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ABSTRACT

A SHORT AND LONG RUN ANALYSIS OF THE KOREAN RURAL DEMAND FOR FOOD AND ITS IMPLICATIONS TO AGRICULTURAL POLICIES

By

Jongtack Yoo

The desire to investigate the rural demand for food in Korea emerged from the fact that relevant research in depth is rare and conventional static models for demand analysis have been inadequate.

It seems less attention has been paid to rural demand analysis, because of the fact that it is more complicated than urban demand analysis. One complication is that rural consumers are also producers of most food products they consume.

It has been asserted that long-run elasticities or effects in economic relationships are greater than short-run elasticities or effects. On the other side of the argument, it is also asserted that short-run effects are greater than long-run effects. In relation with these contradicting arguments, the other problem areas in both theoretical and methodological aspects in empirical demand analysis are instantaneous versus lagged adjustment, money illusion versus no money illusion, and other statistical problems such as aggregation bias and serial correlation.

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A dynamic demand analysis by using a state adjustment model was undertaken. The basic idea of the model was to investigate if consumers adjust their consumption according to psychological inertia (habit) or according to the physical inventory level.

In this study, data were grouped into quarterly and annual data. With quarterly data, a state adjustment model for ten food items and a second-order distributed lag model for two major grains were specified for farm groups classified according to the size of land holdings. With annual data, three systems of equations for the demand for rice and barley-and-wheat were established.

It was found that rice, meat, dairy and processed foods have stronger habit forming aspects than other types of food studied. The adjustment coefficient in the rice demand relationship was the largest next to that of the processed foods. This indicates the degree of the habit forming characteristics of rice and will give a new direction in interpreting static demand analysis. The second order distributed lag model for rice and barley-and-wheat also gave consistent results with those of the state adjustment model; the lagged effects for rice were greater than those of barley-and-wheat, and for other foods, they were negligible.

There was no uniformity about the magnitude of short and long run effects. For rice, meat, dairy products and processed foods, the long run effects were greater than the

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short run effects in absolute terms indicating a possible increase in the demand if income effect is positive and greater than price effect.

As to the differences among farm groups, the adjustment coefficient for the largest farm group showed the smallest value for rice(relative to the other farm groups), indicating that the more wealthy families have more opportunities to switch to other foods. The differences in the adjustment coefficients among the farm groups on other food followed no distinguishable pattern.

When undeflated nominal data were used, the results were less satisfactory, particularly in cases of income coefficients which were mostly negative. A sort of money illusion was interpreted as a rational consumer behavior for the farmer.

In the simulation model, a "three-mode" control method and various levels of government purchase prices of rice and barley were tried. Despite severe fluctuations of the results, an interpretation was established on the basis of the previous analysis; demand for rice would increase moderately or remain stable while demand for barley-and-wheat would decrease. The unstable results were attributed to unstable error terms in the estimated equation system and to exclusion of urban demand and supply response.

Relevancy of the characteristics of foods and its importance to policy issues have long been recognized. In

view of rural consumers' habit formed for rice, the policy instruments such as the purchase price mechanism may be limited.

Consequently future policy should place more emphasis on the rural poverty problem in general. In addition, efforts should be made to lower prices for which rural demands are elastic, such as processed foods and dairy products.

Though there were some encouraging results, there are many areas that should be refined and investigated. They include handling of nonlinear constraints, developing consistency checks with budget constraints and nutritional requirements, making inter-group comparisons of income elasticities, testing the validity of the permanent income hypothesis, and developing more stable and accurate simulation models.

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A SHORT AND LONG RUN ANALYSIS OF THE KOREAN RURAL DEMAND FOR FOOD AND ITS IMPLICATIONS TO AGRICULTURAL POLICIES

By

Jongtack Yoo

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

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INTRODUCTION

Needs for the Research

In empirical demand analysis, we usually adopt a static approach, the basic proposition being that demand is a well defined function of current prices, income and other determinants given a nonmeasurable ordinal utility function and rational consumer behavior. This static reversible demand curve is the basis of using the traditional concept of price elasticity [E1].[1] Since price elasticities have been key elements in formulating and evaluating a government's price policy, these elasticities have been calculated and used for forecasting possible outcomes of the policies without giving much consideration to the basic propositions upon which a demand function is based.

The major problem areas in both theoretical and methodological aspects in empirical demand analysis, as this researcher perceives, are, among other things, definition of consumption--actual use and inventory, short- versus long-run elasticities (whether it is a decreasing or increasing function of time), instantaneous versus lagged adjustment, homogeneity

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[1]Bracketed number refers to items listed in the Bibliography.

(no money illusion) versus inhomogeneity (money illusion) condition, and other statistical problems such as aggregation bias and serial correlation.

Contrary to supply analysis or theory of the firm, it seems less attention has been paid to demand analysis in terms of above problem areas, particularly in the Korean food marketing research. In view of general consensus that most developing countries need more basic research than developed countries, a balance of research activities is desired in the sense discussed above.

Consequently, most agricultural market equilibrium models are some variant of Cobweb or harmonic models with dynamic supply functions and simple static demand functions. Even though such a pattern in research activities is rather understandable in view of distinctive nature and importance of supply and production, it is clearly an oversimplification of the real world to assume perfect knowledge and instantaneous adjustment in demand functions.

There is no general agreement or rule about the distinction and magnitude of short- and long-run elasticities of demand functions. It has been a common practice to apply an intuitive rule that the long run must be greater than a year [T17]. This length of run, however, must be carefully examined according to the various products, particularly in the case of food products, since the frequency of consumer's purchasing varies from several times a week to several times a month or a year. Particularly, rural consumers have less frequent shopping trips due to either institutional or technical regidities. It is recognized, however, that the choice of subperiods in such details can not be incorporated into the analysis due to the limited data. It is, though, relevant in making correct inferences.

Furthermore, there is an argument that it is impossible to measure short-run demand elasticities [N5] despite the fact that short-run elasticities are more relevant and important in analyzing the distinction between actual consumption and consumer inventory in case of nonperishable agricultural products.

In conjunction with short- and long-run elasticities and lagged adjustment, there is an unsettled argument about the appropriateness of the permanent income hypothesis in an individual commodity demand function. The hypothesis may be relevant to discern change in consumption behavior whether it is due to change in taste and preference or due to income (permanent or transitory) change.

The implications of the permanent income hypothesis in relation with rural demand are twofold; first, it is often argued that farmers have variable income compared to urban wage earners and this fact leads to lower income elasticity of demand for food of urban wage earners. It is expected under the permanent income hypothesis that permanent component varies less for farmers than for urban wage earners given tastes and preferences [N4]. It is of interest to find contradicting empirical results in Korea. Daly found rural income elasticity of demand for rice is higher than that of urban demand [B10, D1]. Gustafson, et al [G10] in the case of rural food demand and Hayenga et al. [H4] in the case of rice demand also found similar results as Daly's. Secondly, an inertia in consumption can be interpreted as consumer behavior of adjusting consumption in line with permanent income rather than transitory components of income [H9].

In making inferences on the Korean rural demand for food, it may be a matter of judgement of a researcher which aspect should be emphasized more--permanent income hypothesis or inertia, along with the question of more variablility of farm income. Can we hypothesize that, when farm household income rises, consumers will not immediately attain the higher level of consumption and when income falls they would maintain the level of consumption at their higher income level? Can it be explained by inertia in adjusting food consumption?

Existence of money illusion is also argued in the aggregate consumption function as well as in a demand function for an individual commodity. This argument, however, has rarely been empirically tested and left to further investigations [P4], particularly in demand analysis [B9]. Along with the relative magnitude of the short- and long-run elasticities, the money illusion problem has an important bearing in the methodological approach in projecting a much longer period demand pattern. Most FAO and other long-run demand projections (i.e., [F1]) simply drop the price variables by assuming constant prices which amount to zero long-run price elasticities, or which amount to an assumption of no money illusion. It is in contrast with an OECD long-run projection [O1] which includes price variables implicitly by using a concept of "composite elasticity", which is comparable to "total elasticity" concept [B1]. A study done by Ferris and Sorenson [F2] also includes prices in long term projections.

Nutritional aspects were not considered as an important economic problem in neoclassical economic theory partly because of possible characteristics of public goods and subsequent externalities. Though considered in terms of characteristics of goods and consumer technology [L1] and hedonic price indices [G8, R4], empirical applications in the context of nutrition and human resource development are rare.

Rural demand analysis seems to be much more complicated than urban demand analysis, mainly because of the fact that rural consumers are also producers of most food products they consume. But most related research has emphasized the urban demand analysis, regarding rural demand as a residual and consequently agricultural price policy has been analyzed with respect to urban demand.

The other policy implications of these problems are tantamount. Seasonal and secular price movements, gross farm income, short term outflow of certain agricultural products from consuming areas to producing areas, possible reduction in the consumption of certain farm products, desired level of prices for the economy as a whole, rural migration, and others are directly or indirectly related to rural demand for food.

In this sense, Tolley's remark [T15] is quite appropriate:

> In view of the fact that. . .future shifts in demand will be principle determinant of what is desirable and possible in [Korean] grain policy, there should be no hesitancy in pursuing grain demand analysis.[2]

Scope and Methodology of the Study

The scope of this study includes 10 food items listed in the Farm Household Economy Survey. They are rice, barley-and-wheat, miscellaneous grains, pulses, potatoes, vegetables, meats, dairy products, fish-and-marine products and other processed foods. The first five foods were analyzed in terms of national averages and also for five farm groups classified according to farm land holdings. The last five food items which are reported in expenditure terms were analyzed at the national average level only.

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[2]Tolley, G. S., *ibid*., p. 13.

The basic model adopted in this study was the state adjustment model developed by Houthakker and Taylor, the details of which are explained in Chapter III. The fundamental idea of this model is to investigate whether consumers are adjusting their consumption according to physical stock (inventory adjustment) or psychological inertia (habit forming). To investigate further lagged effects, a second order rational distributed lag model was used where appropriate. For projection and policy simulation, a very simple simulation model was used.

Objectives of the Study

The first set of the research objectives was to find the validity of the following hypotheses in the rural demand for food analysis and see what kinds of effects emerge from these hypotheses:

1. The long-run effects or elasticities are greater than short-run elasticities which are asserted in most economic textbooks.
2. Consumers are free of money illusion and consequently real elasticities are equal to nominal elasticities.
3. There exists a lagged consumption adjustment phenomenon which would differ among different products.
4. Food consumption is a function of permanent income rather than transitory income.

5. Income elasticity is different among different farm groups in the sense that the income elasticity of the lower income group would be greater than that of higher income groups.

Secondly, it was hoped to develop tools or models for the following subject matters:

1. Short- and long-run projections of rural food demand patterns.
2. Degree of aggregation bias in the food demand function.

Thirdly, it was intended to investigate the following policy implications:

1. Level of the government purchase prices of rice and barley and their impacts on rural demand for rice and barley, inventory and market sales.
2. A possibility of induced change in the consumption of grains either through market or nonmarket mechanisms.
3. Other related policy problems such as off-farm employment, rural-urban migration and size distribution of land.

CHAPTER II

LITERATURE SURVEY

Theoretical Aspects and Empirical Works

Norris [N6] differentiates demand theory into long and short run. Short run refers to a period fo time when no changes in income and in established consumption rates occur. The important variables are purchases, savings and stocks of the goods. Long run refers to the period when consumers re-evaluate their commitments and change their habits according to the change in income. In the short run, purchase patterns can vary, even though the consumption pattern remains stable. The difference between the changed pattern and the stable consumption pattern is the change in the inventory level. Thus Norris' definition is synonymous with the usual distinction between static and dynamic demand.

One of the most serious defects of the standard approach in demand analysis is its static nature, which is not essentially changed by an arbitrary inclusion of lagged variables.

An explicit dynamic demand theory has been given by Tintner and by Mosak in the form of maximization of utility over time [T9, T10, T11]. Stone [S11] with wide applications, Nerlove [N3, N4], and Houthakker and Taylor [H9] in the form of a state adjustment hypothesis using nonadditive and additive models.

It is, however, well known that there is no general rule or agreement about the distinction of the length of run, particularly in the case of demand analysis. Marshall [M5] identifies long run as a long period of time which is "normal" as distinguished from "secular" change which refers to gradual change over time caused by changes in the state of arts, population, tastes, etc. To have a well defined demand function it is usually argued that the length of run should not be so short that the desire for variety cannot be satisfied nor so long that the utility function changes [H6].

Mighell and Allen [M9] describe the long run demand curve as an "irreversible adjustment path" compared to "reversible" adjustment of the short run demand curve. This is corresponding to the irreversible supply function argument according to asset fixity notion of Johnson, G.L. [J3, J4], asset in demand theory being tastes and preference or habits depending on different notions of rigidity and adjustment of consumption behavior.

Chernoff [C2] bases the distinction on the technological and institutional rigidites and treats only the permanent component in the long run relationship.

Wold and Jureen [W3] argue that in empirical demand studies trend free data will result in short-run elasticities trend data will give those of intermediate range and the combination of trend, lag in price and adjustment in quantity demanded would produce the long-run elasticities.

Friedman [F9] maintains that the *ceteris paribus* conditions are not substantive but methodological and that the long-run elasticity is greater than the short-run elasticity. The similar conclusions about the magnitude of elasticity for the different length of run are found in Stigler [S7], Nerlove [N4], Shepherd [S52 and Weintraub [W2]. The common reasoning of the similar conclusion is based on lagged adjustment in consumption behavior due to institutional [N4], technological [N4, S2, S7], psychological or habit [N4, S7] and uncertainty [N4] factors.

Samuelson [S1, S2], employing the result of the Le Chatelier principle that the change in volume with respect to a given change in pressure is greater when temperature is permitted to vary in accordance with the conditions of equilibrium, also concludes that the long-run demand elasticity is greater than the short-run elasticity.

Empirically Pasour and Shimper [P3] attempted to compare the two elasticities and concluded that for commodities demanded for actual consumption unlike the demand for changes in storage the long-run demand is more elastic.

The first serious attempt to measure the difference between the short- and long-run demand elasticities was made by Working [W4] in which he found the long-run (5-10 years) demand elasticity for meat is more elastic than the short-run (one year) elasticity. He uses the model

$$P = b_0 Q^{b1} (100q/Q)^{b2} I^{b3} (100c/C)^{b4}$$

Where:

P = Given year's deflated price index of the commodity

Q = Average consumption of preceding 10 years

q = Per capita consumption of the given year

I = Income index

c = Consumer price index for the given year

C = Average consumer price index for preceding 10 years

and the long-run elasticity (E_{lr}) and short-run elasticity (E_{sr}) are $E_{lr} = 1/b_1$

$$E_{sr} = 1/b_2$$

As was discussed by O'Reagan [O2] and Kuznets [K13], improper functional form and wrong derivation of elasticity (elasticity does not always equal the inverse of flexibility or vice versa) detracted from the validity of his work.

Tomek and Cochrane [T16] argue that the long run price elasticity for a product represents a complete quantity adjustment to a given price change where the determinants of the demand are constant, and that the long-run adjustment period is the dated time required for this complete adjustment to take place. Thus, they confine themselves to a static demand function in making the distinction. Using a modified version of Nerlove's distributed lag model and following Fox [F7] and Foote [F11], they formulated a short and long-run adjustment model:

$$q_t = b_0r + b_1rp_t + (1-r)q_{t-1} + b_2ry_t + b_3rp'_t$$

Where:

> q, p, p' and y are quantity, own price, other price and income, respectively.
>
> r is elasticity or coefficient of adjustment $0 \leq r \leq 1$
>
> $b_1 r$ is short-run elasticity
>
> b_1 is long-run elasticity.

It seems that their model (also Nerlove's) necessarily leads to a conclusion that long-run elasticities are greater than short-run elasticities because $0 \leq r \leq 1$. They also calculated the adjustment period (n) by assigning an arbitrary proportion of consumption adjustment (say, 95 percent) such that

$$(1 - r)^n \leq .05$$

Don Paarlberg [P1] also claims that the long-run price quantity relation is far different from the short-run relation, and in the long-run for many farm products a higher price means lower gross income to the farmers and sellers as demand becomes elastic.

Nerlove and Addison's work on food demand in the U.K. [N5] provides the same result.

At the other extreme, the short-run elasticities are argued to be greater than the long run elasticities. That is, elasticity is a decreasing function of time. Conceptually it was asserted by Shepherd [S5] in the case of demand for storage and Breimyer [B6] who cites inflexible characteristics of demand in modern society as the main reason. Empirically it was found by Tomek [T16], Breimyer [B6] both in the case of meat and Pasour [P12] in the case of apples.

In between these two extremes, there is an argument that the elasticity with respect to time may be U shaped [M3, P3]. The reasoning rests on the different types of reaction of consumers according to different purposes of consumption (actual use or storage). As to the formal proof of the belief that long-run elasticity is greater than short-run elasticity, Subotnik [S12] concludes that there is no reason to believe that it is true regardless of the situation. Long-run elasticity may be greater than short-run elasticity when the substitution effect of the last commodity that enters into the long-run consideration is negative and when the real income effect for the last commodity is small.[1]

Griliches [G9] points out that it is not obvious in theory if all long-run responses should be larger than short-run responses:

> This is clearly wrong for inventory models and other speculative situations.[2]

Brandow [B5] states that, in principle, demand may be elastic over a longer period than shorter period with some exceptions, in contrast with Houthakker and Taylor [H9] who argue that[3]

---

[1]For mathematical proof, see Subotnik, A. [S12], p. 554.

[2]Griliches, Z., p. 137.

[3]Houthakker-Taylor, p. 2.

> For habit-forming commodities, the long-term effect of a change in income is larger than the short-term effect, and their consumption is less dependent on income change than are purchases of durables.

Brandow uses a lag model to distinguish the short-run and long-run elasticity such that for a short run,

$$P_{it} - P_{it-1} = r(P^*_{it-1} - P_{it-1}) + c_1(q_{it} - q_{it-1}) + c_2(q_{jt} - q_{jt-1}) + \ldots$$

For long run,

$$P^*_t = a + b_1 q_{it} + b_2 q_{jt} + \ldots$$

where P^*_t is the price which, in the long-run, is consistent with the values in year t.

He found that the long- and short-run price flexibilities were approximately equal in case of meat demand. Further he notes that though not conclusive, demand elasticities should not be required to satisfy the homogeneity relation exactly. By this he seems to implicitly assume an existence of money illusion in demand functions.

Usual approaches to incorporate dynamic elements in demand analysis can be divided into three broad groups: The first is to add a trend term to the static demand equations. The second introduces trends into the parameters of the classical static demand equations (i.e., Stone [S10]). The third is to use distributed lags in demand equations. In this third category, there are wide varieties of forms and underlying assumptions of the distributed lags: (1) no specific assumptions are made with regard to the forms of distributed lag (i.e., Tinbergen [T8] and Alt [A8]), (2) specific assumptions are made about the general forms (Fischer [F3, F14] and Koyck [K12]), and (3) specific forms of distirbuted lag depending on the causes of lags (Nerlove [N4] with pure quantity adjustment and Hick's notion of an expectation [A9, C1, H7] model, and Houthakker and Taylor [H9] with quantity adjustment with respect to physical and/or psychological stocks).

The general forms of demand equations with various distributed lags are briefly listed as follows:

<u>Tinbergen's Model</u>

$$q_t = a + \sum_{o}^{\infty} b_i P_{t-i}$$

Where:

$$E_{sr} = b_o(\bar{p}/\bar{q})$$
$$E_{lr} = (\sum_{o}^{\infty} b_i)(\bar{p}/\bar{p})$$

<u>Fischer's Model</u>

1) $q_t = a + \int_{o}^{\infty} b(u)\ p(t-u)du$ log normal time path

2) $q_t = a + b(\sum_{o}^{N} (N-i)P_{t-i}/\sum_{o}^{N} (N-i))$ short cut method

<u>Koyck's Model</u>

$$q_t = a + b_o P_t + b_1 P_{t-1} + \cdot\cdot\cdot + b_{k-1} P_{t-k+1} + b_k \sum_{o}^{\infty} d^m P_{t-k-m}$$

Let k = 0, then

$$q_t = a(1-d) + b_o p + dq_{t-1} \qquad 0 \leq d < 1$$

and

$$E_{sr} = b_o(p/q)$$

$$E_{lr} = b_o \sum_0^{\infty} d^m \; (\bar{p}/\bar{q}) = (b_o/(1-d)) \quad (\bar{p}/\bar{q})$$

<u>Nerlove's Model</u>

$$Q_t^* = \Gamma X_t^*$$

Where:

Q_t^* and X_t^* are vectors of quantity adjustment and expected prices and income, respectively.

With appropriate transformation, the above equation will become

$$Q_t = AX_t + BQ_{t-1} - CQ_{t-2}$$

Mundlak [M12, M13] presents the procedure for comparing the long- and short-run elasticities applying to the theory of firms.

As to the relationship between the permanent income hypothesis [F9] and demand for individual commodities, there have been considerable arguments in both theoretical and methodological aspects. Nerlove [N4] argues that the notion of permanent income hypothesis, if used in demand analysis, implies that the distributed lag is only in income and it should be for each commodity and for total consumption. One practice in empirical demand study has been to calculate income elasticity from cross section data and insert it into time series analysis [B8, S8, T12, W3]. This pooling method is sometimes argued to be inconsistent with the permanent income hypothesis because the two are different concepts [N4].

Absence of money illusion amounts to the zero degree homogeneity condition and is a rational human behavior assumption in traditional demand theory. Because of this assumption, real prices and income are used in demand equations [T18]. Bronson and Klevorick [B9] suggest using a money illusion index such that:

$$C/P^a = f(Y/P^a)$$

in an aggregate consumption function to see if money illusion exists: if $a = 1$ it does not; if $a = 0$ it does. If there is no money illusion effect, real elasticity is equal to nominal elasticity [W3]. As noted earlier, Brandow argues that the homogeneity condition of elasticities (sum of elasticities are zero) should not be required exactly, "though not conclusive " [B5], which implies that price and income should not be deflated.

Usual approaches to the analysis of demand for stocks have been one of three types: capital goods and investment approach [P2,G7], production and consumption gap approach [B7, T1] and simple time lag approach [P3] and Houthakker and Taylor's approach [H9], the last of which is explained in Chapter III.

Related Research in Korea

Among the numerous studies and surveys on Korean food demand, only a few research efforts which seem to be relevant are reviewed briefly.

No research distinguished explicitly between short-run and long-run demand analysis. Further more, most studies emphasized urban demand analysis.

The Grains Policy Task Force's report [R2] for policy alternatives on rice, barley and wheat dealt essentially with short-term (4 months) demand analysis. It was based on the elasticities for June-September period by using monthly data and a constraint of constant total consumption assumption such that

$$\frac{\partial Q\ \text{total}}{\partial P_i} = \sum_{j=1}^{3} \frac{\partial Qj}{\partial Pi} = 0 \qquad i = 1, 2, 3$$

and assuming the rice price and quantity and wheat quantity fixed in a basic model of $Q = f(P,Y)$. The assumption of constant consumption during the period did not account for consumer inventory.

Furthermore, the report did not include rural income in the demand equation under an assumption of constant rural income during the four-month period. This assumption may imply that rural income is rather stable during a short-term period as compared with urban wage earners, or that rural income plays a rather minor role in determining demand.

In view of its analysis for short-term policy alternatives, dropping the rural income variable may not be such a critical matter. But the relative stability of rural income compared to that of urban income during the June-September period is doubtful because of its strong seasonal pattern and, if rural income response in its demand for grains is significant, it would be better to include it in the analysis.

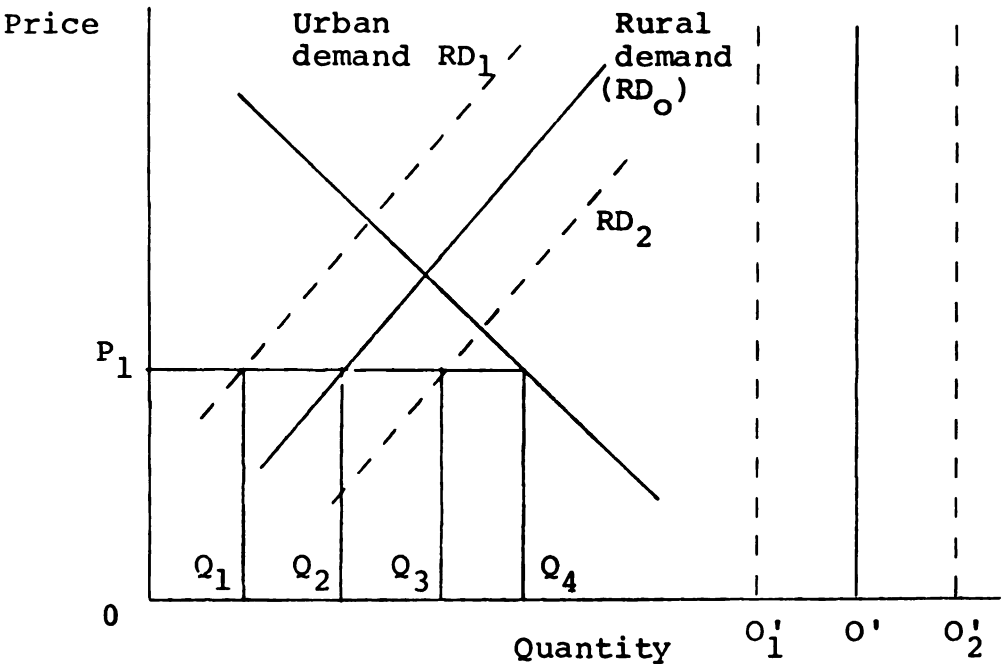
The other interesting point in the report is an assumption of higher rural grain prices than urban consumer prices which is often found in the real situation. This fact alone puts an upward pressure on urban consumer prices because grain movement from production areas to urban consumption areas would be discouraged, or in some cases, the flow would be reversed.

As introduced earlier, Daly, R. F. of USDA [D1] conducted both Korean urban and rural demand analysis for rice with annual data and found that price and income responses of rural consumers are higher than those of urban consumers such that

		Elasticities[4]	
	Rice/Rice	Rice/Barley	Rice/Income
Urban	-1.15	.358	.014
Rural	-4.40	1.32	.68

[4]Daly, R. F., <u>ibid</u>., p. 30-31.

He noted that this is a general phenomenon in a subsistence economy. He attributed chronical shortage of rice to a lower rice price along with very elastic rural demand. He further explained the possible direction of supply and demand by using a graphical approach recognizing the limitations of statistical analysis as in Figure 2.1.



O'_1 and O'_2 reflect the rural demand shifts

Q_2Q_4 = deficit at RD_o and P_1

Q_1Q_4 = deficit at RD_1 and P_1

Q_3Q_4 = deficit at RD_2 and P_1

Figure 2.1. Urban-Rural Demand.

It is apparent from Figure 2.1 that a higher price will reduce deficits or even create a surplus which is consistent with basic economic theory, and also clear that the more elastic (price) the rural demand the greater the deficit at lower prices. He did not explicitly analyze what causes the demand shift when he matches a positive demand shift with a lower price and a negative shift with a higher price; that is, O_1' axis when P_1 and O_2' axis when a higher price.

As usually the case in demand analysis, traditional demand shifters, income and population, may be insufficient to explain underlying consumption behavior and demand shifts.

Moon's [M11] study on rice and barley price policy is also a short-term analysis based on monthly or quarterly data. The main characteristics of his study as far as the demand for grains is concerned were that:

1. Rural demand and sale and urban demand functions for rice and barley under a free market system are specified such that

   $q_{ui} = f(P_{ui}, P_{uj}, P_{ui}\ y_u)$ for urban demand

   $q_{ri} = f(P_{ri}, P_{rj}, \text{stock}_{t-1}, y_r, p_{ri}\ q_i \text{ sold})$ for rural demand.

   where q, p, and y are per capita monthly consumption, monthly prices deflated and income deflated (rural income is from other than q_i), and subscripts u, r, i, and j denote urban, rural, own and other grains, respectively.

2. To incorporate "consumer's taste and preference" in the urban demand equation, he used an additional variable of multiplicative form, $P_{ui}\ y_u$.

3. Another set of rural demand equations and "market transaction" equation were used to analyze policy alternatives such that

$$q_{ri} = r(P_{ri}, p_{rj}, y_r, \text{rural pop., domestic production})$$
$$P_i = m(P_{uit-1}, P_{uj}, y_u, \text{urban pop., total supply of grains})$$

where quarterly data were used. The second equation is essentially an urban demand equation.

4. "Satiety points" where a certain level of price or income does not affect the consumption of rice were introduced such that, from the first set of the equations,

$$dq/dp \mid y^*_u = 0 \quad \text{or } dq/dy_u \mid P^*_{ui} = 0 \quad \text{for urban demand.}$$

It seems that there is little logic, as far as economic theory is concerned, to have two different sets of equations and to include a multiplicative variable which is only useful to derive, what he calls, "satiety points." In addition, there is a technical difficulty that may lead to a misleading inference. His argument can be explained simply by the following Figures 2.2 and 2.3.

Demand curves d_o, d_1 and d_2 represent the relationship depending on various levels of income, and e_o, e_1 and e_2 are Engel curves corresponding to various price levels. Then, contrary to his argument that increasing income could

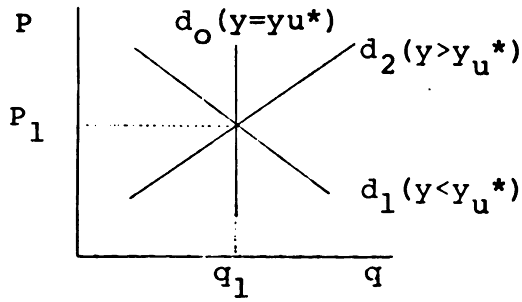


Figure 2.2. Demand Curves for Rice

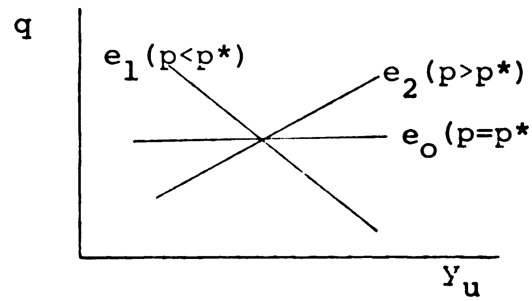


Figure 2.3. Engel Curves of Rice.

result in possible reduction in rice consumption if income increases above y* [P64, M11] the demand curve will have positive slope when $y > y*$. This would lead to a surprisingly different policy conclusion contrary to his previous conclusion which was the same as Daly's; above certain levels of income, lower prices would reduce rice consumption with a demand curve d_2; rice would be a Giffen good while its Engel curve has positive slope when $p > p*$. To avoid this contradiction, his demand curve should be contrained within the range of $p \leq p_1$, $q \geq q_1$, d_o and d_1.

Gustafson et al. [G10] analyzed the demand for nonfood and food using household expenditure data and imposing homogeneity (degree one) condition with respect to expenditure, income and price. They suggested further research to combine the cross section and time series analysis for both urban and rural demand, and to analyze more about the aggregation bias and single equation bias of estimates. The imposed homogeneity (degree one) with respect to expenditure is same as homogeneity (degree zero) condition with respect to quantity demanded.

They indicate that income elasticity for farmer's food demand is greater than that of nonfarmers (1.02 versus 0.32) and that there has been a downward trend in food consumption unaccountable for by changes in price, the most likely explanatory hypothesis being a change in tastes due to urbanization and increased mobility.

They also note that undeflated income, expenditure and prices would not give a good result because of a highly inflationary situation and high correlation among independent variables (with quantity or expenditure as dependent variable). Daly [D1] argued that the analysis using undeflated prices and incomes with the price variable dependent seemed most logical and somewhat more significant statistically in Korean rice demand analysis. These two opinions are not contradicting because they are dealing with different dependent variables. Gustafson et al. pointed out, on the other hand, that deflating by a general price index tends to result in a very high negative correlation between deflated price of food and deflated price of nonfood depending on data. Though it seems not obvious intuitively, it may be true if a general price index could not deflate both prices equivalently.

Hayenga et al. [H4] conducted a single equation analysis of total, urban and rural demand for major grains, meat, fruits and vegetables by using four different sources of aggregate data: Ministry of Agriculture and Fisheries, Economic Planning Board of Korea, FAO of UN and Farm Household Economy Survey data. They implicitly regarded the coefficients as long-run coefficients. They also suggested that regional demand and inventory analysis be conducted. Variables included in each commodity equation varied; mostly quantities, prices and income, prices being sometimes omitted due to the lack of appropriate data. Their work was a good example of how usual regression analysis with different source of data could result in vastly different inferences.

Among the coefficients they found some of them are as follows:

	Rice		Barley	
	Price	Income	Price	Income
Urban	-.760	-.035	-.948[1]	-1.311[1]
Rural	-.143	.296	-.300[1]	- .363[1]

[1]For both barley and wheat.

As in most findings, rural income response on rice demand is positive and urban response is negative. But price responses are smaller in rural than urban areas.

They attribute greater price responsiveness of urban consumers to the alternative substitutes available to the urban consumer and exposure to the greater variety of food consumption patterns than in rural areas, and smaller price responsiveness of rural consumers to less market-orientedness of farmers and to the characteristics of being producers and consumers simultaneously. This is quite a different observation from others, particularly from Daly's. Probably it may be desirable to disaggregate farm groups into some detail and see if they respond in different manners.

The Korean Agricultural Sector Study (KASS) [K1] deals with rural food demand as a residual and calculated rural per capita food consumption, q_t, by using

$$q_t = q_{to}(1 + E_y \frac{Y_t - Y_{to}}{Y_{to}} + E_p \frac{P_t - P_{to}}{P_{to}})$$

where E_y, E_p, y and p are rural income elasticity, price elasticity, gross nominal rural per capita income and average price, respectively and subscript to = 1970. E_y and E_p are calculated outside the simulation model, and some of them seem to be adjusted according to various sources of information including researchers' judgement.

Some of the price and income elasticities that are listed in KASS Special Report (Table 3.10, pp. 3-16, No. 9) are shown below:

	Rural		Urban	
	Price	Income	Price	Income[1]
Rice	.0	.06	- .4	-1.0
Barley	0	- .20	-1.0	-1.0
Wheat	-1.0	.20	- .6	1.5
Pulses	0	.80	- .4	.8
Vegetables	0	.40	- .8	.4
Beef	-1.0	1.7	- .48	1.7
Fish	- .7	.35	- .7	.35

[1]Urban income elasticities are time-varying such that $E_y(t-DT) = E_{y_{to}}(q_t - q_{t-DT})/(q_t - q_{to})$ where DT is a simulation time interval.

One of the interesting points is that most of the elasticities of rural demand are smaller than those of urban demand, and some are set at zero.

A joint study report of Yonsei University of Korea and USDA [G1] utilized cross-sectional data from 1964 and derived three sets of projection parameters for food demand: adult-equivalent scale, total expenditure elasticities for foods and average adult consumption of selected foods. At the time of this study, the full text of the report was not available. Thus some of the major findings are only listed: food consumption patterns have been changing due to urbanization and industrialization; expenditures for grains other than rice are inversely related to income; the lowest income households consume relatively less rice and more barley; the growth rate in food demand in urban areas is twice that in rural areas.

The Agricultural Economics Research Institute (AERI) of Korea conducted studies on the prices, marketing channels and consumption of rice and barley particularly in the Seoul area by using time series data and by exploring some new cross-section surveys [A4]. They also undertook a number of other studies on the supply of and demand for rice [A3]. In the case of demand for rice and barley, they assumed rice price elasticity being -.5 and the income and population effect .50 without explanation [A4]. The other study simply calculated various constant elasticities by inverting the flexibility model of basic demand equations.

Tolley [T13, T14] emphasizing demand for rice as an important factor in the short-run rice price policy, used the upper and lower limit of various elasticities to predict the range of possible outcomes, and he listed annual and seasonal price stabilization, economic efficiency and equity as policy goals.

Other agricultural market surveys include the joint survey of the National Agricultural Cooperatives Federation (NACF) of Korea and International Marketing Institute of the United States for rice, beef, sweet potatoes, ramie and apples [N1], a study on canned foods [A2] and a survey on Honam rice [K10]. They are based primarily on time series and some on limited cross-section surveys.

As has been briefly discussed so far, most studies have been conducted with traditional static demand equations and some with simple distributed lag models. Since there is no such thing as the elasticity and because of difficulties of measurement it is too much to expect consistent estimates from various researchers. An effort should be made, just the same, to develop a reliable estimation process for the structure of food demand. To do this we must recognize the trade offs between data available, economic theory and statistical methods.

CHAPTER III

ANALYTIC APPROACH

As was found in the previous chapters, there is no unique method of differentiating the short- and long-run demand analysis and hence static and dynamic demand. Not even a consensus about the magnitude of respective elasticities or coefficients is found among economists.

Specifications of the model have been heavily dependent upon *a priori* belief that the long run effects or elasticities are greater than those of short run. Employing *a priori* belief in the specification of model is an important method in empirical study of economic phenomenon. Without sound theoretical or *a priori* knowledge, model building of socio-economic reality is usually thought to be infeasible.

There is, however, another method--the "black box" approach [M3, N2]. The basic approach is to start with no knowledge about the system.

In this study, both approaches were employed. As far as the relative magnitude of the short- and long-run effects of the change in prices, income and other variables is concerned, no *a priori* knowledge or propositions were incorporated in the model specification, even though there was one defect in conjunction with the relative magnitude which is discussed later. On the other hand, the relevant variables and other basic economic behavior were based on theory and real-world observations.

Basic Model

The "state adjustment and nonadditive" model formulated by Houthakker and Taylor was used, with some modifications and addition. The model was basically formulated with specific propositions about the consumption behavior and form of distributed lag. It was postulated that the effect of past behavior can be represented by the current values of certain "state variables",[1] an example of which is inventory level, either physical or psychological. The dynamic process is then that of adjustment in physical or psychological stocks (i.e., stock represented by the past habit of eating).

It is "state" adjustment rather than "flow" adjustment of A. R. Bergstrom [H9] or Nerlove [N4]. In the "flow" adjustment model, the dynamic aspect of consumption is viewed as an attempt of a consumer to bring his actual consumption closer to some desired level.[2]

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[1] "State variables" are defined as those variables that are affected by past history [M3, N2].

[2] In "flow adjustment" model, state variable is replaced by q and equation system consists of $dq/dt = \Theta(q^*-q)$ and $q^* = a + by$ where q^* is long run level and q is desired level [H9].

It is a "nonadditive" model in the sense that it does not exactly fit classical static consumer theory and that budget constraints are not introduced in the estimating procedure.[3]

One of the advantages of this approach is that physical inventory levels do not necessarily appear in the final equation system.

It seems desirable to incorporate possible consumption behavior arising from the "subsistence" nature of small farmers, particularly, in the case of basic foods. In cases where price and/or income do not significantly affect consumption level, it can be interpreted either as a habit forming effect and inertia to adjustment or as the existence of a subsistence level of certain commodities.

State Adjustment Model

Using the Houthakker-Taylor's proposition, the following basic demand equation for a quarterly model was formulated for an individual farm household:

$$q_{ijt} = b_{ijo} + b_{ij1}s_{ijt} + b_{ij2}\, y_{jt} + \sum_{i}^{<10} b_{ij3}\, P_{it} + b_{ij4}DV2 + b_{ij5}DV3 + b_{ij6}DV4 + e_{ijt} \qquad 3.1$$

Where:

q = per capita demand rate in either quantity or expenditure term.

---

[3]Additive model uses a quadratic utility function, $u(q,s) = q'a + s'b + 1/2q'Aq + q'Bs + 1/2s'Cs$ and a budget constraint, $p'q = y$, where primes denote transpose.

s = stock, habit or consumer inertia to adjust.

y = gross household income per capita

P = prices

DV2, DV3 and DV4 = quarter dummy variables.

Subscript i = an individual food (i = 1,. . .,10: rice, barley and wheat, miscellaneous grains, pulses, potatoes, vegetables, meats, dairy, fish and marine products and processed foods.

j = household according to farm size (j = 0,. . .,5).

The division of farm household groups into five according to farm size is to facilitate aggregation of rural demand function which will be discussed later in this chapter.

Per capita figures were used rather than per household, even though it is difficult to regard children as decision makers in purchasing and consuming certain goods. Utility of dependent or other family members is more or less dictated by adults who actually purchase and cook foods. Moreover, the number of consumers of different commodities will certainly differ. A good example of this case is education expenditure; it may be assumed that quantity demanded by persons above about thirty years of age is negligible. There are some commodities, on the other hand, that can not be consumed by individuals, of which an example is housing expenditure. In this sense, Stone's "equivalent-adult scale" [S11] seems to make sense. This scale is a weighted sum of the numbers in different age and sex groups.

Since, however, "equivalent-adult scale" should be different among different commodities, there is room for arbitrariness. Particularly, in the case of food consumption that is under consideration in this study, it seems that such a different refinement of adult scale may not be necessary and that the per capita unit might be enough.

Despite this consideration, the scale was tried for annual data using some of the scales from the relative weights of the working class in the United Kingdom developed by Stone [S8]. Such scales are shown in Table 3.1. Stone's scales do not include the age group over 66 years, the scale of which is assumed to be between under 14 years and 15-17 years.

Table 3.1. Adult-Equivalent Scales

Age Group	Male	Female
Under 14	0.52	0.52
14 - 65	1.00	0.90
Over 66[1]	0.65	0.65

[1]This corresponds to Stone's scale of 5-13.

Rate of change in stock (physical or psychological), s, can be expressed by

$$\frac{ds_t}{dt} = q_t - cs_t \qquad 3.2$$

where c represents constant proportional depreciation or consumption rate out of the stock and, for convenience's sake, subscripts i and j are deleted, and dummy variables are omitted.[4]

Solving Equation 3.1 for s_t, then

$$s_t = \frac{1}{b_1}(q_t - b_o - b_2 y_t - \sum_{i=1}^{<10} b_{i3} P_{it}) - \frac{1}{b_1} e_t \qquad 3.3$$

Substitute s_t into Equation 3.2:

$$\frac{ds_t}{dt} = q_t - \frac{c}{b_1}(q_t - b_o - b_2 y_t - \sum_{i=1}^{<10} b_{i3} P_{it}) + \frac{ce_t}{b_1} \qquad 3.4$$

Differentiate Equation 3.1 with respect to t;

$$\frac{dq_t}{dt} = b_1 \frac{ds_t}{dt} + b_2 \frac{dy_t}{dt} + \Sigma b_{i3} \frac{dp_{it}}{dt} + \frac{de_t}{dt} \qquad 3.5$$

Substituting Equation 3.4 into Equation 3.5, then

$$\frac{dq_t}{dt} = b_1 q_t - c(q_t - b_o - b_2 y_t - \Sigma b_{i3} P_{it}) + b_2 \frac{dy_t}{dt}$$

$$+ \Sigma b_{i3} \frac{dp_{it}}{dt} + ce_t + \frac{de_t}{dt}$$

$$= cb_o + (b_1 - c) q_t + b_2 \frac{dy_t}{dt} + \Sigma b_{i3} \frac{dp_{it}}{dt} + cb_2 y_t$$

$$+ \Sigma cb_{i3} p_{it} + ce_t + \frac{de_t}{dt} \qquad 3.6$$

---

[4]Full model is shown in Appendix.

For discrete approximation, Equation 3.6 can be reduced to the following Equation 3.7 by using trapezoidal rule.[5] The usual approach of using finite differences to replace derivatives is less accurate.

$$q_t = A_o + A_1 q_{t-1} + A_2 y_t + A_3 y_{t-1} + \Sigma A_{i4} P_{it} + \Sigma A_{i5} P_{it-1} + V_t \qquad 3.7$$

This reduced equation was used for estimation. Since most of the data cover the period from 1964 to 1972, all of the variables in equation 3.7 cannot be used, particularly in the case of annual data and prices which are either inaccurate or lacking. In those cases, appropriate adjustments are made. When dummy variables are used, the reduced form coefficients are just c times structural coefficients with appropriate adjustments (see Appendix).

If q_t is the rate of consumption per unit of time, dt, then, $\int_t^{t+DT} q\,dt$ is the corresponding total consumption per unit of time, DT.[6]

The relationships between b's and A's are as follows:

$$b_o = A_o(2-b+c)/2c \qquad 3.8$$

$$b_1 = (-2+A_1c+2A_1+c)/(1+A_1) \qquad 3.9$$

$$b_2 = A_2(2-b_1+c)/(2+c) \qquad 3.10$$

---

[5]For derivation of Equation 3.7, see Appendix.

[6]If quarterly data are used, DT = 1/4 and the values of A's in Equation 3.7 will be different (see Appendix). And DT shall not be confused with DT used in the simulation model in Chapter IV.

$$b_2 = A_3(2-b_1+c)/(c-2) \quad 3.11$$

$$b_{i3} = A_{i4}(2-b_1+c)/(2+c) \quad 3.12$$

$$b_{i3} = A_{i5}(2-b_1+c)/(c-2) \quad 3.13$$

and

$$c = 2(A_3+A_2)/(A_2-A_3)$$

$$= 2(A_{i4}+A_{i5})/(A_{i4}-A_{i5}) \quad 3.14$$

Since above Equations 3.8 through 3.14 are over identified, following constraints are given:

$$A_2A_{i5} = A_3A_{i4} \qquad \text{for } i \leqq 1,\ldots,10 \quad 3.15$$

In solving the estimation problem with nonlinear constraints, there have been three methods: (a) "nonlinear least square" method [K6], (b) "constrained least square" by linear approximation of nonlinear constraints suggested by Houthakker and Taylor [H9], and (c) quadratic programming method [B4, H1, W1, T5].

Nonlinear Least Square Method

Minimize

$$S = \sum^{n} [q_t - \frac{2cb_o}{2-(b_1-c)} - \frac{2+(b_1-c)}{2-(b_1-c)} q_{t-1} - b_2 \frac{(2+c)}{2-(b_1-c)} y_t$$

$$- b_2 \frac{(c-2)}{2-(b_1-c)} y_{t-1} - \Sigma b_{i3} \frac{(2+c)}{2-(b_1-c)} p_{it} - \Sigma b_{i3}$$

$$\frac{(c-2)}{2-(b_1-c)} p_{it-1}]^2 \quad 3.16$$

with respect to all b's and c.

Then the resulting estimates are equivalent to the maximum likelihood estimation (MLE) method. It is, however, not guarnateed to generate global optimum values. Also computation are much more complicated because of various combinations of unbounded values of parameters which give most difficulties.

Constrained Least Square by Linear Approximation

Form a Lagrangian equation

$$L = \Sigma(q_t - A_o - A_1 q_{t-1} - A_2 y_t - A_3 y_{t-1} - \Sigma A_{i3} p_{it} - \Sigma A_{i4} p_{it-1})^2 - 2\Sigma\lambda_i (A_2 A_{i5} - A_3 A_{i4}) \qquad 3.17$$

where λ's are Lagrangian multipliers.

Differentiate 3.17 with respect to A's and λ's, then we obtain a system of equations such that

$$\frac{\partial L}{\partial A_i} = 0 \quad \text{and} \quad \frac{\partial L}{\partial \lambda_i} = 0 \qquad \text{for } i \leqq 1, \ldots, 10 \qquad 3.18$$

Solving for A's in terms of λ's gives the following system of equations:

$$\Theta\ (\lambda_i) = A_2 A_{i5} - A_3 A_{i4} \qquad i \leq 1, \ldots, 10 \qquad 3.19$$

Next step is to approximate $\Theta(\lambda_i)$ by a linear system of functions $\Theta_L(\lambda_i)$ which is done by solving each equation for two arbitrary λ_i's and by evaluating $\theta(\lambda_i)$ if it is zero. This procedure continues until it converges.

As in the cases of alternative methods, convergence is not always guaranteed because exact functional forms of Equation 3.10 are unknown and nonlinear.

Quadratic Programming

The problem formulation is the same as the previous methods. There are various kinds of algorithms and operation research techniques; gradient projection method, separable programming by piece-wise linearization. Powell's algorithm, complex methods and others.

However there is no best algorithm; it dpends on the nature of the problems at hand and trade-offs.

In this study, constraints are linearized, which will be discussed in Chapter V.

Long-Run Coefficients

The short- and long-run effects of change in price and income were derived in the following manner. The coefficients of structural Equation 3.1, b's, are interpreted as those of instantaneous adjustment or short-run effects given other variables including the state variable. The long-run coefficient of prices and income, which correspond to entire changes and shifts in demand associated with a once and for all change in the state variable, s, is $b\frac{c}{gc-b_1}$, for $g \neq 1$, that is shown in Equation 3.23.

In the long run, it is postulated that the rate of change in stock, s, in Equation 3.2 is zero such that

$$\frac{ds}{dt} = q^* - cs^* = 0 \qquad 3.20$$

where * denotes long-run level.

Then

$$S^* = q^*/c \qquad 3.21$$

Substitution into Equation 3.1 gives

$$q^* = b_o + (b_1/c)q^* + b_2 y^*_t + \Sigma b_{i3} p^*_{it} \qquad 3.22$$

ignoring other terms including error terms. Hence assuming $b_1 \neq c$

$$q^* = b_o(c/(c-b_1)) + b_2(c/(c-b_1))y^*_t + \Sigma b_{i3}(c/(c-b_1))P^*_{it} \qquad 3.23$$

and

$$s^* = b_o/(c-b_1) + (b_2/(c-b_1))y^*_t + \Sigma(b_{i3}/(c-b_1))P^*_{it} \qquad 3.24$$

Then $b_g(c/(c-b_1))$ is interpreted as the long-run coefficients.

To see the relationship between q_t, s_t, q^* and s^* and the meaning of b_1, the following manipulation is done:

From Equation 3.1 and 3.3.

$$b_1(s_t - s^*) = q_t - (b_o + b_2 y^*_t + \Sigma b_{i3} P^*_{it} + b_1 s^*) \qquad 3.25$$

Replacing y_t and P_{it} with y^* and P^*_{it}, from Equation 3.22 the term in the parenthesis in the right hand side of Equation 3.25 is just q^*.

Hence

$$b_1(s_t - s^*) = q_t - q^* \qquad 3.26$$

where b_1 may be termed the coefficient of adjustment, the notion of which is different from Nerlove's concept. If b_1 is negative, purchases or consumption are above their long-run equilibrium level and the inventory, s, is below its long-run level. It is also the case when the former are below their long-run level and the latter is above its long-run level. Durable goods will give rise to this case given tastes and income. The larger the stock at the beginning, the less consumers will buy. If b_1 is positive, the two deviations (deviation of q_t and s_t from q^* and s^*, respectively) have the same sign; if current inventory is below the long-run level, consumers will buy less, and if it is above the long-run level they will buy more. A plausible explanation of this case, contrast to durable goods, will be habit forming phenomena. For example, prolonged habit of eating rice which implies larger inventory in terms of this model, either from tradition or prestige, will lead to larger consumption above the long-run equilibrium, other things being equal.

There are several advantages in formulating the model in this way compared to Nerlove's model. As briefly discussed earlier, Nerlove conceptualizes several forms of a distributed lag depending on various assumptions. The most complex model includes all of the major assumptions, which are (a) current price and income affect long-run equilibrium level of consumption, (b) uncertainties about prices and income do exist, and (c) institutional and/or technological rigidities in consumption exist. Assumptions (a) and (b) lead to use coefficients of expectations, E, and assumption (c) coefficients of adjustments, R, as discussed in Chapter II. Both of the coefficients or elasticities are bounded between 0 and 1.

The reduced form equations arising from these assumptions are usually in the form of

$$Q_t = \pi_1 X_t + \pi_2 Q_{t-1} + \pi_3 Q_{t-2} \qquad 3.27$$

Then the short-run coefficients or elasticities matrix, π_1, is represented by

$$\pi_1 = R\Gamma E < \Gamma \qquad 3.28$$

where the long-run effects are denoted by Γ.

It is clear from Equation 3.28 that the long-run effect, Γ, is necessarily greater than the short-run effect, π_1, of the change in the independent variable matrix X since $0 < R$, $E < I$. As indicated earlier this approach results from a restrictive _a priori_ knowledge about the relative magnitude of the short- and long-run effects.

It is also clear that b_1 in the state adjustment model corresponds to coefficients of adjustments, R, in Nerlove's model. The meaning and scope of b_1, however, is less restrictive than R, since b_1 can take any value except some special cases which are discussed later. As indicated earlier, one of the defects in the state adjustment model is that it does not count existence of uncertainties in price and income explicitly.

The economic meaning of the coefficients of expectation and adjustment is well documented (Arrow and Nerlove [A3], Nerlove [H7], Cagan [Cl], Friedman [F9], Hicks [H7), Griliches [G7]). In general they are thought to be functions of consumer's economic horizon that is supposed to be affected by social unrest, government price control, degree of price fluctuations and other factors; the more violent and rampant they are, the smaller the coefficients will be.

If we interpret b_1 and c properly, we could remedy a certain aspect of defects in the state adjustment model; a defect of which is exclusion of uncertainties in explicit form. Incidentally, even the combination of the partial adjustment (R) and adaptive expectation (E) could not accomodate the kind of uncertainties with unknown distribution as discussed by Knight [K7]. It is possible to incorporate traditioal coefficients of expectation into the state adjustment model. But this leads to extremely complicated estimation problems with nonlinear constraints of high order. Actually b_1 and c represent all factors of consumer inertia and adjustment in accordance with price and income expectation which is clear from the lagged terms in the Equation 3.7 if we employ the conventional approach of using lagged terms in behavioral equations without specifying exact relationships or distributions.

Since it is perceived that the distributed lag model seems to conform to a priori beliefs, another form of distributed lag, "rational distributed lag", which is discussed in the latter part of this section, was tried to compare the results with the state adjustment model.

We will discuss some implications of special cases.

Special Cases

The occurances and implications of special cases would depend on the way of transforming the equation, Following Houthakker and Taylor, Equation 3.7 takes different forms such that

$$q_t = A_o + A_1 q_{t-1} + A_2 \Delta y_t + A'_3 y_{t-1} \qquad 3.29$$

ignoring other terms for expository purposes.

Then

$$A_o = 2b_o c/(2-(b_1-c)) \qquad 3.30$$

$$A_1 = (2+(b_1-c))/(2-(b_1-c)) \qquad 3.31$$

and

$$A_2 = b_2(2+c)/(2-(b_1-c)) \qquad 3.32$$

which are the same as in Equation 3.7, but

$$A'_3 = b_2 c/(2-(b_1-c)) \qquad 3.33$$

and

$$\Delta y_t = y_t - y_{t-1} \qquad 3.34$$

which are different from those in Equation 3.7.

And, similarily, all the coefficients of lagged terms will be multiplicative of $c/(2-b_1+c)$.

Manipulation of Equation 3.7 in this fashion will make interpretation of some of the special cases different as in cases (b) and (c).

Since it seems less meaningful to create more special cases, the treatment of functional forms in this study did not follow the Houthakker-Taylor method. For example, from Equation 3.29, when $c = 0$, $A'_3 = 0$, but $A_2 \neq 0$. Then the coefficient of the lagged term, y_{t-1}, takes two different values, since $A_2 \Delta y_t = A_2 y_t - A_2 y_{t-1}$.

Let us examine some of the special cases.

(a) $A_1 = 1$ implying that $b_1 = c$[7]

In this case, long term interpretation breaks down as far as the model is concerned since all the coefficients in Equations 3.8 through 3.14 are not defined. This is true because complementary and particular solutions of Equation 3.7 contain A_1^t and $1/(1-A_1)$, respectively.[8] Then there will be no distinction between the short-run and long-run effect since, as $t \rightarrow \infty$, A_1^t remains constant which is also clear from Equation 3.23. It is suggested by Houthakker and Taylor to transform Equation 3.7 as follows:

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[7]If $A_1 = 1$, then $(2+b_1-c)/(2-b_1+c) = 1$ which results in $b_1 = c$.

[8]A general form of first order difference Equation 3.7 is $q_t = I_o A_1^t + f(t)/(1-A_1)$ where I_o is determined from initial conditions and $f(t)$ represents the rest of the terms.

$$q_t - q_{t-1} = A_o + A_2 y_t + A_3 y_{t-1} \qquad 3.35$$

ignoring other terms again.

(b) c = 2 or -2[9]

When c = 2 all the coefficients of the lagged terms will become zero. This is a case of a static model.

When c = -2, the coefficients of current independent values will become zero which will be a special expectational behavior. According to Houthakker and Taylor the case when c = 2 arises if a commodity is bought once a year with a life time of one year and if DT = 1. This line of explanation is plausible if the consumer has no specific concern about the characteristics of such a commodity or if static assumptions hold. In contrast to the previous case, when c = -2, the demand relationship might be governed completely by the past history or habit.

(c) c = 0

Then the definitional Equation 3.2 reduces to

$$ds/dt = q_t \qquad 3.2'$$

and the long run level of q* will become zero. This implies that there is no "feedback" from the past habit, or that there is no desire on the part of the consumer to achieve q*. This case might be that of inferior good according to Houthakker-Taylor.

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[9]When quarterly data are used, it is adjusted with 1/DT (see Appendix).

Estimation

In principle, it is necessary to have both supply and demand equations and to estimate them simultaneously because price and quantity are jointly determined. Unfortunately, however, the simultaneous estimation procedures have seldom given us convincing results in demand analysis [H9]. This may be due to difficulty of deriving appropriate and consistent supply equations and due to the fact that, in case of agricultural products, supply is almost predetermined within a given period.

Thus in this study it was unavoidable to use single equation estimation procedures without specifying the supply functions. In some cases as discussed in projection and simulation techniques, a simultaneous system was tried by treating some of the independent variables as endogenous variables. But it should be noted here that this is not a true simultaneous system in the sense that supply and demand are jointly determined in the conventional approach. It will serve as an instrument to facilitate projection and simulation.

A related problem is autocorrelation which occurs in almost all distributed lag models.[10] Error term, e_t, in

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[10] In contrast to Griliches' [H4], Houthakker and Taylor argue that, "Autocorrelation has been detected much less with the dynamic model than with the static model. This is primarily because the dynamic model is a more adequate specification" [H9, p. 35].

Equation 3.1 and V_t are not the same. V_t is defined by

$$V_t = \frac{(2+c)e_t - (c-2)e_{t-1}}{(2-b_1+c)} \qquad 3.36$$

Depending on the nature of e_t, variance and covariance of V_t have different values.

First let $e_t \sim N(0,\sigma^2)$ which is non-autocorrelated, then V_t will serially correlated:[11]

$$E(V_t, V_{t-1}) = E\ \frac{(2+c)e_t - (c-2)e_{t-1}}{2 - b_1 + c} \cdot \frac{(2+c)e_{t-1} - (c-2)e_{t-2}}{2 - b_1 + c}$$

$$= \frac{(c^2 - 4)}{(2-b_1+c)^2}\,\sigma^2 \qquad 3.37$$

which becomes zero when $c = 2$.

Secondly, if $e_t = e_{t-1} + V_t$ and $V_t \sim (0,\sigma^2)$, then

$$E(V_t, V_{t-1}) = \frac{2(4+c^2)\sigma_{ij} + (C^2 - 4)\sigma^2}{(2 - b_1 + c)^2} \qquad 3.38$$

where σ_{ij} is the covariance between e_t and e_{t-1}.

Thus the Durbin-Watson statistic,

$$D.W. = \frac{\Sigma(\hat{V}_{t+1} - \hat{V}_t)^2}{\Sigma\hat{V}_t^{\,2}} \qquad 3.39$$

should be adjusted in both cases such that when 3.37,

$$E(D.W.) \cong 2 - \frac{c^2 - 4}{c^2 + 4} \qquad 3.40$$

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[11] Subsequent derivations are from Houthakker and Taylor [H9, pp. 35-36] with notations changed.

and when Equation 3.38,

$$E(D.W.) = 2 + 2\,\frac{(4+c^2)\sigma_{ij} - (4-c^2)\sigma^2}{(4-c^2)\sigma_{ij} - (4+c^2)\sigma^2} \qquad 3.41$$

Projection Problem

Projections, in general, can be made either by solving difference Equation 3.7 or by substituting corresponding values. Usually the former method yields more error because of rounding.

The most troublesome problem is how to derive the corresponding independent variables for projections. For this reason, the quarterly model was not used for projection purposes.

Only annual demand equations for rice and barley and wheat were simultaneously estimated using a two stage least square estimation procedure.

These equations were used in a policy experiment by using a simulation technique that is discussed in Chapter IV.

Additive Versus Nonadditive Model

The decision whether to us the nonadditive state adjustment model rather than the additive state adjustment model was a matter of trade-offs. While the nonadditive model does not have to assume an explicit utility function other than utility being a function of quantity, can be estimated by single equation estimation procedure, and also does not require the estimation of marginal utility of money, this model does have some defects. They are that estimates may be biased even with smaller mean square error (MSE) when estimated by single equation procedures, that identification problem in the depreciation rate, c, forces the ratio of the short and long-run effect, $c/(c-b_1)$ in Equation 3.23, to be the same for all independent variables in an equation and that it does not satisfy budget constraint.

The additive model, on the other hand, is free of these defects. But a "quadratic utility function" is arbitrarily defined and this forces the model to estimate marginal utility of money[12] that is subject to change depending upon the form and monotonic transformation of a utility function.[13]

Even though the estimates of simultaneous equations are not biased compared to those of the nonadditive model, their MSE are greater. For policy formulation and projection purposes, the decision of choosing between smaller MSE and an unbiased estimator has not been of unanimous agreement among economists.

According to Mincer-Zarnowitz criteria [M10], the goal of forecasting is the minimization of MSE which is expressed by

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[12] Since quadratic utility function is defined as $(q,s) = q'a + s'b + 1/2q'Aq + q'Bs + 1/2s'Cs$, derivation procedure of final equation by using Lagrangian equation with a budget constraint, $p'q = y$, can not eliminate the multiplier, λ, which is marginal utility of money [H9].

[13] Monotonic transformation of a utility function does not change final demand equation and preference ordering but changes the value of marginal utility of money.

$$MSE = \Sigma \frac{(A_t - E_t)^2}{N} \qquad 3.42$$

where A_t is actual value of forecasted variables, E_t is forecasted value, N is the number of observations.

Theil [T5] uses U as a statistic to measure the goodness of fit of forecasting which is defined as

$$U = \frac{(\Sigma(E_i - A_i)^2)^{1/2}}{\sqrt{\Sigma E_i^2} + \sqrt{\Sigma A_i^2}} \qquad 3.43$$

If U is zero, it implies perfect forecast.

The choice between unbiasedness and smaller MSE depends upon circumstances and loss function of user of the projections. It seems that if we are generating a large number of projections across the economy it would be more important to have unbiased estimates than those having smaller variance.

Rational Distributed Lag Model

If the number of observations is small, as may well be in the case of annual data, and if these successive past observations are not collinear, then the weights with which past and present values are combined can be estimated directly by least squares. When, however, the observations increase, as in the case of quarterly data, it may become necessary to make some reasonable assumptions about lag distributions. In general, these assumptions include popular geometric, arithmetically declining [F3], Pascal [K11] of which inverted v lag and polynomial interpolation distribution are the cases, and rational distributed lag distribution [T5].

The adaptive expectation [C1] model that attributes the lags to uncertainties and the partial adjustment model that attributes the lags to technical, institutional or psychological inertia [N3] usually adopt an assumption of geometrically declining weights of past impacts. A doubt was raised by Griliches [G9] about its generality. He points out that because of wide spread availability of quarterly and monthly data, the assumption that the largest response occurs immediately after the beginning of the adjustment period seems to be quite restrictive. The other distributions, however, are not free of difficulties. For instance, those using the polynomial distribution must decide the degree of polynomial a priori which is not always well established. The rational distributed lag form also requires such assumption.

In any case, distributed lag models suffer from "theoretical adhockery." Examples of various lag functions are given in Table 3.2.

Admitting its theoretical adhockery, Jorgenson's rational distributed lag was used in the rural demand specification, and results were compared with those of a lag distribution arising from state adjustment assumptions.

One of the benefits of using a rational distributed lag is, as he indicates, that it makes equations estimatable in

Table 3.2. Examples of Lag Distribution

$A(L)$[1]	$T(L)$[1]	Distribution
$(1-r)$	$(1-rL)$	Geometric Distribution
$(1-r)$	$(1-rL)^n$	Pascal and General Distribution
$(1-r_1)\ldots$	$(1-r_2L)(1-r_3L)\ldots$	Rational Lag Distribution

[1]In $y_t = b\,\frac{A(L)}{T(L)}\,X_t$ where L is lag operator, (L is a lag operator such that $Ly_t = y_{t-1}, \ldots, L^n = y_{t-n}$) A(L) and T(T) are finite polynomials of rational generating functions and r is root(s) of polynomial(s).

a sense that number of unknown parameters can be kept as small as possible. Another is that the approximation of an arbitrary lag function is possible to any desired degree of accuracy.

The class of rational distributed lag function is defined by the condition that the sequence of the coefficients of W_i in

$$W(S) = W_o + W_1S + W_2S^2 + \ldots \qquad 3.44$$

where $\overset{\infty}{\Sigma} W_i = 1$ which describes the form of lag distribution has a rational generating function of W_i which is denoted by W(S) where

$$W(S) = \frac{A(S)}{T(S)} = \frac{a_o + a_1s +, \ldots, + a_mS^m}{b_o + b_1S +, \ldots, + a_nS^n} = W(L) \qquad 3.45$$

and S is auxiliary dummy variable. W(L) is a short hand notation for a power series or polynomial in lag operator L (rational generating function). Then y_t, a dependent variable, can be expressed by Equation 3.46 with some dependent variable(s), x_t, such that

$$y_t = bW(L)x_t = b\frac{A(L)}{T(L)}\,x_t \qquad 3.47$$

With this concept in mind, let us specify the structural or original equation[14] as

$$q^*_t = b_o + b_{12}y^*_{1t} + b_{22}y^*_{2t} + \Sigma b_{i3}P^*_{it} + b_4 DV2 + b_5 DV3$$
$$+ b_6 DV4 + e_t \qquad 3.48$$

where stars denote the long-run level and also indicate that there exists a rational lag distribution in the variables.

Let us specify a second order rational distributed lag model such that ignoring other terms

$$q_t = W(L)\ (b_o + b_{12}y^*_{1t} + b_{22}y^*_{2t} + \Sigma b_{i3}P^*_{it}) \qquad 3.49$$

where

$$W(L) = A(L)/T(L) = \frac{(a_{k+3} + a_{k+4}L)}{(1-\lambda_i L)(1-\lambda_2 L)}$$
$$\text{for each } k = 0,2,4 \qquad 3.50$$

where a's are defined in Equation 3.51. Then the final form will be

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[14]Terminology differs depending on starting point of logic. Jorgenson treats Equation 3.49 as the original or structural equation. The reason for treating Equation 3.48 as the original is to distinguish between the short and long run.

$$q_t = a_o + a_1 q_{t-1} + a_2 q_{t-2} + a_3 y_{it} + a_4 y_{1t-1} + a_5 y_{2t}$$
$$+ a_6 y_{2t-1} + \Sigma a_{i7} P_t + \Sigma a_{i8} P_{t-1} + a_9 DV2 + a_{10} DV3$$
$$+ a_{11} DV4 + V_t \qquad 3.51$$

which will serve as an equation to be estimated, and where

$$(1-\lambda_1 L)(1-\lambda_2 L)q_t = (1 - (\lambda_1 + \lambda_2)L + \lambda\lambda_2 L^2)q_t$$
$$= q_t - a_1 q_{t-1} - a_2 q_{t-2} \qquad 3.52$$

Where:

$$a_1 = \lambda_1 + \lambda_2 \qquad 3.53$$
$$a_2 = -\lambda_1 \lambda_2 \qquad 3.54$$

What are the relationships between W(L)b, or the coefficients of Equation 3.51 and those in Equation 3.48? In Jorgenson's original article [J5] and Griliches' survey article on distributed lag models [G9] they do not explore these relationships in terms of short and long run. As briefly noted in Chapter II, Tinbergen [T8], Fischer [F3, F4] and Koyck [K11] developed a device to distinguish the short- and long-run effects of price changes.

According to Tinbergen, the short-run coefficient is just that of current price and the long-run coefficient is the sum of the coefficient of the lagged price variable as well as current price. Fischer defines them similarly using both log normal and arithmetically declining lag.

Koyck's method is also similar to the previous method except in the case of long-run coefficients; the long-run coefficient is defined as the coefficient of current price multiplied by lagged power of weight of each period which is summed over the relevant lag period.

The common practice of their approach is to sum the coefficients of all lagged independent variables with different summing methods. The other point is that they use one equation to distinguish the short- and long-run effects. Given an equation of certain distributed lag form, find the relationship.

The basic approach used in this study as far as the rational distributed lag model is concerned was the same as Tinsbergen and Fischer's method for the short-term effect. But for the long-run relationship the structural coefficients were treated as the sum of total weights which is explained below. Let us look at the time path of a transitory change in independent variables on all future q, assuming that all current values of all variables are 1 and all lagged variables are zero. Then weights[15] at t time period, r_j, are given by

$$r_o = a_3 \qquad 3.55$$

$$r_1 = a_4 + a_1 q_t = a_4 + a_1 r_o \qquad 3.56$$

$$r_2 = a_1 r_1 + a_2 q_t = a_1 r_1 + a_2 r_o \qquad 3.57$$

---

[15]The derivations of weight and w_i are from Griliches [G9].

$$r_3 = a_1 r_2 + a_2 r_1 \qquad 3.58$$

$$\vdots$$

$$r_j = a_1 r_{j-1} + a_2 r_{j-2} \qquad 3.59$$

To derive w_i's, which describe the form of the lag and gives the relative influence of differently lagged values of independent variables on current q_t, first we find the sum of r_j such that

$$\Sigma r_j = b_h \Sigma w_i = b_h = \frac{(a_{k+3} \ a \ a_{k+4})}{1 - a_1 = a_2} \qquad 3.60$$

since $\Sigma w_i = 1$ by definition for $h = 2, \ldots, 6$ and $k = 0,2,4$, ignoring other terms.

Normalizing Equation 3.60 such that

$$\frac{\Sigma r_j}{\dfrac{a_{k+3} + a_{k+4}}{1 - a_1 - a_2}} = 1 \qquad 3.61$$

then we have the following relationships:

$$w_o = r_o(1-a_1-a_2)/(a_{k+3} + a_{k+4}) \qquad 3.62$$

$$w_1 = r_1(1-a_1-a_2)/(a_{k+3} + a_{k+4}) \qquad 3.63$$

$$\vdots$$

$$w_j = r_j(1-a_1-a_2)/(a_{k+3} + a_{k+4}) \qquad 3.64$$

Following the guideline defined previously, we may formulate the relationship between the structural coefficidents that are assumed to be long-run coefficients and those in the final equation as follow by using r_j:

Letting $A = 1-a_1-a_2$, then

$$
\begin{aligned}
b_{12} &= (a_3 + a_4)/A \\
b_{22} &= (a_5 + a_6)/A \\
b_{i3} &= (a_{i7} + a_{i8})/A \\
b_4 &= a_9/A \qquad\qquad 3.65 \\
b_5 &= a_{10}/A \\
b_6 &= a_{11}/A \\
v_t &= e_t + a_1 e_{t-1} + a_2 e_{t-2}
\end{aligned}
$$

Specifying the relationship in this manner may not be very appealing, mainly because of no clear-cut mathematical linkage between the "structural equation", 3.48 and the Equations 3.49 or 3.51. However, it seems to be a matter of assumption and of interpretation of b_h in Equation 3.60. Interpretation of long-run effects as an accumulation of the weights of transitory change in the independent variables on future quantity consumed may be a reasonable one as is expressed by Equation 3.60. In this study, logical consistencies were checked with the empirical results from the state adjustment model.

The usefulness of w_j is in describing the lag form. Figure 3.1 shows the relationship between the individual lag distribution and the total lag distribution. The total lag distribution is supposed to show the impact of change in all independent variables on the current dependent variable.

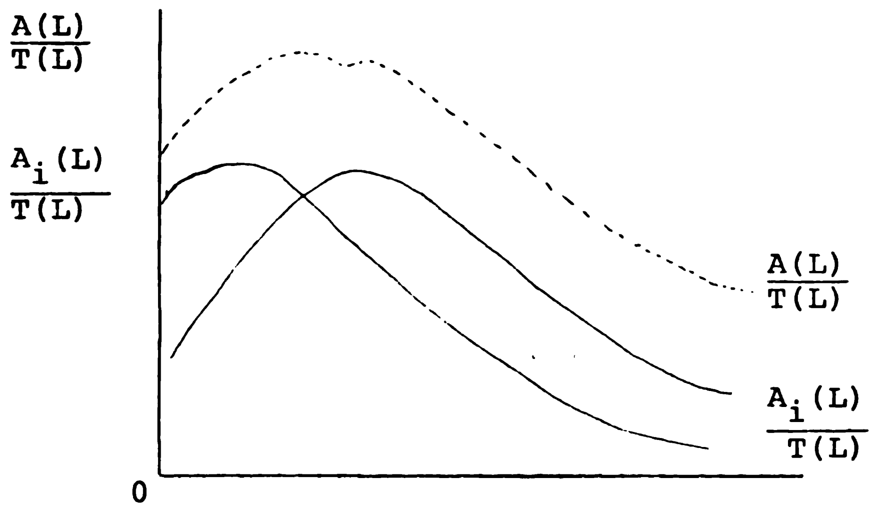

Figure 3.1. Possible Relationship between Individual and Total Lag Distribution.

Depending on the individual lag distribution, the total lag distribution can be a convolutionary shape.

Aggregation Bias

General Consideration

Aggregation is usually thought to be satisfactory by the analysts to the extent that they believe the cost of incorporating detailed information outweighs the reliability of the results from them. Thus the cost and reliability are two important factors that should be taken into account in disaggregation and aggregation.

In the case of Korean rural demand analysis it was assumed that there have been less reliable results in the usual aggregated models and the cost involved in the disaggregated approach is far less. The division of farm households into five according to the size of land holdings seems to be reasonable in view of cost.

Aggregation is said to be "consistent" [G4], when the more detailed data do not give very different results from those of aggregated information.

There are some doubts about the validity of a micro-model that heavily depends on more detailed information than a macro-model does. Peston [P5] argues that any micro theory to explain the same universe as macro theory would be either useless or wrong, if the latter were valid. For example, if household consumption depends not only on its own income but also on the distribution of income, then a micro demand analysis that neglects this latter dependence will suffer specification error, and the predictions based on this micro-model or disaggregated model will be less accurate [G11].

If the behavior of the independent variables is not known, the assumption of consistent aggregation imposes severe restrictions on the usefulness of individual micro functions [G4]. But, if it is known, i.e., income distribution is constant or changes systematically, then this restriction will be less severe even if we include this variable in individual equations.

There are two useful theorems developed and proved by Green [G4] which are condensed into following Theorem 1 without showing proof:

> Theorem 1. It is necessary for consistent aggregation, when the optimal conditions are such that the marginal rates of substitution between any two commodities are same for any two groups, that (a) for each group, each set of points in the commodity space at which marginal rates of substitution are constant, is a straight line, (b) for a given set of marginal rates of substitution, the straight lines for all groups are parallel, and (c) the Engel curves for all groups should pass through their respective origins.[16]

In reality it is difficult to believe that those consistency conditions are given in Theorem 1 are all met. For an example, it may be true that each individual or group of rural households has a certain minimum level of consumption below which his or its utility function is not defined.

In this study, it was assumed that these consistency conditions were not satisfied. It was also recognized that insistence on the impossibility of aggregating any two variables would destroy all marginal analysis in economic theory. Thus it was assumed that there is a degree of disaggregation or aggregation at a certain level that is legitimate.

The purpose of this section was to show aggregation bias in a demand equation when it is specified with average (arithmetic) per capita or per household data. Additional assumptions for this purpose were that the parameters estimated from the demand equation specified with original

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[16]This also applies to aggregation of production functions. It is of interest to note that Klein [K4, K5] argues that only technical relationships should be taken into account in aggregation.

per capita data not averaged arithmetically at the national level are true parameters and that the functional form is linear.

Aggregation Bias

Let the demand equation with original demand equation for each farm group be:

$$q_j = a_j + b_{1j}x_{1j} - b_{2j}x_{2j} \qquad 3.66$$

where x denotes any independent variables, ignoring other terms and subscripts, and also let the equation be estimated from arithmetic average data used in most empirical studies.

$$\bar{q} = a' + b_1'\bar{x}_1 + b_2'\bar{x}_2 \qquad 3.67$$

Where:

$\bar{q} = Q/N$

$\bar{x} = X/N$

Q,X,N = total quantity demanded (Σq_j), independent variables (Σx_j) and total number of households or number of groups, respectively.

Then, under the consistent aggregation assumption, the following relation should hold:

$a' = a_j/N$

$b_1' = b_{1j}/N$

and 3.68

$b_2' = b_{2j}/N$

Aggregation bias is, then, any deviation from Equations 3.68. The exact relationship of bias is derived by Theil [T4] and Green [G4].

CHAPTER IV

SIMULATION MODEL: A CONCEPTUAL FRAMEWORK

Economics and Control Theory

The methods of control theory developed in electrical and communication engineering have been increasingly widespread in empirical studies of economic theory.

In the fields of macroeconomics, the applications of control theory and optimization techniques include, among others, a growth model of a national economy, and an economic planning model focusing on the sectoral allocation of investment over time and short-run fluctuations of general price level and employment. In microeconomics, the applications have been in such areas as consumer choice over lifetimes, theory of firms and resource development, though these applications have been less attractive than those in macro models.

In the past, estimation procedures for determining the coefficients of the economic models have dominated econometrics. Recently, many efforts have been directed toward the simulation and optimization of given models, either deterministic or stochastic.

We have seen that the capability for projection or prediction from the economic model is quite limited because of the inability to conceive fruitful categories of generalization with which to bring intellectual order into the real world and also because of the inability to formulate "high-level hypothesis" that can digest all the useful real world data [H5].

Actually there is no way of avoiding the conditional-probabilistic nature of projections of economic phenomena. Researchers, thus, have to make reasonable assumptions about structural relationships not only between the past and present but also between the sample period and the prediction period. When structural changes are expected to occur during the latter period, the problems confronting the researchers are to specify the change and to establish the new structure.

Two distinctive models have been used for economic applications: (a) deterministic and (b) stochastic control models. Underlying deterministic control models is the assumption that there is a unique value of a variable at each stage of process (single valued function). It can either be static or dynamic. Stochastic control models involve multi-valued functions [M14] including parameter estimation or adjustment at each stage of process.

Economic Applications of Deterministic Models

Most of the economic applications briefly cited above belong to deterministic models. They are macro stabilization models [P8, A5, H8, P9], economic growth models

[P8, K9],models for firms [S4], and sectoral models [R3].

Characteristics of Models

Feed Back Control

Given a linear controllable system specified by

$$dX/dt = AX(t) + BU(t) \qquad 4.1$$

Where X, U, A and B denote an nxl state vector, a mxl control vector, nxn parameters and nxm parameters, respectively, with initial condition being $X(t_o) = X_o$, then a feed back control problem is to find the control vector, U(t), as a function of state vector, X(t), such that certain properties like stability and/or steady state error are attained. The class of feedback controls generally includes the proportional, derivative and integral controls such that

$$U(t) = CX(t) + DdX/dt + F\int X(\tau)d\tau \qquad 4.2$$

in time domain, or

$$\frac{U}{E}(s) = k_p + k_r(s) + \frac{k_i}{s} \qquad 4.3$$

in s domain where E denotes the difference between desired system output and actual output [M4, P8]. The purpose of the control scheme is, then, to determine the unknown coefficients C, D and F or k_r, k_p and k_i. More are discussed here because it is relevant with the simulation model in this study.

Proportional Control: C or k_p

It is a correcting action for the desired level to be made proportional in magnitude and opposite in sign to the error, E, in a system output.

The ratio of the policy variables and error, u/E, may be called a proportional correction factor which is a measure of the strength of the policy or control. As an example, a proportional correction factor of 0.5 would mean that if system output is 2 percent below (or above) the desired value, the government would attempt to manipulate policy variables by an amount of equal to 2% x 0.5 = 1% (or minus 1%) of the actual system output.

There are some defects despite its simple form and ease of application. First, complete correction of an error is difficult to obtain because of the error inherent to the proportional policy measure in a finite time horizon. Secondly, it tends to cause a cyclical fluctuation in the time path of system output, that is, the greater this fluctuation, the stronger the policy and the longer the time lag will be, even though it is smaller than that of an integral policy measure.

Derivative Control: D or Kr

It is used to reduce oscillations of system output by adjusting control variables to the derivative of error. Note that when dE/dt = 0 it gives zero control variables. Thus it will not work for the targets that are constant step functions for a long time period and at the same time when error does not change. Thus usually rate control alone is not used.

Integral Control: F or Ki

An integral control policy is that the policy variables are adjusted proportionally in magnitude and opposite in sign to the cumulated error up to that time.

Integral correction factor is defined the same way as proportional correction factor except that error is integrated.

Even though we can avoid the first defect of a proportional control policy, cyclical fluctuations will become greater, and the longer the error continues, the larger the control variable will become which is usually upper bounded. For this reason the integral control method alone also is rarely used.

In the case where desired policy target is a ramp function, proportional policy measure does not track the target very well. More than that there is usually an upper limit on the policy variable. Alternative measure is to combine proportional and integral policy measures to reduce the tracking error. But the introduction of integral policy measure will often increase oscillation. If derivative or rate control measure is combined, it would dampen oscillation.

Optimal Control

Optimal control requires a performance criterion in addition to Equation 4.1 such as profit, utility or other objective functions.

Given a performance criterion

$$\text{opt. } J = \int_{to}^{t} f(x(t),\ u(t))dt \qquad 4.4$$

subject to

$x(t_{f1})\varepsilon S$

$u(t)\varepsilon U$

for all t

$x(t)\varepsilon X$

then optimal control problem is how to determine u(t) as a function of time (open loop), or a function of X(t) (closed loop) such that Equation 4.4 is optimized subject to given constraints.

The work done in this area for economic applications include Tinbergen [T6], Theil [T5], Fox et al [F8] and Chow [C3].

Adaptive Control

These methods are designed to analyze the various implications of a broad class of admissable controls which may include various sub-optimal (satisficing) controls such as evluation of alternative learning processes, comparisons of alternative approximations to the complex model and sequential analysis of system behavior assuming *a priori*

Baysian probability distribution of unknown parameters. They are principally governed by the flow of information.

The work and economic applications include Theil [T2] and Zellner [Z2].

Economic Applications of Stochastic Control Methods

Since most deterministic models have stochastic counterparts, most of previous applications include stochastic parts. Some of the characteristics of the stochastic control methods are parameter and state estimation and control to optimize the expected value of some performance criterion.

A Simple Simulation Model

The purpose of the simulation in this study is not to give an answer to the question of "how to do", but to give policy makers an information about "how much", given the model. The answer to the former question is out of the scope of this study. In this sense, it may not be a realistic approach. But certainly it can serve as a basis of normative judgements which are unavoidable in policy formulations and implementations.

It is a deterministic control model with dynamic elements using the econometric model specified in the previous chapter. It is also a very simple and basic feed back control scheme with very limited numbers of state, policy and performance variables. It is kept as simple as possible not only because of limited data but also because of a desire to see the workability of the feed back control model for a rural demand system.

The desire to develop a rural demand simulation model has been augmented by very interesting and stimulating ideas of Dr. T. Manetsch of Michigan State University.

According to him, domestic and world-wide food crises may result in the following major consequences:[1]

a. Migration back to rural area

b. Decrease in food supplies, particularly grains, to urban areas

c. Suffering of the lower income groups, particularly those that have no ties with rural population.

d. Farm supply may not respond to price or income changes significantly

e. Inevitable government intervention in the form of food rationing both in consumption and marketing of certain farm products.

His draft paper contains detail model components such as birth and mortality ratios which depend on the nutritional intake level, private and public stocks of foods, population in age, sex, migration from and to rural area, and other factors. An easy and simplest way to incorporate this idea might be to manipulate relevant

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[1]It is summarized from"A Model Builder's Diary" [sic.] by T. Manetsch.

parameters in the model with proper assumptions. For example, such parameters will include the coefficients of population and migration rates.

To use econometrics in simulation models, we can either transform the equation system into "state variable form" [P9] or use the equations directly in simulation. It seems that it is a matter of technique in claculations. In this study estimated equations were used directly.

The scope of the commodities included in the simulation model is limited to rice and barley-and-wheat with annual data. The detailed parts of the model will be described in Chapter V, while a block-diagram of the model is shown in Figure 4.1.

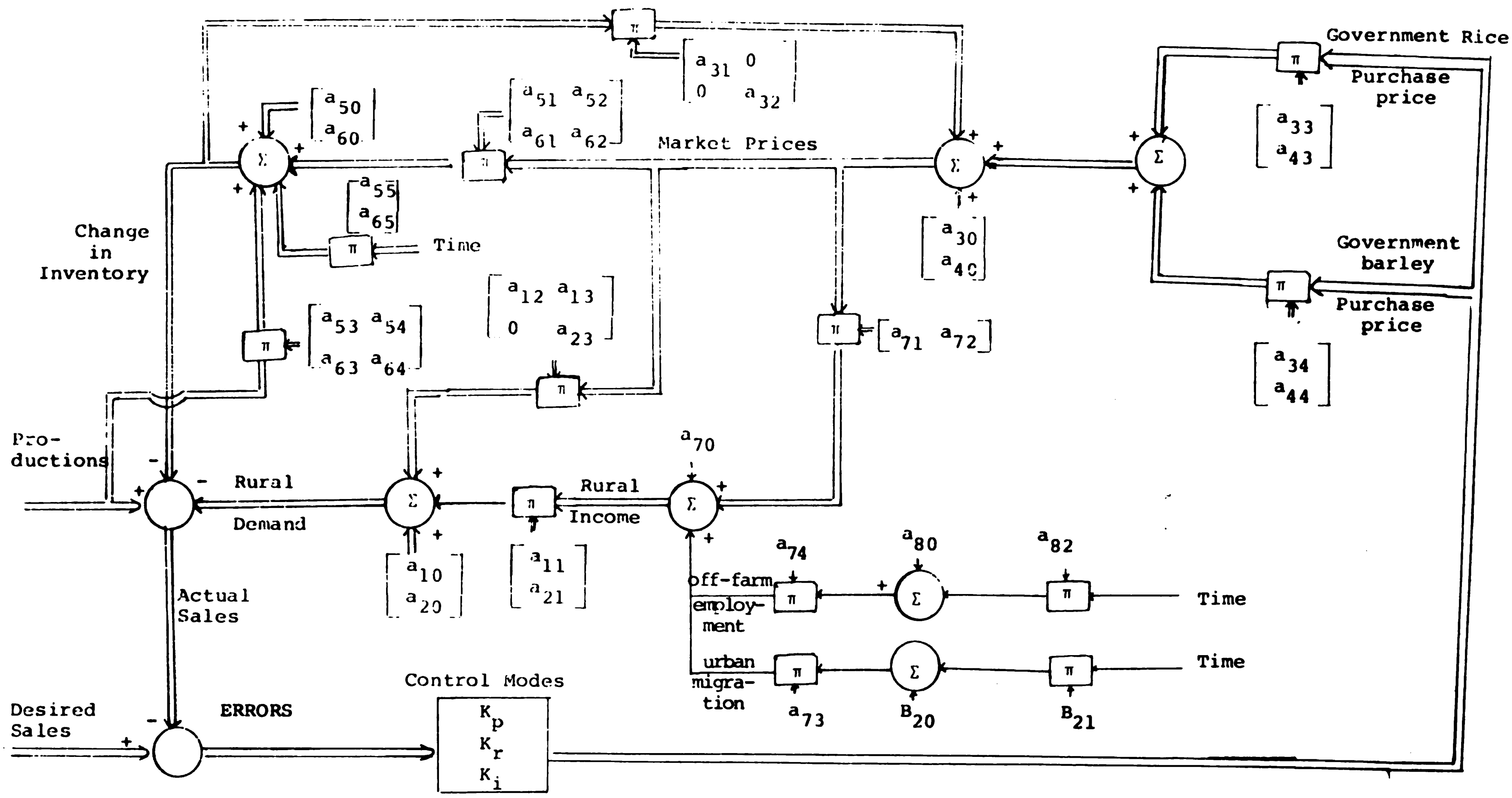

Figure 4.1[1] A Block Diagram for Rural Demand for Rice and Barley-and-Wheat and Government Purchase Prices

[1]Line(s) denote vector(s), arrows show directions of causality and/or flow of calculations, and coefficients in the brackets are parameter matrices or vector(s) to be added (Σ) or multiplied (π).

CHAPTER V

ESTIMATION AND SIMULATION RESULTS AND POLICY IMPLICATIONS

Estimation Results

Data

Most of the data used in this study were from the Farm Household Economy Survey published annually by the Bureau of Statistics, Ministry of Agriculture and Fisheries (MAF) of the Republic of Korea. Other data were from the Monthly Statistical Review of the Bank of Korea and the Statistical Yearbook of MAF. The Farm Household Economy Survey started in 1962. But comprehensive data are available only from 1964. In this study the data covered the period of 1965-1973 for quarterly and annual data.

In analyzing the state adjustment model, annual data which include only 9 observations were not appropriate to be used. Thus for the state adjustment model and the second order rational distributed lag model, only quarterly data were used. For simple simulation and projections, annual data were used.

For rice, barley-and-wheat, miscellaneous grains, pulses and potatoes, actual quantity data were used, while for vegetables, meats, fish-and-marine products, dairy products and processed foods, expenditure data were used. For the first five food items, demand equations were specified for the national average and each farm group, while for the last five food items, only national average demand functions were specified.

The annual simulation and projection model which consisted of a system of equations was also specified with national average data. The adult-equivalent-scale was tried for annual data only.

Variable Definition

q_{ij} = ith food consumed by jth household (ℓ/per capita)

i = 1 = rice, 2 = barley-and-wheat, 3 = miscellaneous grains, 4 = pulses, 5 = potatoes, 6 = vegetables, 7 = meat, 8 = dairy, 9 = fish-and-marine products, 10 = processed foods

j = 0 = national average per household

1 = farm with less than 0.5 cheongbo

2 = farm with 0.5 - 1.0 cheongbo

3 = farm with 1.0 - 1.5 cheongbo

4 = farm with 1.5 - 2.0 cheongbo

5 = farm with over 2.0 cheongbo

y_1 = gross farm income of jth group (Won per capita)

y_2 = gross nonfarm income of jth group (Won per capita)

s = stocks in terms of nonmeasurable psychological habits (or inertia)

SI = lowest actual monthly stocks or change in inventory during a year for food (ℓ/capita)

y = gross household income when quarter, net when annual data ($=y_{1j} + y_{2j}$ - Taxes) (Won per capita)

p = price (index) (1965 = 100)

PQ = production

FPPI = farm purchase price index (1965 = 100)

DV = Quarter Dummy Variables

If 2nd quarter DV2 = 1, otherwise 0

If 3rd quarter DV3 = 1, otherwise 0

If 4th quarter DV4 = 1, otherwise 0

GP1 = Government purchasing price of rice (won/80kg)

GP2 = Government purchasing price of barley (Won/50kg)

PM = Total number of farm households

TM = Percentage of nonfarm workers to total members of family

DL = Average land holdings of jth group (cheongbo/household)

ℓ = Liter (unit for measuring grains)[1]

T = Calendar time (1,. . .,9)

SSFh = Number family members per sex and age group

h = 1, number of family members under age 14 (total)

h = 2, number of family members 14-64 (male)

h = 3, number of family members 14-64 (female)

h = 4, number of family members over 65 (total)

SF = Number of family members per household.

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[1] $1\ell \sim .798$ kg. for rice, .549 kg. for barley and .765 kg. for wheat.

Equations and System of Equations

State Adjustment Model

1. Structural Equation

$$q_t = b_o + b_1 s_t + b_2 y_t + b_3 P_t + b_4 DV2 + b_5 DV3 + b_6 DV4 + e_t \qquad 3.1'$$

2. Reduced form equation to be used in estimation

$$q_t = A_o + A_1 q_{t-1} + A_2 y_t + A_3 y_{t-1} + \Sigma A_{i4} P_{it} + \Sigma A_{i5} P_{it-1} + A_6 DV2 + A_7 DV3 + A_8 DV4 + V_t \qquad 3.7'$$

Rational Distributed Lag Model of Second Order

$$q_t = a_o + a_1 q_{t-1} + a_2 q_{t-2} + a_3 y_{1t} + a_4 y_{1t-1} + a_5 y_{2t} + a_6 y_{2t-1} + \Sigma a_{i7} P_{it} + \Sigma a_{i8} P_{it-1} + a_9 DV2 + a_{10} DV3 + a_{11} DV4 + E_t \qquad 3.50'$$

Equation System for Rice and Barley-and-Wheat with Annual Data

$$Q_{1t} = a_{10} + a_{11} y_t + a_{12} P_{1t} + a_{13} P_{2t}$$
$$Q_{2t} = a_{20} + a_{21} y_t + a_{23} P_{2t}$$
$$P_{1t} = a_{30} + a_{31} SI_{1t} + a_{33} GP1 + a_{34} GP2$$
$$P_{2t} = a_{40} + a_{42} SI_{2t} + a_{43} GP1 + a_{44} GP2 \qquad 5.1$$
$$SI_{1t} = a_{50} + a_{51} P_{1t} + a_{52} P_{2t} + a_{53} PQ_{1t} + a_{54} PQ_{2t} + a_{55} T$$
$$SI_{2t} = a_{60} + a_{61} P_{1t} + a_{62} P_{2t} + a_{63} PQ_{1t} + a_{64} PQ_{2t} + a_{65} T$$
$$y_t = a_{70} + a_{71} P_{1t} + a_{72} P_{2t} + a_{73} PM + a_{74} TM$$
$$TM = a_{80} + a_{81} y_t + a_{82} T$$

Auxiliary Equations

$$\begin{aligned} PQ1 &= B_{10} + B_{11}T \\ PQ2 &= B_{20} + B_{21}T \\ PM &= B_{30} + B_{31}T \\ SF &= B_{40} + B_{41}T \\ SSF_1 &= B_{50} + B_{51}T \\ SSF_2 &= B_{60} + B_{61}T \\ SSF_3 &= B_{70} + B_{71}T \\ SSF_4 &= B_{80} + B_{81}T \end{aligned} \qquad 5.2$$

General Procedures of Estimation

Several functional forms with arithmetic linear, double logarithm and semilogarithm forms have been tried. It was found, in general, that the logarithmic transformation did not significantly improve the equations. Consequently arithmetic linear forms were adopted in most cases. This form is also convenient for calculating relevant structural coefficients.

The models with quarterly data were estimated by OLS. As indicated earlier, it was almost prohibitive to use the simultaneous system procedure because of a large number of variables. A "stepwise-delete-and-add" procedure with an F value of .15 was used to observe the behavior of the coefficients. After this procedure, variables were selected in the light of economic theory, statistical properties, the characteristics of the model at hand and judgement of this researcher. Some of the variables need to be mentioned specifically.

The separate income variables, farm income (y_{1j}) and nonfarm income (y_{2j}), were tried to see how the rural consumers respond to the different sources of income. It was felt that since the farm income comes mainly from crop production which is also a major source of food consumption, rural consumers may not respond to the income change in the same manner as urban consumers do. The income response was expected to be negative as it was found to be in many cases. Nonfarm income was considered as a proxy variable to relate the rural consumption pattern to a possible exposure to nontraditional food consumption--factors that might induce an "eye-opening" to wider "choice set." It was also expected that rural consumers would respond positively to nonfarm income change in contrast to farm income change due to a possible psychological influence stemming from a freer decision to dispose of their products for consumption. As expected, in most cases, the coefficient turned out to be positive and its absolute magnitudes or elasticities were greater than those of farm income; thus, on balance, the net effect of total farm household income was positive.

Despite this "elegancy", there were some problems; increased numbers of constraints, unexpected and unexplainable results in some cases, and large standard errors. Thus, after due considerations about the trade offs, it was decided to combine two sources of income into a single variable. Separate sources of income will be mentioned only when it seems to be appropriate.

Considering the characteristics of the rural consumers, production (PQ) was excluded in demand equations. There are some studies which include production in rural demand equations as in Fox [F7] and Moon [M11]. But the inclusion of production in the demand equation seems to make the nature of the demand equation rather ambiguous by making the demand equation a combination of supply and demand. This procedure also results in high positive correlation (about .7 to .9) of production with farm income, though it is a relevant variable in rural consumption decisions. Thus, in final equations, production was excluded.

Quarter dummy variables are included regardless of their significances, for quarterly consumption levels are thought to be different and also they would represent some other influences that are not explicitly included in the equations.

After the selection of variables and forms of equations, a new OLS estimation procedure was conducted. With these initial results, parameter constraints were imposed as discussed in Chapter III and briefly described in this chapter. Other than equality constraints, the selection of parameters to be fixed was based on the significance level, theoretical and empirical meaningfulness and linearity. For the second order rational distributed lag model and the annual model, no constraints were imposed. For the second order rational distributed lag model, initial results from "stepwise-delete-and-add" procedures with OLS were used. Since it was found that for most food items other than rice and barley-and-wheat more than two-quarter lag effects were not significant, the model was applied only to these two foods. Despite its limited application, it is hoped that the rational distributed lag model would serve to show the performance of different "models." For the annual model, the two-stage-least-square (2SLS) method was used to estimate the system of equations summarized at the beginning of this chapter. It should be noted here that, because of a small number of observations (9) the number of predetermined variables to be used in the equation system has to be less than 9. Otherwise, 2SLS turns out to be the same as OLS.

Estimation Results

The final results of reduced form equations and derived structural coefficients for the quarterly model are tabulated in Table 5.1 through 5.10. The numbers in parentheses are standard deviations. The $\bar{R}^2$s are reported instead of R^2 considering the large number of explanatory variables.

Durbin-Watson statistics were adjusted by following the Houthakker and Taylor method which is explained in Chapter III. When the Durbin-Watson statistics table was used, most of the serial correlation problems were inconclusive.

Table 5.1. Estimation Results of Reduced Form Equations of Demand for Rice (q_{ij}) for Each Group

	Constant	Previous Quarter's Quantity (ℓ/capita) q_{ijt-1}	Gross Income Deflated by FPPI (Won/capita) Y_{jt}	Previous Quarter's Income Deflated by FPPI (Won/capita) Y_{jt-1}	Price Index of Rice (%/FPPI) P_{it}	Previous Quarter's Rice Price Index (%/FPPI) P_{it-1}	Barley-Wheat Price Index (%/FPPI) P_{2t}	Previous Quarter's Barley-Wheat Price Index (%/FPPI) P_{2t-1}	Second Quarter Dummy DV2	Third Quarter Dummy DV3	Fourth Quarter Dummy DV4	$\bar{R}^2$	E.(D.W.)
	A0	A1	A2	A3	A14	A15	A24	A25	A6	A7	A8		
q10 Unrestricted	23.377	.263	.00112	.00119	-.199	-.133	.277	- .0098	-4.328	-10.42	.348	.79	
	(9.89)	(.219)	(.00164)	(.00141)	(.122)	(.14)	(.108)	(.103)	(4.089)	(4.512)	(7.317)		
Restricted	17.981	.313	.00112	- .000013	-.199	.0022	.277	- .0031	-7.538	-14.92	- 4.174	.82	1.12
	(5.57)	(.182)	— -	(.00029)	—	(.053)	—	(.074)	(2.33)	(1.86)	(2.45)		
q11 Unrestricted Double log	-186.383	3.835	2.985	21.203	—	—	—	—	.413	- 9.537	2.847	.88	
	(33.136)	(3.78)	(5.112)	(5.882)					(2.35)	(1.988)	(3.14)		
q12 Unrestricted	25.217	- .183	.0012	.00464	-.2044	-.155	.207	- .005	4.225	- 5.56	3.05	.95	
	(4.935)	(.159)	(.00075)	(.0011)	(.0585)	(.070)	(.048)	(.047)	(2.252)	(2.33)	(3.3)		
Restricted	19.443	.464	.0012	- .000194	-.2044	.033	.207	- .033	-6.064	-15.7	- .211	.91	1.21
	(4.23)	(.148)	—	(.00035)	—	(.06)	—	(.06)	(1.63)	(1.42)	(1.92)		
q13 Unrestricted Double log	.763	.074	.196	—	-.673	.747	.153	—	.05	- .469	- 1.07	.72	
	(1.533)	(.175)	(.289)	—	(.439)	(.388)	(.460)	—	(.09)	(.108)	(.152)		
q14 Unrestricted	22.69	.423	.0012	- .0007	-.202	-.016	.27	- .003	-6.02	-16.46	- 2.25	.89	
	(8.83)	(.192)	(.0009)	(.0007)	(.086)	(.094)	(.075)	(.088)	(3.03)	(3.4)	(5.96)		
Restricted	14.5	.51	.0012	- .0003	-.202	.056	.27	- .075	-4.73	-14.79	.018	.90	1.94
	(5.83)	(.17)	—	(.0002)	—	(.04)	—	(.054)	(1.66)	(1.49)	(2.29)		
q15 Unrestricted	13.87	.55	-.00064	.0003	-.088	.023	.33	- .14	-2.05	-13.06	12.22	.85	
	(10.14)	(.19)	(.00041)	(.0004)	(.103)	(.092)	(.08)	(.09)	(2.68)	(3.45)	(5.12)		
Restricted	12.4	.56	-.00064	.0003	-.088	.039	.33	- .15	-2.06	-13.10	12.19	.88	1.53
	(6.25)	(.15)	—	(.0001)	—	(.017)	—	(.06)	(1.53)	(1.70)	(2.95)		

Table 5.2. Derived Structural Coefficients for Rice (q_{ij})

	Constant	Stock Psycho-logical (s_{jt})	Gross Income Deflated by FPPI (Won/capita) (Y_{jt})	Rice Price Index Deflated by FPPI (Percent) (P_{it})	Barley and Wheat Price Index Deflated by FPPI (Percent) ($P2_t$)	Second Quarter Dummy (DV2)	Third Quarter Dummy (DV3)	Fourth Quarter Dummy (DV4)	Depreciation Rate
Coefficients	b0	b1	b2	b3	b4	b5	b6	b7	c
q10									
Short Run	56.04	3.64	.0009	-.153	.213	-11.74	-23.23	- 6.5	7.82
(Elasticities)			(.166)	(-.45)	(.57)				
Long Run	104.86	---	.00017	-.286	.398	-21.91	-27.23	-12.13	
q12									
Short Run	73.53	2.85	.00095	-.162	.164	- 4.81	-12.45	- .17	5.78
(Elasticities)			(.157)	(-.48)	(.45)				
Long Run	146.55	---	.0019	-.323	.327	- 9.59	-24.81	- .34	
q14									
Short Run	69.86	1.80	.001	-.172	.23	- 4.03	-12.6	.015	4.4
(Elasticities)			(.175)	(-.46)	(.53)				
Long Run	118.27	---	.0017	-.291	.39	- 6.82	-21.3	.025	
q15									
Short Run	76.63	1.06	-.00058	-.08	.3	- 1.87	-11.87	11.05	3.32
(Elasticities)			(-.114)	(-.2)	(.62)				
Long Run	112.57	---	-.00085	-.12	.44	- 2.75	-17.44	16.23	

Table 5.3. Estimation Results of Reduced Form Equation of Demand for Barley-and-Wheat (q_{2j}) for Each Group

	Constant	Previous Quarter's Quantity (q_{2jt-1})	Gross Income Devlated by FPPI (Won/capita) (Y_{jt})	Previous Quarter's Income Deflated (Won/capita) (Y_{jt-1})	Price Index of Rice Deflated by FPPI (Percent) (P_{it})	Previous Quarter's Rice Price Index Deflated by FPPI (Percent) (P_{it-1})	Price Index of Barley and Wheat Deflated (Percent) (P_{2t})	Previous Quarter's Barley and Wheat Price Index Deflated (Percent) (P_{2t-1})	Second Quarter Dummy (DV2)	Third Quarter Dummy (DV3)	Fourth Quarter Dummy (DV4)	$\bar{R}^2$	E(D.W.)
	A0	A1	A2	A3	A14	A15	A24	A25	A6	A7	A8		
q20 Unrestricted	19.6 (6.88)	.223 (.191)	-.00016 (.0008)	-.0011 (.0007)	.119 (.063)	.0094 (.075)	-.242 (.05)	.133 (.056)	1.83 (1.89)	12.71 (2.15)	-4.62 (4.12)	.95	
Restricted	25.74 (4.45)	.033 (.131)	-.0016 —	-.000018 (.000052)	.119 —	.0137 (.039)	-.242 —	-.00 (.00)	4.17 (1.10)	16.82 (1.08)	1.86 (2.44)	.94	1.78
q21 Unrestricted	17.77 (6.21)	.256 (.17)	.0006 (.0013)	-.0026 (.0013)	.066 (.065)	.027 (.083)	-.193 (.053)	.166 (.052)	1.36 (1.96)	12.64 (1.71)	-5.66 (3.39)	.94	
Restricted	9.58 (4.09)	.409 (.143)	.0006 —	-.0005 (.0001)	.066 —	-.062 (.015)	-.193 —	.18 (.04)	4.92 (1.12)	15.85 (1.04)	-3.72 (2.33)	.93	1.64
q22 Unrestricted	22.02 (7.92)	.156 (.205)	-.0005 (.0008)	-.0005 (.0009)	.123 (.063)	-.01 (.07)	-.259 (.05)	.118 (.06)	3.86 (1.73)	15.92 (1.8)	- .17 (3.94)	.95	
Restricted	19.86 (5.71)	.23 (.17)	-.0005 —	.00023 (.00009)	.123 —	-.056 (.023)	-.059 —	.117 (.05)	5.27 (1.03)	17.53 (.88)	.66 (2.6)	.96	1.63
q23 Unrestricted	19.76 (7.22)	.22 (.19)	-.00024 (.00062)	-.00084 (.00058)	.118 (.067)	-.023 (.074)	-.231 (.058)	.142 (.058)	2.16 (2.03)	13.78 (2.48)	-3.61 (3.81)	.94	
Restricted	15.72 (5.41)	.279 (.171)	-.00023 —	.00012 (.00005)	.118 —	-.063 (.027)	-.231 —	.122 (.052)	4.98 (1.13)	17.31 (1.0)	- .68 (2.72)	.94	1.78
q24 Unrestricted	14.19 (6.07)	.11 (.18)	-.00044 (.0007)	.0015 (.0006)	.106 (.071)	-0.77 (.085)	-.151 (.063)	.144 (.062)	-1.21 (2.69)	9.81 (2.78)	-5.07 (5.0)	.93	
Restricted	10.47 (4.99)	.283 (.18)	.00044 —	.00026 (.00014)	.106 —	- .061 (.034)	-.151 —	.087 (.049)	6.34 (1.44)	18.05 (1.23)	1.37 (2.7)	.92	1.97
q25 Unrestricted	17.04 (7.8)	.402 (.204)	.00026 (.00033)	-.00013 (.00013)	.120 (.081)	-.102 (.08)	-.309 (.064)	.172 (.072)	3.59 (2.21)	13.53 (2.85)	-5.75 (4.48)	.90	
Restricted	13.33 (4.23)	.435 (.156)	.00026 —	-.00014 (.00005)	.120 —	-.067 (.023)	-.309 —	.171 (.058)	3.59 (1.17)	13.26 (1.28)	-6.62 (2.60)	.91	1.82

Table 5.4. Derived Structural Coefficients for Barley-and-Wheat (q_{2j})

	Constant	Stock Psycho-Logical (s_{jt})	Gross Income Deflated by FPPI (Won/capita) (Y_{jt})	Price Index of Rice Deflated by FPPI (Percent) (P_{it})	Barley and Wheat Price Index Deflated (Percent) (P_{2t})	Second Quarter Dummy (DV2)	Third Quarter Dummy (DV3)	Fourth Quarter Dummy (DV4)	Depreciation Rate
Coefficients	b0	b1	b2	b3	b4	b5	b6	b7	c
q20									
Short Run	317.7	-4.98	-.00024	.293	- .357	6.15	24.79	2.74	2.51
(Elasticities)			(-.07)	(1.342)	(-1.51)				
Long Run	106.47	—	-.00008	.098	- .12	2.06	8.31	.92	
q21									
Short Run	101.33	-4.48	.000085	.093	- .272	6.94	22.34	-5.24	2.91
(Elasticities)			(.018)	(.41)	(-1.11)				
Long Run	39.9	—	.000033	.037	- .11	2.73	8.8	-2.1	
q22									
Short Run	40.12	-2.05	-.00014	.036	- .071	1.44	4.78	.18	2.96
(Elasticities)			(-.033)	(.156)	(- .28)				
Long Run	23.70	—	-.00008	.21	- .042	.85	2.82	.11	
q23									
Short Run	163.38	-2.55	-.00027	.141	- .275	2.58	16.43	-4.30	2.51
(Elasticities)			(-.079)	(.64)	(-1.148)				
Long Run	81.04	—	-.00013	.07	- .136	1.28	8.15	-2.13	
q24									
Short Run	35.93	-2.41	-.00017	.041	- .059	2.48	7.06	.536	2.06
(Elasticities)			(-.067)	(.21)	(- .279)				
Long Run	16.56	—	-.00008	.019	- .027	1.14	3.25	.247	
q25									
Short Run	53.88	- .75	.00012	.056	- .144	1.67	6.18	-3.09	2.40
(Elasticities)			(.0702)	(.33)	(- .778)				
Long Run	41.05	—	.00009	.043	- .11	1.27	4.71	-2.35	

Table 5.5. Estimation Results of Reduced Form Equations of Demand for Miscellaneous Grains (q_{3j})

	Constant	Previous Quarter's Quantity (ℓ/capita) (q_{3jt-1})	Gross Income Deflated by FPPI (Won/capita) (Y_{jt})	Lagged Income Deflated (Won/capita) (Y_{jt-1})	Price Index of Misc. Grains Deflated by FPPI (Percent) (P_{3t})	Second Quarter Dummy (DV2)	Third Quarter Dummy (DV3)	Fourth Quarter Dummy (DV4)	$\bar{R}^2$
Coefficients	A0	A1	A2	A3	A14	A5	A6	A7	
q30 Unrestricted	3.01 (1.21)	.325 (.175)	-.00017 (.00012)	-.00019 (.0001)	.0178 (.009)	-1.25 (.265)	-2.098 (.326)	-.846 (.601)	.75
q31 Unrestricted	4.464 (1.67)	-.021 (.19)	-.0007 (.0003)	-.0002 (.0003)	.0269 (.0137)	-1.131 (.418)	-2.34 (.439)	-.038 (.74)	.69
q33 Unrestricted	2.82 (1.16)	.398 (.155)	-.000171 (.00009)	-.000175 (.0001)	.0168 (.0097)	-1.34 (.271)	-1.818 (.357)	-.822 (.536)	.71
q34 Unrestricted	1.95 (1.80)	.535 (.148)	-.0001 (.00016)	-.00024 (.00015)	.0362 (.0173)	-1.36 (.59)	-2.31 (.67)	-1.16 (1.18)	.66
q35 Unrestricted	.41 (1.34)	.537 (.148)	-.0001 (.00006)	.00002 (.00005)	.0242 (.0128)	-.814 (.376)	-1.30 (.44)	- .167 (.62)	.52

Table 5.6. *Estimation* Result of Reduced Form Equations of Demand for Pulses (q_{4j}) for each Group

	Constant	Lagged Quantity (ℓ/capita) (q_{4jt-1})	Gross Income Deflated by FPPI (Won/capita) (Y_{jt})	Lagged Income Deflated by FPPI (Won/capita) (Y_{jt-1})	Price Index of Pulses Deflated (Percent) (P_{4t})	Lagged Price Index (Percent) (P_{4t-1})	Second Quarter Dummy (DV2)	Third Quarter Dummy (DV3)	Fourth Quarter Dummy (DV4)	$\bar{R}^2$
Coefficients	A0	A1	A2	A3	A14	A15	A6	A7	A8	
q40										
Unrestricted	4.60	.009	.00017	-.0003	-.0196	.009	-2.016	-2.15	-.015	.72
	(2.15)	(.31)	(.0002)	(.0002)	(.015)	(.015)	(.83)	(1.24)	(1.79)	
Restricted	2.42	.089	.00017	-.00013	-.0196	.015	-1.55	-1.47	.702	.73
	(1.23)	(.29)	---	(.00007)	---	(.008)	(.64)	(1.)	(1.02)	
q41										
Unrestricted	1.32	-.157	.00027	.00002	-.012	.0016	-1.07	-1.094	.849	.91
	(.92)	(.251)	(.0002)	(.000015)	(.007)	(.0066)	(.505)	(.664)	(.936)	
Restricted	1.602	-.153	.00027	-.00001	-.012	.0004	-1.1	-1.12	.82	.92
	(.496)	(.188)	---	(.0007)	---	(.003)	(.31)	(.44)	(.44)	
q43										
Unrestricted	2.25	.146	---	---	-.018	.012	-1.08	- .96	2.31	.88
	(1.22)	(.197)			(.01)	(.01)	(.49)	(.71)	(.78)	
q44										
Unrestricted	3.37	-.001	.00003	-.000007	-.0225	.015	-1.92	-1.88	1.43	.91
	(1.41)	(.192)	(.0001)	(.0001)	(.01)	(.01)	(.59)	(.89)	(1.26)	
Restricted	3.59	-.002	.0003	-.00002	-.0225	.015	-1.99	-1.96	1.35	.92
q45										
Unrestricted	4.796	.175	-.0001	-.00003	-.035	.026	-1.65	-1.59	3.6	.84
	(2.693)	(.209)	(.0001)	(.00009)	(.017)	(.016)	(.99)	(1.38)	(1.52)	
Restricted	3.28	.239	-.0001	.00008	-.035	.021	- .899	- .52	4.73	.85
	(2.13)	(.189)	---	(.00004)	---	(.009)	(.75)	(1.05)	(1.07)	

Table 5.7. Derived Structural Coefficients for Pulses (q_{4j})

	Constant	Psycho-logical Stock (s)	Gross Income Deflated by FPPI (Won/capita) (Y)	Price Index of Pulses Deflated by FPPI (P4)	Second Quarter Dummy (DV2)	Third Quarter Dummy (DV3)	Fourth Quarter Dummy (DV4)	Depreciation Rate
	b0	b1	b2	b3	b4	b5	b6	c
q40								
Short run	64.64	-5.59	.00027	-.032	-2.50	-2.37	1.13	1.1
Long run	10.63		.00005	-.005	-0.41	- .39	.19	
q41								
Short run	11.81	-3.18	.00033	-.014	-1.32	-1.35	.99	7.71
Long run	8.36		.00023	-.01	- .94	- .96	.70	
q43								
Short run	39.21	-4.36	---	-.026	-1.57	-1.4	3.36	1.6
Long run	10.53			-.007	- .42	- .4	.90	
q44								
Short run	71.8	-6.43	.00005	-.038	-3.32	-3.27	2.25	1.6
Long run	35.8		.00001	-.019	-1.66	-1.63	1.12	
q45								
Short run	95.2	-4.03	-.00015	-.051	-1.31	-0.76	6.88	.89
Long run	14.3		-.000023	-.008	- .2	-0.114	1.03	

Table 5.8. Estimation Results of Reduced form Equations of Demand for Potatoes (q_{5j}) for Each Group

	Constant	Lagged Quantity (ℓ/capita) (q_{5j-1})	Gross Income Deflated by FPPI (Won/capita) (Y_{jt})	Lagged Income (Won/capita) (Y_{jt-1})	Potatoes Price Index Deflated by FPPI (Percent) (P5)	Lagged Price Index (Percent) (P_{5-1})	Second Quarter Dummy (DV2)	Third Quarter Dummy (DV3)	Fourth Quarter Dummy (DV4)	$\bar{R}^2$
	A0	A1	A2	A3	A14	A24	A6	A7	A8	
q50	7.01 (3.02)	.659 (.216)	.0002 (.0003)	-.0003 (.0003)	-.031 (.015)	—	-4.46 (.84)	-2.35 (1.54)	- .125 (1.85)	.82
q51	5.96 (4.31)	.701 (.23)	-.0004 (.0006)	.0001 (.0007)	-.030 (.021)	—	-4.11 (1.23)	-1.21 (2.05)	3.35 (2.13)	.82
q52	7.71 (2.94)	.49 (.22)	-.0008 (.0005)	.0002 (.0005)	-.0054 (.026)	—	-4.57 (.87)	-3.06 (1.77)	2.83 (1.95)	.82
q53	7.05 (2.14)	.46 (.19)	.0001 (.0002)	-.0003 (.0002)	-.013 (.013)	—	-4.24 (.69)	-3.28 (1.16)	- .585 (1.35)	.83
q54	8.72 (1.96)	.43 (.18)	.0004 (.0002)	-.0006 (.0002)	-.021 (.014)	—	-4.89 (.89)	-4.10 (1.12)	-3.67 (1.68)	.77
q55	9.50 (2.84)	.008 (.213)	-.0002 (.0001)	-.00003 (.0001)	-.027 (.017)	—	-2.52 (1.0)	-1.57 (1.41)	.078 (1.46)	.38

Table 5.9. Estimation Results of Reduced Form Equations of Demand for Vegetables (q60), Meats (q70), Fish-and-Marine Products (q80), Dairy Products (q90), and Processed Foods (q00) at National Level in Expenditure Terms

	Constant	Previous Quarter's Expenditure Deflated by FPPI (Won/capita) (q_{t-1})	Gross Income Deflated by FPPI (") (Y)	Lagged Income (") (Y_{t-1})	Price Index Deflated by FPPI (Percent) (Pi)	Second Quarter Dummy DV2)	Third Quarter Dummy DV3)	Fourth Quarter Dummy DV4)	$\bar{R}^2$
	A0	A1	A2	A3	A4	A5	A6	A7	
q60 Log Inverse	1.793 (.293)	.0127 (.0019)	-.00016 (.00006)	.00019 (.00006)	--	1.621 (.158)	1.73 (.16)	1.84 (.31)	.88
q70 Log Inverse	3.22 (.41)	.0027 (.005)	.00018 (.00007)	.000008 (.00007)	-.0075 (.0045)	-.252 (.202)	.111 (.205)	-.587 (.370)	.51
q80 Arth. Linear	.869 (1.124)	.43 (.16)	.0006 (.0002)	-.0002 (.0002)	--	-.252 (.67)	-1.187 (.80)	-3.459 (1.201)	.67
q90 Log Inverse	2.93 (.26)	.0044 (.0045)	.00002 (.00005)	.0001 (.00006)	--	.426 (.157)	.237 (.244)	.370 (.299)	.52
q00 Log Inverse	2.898 (.613)	.0004 (.0013)	.00007 (.0008)	.00005 (.00008)	--	-.245 (.445)	.603 (.473)	2.14 (.53)	.96

Table 5.10. Derived Structural Coefficients for Miscellaneous Grains (q30), Potatoes (q50), Vegetables (q60), Meats (q70), Dairy Products (q80), Fish-and-Marine Products (q90) and Processed Foods (q00) at National Average

	Constant	Psycho-logical Stock s	Gross Income Deflated by FPPI (Won/capita) Y	Price Index Deflated by FPPI (Percent) P	Second Quarter Dummy DV2	Third Quarter Dummy DV3	Fourth Quarter Dummy DV4	Depreciation Rate
	b0	b1	b2	b3	b4	b5	b6	c
q30								
Short run	4.14	-37.01	-.00012	.013	- .9	-1.51	- .61	-144
Long run	3.01		-.00009	.0095	- .66	-1.1	.44	
q50								
Short run	- 5.95	- 3.24	.0003	-.047	-6.72	-3.54	-1.25	- 1.6
Long run	5.81		-.0003	.046	6.56	3.45	1.22	
q60								
Short run	-46.06	- 8.49	-.0003	---	2.95	3.15	3.35	- .686
Long run	4.05		.00003	--	- .26	- .28	- .29	
q70								
Short run	11.76	.787	.00017	-.0071	-.240	.106	- .559	8.74
Long run	12.92		.00019	.0078	-.264	.117	- .614	
q80								
Short run	35.54	.788	.001	--	-.43	-2.02	-5.89	4.0
Long run	44.25		.0013	--	-.54	-2.52	-7.34	
q90								
Short run	- 1.913	- 4.98	-.000005	--	-.104	- .06	- .09	- 12.0
q00								
Short run	5.55	10.	.00006	--	-.201	.5	1.76	48
Long run	6.99		.00008	--	-.253	.63	2.22	

An Overview

A general impression is that the rural economy seems to be dominated by grain production and consumption. A complete set of structural and reduced form equation parameters were possible to be established in the case of rice and barley-and-wheat except rice demand equations for the two farm groups; farm size with less than 0.5 cheongbo and 1.0 - 1.5 cheongbo. Less but relatively stable and significant results were found in the case of pulses. This might characterize the Korean rural economy. The expression that "cooked rice and soy sauce" are enough for dinner or lunch, has been a common belief for the farmers or for urban poor people.

Income effects of most foods are positive except in the cases of barley-and-wheat, miscellaneous grains, and vegetables for national average level demand equations, as are shown in Table 5.11.

The negative income effects of barley-and-wheat seem to be less obvious when the importance of wheat for various uses is considered. It seems that the data reported in the Farm Household Economy Survey give much more weight to barley when they aggregate barley and wheat into a single food item "barley-and-wheat." If this is the case, then the negative relationship seems to be realistic, considering its minor role in food consumption compared to rice and possible access to other foods such as rice, meats, dairy and others as income increases. For miscellaneous grains and vegetables,

Table 5.11. Estimated Coefficients of Income and Price for Various Foods (National Average Reduced Form Equations; Unrestricted)

Foods	Income	Price
Rice	.00112	-.199
Barley-Wheat	-.00016	-.242
Miscellaneous Grains	-.00017	.0178
Pulses	.00017	-.0196
Potatoes	.0002	-.031
Vegetables	-.00016	---
Meats	.00018	-.0075
Dairy	.0006	---
Fish and Marine Products	.00002	---
Processed Foods	.00007	---

as income increases would also have the opportunity to substitute higher quality food for miscellaneous grains and vegetables.

The price effects for miscellaneous grains turn out to be positive in all farm groups' demand equations. Are they Giffen goods? It is too early to conclude that they are.

Other than basic food grains, particularly rice and barley-and-wheat, lagged effects beyond two quarters seem to be negligible. This may suggest that prolonged habitual inertia are stronger and rural consumers' expectation about price and income remain longer for rice and barley-and-wheat.

The depreication rate, c; (the coefficient of "Psychological stock") shows positive signs for rice, barley-and-wheat, pulses, vegetables, meats, dairy products and processed foods and negative signs for miscellaneous grains, potatoes, and fish-and-marine products in the case of national average level. The proper interpretation of the meaning of this coefficient, c, is not given in the Houthakker and Taylor model except that it serves as an intermediate role to derive b_1 and other structural coefficients. If we rewrite Equation 3.2 in a discrete approximation form such that

$$q_t = \Delta s_t + cs_t \qquad 3.2'$$

then we can interpret that, if psychological stocks are constant, the higher (and positive) is c, the more they consume, other things being equal. For example, the value of c for rice is larger than that of barley-and-wheat as shown in Table 5.12.

According to the implication of the state adjustment model, the negative sign of b_1 implies that the consumption pattern of a food is above long-run equilibrium level if its inventory (or psychological inertia) is below its long-run equilibrium, or that the consumption pattern is below the long-run equilibrium if its inventory (or psychological inertia) is above their long-run equilibrium level. The more inventory to begin with, the less will consumers buy, or the other way around. If b_1 is positive, the two deviations

Table 5.12. Depreciation Rate (c) and Adjustment Coefficients (b_1) (National Average)

Foods	c	b_1
Rice	7.82	3.64
Barley-Wheat	2.51	- 4.98
Miscellaneous Grains	-144	-37
Pulses	1.1	- 5.59
Potatoes	- 1.6	- 3.24
Vegetables	.69	- 8.5
Meats	8.74	.79
Dairy Products	4	.79
Fish and Marine Products	- 12	- 5
Processed Foods	48	10

between the short-run consumption level and psychological inertia and between long-run consumption level and psychological inertia have same sign, implying that it has a habit forming effect.

As shown in Table 5.12, the signs of b_1 for rice, meats, dairy products and processed food are positive, and others are negative. Thus the former group of foods may be said to have habit forming effects, while the latter have inventory adjustment effect as can be seen in usual durable goods analysis. In the case of rice, there were strong elements of habit forming phenomena as noted earlier. Other cases may not be intuitively appealing. One may argue that every food has both habit forming and inventory adjustment elements. That may well be true. The point is, which element is stronger? The purpose of the state adjustment model is to identify this relative stronger or weaker element. Viewing this way, the positive sign on meats, dairy products and processed food have stronger habit forming elements. As to the magnitude of the coefficients, rice is the highest among this group except that of the processed foods. Here it should be noted that the commodity definition of processed foods reported in the Farm Household Economy Survey is not given. Judging from the data on quantity consumed and expenditure, it seems that it does include not only those from commercial channels, the processed foods proper, but also includes those made at home such as noodles and rice cookies. Thus, it may be safe to say that the processed foods are really another form of composite foods consisting of all grains.

Other derived coefficients are shown in Table 5.2 for rice, Table 5.4 for barley-and-wheat, Table 5.7 for pulses and Table 5.10 for the rest of foods only in cases of national average levels. The short and long run structural coefficients of income and prices and conventional short-run elasticities, all at national average levels, are summarized in Table 5.13.

It is found that long-run coefficients are greater in absolute value terms than short-run coefficients for

Table 5.13. Short- and Long-Run Coefficients and Short-Run Elasticities at National Level

Foods	Income			Price		
	Short Run	Elasticities	Long Run	Short Run	Elasticities	Long Run
Rice	.0009	(.167)	.0017	- .153	(- .446)	- .286
Barley-and-Wheat	- .00024	(-.0697)	- .00008	- .357	(-1.511)	- .12
Miscellaneous Grains	- .00012	(-.430)	- .00009	.013	(.654)	.0095
Pulses	.00027	(.92)	.00005	- .032	(-1.69)	- .005
Potatoes	.0003	(.423)	- .0003	- .047	(-1.025)	.046
Vegetables	- .0003	(-1.922)	.00003	---	---	---
Meats	.00017	(1.09)	.00019	- .0071	(-1.78)	- .0078
Dairy Products	.001	(6.41)	.0013	---	---	---
Fish-and-Marine Products	---	---	---	---	---	---
Processed Foods	.0006	(3.85)	.0008	---	---	---

rice, vegetable, meats, dairy products and processed foods. For fish-and-marine products, no significant results are found. The long-run coefficients of other foods are less in absolute value terms than those of short-run coefficients. Interestingly enough, short-run coefficients of potatoes and vegetables change signs from the short-run relationship to the long run. It seems that current potato consumption will reverse its direction with respect to both income and prices, thus, in the long run it would be another inferior goods. The sign shift of the vegetable demand relationship with respect to income, from negative to positive, may be explained by the possibility that poor farmers can not now afford to buy vegetables due to immediate needs for (and/or stronger habitual inertia attached to) other foods; but if income increases enough, they might be able to demand more vegetables. This can be done either by withholding produced vegetables from the markets or by increasing purchases. Incidentally, farmers' actual cash expenditures on vegetables are larger in proportion (about 24.5 percent of total implicit expenditures, compared to 1.8 percent for rice and 6.4 percent for barley-and-wheat)at 1973 annual national average figures.

In interpreting long-run coefficients, care should be taken. As defined earlier in Equation 3.2, the long run is defied as

$$\frac{ds_t}{dt} = 0$$

that is; it is defined as that point where there is no further change in the psychological stock level (or consumption habit is constant). It does not say anything about the magnitudes of the explanatory variables.

For example, it was found that in the case of national average rice consumption per capita, long run coefficients are greater than short-run coefficients as shown in Table 5.3. Thus we can infer that as long as current rice consumption habit prolongs, the long run value of each coefficient will be multiplied by 1.933 which is derived from

$$\frac{c}{b_1 - c}$$

Here again, the problem is to what specific time period does the long run refer. As far as the model is concerned, there is no specific time framework given except the definition; the long-run equilibrium. This is one of the reasons why the long-run relationship is not used for numerical projections. This may be one of the weaknesses that economists have to face. But at least one can make inference about the future direction.

It can be expected that in the case of highly inflationary situations, undeflated data, particularly prices, would give some biased results in statistical analysis. In this study it was found that with undeflated data, (prices and incomes), the signs of own price have shown correct direction in many cases. But this is not the case for the income variable. Since quantity of food consumption is relatively stable with respect to nominal prices and incomes it can be easily expected that the income effect would be negative. This was also indicated by Gustafson [G10]. For instance, nominal income effects on rice consumption turned out to be negative for all groups except for national averages which is hardly explainable with economic theory for normal goods.

Apart from this methodological problem, there seems to be a problem of money illusion. Under economic theory, if both prices and incomes are increasing in same proportion, quantity demanded will remain at the same level as before the changes. This is the homogeneity condition in mathematical terms. This condition, however, may not strictly hold in the real world. First of all, all prices are not changing in the same proportion as income. For rural consumers, this fact alone gives some constraints on their consumption in two aspects; first, since more income is expected from higher prices, their consumption of foods produced by their own hands will be restricted, other things being equal; secondly, rise in nonfood prices would add psychological influences to their food consumption, the net influence of prices of foods and income change being somewhat to discourage food consumption, ceteris paribus.

Viewed this way, negative nominal income effects are completely rational for the farmers in contrast to urban

consumers. In other words, money illusion which is discarded in neoclassical economic demand theory may be a result of rational consumer behavior. The degree of negative nominal income effects has shown to be stronger for rice. Interestingly enough, for barley-and-wheat, nominal income effects have shown positive signs for all farm groups including national average level. Other food demand equations revealed little significant differences between the two contradictory results. Recognizing that money illusion may be a rational behavior for rural consumers (farmers), the characteristics of an individual food in terms of habit inertia and historical patterns also have to be taken into consideration in general, which also served as an important role in choosing parameters to be constrained. Thus it was decided to use deflated data rather than undeflated data.

According to Nerlove [N3], a test of the permanent income hypothesis can be accomplished by examining whether the distributed lag is significant only in the income variable and/or whether distributed lags are the same for each individual commodity. Since total consumption function is not estimated, it may be inappropriate to test permanent income hypothesis by the significant level of the coefficients of lagged income variables. Following the Nerlove procedure of testing the hypothesis, there is no lagged income variable appearing in the equation system, implicitly implying that the corresponding coefficients are zero.

without going through all the details of testing procedure, it seems that the results from this study are not convincing. But at the conventional 5 percent significance level, most of the coefficients of lagged income variables turned out to be insignificatn except in cases of rice (q11 and q12), barley-and-wheat (q21 and q24), potatoes (q54), vegetable (q60) and the fish-and-marine products (q90). For rice, rural poor consumers in the group of farm size with less than 1.0 cheongbo may spend more as their transistory income increases compared to the upper income group. But again, without further investigation, existing results do not give any further conclusions. In this sense, this study failed to reveal correct premises.

It was also found that consistent aggregation was difficult because the sample sizes were different among different farm groups. Moreover different functional forms added to the difficulty in checking the aggregation bias. Despite these difficulties, an attempt was made to see how biases might be found. In many cases, coefficients of the national average demand equations were not consistent with those derived by averaging each farm group's coefficients.

Second Order Distributed Lag Model

As indicated earlier, no significant coefficients could be found in demand equations other than for rice and barley-and-wheat. Thus only two equations at the national average level with quarterly data and with two sources of income were analyzed. Relevant coefficients are shown in Table 5.14. Following the procedure described in Chapter III, lag distributions of four important variables, farm income, nonfarm income and two prices are graphed in Figure 5.1 and 5.2. Since the solutions of both demand equations have complex roots,[1] the system is oscillatory and has a negative lag distribution, but it converges as time approaches infinity.

It is clear from the figures that the lagged effects of each variable in the rice demand function are longer but smaller than those in the barley-and-wheat demand function. From this we can infer that rural consumers attach more importance to rice than barley-and-wheat.

The smaller magnitude of oscillation may also imply its relative stability and prolongedness in terms of psychological inertia. This also seems to be consistent with the previous results and with the finding that lagged effects beyond one quarter are not significant for other foods. The only significant coefficient of two-period's lagged quantity for other foods is in the case of the demand for pulses for farm size less than 0.5 cheongbo.

Annual Demand Equations for Rice and Barley-and-Wheat

Three systems of eight equations were tried--one with the lowest monthly actual inventory level during the year,

---

[1]It is because $-4(a_9) > (a_1)^2$

Table 5.14. Estimation Results for Rice (q10) and Barley-and-Wheat (q20) in the Second Order Distributed Lag Model

	Constant	One Period Lagged Quantity (ℓ/capita)	Two Period Lagged Quantity (ℓ/capita)	Farm Income Deflated by FPPI (Won/capita)	Nonfarm Income Deflated FPPI (Won/capita)	Lagged Farm Income	Lagged Nonfarm Income	Price Index Rice Deflated by FPPI (Percent)	Price Index of Barley-and-Wheat (%/FPPI)	Lagged Rice Price Index (%/FPPI)	Lagged Barley-and-Wheat Index (%/FPPI)	Third Quarter Dummy
		q-1	q-2	Y_1	Y_2	Y_{1-1}	Y_{2-1}	P_1	P_2	P_{1-1}	P_{2-1}	DV3
	ao	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11
q10	23.21	.25	-.384	-.0005	.015	.002	-.004	-.208	.323	-.156	-.009	—
			(.113)	(.0009)	(.005)	(.001)	(.004)	(.079)	(.077)	(.104)	(.083)	
q20	34.52	.078	-.22	-.001	.001	.0005	-.005	.099	-.209	.0036	.57	12.46
		(.144)	(.11)	(.0008)	(.0035)	(.0009)	(.003)	(.063)	(.053)	(.074)	(.052)	(1.48)

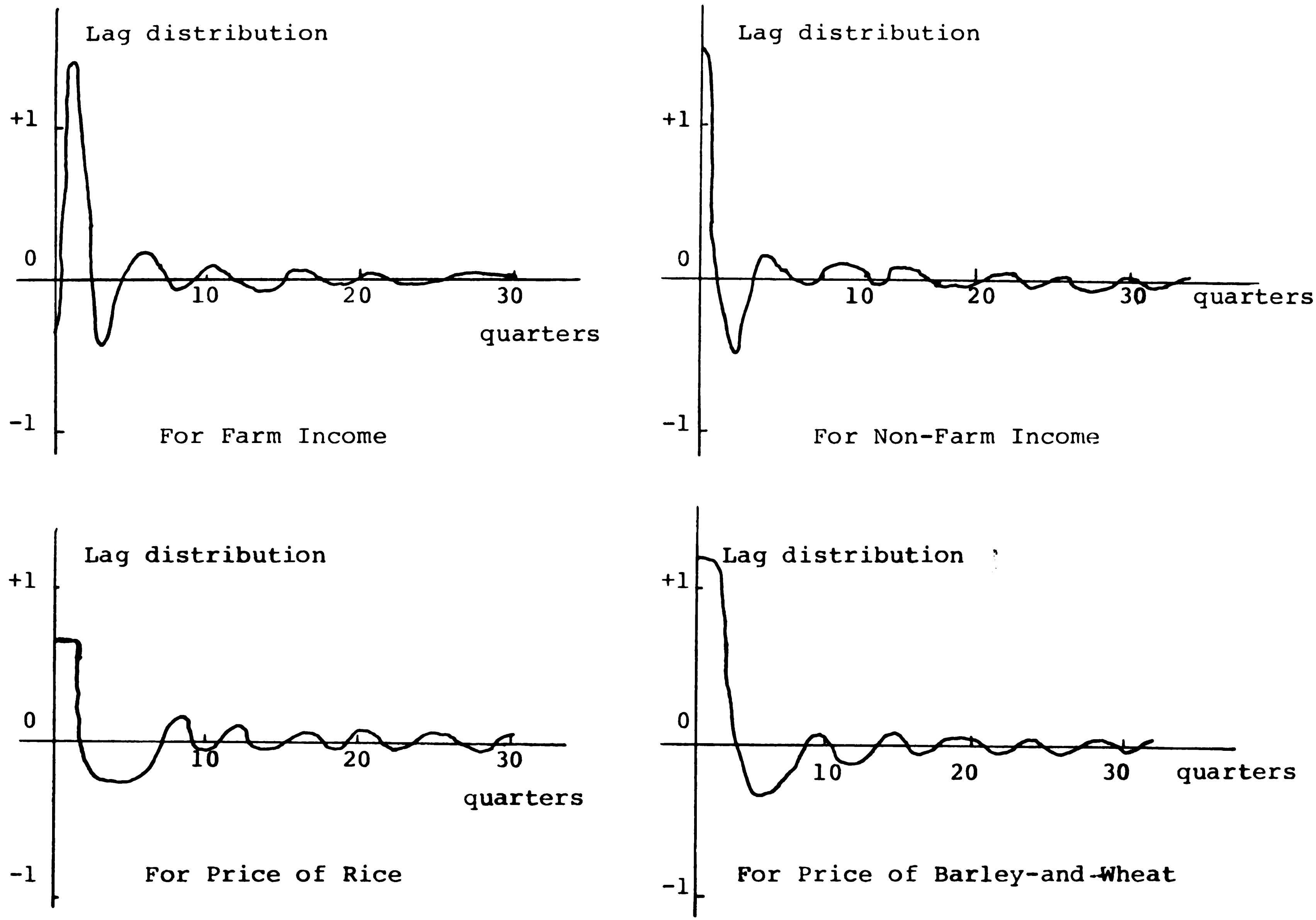


Figure 5.1. Lag Distribution For Rice Demand (National Average)

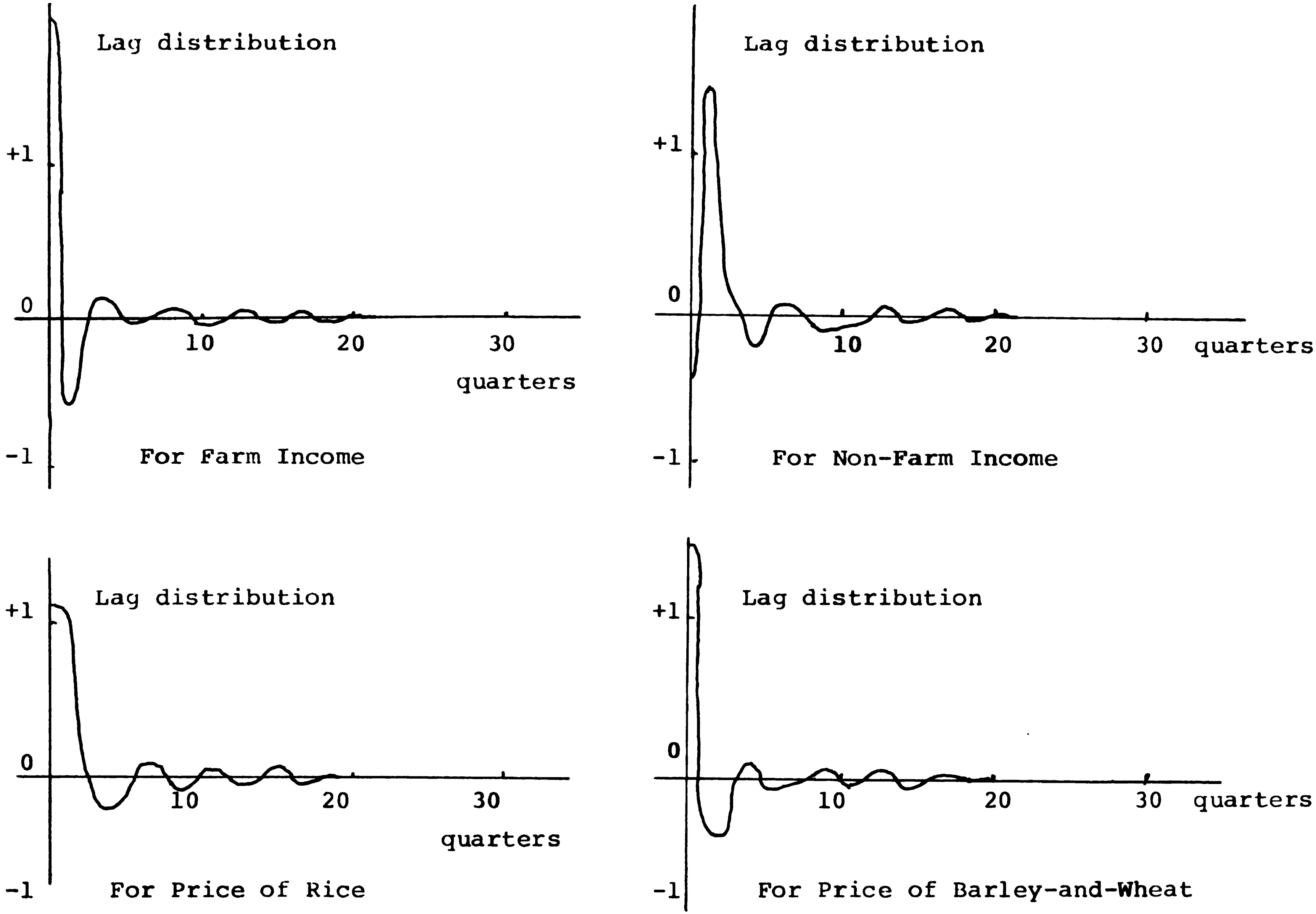


Figure 5.2. Lag Distribution For Barley-and-Wheat (National Average)

the second with the change in ending inventory in terms of calendar year and the third with the adult-equivalent-scaled variables. The results are summarized in Tables 5.15 through 5.18.

The reason why the lowest monthly inventory level was chosen is based on an assumption that farmers may attach more importance on the lowest inventory level in making consumption decisions rather than the change in inventory. It may make no difference between the lowest inventory and change in inventory level. Let us assume that one household has a large inventory and another has a smaller inventory from the beginning but the changes in inventory level are the same for both households. The fact that the former will leave still larger ending inventory than the latter seems to influence consumption differently. One shortcoming of using the lowest inventory level, however, is that it does not satisfy the indentity:

$$\text{Production} = \text{Consumption} + \text{Sales} + \text{Change in Inventory} \quad 5.3$$

which will be used in simulation model.

To remedy this shortcoming, change in inventory level from previous year's ending inventory to current year's ending inventory level measured in December was used. In this case, there are two alternative ways of incorporating the identity relationship 5.3. The one is to regard sales

Table 5.15. National Average Demand for Rice (q10) and Barley-and-Wheat (q20) with Annual Data: 2SLS (Lowest Inventory Level Used)

	Constant	Net Income Deflated by FPPI (Won/capita) Y	Rice Price Index Deflated by FPPI (Percent) P1	Barley-and-Wheat Price Index Deflated by FPPI (Percent) P2			
	A(10)	A(11)	A(12)	A(13)		R^2	
Q10	155.622	.0031 (.0013)	-2.110 (1.149)	1.38 (.70)		.67	
	A(20)	A(21)	A(22)	A(23)			
Q20	114.52	-.00063 (.0004)	---	-.149 (.179)		.65	
		Lowest Inventory Level (ℓ/month)	Gov't. Purchase Price of Rice (Won/80kg.) Deflated	Gov't. Purchase Price of Barley (Won/60kg.) Deflated			
	A(30)	A(31)	A(32)	A(33)			
P1	4.64	-.254 (.171)	1.543 (.354)	5.701 (1.279)		.95	
	A(40)	A(41)	A(42)	A(43)			
P2	-2.4	-.35 (.13)	1.63 (.35)	5.5 (.95)		.97	
		P1	P2				
	A(50)	A(51)	A(52)				
Lowest Inventory of Rice SI1	-49.196	.599 (.85)	.28 (.78)			.56	
	A(60)	A(61)	A(62)				
For Barley and Wheat SI2	-29.77	1.51 (.90)	-.96 (.83)			.42	
		P(1)	P(2)	Off-Farm Workers/ Total Family (Percent) TM	Total Number of Rural Household PM		
	A(70)	A(71)	A(72)	A(73)	A(74)	R^2	D.W.
Y	-234237.58	447.57 (202.64)	15985.94 (20655.92)	11076.93 (5404.28)	.07 .05	.90	1.7
		Y	Time				
	A(80)	A(81)	A(82)				
TM	2.282	-.00006 (.00005)	.184 (.1)			.56	1.6

Table 5.16. Auxiliary Equations for Projection and Simulation

	Constant	Time	$\bar{R}^2$
Rice Production ℓ/Household PQ (10)	299.81 (14.79)	9.45 (2.63)	.65
Barley-Wheat Production (ℓ/Household) PQ (20)	159.75 (8.72)	-2.53 (1.55)	.28
Number of Rural Households PM	2579718	-13215.4 (4937.6)	.51
Number of Family/Household SF	6.354 (0.02)	-.075 (.004)	.98

to market as residuals, the other is to make the changes in inventory as residuals. Both have rationale. The first might be based on an assumption of more emphasis on food consumption per se and the second on farm income attainable from selling their products. In this study, the former method was chosen.

The results show little differences from the quarterly model. Signs of the coefficients of prices and income were the same; the income effect for barley-and-wheat being negative. Results show that government purchase prices of rice and barley have significant and positive effect on both prices and income.

Table 5.17. National Average Demand for Rice, Q(10), and Barley-and-Wheat, Q(20), (Annual Data): Simultaneous Equation System (2SLS) with the Lowest Inventory - Adult Equivalent Scale (AES)

	Constant	Net Income/ Capita (Won/AES) Y1	Price Index (Percent) Deflated P(1)	Price of Barley-Wheat (Percent) Deflated P(2)			R^2	D.W.
	C(10)	C(11)	C(12)	C(13)				
Q'(10)	208.901	.0031 (.0013)	-2.682 (1.533)	1.701 .951			.60	2.46
	C(20)	C(21)	C(22)	C(23)				
Q'(20)	160.638	-.00057 (.0004)	---	-.306 (.201)			.70	2.05
		Lowest Stock During Year Rice (SI(10) Barley-Wheat (SI(20) (ℓ/Month)	Gov't. Purchase Price of Rice (Won/ 80kg.)	Gov't. Purchase Price of Barley (Won/50kg.)				
	C(30)	C(31)	C(32)	C(33)				
P(1)	5.241	-.192 (.134)	1.536 (.362)	5.66 (1.3)			.95	2.49
	C(40)	C(41)	C(42)	C(43)				
P(2)	-.016	-.003 (.00097)	.016 (.0034)	.055 (.0092)			.97	2.84
		P1	P2					
	C(50)	C(51)	C(52)					
S'I(10)	-62.603	.821 (1.11)	32.24 (102.46)				.55	2.31
	C(60)	C(61)	C(62)					
S'I(20)	-37.08	2.032 (1.185)	-133.623 (108.93)				.43	2.16
		P1	P2	Off-Farm Worker/ Total Family (Percent) TM	Total Rural House-hold PM	Land Distribution (Cheongbo/ Household) DL		
	A(70)	A(71)	A(82)	A(73)	A(74)	A(75)		
Y'	-699652.82	486.55 (749.59)	65944.17 (97878.91)	31455.24 (23535.15)	.223 (.18)	3390.468 (51113.29)	.78	2.8
		Y'	Time					
	C(80)	C(81)	C(82)					
TM	2.41	-.00005 (.00005)	.195 (.109)					

Table 5.18. National Annual Average Demand Equations System for Rice and Barley-and-Wheat with Change in Inventory Level

	Constant	Y		P1		P2		R^2	D.W.
	A(10)	A(11)		A(12)		A(13)			
Q10	129.88	.0023 (.00097)		-1.252 (.715)		.929 (.458)		.76	1.88
	A(20)	A(21)		A(22)		A(23)			
Q20	116.54	-.00054 (.0004)		---		-.193 (.171)		.66	1.82
		Change in Rice Inventory (ℓ/Year per capita) SI1		Change in Barley-Wheat Inventory (ℓ/Year/ capita) SI2		GP1	GP2		
	A(30)	A(31)		A(32)		A(33)	A(34)		
P1	16.017	-.037 (.031)		---		.014 (.003)	.0402 (.0125)	.94	2.62
	A(40)	A(41)		A(42)		A(43)	A(44)		
P2	-1.634	---		.114 (.133)		.0105 (.004)	.062 (.016)	.91	2.45
		P1	P2	Rice Production (ℓ/capita/ Year) PQ1	Barley-Wheat Production (ℓ/capita/ Year) PQ2	Calendar Year T			
	A(50)	A(51)	A(52)	A(53)	A(54)	A(55)			
SI1	336.26	4.402 (5.65)	-7.1 (5.2)	1.63 (.77)	-4.07 (2.26)	-18.29 (13.79)		.75	2.01
	A(60)	A(61)	A(62)	A(63)	A(64)	A(65)			
SI2	246.11	1.389 (2.025)	-1.504 (1.874)	-.115 (.276)	-1.177 (.811)	-5.92 (4.94)		.68	2.62
		P1	P2	Off-Farm Employment (Percent Total Family) TM	Number of Rural Household PM				
	A(70)	A(71)	A(72)	A(73)	A(74)				
Y	-472087	497.06 (272.28)	352.56 (308.11)	20334.1 (9582.9)	.149 (.09)			.83	2.46
		Y	T						
	A(80)	A(81)	A(82)						
TM	2.22	-.00006 (.00005)	.176 (.098)					.56	1.62

There was little difference between the respective coefficients in the per capita model and the adult-equivalent-scaled model; coefficients of income were almost the same, but those of prices were greater in absolute value terms for the adult-equivalent-scaled equations (AES) than for the per capita equations (PC). This relationship is shown in Table 5.19 which is abstracted from Table 5.15 and 5.18.

Table 5.19. Income and Price Coefficients of Annual Model with Per Capita and Adult-Equivalent Scale

	Net Income Deflated by FPPI (Won/PC,AES)	Price Index of Rice Deflated (Percent)	Price Index of Barley-and-Wheat Deflated (Percent)
<u>Rice</u>			
Per Capita	.0031	-2.11	1.38
	(.0013)	(1.49)	(.71)
Adult-Equivalent Scale	.0031 (.0013)	-2.68 (1.53)	1.71 (.95)
<u>Barley-and-Wheat</u>			
Per Capita	-.00063 (.0004)	--- ---	-.149 (.179)
Adult-Equivalent Scale	-.00057 (.0004)	--- ---	-.306 (.201)

As expected, the income coefficients were of about the same magnitude because both quantities and income were deflated by the same scales, respectively, but prices were not. Apart from this methodological difference, we faced choice of "correct" parameters. Though it was crude enough to scale quantities and income with .52 for age group under 14, with 1.0 for male adult and .9 for female adult both between 14-65 and with .65 over 65, we recognized that there were certain differences of quantities and income that go into decision making process for consumption depending on the age and sex structure of a family.

If this is the case, we are under-estimating price coefficients when we use ordinary per capita variables. Thus in the actual policy making stage, this point should be taken into consideration.

Differences in the absolute magnitudes of coefficients of estimated equations between the quarterly model and the annual model, were not apparent in this study. But, given the same variables, quarterly coefficients were smaller than those of the annual model because of DT = .25 which entered into the calculation process of deriving structural coefficients. Another plausible expanation for small quarterly coefficients may come from the permanent income hypothesis [A1, H9]. This point is also important in making correct inferences and for the policy making process.

In the simulation model and projection, change in inventory level instead of the lowest level of inventory was used and the system of equation was re-estimated by using 2SLS. The results of the estimation are shown in Table 5.18. Demand equations were not much different from those with the lowest inventory level and government purchasing prices of rice and barley did affect prices and income significantly.

Since identity relationship 5.3 holds, equations for inventory change can be rewritten as follows:

$$PQ_1 - Q_1 - SALES = A(50) + A(51)P_1 + A(52)P_2 + A(53)PQ_1 + A(54)PQ_2 + A(55)T \qquad 5.4$$

Substitution of demand equation, Q_1, and rearrangement of terms disregarding other terms for convenience's sake gave the following market supply equation;

$$\underset{(Rice)}{SALES} \sim - A(50) - [A(51) - A(12)]P_1 - [A(52) - A(13)]P_2 \qquad 5.5$$

Similarily, for barley-and-wheat,

$$\underset{\text{(Barley-and Wheat)}}{SALES} \sim - A(60) - A(61)P_1 - [A(62) - A(23)]P_2 \qquad 5.6$$

From the above equations, it is clear that for the market supply equations to have positive slopes with respect to their own prices, A(12), the price coefficient of rice demand equation, and A(23), the price coefficient of barley-and-wheat equation should be greater, algebraically, than A(51) and A(52) respectively.

Using the estimated results from the Table 5.21, equations 5.5 and 5.6 become

$$\underset{\text{(Rice)}}{\text{SALES}} \sim -\ 336.26 - 5.7P_1 + 8.4\ P_2 \qquad 5.7$$

and

$$\underset{\text{(Barley-and-Wheat)}}{\text{SALES}} \sim 246.11 + 1.7P_2 + 1.7P_2 - 1.39P_1 \qquad 5.8$$

Surprisingly, the rice market supply equation had a negative slope while barley-and-wheat had a positive one. Since they are only partial equations which do not count for other terms and because of large standard errors of A(51) and A(52), it is not conclusive at this point whether we can accept the results. Total effects were analyzed in the simulation model.

According to the results at hand, all show that rural income per household is positively correlated with the remaining total number of farm households in all three equation systems (.7, .223 and .149) though two systems result in larger standard errors. With small number of observations, it is too early to conclude urban migration is harmbul to the rural economy. But it is suggested as a topic for further policy analysis [H3].

Off-farm employment rate, TM, shows positive correlation with income when TM is an explanatory variable but negative when it is a dependent variable. With more off-farm employment opportunities, more income is expected. On the other hand, increasing income seems to discourage seeking off-farm work.

Simulation

The equation system used in a very simple simulation model was based on the systems of equations 5.1 through 5.2. The model was applied to only rice and barley-and-wheat. This is mainly because the most important policy variables that can be identified and that are available are the government purchasing prices of rice (GP1) and barley (GP2). These two policy variables clearly have given a tremendous impact to rural economy.

To simulate the block-diagram model in Chapter IV with a three-mode feed back control technique, it was necessary to find a linearized and discrete approximation of control equation such that

$$\begin{aligned} U_t &= f(\text{ERROR}) \\ &= f(\text{Desired Sale [DSAL]} - \text{Actual Sale [ASAL]}) \\ &= K_p\ \text{ERROR}_t + K_r\left(\frac{\text{ERROR}_t - \text{ERROR}_{t-1}}{DT}\right) \\ &\qquad + K_i\ \left(\sum_{o}^{T} \text{ERROR}_t\right) \end{aligned} \qquad 5.7$$

Where U_t is policy variable matrix such that

$$U_t = \begin{bmatrix} GP1 \\ GP2 \end{bmatrix}$$

and K_p, K_r, and K_i are proportional, derivative and integral policy modes, respectively. The second term of equation 5.9 is linear approximation of $\frac{d(\text{ERROR}_t)}{dt}$ and the third is that of $\int$(ERROR)dt. ERROR is a matrix defined as

$$ERROR_t = \begin{bmatrix} DSRDR_t - ASALR_t \\ DSRDB_t - ASALB_t \end{bmatrix} \quad 5.11$$

where ASAL is an implicit actual marketed quantity of rice and barley-and-wheat per household. It is implicit because it does not account for amounts not marketed but consumed for various purposes other than direct human consumption. Thus this figure does not necessarily match actual quantity marketed which is reported in various sources, and exceeds the actual quantity marketed. Then

$$ASAL = \text{Production [PQ]} - \text{Demand [Q]} - \text{Change in Inventory [SI]} \quad 5.12$$

The desired quantity of sale DSRD is assumed to take the following equational forms

$$DSRDR = 1210.4\ (1 + .05\ \sqrt{T})\ ,\ 1964 \le T \le 1973 \quad 5.13$$

$$DSRDR = 1689.69\ ,\ T > 1973 \quad 5.14$$

$$DSRDB = 350\ (1 + .03\ \sqrt{T})\ ,\ 1964 \le T \le 1973 \quad 5.15$$

$$DSRDB = 510.72\ ,\ T > 1973 \quad 5.16$$

where DSRDR and DSRDB are desired quantity of rice and barley-and-wheat to be marketed per household, respectively, and the initial values of which are actual implicit sales in 1965. Upper limits which are set about 10 percent higher than the peak sales during past 10 years are given, considering reasonable ranges of production and demand.

Coefficients, .05 and .03, are derived from rates of population growth (assumed to be around .02) and other additional factors such as urbanization, production and governmental demand increase.

One of the difficulties in this discrete version of the three-modes control equation was to find out corresponding control parameters K_p, K_r, and K_i. A simple but costly method is to run the simulation model during the sample period many times with various alternative values of these parameters. Other methods would be computer optimization techniques such as COMPLEX or Bard's computer version of Newton-Gauss method [K2]. In this study, a less costly and less elegant method is used. Relevant data were generated by using assumed DSRD quantities and actual implicit sale quantities. Then an ordinary least square (OLS) method was used to generate K_p, K_r, and K_i outside the simulation model, assuming that policy makers have had such control schemes in mind during the sample period and simulation period. The generated parameter values are shown in Table 5.20. "Adjusting Factors" are the constant term in OLS estimated equation.

Table 5.20. Generated Control Parameter Values of K_p, K_r, K_i

		K_p	K_r	K_i	Adjusting Factor (Constant)
GP1	3-mode	.171	-.373	1.04	2888.11
GP2	3-mode	-.025	-.143	1.30	618.5

Along with these parameters, and alternative arbitrary values of them, the model has been run by incorporating a time delay (DELAY) in market sales. Unfortunately due to the nature of the equation system which uses the estimated parameters, arbitrary variations of parameter values have given unacceptably large errors. Thus after many trials it was decided to use a simultaneous-equation solution type simulation with fixed parameters with a few adjustments. The results of the simulation are given in Table 5.21 and 5.22 and Figure 5.3.

The value of DT, simulation period, is chosen as 1, on the following ground despite possible larger simulation errors due to the large value of DT.

(1) Parameters are estimated with annual data, thus if we use, for example, Q.DT (rate) variable rather than Q (stock) in the simulation, the extrapolation exceeds far beyond the sample range, thus resulting in larger errors. These errors have been larger, particularly due to the simultaneous nature of the system.

(2) One possible way of constructing rate variables is to divide all dependent variables by multiplying DT and later to sum or integrate them. But this would give the same result as using DT = 1.

(3) Government decisions on the level of purchase prices are assumed to be made annually, which is the most usual case. Thus, it seems to be reasonable to base the

Table 5.21. Simulated Results of Rice Demand and Sales: Desired Sale = 1210.4 (1 + .05 $\sqrt{T}$) until 1973, 1589.69 after 1974 and **GP1 = .171 ERROR t = .37** $\frac{d(\text{ERROR } t)}{dt}$ + 1.04 $\int$ (ERROR) dt[1]

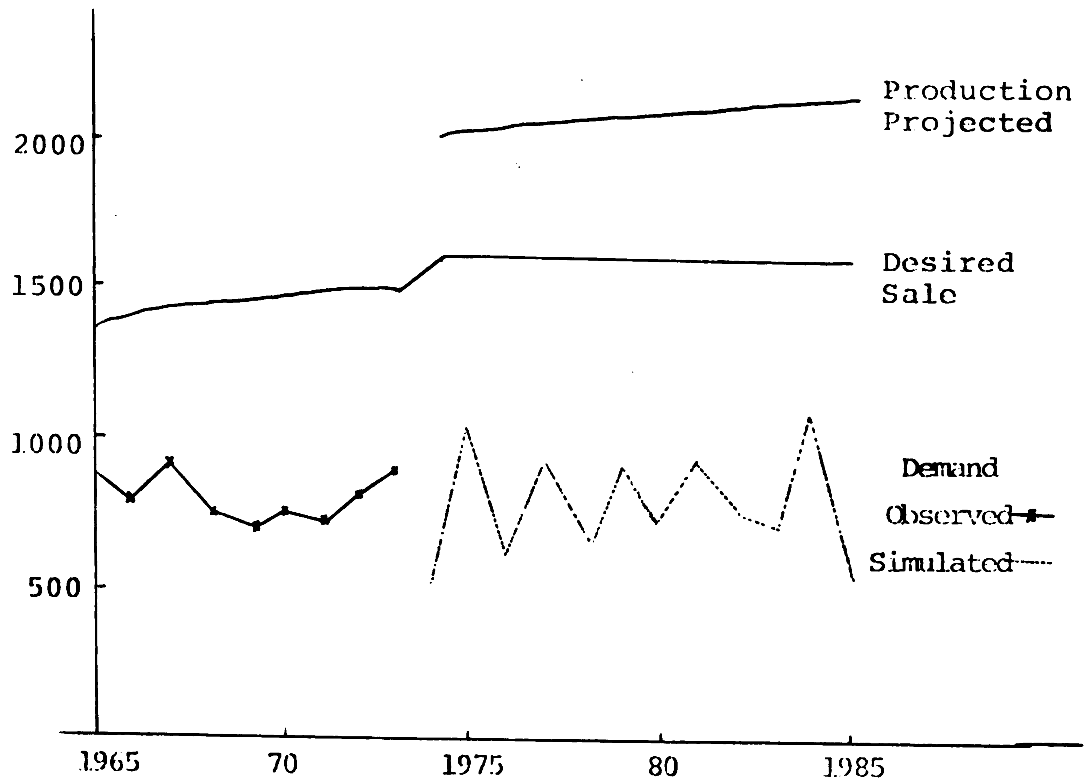
Year	Production		Demand		Change in Inventory		Implicit Sale		Gov't Rice Purchase Price		Market Price	
	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated
	ℓ/Household								--Won/80kg/FPPI---		------%/FPPI-------	
1965	1828	1942	860	870	-242	-286	1210	1358	3150		100.0	101.9
1966	2127	1977	829	827	126	218	1172	935	2995		94.1	102.7
1967	2119	2011	904	870	-188	- 54	1402	1195	3035		91.5	90.9
1968	1907	2044	827	827	-267	-360	1347	1577	2760		89.9	100.4
1969	2131	2074	793	782	158	115	1146	1177	3071		97.2	95.1
1970	1940	2105	820	819	- 69	3	1189	1289	3625		96.7	96.7
1971	2238	2133	826	891	657	356	755	886	3856		103.3	98.9
1972	2122	2159	863	858	-277	-294	1536	1595	4041		122.9	93.6
1973	2223	2185	937	901	19	223	1267	1061	3348		111.7	101.6
1974		2209		459		544		1207		3144		91.8
1975		2232		1154		-477		1554		3438		112.1
1976		2253		677		482		1093		3253		100.0
1977		2273		958		-245		1559		3701		113.0
1978		2292		860		412		1019		3262		101.8
1979		2309		771		20		1517		3859		111.9
1980		2324		1010		323		991		3332		104.3
1981		2338		625		268		1446		4020		111.1
1982		2351		1115		248		987		3470		107.3
1983		2362		524		470		1368		4215		111.5
1984		2372		1177		208		987		3683		110.8
1985		2380		461		618		1302		4486		113.6

[1] Kp = .171, Kr = -.37 and Ki = 1.04 during sample period (1965-1973), but Kp was time-varying during simulation period (1974-1985).

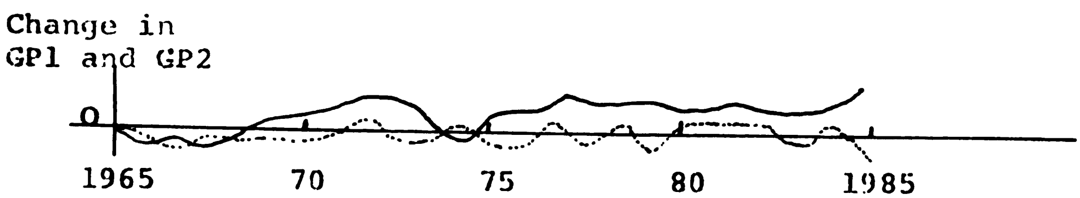
Table 5.22. Simulated Results of Barley-and-Wheat Demand and Sales: Desired Sale = 350 $(1 + .03\sqrt{T})$ until 1973, 510.72 after 1973, and GP2 = $-.03\ ERROR\ t - .14\ \frac{d\ (ERROR\ t)}{dt} + 1.3 \int ERROR_t\, dt$[1]

Year	Production		Demand		Change in Inventory		Implicit Sale		Gov't Barley Purchase Price		Barley-Wheat Market	
	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated	Actual	Estimated or Simulated
	ℓ/Household								Won/50kg/FPPI		%/FPPI	
1965	879	987	527	552	234	192	119	243	1005		100.0	98.1
1966	978	960	582	561	41	85	355	314	896		100.9	85.7
1967	941	932	571	545	- 66	2	390	385	858		97.3	82.4
1968	976	906	548	544	19	- 14	409	376	876		81.2	82.2
1969	976	880	532	527	57	- 14	388	367	874		80.2	86.3
1970	856	854	500	522	- 1	59	357	273	759		84.3	83.6
1971	768	828	469	485	80	12	219	331	943		97.7	99.5
1972	835	803	471	448	-100	- 80	464	435	1137		111.9	109.5
1973	718	778	449	456	- 40	- 19	309	341	942		89.7	107.8
1974		754		576		- 22		200		748		74.9
1975		730		375		-216		571		1292		114.4
1976		706		494		- 72		284		886		83.3
1977		683		402		-222		503		1214		111.3
1978		660		431		-137		366		964		88.0
1979		637		429		-223		430		1121		105.7
1980		615		374		-202		443		1048		93.7
1981		593		447		-222		369		1034		100.4
1982		572		328		-259		503		1119		99.5
1983		551		452		-226		324		964		96.8
1984		530		292		-305		544		1171		104.7
1985		510		446		-233		297		917		

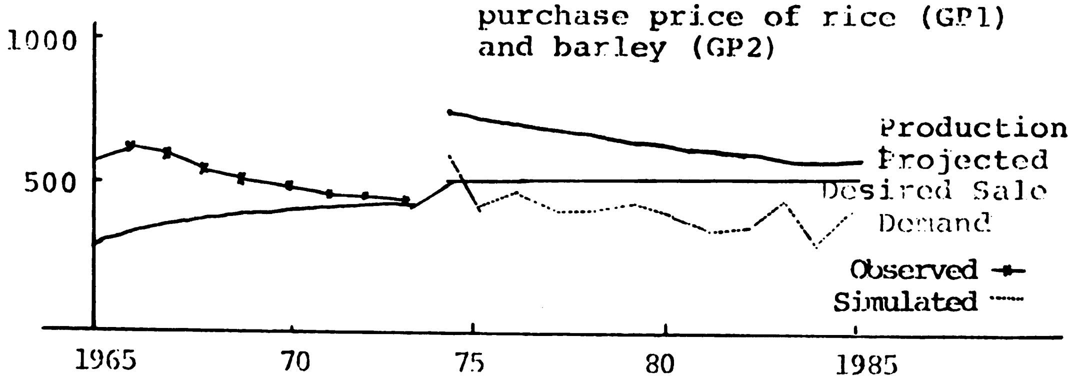
[1] Kp = -.03, Kr = .14 and Ki = 1.3 during the sample period (1965-1973), but Kp was time-varying during simulation period (1974-1985)



(A) Rice Demand



(B) Change in government real purchase price of rice (GP1) and barley (GP2)



(C) Barley-and-Wheat Demand

Figure 5.3. Simulated results by using "three-mode" control scheme.

model on this fact, even though there is no technical difficulty to incorporate this decision rule in the model with fine time series (i.e., DT less than 1).

It was also decided not to incorporate the time delay factor, mainly because the data used in this model are *ex post* values reported at the end of the year. It is possible to assume certain quantities which are in the input channels which will be marketed in the future. But considering the fact that the purpose of incorporating this simulation model is restricted to rural demand analysis and projections, no further elaborations were attempted.

According to the results as shown in Table 5.21 and 5.22, the projected demand for rice in 1984 is 1177 ℓ/household in 1974 to 1177 ℓ/household in 1984 for rice and from 292 ℓ in 1984 to 576 ℓ in 1974 for barley-and-wheat. The fluctuation may have originated from decision functions that were set to adjust government purchasing prices annually in such a way that the proportional control parameter K_p is increased upward holding other control parameters constant during simulation period (1973-1985).

Also, since the model with a "three-mode" control scheme is more or less of academic interest and may or may not represent a realistic version of government policy, an intuitive but more realistic version of simulation model was tried. The policy variables used were the same as before but with a decision rule to increase or decrease purchasing prices at a certain fixed level annually. During the past ten years, the farm purchase price index (FPPI) has risen about 25 percent annually, while government purchase prices of rice and barley have been increasing annually about 38 percent and 34 percent in nominal terms, respectively. Thus these are reasonable assumption based on past experience.

To experiment, extreme values were chosen. Four of the alternative policy measures were chosen and their results are shown in Table 5.23 and Figure 5.4. The first column of Table 5.23 shows the possible trend of demand for rice and barley-and-wheat when the rice purchase price, GP1 is assumed to be increased initially 40 percent in 1974 over that of 1973 in real terms and increased 5 percent annually thereafter; while the barley purchase price, GP2, is to be decreased initially 20 percent below the 1973 purchase price in real terms and decreased 2.5 percent annually thereafter.

According this fixed rate increase or decrease in purchase prices, rice demand is projected to be 886 ℓ per household in 1975, 902 ℓ per household in 1979 and 928 ℓ in 1983 and 587 ℓ in 1984. Demand for barley-and-wheat is projected to be 434 ℓ per household in 1975, 390 ℓ in 1979 and 414 ℓ in 1984. Despite this large increase in the rice purchasing price and drastic decrease in the barley purchasing price, market price rice increased only about 20 percent and barley-and-wheat price decreased only about 6 percent in real terms from the 1965 base period.

Table 5.23. Simulated Results of Rice and Barley-and-Wheat Demand with Fixed Rate Changes in Real Purchase Prices; GP1 = $3348(1 + r_1T)$ and GP2 = $942(1 + r_2T)$ where r_1 and r_2 are Annual Rates of Change

Year	Intital 40% increase for rice 20 % decrease for Barley-Wheat and $r_1 = 5\%$ $r_2 = -2.5\%$		Initial 85% increase for rice 40% decrease for Barley-Wheat and $r_1 = 10\%$ $r_2 = -5\%$		$r_1 = 5\%$ $r_2 = -2.5\%$		$r_1 = 10\%$ $r_2 = -5\%$	
	Rice	Barley-Wheat	Rice	Barley-Wheat	Rice	Barley-Wheat	Rice	Barley-Wheat
	ℓ/Household							
1974	762	478	688	475	583	621	574	620
1975	886	434	911	408	1183	443	1179	440
1976	732	461	654	457	470	608	456	604
1977	894	412	923	382	1272	406	1264	399
1978	702	447	611	444	396	609	350	602
1979	902	390	940	354	1360	365	1348	354
1980	669	435	561	432	255	615	231	605
1981	913	368	963	326	1465	319	1450	306
1982	631	424	504	423	119	626	90	614
1983	928	344	993	296	1593	268	1576	252
1984	587	414	438	416	- 0	644	- 0	630

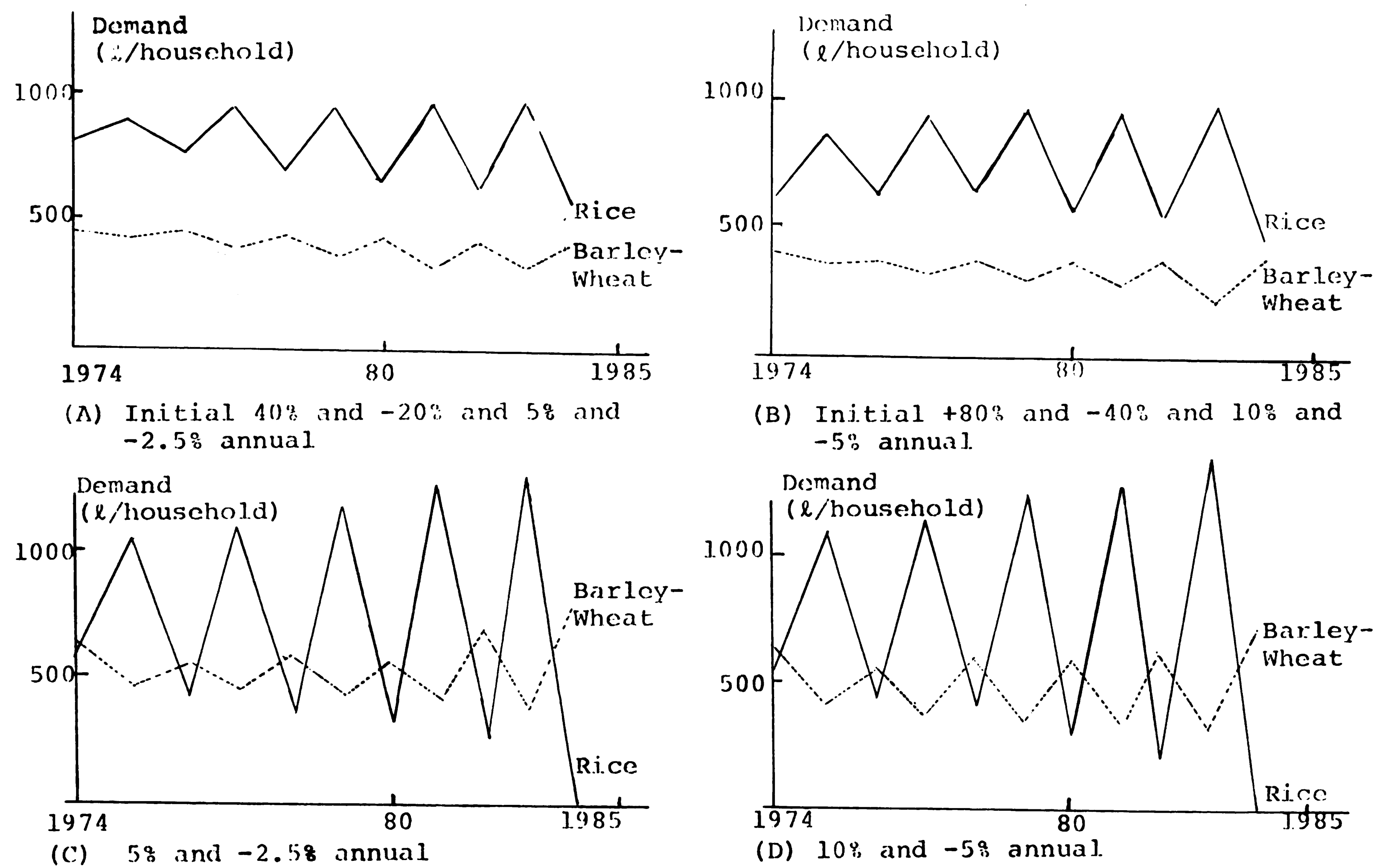


Figure 5.4. Various experimental government purchase prices of rice (GP1) and barley (GP2) and results.

When the purchasing prices on rice were increased 85 percent initially in 1974 and increased 10 percent annually thereafter and on barley decreased 40 percent initially in 1974 and decreased 5 percent annually thereafter, demand for rice and barley-and-wheat did not differ much from the first case. This is shown in the second column of Table 5.23.

On the other extreme, it was assumed that the purchasing price of rice increased only 5 percent annually and the barley purchase price decreased by 2.5 percent a year in real terms.

This produced much different results and the demand for rice fluctuated wildly and dropped below zero in 1985. The demand for barley-and-wheat increased to a record high of 644 liters per household in 1985. When both rates were set at +10 percent and -5 percent, respectively, the results show little differences from the case first discussed. In both cases, rural income decreased to below zero in some years which accelerated a drastic decline in demand for rice.

Even taking both estimation and simulation errors into the consideration, a drastic change in demand for rice and barley-and-wheat is not expected.

The basis of this judgement rests on the previous findings in the quarterly model that the long-run effect of changes in explanatory variables on the demand for rice would be greater than short-run effects while the long-run effect on barley-and-wheat is smaller than short-run effects. It also rests on the simulation results that show certain regularity despite fluctuations; the regularity in the sense that fluctuations occur almost every other year showing that demand for rice remains stable but increasing and demand for barley-and-wheat somewhat decreasing.

Comments on the Simulation Model

The wide fluctuations of the simulation results were thought to come from following sources:

First, most error terms in the equation system changed signs almost every other year. This fact alone aggrevated fluctuations when the values of independent and endogenous variables were extrapolated.

Secondly, price equations, particularly, for rice, did not incorporate urban demand and supply response.

Third, equations for the change in inventory levels were less reliable resulting in greater errors, and in many cases estimated signs of change in inventory levels were opposite to the actual directions of the change. Harmonic functions were tried but failed to establish improved equations.

Because of inherent instability of linear econometric models, instability in the sense that no extrapolations are permitted and that parameters are fixed, simulation and simultaneous solution errors based on a linear econometric model have been encountered in many places. Here we have to say something about the validity of the model at hand, or any other model at large. The validity of the model does not rest on the model per se. It has to be checked with sound judgment about reality.

To improve simulation results, it is necessary to refine the equation system and to incorporate urban demand and production response. Since this study was limited to rural demand analysis, the required refinements were not developed.

A trial of the simulation model in this study, however, did give some guidelines for future policy simulation.

Policy Implications

As far as rural demand analysis is concerned, there seems to be a very little room for the government to control directly demand per se. Historically, there has been no such a policy as a rural food demand policy. Rather, policies have been directed towards the facilitation of the outflow of farm products to urban consuming areas through improvements of infrastructures, price supports and so on, while there has been continuous government effort to manipulate urban demand, particularly for major grains.

Thus, the policy implications of the rural demand analysis encompass almost all aspects of the rural economy as well as rural welfare which are not the purpose of this study. Policy implications are discussed only within the framework of the analysis so far done. Actually all of the policy related analyses were discussed in the previous two sections.

One important implicit implication underlying this study is the adjustment pace of the rural consumers for each food item. Given the findings that rice consumption is heavily habit oriented and that long run effects of independent variables on rice consumption are stronger than short run effects, the impact of government policy measures such as purchase prices will be severely limited when it is used for the purpose of inducing market sales of farm products.

The effect of inertia may be reinforced by increasing rural income which is positively related to the level of government purchase prices. The evidence of this was shown in the previous simulation section. It was found that when the purchase price of rice is assumed to increase at an annual rate of 5% while the barley purchasing price is to be decreased by 2.5%, rural national average household income decreased sharply, sometimes to below zero which is of course not admissible. But at least we can trace the causality and trend. The role of two major grains, rice and barley-and-wheat in the Korean rural economy is predominant, about 70% to 75% of farm income are from these two products.

Thus as far as policy questions are concerned these two food grains have to be the center of the discussion.

The proportion of rice channeled to the government reached a peak in 1972 at 9.5% of the total production and

20.65% of the actual marketed quantity. The quantity purchased through the price mechanism was 8.2% of total production and 17.83% of actual marketed quantity.

On the other hand, barley acquired by the government was 19% of total production or 65.35% of total quantity marketed in 1972. The quantity purchased through the government purchase price program was 18.4% of total production or 63.36% of total marketed quantity during the same year. Incidentlly, the reason why the government purchase price of wheat was not incorporated in the model was because only about 20% of total supply of wheat had been produced domestically. The impact of the government wheat purchase price was assumed to be negligible.

In view of the smaller quantity purchased by the government, the weight that rural consumers put on the government rice purchase price may not be as high as the weight on the barley purchase price. It was found in the state adjustment model with quarterly data that the price elasticity of barley-and-wheat is greater than that of rice (-1.511 for the former and -.446 for the latter) while the income elasticity is smaller and negative (-.0697 for the former and .167 for the latter). It was also revealed that the adjustment coefficient for rice is larger (3.64) than for barley-and-wheat (-4.98). Indeed the coefficient for rice is the largest next to the processed foods.

Since the results from the quarterly state adjustment model seem to be consistent with rural consumer behavior, the sensitivity to the government purchase price of rice is expected to be less significant compared to barley-and-wheat. The results from the annual model with partial analysis seem to support it; in Table 5.24, coefficients and elasticities of prices and quantities demanded with respect to two purchase prices are shown.

Table 5.24. Price Response to the Government Rice and Barley Purchase Prices (Partial Analysis)

		Gov't Rice Pur. Price deflated by FPPI (Won/80kg) GP1	Gov't Barley Pur. Price deflated by FPPI (Won/50kg) GP2
Rice price index deflated by FPPI (%)	P1	.0139	.04017
(elasticities)		(.4662)	(.3745)
Barley-and-Wheat price deflated by FPPI (%)	P2	.0105	.0623
(elasticities)		(.381)	(.6320)
Demand for rice (ℓ/capita)	Q1	-.00213[1]	--
(elasticity)		(-.051)	
Demand for barley-wheat (ℓ/capita)	Q2	--	-.0222[1]
(elasticity)			(-.2424)

[1]They are calculated by $\frac{d(q_i)}{d(GP_i)} = \frac{d(q_i)}{d(P_i)} \frac{d(P_i)}{d(GP_i)}$, i = 1,2

Own price response to its corresponding government purchase price is higher than the cross responses, but the rice price is less responsive (or less elastic) than is the barley-and-wheat price to their respective purchase price. Both are inelastic however. The less responsiveness of the rice market price, specifically, the price received by the farmers, seems to come from both a high adjustment coefficient and from smaller portion of government intervention vis-a-vis barley-and-wheat.

Rural consumers' demand response to the government purchase price is also less elastic (-.051) than barley-and-wheat (-.2424) as shown in Table 5.24.

It was mentioned earlier in this chapter that partial analysis of market supply (sale) equation for rice turned out to be negatively sloped with respect to its market price. Equation 5.7 was

$$\underset{\text{(rice)}}{\text{SALES}} \sim -336.26 - 5.7\,P_1 + 8.4\,P_2 \qquad 5.7$$

To have positively sloped market supply equation, A(51), which is the price coefficient of the inventory equation, should be less than A(12), which is the price coefficient of demand equation, <u>ceteris</u> <u>paribus</u>, because -5.7 = -(A51) - A(12)). The estimated value of A(51) and A(12) were 4.4 and -1.3, respectively. If we accept the reliability of these two coefficients, particularly, of the former, the government purchase price increase would not guarantee large market sales of rice, given other things being equal.

The result from the simulation ("3-mode" control scheme), though unstable, indicated that implicit market sales of rice in 1985 would be 1302 ℓ/household (which is less than the 1536 ℓ/household peak in 1972) and that the inventory changes would show steady positive values after 1978, even with projected increase in production which was supposed to increase sales from farms.

To put above analysis together, following summary Table 5.25 would give some idea of possible direction.

Table 5.25. Possible Results from Various Level of Government Purchase Prices (Partial Analysis)[1]

Government purchase price of rice (Won/80kg) (1965 constant FPPI)	Demand for Rice (ℓ/household)	Government purchase price of barley (Won/50kg) (1965 constant FPPI)	Demand for barley-and-wheat (ℓ/household)
(3150)	(860.00)	(1005)	(527)
3465	859.33	1106	524.66
(3625)	(820)		
3780	858.66	1206	522.54
(3856)	(826)	(1141)	(471)
4725	856.65	1508	515.83
6300	853.30	2010	504.31

[1]Figures in the parentheses are actually observed ones, and all partial effects are calculated on the basis of Table 5.24.

The above partial analysis clearly does not give a total picture as did the previous simulation model. But it is, at least, useful for isolating a single effect and does give stable solution.

A price insensitive demand behavior and low marketable supplies at farm level, will force the government to rely on an old tool of tax in kind to secure domestic food supply for the rest of economy. This is a form of food rationing. As psychological and physical fear of world and nation wide food crisis develops, it is quite possible the farmers will be reluctant to market their products, either to protect their family food supply or to speculate on higher prices.

This is of course a final resort to the government when its purchase program does not work adequately. In this situation combined with very rigid rural demand behavior, an alternative is food rationing. Care, however, should be given to the adequacy of rural demand for their nutritional level. To keep balance, government should think about supplying alternative sources of food to the farmers in exchange for their products.

As far as the model at hand is concerned, rural income distribution is indirectly related to size of farm.

According to the Farmland Reform Law, it is illegal to own more than 3 cheongbo (2.975 hectares or 7.352 acres) with minor exceptions. The farm land ownership pattern was such that about 50% of the farm land was owned by or under the control of only about 4% of the total farm households [U1]. Now, since the land reform, about 70% of all farm household are full owners and operators.

The causes of the skewness of the distribution of agricultural income, are thought to be unequal distribution of farm land and capital resources [B3].

The other concern was with respect to the correlation between farm income and the size of the farm land which in turn affects rural demand.

As was mentioned earlier, it failed to establish short and long run demand relationships for farm groups with less than 0.5 and with 1.0 - 1.5 <u>cheongbo</u> in case of rice.

Income effects of demand for rice showed positive for all farm groups except the "highest income group" with the farm size above 2 <u>cheongbo</u> as shown in Table 5.1 and 5.2. For the farm with more than 2 <u>cheongbo</u>, thus, the demand shows negative income effect, indicating that they can afford to switch to other foods.

This result is consistent with the lowest adjustment (b_1) and depreciation rate (c) among all farm groups except those two groups excluded as shown in Table 5.26.

Table 5.26. Adjustment Coefficient (b_1) and Depreciation Rate (c) for each farm group.

Farm size (cheongbo)	Rice		Barley - Wheat		Pulses	
	b_1	c	b_1	c	b_1	c
less than 0.5	-	-	-4.5	2.9	-3.2	7.7
0.5 - 1.0	2.9	5.8	-2.1	3.	-	-
1.0 - 1.5	-	-	2.6	2.5	-4.4	1.6
1.5 - 2.0	1.8	4.4	-2.4	2.1	-6.4	1.6
Above 2.0	1.1	3.3	- .8	2.4	-4.0	.9

For barley-and-wheat demand, income effects were negative for three farm groups between 0.5 - 2.0 cheongbo and positive for the lowest and the highest farm size groups. It seems that for the lowest farm size group that they are still too poor to consume more rice than barley-and-wheat and that they have to eat relatively more barley-and-wheat as their income increases. For the largest farm size group, it is difficult to explain the positive income effect. Possibly, this group has been positively influenced by the government policy of encouraging barley-and-wheat consumption.

Assuming that the education level is positively related to farm size, the above explanation does not deviate far from reality. The lowest inventory adjustment coefficient of this group reflected their relatively stable income.

The same line of argument can be made for demand for pulses in which the largest farm group responded negatively to income change.

As for the miscellaneous grains, the all groups demand relationship showed negative income effects and positively sloped demand curve with respect to price.

In case of potatoes, for the two groups falling within 1.0 - 2.0 cheongbo, the income effect was positive while for others negative. No plausible explanations were possible.

Even though there was no uniform pattern to the magnitude of responses to price change, it was found that they were smaller for the farm group with more than 2.0 cheongbo than for the farm group with less than 0.5 cheongbo in the rice and barley-and-wheat demand relationships, which was as expected; the richer, the less they worry about price changes.

With the analysis so far done, it is difficult to draw significant policy implications. Let us see what the real situation is for rice and barley-and-wheat. Table 5.27 shows the percentages of farm households in each group relative to the total number of farm households, their land holdings in 1972, consumption and sales in 1973.

Table 5.27. Selected Statistics for Each Farm Group

Farm size (cheongbo)	Rice				
	Percent total household	Percent total land	Pro-duction (ℓ/house.)	sumption (ℓ/capita)	Actual sale (ℓ/house.)
Less than 0.5	32.7	11.4	626	141	179
0.5 - 1.0	31.7	27.4	1631	160	657
1.0 - 1.5	18.0	25.6	2716	164	1114
1.5 - 210	7.9	15.7	4007	182	1849
Over 2.0	6.2	19.9	5981	201	3046

	Barley-and-Wheat		
	Production (ℓ/house.)	Consumption (ℓ/capita)	Actual sale (ℓ/house.)
Less than 0.5	366	82	58
0.5 - 1.0	711	83	231
1.0 - 1.5	921	81	357
1.5 - 2.0	961	72	444
Over 2.0	889	58	362

Sources: Year Book of Agriculture and Forestry Statistics: Grain statistics (1973), MAF, Korea.

Report on the Results of Farm Household Economy Survey. (1974), MAF, Korea.

It shows that larger farm groups produce and consume more rice and while consuming less barley-and-wheat.

Since the largest farm group's income effect of rice demand was negative, it could be expected that marketings from this group would increase, while other farm groups would consume more, other things being equal.

CHAPTER VI

CONCLUSION

A dynamic analysis for Korean rural food demand was undertaken. Particular emphasis was put on the rural consumers' behavior of adjusting their consumption in line with their past habits or possible psychological inertia which are relevant in distinguishing short and long run analysis by using the model developed by Houthakker and Taylor.

The desire to do a research on the rural demand for foods in Korea grew out of the fact that relevant research in depth is rare and also grew out of an uneasiness with conventional static models for demand analysis. In this sense, this study was intended to investigate both practical and disciplinary questions.

It has long been asserted by many economists that long run elasticities or effects of changes in independent variables on the dependent variable are larger than the short run elasticities or effects [S1, S2].

On the other side of argument, it is also asserted that short run effects are greater than long run effects because of inflexible characteristics of modern society's demand for foods [B5] and because of the demand for inventory [S5].

Other areas in demand analysis that have been of interest to many researchers are existence or non-existence of money illusion, permanent income versus absolute income hypothesis and aggregation problems.

The basic idea of the state adjustment model is to investigate if consumers are adjusting their consumption according to psychological inertia or according to the physical inventory level.

In this study, data were grouped into two categories: quarterly and annual. With quarterly data, a state adjustment model for ten food items and two second order rational distributed lag models for rice and barley-and-wheat were specified. With annual data covering 9 years, three systems of equations for demand for rice and barley-and-wheat were established; one with usual per capita variables, the other for adult-equivalent-scaled variables, and the third with per capita variables using the change in inventory level rather than the lowest level of inventory during the year which was used for the simulation model.

For simulation, two important policy variables, the governmentpurchase prices of rice and barley, were used.

The most important and most difficult problem was to keep consistency during the estimation procedure among different models and to make consistent interpretations after estimations and simulations.

As far as methodology was concerned, the ordinary least square (OLS) method was used for quarterly data and two-stage least square (2SLS) for annual data.

Since the reduced form equations of the state adjustment model were over-identified with respect to parameters, a second step was necessary to find single valued parameters. To avoid this second step, a nonlinear estimation procedure was tried by using Bard's computer version of the Newton-Gauss method. But even after 200 iterations, convergence was not found. Thus, considering the constraints imposed by both cost and time, a short cut method was inevitable. This was done by linear approximation of nonlinear constraints. To have linear approximated constraints, judgment was necessary; judgment about the signs and reasonable range of standard error of parameters in view of economic theory, real world observations and statistical reliability.

No empirical study was found which uses this kind of linear approximation of nonlinear constraints.

A pooling method of time series and cross section analysis was employed in this study in the sense that parameters from another analysis (i.e., cross section) were entered into time-series analysis. However, the parameters which were fixed in this study were not from cross section analysis but from time series analysis. Disputes about the method should be left to further investigations in future studies.

Most foods have both habit forming and inventory adjustment characteristics. But it is also true that one of these two aspects is much stronger than the other depending on the individual food.

Relevancy of the characteristics of foods to policy issues and its importance have long been recognized. Conventional concepts of elasticities in demand and supply analysis deal essentially with the characteristics of goods. In this sense, there seems to be nothing new in the dynamic state adjustment model. It is, however, more explicit in analyzing the characteristics of commodities in demand relationships than static demand analysis.

The major findings of this study are briefly listed as follows:

1. It was found that rice, meats, dairy and processed foods have stronger habit forming aspects. The adjustment coefficient in the rice demand relationship was the largest next to that of the processed foods. There has been no empirical proof in demand analysis that rice is a heavily habit oriented food. In this sense, the result will give a new direction in interpreting conventional static demand analysis. Since usual static demand analysis is limited to estimating price and/or income elasticities, the results from the static approach might overestimate price and income effects on the demand for habit oriented foods. The results from this study may be helpful to explain certain rigidities in consumption behavior.

Other foods including barley-and-wheat revealed inventory-adjustment characteristics. One form of consumer behavior is to adjust their consumption (purchases) according to inventory levels. The more inventory they have, the less consumers will buy. The best example of such case would be durable goods.

As to the differences among farm groups which are grouped into five according to size of farm land holdings, adjustment coefficients for the largest farm group showed the smallest value for rice, indicating that the more wealthy families have more opportunity to switch to other foods.

The differences in other cases did not show any distinguishable uniformity.

2. Negative income effects were found for national averages on barley-and-wheat, miscellaneous grains, and vegetables in the short run demand relationship, of which vegetables changed into positive income effect in the long run. Demand for rice for the largest farm size group had a negative income effect; at the same time, this group responded positively for barley-and-wheat with respect to income. This indicates that the largest farm size group could afford to change their traditional rice-oriented diet to other products.

3. Miscellaneous grains turned out to be inferior goods in the economic sense in both long and short run, while potatoes were inferior goods in the long run.

4. There was no uniformity about the magnitude of short and long run coefficients. For rice, meat, dairy products and processed foods, the long run effects were greater than the short run effects in absolute value terms indicating a possible increase in the demand if the income effect is positive and greater than the price effect. For others, long run effects were shown to be smaller except in case of fish-and-marine products where no long and short run relationship could be established due to far less significant statistical results.

5. The findings in the state adjustment model seemed to be consistent with the results from the second order distributed lag model in the sense that lagged effects beyond two quarters were negligible for foods other than rice and barley-and-wheat. Lagged effects remained longer for rice than for barley-and-wheat. The findings were also consistent with the annual national average model for rice and barley-and-wheat.

6. In many cases, farmers' nonfarm and farm income effects were different, the former being positive while the latter negative, but leaving the total income effect to be positive. It was expected that farmers would reduce their consumption of grains in order to increase their cash farm income from expanded grain sales. Therefore, the signs on the coefficients of farmers' farm income relative to consumption of grain would be negative. The positive effect of farmers' non-farm income on grain consumption

was attributed to less dependence on farm income and consequently less constraint on purchasing patterns.

7. When undeflated nominal data were used, the results were less satisfactory, particularly in cases of income coefficients which were mostly negative. A sort of money illusion was interpreted as a rational consumer behavior, particularly for the farmer. As prices of grains or other farm products increase, their farm income would also increase which in turn would discourage more consumption of products with a negative income elasticity as pointed out earlier. Even when all consumer prices and income are changing in the same direction and magnitude, farmers may think they become relatively poorer or richer than before. Thus, as nominal income increases even though real income may fall, farmers may respond by reducing consumption of products with a negative income elasticity.

8. In the simulation model, a "three-mode" control method was tried.

Under assumed government purchase prices, the annual model for rice and barley-and-wheat was simulated. Despite severe fluctuations of results and errors, an interpretation was established on the basis of the previous analysis results; demand for rice would increase moderately or remain stable while demand for barley-and-wheat would decrease.

The unstable results were attributed to the fact that errors in the estimated equation system changed signs in almost every other year which aggrevated the fluctuations when independent variables were extrapolated. These results were also attributed to the fact that urban demand and production responses were not included in the equation system. To remedy these defects, the specification of a complete market model is required including the urban sector and the supply sector.

The simulation model tried in this study, however, did provide some guidelines for future research.

9. It was also found that the total number of rural households, off-farm employment rate and average land holdings were positively correlated with farm household income.

10. Policy implications were as follows:

a. The policy instruments such as government purchase prices of rice and barley-and-wheat might be limited in generating desired marketings of rice because of rural consumers' habits formed for a long time. It was found in a partial analysis that the rice market price and demand were less sensitive to the government rice purchase price than the barley-and-wheat market price and demand to government barley purchase price.

b. As world and nation wide food crises develop, farmers may well be reluctant to sell more foods either to protect their own families or to speculate on higher prices. If such is the case, the government should seek stronger policy tools to induce sales from rural sector. Such policy tools include incentive schemes through both farm product and farm input price mechanism. Market rationing may be the last and worst solution.

c. In view of skewness of rural income distribution, future policy should place more emphasis on the rural poverty problem. Statistics show that more than 60% of total farm households own less than 1.0 cheongbo per household. With this small size of farm which is directly related to household income, their food consumption is mostly limited to grains.

d. Since demand for foods other than grains was very elastic (price and income), efforts should be made to provide farmers these foods at lower prices.

11. It was found that aggregation bias does exist in some cases in the qurterly model. If we assume the coefficients for each farm group (micro relationship) represent the true ones, the national average demand equation did not meet the consistency theorem. The average of the coefficients of demand equations of all farm groups for each food was not consistent with the coefficients of demand equation estimated from aggregated data nationwide. This may be explained in part by the different sample sizes for each farm group.

Despite some encouraging results, there are many areas that should be refined and investigated further for more reliable estimates and for more useful policy guidelines.

Needs for Further Research

As indicated, many areas will require more intensive research. In future research, attention should be given to the following considerations:

1. Handling nonlinear constraints is not based on strong statistical grounds.

2. Consistency checks, particularly, with budget constraints and upper and lower bounds on nutritional requirements were not incorporated in this study, partly because of the non-additive nature of the model and partly due to insufficient data.

3. Inter-group income eleasticity comparisons failed to provide a basis for conclusions.

4. Insufficient analysis was done on the permanent income hypothesis testing partly because of urban demand relationships were not measured in this study.

5. To have a stable simulation model, it is necessary to specify a complete market system including urban demand and the supply sector.

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APPENDIX

APPENDIX

Equation 3-6 is rewritten as follows (including dummy variables):

$$\frac{dq_t}{dt} = b_1 q_t - c(q_t - b_o - b_2 y_t - \Sigma b_{i3} p_{it}$$

$$- b_4 DV2 - b_5 DV3 - b_6 DV4 - e_t) + b_2 \frac{dy_t}{dt}$$

$$+ \Sigma b_{i3} \frac{dp_{it}}{dt_i} + \frac{de_t}{dt} \qquad \text{A1}$$

Equation A1 is reduced to equation 3-7 by using trapezoidal rule and finite approximation of derivatives; In general

$$\int_{t_o}^{t+DT} f(x)dt \approx f(t_o) + \frac{DT}{2}\left[f(t+DT) - f(t_o)\right]$$

$$= \frac{DT}{2}\left[f(t+DT) + f(t_o)\right] \qquad \text{A2}$$

and $$\int_{t_o}^{t+DT} \frac{df(x)}{dt}\,dt \approx f(t+DT) - f(t_o) \qquad \text{A3}$$

If q_t in equation A1 is the rate of consumption per unit of time, dt, then $\int q_t dt$ is the corresponding total consumption in an interval, DT, such that

$$\bar{q}_t = \int_{t_o}^{t+DT} q_t dt \qquad \text{A4}$$

and other variables also follow same interpretations. Integrating equation A1 such that (other subscripts are deleted):

$$\int \frac{dq}{dt} dt = DTCb_o + (b_1 - c) \int q_t dt + cb_2 \int y_t dt$$

$$+ b_2 \int \frac{dy_t}{dt} dt + \Sigma cb_{i3} \int p_{it} dt + \Sigma b_{i3} \int \frac{dp_{it}}{dt} dt$$

$$+ cb_4 \int DV2dt + cb_5 \int DV3dt + cb_6 \int DV4dt$$

$$+ c \int e_t dt + \int \frac{de_t}{dt} dt \qquad \text{A5}$$

Applying A2 and A3, equation A5 becomes:

$$q_{t+1} - q_t = DT\ cb_o + \frac{DT}{2}(b_1 - c)(q_{t+1} + q_t)$$

$$+ \frac{DT}{2} cb_2(y_{t+1} + y_t) + b_2(y_{t+1} - y_t)$$

$$+\Sigma \frac{DT}{2}c\ b_{i3}(p_{it+1} + p_{it}) + \Sigma b_{i3}(p_{it+1} - p_{it})$$

$$+ \frac{DT}{2}cb_4(DV2_{t+1} + DV2) + \frac{DT}{2}cb_5(DV3_{t+1} + DV3)$$

$$+ \frac{DT}{2}cb_6(DV4_{t+1} + DV4) + \frac{DT}{2}c(e_{t+1} + e_t)$$

$$+ (e_{t+1} - e_t) \qquad \text{A6}$$

Rearranging terms,

$$\left[1 - \frac{DT}{2}(b_1 - c)\right]q_{t+1} = DTcb_o + \left[(1 + \frac{DT}{2}(b_1 - c)\right]q_t$$

$$+ b_2(1 + \frac{DTc}{2})y_{t+1} + b_2(\frac{DTc}{2} - c)y_t$$

$$+ \Sigma b_{i3}(1 + \frac{DTc}{2})p_{it+1} + \Sigma b_{i3}(\frac{DTc}{2} - 1)p_{it}$$

$$+ DTcb_4DV2 + DTcb_5DV3 + DTcb_6DV4$$

$$+ (\frac{DTC+2}{2})e_{t+1} + (\frac{DTc-2}{2})e_t \qquad A7$$

Note that $DV2_{t+1}$ = DV2 which holds for other quarter dummy variables.

Lagging one period backward and rearranging terms after one more integration (recall equation A4)

$$\bar{q}_t = \frac{DT^2 2cb_o}{2-DT(b_1-c)} + \frac{2+DT(b_1-c)}{2-DT(b_1-c)}\bar{q}_{t-1} + \frac{b_2(2+DTc)}{2-DT(b_1-c)}\bar{y}_t$$

$$+ \frac{b_2(DTc-2)}{2-DT(b_1-c)}\bar{y}_{t-1} + \Sigma b_{i3}\frac{2+DTc}{2-DT(b_1-c)}\bar{p}_{it}$$

$$+ \Sigma b_{i3}\frac{DTc-2}{2-Dt(b_1-c)}\bar{p}_{it-1} + b_4\frac{DTc}{2-DT(b_1-c)}DV2$$

$$+ b_5\frac{DTc}{2-DT(b_1-c)}DV3 + b_6\frac{DTc}{2-DT(b_1-c)}DV4$$

$$+ \frac{DTc+2}{2-DT(b_1-c)} \bar{e}_t - \frac{2-DTc}{2-DT(b_1-c)} \bar{e}_{t-1} \qquad \text{A8}$$

For notational convenience, let $\bar{q}_t = q$, $\bar{y} = y$, and etc.

Then,

$$q_t = A_o + A_1q_{t-1} + A_2y_t + A_3y_{t-1}$$
$$+ \Sigma A_{i4}p_{it} + \Sigma A_{i5}p_{it-1} + A_6DV2$$
$$+ A_7DV3 + A_8DV4 + V_t \qquad \text{A9}$$

Equation A9 is the same equation as equation 3-7 except quarter dummy variables. Also in equation 3-7 and in other equations in Chapter III, relationships among coefficients were expressed by assuming DT = 1. If quarterly data are used, DT = 1/4.

Since the structural equation corresponding to equation A1 is

$$q_t = b_o + b_1s + b_2y_t + \Sigma b_{i3}p_{it} + b_4DV2$$
$$+ b_5DV3 + b_6 DV4 + e_t \qquad \text{A10}$$

We have overidentified parameters as shown in Chapter III.

If we include more than one commodity and price, the numbers of constraints are increasing.