requirements and prerequisites for institutionalization of the general system simulation approach into a national agricultural decision framework, and the second, chapter 17, indicates the amount and kind of training for indigenous personnel necessary to institutionalize the approach effectively. The third, chapter 18, illustrates the generalizations indicated in the previous two chapters through the experience in Korea, and the last, chapter 19, discusses the future directions necessary to further develop the approach in Korea, as well as to transfer the general approach to other developing (or developed) countries, subject matter areas, and problems.

PN-AAF-363

PART FOUR

THE KOREAN GRAIN SUBSECTOR MODELS

107 p.

14
THE GRAIN MANAGEMENT PROGRAM MODEL

Forrest J. Gibson

INTRODUCTION

The Korean Grain Management Program (GMP) model is a major supplementary component of the Korean Agricultural Sector Model (KASM). The major food grains — namely, rice, barley, and wheat — are identified explicitly in KASM along with 15 other agricultural commodities. The strength of KASM is fairly uniform over all commodities identified, and problems relevant to food grain can be analyzed in as much depth as other commodities. However, the broad design of KASM, encompassing the entire agricultural sector with its linkages to the nonagricultural sector and intermediate to long-term planning horizons of 5 to 25 years, must by necessity limit the depth of investigations into problems relevant to particular agricultural commodities such as food grains. Because food grains are by far the most important agricultural commodity group in Korea, more depth and detail are often needed in studying problems related to these commodities than can be provided from KASM alone. The GMP model focuses solely on the Korean food grain system and grain management program. With this sharp focus on the food grain portion of the agricultural sector, the GMP model can be used to supplement the broader KASM and provide insight into and analysis of food grain problems not otherwise possible.

The objective of this chapter is to convey a general understanding of the overall concept of the GMP model, including (1) the felt need for and objectives of the model; (2) the general concepts, rationale, and techniques underlying the model's design; and (3) what the model can do to assist researchers and decision makers in Korea. Some equations are found in the discussion to aid in the description of key concepts and relationships. However, emphasis is on the "whys" or rationale behind the design aspects of the model rather than on the specific "hows" or mathematical relationships of the model. Technical specialists interested in a thorough description of the mathematical equations and relationships of the model must look elsewhere [56] for this type of description.

NEED FOR THE GMP MODEL IN KOREA

Since the original Grain Management Law was enacted in 1950, the basic objectives of all grain management programs in Korea have been to assure adequate food grain supplies for the Korean people and to stabilize the national economy, which is greatly affected by the domestic food grain system. There is no question about the importance of food grain programs to the Korean people and national economy.[1] The three major food grains — rice, barley, and wheat — account for 70 per cent of the total average daily calorie and protein intake of the Korean people [164]. Rice production alone provides 50 per cent of the average cash income of Korean farmers, and urban consumers spend more than 32 per cent of their total household budgets (64 per cent of their food and beverage budgets) on rice, barley, and wheat. Cereal grains (of which rice, barley, and wheat constitute 95 per cent) have a weight of 0.18 in the consumer price index. This far exceeds the weight given any other commodity group, including energy, housing, and clothing. Because of the great effect of grain on the national economy, the Korean government must play a very active role in grain markets to assure stabilized food grain prices. In recent years this has been a very costly undertaking as indicated by the deficit in the Grain Management Special Account [90], which rose from $5 million in 1972 to well over $700 million by the end of 1975.

Korea is also a country with a chronic deficit in food grain and must depend on foreign sources every year to supplement its inadequate domestic supplies. Self-sufficiency goals for rice and barley have been hard sought by government officials for many years. New high-yielding rice varieties [164] have boosted rice production nearly 18 per cent during the past five years, but requirements for food grains continue to grow faster than domestic production.

The complexity of managing food grains in Korea is evidenced throughout history, back through the days of Japanese occupation [131]. Chronic problems of assuring adequate supplies, price stabilization, and managing existing grain stocks occur today in much the same manner they have occurred during the past 30 years. Means of reckoning with food grain problems have also remained very similar to the old methods. Mainly, they consist of human judgments by decision makers who, drawing on their own knowledge and the knowledge of others, attempt to construct a mental picture of the complex interrelationships within the food grain system and visualize the consequences of alternative courses of action. Quantitative analyses of critical grain management problems are sometimes available to the decision maker, but these are generally done on an ad hoc basis and often are either too simplistic, require too many unrealistic assumptions, or are too theoretical to have any value in attacking real-world problems.

OBJECTIVES OF THE MODEL

The design of the GMP model has two main objectives: (1) to approximate, at an acceptable level of detail and accuracy, the real-world (dynamic) food grain system in Korea as it responds to various grain management programs, policies, and decisions; and (2) to design control systems for the model that will enable its use as an on-line grain management tool by government administrators in directing existing grain management programs to achieve prescribed objectives.

The aim of the first objective is to furnish the policy analyst and decision maker an analytical tool with which they can speedily investigate the potential consequences of alternative proposed solutions to a variety of grain management problems. The detail required from the model is dictated by the kinds and amount of information analysts and decision makers must have about the performance of the food grain system to make sound selections among alternative programs and policies under investigation. The accuracy required from the model need not always be in the precise magnitude of the variables generated but, rather, in the capability of producing valid comparisons among alternatives being studied.

The second objective is aimed at developing a set of management strategies that can be adopted by government officials in administering existing grain management policies. Seasonal price control of food grains is the main concern of this objective, since it remains one of the most perplexing and costly problems facing grain management officials. Ideally, if the GMP simulation model can be made to approximate the real-world dynamic Korean grain system, with supply, demand, and price relationships responding in a realistic manner, then the decision rules developed for controlling market prices generated by the model should imply relevant real-world decision rules required to steer actual market prices toward seasonal price policy objectives.

GENERAL DESCRIPTION OF THE MODEL

Thus far we have viewed the GMP model very generally and done little more than describe its relationship with the overall agricultural sector model, indicate the motivation for focusing sharply on the food grain subsector in Korea, and state the general objectives for the model. We will now describe the model in more specific terms.

Method

The general system simulation approach was used in the design of the GMP model (see chapter 2 and also [127, 151]). Techniques from various disciplines (including system design, econometric analysis, economics, operations research, linear and nonlinear systems, and automatic feedback control theory) were used in the model's development. The model itself is a nonlinear, dynamic system model that has some time-varying parameters.

The model is fully computerized and uses FORTRAN computer language. Solutions to model differential equations are gained through numerical integration techniques stepwise through time. Each solution interval of the system model also enables the calculation of all other variables through simple algebraic relationships. Many of the model calculations are internal to the computer and are not output. Solution intervals necessitated by conditions for system stability are not always of interest in generating time series data. For example, solution intervals of one to two days are necessary within the computer, but users may require output of time series data only in intervals of weeks or months. Some variables are used only as intermediate variables for calculation purposes and are not meaningful in the real world. The model produces summary data at prespecified intervals that can be output in table format for the convenience of the model user.

Size of the Model

The generalized nature of the GMP model, making it applicable to a broad range of grain management problems and capable of generating the kinds of information decision makers need to solve these problems, necessitates its being large in size. The model contains approximately 4,300 executable statements and generates more than 2,000 variables. Core requirements exceed 120K octal words. Execution time for a full run of the model on a CDC Cyber 70, using a simulation time increment of 1/200 of a year (1.8 days) for a two-year run, is about three minutes of central processor time.[2]

Program and Policy Issues

In its current state of development, the model has direct application to the following grain management program and policy issues:

1. The timing and quantity of government grain purchases and/or releases in order to control farm and/or urban market prices
2. Price and, hence, government subsidy requirements of government-regulated wheat flour
3. Location, quantity, and movement of government-controlled grain stocks
4. Quantity and scheduling of foreign grain imports
5. Purchase and release prices of government grains
6. Policy objectives with respect to seasonal price patterns
7. Government purchase programs for domestic grains
8. Self-sufficiency in food grain
9. Programmed grain consumption by farm and nonfarm consumers
10. Repayment schedules for foreign grain loans
11. Grain milling extraction rates
12. Warehouse construction programs

More will be said about some of these important policy issues later in the chapter when we describe the policy orientation of the model.

Model Design

The design of the GMP model can be organized into three different categories: (1) grain system operations, (2) policy orientation, and (3) system performance. Model design under the *first* category is used to approximate the dynamic behavior of the real-world food grain system in Korea. This portion of the model simulates the production, importation, movements, processing, storage, and disappearance of food grains in Korea over time. Economic forces — namely, food grain supply, demand, and prices — that govern much of the system operations behavior are also simulated in this portion of the model. The system operations model is designed and its parameters are estimated to reflect real-world system structure, human behavior, management decisions, and system constraints. The *second* category of model design, policy orientation, has the purpose of orienting the model toward usefulness as an analytical device for studying particular grain management problems. The *third* category of design, system performance, is necessary to provide model users with specific information about the (simulated) performance of the real-world system so that well-informed choices can be made among alternative management strategies under study. Self-checks into actual model performance for tuning, testing, and validation purposes, such as how well it tracks past data, are also built into this portion of the model. More will be said later regarding model design under each of these categories.

Disaggregation

To provide the level of detail required by potential users and to represent the state of the food grain system extensively enough to capture the important interrelationships and dynamics required to fulfill model objectives, the GMP model is disaggregated across six dimensions. These dimensions are summarized below.

Subsectors	*Population*	*Food Grain Commodities*
Farm	Farm	Rice
Urban households	Nonfarm	Barley
Private market		Wheat
Government		

Grain Forms	*Position Points*	*Government Warehouse*
Rough	Production areas	Low-temperature
Hulled	Seaports	Class A
Polished (pressed)	Consumption area terminals	Class B
Flour and flour products	Retail sales stores	Class C
		Auxiliary

Subsectors. The GMP model disaggregates the Korean grain system into four subsectors: (1) farm, (2) urban and nonfarm consumer households, (3) private market, and (4) government. Generally, grain management program objectives are aimed at the individuals making up these components of the overall grain system and may be different for one subsector than for another. Behavior characteristics are also different in each subsector. Consumption behavior in the farm sector differs from that in the urban sector in that farmers must decide whether to consume or market their food grains for needed cash. The private market differs from government marketing channels in that it consists of entrepreneurs motivated by profit incentives to move and store grain, whereas the government is motivated to carry out grain operations in order to achieve grain policy objectives for the entire system.

Food Grain Commodities. Food grain commodities identified by the GMP model are rice, barley, and wheat, the major food grains in Korea, accounting for more than 95 per cent of total food grain consumption by humans. Rice is by far the most important food grain commodity, accounting for about 51 per cent of total human food grain consumption. Barley and wheat follow rice in importance, each of these grains accounting for around 22 per cent of total food grain consumption.

Grain Forms. The GMP model traces through time all physical operations on food grains from planting to final consumption. All food grains undergo changes in physical characteristics through processing before they are consumed by humans. The rice hull remains on the grain after harvest. This hull provides a protective shell around each kernel and enhances the storability of the grain. Common practice is to leave the rice in unhulled (or paddy) form until shortly before it is marketed or consumed. Paddy rice, however, is more bulky than hulled rice and requires twice the storage space. Rice processing can be divided into two stages, hulling and polishing. The hulling process merely knocks the outer hull off the grain, leaving what is commonly called hulled (or brown) rice. Brown rice does not have the storage qualities of paddy rice but still maintains its taste qualities during prolonged storage much better than rice in the final polished form. Rice is imported in its brown form and polished in government-licensed mills shortly before release onto the market. Rice hulls have little economic value but are used as fill for pillows and mattresses and also serve as a good absorbent. Rice bran, however, has high economic value and is used as a high-quality animal feed and in the production of rice bran oil.

Both common and naked barley are produced in Korea. Each of these grains has different physical characteristics after harvest, but after milling the polished form of the two grains appears similar. Common barley has a fibrous hull firmly attached to the grain. This hull must be ground off, the bran by-product going mainly to animal feed. Naked barley appears somewhat similar to wheat after harvest because of its skinlike covering over each kernel. This covering is ground off during the milling process. The bran by-product also goes mostly to animal feed products. Barley can also undergo further processing into pressed form. At this stage of processing, polished barley is parboiled briefly, dried, and rolled to enhance the cooking qualities of the grain, especially when mixed with rice. Supplemental nutrients are often added to pressed barley.

Since 1971 the Korean government has undertaken a program of mixing rice and pressed barley. Currently the mix ratio of rice to pressed barley is 70 to 30. The program has intensified in recent years, and now all government rice is mixed with barley before release.

The vast majority of wheat consumed in Korea is in the form of wheat flour and wheat flour products. More than 90 per cent of the wheat consumed in Korea comes from wheat imports that are milled into flour by members of the Korean Flour Millers Industrial Association (KOFMIA) and sold to various wheat flour processing industries throughout the country.

As indicated in the preceding discussion, food grains can take on a multitude of forms before consumption by humans. The GMP model disaggregates by grain forms but only to the extent of absolute necessity, since disaggregation in any dimension means added complexity to the model. Table 15 indicates model disaggregation of food grains by form.

TABLE 15
Model Disaggregation of Food Grains by Form and Commodity

Commodity	Unhulled (Whole Grain)	Hulled	Polished (Pressed)	Flour (Flour Products)
Rice	X	X	X	
Barley	X		X	
Wheat	X			X

Position Points. The GMP model keeps tabs on the physical location of food grains until final disappearance. Position is an important dimension of system disaggregation when it comes to estimating the parameters for storage and flow capacities in the model. Domestic grains must move from farm positions through commercial marketing channels, undergoing processing and storage over time, before they eventually arrive in urban consumer households for consumption. Imported grains must move into seaport facilities from foreign countries, move into urban areas, undergo processing, and move into retail sales outlets before they arrive in urban households. In general, domestic grains are processed and stored in production areas and move into consumption areas as required to meet urban demand requirements. Imported grains are processed in urban areas.

Government Warehousing Classes. The last dimension of GMP model disaggregation is classification of government-controlled warehousing facilities for food grains. Although of lesser importance than other disaggregations of the model for immediate use, this dimension enables the GMP to be used in addressing grain management problems related to storage practices for government-controlled grains [59]. The model identifies five classifications of warehouse facilities: (1) low-temperature, (2) Class A, (3) Class B, (4) Class C, and (5) auxiliary storage. Each of these classifications of warehouses has different unit construction costs, storage charges, and storage loss characteristics over the four seasons of the year. Table 16 indicates the distribution of the five classes of government-controlled warehousing facilities as of June 1974. The distribution of these classes of warehouses changes over time with depreciation, salvage, renovation, and new warehouse construction programs. The GMP model keeps

TABLE 16
Capacity and Capacity Distribution
of Storage by Class

Warehouse Class	Capacity (1,000 metric tons)	Per cent
Low-temperature	172	11
Class A	89	6
Class B	473	32
Class C	554	37
Under grade (auxiliary)	217	14
TOTAL	1,505	100

Source: Korea, Ministry of Agriculture and Fisheries, *Yearbook of Agriculture and Forestry Statistics*, Grain Statistics 1974.

tabs on this distribution and simulates expected loss rates from storage over time.

GRAIN SYSTEM OPERATIONS MODEL

A major portion of the GMP model design is devoted to describing the time, space, and form processes of grain operations occurring within the Korean grain system. This includes the simulation of physical grain operations, such as production, importation, market supply and demand, actual grain transactions, grain movements and processing, storage, and consumption. It also includes the modeling of economic forces, such as farm and urban market prices, which have major effects on the behavior of the grain operations system. Parameters for physical processes are estimated and constrained to real-world characteristics to reflect realistic system performance.

The basic structure of the grain system operations model is found in four subsector models representing (1) farm, (2) urban or nonfarm, (3) private market, and (4) government subsectors of the real-world grain system. These models are linked and become closely interrelated components of the overall system through a market price generation and transaction mechanism. Once the subsectors are linked, the grain system operations model must not be considered as four separate subsector models, but as a fully integrated system with virtually all (internal) variables related, directly or indirectly.

In describing the grain system operations model, it is desirable to emphasize the "whole" system concept; however, it is difficult to do so when describing the model subsector by subsector. The procedure used is to describe briefly the individual subsector component models in general terms to give the reader a comprehension of their individual attributes and functions. From there, discussion of the model will be centered around actual system operations, such as production, importation, grain movements, storage, and consumption.

Descriptions of Subsector Components

Farm Subsector. The farm subsector model is structured and its parameters are estimated to simulate the production, storage, marketing, and consumption (human and nonhuman) of food grains at the farm level. Farmers respond to past experience, cost factors, prevailing market conditions, and future expectations in their decision processes regarding farm grain management operations. The GMP model attempts to capture some of the important factors and rules going into farm decision processes and reflects the effect of these decisions as they are passed on to other subsectors and are propagated throughout the entire food grain system.

Urban Subsector. The urban demand component model simulates the demand, consumption, and food grain storage characteristics of urban consumer households. Effective market demand for food grains is keyed to both current consumption levels and household grain inventory adjustments. These storage adjustments are responsive to food grain price levels, as well as to future expectation of market prices. Consumption is responsive to food grain prices and also to the level of existing household grain inventories. When inventories become critically low, reflecting inadequate market supplies, consumption is suppressed, reflecting a tightening-of-the-belt phenomenon during times of food grain shortages.

Private Market Subsector. The private market subsector model reflects the structure, constaints, and decision processes that govern the flow, processing, and storage of food grains through nongovernment marketing channels. Decision and management processes of individual participants (including collectors, assemblers, millers, shippers, commissioners, wholesalers, and retailers) of the private market are modeled. Domestic grains are purchased, stored, and sold according to rational, private market demand and supply functions. Grains move into private marketing channels at various position points and are processed where appropriate. They then continue through the private marketing system to retail sales positions, where they move out of the private market subsector and into urban household storage via sales transactions. Imported wheat operations, which are handled by the private market, are also simulated.

Government Subsector. Internal government food grain operations, including domestic purchases, imports, storage, milling, transportation, and releases, are simulated in this subsector model. Decision processes required to administer existing grain management programs and policies, such as farm and/or urban price stabilization and control of reserve food grain stock levels through importation of foreign grains, are also designed into the model. This aspect of the model, however, does not strive to replicate existing real-world government decision processes as the private market subsector model does for the private market. Instead, the model is designed as a tool for prescriptive analysis of government grain operations that would be necessary to achieve targeted policy objectives. The attempt of the model here is to *improve* on existing government decisions by providing insight and guidelines for government officials actively engaged in these difficult decisions.

Subsector Linkage

The four subsector components of the GMP model are linked together by a price and transaction (PAT) mechanism. This mechanism is used to interface food grain supply and demand relationships in farm and urban markets, generate market prices, and calculate actual grain transactions that occur throughout time.

The grain market price and transaction mechanism operates both in the farm and urban consumer markets. On the farm market side, government and private market demands for grains are interfaced with farm marketings. Free-market decision of farmers to market into either the private or government sectors are reflected in the PAT mechanism. These choices depend on the relative levels of government and private market demands, the relative buying prices being paid by the government and private market subsectors, and the relative convenience to the farmer in marketing into each of these subsectors. Grain transactions occur so that total farm sales during any period of time are equal to total government and private market domestic grain purchases.

On the urban consumer market side, grain marketings from the private and government subsectors are interfaced with urban consumer demands for grains. Free-market decisions of urban consumers to buy from either the private or government subsectors are reflected in the PAT mechanism. These choices depend on the relative levels of government and private grain marketings, the relative selling prices of government and private market grains, and also on the relative quality of government and private market grains. Grain transactions occur so that total government and private grain sales during any period of time are equal to total urban consumer purchases.

The price and transaction mechanism contains parameters that can be altered to reflect government countermeasure policies designed to suppress normal free-market decisions of farmers and urban consumers in choosing between private and government markets. More will be said about this while we are discussing the policy orientation design aspects of the model.

Figure 42 illustrates the basic conceptualization of the GMP component models and depicts the linkages provided by the PAT mechanism. The figure gives a simple view of the overall system concept and shows (domestic) grain flows through the marketing channels. All demands, supplies, and prices are indicated as being endogenous to the system. This is always true, except for government policies — such as government demand and supply — which can be either endogenous or exogenous, depending on what use is being made of the model.

Historical tracking experiments, which determine how well the model can reproduce historical time series data, require that government demand and supply correspond with actual purchase and release programs prevailing during the period of the model run. Government imports and purchase and release prices also must correspond to actual historical data on these series for tracking purposes. Other runs of the model may require investigation into "what if" effects of alternative government purchase prices or alternative government purchase programs (during different times of the year) or alternative release prices. In these run modes of the model, government policies are specified by the user. In the configuration of Figure 42, the model also has the capability of calculating some govern-

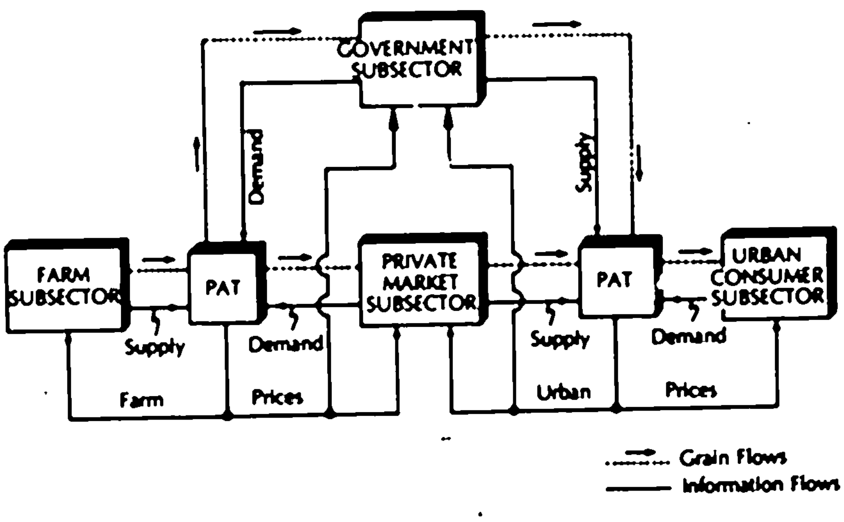

FIG. 42. Grain management program — model linkage.

ment policies endogenously, such as supply and/or demand, to meet certain policy objectives, such as targeted seasonal price policies.

Many of the causal relationships of the GMP system model are not shown in Figure 42. To see them, it is helpful to view the model in terms of the major system processes simulated and their interrelationships. Figure 43 is a causal map of the GMP model showing some of these interrelationships. Major grain flows are depicted in the figure. Domestic production moves into farm storage and out again (through time) to various dispositions; i.e., farm-household consumption, farm-livestock consumption, seed requirements, and farm commercial sales.

Farm sales are shown divided among private and government marketing channels, some sales bypassing formal marketing channels altogether. Farm-commercialized grains then move into private and government storage and remain there until they move into urban household storage through market transactions. Grains move out of urban household storage as they are consumed by urban people. Government imports are shown as an additional source of grain, and government uses as an additional disposition of grain.

Grain storage, shown in Figure 43 by the four rectangular boxes, depicts grain ownership by farmers, urban (nonfarm) consumers, the government, and the private market. Many activities are occurring within each of the grain storage blocks: grains are moving in and out of various storage facilities and being processed, stored, and moved from one position to another. Imported grains are being loaded, shipped, and discharged at port facilities, oftentimes queuing up at ports if arrivals exceed discharge capacity. All these operations require time, space, and form transformations, and it is these processes that the grain operations model is simulating.

The demand and supply processes indicated in Figure 43 do not come in direct contact with grain flows but are used as information processes to calculate market transactions and to provide the forces that cause market prices to change over time. Both "demand" and "supply," as perceived in the GMP model, have a connotation of intent. For example, "farm supply" (or farm marketings) is the rate at which farmers make their grains available for sale — i.e., how fast they would like to sell their grains — and "government demand" represents the rate at which the government intends and is able to purchase grains from farmers, and so forth. "Supply," as used in the model, does not refer to the amount of grain in storage in the farm, government, or private subsectors, but to the amount each subsector is making available for sale.

To help the reader become acquainted with the causal map of Figure 43, let us consider the calculation of, say, private market purchases.

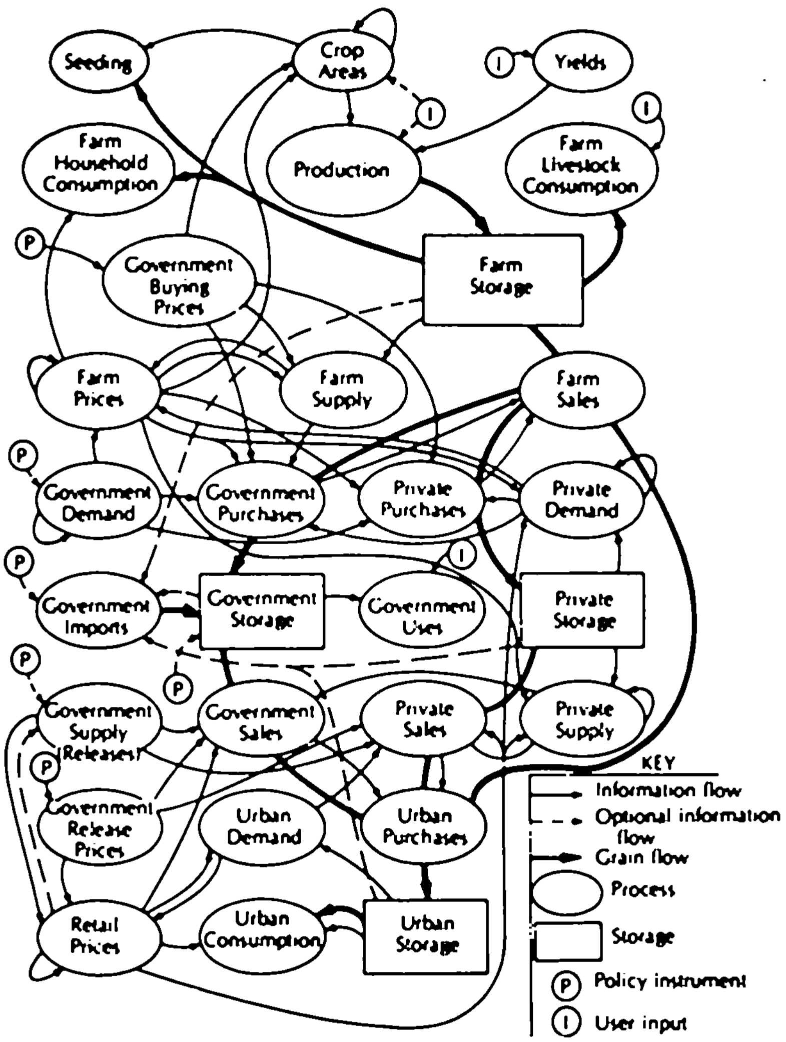

FIG. 43. Causal map of grain management program model.

Arrows entering the "private purchases" process indicate that private purchases are a function of private demand (i.e., the rate at which the private market wishes to purchase), government demand, farm supply, farm price, and government purchasing price. When the government is active in a purchase program, government demand competes with private demand for farm market supplies. Relative price differences between government purchase price and private market price affect farm choices to market into the respective markets. Also the size of the relative demands implies the accessibility of the alternative markets to farmers, affecting the farm marketings into government or private markets. Finally, farm marketings into the private market are interfaced with private demand and actual transactions (private purchases) are calculated. Other interrelationships depicted in Figure 43 can be traced in a similar way. The reader may review Figure 43 as a helpful reference in later discussion.

System Operation Processes

The GMP should be viewed in the "system" context and not as a set of isolated subcomponent models connected in a loosely knit fashion. We now describe in more detail some of the important processes that are simulated in the system operations model.

Domestic Production. The process of domestic production consists of both human decision (by farmers) and physical processes. Farmers decide, on the basis of past experience and future expectations, the land area to be planted in the various food grains. However, the seasonal nature of food grain production dictates closely when each crop will be planted, its maturation time, and when it will be harvested. Barley and wheat are planted in the fall and harvested in May and June of the following year. Rice is transplanted during June and harvested in the fall. Southern regions of the country are capable of producing one crop of rice plus one crop of barley (or wheat) during a single year. Some regions are very well suited for double cropping; others are not suited at all for this practice, with a continuum of suitability in between. In the critical regions during June, one can observe a sequence of barley harvest, paddy preparation, and rice transplanting operations occurring simultaneously on the same land area. New rice varieties, which allow for a shorter growing season, give more farmers the opportunity to double-crop rice with barley or wheat.

Land areas planted in rice, barley, and wheat by farmers can be calculated internally by the GMP model. The user still maintains the option of specifying these land areas before a model run if he so desires, but the model has the internal capability to determine the impact of various grain management programs and policies under study on domestic grain production. Several factors are seen to influence farmers' decisions and are included in this decision process. For example, relative returns between new high-yielding rice varieties and traditional rice varieties influence the diffusion process of adopting new varieties by farmers. New varieties have a higher expected yield, but also require higher production costs. With more invested, farmers must assume greater risks in raising the new varieties, which are also more susceptible to crop damage in bad years. Undesirable results from raising new varieties, such as yield reductions larger than those expected because of poor weather or unfavorable economic value of the new varieties, can cause recidivism effects influencing farmers to change back to more reliable traditional varieties.[3] Shorter growing seasons of new rice varieties make it possible for more farmers to double-crop more barley or wheat with rice. These factors are included in the production decision calculations and used to project land areas planted in rice (high-yielding and traditional varieties), barley, and wheat.

Yields are not modeled endogenously by the GMP model. Users must furnish expected yields, including expected yields of high-yielding rice varieties. This allows the various impacts of high or low crop yields throughout the grain system and the resulting impact on the following years' production decisions to be investigated.

The GMP is a process-oriented model in which domestic food grain production, as well as other processes occurring in the real-world system, is simulated through time. Good reasons exist for needing to replicate the actual physical production processes in the model: the seasonal patterns of crop planting, cultivating, harvesting, and sales of food grains determine the timing of production costs and revenue flows of farmers. Farmers' behavior patterns are strongly linked with their current financial situation and credit obligations. High interest rates, plus the normal terms of credit arrangements, give farmers much incentive to satisfy debt obligations soon after harvest, greatly affecting their food grain marketing patterns, which in turn affect seasonal farm market prices. Farm inventory levels also seem to have a marked effect on marketing patterns and, consequently, on farm market prices during the year. Since one of the main objectives of the GMP is to generate valid market price movements during the year, the need for modeling physical production processes becomes evident.

Distributed delay functions, which calculate the solutions to higher order differential equations, are used in the model to simulate the various production processes (i.e., planting, cultivating, and harvesting) during the year. Land areas in the form of impulses (with no time dimension) are entered into the production process delays at precise times during the year corresponding to the beginning of each production activity. The delays then distribute these areas over the normal period of the activity, simulating the production processes. Unit cost factors are applied to each operation to give production cost flows. Expected yields (input by the user) are applied to the output of the harvest delays to generate harvest rates and the flow of domestic production into farm storage.

Human Consumption. Both farm and urban (nonfarm) food grain consumption are simulated in the GMP model. Consumption patterns vary with own- and substitute-food grain prices, as well as with income. The equation below indicates the Cobb-Douglas form used in the model to generate farm and urban consumption behavior for commodity *i*:

$$Q_i(t) = A_i P_1(t)^{\varepsilon_{i1}(t)} P_2(t)^{\varepsilon_{i2}(t)} P_3(t)^{\varepsilon_{i3}(t)} Y(t)^{\varepsilon_{iY}} POP(t)$$

where Q, A, P, Y, ϵ, and POP are total consumption, a constant, prices, per capita income, price and income elasticities of demand, and population, respectively, for each subsector. The reader will note that the price elasticities of demand (ε_{i1}, ε_{i2}, ε_{i3}) are indicated as functions of time, whereas the income elasticity (ε_{iY}) is not. Three sets of price elasticities are used in each of the farm and urban consumption functions to represent the seasonal nature of consumption behavior in Korea. The values of these parameters were estimated off-line for three seasons during the year. During a model run the values of the parameters move linearly toward the succeeding set of estimated values as time evolves, so that the Cobb-Douglas functions used in the model have continuous time-varying parameters. This was necessary to achieve valid seasonal consumption behavior for farm and urban populations.

The three seasons of the year for which the consumption parameters were estimated are (1) October through January, (2) February through May, and (3) June through September. This choice of three distinct seasons is quite reasonable for the Korean situation [134]. Rice harvest occurs during October and November; thus the first seasonal period corresponds to the rice harvest and postharvest period when farm stocks are the highest and a glut of new grain appears on the market. The second period, February through May, is the so-called off-season, when no harvesting is occurring and farm stock levels of all grains are depleting. The third seasonal period, June through September, corresponds to the barley (and wheat) harvest and postharvest season, when barley stocks are highest. Rice transplanting and cultivation also occur during this period.

An additional consumption behavior characteristic included in the design of the urban subsector model is the phenomenon of suppressed consumption whenever stock levels of household food grain are low. Situations may arise in which sufficient food grain supplies are not available (at any price) to urban households. In such a situation, when household stock levels are dwindling to critically low levels and cannot be replenished with additional purchases, it is reasonable to assume that household consumption levels would be curtailed, even though market prices for food grain (if available) may not bring about such a reduction in consumption demand. The alternative to this assumption is that urban households would eat themselves out of food grain supplies with no concern for tomorrow. Stock levels will eventually be exhausted under either assumption, but the former seems (to model designers) to be a much more realistic view. Therefore, the concept of actual food grain consumption, along with normal food grain consumption, based on household inventory stock levels is expressed in the model.

The function used for suppressing normal urban consumption demand is illustrated in Figure 44. The ordinate value of the function ranges from zero to one. The argument of the function expresses the length of time current urban household inventory level could sustain current normal urban consumption demand. The actual values of the function are, of course, unknown. Values presented in the figure represent starting "guess-timates" used in the model. Sensitivity testing can indicate the importance of accurate values of this function on model results and, thus, the need for further research in determining its true character.

Grain Storage, Movements, and Processing. Grain storage, movements, and processing occur within the GMP model in much the same manner as in reality. Harvest season approaches, and domestic grains begin to flow into farm storage facilities in rough form. Farm rough grain

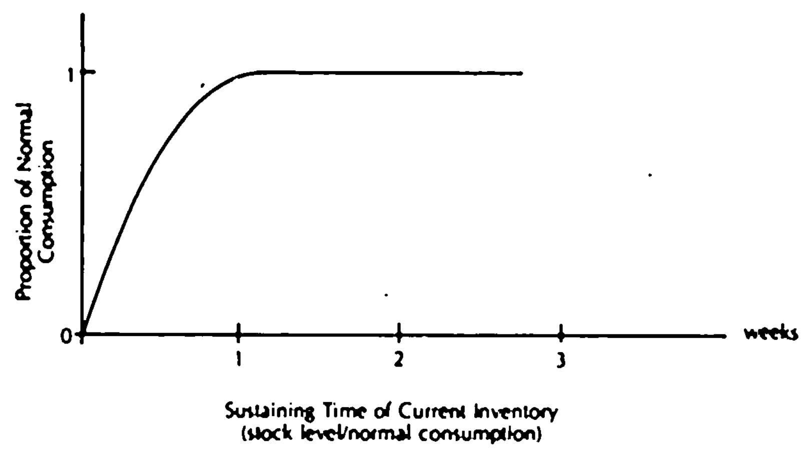

FIG. 44. Urban household consumption constraint function.

stocks are depleted (over time) by outflows for purposes of (1) seed for planting new crops, (2) animal feed, (3) market sales, and (4) milling into polished form. Most farmers use toll milling services of private millers, paying a toll charge of (currently) 4 per cent of the polished product. The remaining polished grains return to farm storage from where they are either consumed on the farm or sold.

The private market subsector purchases grain from farmers in both rough and polished form. Rough grains remain in production areas until they are milled into polished form. They then move out of production-area positions by truck or train to consumption-area terminal-point positions, from where they are distributed to retail stores for sale.

The government (under current purchasing programs) purchases domestic grains in rough form only. These grains are stored in production-area positions and milled shortly before they are moved into consumption-area positions. Government-polished grains in consumption areas are released (according to government policy) and distributed to private market retail stores registered to handle government-controlled grains.

Grain imports arrive at port facilities in unpolished form. These grains enter port storage positions and then move into consumption-area positions, where they are stored and then milled into polished grain form. Oftentimes, imported grains are blended with domestic grains to standardize the quality of government grains before release.

Urban households also maintain grain storage. Although small in comparison to the other subsectors in the system, this storage function has a very important effect on the performance of the overall grain system. Urban household storage is depleted through consumption. As mentioned previously, urban household stock levels, when critically low, may have a dampening effect on consumption. Figure 45 depicts the major grain flows and storage functions mentioned above and represented in the GMP system operations model.

Figure 45 also identifies 14 distinct food grain inventories for rice and barley represented in the grain system operations model. Not shown in the figure are the flows, processing, and storage of industrial wheat, which is comprised of about 90 per cent imports. Industrial wheat flour milling operations are also represented in the model. Wheat inventories are identified at three additional positions not shown in Figure 45, namely, port storage facilities, flour milling warehouses for wheat, and flour miller warehouses for wheat flour. The wheat flour product processing industry, such as noodle and bakery manufacturers, is modeled only in the aggregate. Wheat grain inventories in this subsector are represented with a delay function reflecting the wheat flour industry's storage and processing opera-

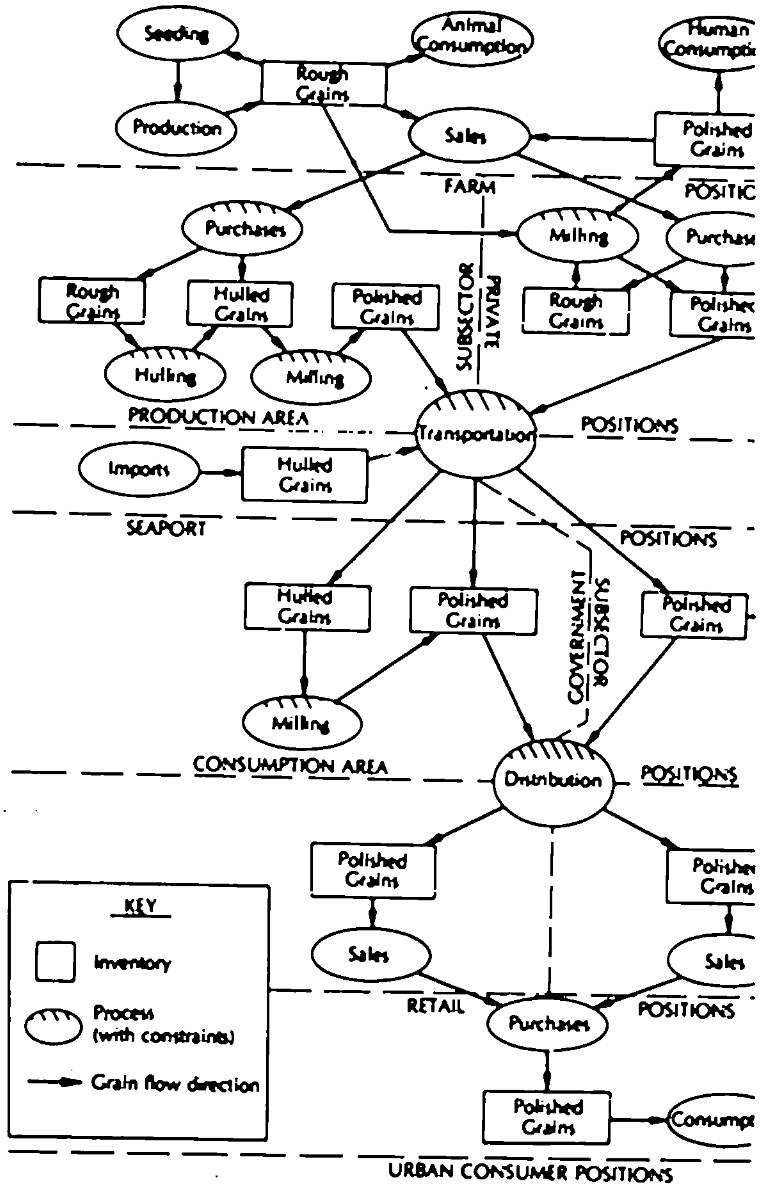

FIG. 45. Grain management program grain flows and storage.

tions. If grain inventories in import pipelines are also considered, the GMP model identifies food grain inventories at 20 distinct positions. In this section we describe some of the modeling techniques used to simulate the processes involved in managing these inventories.

Each individual inventory of the GMP model is handled somewhat differently to best replicate what is actually occurring in the real-world system. The general discussion in this section best fits the inventory management processes of the private and government marketing subsectors. Decision processes for farm, urban, and wheat flour industrial sectors are somewhat different but similar enough not to be separately detailed.

Figure 46 can be a useful aid in describing the basic concept behind the design of the position-point inventory management component of the private and government subsector models. Note that the figure is general in that not all inventories nor any particular position-point inventory are depicted. The three inventories, called I, II, and III, represent position-point inventories along market channels. A basic assumption of the model is that food grains proceed through the market channels in a nonreversible manner. For example, grains do not flow from consumption-area sales store positions back to mills located in production areas. In the figure this one-way flow of grains is assumed to be in the order of positions I, II, and III, progressively. The management strategy depicted in the figure is for position II. Other position-point inventory management strategies would appear similar.

Automatic feedback control techniques are used to represent real-world inventory management processes. Managers for inventories at position II in Figure 46 are aware of current inventory levels, depicted by the feedback information loop. This information on current inventory level is compared with an ideal pattern of inventory level for this position. When a discrepancy is observed between actual and desired inventory levels for this position, corrective action is taken. However, many constraints and limitations exist in the real-world system that can affect how much and what type of corrective action can be taken. A "pull-forward" concept of grain flows seems to best represent real-world phenomena. This is to say, inventories at any particular position may be built by placing orders to preceding position points. However, inventories may not be depleted by shipments to succeeding positions unless orders for shipments exist from those positions. This flow limitation concept is used to propagate urban consumer demand back through private marketing channels to the farm market.

Other constraints also exist. The rate at which orders can be filled for inventory position II depends on the system's capacity to move stocks between positions I and II. This may involve milling capacity, if position I

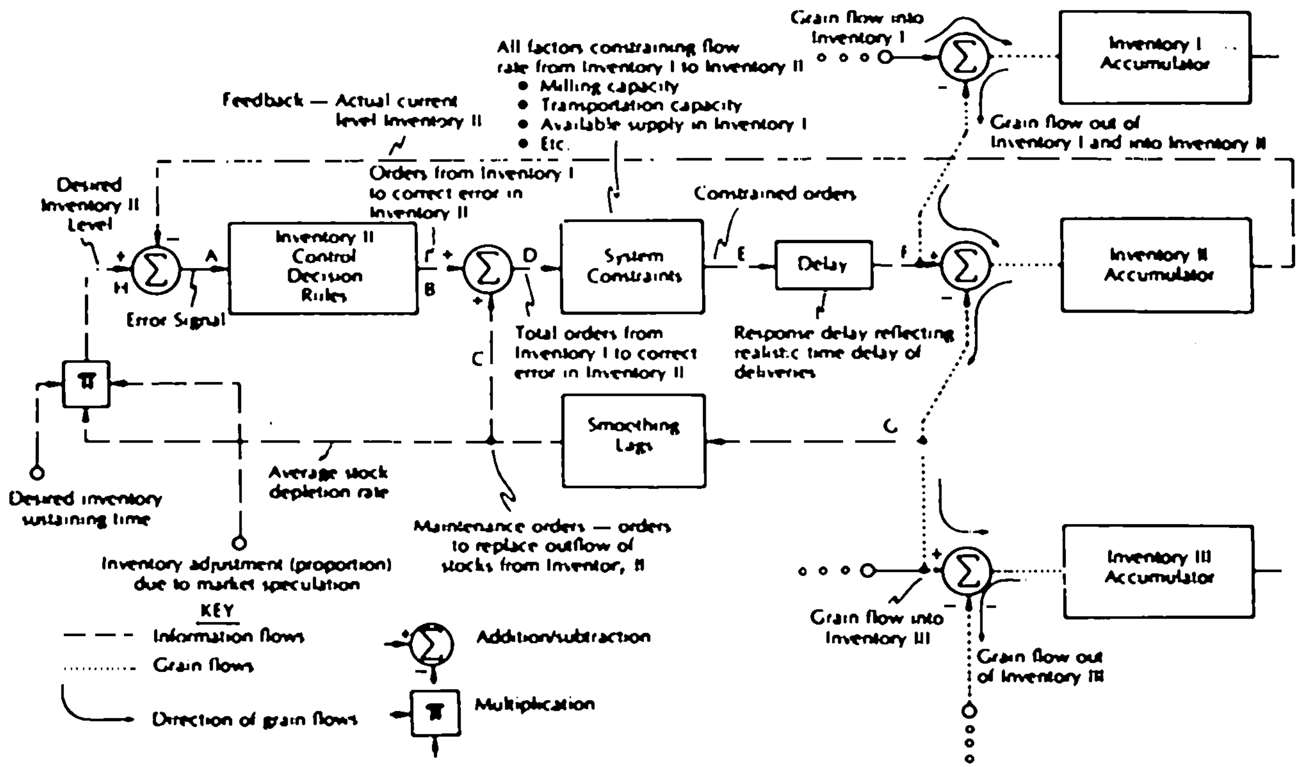

FIG. 46. Basic scheme for inventory management.*

inventory is in rough form and position II inventory is in polished form. It may also involve transportation capacity, if position I is located in production areas and position II is located in consumption areas. Then, of course, stocks must be present at position I before orders can be filled for increasing position II inventories. Time delays are also involved in placing orders, grain handling, milling, transportation, and deliveries of grains to position II.[4]

Market Supply and Demand. We have described in general terms the movements and handling of grains within the GMP model. This degree of modeling effort and design is necessary to represent accurately the physical system constraints of grain movements between farm and urban consumer markets. We now describe some of the important model functions that determine the supply and demand for grains in the farm and urban marketplaces and that are the primary factors in determining market prices.

At this point it is appropriate to mention an important and useful characteristic of the GMP model — its modularity. Nothing in the model prevents the swapping in and out of various functions used to calculate behavioral characteristics, such as production responses, consumption, or marketing behavior. The model is used with the best set of functions available at the time, continual off-line work being done to research "better" or more up-to-date functions to use. As "better" functions become available, they can be inserted into the model and tested. If they test out, they can remain in the model until replaced, with little other effort involved. Therefore, in describing, say, the farm marketing behavioral response of the GMP model, we do not discuss any particular function used in the model, for no function can be considered permanent — and no particular behavioral function should be construed as representing the GMP model, for the model itself provides the structure and dynamic framework for testing and using behavioral functions that are in a continual state of evolutionary development over time.

The supply of domestically produced grains on the market plays a vital role in market price behavior. Farmers' behavior in marketing their available supplies of food grains depends greatly on their credit situation, available stocks, and also on market prices that they can receive for their products [132]. Government purchase prices and the timing of purchase programs also affect farm marketing behavior. These factors and others are combined in a set of farm marketing equations used in the GMP model.

Urban household demand in the marketplace is not taken directly from the human consumption function described in an earlier section. Rather the GMP model also simulates the storage function of urban households so that effective urban demand in the marketplace represents not only urban consumption patterns but also urban household decisions to manage home inventory stock levels. General price levels, price changes, and anticipated price levels all play a part in the urban household consumption and inventory management strategy.

Government demand and supply for food grains are policy variables representing specific grain management programs and objectives. The GMP model provides model users many opportunities to explore the use of these powerful instruments in dealing with several grain management problems. Much more will be said regarding government demand and supply of food grains in a later section of this chapter, dealing with the policy orientation of the GMP model.

The private market, acting as a major channel between farm producers and urban consumers, plays a vital role in the overall grain system. Market supply and demand functions generated in this subsector are the critical link between markets and play a critical role in influencing market prices. Unlike the government subsector, whose demand and supply functions are based on grain management program objectives, the private market subsector, like any free enterprise, is motivated to act through the quest for profit.

The GMP model recognizes two possibilities for generating profits from private market activities. The *first* is to move grains through the system and realize a net profit margin between buying and selling price. Assuming that unit costs do not increase with volume, the more grain that can be moved through the system, the higher will be the total profits. The *second* potential means of generating profits available to the private marketing subsector is to purchase grains on the farm market, hold them over time, and realize a profit from increases in urban market prices. This second means of realizing profits naturally has inherent speculative risks because of accumulating storage and interest costs over time and the uncertainty of urban market prices in the future.

The GMP model has a speculative behavior mechanism that forecasts future urban prices and demand available to the private marketing subsector. These forecasts are initialized at the beginning of each model run with empirical price and demand data from the past several years. As the simulation run progresses through time, model-generated data (prices and demands) are merged with initial past data, the most recent data being weighted heaviest. Seasonal patterns in data are recognized by the forecasting mechanism. Repeating or persistent seasonal patterns act to reinforce confidence. The speculative response mechanism continually monitors current prices and forecasts and generates desired private market inventory levels through time, which (it thinks) can be held for a profit. Private market demand and supply functions of the GMP model reflect this speculative storage behavioral phenomenon.

Both marketing margin (flow) and market speculation (storage) incentives for generating profits are factors in the demand and supply functions of the private market. The flow component of demand and supply responds to changing margins between farm and urban market prices. As margins increase, the incentive to deal in more grain also increases; both the private market supply and demand increase. The effect of this is to increase farm prices (increased demand) and decrease urban prices (increased supply), thus reducing the marketing margin. As margins decrease, the incentive to deal in grains also decreases; both private market supply and demand decrease. The effect of this response is to decrease farm prices (decreased demand) and increase urban prices (decreased supply), thus increasing the marketing margin. The net effect of the flow incentive factor is the influence it has upon maintaining normal farm and urban market price margins.

The storage component of private market demand and supply does not affect marketing margins but has an amplifying effect on the market price changes. As urban price rises exceed the cost of holding grains, the storage incentive component acts to increase private market inventories. Increased demand and decreased supply act to amplify already rising urban prices (and increase farm prices as well). When storage is no longer foreseen as a feasible profit-making activity (e.g., when urban prices are falling), the storage incentive component acts to decrease excess private market inventories. Decreased demand and increased supply again have an amplifying effect on already decreasing urban prices (and act to decrease farm prices as well).

The relative influences of flow and storage incentives on total private market demand and supply, of course, are not known. The model-tuning process, however, enables model designers to test various weighting factors for the two components. It is interesting to note that the model-tuning process for rice indicated that in the farm market best results were gained by weighting the marketing margin (flow) responses much more heavily than the storage behavioral responses. However, in the urban market, best results were gained by attaching approximately equal weights to the flow and storage responses. The logic of this phenomenon is reasonable: merchants located in production areas, dealing in farm markets, are risking much more in holding grains on the basis of anticipated urban market price rises than merchants located in urban areas dealing directly with urban markets. This is due to the longer delay time required to market grains stored in production areas should the urban market suddenly begin to decline, as compared to those held, say, by commissioners or retail sales store merchants.

Market Prices. Farm and urban market prices are generated in the GMP model by bringing market supplies and demands for grains together mathematically. Basically, the price generation function describes the dynamic changes in market prices in response to disequilibriums of supply and demand over time. On the farm market, private market demand and government demand are combined and compared with the available farm supply. An excess market demand causes prices to rise, whereas an excess market supply causes prices to decline. On the urban market side, private market supply and government supply (releases) are combined and compared with urban demand. Again, an excess market demand causes prices to rise, and an excess market supply causes prices to fall.

The model recognizes the possibility that supply and demand from government and private subsectors may have different degrees of influence on market prices; that is, private demand may have a greater effect on farm prices than an equal amount of government demand, or vice versa. A similar assumption is made for urban market supplies from the two subsectors. One of the tasks in the model-tuning process was to assign values to the relative importance of these two sources of market supply and demand.

POLICY ORIENTATION

In an earlier section of this chapter we listed several grain management program and policy issues that the GMP model is suited to analyze. The model should provide guidance and insight to researchers and decision makers concerned with real-world grain management problems. The GMP model — and, for that matter, any simulation model — does not automatically become a useful analytical tool merely by being verified with respect to the real-world system it is representing. Much thought and model design must be devoted to bringing to the surface the important policy instruments and system variables under control of the eventual model user, making them apparent and readily accessible. Strict attention is necessary to assure that these policy instruments are *connected* in a realistic manner to the overall system.

The GMP model is designed for use by the government sector and is thus oriented toward addressing issues of interest to decision makers in that sector. The same model conceivably could be oriented toward the interest of other decision makers in the system, such as farm cooperatives, the Private Millers Association, wholesale commissioners, or the Korean Flour Millers Industrial Association (KOFMIA). As such, the model would have a different policy (or use) orientation, with design emphasis on instruments under the control of these model users.

It is difficult to clearly classify all types of grain management program and policy issues of interest, or potential interest, to the Korean government. About the best that can be done is to isolate some of the important issues into three categories. *First* are problems in grain management policy and program development for planning and investigative purposes. Analyses in this category may be aimed at investigating the consequences of continuing current policies or changing policies to better meet current conditions. Basically, the model users are interested in asking "what if" types of questions of the model. These questions can be for periods in the past as well as for periods in the future. For example, "what if" government policy on a particular issue, say, barley purchase price, had been different during the past crop season? What effects would such a difference have on changing the behavior and performance of the grain system through time and up to its current state? Or "what if" barley purchase price policy were changed now? What would be the consequences of such an action compared with continuing past policy for, say, two years into the future?

A *second* category of problems of interest to government officials are problems in current policy administration. Here model users are interested in asking "how" types of questions. For example, planning studies may indicate a desirable seasonable price pattern for the upcoming year, or the president may set by decree limits on domestic grain prices. "How" should government release programs be administered to best meet these objectives? How much government grain will be needed? What about the timing and amounts of government grain release? What pricing should the government set on these release grains, and what about replenishing government grain stocks?

The *third* category of problems of potential interest can be referred to as crisis situations. The world grain situation may suddenly change, world grain prices soar, and/or fuel prices jump. Or perhaps a recent drastic change in domestic grain policy is observed to have unanticipated bad effects. Model users who are contending with these situations may be asking "now what" types of questions. For example, world wheat prices begin to soar and the government (as in 1974) raises the price of wheat flour by some 60 per cent. Wheat demand drops; but subsequently rice demand increases and domestic rice prices begin to rise, seemingly in an uncontrollable fashion. Now what should the government do? Should it pour huge amounts of government rice or mixed grains on the market to attempt to bring price into control? What combination of release prices should they seek? Should they lower flour prices and pay increased subsidies to flour millers? Should they increase barley releases, lower or increase barley prices, or should they undertake a combination of the above actions in dealing with the crisis?

A general description is in order of the design orientation of the GMP with respect to some specific policy and program issues of the first two categories mentioned above; namely, problems of grain policy planning (and development) and problems of administering existing grain management operations. It is hoped that the reader, after becoming familiar with some of what the model can do, will begin to see for himself how it can be used in complex grain crisis situations as a guide and an analytical tool for government officials searching for cures.

Annual Food Plans

The utility of the GMP model as a grain management tool is greatly enhanced by including the capability of formulating alternative annual food (grain) plans and measuring the consequences of these plans in conjunction with seasonal grain management policies and programs. Basically, a food (grain) plan consists of estimates of food grain requirements and supplies for the upcoming year. Food grain requirements are estimated as the total of expected food requirements of farm and nonfarm households; government requirements for use of military and government institutions, prisons, and relief; requirements for livestock feed; seed requirements for the next planting season; and requirements for food processing and industrial use. Expected waste and losses are also counted in the total requirement estimate. Food grain supplies are estimated as the total of expected production for the upcoming crop year, plus carry-in — *plus* programmed imports, which are given values to equate supplies with expected requirements.

A number of ways can be taken in arriving at estimates of household food grain requirements, depending on the issues at hand. For example, relative world market prices may be such that grain management officials responsible for developing a particular food (grain) plan may desire to change the diet mix of food grains (rice, barley, and wheat) to economize on foreign exchange expenditures for food grain imports. Self-sufficiency goals for certain food grain commodities may be important issues to officials formulating a food plan. In deciding on a zero import requirement for these commodities, officials developing the food plan must be reasonably confident that domestic supplies are adequate to support normal consumption levels over the period of the plan and/or that supplies of substitute grains are planned adequately to preclude drastic price increases in the "self-sufficient" commodities. Socially tolerable limits of shifts in consumption patterns to less preferred food grains must also be considered from a political standpoint. The basic price structure of food grain may also be of primary concern, since food grains likely play a dominant role in the consumer price index. In short, formulating a typical food plan requires keen concern over economic, social, and political implications.

Generalized Demand-Price Analyzer. Government officials engaged in formulating a basic annual food (grain) plan are concerned with both quantities and prices of food grains for the upcoming planning period. The generalized demand-price analyzer (a derivation of which is detailed in chapter 15) enables the model user to specify a mix of prices and/or demands for food grains for a particular food plan. The model then uses linear algebraic techniques to solve for the unspecified prices and/or demands, the result being a full set of annual average food grain prices and demands that are consistent with the Korean food grain demand system specified in the model.

If a specific food (grain) plan requires that domestic supplies be supplemented by imports, the government must import the required amount of grains during the upcoming year and assure that they are available (and in the right amounts) when needed. Such a plan also will require that basic (annual) food grain price levels and relationships during the upcoming year realize the planned consumption levels of rural and urban populations. The government will have to monitor prices throughout the year and administer its domestic grain operations to assure that these annual price levels are met. The GMP model can provide guidelines into these (and other) types of operating and management problems.

Seasonal Price Policies

Establishment of annual food plans and appropriate importation of deficit food grain commodities by government will not assure domestic seasonal price stability. Domestic food grain prices may vary widely during the year, depending on available market supplies. These variations, if too large, can have adverse effects on both farm and urban populations, especially the lower-income groups. To assure seasonal price stability in domestic food grain prices, it may become necessary for the government to monitor current market conditions and play an active role in domestic grain dealings (buying and selling).

Seasonal price policy objectives may vary from striving to keep domestic prices within tolerable bounds to targeting prices to follow precise seasonal patterns. Choosing a desirable seasonal price policy (or a *set* of seasonal price policies for the different food grains) is important in influencing the overall grain system to operate in a desirable manner [133, 134]. Various seasonal price patterns can influence farm consumption behavior, farm storage and marketing behavior, farm income from grains, and the amount of domestic grains made available for urban consumption. Price patterns also affect the storage and marketing behavior of the private marketing subsector (complementary to government marketing activities). Given proper price incentives, the private subsector can be motivated to function as an effective grain storage and distribution system for moving and processing large amounts of domestic grains over time from farmers to urban consumers.

The GMP model can be used to investigate effects of various seasonal grain price policies on the performance of the overall grain system. Just how the GMP model can be used to guide the actions of the government to assure that domestic food grain prices behave in a prescribed manner is discussed below.

Seasonal Price Control. Given seasonal price objectives, government officials must closely monitor market prices and order appropriate government market activities when prices begin to stray from the desired patterns. Information on current market prices is often delayed in getting to decision makers. This information may have inherent measurement errors, for example because of imperfect market surveys or human errors in compiling vast amounts of data. Faced with this information, government officials must act in ordering the next day's grain releases or scheduling grain releases over, say, the next week. Normally the analytical tools available to these government officials are few, if they exist at all. Mostly, these decisions are made on the basis of hand calculation, past experience, and human intuition. Some officials may become quite skilled at ordering government grain releases in the appropriate amounts and in a timely manner to control urban food grain prices. Others may miss early signals of impending trouble and delay releases or not release appropriate amounts to head off market price rises. Suddenly, prices may soar out of control, requiring huge amounts of government releases to bring them down again.

The seasonal price control mechanism developed for the GMP model simulates the decision processes involved in attempting to control market prices to prespecified targets. Automatic feedback control techniques are used to monitor current market prices, to compare these prices with desired price patterns, and to generate corrective government grain activities (buying and/or selling) to influence market prices to follow desired seasonal patterns.

Figure 47 depicts the basic design of the price control mechanism developed for the GMP model. Important points along the figure are lettered to assist the following narrative description. Point A of Figure 47 identifies the desired seasonal price patterns that are reference inputs to the price control mechanism. These price patterns represent what grain management decision makers feel would produce the "most desirable" grain system response in meeting the objectives of seasonal price policies. Several alternative seasonal price patterns can be tested with the model to arrive at a "most desirable" pattern.

Point B identifies the error signals that are produced by comparing desired price patterns with information on actual price patterns produced by the simulation model.

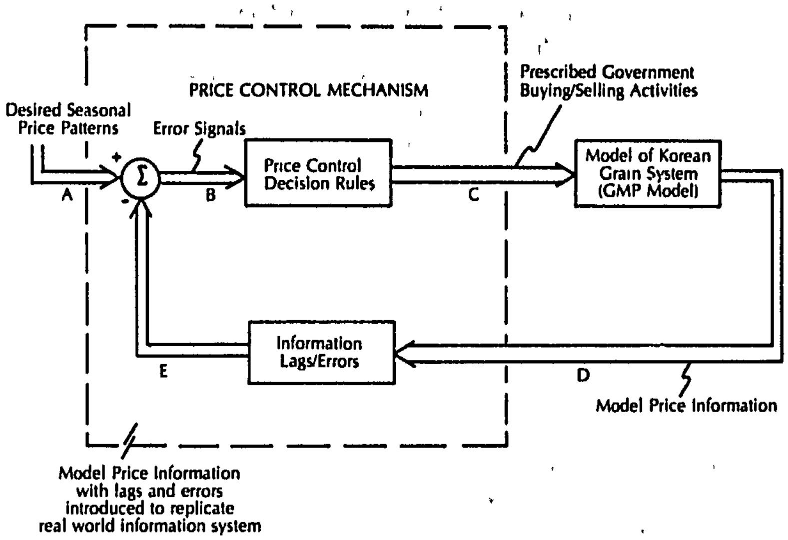

FIG. 47. Seasonal price control mechanism.

Point C identifies the prescribed government buying and selling activities produced by applying specific decision rules to error signals represented at point B. These decision rules are developed by model designers, using system control theory and a process of trial and error, until the resulting prescriptions produce the most acceptable system responses.[5]

Point D identifies food grain prices produced by the GMP simulation model with the government undertaking the actions prescribed at point C. These model prices are then fed back into the price control mechanism for comparison with desired price patterns. Note that an attempt is made to replicate information lags and errors in observing market prices (point E). This is done to effect a control design more applicable to the real-world situation.

In using the GMP model for determining actual government buying and selling activities required to control market prices, the following approach might be taken:

1. The GMP simulation model is initialized as closely as possible to the current real-world situation, including current food grain price levels, rates of change of prices, system inventory levels, current urban consumption demand, and other states of the real-world system reflected in the model.

2. The model is run over a desired time horizon, say, one year, to determine a tentative schedule of government grain activities (e.g., the amounts and timing of government grain releases) required to control (urban) food grain prices to desired patterns.
3. The schedule of government grain activities derived in step 2 is used for the basic planned scheduling for government grain releases. As time evolves, real-world prices will almost certainly deviate from the desired patterns. This error is due to model errors, measurement error in the real world, incomplete model specification, and random disturbances that affect the real-world system.
4. To compensate for the price deviations observed in step 3, a release schedule for corrective action is determined, again using the system model. This time the error signals observed in the real world are input to the model price control mechanism. These prescribed corrective action releases are then superimposed on the original basic plan for government grain releases.
5. The above process is repeated as frequently as necessary to keep the model prescriptions well in line with the real-world situation.

Foreign Grain Import Scheduling

The annual food plan mechanism described earlier can be used to approximate the level of foreign grain imports necessary to keep annual price levels in line with price policy objectives. Scheduling of foreign grain imports, however, is an important decision process that can be very costly if not managed properly. Foreign grains that arrive in-country during times of high inventory levels require prolonged storage times or increase the storage time requirements of existing government stocks.

For reasons of national security and to assure adequate buffer stocks for seasonal price stabilization, it is also necessary for the government to maintain reserve grain stock levels at some minimum level. The GMP model can be used to determine import scheduling required to assure that government reserve stock levels do not dwindle below minimum acceptable levels, regardless of government release (and domestic purchasing) programs designed for seasonal price control. The mechanism used in the model uses automatic feedback control techniques in much the same manner that they are used for controlling domestic position-point inventories. Government stock levels are monitored by the model and compared to minimum reserve stock level requirements. When stock levels are observed to be approaching minimum acceptable levels, new import orders are commanded. The intensity and timing of these orders are attuned with current government domestic purchase and release activities and compensate for lag times between import orders and deliveries.

Government Purchase Programs

In carrying on government price stabilization (and control) programs, it is necessary for the government to play an active role in the domestic grain markets. We have described the important aspects of the seasonal price control mechanism of the GMP for controlling urban food grain prices through government grain releases. The government also has an influence on farm market price behavior through its grain release programs, because urban and farm market prices are *connected* in the real-world system as well as in the GMP model. However, no attempt is made in the model (or in the real world) to influence farm prices in any predetermined manner through government releases. A more direct linkage with farm market prices is gained through government purchase programs. Korea does not have an active program for controlling farm prices, because the government purchasing programs always occur during and immediately following the harvest season. The primary objective of these programs is to replenish government grain stocks from domestic supplies. One of the resulting consequences of the increased demand after harvest that is due to these purchasing programs is the dampening after harvest of farm price declines that normally occur. This is considered a "good" result of purchase programs but not a primary motive for the programs. The GMP price controller is designed to prescribe both government purchase and release patterns necessary for controlling either or both farm and urban prices to prespecified seasonal targets. Variations of current purchasing programs can also be investigated by the model, without strict farm price control as the primary objective. Programs of extended buying periods, and/or increasing government buying price throughout the buying period to motivate farmers to store their grains longer before marketing can be investigated [134].

Government Grain Management Procedures

Another group of policy issues to which the design of the GMP model is oriented are questions of management procedures used on government-controlled grains. The government traditionally purchases paddy rice from farmers, since the paddy form increases storability. However, the storage space requirement of paddy rice, being approximately twice that of brown rice (hulled rice), oftentimes puts a critical strain on existing storage facilities. Overflows are often piled out-of-doors or placed in very inadequate storage facilities and are subject to high losses. Solutions to such problems are usually prescribed as construction of additional government warehouse capacity. Alternatives to the construction solution exist, and the design of the GMP model is oriented to allow the study of several of these alternatives. For example, to take the pressure off government storage facilities, a portion of government domestic rice purchases could be received in brown (hulled) form. These grains would require one-half the storage space of those in paddy form and could be milled and moved onto the market before government grains stored in rough form. Another management alternative for government grains may be to hull government rice in production areas in amounts necessary to eliminate inventory overflows and then to re-store it in brown rice form. When needed in consumption areas it could be milled in production areas or moved into consumption areas in brown rice form and milled there in government-licensed mills normally operating only in imported grains. Additional handling costs are, of course, inherent in such alternatives to grain management procedures. The feasibility of such activities rather than construction of additional warehouse facilities, or simply letting overflows occur during peak periods, would require very detailed investigation. The GMP model is designed to aid in such studies.

Government Warehouse Construction Programs

In the GMP model government warehouse construction programs have less significance when the model is used for short-term policy issues — say, one to two years. However, when using the GMP model for addressing longer-term policy issues or when running the model in conjunction with the Korean Agricultural Sector Model (KASM), government warehousing programs may have major implications in grain management policy formulation. Specific warehousing construction programs may themselves be the central issue in a particular grain management program study. In such instances, this component of the GMP model stands able to provide important information to researchers and decision makers.

Government-owned or -leased warehousing facilities are classified into five major categories: (1) low-temperature, (2) Class A, (3) Class B, (4) Class C, and (5) auxiliary storage. These categories are based on construction design and suitability for grain storage, with the low-temperature facilities being most elaborate and Class C and auxiliary being least elaborate, usually deteriorated in condition and least suitable for grain storage. Each of these warehouse classifications has inherently different unit construction costs (or storage charges, if not owned by the government) and storage loss characteristics over the four seasons of the year. Government warehouse construction programs are allowed to build additional warehouse facilities in the first three categories (low-temperature, Class A, and Class B), but not in the latter two (Class C and auxiliary). Class A and Class B facilities depreciate over time to lower categories.

The government warehousing component allows government construction programs in each of the first three categories and a choice of construction location in seaports, production areas, or consumption areas. The model then monitors the amount, distribution, and location of government warehousing facilities through time, on the basis of new construction programs (if they exist), the normal declassification process of Class A and B facilities, and the salvage and disappearance of Class C and auxiliary facilities.

The government warehousing component is also linked with the government grain operations model. That is, the position-point storage capacities and loss rates applied to government grain inventories of the government operations model are consistent with the government warehousing component.

SYSTEM PERFORMANCE

The third and final category of the GMP model design is system performance. Model design under this category is perhaps not as difficult as modeling the operational grain system and orienting the model to address real-world problems, but it is certainly just as important. Without meaningful measurement of system performance, model users have the means for neither judging among alternative grain management policies nor analyzing the results of model runs. Careful attention must be given to the design of system performance measurements to assure that they are consistent with the model user's needs. These needs are best defined by potential model users themselves (i.e., policy analysts and decision makers); therefore, much interaction is required between these people and model designers.

Several types of system performance measurements can be output from the GMP model. Information can be presented in a form and in the units requested by model users.

Forms of Model Output

Regardless of what information is made available from a simulation run, it is always helpful to have an option of viewing the information in several forms. Specially designed summary tables are one option for viewing results of GMP model runs. Although the model simulates the operations (and measures performance) of the grain system through time, model users are often concerned about summary information describing system performance over a specific period of time. Users of the GMP model have the option of defining the periods for which summary tables are output, as well as which tables are output. In analyzing model results, however, oftentimes it is helpful, and necessary, to know the time paths actually traveled by particular system variables. The GMP model gives the user the opportunity of viewing any set of model variables (including performance criteria) in time series form. These series can be output in tabular and/or plot form, depending on the request of the user. The user can also specify which variables appear together on the time series plots and/or tables.

Operations Performance

Table 17 summarizes some of the important system operation performance measurements available to model users. Time series of these variables have a one-to-one correspondence with variables generated in the grain system operations model, although the user has an option of specifying the interval at which the time series are output. Summary tables present information about the performance of model time series variables in a number of ways. For example, average values for some variables, such as prices, inventories, and consumption rates, are calculated and presented in summary tables. Maximum and minimum values attained by time series variables are also presented if such information is deemed necessary. Even the calendar dates of when maximums and minimums are observed to occur are printed in various summary tables which are available to model users. Many other system performance variables not indicated in the table are also available.

Accounting

The GMP model provides detailed cash flow analyses for all subsectors. Such information is very important performance criteria in analyzing various grain management problems. Table 18 summarizes some of the important accounting data provided by the GMP model.

Special Criteria

Depending on the issues at hand, special performance criteria can be measured and presented to model users to assist them in determining the consequences of particular grain management programs and policies. For example, use of the model in determining the effects of critical food grain shortages (brought about by a hypothetical world crop failure, warfare, or other reason) and developing plans for dealing with such a crisis situation may raise questions regarding nutrition levels, nutritional deficits, and even death rates from starvation. Other uses of the model — say, to determine the effects of radical changes in grain management policy or changes from normal diet levels or diet mixes of food grains — are possible, and the model can be altered to generate appropriate performance indicators to measure these effects. Model users working with technicians can develop any number of special criteria to be used in analyzing such questions.

TABLE 17
Grain System Performance — Operations

Variable	Unit	Farm		Urban		Private		Government		Total System	
		Time Series	Summary Tables	Time Series	Summary Tables	Time Series	Summary Tables	Time Series	Summary Tables	Time Series	Summary Tables
Production	MT/yr*	X									
	MT		X								
Imports	MT/yr					X		X		X	
	MT						X		X		X
Sales	MT/yr	X				X		X			
	MT		X				X		X		
Purchases	MT/yr			X		X		X			
	MT				X		X		X		
Consumption	kg/cap/yr†	X	X	X	X						
	MT/yr	X	X	X	X						
	MT		X		X						
Inventories	MT	X	X	X	X	X	X	X	X	X	X
By form	MT	X				X		X			
By position	MT	X	X	X	X	X	X	X	X	X	X
Carry-overs	MT		X		X		X		X		X
Stock changes	MT		X		X		X		X		X
Processing	MT/yr					X		X			
	MT						X		X		
Population	people	X	X	X	X						
Prices	won/bag	X	X	X	X						

*MT — metric tons
yr — year
†kg/cap/yr — kilograms per capita per year

TABLE 18
Grain System Performance — Accounting

Variable	Unit	Farm		Urban		Private		Government	
		Cash Flow	Summary Tables	Cash Flow	Summary Tables	Cash Flow	Summary Tables	Cash Flow	Summary Tables
Revenues									
Grain sales	won/yr*	X				X		X	
	won		X				X		X
Product sales	won/yr					X		X	
	won						X		X
By-product sales	won/yr					X		X	
	won						X		X
Value of grain consumption	won		X						
Expenditures									
Domestic production cost	won/yr	X							
	won		X						
Grain purchases	won/yr			X		X		X	
	won				X		X		X
	won/HH†				X				
Grain operations	won/yr					X		X	
	won						X		X
Processing	won/yr	X				X			
	won		X				X		X

Storage	won/yr			X		X	
	won				X		X
Credit	won/yr	X		X		X	
	won		X		X		X
Foreign exchange (imports)	won/yr					X	
	won						X
Payments to principle and interest (imports)	won/yr			X		X	
	won				X		X
Subsidy payments	won/yr					X	
	won						X
Warehouse construction	won/yr					X	
	won						X
Administration	won/yr					X	
	won						X
Cash Flow Analysis							
Gross returns	won/yr	X		X		X	
	won		X		X		X
Value of stock level changes	won		X		X		X
Net returns	won/yr	X		X		X	
	won		X		X		X
	won/HH		X				

*yr — year
†HH — household

Model Performance

To this point we have described some of the important information furnished by the GMP model regarding the performance of the *simulated* system. The model also monitors its own performance. When using the model to investigate various seasonal price stabilization or control strategies, the user is furnished with summary information on how well these strategies actually work to influence (simulated) market prices to move along targeted seasonal patterns. Many comparisons between targeted and resulting price patterns are made. Some of these comparisons can be displayed in a format like the following:

Price Measurement	*Unit*	*Target*	*Results*
Average	won/bag	—	—
High	"	—	—
Low	"	—	—
High/low ratio	no unit	—	—
Maximum rise	percentage/yr	—	—
Maximum fall	"	—	—
Average trend	"	—	—
Coefficient of variation	no unit	—	—

The model also maintains a data bank of important grain statistics from past years. This bank is used for two major purposes: (1) model testing and tuning, and (2) automatic model initialization.

Designers of the GMP model realize that if the GMP model is to gain and maintain credibility as a viable analytical tool for grain management, it must be under continual scrutiny and testing to improve its performance and keep it attuned to the changing real world [170]. The GMP data bank provides model designers and users with automatic access to important grain statistics needed to determine how accurately the model can reproduce past data. Users can compare time series data from tables or plots on which empirical data are overlayed on model-generated data of the same variable. The model also can provide statistical information on "fits" between model-generated and empirical data, such as sum of least squares, coefficients of determination (R^2), and B-coefficients, which regress model results on empirical data.

The data bank also serves for automatic model initialization at any time point in the past for which data are present. The GMP data bank currently contains monthly and annual statistical data from 1966 through the later part of 1977. Table 19 indicates some of the specific time series present in the GMP data bank. Maintenance of this bank with current and accurate information is crucial if the model is to serve its role as a grain management tool, ready to provide timely and valid analyses of current grain management problems.

A SAMPLE OF *GMP* MODEL TESTING AND RESULTS

Previous discussion has described the basic concept of the GMP model, indicated some of the procedures used in its design and suggested some of the wide range of potential uses that can be made of the model. To accomplish this overall perspective of the model, it has been necessary (for the most part) to discuss the model in very general abstract terms. With this background, we can now demonstrate a sample run of the model with some specific model testing and results.

The Example

In this example of GMP model results we limit ourselves to two runs of the model. Both runs serve to demonstrate the kinds of credibility testing (see chapter 2) to which the GMP model is constantly subjected. The time period under investigation for both runs is the three-year period beginning 1 January 1974 and ending 31 December 1976. Although this is now an historical period, the reader should note that absolutely no information regarding market prices, consumption rates, or any other endogenous model variables beyond the initial starting conditions on 1 January 1974 has been provided to the model. This includes model parameter estimates such as consumption elasticities which were based on time series data available before 1974.

Historical Tracking. The first run tests the GMP model's ability to replicate the real-world grain system operations and provides a base with which other run results can be compared. The model is initialized (automatically) at the beginning of the run from data provided from the data bank representing consumption levels, market prices, food grain stock levels, etc., prevailing on 1 January 1974. The model then proceeds to step through time, calculating all system variables at increments of 1/200 year (1.8 day) intervals for three years. Government policies and grain activities such as buying and release prices, imports, domestic purchases and releases are input to the model from the data bank and represent actual real-world values (according to available data) for these variables throughout the model run.[6]

Grain Management Policy Alternative. Judging from what has already been said about the scope of the GMP model for investigating a wide range of grain management issues, the reader should realize that it is impossible to demonstrate all aspects of the model in a single alternative run. We choose here a very simple example:

TABLE 19
GMP Data Bank for Model Initialization, Historical Tracking, and Grain Policy Analysis (December 1976)

Series Description	Unit	Period of Data (Year, Month) Start	End	Data Points
Monthly prices received by farmers (Polished equivalent)				
Rice	won/80 kg*	66.1	76.8	128
Barley	won/76.5 kg	66.1	76.8	128
Wheat	won/76 kg	66.1	76.8	128
Monthly consumer prices (Seoul)				
Rice	won/80 kg	66.1	76.9	129
Barley	won/76.5 kg	66.1	76.9	129
Wheat flour	won/22 kg	66.1	76.9	129
Government purchase prices				
Rice	won/80 kg	1965	1976	12
Barley	won/76.5 kg	1965	1976	12
Government release prices by month				
Rice	won/80 kg	66.1	76.9	129
Barley	won/76.5 kg	66.1	76.9	129
Monthly price indexes				
Consumer price index (excluding cereals)	(1970=1)	66.1	76.9	129
Wholesale price index (excluding grains)	(1970=1)	66.1	76.9	129
Monthly consumption				
Rice (farm)	kg/cap/yr†	66.1	76.8	128
(urban)	"	66.1	76.8	128
Barley (farm)	"	66.1	76.8	128
(urban)	"	66.1	76.8	128
Wheat (national)	"	66.1	76.7	127
Monthly inventories				
Rice (farm)	MT‡	66.1	76.8	128
(government)	"	66.1	76.10	130
(urban)	"	66.1	76.8	128
Barley (farm)	"	66.1	76.8	128
(government)	"	66.1	76.10	130
(urban)	"	66.1	76.8	128
Wheat (national)	"	66.1	76.7	127
Monthly farm sales				
Rice	MT/mo.§	66.1	75.9	117
Barley	MT/mo.	66.1	75.5	113
Monthly government purchases				
Rice	MT/mo.	66.1	76.10	130
Barley	MT/mo.	66.1	76.12	132
Monthly import arrivals				
Rice	MT/mo.	66.1	76.9	129
Barley	MT/mo.	66.1	76.9	129
Wheat	MT/mo.	66.1	76.9	129
TOTAL				3,855

*kg — kilogram
†kg/cap/yr — kilograms per capita per year
‡MT — metric tons
§mo. — month

> Suppose the government wishes to investigate the consequences of undertaking an active urban rice price control program to attempt to influence urban rice price to move along a prespecified seasonal pattern. The government also requires some prescriptive guidelines as to just how it should manage its release program to achieve this seasonal price pattern. To sweeten the example a little further, suppose the government also undertakes an import policy to replenish its stocks of rice from foreign imports only to the extent of maintaining its rice stock levels at a minimum of 400,000 metric tons. The government requires guidelines for scheduling import orders to maintain this minimum stock level.

For a sound comparison between model results of the baseline run and this policy alternative run, all other government policies and grain activities (other than rice releases and imports) are identical in the two runs; government purchase programs remain the same, and government buying and release prices remain the same.

Historical Tracking Results

Figures 48 through 51 illustrate a limited set of the system time series variables generated in the baseline (historical tracking) run of the model.[7] Data from the GMP data bank are plotted along with model-generated variables so that the reader has a clear view of just how well the model performed during this test run. Tracking performance is also measured quantitatively through the use of various statistical measurements (see Table 20). Figure 48 illustrates the consumption of rice and barley by the farm population. These series were chosen to demonstrate the ability of the model to represent the substitution effect between rice and barley consumption, especially in the farm population where it is normally more prevalent. Although these results appear good, other tests of the model indicate that the consumption behavior equations used in the model perform much better when provided actual farm and urban market prices. The reader must recall that these functions are driven by model-generated prices.

Figure 49 illustrates government rice inventories, modeled and actual, throughout the period of the baseline run. Other system inventories such as farm, private market, and urban household inventories could also be illustrated but are not included in order to simplify the illustration. The seemingly poor performance of the model in reproducing government inventories during the period actually points out another potentially useful aspect of the model — verification of data consistency. In this run, all government grain activities were input from historical data, i.e., government purchases, government releases, and imports. The government rice

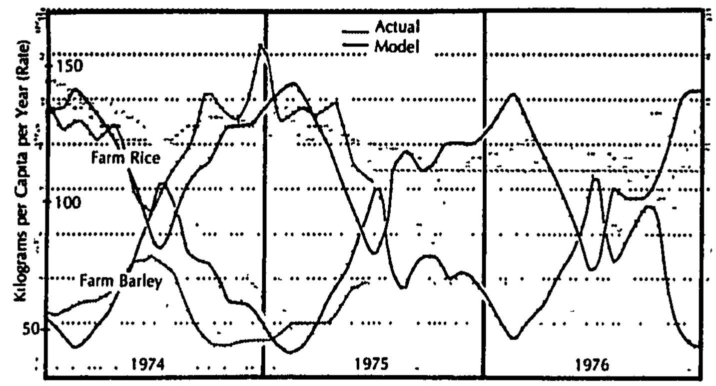

FIG. 48. Food grain consumption tracking.

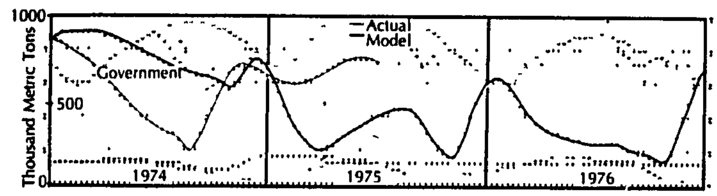

FIG. 49. Rice inventory tracking.

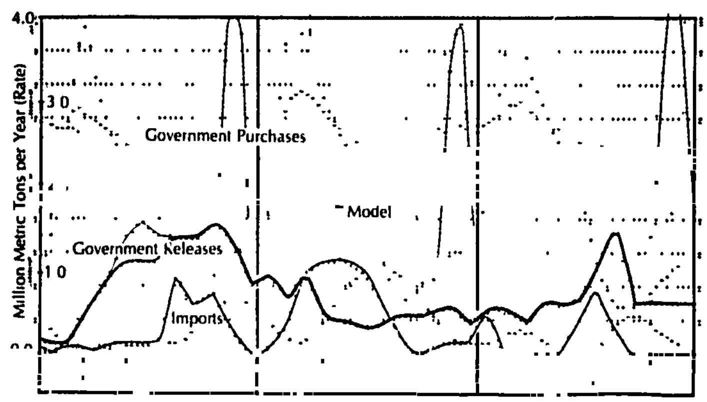

FIG. 50. Rice marketing activities.

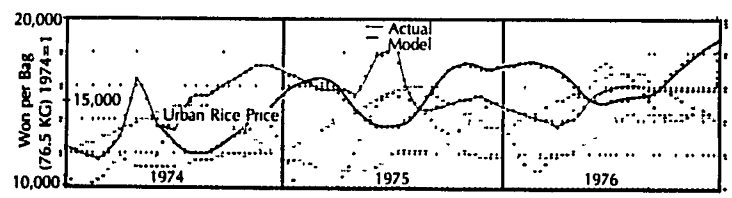

FIG. 51. Urban rice price tracking.

inventory level generated is merely an accounting of government grain accumulations from this data, indicating an inconsistency in official government data — either in grain activities reported, inventory levels, or both.[8]

Figure 50 illustrates a portion of rice marketing activities during the period of the historical tracking run. Government rice purchases, releases, and imports are shown. Private market purchases and sales as well as farm sales and urban purchases that equal the sum of government and private purchases and sales, respectively, could also be shown; but this would make the figure much too difficult to follow. The reader will later be asked to refer back to this figure to compare the changes in government grain activities (releases and imports) prescribed in the policy alternative run.

Figure 51 illustrates the greatest challenge to the GMP model — simulating market prices. The figure displays actual versus model urban market rice price during the period of the run.[9] These results represent the culmination of much hand tuning of the model (the process of assigning values to model parameters affecting the pricing function). In all, close to ten major parameters (tuning knobs) are involved in the performance of the pricing functions. This is far too many parameters to adjust simultaneously by hand to achieve maximum model performance — it is like tuning an engine carborator with ten needle valves without the aid of a machine. Nevertheless, model designers are pleased with the level of performance indicated. Model prices are not bounded in any way, precluding the situation present in many simulation models where model variables, more often than not, *ride the bounds*. Hand tuning of the pricing function indicates that the GMP model has the parameters and model construction to alter the behavior of the pricing functions in virtually any conceivable manner. All that is needed is some automated assistance in finding the proper value of these parameters to maximize model performance. Computerized optimization packages suitable for such tasks are available and can be applied to explore the parameter space of the model efficiently to attain (undoubtedly) much more accuracy [26].

As mentioned in an earlier section, the GMP model provides various measurements of its own performance in tracking key variables. Some of these measurements are given in Table 20 for the key variables discussed above and others not discussed.

Policy Alternative Results

We have now established a baseline for making judgments regarding the outcomes of alternative grain management policies. Although it has been made clearly evident that the model is far from perfect in accurately reproducing past grain system performance, it is important to note that

TABLE 20
Historical Tracking Performance

Key Variable	Rice			Barley*		
	Measurement of Performance			Measurement of Performance		
	SSE†	B-coef‡	R^2§	SSE	B-coef	R^2
Farm price	.255 (12%)	1.88	.325	.248 (12%)	.231	.082
Urban price	.213 (11%)	.409	.385	.212 (11%)	−.333	−.467
Farm consumption	.271 (12%)	.517	.522	.593 (18%)	.412	.091
Urban consumption	.037 (5%)	.359	.388	.534 (17%)	.283	.628
Farm inventories	.113 (8%)	.994	.975	1.509 (29%)	1.345	.895
Farm sales	NA‖	.800	.654	NA	.499	.387

*Poor performance in barley is indicated because most model-tuning effort at time of run had been devoted to rice. Much improvement in performance can be expected.

†Sum of square errors (number in parentheses is percentage of error).

‡B-coefficient of regression equation when model results are regressed on actual data (should be one).

§Coefficient of determination with sign (should be one).

‖Not available because of program error (bug).

whatever deficiencies the model has in the baseline run are also present in alternative runs. If the model has invalid initialization data, invalid input variables, or invalid accounting coefficients in the baseline run, then the same information and parameters are present in the second run. If these model deficiencies cause errors in model results, these errors should run in the same directions in both runs, tending to cancel when comparisons are made between run results.

Figures 52 through 55 illustrate the same time series variables that were illustrated from the historical tracking (baseline) run. The reader is free to view the two sets of plots and make any comparisons he wishes. Of most interest, however, is to note the changes in government imports, government stock levels, and government releases of rice indicated between the two runs (Figures 49, 50, 53 and 54). Figure 55 illustrates the targeted seasonal urban price policy for rice under investigation along with actual (simulated) urban rice price realized by undertaking the government releases indicated in Figure 54. The figure indicates that the strategy used in the model for observing actual and desired price behavior and issuing release orders was quite successful in achieving the desired results. This strategy will not be discussed here in detail except for one point: the reader's attention is called to the early warning capability of the urban rice price control strategy. Sizable government releases are called for long in

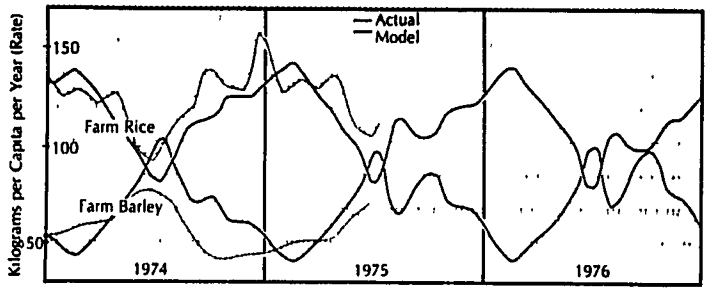

FIG. 52. Food grain consumption policy alternative.

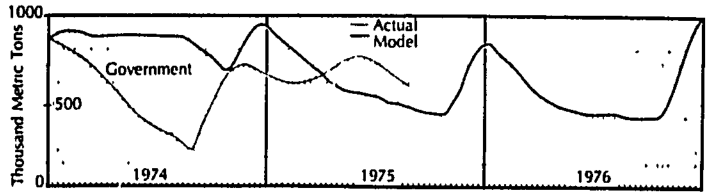

FIG. 53. Rice inventory policy alternative.

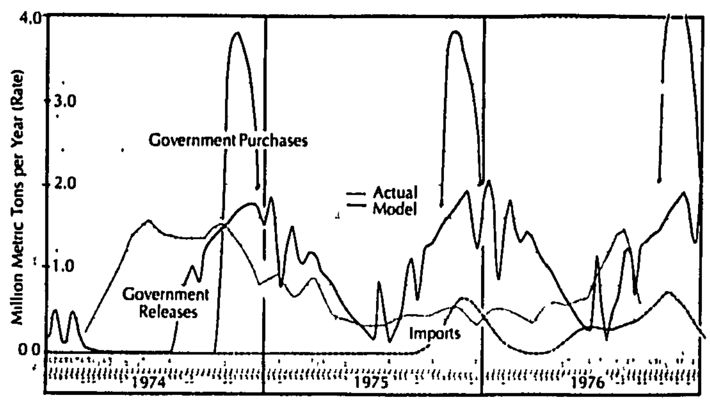

FIG. 54. Marketing activity policy alternative.

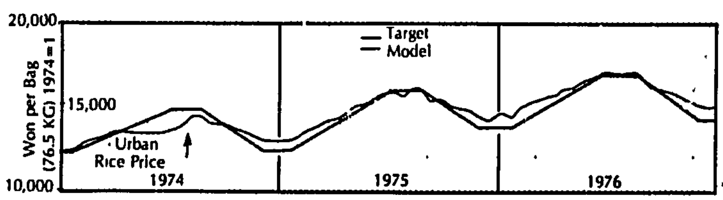

FIG. 55. Urban rice price control.

advance of the time urban prices move above target levels. This can be seen by noting the position of the arrow in Figure 55, which indicates the time at which government releases are begun in order to turn urban prices downward.

Comparisons of Test Runs Results

Thus far we have presented some of the highlights of the results of both the baseline (historical tracking) run and the policy alternative (urban rice price plus rice import control) run. The plots and performance tables serve a useful purpose but give little information as to which of the two runs produced the *best* results. Many comparisons can be made to make this determination, depending on the objectives of the grain management policy under consideration. Oftentimes both good and bad consequences will be indicated for particular policy alternatives under study; however, it is up to the decision maker to weigh these results and make the final determination.

The basic question here is this: Would Korea's food grain situation be better (or worse) today if the government had undertaken the grain management policy alternative studied in the second run of the example? As has been done throughout this example, we must severely limit ourselves in the comparisons and analyses made between the two test runs under consideration.

Table 21 enables the reader to compare selected items, such as imports, farm commercial sales of food grains, government share in the market, food grain consumption, etc., between the two test runs. The table also provides information on actual data on these selected items for 1974, 1975, and 1976. Comparisons between actual data and baseline results will (with the other information already given) help to establish the level of credibility the reader wishes to give the model for this particular test. The table is fairly self-explanatory and will not be further discussed.

Table 22 presents the impact of both runs on a pseudo grain management special account. Baseline, policy alternative, and a comparison of run results is given in the table for calendar years 1974, 1975, and 1976. The table gives an abbreviated analysis for 1974 and 1976, and a more detailed analysis for 1975. Major line items in the table are (1) revenues, (2) expenditures, and (3) stock changes. Net account changes are also indicated for each year and are simply revenues minus expenditures plus the value of stock changes. The table gives run results for rice, barley, and wheat accounts. A total accounts column is also presented. In 1974, the table states that the baseline run indicated a 94 billion won (approximately 235 million U.S. dollars) loss in total grain accounts. The policy alternative run indicated an 82 billion won loss in total grain accounts for 1974.

TABLE 21
Comparison of Selected Items for Model Test Runs
(in thousands of metric tons or kilograms per capita per year where applicable)

Selected Items	Calendar Year 1974			Calendar Year 1975			Calendar Year 1976		
	Actual Data	Baseline Run Results	Policy Run Results	Actual Data	Baseline Run Results	Policy Run Results	Actual Data	Baseline Run Results	Policy Run Results
Imports	252	253	0	480	483	153	165	160	278
Farm sales	1,805	2,192	2,230	2,095	2,429	2,294	NA*	2,497	2,427
Government	756	623	641	780	524	654	789	672	779
Private	1,049	1,569	1,589	1,315	1,905	1,640	NA	1,825	1,648
Urban purchases	2,781	2,534	2,643	2,567	2,563	2,585	2,621	2,395	2,624
Government	1,092	937	572	484	523	1,021	687	484	1,160
Private	1,689	1,597	2,071	2,083	2,040	2,564	1,934	1,911	1,464
Human consumption	4,390	4,180	4,152	4,354	4,113	4,215	4,391	3,962	4,185
Average per-capita	127	121	120	123	116	119	121	110	116
Urban consumption	2,757	2,617	2,610	2,567	2,522	2,619	2,621	2,427	2,634
Average per-capita	130	125	125	119	117	122	117	108	118
Farm consumption	1,665	1,563	1,542	1,787	1,591	1,596	1,770	1,535	1,551
Average per-capita	123	115	114	129	114	115	128	111	112

* NA — not available

TABLE 22
Grain Management Special Accounts (in billions of won)

Line Item	Baseline Run Results				Policy Alternative Results				Comparison of Run Results			
	A Rice	B Barley	C Wheat	D Total	E Rice	F Barley	G Wheat	H Total	E-A Rice	F-B Barley	G-C Wheat	H-D Total
Results for Calendar Year 1974 (Abbreviated Analysis)												
Revenues	141	43	...	184	93	43	...	136	−48	0	...	−48
Expenditures	172	50	61	283	139	51	61	251	−33	1	0	−32
Stock changes*	−16	21	...	5	12	21	...	33	28	0	...	28
Account changes	−47	14	−61	−94	−34	13	−61	−82	13	−1	...	12
Results for Calendar Year 1975 (Detailed Analysis)												
Revenues	101	45	...	146	199	45	...	244	98	0	...	98
By-product sales	1	2	...	3	1	2	...	3	0	0	0	0
Product sales	100	43	...	143	198	43	...	241	98	0	...	98
Expenditures	202	75	18	295	190	75	20	285	−12	0	2	−10
Domestic purchases	117	47	...	164	159	47	...	206	42	0	...	42
Foreign purchases	70	14	...	84	15	14	...	29	−55	0	...	−55
Subsidies†	...	...	18	18	...	...	20	20	...	...	2	2
Grain operations	15	14	...	29	16	14	...	30	1	0	...	1
(Handling)	(11)	(10)	(−)	(21)	(13)	(10)	(...)	(23)	(2)	(0)	(...)	(2)
(Processing)	(2)	(1)	(−)	(3)	(1)	(1)	(...)	(2)	(−1)	(0)	(...)	(−1)
(Storage)	(2)	(3)	(−)	(5)	(2)	(3)	(...)	(5)	(0)	(0)	(...)	(0)
Stock changes	−44	48	−	4	−23	48	...	25	21	0	...	21
Account changes	−145	18	−18	−145	−14	18	−10	−16	131	0	−2	129
Results for Calendar Year 1976 (Abbreviated Analysis)												
Revenues	114	35	...	149	269	35	...	304	155	0	...	155
Expenditures	45	74	10	129	287	76	10	373	242	2	0	244
Stock changes	−113	12	...	−10	42	12	...	54	155	0	...	155
Account changes	−44	−27	−10	−81	24	−29	−10	−15	68	−2	0	66
Summary Results for 3-Year Period 1974–76 (Abbreviated Analysis)												
Revenue	356	123	...	479	561	123	...	684	205	0	...	205
Expenditures	419	199	89	707	616	202	91	909	197	3	2	202
Stock changes	−173	81	...	−92	31	81	...	112	204	0	...	204
Account changes	−236	5	−89	−320	−24	2	−91	−113	212	−3	−2	207

*Difference between opening and ending inventories values at period-end prices
†Table does not reflect policy change in wheat subsidies made in early 1976.

Comparing these results, the table states that a 12 billion won savings was indicated in the policy alternative run for 1974. Summary results are also given for the three-year time period of the test. Table 22 states that a 207 billion won (approximately 431 million U.S. dollars) savings was indicated in the policy alternative run results for the three-year period. A 212 billion won savings (under the policy alternative) is indicated in the rice account over the three-year period, while barley and wheat accounts show 3 and 2 billion won losses, respectively.

The savings in the rice account indicated in Table 22 are derived from two major sources: (1) delayed sales of government grains at increased prices, and (2) differences in import levels and in changes of stock levels. Some overall savings are indicated in grain operations costs for the three-year period but, as can be seen in the table, the policy alternative run actually resulted in a greater cost of grain operations in 1975.

Interpreting the Results

A very brief review of the comparisons between the two test runs has been given. Much more analysis of the results would be necessary to form a sound judgment if the model were being used in a real-world decision process. Evidently, as indicated by the model, the government may have realized major savings between 1974 and 1976 by establishing an import policy similar to the one studied in the policy alternative. There are also indications that the government may have been delinquent in making upward adjustments in rice release prices. These price increases are implied by the delayed releases that occurred after price increases were already in effect. The increased release prices did not seem to hinder the effect of government releases on the control of urban rice price.

The reader, no doubt, has begun forming his own opinions and questions regarding the results of this test example. If he were working with the GMP he would undoubtedly ask for more analysis or alternative runs to help substantiate his interpretations and answer questions brought to light here. Such activity is what the GMP model is all about — relieving the user of the drudgery of calculation, while at the same time lending insight into the complexities of managing the food grain system.

15
food grain pricing analysis: periodic pricing decisions by government

Alan R. Thodey

Governments have long been involved in influencing the price level of food grains. Their involvement has increased markedly in recent years, especially in the developing countries. It ranges from establishing food grain import and export policies to achieve desired price levels and other objectives to intervening directly in the market in support of those objectives. At one extreme, this direct intervention takes the form of complete government control and operation of the marketing system — from producer to final consumer. At the other extreme are relatively small-scale buffer stock and price stabilization programs aimed at normalizing the flow of grain through the marketing system by buying and storing in periods of relatively low prices and selling when prices approach unacceptably high levels. Subsidies aimed at lowering final consumer prices frequently form an integral part of these programs.

In deciding "target" price levels, governments generally attempt to achieve multiple objectives, each objective being weighted subjectively. One of the commonly sought objectives is to increase farm output through price incentives. In some countries such as Korea, the objective of increasing output is also accompanied by a desire to raise farm income levels relative to nonfarm incomes. At the same time, there is a desire for prices to be sufficiently low that wage earners are able to achieve a reasonable level of living, including an adequate diet. Such objectives are often contradictory and require compromise in implementation. These compromises, in turn, are conditioned by such factors as fiscal, monetary, and foreign exchange limitations, as well as by limited government administrative capacity. Deciding how well various alternative prices satisfy the sought objectives within related constraints requires careful and detailed analysis, particularly in situations in which several major food grains are consumed.

This chapter presents one approach to the analysis of the consequences of alternative price levels as bases for setting government price targets on a periodic basis, such as several times per year. The analysis employs a relatively simple, one-period projection model specifically designed to indicate the consequences of alternative prices on selected policy variables. As such, it is a problem-solving model. The actual selection of the set of prices that "best" meets the objectives of the government must ultimately be the responsibility of the policy makers, although such an analysis can produce recommendations as a basis for such a decision.

The model described was first developed and used in the Republic of Korea in mid-1974 to analyze alternative selling prices for government-owned rice stocks and imported wheat so as to prevent the existing government rice stock from being exhausted before the next rice harvest four months away [106]. As such, it formed one of several analyses used by the Food Bureau, Ministry of Agriculture and Fisheries, in making its selling price recommendations to the government. Subsequently, it has been used to analyze the consequences of alternative producer prices for rice and barley to be purchased by the government in the months following harvest as part of the government grain management program [103, 104, 105]. The model is described in detail elsewhere [165].

FOOD GRAIN PRICING IN KOREA

After two decades of decreasing involvement, the Korean government began increasing its role in the grain marketing system at the beginning of the Third Five-Year Economic Development Plan in 1972. It is now a major handler of grain — equivalent to 38 and 52 per cent of rice and barley nonfarm consumption, respectively, in rice year 1975 — and the primary determinant of grain prices. At the producer level, the government is the major buyer of grain in the months following harvest; the price is announced just before the government begins to buy and sets the basis for all producer-level prices during the purchasing period. Following this period, producer prices are jointly set by the private marketing system and the National Agricultural Cooperative Federation, although these prices are influenced by government release prices. Because the government buys rice at one uniform price and does not offer a premium for the preferred traditional varieties, it tends to buy mostly the newly introduced but less-preferred "tongil" high-yielding variety rice. The private and cooperative marketing system is then left to set the premium for the preferred traditional varieties.

Since June 1974, the government has marketed all of its rice and much of its barley as mixed grain (70 per cent rice and 30 per cent pressed barley), most of it being sold directly to consumers through government-controlled outlets. In addition some grain (mixed grain and barley) is released into the wholesale markets when rice and barley prices are tending towards unacceptably high levels. These releases occur at prices set periodically (now twice per year, previously once per year) by the government, and they have some influence on wholesale price levels. Such releases result in a relatively stable relationship between government release prices and private market prices. All rice and barley imports are handled by the government and are sold in the same way as domestically produced supplies.

Wheat is imported by a flour millers' association and the government subsidizes the cost difference between the millers' cost and the controlled selling price for wheat flour. Hence, all three major food grains — rice, barley, and wheat — are included in the government's grain management operations. Beginning with rice year 1974 (1 November 1973 — 31 October 1974), the cost of this program has risen dramatically. The total deficit amounted to more than $1 billion by 31 October 1975, including more than $500 million incurred during rice year 1975.

THE KOREAN GOVERNMENT'S FOOD GRAIN PRICING DECISION

The government of Korea plays a dominant role in determining producer and consumer food grain prices in support of various objectives. The major objectives are (not in order of importance): (1) self-sufficiency in rice and barley — increased production and decreased consumption, (2) improved real farm incomes (in approximate parity with nonfarm incomes), (3) reasonable food grain prices for wage earners (consistent with rising real incomes and major industrialization and export promotion programs), (4) control of inflation in food prices, and (5) minimization of foreign exchange expenditure.

In weighing various alternative purchase and release prices, the government considers their effect on the above objectives, as well as on various other aspects of the agricultural sector and the total economy. Some of the factors considered are:

1. Supply factors
   - — Effect on the level of real farm income
   - — Ratio between prices received and paid by farmers
   - — Effect on next year's supply of grain

2. Demand factors
   — Effect on the level of real nonfarm income
   — Contribution to inflation as indicated by the price indexes of food grains and all consumer goods
   — Effect on the level of per capita farm and nonfarm grain consumption
3. Supply-demand balance factors
   — Effect on the level of self-sufficiency as indicated by potential grain surpluses (grain reserves) and deficits (imports)
   — Effect on the level of foreign exchange requirements
   — Effect on the change in the deficit in the government's grain management (special) account used to subsidize the marketing of grain

The actual selection of the prices considered to best achieve the objectives sought is a political decision. During the political process weights must be placed on each objective so that the objectives can be traded off against one another. Because of this need for weighting, the analyst considers various alternatives, obtains the consequences of each alternative, and then ranks them in terms of how well they satisfy the objectives sought. These results then provide an input into the decision process for selecting the final set of prices.

DESCRIPTION OF THE ANALYTICAL MODEL

Given the objectives above and the existing availability of relevant data in Korea, it was possible to construct a relatively small, one-period model to evaluate the effect of alternative government purchase and release prices on the factors listed. This model, known as the annual grain price policy analyzer (AGPPA), makes its projections by applying various change parameters to a set of initial conditions and then accounting for the consequences of the resulting changes. The central component of the model is a system of demand equations that project the per capita demand for the three most important grains — rice, barley, and wheat flour — separately for the farm and nonfarm populations, given the set of prespecified government purchase and release prices.[1] These projections are based on the per capita demand for each grain in a base period adjusted for the effect of changes in the real price of each grain (direct price effect), the real price of the other two grains (substitution effect), and the level of real income (income effect). The matrices of price elasticities used are critical in determining the reasonableness, as well as the stability, of the resulting projections: after trying several alternative methods to estimate cross-price elasticities of demand, a method using a set of substitution proportions was finally used.[2]

AGPPA contains three main operating steps. First, values for the exogenously determined (prespecified) variables and parameters are introduced for the farm and nonfarm sectors, as appropriate. These are grouped as follows:

1. Estimated per capita grain consumption in the base period
2. Projected price and income elasticities of demand
3. Projected population
4. Estimated producer, consumer, and government prices in the base period
5. Projected prices (of imports and domestic wheat) and price relationships (of government to market prices)
6. Projected nongrain price index and consumer price index weights
7. Estimated base period and projected income
8. Projected industrial grain consumption
9. Projected area, yield, and cost of production
10. Projected harvesting, storage/marketing, and import losses and processing ratios
11. Projected bag weights
12. Projected government grain handling and management costs

Second, the values of the prespecified policy variables are indicated. These are:

1. Proposed government purchase (quantity) targets of rice, common barley, and naked barley
2. Proposed government purchase price of rice, common barley, and naked barley
3. Proposed government release price of rice (equivalent price in mixed grain), barley, and wheat flour[3]

And finally, AGPPA converts some of the prespecified data and projects selected variables on the basis of prespecified relationships, including:

1. Conversion of proposed government purchase targets to metric tons
2. Conversion of proposed percentage changes in government purchase and release prices to a price per bag at the producer, wholesale, and consumer levels
3. Projection of production and consumable domestic output
4. Projection of average producer and consumer prices (based on 2 above)
5. Projection of gross and net farm income and the proportional change in real per capita farm income over a reference period
6. Projection of per capita de... and total human and industrial consumption requirements
7. Projection of quantity and foreign exchange costs of imports re-

quired to fill the gap between the projected requirements and the consumable domestic supply of each grain (and ratio of self-sufficiency)

8. Projection of government grain management costs (change in the deficit in the grain management special account)
9. Projection of level of the consumer price index for grains and for all items

The model is structured to project one period ahead from a base period, which is generally a best estimate of the current situation. The projection period can be of any time length, such as one season or one year, but it must be the same length as the base period. For the grain and consumer price indexes, a reference period that may precede the base period is permitted; however, the reference and base periods may coincide. On the supply side, four commodities are included — rice, common barley, naked barley, and wheat. On the demand side, three commodities are included — rice, barley, and wheat flour (or in some cases, wheat).

EXAMPLE OF MODEL APPLICATION

Policy Assumptions

Seven alternative sets of purchase and release prices were analyzed for the rice purchase price decision in rice year (RY) 1976 (1 November 1975 to 31 October 1976). As barley purchase prices had been raised the previous July and rice and barley release prices and wheat flour prices the previous April, the average increase (weighted equally by month) of barley and wheat flour prices in the previous year was assumed to represent the average increase during RY 1976. The alternative increases considered in rice prices are shown in Table 23.

TABLE 23
Percentage Increases in Rice Prices by Alternative
(Percentage Change from RY 1975)

Alternative	Rice Purchase Price	Rice Release Price*	Other Prices for All Alternatives	
1	20	20	*Purchase Prices*	
2	20	30	Common barley	22.1
3	25	20	Naked barley	22.1
4	25	25		
5	25	30	*Release Prices*	
6	30	20	Barley	20.6
7	30	30	Wheat flour	20.0

*Based on the equivalent price of rice sold as mixed grain, assuming barley prices as given.

The alternative price changes selected were judged to represent the most likely range of rice prices that would be considered by the government on the basis of the following factors:

1. The price increases announced earlier in the year for grains, particularly barley.
2. A rise of 29.6 per cent above the previous year's price in the private market price of medium-quality rice by July 1975.
3. Increases in the index of prices paid by farmers throughout Korea of 18.4 per cent for farm supplies, wages, and charges; and 22.9 per cent for all consumption items during the year to June 1975.
4. Increases in the consumer price index in all cities of 27.7 per cent for all items, 51.4 per cent for cereals, and 21.4 per cent for all noncereal items during the year to June 1975.
5. A negligible increase of .8 per cent in the index of all prices received by farmers relative to that of prices paid by farmers in the year ending June 1975 (the previous year this parity ratio fell by 3.2 per cent).
6. Farm productivity was projected to be possibly 5 per cent higher, because of a projected rice production increase of up to 3.6 per cent and a decline in the number of farm families of 1.8 per cent.
7. Even though Korea was possibly self-sufficient in rice in RY 1975, it had a strong desire to build buffer stocks during the next few years by encouraging rice production (partly through favorable producer prices) and discouraging rice consumption (partly through unfavorable relative consumer prices).
8. A desire on the part of the government to reduce its grain management deficits, partly by increasing release prices relative to purchase prices.

The government purchase targets assumed in the analysis are shown in Table 24.

TABLE 24
Government Grain Purchase Targets

Grain	Purchase Target		Harvested Production* (thousands of metric tons)	Target as Percentage of Production
	Cost Basis	Quantity (thousands of metric tons)		
Rice	Target RY 1976	1,008	4,387	23
Barley				
Common	Actual 1975	182	823	22
Naked	Actual 1975	338	1,161	29
Wheat	Actual 1975	...	127	...

*Crop-cutting survey yield adjusted for harvesting losses and seed.

The target for rice was already determined by the government on the basis of its past experience and financial, administrative, and logistical capacity. The purchase targets for barley had already been achieved several months earlier.

Results of Analysis

Farm income (net return to farm resources) per household from rice was projected to rise by 27 to 40 per cent at most above its level in RY 1975 as the average producer price was raised by 20 to 30 per cent, respectively (Table 25). Three factors worked together to raise income per household faster than the average increase in prices: (1) average production costs were assumed to have risen by 18.4 per cent above those in RY 1975, (2) average yield was projected to increase by 3.6 per cent, and (3) the number of farms was projected to decline by 1.8 per cent. The average increase in farm income from all grains was projected to be even more favorable, ranging from 31 to 43 per cent. The actual increase in farm income could be expected to be less because the actual outcome of the three factors above was likely to be less favorable than projected.[4] Also, the "real" increase in income would be much less because of the effect of price inflation. For example, the index of prices paid by farmers for all consumption items rose by 22.9 per cent during the year to June 1975.

Under the price increases assumed for farm and nonfarm households,[5] Table 26 indicates that per capita rice and wheat flour consumption was projected to increase and barley consumption to decrease in RY 1976. The only exception was in farm households that responded to a 30 per cent increase in producer rice prices — their per capita rice consumption declined slightly (0.4 per cent). These changes were offsetting and resulted in per capita total grain consumption being relatively stable — the change from RY 1975 for farm households was projected to be only from −0.2 to 0.3 per cent and for nonfarm households from 0.6 to 1.1 per cent. The changes in per capita grain consumption resulted more from the effect of increased real income (e.g., assumed to be 8 per cent for nonfarm households) than from the effect of increased real grain prices. In fact, a 20 per cent increase in purchase and release prices had no effect on consumption, since a 20 per cent increase in nongrain prices (the deflator to obtain real grain prices) was assumed. Hence, the effect of 4.2 and 8.3 per cent real increases in rice prices were indicated by grain price increases of 25 and 30 per cent.

The total consumption requirement can be estimated by applying a population projection to the per capita consumption estimates (Table 26). Although total farm requirements were projected to decline, they were more than offset by projected increases in nonfarm consumption (Table

TABLE 25
Projected Consequences of Alternative
Purchase and Release Prices for Rice in Rice Year 1976

Alternative	Farm Income per Household* (percentage change from RY 1975)		Total Consumption Requirement (percentage change from RY 1975)						Self-Sufficiency Index†		Foreign Exchange Costs‡ (millions of U.S. dollars)	Change in GMSA Deficit§ (billion won)	
			Rice			Total Grains							
	Rice	Total	Farm	Nonfarm	Total	Farm	Nonfarm	Total	Rice	Barley		Rice	Total Grains‖
1	27	31	−.7	5.6	3.4	−1.7	4.3	2.2	101	101	369	44	108
2	27	31	−.7	4.1	2.4	−1.7	3.9	1.9	102	101	372	25	89
3	34	37	−1.4	5.6	3.1	−1.9	4.3	2.1	101	101	370	53	127
4	34	37	−1.4	4.8	2.6	−1.9	4.1	2.0	102	101	372	44	107
5	37	37	−1.4	4.1	2.2	−1.9	3.9	1.9	102	101	373	34	98
6	40	43	−2.1	5.6	2.9	−2.0	4.3	2.0	101	102	371	63	127
7	40	43	−2.1	4.1	1.9	−2.0	3.9	1.8	102	101	374	44	108

*Return to land, capital, labor, and management per farm household. Increase in return from common barley, naked barley, and wheat projected at 69, 53, and 35 per cent, respectively, under all alternatives.

†Self-sufficiency index = $\frac{\text{consumable domestic production}}{\text{total consumption requirements}} \times 100$. Wheat and total grains projected to average 4 and 78 per cent, respectively, under all alternatives.

‡Wheat only (rice and barley surpluses assumed to be stockpiled rather than exported).

§The change in the grain management special account deficit indicates the cost to the government of its grain operations. Deficit for barley and wheat projected at 24 and 28 billion won, respectively, under all alternatives ($1 U.S. = 485 won).

‖Includes 11 billion won for interest on the accumulated GMSA debt as of October 31, 1975.

Source: [103], Tables 2-7.

TABLE 26
Projected Per Capita Grain Consumption under Alternative Rice Prices in Rice Year 1976

Increase in Rice Purchase or Release Price (percentage above 1975)	Unit	Per Capita Farm Consumption				Per Capita Nonfarm Consumption			
		Rice	Barley	Wheat Flour	Total	Rice	Barley	Wheat Flour	Total
20	kilograms per capita	108.5	63.7	37.7	209.9	123.8	44.7	42.6	211.2
25	kilograms per capita	107.8	63.6	38.0	209.4	123.0	44.8	42.9	210.7
30	kilograms per capita	107.0	63.4	38.4	208.9	122.1	44.9	43.2	210.2
20	percentage change from 1975	1.0	−2.0	−2.1	.3	2.0	−2.8	2.5	1.1
25	percentage change from 1975	.4	−2.1	2.9	.0	1.4	−2.6	3.2	.8
30	percentage change from 1975	−.4	−2.4	4.0	−.2	.6	−2.4	3.9	.6

25). These changes, however, were largely explained by a 1.8 per cent decrease in the farm population and by 3.5 and 1.5 per cent increases in the nonfarm and total populations, respectively.

Comparing the consumable output (production adjusted for harvest and market losses and self-produced grain fed on farms) with the human, industrial, and purchased feed consumption requirement, Table 25 indicates that Korea was expected to be self-sufficient in rice and barley in RY 1976. A similar achievement was expected in RY 1975 when the buildup in stocks was expected to exceed imports; in fact, the projections were somewhat optimistic since a slight short-fall occurred. Nevertheless, even near self-sufficiency was a noticeable achievement, since Korea had imported a significant proportion of its rice and barley supplies in previous years. With self-sufficiency achieved in RY 1976, only wheat imports were necessary. This resulted in a drop in foreign exchange costs of about 40 per cent below FY 1975 levels under all alternatives.

The cost of government grain management operations (GMSA deficit in Table 25) in RY 1976 was projected to range from 89 to 127 billion won (184 to 262 million U.S. dollars), including interest of 11 billion won on the accrued debt. The percentage of change from RY 1975 ranged from a decline of 20 per cent (alternative 2 — a 20 per cent increase in purchase prices and a 30 per cent increase in release prices) to an increase of 15 per cent (alternative 6 — reversing the percentage of increases of alternative 2).

The impact of the three alternative rice release prices — 20, 25, and 30 per cent above the average for RY 1975 — on the grains component of the consumer price index (CPI) was 20, 25, and 29 per cent, respectively. Assuming an average increase of 20 per cent in the nongrain components of the CPI, the overall increase in the CPI was 20, 21, and 22 per cent, respectively.

Policy Suggestions

The criteria for deciding government grain prices in RY 1976 was the effect of alternative prices on (1) the level of price inflation, (2) the level of "real" and money income per farm household from grains, (3) the production of grain in RY 1977; (4) the cost to the government of its grain management operations; (5) rice and barley self-sufficiency; (6) foreign exchange expenditure for grain; and (7) the adequacy of grain consumption, especially by lower-income households. The actual order of importance of these factors depended upon the weight the government attached to each of them.

Probably the most important of these factors for RY 1976 was the cost to the government of the prices selected. Not only was there an overall budget limitation, but there was also increasing awareness of the role the resulting deficit had been playing in the overall rate of inflation in Korea. In addition, the differential effect on the other factors appeared to be of less significance. For example, goals of achieving self-sufficiency in rice and barley production and in achieving parity of farm and nonfarm incomes (in terms of real living standards) were relatively close to being satisfied. Hence, it seemed that food grain pricing policy should be directed towards maintaining the parity of farm incomes while cutting substantially the cost of government grain management operations. This suggested that the increase in rice release prices should run ahead of the increase in rice purchase prices by 5 to 10 per cent (such as in alternatives 2 or 5).

This type of analysis highlights the interdependency of (1) purchase and release prices; and (2) the supply, demand, and price situation for all food grains, and (3) the need for all of these factors to be considered in formulating a grains pricing policy in Korea. The trend in Korea towards considering more than one price at a time is encouraging and should be continued.

SUMMARY AND CONCLUSIONS

Through the use of a relatively simple problem-solving model — the annual grain price policy analyzer — it has been possible to provide a better basis to the government of Korea for formulating its food grain pricing policy. This model incorporates a system of demand equations to project simultaneously the per capita demand for three food grains in the farm and nonfarm sectors in the next period. The projection of other relevant policy variables is based on prespecified relationships with the use of these demand projections and other exogenous estimates and projections.

AGPPA was developed for a specific purpose, and its results must be interpreted within that context. Its main purpose is to provide projections of variables considered relevant to the periodic setting of government purchase and release prices under alternative sets of prices. One result of its use has been to encourage increased consideration of the consequences of alternative sets of purchase and release prices for several grains.

Several modifications of the model are possible that would significantly improve its usefulness. First, the rice-barley mix is really a separate grain, with its own distinct demand characteristics, and thus should be included separately in the model. Data are expected to become available shortly that would permit the relevant parameters and relationships to be estimated. Second, the model currently does not project the effect of the cost of government grain operations on overall price levels (assuming that it continues to add to government borrowings). Third, by restructuring the model, it seems possible to set it within a linear programming framework, which would permit purchase and release prices to be derived that would optimize the most important policy objective; the remaining policy objectives would be incorporated as constraints.[6] Fourth, by incorporating a set of supply response functions, the model could provide projections of the impact of alternative prices on food grain supplies in the following year. And finally, alternative import and buffer stock policies, dependent on either time or quantity, could be incorporated into the model.

CHAPTER 11

1. After the groupings were first identified and used in the model, it became desirable to separate the resource allocation decisions for vegetables into summer, fall, and winter vegetables. Similarly, the resource allocation model disaggregates potatoes into sweet and white potatoes. These three supply activities are then added together for interaction in the demand-price-trade component.

2. However, for such purposes as estimating base-period prices and average nutritional value, each commodity within the group is weighted according to its base-period quantity.

3. A detailed description and critical analysis of the Korean agricultural data system are contained in [35].

4. Data are considered consistent when (1) the same variable is measured in exactly the same way over time, (2) different measures of the same variables are identical, and (3) the sum of various component parts of a variable equal the total derived by an alternative method.

5. The estimation procedures employed are described in [164].

6. See Alan R. Thodey [164], chapter V.

7. This is reported further in chapter 13.

CHAPTER 12

1. Other studies had already investigated investment options in crop improvement research and extension. For example, see [50]. Indeed, this study, which used KASM as one of its analytical tools, provided the analytical basis for decisions by the Korean and U.S. governments to finance and carry out a crop improvement research program in Korea.

2. Indexes of national average rice consumption are not plotted since the policy alternatives are assumed to affect directly nonfarm consumers only.

3. Since Korea's domestic rice price is about double the world price, it is assumed Korea cannot export surpluses. If government export subsidies were given to encourage exports, stocks would not rise so high.

4. Prices are constrained to fall no more than 5 per cent per year *in real terms*. If a 10 per cent inflation rate is assumed, this would mean prices are constrained to rise *at least* 5 per cent per year in nominal terms.

CHAPTER 13

1. For more background information on grain policy in Korea, see [90, 131, 134, 159, 170].

2. Computer costs for a run of the GMP vary considerably depending on the length of run, size of simulation increment, amount of analysis and output required, the particular computer used, etc. The test runs described at the end of this chapter cost approximately $25 on the MSU Control Data 6500 computer. Cost in Korea on a CDC Cyber 70 would be somewhat less for the same runs.

3. Production costs for high-yielding "Tongil" varieties exceed traditional variety costs by about 20 per cent. In 1974, Tongil yield was estimated to be 34 per cent greater than traditional varieties, giving a positive influence on the diffusion process with 40 per cent more area going into Tongil production in 1975 [156]. In 1972, however, Tongil yields suffered from bad weather conditions and exceeded ordi-

nary yields by only 20 per cent. This caused a negative effect on the diffusion process with Tongil area declining by 26 per cent in 1973.

4. Although Figure 46 is fairly well annotated, a brief narrative description of the figure will help bring across the basic concept of the design. Key points along the figure are lettered to assist in the narrative description. Readers not interested in this amount of detail are asked to skip over the following discussion.

Point A of the figure corresponds to the inventory error signal mentioned above. This signal is the net difference between actual observed inventory level at position II and the desired inventory level represented at point H of the figure.

Point B corresponds to the normal response action that would be undertaken by inventory managers for position II. Decision rules used in correcting errors in position II inventory may depend on the magnitude of the error, how fast the error is changing, and how long it has persisted.

Point C represents replenishment orders placed by position II inventory managers to cover the loss of stock that is due to fulfilling orders placed by position III managers. The smoothing lag function is used to calculate the average rate at which stocks are being depleted.

Point D represents the total or net orders placed for adjusting position II inventory toward the desired level. Note that although it was mentioned earlier that managers cannot control inventories downward by shipping grain stocks to succeeding positions, grain stocks can still be controlled downward by not replenishing stocks as fast as they are removed. Suppose, for example, the control signal at point B calls for the depletion of position II stocks at a rate of 1,000 metric tons per day. Suppose also that position III is receiving stocks from position II at an average rate of 2,000 metric tons per day. The replenishment order signal at point C of the diagram is then 2,000 metric tons per day. Net orders placed represented at point D would then be 1,000 metric tons per day, meaning that position II stocks would realize a net depletion rate of 1,000 metric tons per day.

Point E represents the constrained orders for adjusting position II inventories. We have already mentioned several limitations and constraints, such as existing stocks at position I, milling capacities, transportation capacities, etc. "Call-forward" and one-way flow limitations are also assured by the system constraint function.

Point F is a time-lag function of the order signal at point E, representing filled orders from position I into position II inventories. Note that orders in process are considered as remaining in position I inventory until delivered to position II.

Point G is a signal representing the rate at which stocks are being removed from position II inventory.

Point H is the desired level at which inventory managers at position II would like to maintain their inventories. For normal operations, managers simply desire stock levels adequate to sustain their operations for a predetermined length of time. These stock levels are planned so as to give managers the ability to respond to sudden rises in demand (orders) from succeeding position points and time to replenish their stocks.

5. To become more specific, a series consumption proportional-plus-derivative-plus-integral control scheme is used in the design of the price controller. The matrix equation below describes the design for controlling urban rice and barley prices simultaneously.

$$\begin{bmatrix} GMKTSU_1 \\ GMKTSU_2 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} PUER_1(t) \\ PUER_2(t) \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \frac{d}{dt} \begin{bmatrix} PUER_1(t) \\ PUER_2(t) \end{bmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \int_{t_0}^{t} \begin{bmatrix} PUER_1(t) \\ PUER_2(t) \end{bmatrix} dt$$

where:

GMKTSU = government grain release orders — metric tons/year
PUER = error signal — observed deviation between desired price and actual prevailing market price — won/bag
a,b,c = control parameter matrices

The elements of the control parameter matrices in the equation describe how government release orders (should) respond to the various functions or the error signals. The diagonal elements describe release orders in response to own price errors (e.g., rice releases to control errors in urban rice prices), while the off-diagonal elements describe release orders required to compensate for cross effects among commodity prices being controlled [46].

6. By altering these *actual* government policies and grain activities, users could investigate the "what if" type questions mentioned earlier in this chapter.

7. The number of variables illustrated must be severely limited to avoid confusion for the reader, and to avoid the ever present hazard of too much detail for the purpose at hand.

8. Discrepancies between actual and model-generated government activities (purchases and sales) will be indicated in later summary tables. This is a subtlety of this particular test run, which has the farm and urban market choice mechanism operating. Government *demand* and *supply* throughout the run correspond to data bank values of government *purchases* and *sales*, respectively. Therefore, model-generated government activities will be somewhat different than actual. Other tests of the model indicate that what has been said about the inconsistency of official government data is true; discrepancies in government activities from actual in this run make some differences in the final results, but the inconsistencies are still evident in runs which produce exact values of government purchases and sales.

9. The food grain system in Korea in early 1974 was in a state of much flux. Price tracking has proven to be very difficult through this period, and therefore was not started until early May 1974 in this particular run.

CHAPTER 15

1. As finally used in Korea, AGPPA requires that government purchase and release prices be prespecified. Then it solves for projected per capita demand. The initial model was more general, since it permitted any combination of prices and per capita demands to be prespecified and then solved for the remaining variables (three for each population). See [165], appendix 8.

2. The elasticities estimated from regression analysis proved to be sufficiently inconsistent that they could not be used directly. This appears to be the result of various nonprice and nonincome factors not included in the statistical analysis of time series data. Instead, the income elasticities used were obtained from the analysis of the most recent cross-section data; own price elasticities, from the analysis of time series data on the basis of reasonableness and of consistency with other estimates; and cross-price elasticities, from judgments by food grain specialists about how the other two grains substitute for each grain as its own prices change. An important factor considered in making these judgments was the historical tendency for total grain consumption in Korea to remain relatively stable, despite substantial shifts in the consumption of individual grains. See [165], appendix B.

3. The average factory selling price of wheat flour is controlled by the government, rather than by the flow of flour stocks directly.

4. This occurred, in fact, with the yield of rice, where disease and weather factors resulted in a lower-than-expected yield.

5. Average producer prices for farm households and average consumer prices for nonfarm households.

6. The basis for such a model, identified as the "Optimum Prices Submodel — AGPPA 2," is described in [165], appendix C.

Part 5

CHAPTER 17

1. Based upon U.S. standards.

2. William A. Mehrens and Steven M. Downing, "Candidate Selection Procedures: Multinational Program of Study in Systems Analysis for Developmental Planning," Training Program Paper (East Lansing: Michigan State University, 16 April 1974).

Part 5

CHAPTER 18

1. In May 1973, a KASS Issue Paper [160] explained to decision makers how the then-current KASS model could be used in preliminary planning for the Fourth Five-Year Plan; and in summer 1973 a one-week workshop was held for decision makers and economic analysts in government and private agencies to explore the major methodologies and research findings employed by KASS.

2. After project approval was given by MAF in 1972, it took considerable time to locate the appropriate people, process them through the AID/ROKG training program, and get them accepted in U.S. institutions.

3. Some of these staff members received training grants from other than AID sources.

Part 5

CHAPTER 19

1. Examples include Lee [118], who projected technological change in Korean agriculture, with the use of CLASS delay routines for lags in the acceptance of innovation and CLASS table functions for the allocation of resources to education and extension work for the diffusion of innovations; Nweke [139], who, in his model of Nigerian forestry demand, used CLASS distributed delay routines to model the replacement needs for wooden structures, CLASS table functions for

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