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INITIAL ESTIMATES OF PRICE AND INCOME ELASTICITIES OF MAJOR AGRICULTURAL COMMODITIES FOR BOLIVIA AND ECUADOR FROM TIME SERIES DATA

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AN INTERIM PROGRESS REPORT OF INITIAL ATTEMPTS TO ESTIMATE PRICE AND INCOME ELASTICITIES OF MAJOR AGRICULTURAL COMMODITIES FOR BOLIVIA AND ECUADOR FROM TIME SERIES DATA

The purpose of this report is to present the initial results of attempts to estimate price and income elasticities for selected agricultural products in Bolivia and Ecuador. The report is not final in any way, and does not pretend to cover the broad objectives of the study mentioned below.

The format followed in this report is essentially the same as that expected to be followed in the final version of the overall study. As mentioned above, this report only includes what has been done to this point in achieving the objective of this research effort. Consequently, the substance of the final version of the study should differ from this report. In the final version the review of literature will be more complete. A background section will be added including material on the development of the agricultural sector in post World War II years, and on policies surrounding agricultural prices (objectives 1, 2, and 3 below). The conceptual models, the data, and the statistical results will all be modified as additional data and information are gathered, and further insight gained into the institutions which surround the markets for such products in each country (objective 4 below). Finally, a section on policy conclusions and recommendations will be added based upon the results from the final rounds of estimation (objectives 5 and 6 below).

Introduction and Problem Statement

The development of new seeds has significantly increased production of cereal crops in many less developed countries.[1] While much of the increase has come in Asia, Mexico has had successes, and other Latin American and African countries may be expected to adopt the new seeds. Countries that were importers of rice and wheat a few years ago, are now counting the foreign exchange to be earned from exporting such crops. Concurrently, economists are concerned with possible market excesses, of less developed countries gaining access to world markets, and the internal adjustments implied by large increases in production in less developed countries.[2]

At the same time, the pioneering effort of the Ford and Rockefeller Foundations in developing the new cereal varieties has spurred on research efforts to develop other higher yielding varieties of cereal crops (especially sorghums). Almost certainly this will precipitate further research on improving cereals, and production of other crops (both vegetable and animal) through improved strains. Such research will eventually be translated into production increases.

An essential element in the increased production of wheat and rice has been the use of irrigation and fertilizers with the improved seeds. Indeed, the use of only the seeds, or the seeds and fertilizers alone, have had little effect on production.[3] Irrigation is critical to yield response with improved seed varieties. Irrigation also plays a role in increasing the output from traditional seeds if used in conjunction with fertilization. However, little evidence exists on this point.

Utah State University is attempting to help increase food production in arid and sub-humid lands of less developed countries through an inter-disciplinary research effort, with emphasis on improved water management. Irrigation engineers, agronomists, and plant breeders are conducting production-interaction and drainage-salinity experiments in several Latin American countries to determine optimum production practices. At the same time, agricultural economists at Utah State University are involved in evaluating the economic efficiency of alternative land and water management practices, and their primary and secondary economic benefits and impacts.

This study was undertaken as an initial effort to obtain basic information necessary to assess some of the economic impacts from increased agricultural production. The purpose of the study was to quantify the effect of changes in the supply of and demand for various agricultural crops on equilibrium prices and quantities (and hence, rural income). This was done by estimating the structural parameters of the markets for various commodities. The demand side must be considered since changes in demand affect the profitability of adopting the new production techniques as well as the feasibility of public investment which might be associated with the program.

This study concerns both Bolivia and Ecuador. Bolivia has moved to self-sufficiency in the last ten years in the production of sugar, rice, and cotton. Ecuador has imported 55 percent to 65 percent of its total wheat consumption in every year between 1952-1966, but is mainly self-sufficient in all other food commodities and exports bananas, coffee, cocoa, and some rice. A Rockefeller program in improved

potato varieties has more than doubled traditional yields of this important vegetable. Recently experiments with IR-8 rice has shown the feasibility of rapidly increasing the production of this cereal in Ecuador. As these countries adopt the new water management-seed fertilizer techniques, further increases in production can be expected. Given favorable circumstances, both may possibly move to self-sufficiency in the production of wheat as well as other crops. Consequently, knowledge of the price and income elasticities of these key agricultural crops is of vital concern in planning for the future of the agricultural sector. For example, what effect will increases in production have on prices and rural income? How will increases in income affect demand for various crops?

The recent world-wide developments in the technology of agricultural production. Bolivia's recent moves to self-sufficiency, and Ecuador's experience with rice and potatoes underscore the urgency in obtaining information for production planning in agriculture. Of high priority are the price and income elasticities for the key agricultural products.

Objectives

The main purpose of this study is to increase our knowledge of the market for selected agricultural products in Bolivia and Ecuador.[4] This is set forth as sub-objective 2 of PO-B in the 1970-71 plan of work on AID/csd-2167. The study utilizes secondary data to provide background information on agricultural production, consumption, income growth, demographic factors, and institutional factors (such as price policy). In addition, time series data are used to fit econometric

models of the markets for the selected products at the retail level. The objective here is to quantify the important economic forces in each of the markets as a basis for evaluating present and proposed policy.

The following are the specific objectives of the study:

(1) To provide background material on the development of the agricultural sector in post World War II years, and on general policy pursued in this period.

(2) To analyze trends in production, consumption of selected agricultural products, income growth, and population characteristics for the same period.

(3) To analyze the role and effectiveness of various pricing policies surrounding the selected agricultural products.

(4) To develop and estimate econometric models of the national market for selected agricultural products in order to get price and income elasticities for such products.

(5) To utilize these results to understand the interrelations among such crops, and evaluate existing and proposed policies especially as they relate to the adoption of water management techniques in conjunction with seeds and fertilizers.

(6) To make suggestions for further research to increase understanding of the markets for these selected crops.

Previous Studies

In 1961, G. E. Brandow presented the results of a study of the price and income consequences of different forms of supply control in U. S. agriculture. The basic model was developed using his prior

statistical estimates of direct price and income elasticities for major food items. By using the homogeneity assumption, the symmetry relation, and assumptions about the cross elasticities for non-food, the cross elasticities for various food items were synthesized.[5] In this manner, a matrix of income elasticities and direct and cross price elasticities was developed. This model is essentially a general equilibrium-type model with the supply of each commodity fixed. Thus, the price elasticity of supply is assumed to be zero.

The model is synthesized at the retail level. Brandow shows that marketing margins are very stable as price and quantities fluctuate. Consequently, the difference between farm level and retail elasticities depend on the size of the marketing margins. This relation was used by Brandow to calculate farm level demand.[6]

Brandow's findings are generally consistent with other empirical results. The demand for all food as a group is less elastic than the demand for individual commodities. Thus, a small change in the total food supply causes large changes in farm prices. Also, demand at the farm level is less elastic than demand at retail, and changes in the supply of any food has a greater impact on farm prices than on retail prices.

Mata utilized Brandow's conceptual model to derive a matrix of price and income elasticities for ten selected agricultural products at retail in Venezuela. The model was used to assess the effects of import restrictions, the effect of production responses from minimum price policies on prices of agricultural products, and the effect of projected supply on prices. Most of the direct price and income elasticities were taken from a USDA study as attempts to estimate

direct price and income elasticities from other data sources failed due to data limitations.

Vasquez-Morales utilized time series data for 1930-1965 in an attempt to estimate price and income elasticities for corn, beans, wheat, and rice, in Mexico.[7] Data were adjusted to account for known deficiencies and a number of different models were estimated including both single, and simultaneous equation models.[8] The best results were obtained in a simultaneous model where rural income was also considered endogenous. Vasquez-Morales concludes "that the most important contribution of this study is to make evident the difficulty of studying the demand for agricultural products in Mexico with time series data." His best results were generally not supportive of the model used although they suggested that the price elasticities of demand for the four commodities are relatively elastic and that rural income elasticities are greater than urban. Vasquez-Morales recommends that further study on demand in Mexico be done by utilizing cross-sectional data rather than time series.

Some Conceptual Problems

The demand for a final good is derived from the consumer maximizing his utility from the bundle of goods he consumes, subject to his income constraint. As the price of one good varies with the price of other goods and income held constant, a demand curve for the first good is determined. Thus, the quantity demanded of a final good is some function of its own price, the price of substitute and complementary goods, and the level of income, given tastes and preferences. Summing over all consumers yields the market demand curve for the product.

The supply of a final good is derived from the underlying production function for the good. The quantity supplies is some function of its own price, the price of the inputs used in producing the product, and the price of alternative goods that could be produced with the same inputs in some short time period. Summing over all supply curves of all producers yields the market supply curve. The intersection of the market demand and supply curves determines an equilibrium price. This is the demand price faced by producers, and the supply price faced by consumers and is completely elastic to each individual producer and consumer, unless he be the only producer or consumer, in which case he faces the market curve. This latter case is highly unlikely in the markets for basic food commodities in a less developed country.

This traditional derivation of the demand and supply relations is straight forward. Yet, there is room for confusion in attempting to develop a conceptual model of the markets for products of the agricultural sector. This confusion revolves around several points: (1) Should the conceptual model be the same at the retail and farm level; (2) What are the consequences of treating supply as completely inelastic; and (3) What are the implications of treating some prices as exogenous when they are endogenous. These points are discussed in the order listed.

The Model at Retail v.s. Farm Level

Traditionally in estimating the demand for farm products at retail and at the farm, retail prices are used to first estimate (or synthesize in some cases) retail demand. Then, using the argument that farm prices differ from retail prices by marketing and processing margins, and that these margins change only slightly as prices vary, the retail prices

are adjusted by the amount of the margins to estimate farm level demand relations. As long as marketing margins are some fixed amount at all prices, a proportionate price change has a greater effect on quantity at the retail than at the farm level. That is, the elasticity is greater at the retail level. If the margin is the same proportion of the retail price at all prices, then farm and retail price elasticities would be equal.

This traditional approach was used in Brandow's study to develop price elasticities at the farm level. The above approach assumes that supply of the agricultural product is derived from the agricultural production function for both the farm and retail level. Generally, this supply is treated as a stock; i.e. it is fixed. Demand at retail is derived from consumers maximizing utility as they choose consumption items subject to their budget constraint. While this approach may yield results that are in the ball park (as long as the farm prices do vary from retail only by processing and marketing margins, for all prices), there is a conceptually more appealing approach.

The demand for agricultural products at the farm level is, in general, a derived demand. The products actually become inputs in other production processes and so the demand for these agricultural products is derived from those production functions. For example, potatoes are utilized as a raw input along with labor, capital equipment, land, and buildings, to produce washed, graded, and packaged raw potatoes, and a variety of processed potato products including frozen, dehydrated, milled (flour), and processed (alcohol) potato products. Thus, there are a variety of production processes that demand raw potatoes as an input. The demand for potatoes at the farm level then

is some function of the price of such potatoes, the price of inputs (capital and labor) used in producing the final product (graded potatoes, frozen, dehydrated, alcohol, and flour), and the price of the product.[9] The supply of potatoes at the farm level is some function of their price, the cost of farm labor, fertilizers, water, etcetera, and is derived from the farm production function for potatoes. By summing over all demand curves and supply curves, the market price to the supplier of raw potatoes (the farms), and the demander of raw potatoes (the marketers and processors) is determined.

The demand at retail is determined in a completely different market. The demand for these products produced from raw potatoes, labor, and capital (sacked and graded potatoes, dehydrated and frozen products, alcohol, and flour) is derived from consumers maximizing utility as they choose their bundles of consumption goods subject to income.[10] If we aggregate all the potato products to a weighted price and potato (or value) equivalent and sum over all consumers, we have the market demand for the potato products. The supply of such products is derived from the production function of the producers of such products. The intersection of this supply and demand curve determines the retail market price (the supply price to consumers, and the demand price to producers). If the marketing margins are fixed as prices change, then using the retail market to get farm demand may be okay as an approximation. However, this conceptualization is closer to the theory of production and consumption, and would lead to better estimates if the margins varied at different prices. The aggregation problem due to varied products produced from the raw farm products does present a problem, however.

This conceptual problem is probably much less serious in developing nations relative to so called developed nations. This is because a large proportion of food is consumed in its raw form in such countries with consumers doing most of the processing in their homes. However, in a country like the U. S. the share of food that is purchased at retail in its raw form is a much smaller proportion of total output for most agricultural crops. Thus, the marketing and processing margin is much greater in developed countries than in LDC's. This implies that the farm and retail price elasticities are much closer in LDC's than in developed countries. Because of this, elasticities derived from retail prices in less developed countries also approximate farm level elasticities and may be used for policy evaluation at the farm level.

The Consequences of Treating Supply as Completely Inelastic

The discussion of the demand for and supply of a final good implies the following partial equilibrium supply and demand model for good Q_1.

(1) Demand: $Q_1 = f(P_1, P_i, Y)$

(2) Supply: $Q_1 = f(P_1, W_j, P_i)$

where Q_1 = quantity demanded and supplied per capita

P_1 = price of good 1

P_i = price of substitute and complementary goods, $i = 2, \ldots n$

Y = income per capita

W_j = cost of inputs used in producing Q_1, $j = 1, \ldots n$

where $D = S$, and it is assumed that $P_i = P_2$ and $W_j = W_1$.

This model can then be written stochastically as:

(3) Demand: $Q_1 = a_1 + \beta_1 P_1 + \beta_2 P_2 + \beta_3 Y + u_1$

(4) Supply: $Q_1 = a_2 + \beta_4 P_1 = \beta_5 W_1 + \beta_6 P_2 + u_2$

where the equations (3) and (4) are linear in the logs of the variables and the estimates of the b_i are estimates of the respective elasticities.

Since demand equals supply, the equations (3) and (4) can be set equal to each other and solved for Q_1 and/or P_1.[11] Such equations show the endogenous variables in the systems as a function of all the exogenous variables.[12] The equations are referred to as reduced forms and their coefficients are combinations of the coefficients of the structures as follows:

(5) Price Reduced Form: $P_1 = \frac{a_2-a_1}{b_1-b_4} - \frac{b_3}{b_1-b_4} Y + \frac{b_5}{b_1-b_4} W_1 + \frac{b_6-b_2}{b_1-b_4} P_2$

(6) Quantity Reduced Form: $Q_1 = \frac{a_1b_4-a_2b_1}{b_4-b_1} + \frac{b_2b_4-b_1b_6}{b_4-b_1} P_2 + \frac{b_3b_4}{b_4-b_1} Y + \frac{b_4b_5}{b_4-b_1} W_1$

In principle, the reduced form parameters could be estimated by least squares or calculated from the structural parameters. However, our concern is with the economic interpretation of the structural coefficients. Once this is understood, the consequences of assuming supply completely inelastic will be apparent.

First, we turn to the estimated demand equation (3). The coefficient b_1 is an estimate of the price elasticity of demand. It measures by how far prices change with a given change in the quantity demanded or vice versa (that is, no causality is implied). Consequently, it reflects movements along the demand curve. On the other hand, coefficients b_2 and b_3 measure shifts in the demand curve at all prices. If P_2 is the price of a substitute, then the coefficient b_2 would be positive. It would tell us by how far the demand for Q_1 increased at

all prices for a given increase in P_2 (that is, by how much the curve shifted to the right). A similar interpretation is given to b_3. Thus, b_1 indicates movements along the demand curve (changes in quantity demanded) while b_2 and b_3 show shifts in the curve (changes in demand).

In the supply curve, the coefficient b_4 is the price elasticity of supply. It measures movements along the supply curve or changes in the quantity supplied. The coefficients b_5 and b_6 are supply curve shifters and measure the change in supply at all prices due to change in price of inputs (W_1) or price of other goods that could be produced with such inputs (P_2).

The reduced farm coefficients essentially show the final impact on equilibrium price and/or quantity of changes in demand or supply. For example, what is the effect on price and quantity of a ten percent increase in income (Y)? The increase in Y shifts the demand curve to the right. The amount of the shift at all prices is determined by the coefficient b_3. In Figure A, let D_1D_1 represent the original demand curve, and D_2D_2 the demand curve after the ten percent increase in income. The original equilibrium is at P_1 and Q_1 and the new equilibrium at P_2 and Q_2. The final impact on equilibrium price and quantity P_1 and Q_1 is determined in the reduced forms. In equation (5), the coefficient on Y is $\frac{-b_3}{b_1-b_4}$. As can be seen, the final effect of an increase in income on price depends on not only the structural income coefficient (b_3), but also the price elasticity of demand (b_1) and of supply (b_4). In a similar fashion, the final effect on quantity demanded of an increase in income can be determined from equation (6).

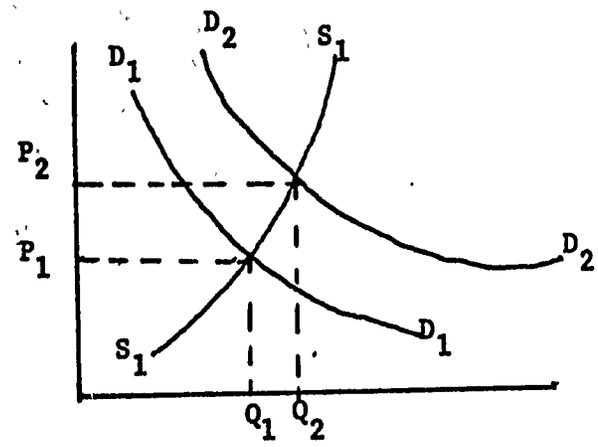

Figure A.

The coefficient is $\frac{b_3 b_4}{b_4 - b_1}$. Thus, if the supply curve is elastic ($b_4 > 1$), the increase in income tends to increase the quantity demanded proportionately more than the price. If the supply curve is inelastic ($b_4 < 1$) the effect of an increase in income is to increase the quantity demanded proportionately less than price.

It should be noted that the price elasticity of demand also affects the final equilibrium price and quantity. As b_1 gets larger, the effect of an increase in income on price and quantity gets smaller. This is because a more elastic demand curve, when shifted by a given increase in income, intersects the supply curve at a lower price and quantity than would a more inelastic demand curve.

In the same way, decreases in W_1 cause rightward shifts in the supply curve. The relative impact on price and quantity depends on the elasticity of the demand curve. If the demand curve is elastic, then the shift of the supply curve has a greater impact on quantity than price. If it is inelastic, the opposite is the case. The elasticity of the supply curve also affects the final equilibrium price and quantity. As b_4 gets larger, the effect of a decrease in W_1 on price gets

larger and quantity gets smaller. This is because a more elastic supply curve, when shifted by a decrease in the price of inputs, intersects the demand curve at a higher equilibrium price and lower quantity than would a more inelastic supply curve.

Thus, it can be seen that the final effect on equilibrium price and quantity of shifts in the supply curve and/or demand curve depend on both the price elasticity of demand and of supply.

If one assumes that supply is perfectly inelastic (with price elasticity of 0) when in fact the supply curve has some responsiveness, policy decisions from such a model may lead to error. For example, an increase in income (Y) increases both the equilibrium quantity and price. Even though the supply response in agriculture may be very inelastic in the short run, in the long run it is likely to have some responsiveness, and increased income would likely lead to quantity as well as price increases. In the same vein, the supply price elasticity affects the final equilibrium price and quantity of a shift in the supply curve (due to a change in W_1 for example). And the more elastic the supply curve, the greater the difference between equilibriums.

Co-determined v.s. Exogenous Variables

If the demand for a commodity is estimated in a single equation model by ordinary least squares, when supply has some responsiveness, the resulting parameter estimates will be biased. This results from a mis-specification of the model and is called least squares-bias. For example, if the quantity and price of beans are simultaneously determined, and price is treated as exogenous, then the results will be spurious if estimated by ordinary least squares. Adding an equation

to explain the endogenous variable (price of beans) will conceptually correct this problem. Estimations have been developed to estimate simultaneous systems.

In the same manner, any other prices that are included in a single equation model that are really co-determined with the dependent variable (quantity in the bean example), will lead to biased estimates of the parameters. If the price of wheat is included and wheat is a strong substitute for beans, another equation needs to be added to explain the price of wheat.

While a completely inelastic supply equation may approximate the short run supply in agriculture, empirical evidence suggests that in the long run, the supply of a commodity is more responsive to price change than in the short run. Since policy is concerned with the longer run,[13] assuming supply inelastic and formulating policy based on such results will lead to problems.

Ecuador

The Conceptual Model

Data restrictions and aggregation problems required some assumptions to be made in the development of the initial conceptual model. Consumer theory (as summarized above) is really concerned with one micro-unit, the individual or consuming unit. Yet the model is to be estimated at the national level for several selected agricultural products for the "average" consumer. It is assumed that this aggregation process does not invalidate the model. That is, aggregate "average" human behavior is assumed to be the same as the behavior of an individual.

Data restrictions limited the scope of the model as well as the number of products for which the model was estimated. It is fairly obvious that there is some supply response in agriculture in the long run. Yet data does not seem to exist to estimate the supply equation. Consequently, a second assumption of the initial model is that supply response is zero or that price elasticity of supply is completely inelastic. (This assumption will hopefully be relaxed in estimating later models.) Finally, prices of substitute commodities are probably endogenous, i.e. co-determined with the quantity of the commodity of intent. Thus, they would require another equation to explain them. However, apparent lack of other exogenous variables to satisfy the a priori identification requirements preclude the use of a simultaneous equation model. Hence it is also assumed that the prices of substitutes are also exogenous. This implies the following set of single equation conceptual models for (n) products.

$$Q_1 = f(P_1, P_2, \ldots . P_n, Y)$$

$$Q_2 = f(P_2, P_1, P_3, \ldots . P_n, Y)$$

$$Q_n = f(P_n, P_1, P_2, \ldots . P_{n-1}, Y)$$

where Q_1 = per capita consumption of product 1

P_1 = price of product 1

P_2 = prices of product 2, . . .n where n = 1, . . . 10

$\vdots$

P_n =

1 = cacao	6 = coffee
2 = bananas	7 = barley
3 = sugar	8 = corn
4 = rice	9 = potatoes
5 = wheat	10 = beef

Y = per capita income

The Statistical Model and Estimation Procedures

For estimation purposes the model is linear in the logs of the variables as follows:

$$\log Q_1 = \log a_1 + b_1 \log P_1 + b_2 \log P_2 + \ldots . b_n \log P_n + b_n + \log Y + U_1$$

$$\log Q_2 = \log a_2 + b_1 \log P_2 + b_2 \log P_1 + b_3 \log P_3 + \ldots b_n \log P_n + b_n + \log Y + U_2$$

$$\vdots$$

$$\log Q_n = \log a_n + b_1 \log P_n + b_2 \log P_1 + \ldots . b_n \log P_{n-1} + b_n + \log Y + U_n$$

Thus, the coefficients will be estimates of the respective elasticities. The usual assumptions are made about the error term (U_i), including the assumption of normality so that hypotheses about the estimated parameters may be tested.

Based on theoretical grounds, one can specify expected signs on the direct price elasticity in each of the equations, and on income elasticities. The direct price coefficient should be negative, while income per capita should be positive in most cases (except for inferior goods). Further, as the basic food commodities in an underdeveloped economy would be expected to be rather strong substitutes for each other, given the low income level of most of the consumers, we would expect most of the cross elasticities to be positive.

The Data

Several sources were used to compile the data on Ecuadorian products. The general scheme was to compile all data from all sources available for each crop in order to have a comprehensive coverage from which a reasonable time series could be compiled. The following are

the main sources used:

1. Ricapilacion Estadisticas Agropecuria - Departmento Tecnico Agropecurio De La Camara De Agricultura De La 1 Zona - Quito, Ecuador - 1965. This source contains data on several agricultural products and exports and imports. It also includes a series of prices for many agricultural products for covering the period 1950-1963. It is a publication of economic data gathered from many sources.

2. Ecuador, Selected Economic Data - Prepared by Clarence Zuvekas, USAID Economic Advisor - Quito, 1970. This source contains data with economic relevance since 1950. It covers areas like national income accounts, production, prices, population, employment and international trade. Population figures as given in this source were used in our analysis.

3. Studios Sobre Produccion y Comercializacion Del Arroz - Banco National de Fomento. This source gives general information about rice production and cost of production in Ecuador. It has two time series of data, one for exports and the other for production of rice.

4. Produccion Agricola del Ecuador en el Anos 1962-1968. These are seven little pamphlets containing production figures of major agricultural products as well as a one year set of prices for each.

5. F.A.O. Yearbooks of Production were used to get a complete time series on production of Ecuadorian products. Several yearbooks were used to obtain a complete series.

6. F.A.O. Trade Yearbooks were used to obtain data on exports and imports of Ecuadorian agricultural products.

7. U.N. Yearbooks of International Trade Statistics were used

to get trade data also.

8. Statistical Yearbooks of the United Nations - Table 160. This table included some figures (not many) about per capita consumption of certain products.

9. Banco Central Del Ecuador: Dec. 1969. Some figures on production, exports and imports as well as prices were used.

10. Survey of grain marketing and storage, 1963. Henry N. Rues, Kansas City, AID. This source contained some general information about production and disposition of wheat, corn and barley.

11. Production and cost statistics for agricultural products in Ecuador (INIAP).

12. Price tables. These are tables containing a series of prices apparently summarized from source 4.

13. Indices de Precios al Consumidor, Junio, 1970. These are pamphlets including consumer price indexes.

14. Commission Nacional del Azucar, 1 & 2, 1970. This source includes special information about sugar.

The period covered in this study is 1952-1967. Few sources gave data related to the full period. In several cases, two or more sources were used to obtain a full coverage. This approach involves a possible inconsistency in the data arising from the different methods of estimation and/or the different accounting periods covered in each source.

Prices used are supposed to be market prices. Whether these prices are the actual prices available in the market place or the stipulated official prices is not possible to tell from the sources available.

In order to determine the annual apparent per capita consumption of each agricultural product, national production was added to imports and total exports, seed and waste were deducted. Data on production can be considered complete and fairly reliable. Imports and exports figures can also be considered reliable. Seed and waste figures were not available for any product on a time series basis. It was assumed that correction at a flat percentage of production would not affect the interrelation between products or the cross elasticities. There was no data available on quantities stocked from year to year also. Correction for stocks could be made by assuming a certain percentage stocked each year but this would then be the same case as that of seeds and waste. The estimation of apparent consumption, therefore, includes no adjustment for seed and waste. In one case, (bananas), a 10 percent correction was made for waste because production figures were very high. Yet, 10 percent seems to be very low waste correction.

The apparent consumption figure is divided by the population to obtain the per capita consumption.

Real per capita domestic consumption was obtained by deflating domestic consumption (source 2), using the wholesale price index with 1954 as the base year (source 2) and dividing by population (source 2).

Per capita national income is obtained by dividing national income (1960 = 100) by population (source 2). Population is given in a table in source 2.

Prices were obtained mainly from sources 1 and 4. Several other sources were used less frequently. Consumer price indexes were obtained from source 2 with 1965 = 100. Source 2 gives general indexes and an index for food and beverages prices. These indexes are given for two

main cities, Guayaquil and Quito. The index for Quito was used because it covers the whole period considered.

Ten products were analyzed in the study. These are the most important products which have data covering the period 1952-67. The following is a brief summary of how the consumption figures of each product were determined:

1. Cacao: Data on production of cacao was obtained from sources 2, 4 and 5. Although estimates from all sources were fairly consistent, sources 2 and 6 were closest for the available years. Export figures were obtained from sources 6, 7 and 12, which gave almost identical figures. Source 6, however, covered the full period and was consistent with other sources, so it was chosen. No import figures were reported. Prices were given in source 12 in sucres per 46 kgm. for the period 1961-67. They were converted to sucres per kgm. Prices for 1952-1960 were estimated by using the price of 1965 = 100 along with the index numbers of source 14.

2. Bananas: Production data were obtained from sources 1, 2 and 5. Sources 1 and 2 were more consistent so they were used. Source 5 gave generally higher figures than the other two sources. Export figures were given in sources 6, 7 and 9. Source 6 gave more likely and complete setsof export figures.

Prices for bananas were not available except in recimos (bunches). Using source 9 (exports in recimos and kilos) a recimo was found to weigh an average of 25 kgms. Using a rate of about 25 kgm./recimo, conversion was made and prices from source 12 were used for 1961-67. For earlier years, the index of source 14 was used along with the price of 1965 = 100 of source 12. A 10 percent reduction for waste was made.

3. Sugar: Production data were available for sugar cane, centrifugal sugar and non-centrifugal sugar. Prices were not quoted in terms of any such breakdown. The prices were given in terms of "sugar". Source 15-1 gives a series of figures of internal consumption of sugar which seems to be consistent. Source 8 gives per capita consumption of sugar for the years 1963, 1966 and 1967. Per capita consumption calculated from the consumption figures of source 15 are very close to those given in source 8. Hence, consumption figures of source 15 were used.

Prices for 1952-63 were used as in source 1 while prices for 1964-67 were estimated by using the price index of the central bank.

4. Rice: Sources 3, 4 and 9 give production figures in terms of net rice while sources 2 and 5 give these figures in terms of rice in hulls. Production figures for the years 60, 61 and 62 are the same in both sources 3 and 9, while production figures of source 4 are different from source 9. Therefore, 9 and 3 were chosen since they give more consistent figures. The rate of conversion from rice in hull to net rice is not available, and hence the figures of sources 2 and 5 could not be used to cross-check data from sources 3 and 9.

Exports figures were obtained from source 6 (52-64), source 7 (56-66), source 3 (52-62), and source 9 (60-66). Sources 3, 7 and 9 give very close figures for the years in common and hence they were used.

Prices were obtained from sources 1, 9 and 13. Sources 1 and 13 give two sets of prices: Prices of 1st grade rice and prices of 2nd grade. These two sets were averaged to obtain a price for all rice.

5. Wheat: Production figures were available for different periods in sources 1, 2, 4, 5 and 9. Sources 1, 4 and 9 were more heavily

relied on since they gave a more consistent series. In fact, figures from all sources are considerably close.

There is no reported export of wheat but a substantial amount of imports in Ecuador.

Imports figures were given in sources 1, 6 and 7. Sources 6 and 1 give very close series and hence they were used. Adding imports to production and dividing by the population gives a per capita consumption series which is very close to a series given in source 1. This adds confidence in the production and import data used.

Prices for the period 1960-67 were obtained from source 13. For earlier years, the price index of wheat from source 1 was used along with the price of 1960 = 100 from source 13 to get an estimation of 1952-1959 prices.

6. Coffee: Production figures were obtained from sources 2, 4, 5 and 9. All sources except 9 gave very close figures. They were used.

Export figures were the same from all sources: 6, 7 and 9.

Prices for 1960-67 were obtained from source 13 and prices for the period 1952-1959 were obtained from source 1. Source 13 gives prices of coffee beans while source 1 gives prices of ground coffee. The years common to both sources 1 and 13 were used to find the relation between prices of grain and ground coffee (1:3.1).

7. Barley: Production figures were obtained from sources 1, 2, 4 and 5. Source 5 has a complete set of figures which are close to the figures of the other sources. Therefore, source 5 was used.

Imports and exports of barley were found in source 6 and are negligible.

Prices for the period 1960-67 were obtained from source 13. Prices for earlier years were obtained from source 1 for the period 1952-57 and for the remaining period the price index given in source 1 for barley was used to estimate prices.

8. Corn: Production figures were given in sources 1, 2, 4 and 5. All sources give approximate figures but source 5 was chosen since it gives a complete set of figures for the whole period.

There were no published reports of exports or imports of corn.

Prices were obtained from source 13 for the period 1960-67 and from source 1 for the period 1952-59 (converted to sucres/kgm.).

9. Potatoes: Production figures for potatoes were obtained from sources 2, 4 and 5. Source five was chosen since it is complete and consistent with source 4. Source 2 gives relatively higher figures and is incomplete.

Exports and imports of potatoes were negligible.

Prices were taken directly from sources 13 and 1 after converting them to sucres/kgm.

10. Beef: Production figures were obtained from sources 1, 2 and 5. Source five gave two sets of data, one in terms of beef meat and the other in terms of animals slaughtered. The first set was not complete so the second set was used to complete and to check the first data. The figures check very closely. Sources 1 and 5 gave very close figures for the years common to both and hence they were chosen. Both sources together give a complete and apparently consistent series.

There were no figures available on export or imports of beef meat.

Prices for the period 1952-63 were obtained from source 1. This source gives prices in sucre/lb. for two grades of meat: Grade 1 and

Table 1. Estimates of price and income elasticities for selected ag products in Ecuador.[a]

Quantity \ Price	Constant	1 Cacao	2 Bananas	3 Sugar	4 Rice	5 Wheat	6 Coffee	7 Barley	8 Corn	9 Potatoes	0 Beef	Income	R^2
Cacao	-30.17	-1.60		11.26'		-7.52'		2.45'	-3.70	.90		3.74	.55
Bananas	-52.24	2.43^0	-5.33**		-3.80**			.91^0		-1.54**	2.76**	5.64**	.96
Sugar	-51.07	.48	-1.04	-3.28*	.47			-.97'	2.70*	.04		6.68*	.82
Rice	96.81			7.00*	-1.50'	-1.55		2.20*	-1.32'	-2.26*		-12.36**	.74
Wheat	-3.92	-1.09			-1.11^0	-.43	.41		1.23**			1.09	.62
Coffee	-60.22		-2.78'	-4.22'		-3.56^0	-2.49**	1.23^0			6.97**	2.78^0	.93
Barley	63.59	1.03'	4.10**	-1.19	-.26	-1.32'		-1.07**		.35'		-7.06**	.94
Corn	9.21	1.91**	-1.87^0					.005	-.97*	-.43*	1.29^0	-1.71^0	.88
Potatoes	22.74	-2.01^0	.99				-.34	-1.06'	3.10**	-.71*	.98	-2.15	.93
Beef	-21.79		.53	-.97	-.18		-.25'	-.52	.85'	.10	-.16	3.27*	.91

[a] Two asterisks (**) denote a 1% level of significance, one asterisk (*) a 5% level, zero (0) the 10% level, and an apostrophe (') that the coefficient approaches significance at the 10% level with sufficient degrees of freedom.

Grade 2. A simple average price was taken as a general price for beef meat and then converted into sucres/kgm. Prices for 1964-1967 were estimated by using the consumer price index for food given in source 2 along with prices of source 1.

The following conclusions can be reached about the data:

1. Different sets of data and different sources were used to establish complete data series. Data from any one source in most cases was incomplete requiring use of other series when they were available.

2. No detailed information about waste, seed, exports and imports were available. Hence, apparent consumption per capita estimates may be biased upwards.

3. Prices in Ecuador have two levels; one is the official price and the other is the market price. The two prices are not identical. There is no indication in any of the sources used as to whether the recorded prices were official or market prices.

The Statistical Results

A number of variations were performed with the basic model. These were done in an attempt to improve the statistical results and determine their stability. These variations involved (with one exception) the modification of the demand equation for individual commodities by deleting certain of the prices of substitute commodities and in some cases including a trend variable.

The exception involved an attempt to estimate income elasticities from the relationship that quantity is some function of income. Not all of these results are discussed below. Only those which improve results or illustrate some aspect of the model, are presented.

The results of estimating the basic model specified above are presented in Table 1, in matrix form.[14] Each row is a separate regression and is the ordinary least square equation for the commodity named in the left-hand column, with quantity as the dependent variable. The variables at the column headings are the prices included in each equation. The direct price coefficients are consequently the diagonal of the matrix.

The results are encouraging, given the kinds of data and conceptual problems involved. The R^2's are reasonably high except in the case of cacao, wheat, and rice. Thus, the models explain most of the variation in quantity consumed per capita of bananas, sugar, coffee, barley, corn, potatoes, and beef. In all cases, the own price elasticities had the expected sign, and six of the ten own price coefficients were significant at the 5 percent level or better. One coefficient approached significance at the 10 percent level. Furthermore, the coefficients of five of these seven commodities were larger than 1, suggesting that there are quite a few substitutes for such commodities, which is consistent with a priori expectations.

Commodities with relatively small price elasticities are beef and wheat. Although these coefficients are not significantly different from zero, the relatively small coefficients are consistent with the kind of product, i.e., there are probably fewer substitutes for beef and bread (wheat) than for the other commodities.

The income elasticity of demand was positive and greater than the one for cacao, bananas, sugar, wheat, coffee, and beef. Of these, the coefficients for bananas, sugar, coffee, and beef were significant at the 5 percent level or better. However, negative income elasticities

were obtained on rice, barley, corn, and potatoes, suggesting that these products are inferior goods. Of these four, three are significantly different from zero, with rice and barley being significant at the 1 per cent level, and corn at the 10 percent level. These results also tend to support the model. Rice is a subsistence crop on the coast along with corn. Barley is the staple subsistence crop of the Sierra (of the Indians) along with corn. It is possible that real increases in income lead to absolute decreases in the aggregate quantity demand of these goods as consumers switch to other more acceptable substitutes.

The models lead to inconsistent results in classifying commodities as substitute or complement on the basis of the sign of the estimated cross elasticity coefficient. This occurs, for example, with cacao where the cross elasticity of the price of corn with respect to cacao is -3.70. In the corn equation, the cross elasticity of cacao with respect to corn is 1.91. In the first case the sign suggests that the goods are complements, in the second, substitutes. Of 18 possible checks on cross classifications (i.e. with the price good B in the demand equation for good A, and vice versa) ten of the sets of signs were inconsistent. This tends to diminish the acceptability of the results of the model.

The basic model for each commodity included the prices of all other commodities, as well as its own price and income. These models were modified for each commodity by deleting certain of the prices of other commodities. Cacao was deleted as it is mainly grown for export, and is not thought to be an important part of the average Ecuadorian diet. Other variables were deleted because of regional consumption patterns. For example, bananas and rice are consumed heavily on the coast, while rice, potatoes, and barley are consumed in the Sierra. On

this basis, models were built reflecting regional consumption habits. These models require regional data. That is, one needs to know the quantity of rice consumed per capita in the coastal region and the prices established there, in order to estimate the demand for rice in that region. These so-called "regional" models were estimated with national data. The results were, in general, poor, except for bananas, sugar, potatoes, and beef. These results are presented in Table 2.

Table 2. Estimates of price and income elasticities for bananas, sugar, potatoes, and beef, with the basic model modified by deleting certain prices.[a]

q \ P	Cnst.	Bananas	Sugar	Rice	Barley	Corn	Potatoes	Beef	Income	R^2
Bananas	-59.47	-3.37*		-2.75*				2.61*	7.29*	.82
Sugar	-37.05		-3.19*		-1.11**	2.85**	-.05		5.20*	.80
Potatoes	9.63				-1.04*	2.88**	-.98**	-.22	-.89	.87
Beef	-23.30				- .40*	.61'	-.04	-.23°	3.31**	.84

[a]Two asterisks (**) denote a 1% level of significance, one asterisk (*) a 5% level, zero (0) the 10% level, and an apostrophe (') that the coefficient approaches significance at the 10% level with sufficient degrees of freedom.

The R^2's are all quite high. This suggests that a large share of the variation in quantity demanded is explained by each of the equations. In addition, the own price coefficients are all negative and significantly different from zero at the 10 percent level or better. Finally, most of the cross elasticities are also significant at the 5 percent level or better, as are three of the four income elasticities.

In the banana equation, the elasticities are not very stable when compared with the original model for bananas. The own price coefficient, and the rice cross-coefficient get smaller, while the income coefficient

gets larger. Only the cross elasticity on beef is relatively stable.

The equation for sugar has coefficients that are quite stable between the two models. In the equation for potatoes, however, the coefficients are not as stable. The equation for beef is relatively stable between the two models.

Other model alterations included the addition of a trend variable with income present, and with income deleted. The rationale for the trend was to attempt to measure changes in taste over time. Due to high intercorrelation between income and time, the trend variable was not significant when included with income. When included alone, it tended to pick up the effect of income, being significant in some cases. However, it was usually not significantly different from zero at usually accepted statistical levels.

A final adaptation was to measure the income elasticity of demand by regressing quantity demanded on incomes. The results for the ten commodities are presented in Table 3.

Table 3. Income elasticities of demand for selected ag products[a,b]

	Cacao	Bananas	Sugar	Rice	Wheat	Coffee	Barley	Corn	Potatoes	Beef
Income Elast.	4.36*	3.32*	2.27**	.06	.37	2.58°	-2.05**	-.45	2.43*	1.71**
R^2	.26	.23	.38	.0001	.03	.12	.45	.04	.29	.63

[a]Based on the model Q = f(Y) where Q = quantity demanded and Y equals income, both on a per capita basis.

[b]Two asterisks (**) denote a 1% level of significance, one asterisk (*) a 5% level, zero (0) the 10% level, and an apostrophe (') that the coefficient approaches significance at the 10% level with sufficient degrees of freedom.

Although the R^2 are quite low (except for beef) the coefficients are significant at the 5 percent level or better for six of the 10

commodities and at the 10 percent level for one other. However, the coefficients are different in magnitude from those obtained from the basic model. Further, although the signs agree for most of the coefficients between the two models, the signs differ for potatoes and beef. The results of the basic model imply that these goods are inferior, while this model suggests the contrary. In the case of rice, the income coefficient is highly significant and negative, whereas in this model it is not significant. This implies that rice is an inferior good. However, the opposite is true for potatoes. That is, its coefficient is significant and positive in this model, but negative and not significant in the basic model. Then there is some question about whether or not potatoes is an inferior good. The basis for selecting between the results of the two models is somewhat subjective. However, consumer theory implies that quantity demanded depends on other variables (prices) as well as income.

Bolivia

Conceptual and Statistical Models

All of the conceptual problems discussed for Ecuador also hold for the Bolivian case. Hence, neither the conceptual problems nor econometric models will be discussed here. The basic models estimated are conceptually the same. However, data were available for only six commodities instead of ten and the series could only be synthesized for a nine-year period (1960-68).

The Data

(This section is still being prepared)

Table 4. Price and Income Elasticities for Bolivia from National Models

Quantity \ Price	Constant Term	Coffee	Rice	Potatoes	Beef	Peanuts	Flour	Income	R^2
Coffee	7.90	-6.02*	.88'	1.76^0		.49'	.37'	-1.29'	.96
Rice	.61	1.38'	-.18	-1.29*		-.64*		.56	.96
Potatoes	7.71			- .63*	-.58'		.09'	- .76'	.76
Beef	1.78	2.04	-.55	-1.71'	- .27		-.31	- .35	.89
Peanuts	4.21		.38^0	- .26'	-2.60*	.17		.38	.98
Flour	2.87			- .04'		.04'	-.02'	.15^0	.95

The Statistical Results

The basic model estimated for each commodity included as the dependent variables the quantity demanded per capita regressed on its price, the price of other goods, and income per capita. The results from estimating this model for each of the commodities is presented in matrix form in Table 4. The direct price elasticities form the diagonal of the matrix. In some cases other prices are not in matrix as their presence leads to multi-collinearity problems.

The results are statistically weak, when compared to those obtained for Ecuador. Although the R^2 are quite high, there are not many significant coefficients. This is symptomatic of multi-collinearity problems. In all cases except for peanuts, the own price elasticity was negative as expected, but only coffee and potatoes had coefficients that were significantly different from zero at the 5 percent level or better.

The coffee coefficient was very elastic suggesting a great number of substitutes for coffee, or else a lot of uses for coffee. This does not seem plausible. However, the related small coefficient on beef relative to potatoes was consistent with the nature of demand for these two products.

The income elasticity was positive for only three of the six goods. Of these three, only flour had a significant coefficient, and that was the 10 percent level. Coffee, potatoes, and beef had negative coefficients on income, suggesting that they are inferior goods. While this may be true for potatoes, it certainly is not plausible for beef or coffee.

Table 5. Price Elasticities for Bolivia

	Price	R^2
Coffee	-1.03**	.77
Rice	- .44*	.34
Potatoes	- .35*	.48
Beef	-1.12°	.24
Peanuts	-1.02**	.51
Flour	- .06**.	.68

The models also lead to inconsistencies in classifying commodities as substitutes or complements by cross elasticities. In three of five cases where cross checks were possible, the models had the same signs on products. In the other two cases, the results were inconsistent.

The results of this model are not strongly supportive of the underlying theory, and tend to not be very useful for policy purposes.

Another model was estimated in an attempt to determine own price elasticities. This model simply regresses quantity demanded to its price. The results are presented in Table 5.

The variation in quantity demanded is largely explained by price except in the case of rice and beef, as evidenced by the fairly large R^2's. Further, all of the price elasticities have the expected negative sign. All are significant at the 5 percent level or better, except for beef which is significant at the 10 percent level.

Not too much can be inferred from the relative magnitudes of the elasticities. One would almost expect the elasticities of rice and potatoes to be relatively large, due to the substitutes available for these goods. By the same token, the coefficients of coffee, beef, and peanuts, one would expect to be relatively smaller. Finally, the coefficient on flour is small, as expected, reflecting the fact that there are few substitutes for this commodity.

Summary and Conclusions

As indicated in the introduction, this is only a progress report. Hence, this section will not summarize results nor attempt to lay out conclusions about policy implied by such results. Rather, the conclusions will revolve around ways of improving this initial and exploratory round of estimates.

There are several ways in which the results may be improved. Some of these ways have been discussed in the section on conceptual problems. These revolved around expanding the model to account for simultaneous determination of prices and the difference between retail and farm prices. Attempts will be made to obtain data to expand the model to account for other equations affecting price and quantity.

However, other conceptual problems may exist. We have assumed away the conceptual problem posed by aggregation to the national level in both countries. But in Ecuador, for example, there are two very dissimilar consumption regions. One is the Sierra, where barley, corn, and potatoes are staples, and the other is the coast where rice, bananas, and sugar are consumed along with fish. Attempts should be made to get regional consumptions and income figures. Then models should be developed and estimated for each region.

Second, in Ecuador, data should be gathered for fish, an important consumption item not included in the models presented above. This commodity is a staple in the diet of people on the coast and certainly should be in the model.

A third problem germane to both countries is related to the share of each product that is consumed outside the market economy. We have no way of knowing whether our apparent consumption includes that grown at home. The data sources just do not discuss this point. Thus, we may have market prices but not market quantities. In the same vein prices may be official prices which are not adhered to in the markets. More knowledge on price institutions is needed to answer these questions. Even after they are answered, we must come to grips with the

existence of a large subsistence sector and its effect on supply and demand. A conceptual framework is needed to handle this.

FOOTNOTES

[1]See U.S. Department of Agriculture, Rice Situation, Economic Research Service, RS-15, March 1970; Lyle P. Schertz, "The Green Revolution: Production and World Trade," Columbia Journal of World Business, 5 (March-April 1970); U.S. Department of Agriculture, The Impact of New Grain Varieties in Asia, (by Joseph Willett). Washington, D.C.: Economic Research Service No. 275, July 1969; and Edward B. Rice, "Spring Review of the New Cereal Varieties," Agency for International Development, Evaluation Paper 2, Washington, D.C., January 1970, for a history of the increased production.

[2]This has somewhat brightened the gloomy picture of mass world starvation painted so vividly by the Malthusian Apologists in the 1960's.

[3]See Walter P. Falcon, "The Green Revolution: Generations of Problems," American Journal of Agricultural Economics, December 1970.

[4]Ultimately, the results will be used to assess the primary and secondary economic benefits and impacts of improved land and water management practices and to assess the economic feasibility of such techniques. This would involve (1) calculating alternative benefit-cost ratios from alternative irrigation-drainage projects, (2) comparing expected prices to costs of production (prices must reflect demand as well as supply considerations), and (3) assess whether or not farmers will adapt the improved water management, thus leading to the increased output (this may involve some dynamics as well as comparative tactics).

[5]The homogeneity assumption is only valid under comparative static conditions. Also, see Frisch for an elaboration of the assumptions involved.

[6]He also estimated demand for export and industrial use, total farm level, and food and livestock relationships.

[7]Mateo Vasquez-Morales, "Analysis of Demand for Corn, Beans, Wheat and Rice in Mexico," Unpublished Master's Thesis, Iowa State University, 1969.

[8]No attempt was made to estimate supply equations in any of the simultaneous models.

[9]If we aggregated the production function so that we had total value of all potato products as a function of total potatoes, labor, and capital, we could derive an aggregate demand function. Then, the demand at the farm level would be a function of the price of potatoes, the composite (weighted) price of labor, weighted price of capital, and weighted price of the product.

[10]Making the simplifying assumption that alcohol and flour are final goods.

[11]To solve for P_1 each equation would have to be solved for P_1 initially so that $P_1 = f(Q_1, P_2, Y)$, and $P_1 = f(Q_1, W_1, P_2)$.

[12]The variables P_2, Y, and W, are assumed exogenous for didactic purposes. In actuality, P_2 is probably co-determined with Q_1 (endogenous). If so, then not accounting for this by including another equation to explain P_2 will lead to a biased estimate of the parameters β_2 and β_6.

[13]The success of a policy is usually judged on how well it succeeds over time rather than the first three month period.

[14]The model was estimated initially with a step wise, least squares routine that forced the own price into the equation, and then brought in the other variables one by one based on the size of the partial correlation coefficient, and a t test. When the critical t value was reached, the regression terminated. However, in the initial model, the tolerance level of t was set low enough that all variables were included. Inclusion of all the variables led to much weaker coefficients (statistically) probably due to multi-collinearity problems. Consequently, each equation includes only those variables that are reasonably strong statistically. The decision on which variables to delete was based on inspection of the estimated model with all variables present. When the addition of one more variable caused the t tests for a large number of the included set to become insignificant, that variable, and all other variables not yet included, were excluded. The fact that the R^2 remained large while the significance of the included set declined, suggest problems of multi-collinearity.