STRUCTURAL CHANGE IN THE U.S. SOYBEAN AND SOYBEAN PRODUCTS MARKETS: A SYSTEMATIC VARYING COEFFICIENT SIMULTANEOUS SYSTEM APPROACH

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Overview of the Research

The soybean industry is an interesting area for investigation. It is extremely complex and has been changing rather dramatically over the last 10 to 15 years. There exists a high degree of interaction among the markets for soybeans, soybean oil and soybean meal. Recent shocks and changes in the world economic environment have impacted substantially on the industry altering the demand for its products and even changing the participants and their roles in the marketplace.

Understanding the behavior of the soybean industry is important to market participants, producers and consumers alike. Changes in market structure can influence demand and supply conditions, price movements and can cause rather considerable changes in farmer income and the prices that consumers pay for related final products. Under these circumstances, the value of accurate forecasting of prices and quantities increases in importance. Also, knowledge of changing structural parameters (e.g. elasticities) can be crucial to government decision-makers in analyzing the effects of alternative farm policies.

The general thrust of this thesis involves the econometric modeling of structural change in the U.S. soybean and soybean products markets. A quarterly econometric model is specified within the framework of a systematic varying coefficients simultaneous system. Changing parameters will be identified and an examination of the forecasting performance of the model will be made.

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CHAPTER 1

INTRODUCTION

The United States is by far the world's largest supplier of soybeans. However, over the last decade South America, especially Brazil, has significantly expanded production and their exports now account for a greater share of world trade in soybeans and soybean products. Thus, the U.S. export prospects are linked to both the quantities and timing of South American exports of soybeans and soybean products.

The world trade in soybeans and soybean products as a share of world food and raw material trade has also been expanding, though slowly, over the last two decades. As economic progress accelerated after World War II, consumers in developed and developing countries tended to change their dietary habits. These dietary changes included shifts to more meat, poultry, salad, cooking oils, shortening and margarine. This increased production of meat and poultry generates in turn a higher demand for high protein feed and thus soybean meal.

The major markets for U.S. soybeans are the European Community, Japan, Spain, Taiwan and Mexico. These countries import soybeans in order to crush them to supplement imported meal supplies mainly for internal meal consumption. However, the strengthening of the dollar against some of the importing countries' currencies causes soybeans to become more expensive and thus to reduce the amount exported by the U.S. The weak demand in the export market can translate to proportionately lower product prices relative to the price of soybeans. The resulting narrow crush margins in turn causes processors to slow down domestic crushing. Eventually producer prices will be reduced.

1.1 The Research Problem

A commodity like soybeans and soybean products has experienced high levels of variation in prices and quantities during the last decade. Beginning in the 1972/73 crop year high price variability has been an important feature of soybeans and soybean products (Meyers and Hacklander). In terms of average annual wholesale prices, beans reached a peak in 1976/77, soybean oil in 1973/74 and soymeal in 1972/73.

These changes may be attributed to a change in the structural relationships of the industry. Since World War II there has been a rapid growth (both in value and complexity) in the world markets for oils and high protein meals. During this period the U.S. changed from being a net importer of fats and oils to a major exporter. China and India in turn became insignificant exporters.

Beginning in 1970 Brazil has challenged the position of the U.S. as the major supplier to the world market. In 1977, for example, Brazil exported more soybean meal and almost as much soybean oil as the U.S. (Williams and Thompson). This has had a major impact on prices in the U.S. soybean industry. It has also been reported that whenever Brazil experiences production shortfalls in soybeans, it tries to maintain crushings and meal exports by cutting back on soybean exports.

Several factors have contributed to Brazil's successful entry into the world soybean market. These include (1) very strong and rapidly rising world market on the basis of livestock demand for high protein meal; (2) restrictive U.S. export policies which might have made her traditional customers to turn to Brazil as an alternative supplier; (3) Brazilian soybeans have higher oil content (19.5 to 20 percent) than U.S. soybeans (17.7 percent) although some reports contend that Brazilian soyoil is higher in free fatty acids resulting in larger refining losses; (4) relatively high profitability of soybean production and (5) the move toward stimulative rather than restrictive export policies since 1968 (Thompson et al.).

Soybeans and soybean meal are becoming more important to markets such as the USSR, Eastern Europe, the Middle East and China as they are continuing to expand and modernize their livestock industries. For example, China purchased 850,000 metric tons in 1980 compared to 139,000 purchased the year earlier. This is due to China's objective to increase livestock production in order to meet growing food requirements. However, in the traditional markets of Western Europe and Japan growth in demand could slow down as optimum levels of soybean meal use are achieved. Soybean oil also faces pressure of increased supplies of alternative vegetable oils, especially palm oil. However, the use of vegetable oil as fuel is slowly emerging as a potential supplement to petroleum-based oil.

The possible change in structure implies that econometric models which do not account for the changing environment are inappropriate. When structural change takes place it means that the dependent variable responds differently to a per unit change in the explanatory variable over different periods in time. For example, equal doses of capital and labor in the crushing process of beans may yield different levels of outputs of meal and oil over different years. This may be due to technical progress, change in labor efficiency and managerial ability during the course of the sample period. Also the same amounts of soybean meal fed to livestock may yield different output as other components of the formula feed, managerial and professional efficiency of the farmer vary over different time periods. If the estimated model does not consider the structural change its forecasting ability will be inappropriate or poor. In addition, the disregard of a change can mean inappropriate interpretation of the impact of government programs in the market and international trade as depicted by the multipliers.

This research emphasizes the question of structural change and estimation of parameters associated with these changes in the soybean complex. The reparameterization and understanding of the changed structure has important implications in demand and price analysis. Improved elasticity estimates and forecasting ability can influence decisions in marketing programs, processing activities, domestic and international trade as well as government commodity policies.

1.2 Research Objectives and Organization of the Dissertation

The general research objective is an attempt to formulate an appropriate econometric model of the U.S. soybean sector to examine the impact of changes in various demand and supply variables on prices, storage, utilization and processing levels of soybeans, soyoil and soymeal. This should increase our understanding of the soybean market complex in a framework of changing structure.

The specific objectives of the study include

(a) Examination of changes in structural coefficients over time

(b) Examination of how the changing structure influences the forecasting ability of econometric representation of the soybean complex and

(c) Identification of the changing elasticities.

The above objectives are to be achieved by developing an econometric model of the soybean complex that permits coefficients to vary over time. Brazil as a new major producer of soybeans can no longer be considered as a small country when considering the soybean complex of the U.S. Thus decisions in Brazil concerning prices and quantities to be exported to the world markets affect prices and quantities of oil crops traded on international markets. In terms of the current model quantities of soybean meal exported by Brazil along with the quarterly time trend were used as explanatory variables of the systematic varying slope coefficients.

The activities of other countries are basically considered exogenous. This may be considered as a misspecification but data availability could not permit otherwise. However models like the present one that permit coefficients to change could be thought of as a means of capturing this apparent misspecification (Rausser, et al.).

In order to achieve the above mentioned objectives, the dissertation is divided into seven chapters. The first one introduces the subject matter followed by a short descriptive survey of Japan and the European Community as the major markets for U.S. soybeans and soybean meal. The third chapter is an overview of the literature about the U.S. soybean quarterly models. The fourth chapter reviews both the theoretical and applied structural change models. The fifth chapter specifies the economic models that are analyzed. Chapter six discusses the statistical models that are estimated. This includes the results and comparison of parameter values and forecasting abilities of the estimated models. The last chapter is devoted to the implications and conclusions drawn from the obtained results.

CHAPTER 2

MAJOR MARKETS OF U.S. SOYBEANS AND SOYBEAN MEAL

In 1964/65, about 67% (473 million bushels) of the U.S. soybean crop was processed at domestic oil mills and about 29% (206 million bushels) was exported as beans. Since then until 1980/81, the volume of soybeans crushed domestically increased at an average rate of about 7% (32 million bushels), the volume of soybean exports grew about 15% (31 million bushels) and the volume of soymeal exports grew about 14% (288,000 short tons) per year. In 1980/81 an estimated 50% (1,011 million bushels) of soybeans produced in the U.S. were crushed into soymeal and soyoil and about 36% (734 million bushels) exported as beans. This indicates that the proportion of soybean crop crushed has declined while exports of soybeans have expanded over time.

Most of the world markets for U.S. soybeans and soymeal are in Western Europe and East Asia. Over the past two decades these countries, particularly the EC and Japan, have greatly increased their demand for meat. This in turn has given rise to rapidly increasing investment in the commercial livestock sector and provided markets for U.S. exports of feedstuffs.

2.1 Japanese Market

During the 70's and continuing into the 80's the U.S. has been the leading supplier of the three most vital feedstuffs (corn, sorghum and soybeans) to the Japanese livestock industry. Japan produces only 2 percent of her total domestic consumption of coarse grain while livestock feeding accounts for 80-85 percent of this total. In 1980, for example, Japan imported about 15.7 metric tons of coarse grain from the U.S. of which about 90 percent was comprised of corn and sorghum. During the 70's also, Japanese imports of soybeans and soybean meal grew at an annual rate of 3.7 percent. The U.S. supplied about 90 percent of the beans and more than 80 percent of the soybean meal (U.S. Foreign Agricultural Economic Service). However, increased competition by Brazil has tended to reduce the U.S. share of the Japanese soybean meal imports.

Over the past decade the combined value of corn, sorghum and soybeans represented about one half of the total value of U.S. agricultural exports to Japan. Japan also imported more than one fifth of the total U.S. soybean exports during the last decade.

Japanese consumption of livestock products almost quadrupled between 1964 and 1980 (see Table 1). The changed consumption pattern can best be explained by increased family income, price of livestock products and substitutes, changing cultural and religious values as well as urbanization. Over the past two decades Japanese real income grew at an 8 percent annual growth rate in real G.N.P (U.S. Foreign Agricultural Economic Service). A large portion of a typical Japanese family food budget is spent on meat and fish and substantial amounts of food is consumed away from home. The decline of real prices of

TABLE 1: JAPAN MEAT CONSUMPTION AND IMPORTS OF SOYBEANS AND COARSE GRAINS

YEAR	PER CAPITA CONSUMPTION OF BEEF, PORK AND CHICKEN	PRIVATE CONSUMPTION EXPENDITURE	IMPORT OF SOYBEANS	IMPORT OF COARSE GRAINS	POPULATION
	KG	Billion Yen	1000 MT	1000 MT	Million
1964	5.8	15656	1607	4774	97.1
1965	6.2	18486	1847	5628	98.5
1966	7.4	21437	2168	6393	99.0
1967	8.2	24705	2170	7289	100.2
1968	8.3	28632	2421	8194	101.5
1969	9.2	33293	2591	9171	102.5
1970	10.5	38647	3244	10826	103.6
1971	11.7	43559	3212	10069	105.1
1972	12.7	50267	3396	10974	106.3
1973	13.8	60489	3634	13154	108.7
1974	14.1	73629	3244	14073	110.1
1975	14.2	85539	3334	13106	112.0
1976	16.2	96886	3554	14616	113.2
1977	17.8	107836	3602	16337	114.0
1978	19.1	118612	4260	17397	115.3
1979	20.5	129568	4132	18650	116.2
1980	20.8	139472	4401	18707	117.3

Source: U.S. Foreign Agricultural Economic Service, 1983.

livestock products (except beef) has also encouraged consumption of these products.

2.2 EC Market For U.S. Agricultural Products

During the 70's the U.S. was the principal supplier of agricultural commodities to the EC. U.S. ranked among the top three alongside the Netherlands and France when the intra-EC trade is included. However, the EC has been the slowest growing, in percentage terms, of all U.S. agricultural export markets in comparison to Japan, the Soviet Union, Latin America, Africa, Asia and Eastern Europe. The slowing trend is due to a rapid expansion of the EC's own farm production as well as the ability to meet an increasing share of its own needs.

The EC's growth in farm production is attributed to the Community's Common Agricultural Policy (CAP). This policy was established to provide farmers with a level of income comparable to that of the nonfarm population. However, the policy has generated an economy of artificially high food prices and costly farm surpluses.

Animal feedstuffs account for approximately two-thirds of EC agricultural imports from the U.S. For example, oilseeds, mainly soybeans, were the largest EC imports from the U.S. during 1977-79, averaging about 32 percent of total EC agricultural purchases. During the same period corn was the second largest at 19.8 percent and soymeal, corn glutten feed, citrus pulp and several other feed ingredients accounted for an additional 13.2 percent (U.S. Foreign Agricultural Economic Service).

When EC members are considered on an individual basis West Germany, the Netherlands and the United Kingdom have been the three leading importers of U.S. agricultural goods over the years. For example in the 1977-79 period U.S. agricultural exports to the EC were distributed as follows: West German, 26 percent; the Netherlands, 20 percent; the United Kingdom, 17 percent; Italy, 13 percent; France, 12 percent; Belgium-Luxembourg, 8 percent; Denmark, 3 percent and Ireland, 1 percent (U.S. Foreign Agricultural Economic Service). However, this distribution could be subject to some slight error due to unreported transhipments. The differing magnitudes of the imports could be attributed to the following factors: extent and type of livestock production, population size, level of disposable income, geographic location and the strength of the member's currency against the U.S dollar.

Most of the agricultural commodity prices covered by CAP are fixed well above the world market prices. In order for such a policy to be effective it requires high protective measures as well as subsidies to facilitate exports. The most important measure is government intervention whereby the authority purchases the commodity at a price guaranteed as the floor price. This policy has generated unprecedented surpluses especially for corn and tobacco. To guard the intervention prices against being undermined by cheap imports the EC applies variable levies and offers export subsidies for commodities open to intervention. However, oilseeds and oilseed meals which are among commodities of major importance to the U.S. trade are not included in the EC's variable levy system.

During the last decade the EC rapidly developed soybean meal as the primary high-protein ingredient in animal feeds. During this period crushers more than doubled their meal production but supply was still short of domestic demand. EC member governments have also encouraged soybean production at home through price support subsidies and direct payments, but unfavorable climatic and other factors have disappointed yields when compared to rapeseed, wheat and feed grains.

Before 1970 the U.S. was virtually the only commercial supplier of soybeans and her share to the EC averaged over 90 percent during 1967-1971 (see Table 2). The lowest U.S. share of 76.0 percent occurred during 1973-75. The Brazil share was small until 1975 when it reached 27 percent before receding to 3.1 percent in 1979. This drop in Brazil's share was due to the sudden change in export policies which now emphasize the export of soybean meal with its value-added content rather than soybeans. Argentina emerged as an important soybean supplier starting in 1977. By 1979 Argentina's share of the EC market was 16.9 percent which more than filled the gap left by Brazil's decline.

Soybean meal is the third largest U.S. agricultural export to the EC in terms of value after soybeans and corn. The U.S. volume share fell from 55.9 to 31.0 percent in 1974-79. This decline was due to the rising Brazilian share which actually outstripped the U.S. in 1977.

TABLE 2: EC SOYBEAN IMPORTS[1] BY VOLUME AND SUPPLIER SHARE[2]

1000 MT

YEAR	U.S.	BRAZIL	ARGENTINA	PARAGUAY	OTHER
1967	3275 (89.2)	223 (6.0)	3 (0.1)	2 (0.1)	169 (4.6)
1968	3333 (93.5)	71 (2.0)	6 (0.2)	3 (0.1)	151 (4.2)
1969	3602 (91.5)	249 (6.3)	0 (0)	0 (0)	78 (2.2)
1970	5296 (94.4)	226 (4.0)	0 (0)	0 (0)	87 (1.6)
1971	5292 (94.3)	165 (2.9)	0 (0)	8 (0.1)	149 (2.7)
1972	5318 (85.9)	727 (11.7)	8 (0.1)	33 (0.5)	108 (1.8)
1973	5448 (81.7)	1107 (11.6)	0 (0)	26 (0.4)	84 (1.3)
1974	6630 (75.6)	1920 (21.9)	6 (0.1)	81 (0.9)	130 (1.5)
1975	5507 (70.8)	2133 (27.4)	8 (0.1)	73 (0.9)	63 (0.8)
1976	6991 (81.7)	1326 (15.5)	60 (0.7)	144 (1.7)	31 (0.4)
1977	7164 (81.9)	917 (10.5)	459 (5.2)	180 (2.0)	32 (0.4)
1978	8918 (82.3)	363 (3.4)	1367 (12.6)	173 (1.6)	16 (0.1)
1979	9092 (77.6)	368 (3.1)	1978 (16.9)	229 (2.0)	46 (0.4)

Source: U.S. Foreign Agricultural Economic Service, 1983.

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[1] EC imports from listed countries

[2] Number in brackets represent percent share of the market

This brief review of the principal importers of U.S. soybeans and soybean meal provides an indication of how the effect of some demand shifters in the U.S. export market may have changed over time. Many of the factors affecting demand in the nations just mentioned have also occurred in the U.S. and many other parts of the World.

The evidence suggests that the EC and Japan will continue through the 80's as sizable importers of feedgrains, oilseeds and livestock products. This is because of the demand potential of an affluent population, compatibility of food preferences and the limited production potential of their lands. The U.S. with its comparative advantages and with its capacity to produce and market large amounts of grains and oilseeds, will maintain a prominent position in the markets of Japan and the EC.

CHAPTER 3

SELECTED QUARTERLY ECONOMETRIC MODELS

The current study builds primarily on other previous quarterly models of commodities seasonally produced and continuously stored. As noted by earlier authors (e.g. Subotnik, et al.), the specific economic behavior that is characteristic of quarterly data include the following:

(a) Allocation of stocks from quarter to quarter within a crop year

(b) Possibility that demand relations and other structural equations may differ from quarter to quarter

(c) The fact that production of soybeans is not a quarterly phenomenon. Though production occurs only in the first quarter of the crop year, the decision to produce is initiated in the third quarter of the previous year.

Subotnik, et al. developed an intriguing framework to incorporate these characteristics into a quarterly market model. This was done by providing a simplified model to capture the essential features of the markets for current utilization in which cash price is generated and the futures markets in which futures price and quarterly ending stocks are generated.

The expected profit function for an agent involved in actual production activities using soybeans, soyoil or soymeal is:

$E\pi_t(y_t, S_t) = P_t^x * f(y_t) - P_t^c y_t + (P_t^f - P_t^c)S_t - C(S_t)$

where

$E\pi_t$ = expected profit at time t

$f(y_t)$ = production function of outputs using any of the three commodities as input

P_t^x = market price of outputs

P_t^c = spot price of input at time t

S_t = ending stocks at time t

$C(S_t)$ = cost function for carrying stocks from time t into (t+1).

P_t^f = futures price of outputs

The function given above implies joint profit maximization which involves both current production and stock holding activities. The conditions for profit maximization are that $P_t^x * f'(y_t) = P_t^c$ and $C'(S_t) = P_t^f - P_t^c$, where $f'(y_t)$ is the marginal product of y and $C'(S_t)$ is the marginal cost of carrying stocks from t to t+1. The expression given by $P_t^x * f'(y_t) = P_t^c$ is clearly a demand for current utilization. For soybeans this includes crushing, export and seed; for soyoil it includes food manufacturing and export and for soymeal it includes animal feed and export. This demand function could be rearranged and rewritten as $D_c = D_c(P_t^c, P_t^x)$.

The supply function of either soybeans, soyoil or soymeal for current utilization is the inverse of the equation given by $C'(S_t) = P_t^f - P_t^c$. If Q_c is the amount supplied for current use in the production of soyoil and soymeal, livestock, margarine and other consumption, then $Q_c=S_{t-1}-S_t$. This means $C'(S_{t-1}-Q_c)=P^f_t-P^c_t$ which implies that $Q_c=Q_c(P^f_t-P^c_t, S_{t-1})$. This supply function implies that $\partial Q_c/\partial P^c=(\partial C'/\partial S)^{-1}>0$ which follows directly from the usual second order conditions for cost minimization. Similarly $\partial Q_c/\partial P^f<0$ and $\partial Q_c/\partial(P^f-P^c)<0$ which implies $\partial S/\partial(P^f_t-P^f_t)>0$. For any given values of P^f and S_{t-1} the expressions given by $D_c=D_c(P^c,P^x)$, $Q_c=S_{t-1}-S_t$ and $Q_c=Q\ (P^f_t-P^c_t, S_{t-1})$ provide solutions for D_c, Q_c and S when $D_c=Q_c$.

In order for P^f to be included within the simultaneous model solution there should be at least two types of economic agents divided among those who carry stocks into period t and those who do not but are involved in the market of a commodity in question. The latter type is regarded as composed of high cost agents whose desire to have additional stocks on hand is overcome by the perceived risk of holding such stocks after some level say T of P^f-P^c. It is then hypothesized that at higher levels of P^f-P^c these high cost agents will supply less storage along TV (see Figure 1). It means then that high-cost agents will satisfy some of their needs for future inventory by purchasing contracts equal to VW for forward delivery.

The total demand for carry out stocks (supply of storage) is therefore given by curve MYFX in figure 1. If the FX portion of this function is written as $D_s=D_s(P^f-P^c)$ it would be the relevant portion of the demand for carry out stocks to be used in the empirical model. Equilibrium is achieved where FX

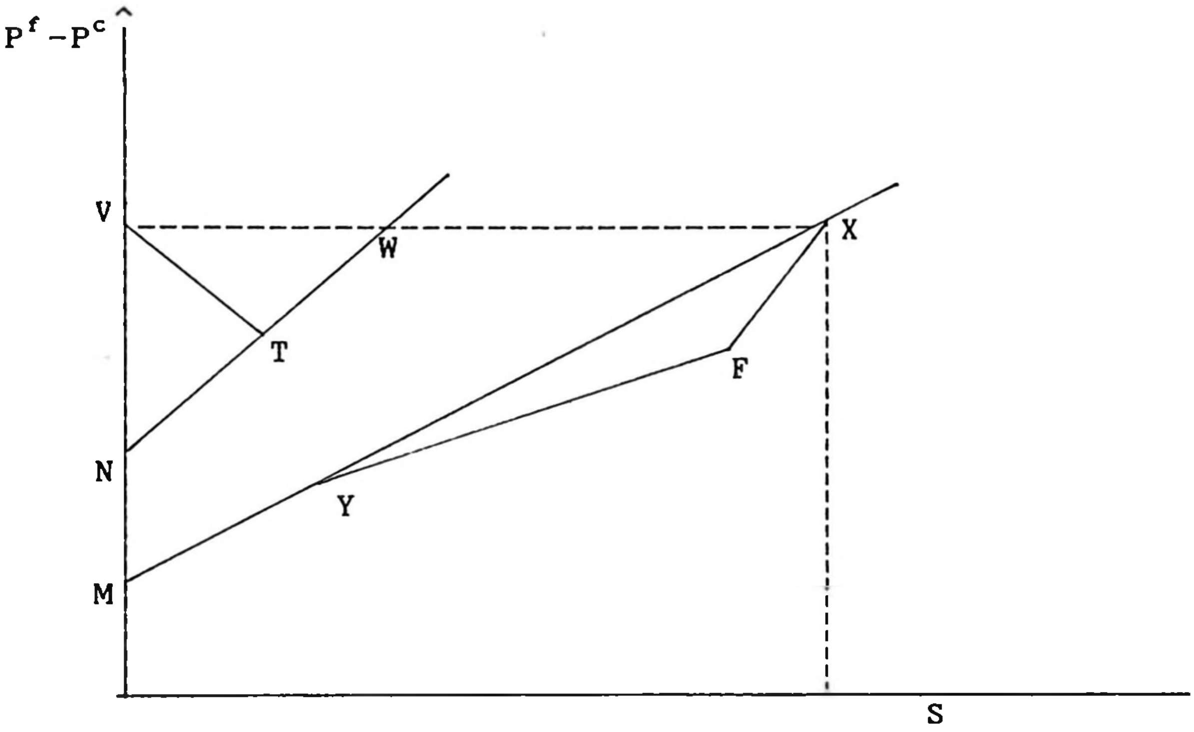

Figure 1: Supply of Storage

intersects with the supply of stocks at point X. At any given level of P^c, these relations will determine P^f and S and hence equilibrium will occur in both spot and futures markets.

Having constructed the above theoretical model, Subotnik, et al. did a study that was designed mainly for short term predictions and policy analysis. However, in the quarterly corn market model, corn production was introduced as a once-a-year occurrence in order to be able to predict several quarters ahead.

The empirical model contained demand for current corn utilization, demand for carry-out stocks, quarterly supply of corn for current use, and identity to provide period-to-period balance of carry-in stocks, utilization and carry-out stocks and an identity to assure clearing of current markets.

The estimated quarterly model contained seven equations and seven jointly determined variables. These variables are the cash and futures corn prices; quantities of corn demanded for food, feed and exports; and on-farm and off-farm stocks.

As utilization increases over time in the year, stocks of corn tend to decline from the first quarter to the last quarter. But there does not seem to be a systematic increase in prices, implying that quarterly observations may not be generated by the same structure on a yearly basis. In view of this fact, the general quarterly linear model of the behavioral equation was specified as follows:

$$Y_{it} = \sum_{i} \alpha_i D_i + \sum_{j} \gamma_j Z_{j,it} + \sum_{ij}\sum \delta_{ij} D_i Z_{j,it} + \sum_{r} B_r X_{r,it} + \sum_{ir}\sum \epsilon_{ir} D_i X_r + \mu_{it}$$

where:

Y_{it} = left-hand endogenous variables in quarter i, year t,

$i = 1, 2, 3, 4; \quad t = 1, 2, \ldots T$

Z_j = j^{th} right-hand endogenous variable, $j = 1, \ldots J$

X_r = r^{th} predetermined variable, $r = 1, \ldots R$

μ_{it} = random element with $E\,\mu_{it} = 0$ and

$E\mu_{i't}\,\mu_{it} = \sigma_i^2$ for all t and $i = i'$

0 for all t and $i \neq i'$

D_i = quarterly dummy variable equal to 1 in quarter i, 0 otherwise (i=1,2,3, with Oct.-Dec. as the first quarter). D_4=1. α, γ, β, σ and ϵ are the unknown stable parameters. The terms with the double summation signs were included to capture quarterly changes in slope coefficients.

The estimates were obtained by two-stage least squares method and were generally plausible in sign and magnitude. Most coefficients were large relative to their standard errors. A historical solution of the model was obtained by means of the Gauss-Seidel algorithm. Tests conducted on the statistical properties of these solutions when compared to actual values suggested that the model's forecasts were unbiased and efficient.

One of the study's findings is that while the on-farm stocks were significantly affected by spot prices, the difference between spot and futures prices had no systematic effect on them. On the other hand spot prices significantly affected off-farm stocks in the last two quarters while the difference between spot and futures prices did so in the first two quarters. This suggests that holding of off-farm stocks may be the only one dominated by speculative motives. Another conclusion is that futures markets may not affect intertemporal allocation in the last two quarters as strongly as they do in the first two. The reason may be that forecasts of the new crop become more accurate as harvest time approaches and that spot prices already include information becoming available about the next crop. The coefficients of the spot price and corn price basis were negative indicating that as spot and corn price basis increase, stock owners prefer to supply more to the current market and hold less stocks.

The effects of capacity bottlenecks in storage and transportation were presented by the yearly quantity of corn produced. This variable appeared in the first quarter only when capacity constraints are most likely to become a bottleneck between inventory holders and users.

The export demand for U.S. corn was found to depend on the price of corn, prices of wheat and barley, national income of importing nations and the volume of competitive exports. While the price of barley seemed to affect corn exports in the first two quarters, wheat prices did so in the last two. This is due to the wheat harvest being concentrated in the May - August period while most barley is harvested after August 1.

The competitive export data was not readily available on a quarterly basis resulting in the use of annual figures. But these yearly data relate to crop years that differ from the U.S. crop year. For example, while the domestic crop year extends from October to September, the crop year of foreign competitors is approximately from May to April. Thus, exports in the third and fourth quarters (the U.S. crop year) are affected by competitive exports in the first two quarters of the foreign crop year. Similarly, exports of the U.S. in the first and second quarters are affected by competitive exports in the last two quarters of the foreign crop year. These two effects were measured by two different variables. Also, USDA data on the relative allocation of foreign exports of corn suggest that about 65 percent of these exports correspond to the third and fourth domestic quarters and about 35 percent to the first and second domestic quarters. Thus, by adjusting the coefficients of the relevant variable it was concluded that on a proportionate basis, yearly competitive exports affected the demand for domestic exports equally in all quarters.

The supply for current utilization was estimated with the price of corn as the dependent variable. There were no seasonal characteristics found. The coefficient for the difference between stocks and utilization was very small but significant. The authors noted that this coefficient is an estimate of the slope of the marginal cost function for holding stocks and inferred from its size that the cost function for stock holding was approximately linear.

As a whole the model was specified to include crucial variables that are known to affect the U.S. corn market. Among these were the prices and output of livestock, prices of other grains and soybean meal, an index of U.S. food prices, income and exports in relevant foreign nations, support prices for corn and soybeans and CCC holding of corn.

Several other recent studies have been done on the U.S. soybean sector but except those by Beeson and Lamm most have been on an annual basis. A recent paper by Arzac et al. also represents a quarterly model involving feed grains and livestock markets.

The study by Lamm was undertaken to develop an econometric model for predicting quarterly prices of soybeans, soybean oil and soybean meal. The three equation model was specified as follows:

$P_t = f(O_t, M_t)$

$O_t = f(Z_t, X_t, S_t, C_t, N_t, A_t)$

$M_t = f(Z_t, X_t, S_t, F_t, G_t, H_t, M_{t-1})$

where P_t = quarterly price of soybeans, \$ per bu.; O_t = quarterly price of oil, ¢ per lb.; M_t = quarterly price of soybean meal, \$ per ton; Z_t = soybean production, mil. bu.; X_t = net exports and other uses of soybeans (other than crushing), mil. bu.; S_t = change in soybean mill stocks from end of quarter t-1 to the end of quarter t; C_t = quarterly price of cottonseed oil, ¢ per lb.; N_t = quarterly price of corn oil, ¢ per lb.; A_t = quarterly price of palm oil, ¢ per lb.; F_t = quarterly price of cottenseed meal, \$ per ton; G_t = quarterly price of corn, \$ per bu.; H_t = net exports of soybean meal, 1000 tons; and M_{t-1} represents lagged quarterly price of soybean meal.

The model was estimated using ordinary least squares method of analysis. The variances of the independent variables were smaller overtime than those of dependent variables, and it was concluded that the independent variables should be easier to predict on a subjective basis. These subjective predictions were then used to generate predicted values of the dependent variables. However, the readers were cautioned that the purpose of making price predictions was mainly to illustrate how that particular model was used rather than to attempt to accurately forecast the respective prices.

The findings of the analysis were as follows:

(a) Soybean oil prices declined in the second quarter, rose in the third and sagged again in the last quarter.

(b) Soybean prices declined steadily throughout the year with the largest decrease in the fourth quarter.

(c) Soybean meal prices were predicted to decline throughout the year.

The study by Arzac et al. was undertaken to provide quarterly forecasts for such variables as livestock and grain production; prices of meat, live animals and feed grains; the retail-producer price spreads for meat products and consumer demand for meat. The econometric model consisted of 42 equations of which 5 were market clearing equations and 14 were identities. The structural equations were arranged into the following five blocks:

1. (1) Consumer demand for meat (5 equations)
2. (2) Retail and producer price relations (4 equations)
3. (3) Livestock production, inventory and supply relations (11 equations)
4. (4) Demand and supply of feed grains (4 equations) and
5. (5) Market clearing equations and identities (19 equations).

The striking feature of the model was the incorporation of quarterly, semiannual and annual variables. The equations that were estimated semiannually and annually were because of data limitations as well as events and decisions that essentially occur once a year.

The structural equations not characterized by simultaneous determination of endogenous variables were estimated by ordinary least squares and all others by two-stage least squares. Dummy variables were introduced in quarterly demand and supply equations just as in the Subotnik et al. model in order to allow for seasonal effects. Only variables with expected signs were retained for further analysis even when statistically insignificant.

The forecasting accuracy of the model was compared to a fourth-order-autoregressive model with the root-mean-squared-error as the fraction of the mean used as criterion of performance. The findings were that the forecasting performance of the model within and beyond the sample was accurate relative to autoregressive forecasting.

A recent study by Beeson modeled the soybean complex along the same lines as the Subotnik et al. model. The analysis covered 1958 - 1977 crop years. The model predicted the simulation tract with only slight errors prior to 1972 and after 1975. However, the inclusion of dummy variables could not capture the instability that occurred during the 1972-75 period.

The domestic consumption of soybean meal and soybean oil was predicted more accurately than any other endogenous variables. The price forecasts were directionally accurate but forecast errors after 1972 tended to increase. The export and storage equations were the most difficult to specify. The author attributed estimation difficulties to lack of foreign data on a quarterly basis. However, the study did not include a foreign exchange rate variable which is an important shifter of export demand.

While most of the above studies tried to model the soybean complex by considering several simultaneous relationships of demand and supply, they all failed to account for structural changes that have characterized sectors of the soybean economy. The sectors include production, processing and markets for soybean products. The changes on the other hand have been characterized by shifts in size and number of farms, in areas of production, fewer but larger efficient processing oil mills as well as expanded domestic and foreign markets. Since statistical models are used as tools in market forecasting, ignorance of the changing structure may prevent the forecaster from obtaining a more systematic understanding of highly complex related events.

The model applied by Lamm was admittedly developed as an experiment and not to accurately forecast the respective prices. For example, the subjective prediction of independent variables limits general usage of the model. Beeson's study, on the other hand, did not include the foreign exchange variable which has a significant impact on the changing domestic prices in the foreign soybean markets.

The study to be undertaken by the author will follow the basic model as developed by Subotnik et al. but will modify some of the statistical relationships by introducing time varying parameters.

CHAPTER 4

STRUCTURAL CHANGE MODELS

The idea of structural change has been in the econometric literature for sometime. There are a number of different approaches that attempt to incorporate changing parameters in econometric estimation. However, most of these approaches have been developed within the framework of a single equation model. The selected review of literature will examine first single equation estimation techniques and then briefly discuss some approaches that examine structural change in a simultaneous framework. The specific approach to be used in this study will be presented later.

4.1 Selected Single Equation Models

Consider a single equation with one explanatory variable.

(1) $y_t = X_t \beta_t + \mu_t$

where y_t is endogenous, X_t is exogenous and μ_t a random error term, $\mu_t \sim (0, \sigma_u^2), E(\mu'_t X_t) = E(\mu'_t \beta_t) = 0$ $t = 1 \ldots T$. Note that the coefficent parameter β_t is subscripted so that it can change overtime with systematic or random changes. For example consumption demand of a given commodity can depend on past experience or on dietary change that affect taste leading to variation in the parameter structure. The changing response coefficent can be specified as

(2) $\beta_t = \beta_0 + L(X_t) + Z_t \alpha + e_t$

where

$e_t \sim (0, \sigma_e^2), E(e'_t X_t) = E(e'_t L(X_t)) = 0 \qquad t = 1,2,\ldots T.$

$L(X_t)$ represents the effects of variables within the system whereas the term Z_t represents the effect on the coefficents by the outside environment. When (2) is substituted into (1) equation (3) results:

$$(3) \quad y_t = X_t \beta_0 + L(X_t) X_t + X_t Z_t \alpha + \epsilon_t$$

where $\epsilon_t = X_t e_t + \mu_t$.

The function $L(X_t)$ is usually specified to reflect the impact of past values of the X's and when expressed as a geometric distributed lag the varying parameter becomes:

$$(4) \quad \beta_t = \beta_0 + \delta X_{t-1} + \delta^2 X_{t-2} + \delta^3 X_{t-3} + \ldots + \alpha Z_t + e_t \qquad 0 < \delta < 1$$

Thus

$$(5) \quad \beta_{t-1} = \beta_0 + \delta X_{t-2} + \delta^2 X_{t-3} + \delta^3 X_{t-4} + \alpha \ldots + Z_{t-1} + e_{t-1}$$

If equation (5) is multiplied by δ and subtracted from equation (4) we get:

$$(6) \quad \beta_t = \delta \beta_{t-1} + (1-\delta)\beta_0 + \delta X_{t-1} + \alpha(Z_t - \delta Z_{t-1}) + (e_t - \delta e_{t-1})$$

Equation (6) allows a variety of specifications that have appeared in the literature on parameter variation. Although the expression $L(X_t)$ was specified as a given distributed lag other forms are possible. This can be seen by rewriting equation (6) as

$$(7) \quad \beta_t = \delta_0 \beta_0 + \delta_1 \beta_{t-1} + \delta_2 X_{t-1} + \alpha Z_t^* + \epsilon_t$$

where in this case the parameters associated with β_{t-1} and X_{t-1} differ. In order for (7) to be equivalent to (6), $\delta_1 = \delta_2 = \delta$; $\delta_0 = 1 - \delta$; $Z_t^* = (Z_t - \delta Z_{t-1})$ and $\epsilon_t = e_t - \delta e_{t-1}$. Some special cases of parameter variation specification embedded in the general representation are considered below:

(a) The constant parameter classical model: $\delta_0 = 1, \delta_1 = 0, \delta_2 = 0, \alpha = 0, \epsilon_t = 0$. Hence, $\beta_t = \beta_0$ for all t.

(b) The Cooley and Prescott (1973a) adaptive regression model: $\delta_0 = 0$, $\delta_1 = 1$, $\delta_2 = 0$, $\alpha = 0$, $\mu_t = 0$, $Z_t = 1$ for all t. Hence, $\beta_t = \beta_{t-1} + \epsilon_t$. With this specification the parameter evolves in accordance with a random walk model which does not allow for turning points in behavior of the time-varying parameter.

(c) The Belsey (1973b) systematic parameter variation model: $\delta_0 = 0$, $\delta_1 = 0$, $\delta_2 = 0$ for all t. Hence, $\beta_t = \alpha_0 + Z_t + \epsilon_t$. This specification would be important if influences from outside the model are believed to motivate systematic changes in the parameters.

(d) The Swamy random coefficient model: $\delta_0 = 1$, $\delta_1 = 0$, $\delta_2 = 0$, $\alpha = 0$ for all t. Hence, $\beta_t = \beta_0 + \epsilon_t$. A number of assumptions about the error term ϵ_t can be considered. The simplest assumption is where $E(\epsilon_{it}\epsilon'_{it}) = \sigma_{ii} I$ and $E(\epsilon_{it}\epsilon'_{jt}) = 0$ for $i \neq j$.

(e) The Cooley and Prescott (1973b) time-varying parameter model: $\delta_0 = 0$, $\delta_1 = 1$, $\delta_2 = 0$, $\alpha = 0$ and $\mu_t = 0$ for all t.

Hence

$$\beta_t = \beta_t^p + \eta_t$$

$$t = 1 \ldots . T$$

$$\beta_t^p = \beta_{t-1}^p + V_t$$

where p denotes the permanent component of the parameter vector and η_t and V_t are independent normal random vectors with mean vector zero and variance matrices $(1-\gamma)\sigma^2 \Sigma$ and $\gamma\sigma^2 \Sigma_v$ repectively. The transitory changes in the parameter are reflected in the additive error and reflects the relative magnitudes of the permanent and transitory changes. By focusing on one period past the sample being considered and by repeated substitution, the varying parameter becomes

$\beta_t = \beta^p_{T+1} - \sum_{j=t+1}^{T+1} V_j + \eta_t$. When β_t is substituted into the original equation the following expression is obtained:

$$y_t = X_t \beta^p_{T+1} + X_t (\eta_t - \sum_{j=t+1}^{T+1} V_j) \qquad t = 1 \ldots T$$

If γ is known the generalized least squares estimation can get estimates of β^p_{T+1}. If γ is unknown, estimates of β^p_{T+1} and σ^2 both conditional on γ can be obtained by maximizing the relevant likelihood with respect to β^p_{T+1} and σ^2. These estimates can then be substituted back to get a concentrated likelihood function which in turn would be maximized with respect to γ to get γ. This latter estimate can then be inserted into the two former conditional functions to get estimates of β^p_{T+1} and σ^2.

Even though this model can be estimated and interpreted easily it is the actual application which poses several problems. One of the major problems is the assumption that Σ and Σ_v are known a priori, which presumes the ability to specify the relative variability of parameters. If no a priori knowledge is available it is suggested that the user can assume $\Sigma = \Sigma_v$ and diagonal.

(f)Singh et al. mean response model: $\delta_0 = 1$, $\delta_1 = 0$, $\delta_2 = 0$, $Z_t = 1$ and $\alpha = \alpha f(t)$. Hence, $\beta_t = \beta_0 + \alpha f(t) + \epsilon_t$ where f(t) is some function of time. This case provides a mild generalization to the Belsey (c) and the random coefficient model of Swamy (d). The added feature of this formulation is the inclusion of a linear function of time which leads to a presumed continuous evolution of the time parameters.

Richard Stone applied the time varying parameter procedure when he developed models for demand projections. The varying parameters were used when introducing changes in consumers' tastes. This was done under the assumption that changing parameters over time are due mainly to the fact that a rising standard of living will lead to higher levels of commitments and to a redistribution of uncommitted expenditure over the different types of commodities. The specific changing parameters were made functions of time: $b_\theta = \alpha_0 + \alpha_1 \theta$

$$C_\theta = \gamma_0 + \gamma_1 \theta$$

where

θ = time trend in years

b_θ = proportions in which the consumer devotes uncommitted expenditure to the different commodities.

C_θ = purchases to which the average consumer is committed.

It was stated that the model could be made to work better if the linear trends were replaced by more complicated trends such as quadratic trends. But it was cautioned that even though these complicated trends may work better the tendencies to accelerate or decelerate changes may not continue indefinitely nor be allowed to make tastes negative.

(g) The Goldfeld and Quandt switching regression model: $\delta_0=0$, $\delta_1=0$, $\delta_2=0$, $\epsilon_t=0$, $\alpha=1$ and $Z_t=\beta_1$ for $t\in I_1$ and $Z_t=\beta_2$ for $t\in I_2$ where I_1 and I_2 are indices for which separate regression equations hold for two regimes. Hence

$$y_t=X_t\beta_1+\mu_t \qquad t\in I_1$$

$$y_t=X_t\beta_2+\mu_t \qquad t\in I_2$$

This model generalizes the conventional dummy variable formulation which presumes the availability of a priori information to classify various regimes. When the a priori information is not readily available the Goldfeld and Quandt approach which endogenises the distribution of the regimes would be preferable particularly if parameters move by discrete jumps.

(h) The spline regression model (Poirier, Huang et al., Nyankori et al., Suits et al. and Robb). In the spline specification linear, quadratic, cubic and other special forms of splines can be specified. The simplest form is the linear specification where the intercept term is regarded constant and for the slope, $\delta_0=1$, $\delta_1=0$, $\delta_2=0$, $\epsilon_t=0$ and α and Z_t are defined as the vectors $\alpha=(\alpha_1,\alpha_2)$ and $Z_t=(t,(t-\bar{t}))$. Hence for the slope coefficient:

$\beta_t=\beta_0+\alpha_1 t+\alpha_2(t-\bar{t})$ where $(t-\bar{t})$ is restricted to equal zero for $t\leq\bar{t}$.

A representative application of spline regression approach was by Nyankori and Miller who examined the nature of structural change in the U.S. retail demand for meats. The per capita consumption of each type of meat (beef, pork, chicken and turkey) was expressed as a function of own price, price of other meats, income and seasonal dummies. In order to identify points of structural change a cumulative sums of squares test as suggested by Brown et al. was applied. This involves plotting against time the values for

$$S = \sum_{j=k+1}^{r} e_j^2 \Big/ \sum_{j=k+1}^{T} e_j^2 \qquad r = k+1, \ldots . T \qquad \text{where}$$

the e_j's are residuals. The expectation of S_r is $(r-k)/(T-k)$ and the pair of significance lines are given by $(r-k)/(T-k) \pm C$ where C is obtained from the table of Significance Values for Cumulative Sums of Squares Test. The point of coefficient change is assumed to be located where the sample path moves outside the significance lines. However, it is cautioned that the effect of an individual coefficient change may be offset or reinforced by changes in coefficients of other independent variables. It is thus recommended that an appropriate test for structural change in the whole equation should be based on an F-test which tests relevant coefficients simultaneously. In fact basing on this test structural change was found to have taken place in the beef and chicken demand equations only.

(i) The Kalman Filter Models (Cooper (1973), Belsey (1973a) and Rausser and Mundlak (1978)): $\delta_0 = 0$, $\delta_1 = \phi$, $\delta_2 = \alpha = 0$ where ϕ is a (kxk) matrix of transition probabilities and k the number of varying parameters. Hence $\beta_t = \phi_{t-1} + V_t$. This case provides a generalization to the Cooley and Prescott adaptive regression model. The difference between the two is that the latter considers the transition probabilities as certain i.e. equal to one while the Kalman Filter model allows a range of these probabilities. The general structure of the

Kalman Filter time varying coefficients is usually given by

$$\beta_{t+1} = \phi \beta_t + V_{t+1} \qquad t = 0 \ldots\ldots T$$

where $E(V_t)=0, E(V_t V_t')=\Sigma$ and V_t , μ_s are uncorrelated for all s and t, μ_s being the error term of the basic model. By assuming that T, Σ and β_0 are known a priori, the structure can be recast as a mixed estimation problem. Given that the compact notation of the time varying parameter is $\beta = \phi_1 \beta_0 + \phi_2 V$, this could be rewritten as $\phi_1 \beta_0 = \beta - \phi_2 V$ and direct application of generalized least squares estimation would lead to

$$\hat{\beta} = (\frac{1}{\sigma^2} (x'x)^{-1} + \Omega^{-1})^{-1} (\frac{1}{\sigma^2} x'y + \Omega^{-1} \phi_1 \beta_0)$$

and $\Sigma_{\hat{\beta}} = (\frac{1}{\sigma^2} (x'x)^{-1} + \Omega^{-1})^{-1}$

where $\Omega = \phi_2 (I_T \otimes \Sigma) \phi_2'$

The main problem with this model is how to obtain the values of ϕ, Σ, β_0 and σ^2 . However if ϕ and Σ are known the estimate for β_0 could be found by maximum likelihood methods.

To the present this has been the extent of empirical work on dealing with structural change. Although the review was not exhaustive other types of work are just slight modifications of what has been given. In the next section a methodology is presented that permits structural change in a simultaneous framework. The specific approach applied in this study is given in detail in Chapter 5.

4.2 Selected Simultaneous System Models

Goldfeld et al. and Barten et al. consider estimation of simultaneous linear models when the structural coefficients differ for some observations for which the model is postulated to be valid.

The simultaneous specification given by Goldfeld et al. is of the following form:

$$\beta y_i + \Gamma Z_i = \mu_i \qquad i = 1, \ldots\ldots, n$$

where $y_i = (y_{i1}, \ldots\ldots y_{tg})$ is the i^{th} observation on the vector of g endogenous variables; $Z_i = (Z_{i1}, \ldots\ldots Z_{ik})$ is the i^{th} observation on the vector of non-stochastic exogenous variables, $\mu_i = (\mu_{i1}, \ldots, \mu_{ig})$ is the i^{th} realization of the vector of unobservable error terms. The structural change is present within the range of index i if

$$(8) \qquad \beta_1 y_i + \Gamma_1 Z_i = \mu_{1i} \qquad \mu_{1i} \sim N(0, \Sigma_1) \text{ for } i \in I_1$$

$$(9) \qquad \beta_2 y_i + \Gamma_2 Z_i = \mu_{2i} \qquad \mu_{2i} \sim N(0, \Sigma_2) \text{ for } i \in I_2$$

where $I_1 \cap I_2 =$ null vector and $I_1 \cup I_2 = (1, \ldots n)$ and $(\beta_1 \; \Gamma_1 \; \Sigma_1) \neq (\beta_2 \, \Gamma_2 \, \Sigma_2)$.

When the separation of the sample is given a priori, the approach is to obtain full information maximum likelihood estimates with and without the restriction that $(\beta_1 \; \Gamma_1 \; \Sigma_1) = (\beta_2 \, \Gamma_2 \, \Sigma_2)$. This leads to forming a natural likelihood ratio which is a chow-type statistic conforming to asymptotic theory for testing $-2\log\ell$ where $\ell = \underset{w \in \Omega_0}{L(\hat{w})} \, / \underset{w \in \Omega}{L(\hat{w})}$. When the investigator needs to test the hypothesis that $(\beta_1 \; \Gamma_1 \; \Sigma_1) = (\beta_2 \, \Gamma_2 \, \Sigma_2)$ and to perform structural coefficent estimation as well as to estimate the appropriate sample separation, three methods are suggested.

The first is the full information maximum likelihood (FIML) method. In this method the stochastic switching structures are considered where values for the endogenous variables are generated from (8) and (9) with probabilities λ and $1-\lambda$ respectively. Assuming that $\Sigma_1 = \Sigma_2 = \Sigma$ the joint probability density function (p.d.f) of the vector of endogenous variable y in the j^{th} structure is formulated as

$$h_j(y) = (2\pi)^{-g/2} (\det\Sigma)^{-1/2} |\det\beta_j| \exp\{-1/2(\beta_j y + \Gamma_j Z)' \Sigma^{-1} (\beta_j y + \Gamma_j Z)\}$$

By denoting $\lambda_1 = \lambda$ and $\lambda_2 = 1-\lambda$ the joint pdf of y is

$$h(y) = \sum_{j=1}^{2} \lambda_j h_j(y)$$

and the loglikelihood in a sample of n observations is

$$L = \sum_{i=1}^{n} \log \sum_{j=1}^{2} \lambda_j (2\pi)^{-g/2} (\det\Sigma)^{-1/2} |\det\beta_j| \exp\{-1/2(\beta_j y_i + \Gamma_j Z_i)' \Sigma^{-1} (\beta_j y_i + \Gamma_j Z_i)\}$$

The maximization of the loglikelihood with respect to β_j, Γ_j, λ and Σ yields full information maximum likelihood estimates under the specifications of (8) and (9). The assumption $\Sigma_1 = \Sigma_2$ is necessary for the maximum likelihood estimates to be consistent.

The second method is also FIML but the latter considers deterministic switching structures where regimes are chosen on the basis of value of some observable exogenous variables. The switching mechanism is specified as

(10) $\beta_1 y_i + \Gamma_1 Z_i = \mu_{1i}$ $\qquad \mu_{1i} \sim N(0, \Sigma_1)$ if $\phi' w_i > 0$

(11) $\beta_2 y_i + \Gamma_2 Z_i = \mu_{2i}$ $\qquad \mu_{2i} \sim N(0, \Sigma_2)$ if $\phi' w_i < 0$

where w_i = i^{th} observation on a vector of m exogenous variables which may include some of the z variables appearing in the structure. ϕ is a vector of unknown coefficients.

Define a variable with values d_i such that

$d_i=0$ if $\phi w_i \leqq 0$

$d_i=1$ otherwise

Multiply (10) by d_i, (11) by $1-d_i$ and add to get

(12) $(d_i\beta_1+(1-d_i)\beta_2)y_i+(d_i\Gamma_1+(1-d_i)\Gamma_2)Z_i=d_i\mu_{1i}+(1-d_i)\mu_{2i}$

Let

$d_i\beta_1+(1-d_i)\beta_2=\beta_i$; $d_i\Gamma_1+(1-d_i)\Gamma_2=\Gamma_i$;

$d_i\mu_{1i}+(1-d_i)\mu_{2i}=\mu_i$; $d_i^2\Sigma_1+(1-d_i)^2\Sigma_2=\Sigma_i$

The expression given by (12) can then be rewritten as

(13) $\beta_i y_i+\Gamma_i Z_i=\mu_i$

where $\mu_i \sim N(0,\Sigma)$. The pdf corresponding to the i^{th} observation is

$$h(y_i)=(2\pi)^{-g/2}(\det\Sigma_i)^{-1/2}|\det\beta_i|$$

$$\exp\{-1/2(\beta_i y_i+\Gamma_i Z_i)'\Sigma_i^{-1}(\beta_i y_i+\Gamma_i Z_i)\}$$

and the loglikelihood is as usual given by

$$L=\sum_{i=1}^{n}\log h(y_i).$$

The maximization of this function w.r.t β_1, Γ_1, Σ_1, β_2, Γ_2 and Σ_2 would yield FIML estimates. However, due to computational difficulties of the above methods a two stage least squares method was also discussed.

By partitioning the set into two subsets the presence of a structural shift at i is expressed as

$y_i\beta_1'+Z_i\Gamma_1'=\mu_{1i}$

$y_{n-i}\beta_2'+Z_{n-i}\Gamma_2'=\mu_{2,n-i}$

and the corresponding reduced form is

$y_i=Z_i\Pi_1+V_{1i}$

$y_{n-i}=Z_{n-i}\Pi_2+V_{2i}$

The reduced form likelihood function conditional on i is

$$L=(2\pi)^{-ng/2}(\det\Omega_1)^{-1/2}(\det\Omega_2)^{-(n-i)/2}$$

$$\exp\{-1/2\ t_r[(y_i-Z_i\Pi_i)\Omega_1^{-1}(y_i-Z_i\Pi_i)\qquad(14)$$

$$(y_{n-i}-Z_{n-i}\Pi_2)\Omega_2^{-1}(y_{n-i}-Z_{n-i}\Pi_2)]\}$$

where $\Omega_j=\beta_j^{-1}\Sigma_j\beta_j^{-1}$. The maximization of (14) conditional on i yields the separate OLS estimates for the two versions of the reduced form equations.

Having determined an estimate for i, the 2SLS may be applied to an equation by the method discussed by Barten et al. In the first stage OLS is applied separately to both versions of the reduced form equations. In the second stage OLS is applied to the structural form equation by equation with the right-hand jointly dependent variables replaced by their estimated counterparts.

Tsurumi et al. (1982) derived a limited information maximum likelihood (LIML) procedure for estimating the parameters of a transition function as well as of regression lines and compared its performance with those of the Bayesian estimates by conducting sampling experiments.

It is assumed that the parameter shift occurs in one of the endogenous variables in a simultaneous equation model

$$y_{t1}=\gamma_{12}y_{t2}+\gamma_{12}'\ \mathrm{trn}(s_t/\eta)y_{t2}+\ldots+\gamma_{1m_1-1}y_{tm_1-1}$$

$$+\beta_{11}X_{t1}+\ldots+\beta_{1K_1}X_{tK_1}+\mu_{t1}\qquad t=1,\ldots.,N$$

or $y_1=Y_1\gamma_1+X_1\beta_1+\mu_1$

where y_{ti} = the i^{th} endogenous variable included in the equation, $i=1,\ldots.,m_1-1$

X_{ti} = the i^{th} exogenous variable included in the right-hand side of the equation, $i = 1, \ldots, K_1$

μ_{t1} = error term of the first equation that is normally distributed

$y_i = (y_{1i}, \ldots y_{Ni})$

$S_t = 0$ for $t \leq t^*$

$= t - t^*$ for $t > t^*$

and t^* and η are unknown parameters to be estimated; t^* represents a join point while η indicates the nature of the shift. The maximization of the concentrated loglikelihood function w.r.t t^* and η would yield the LIML estimators of t^* and η. Once the pair of t^* and η estimates are obtained, the value of γ_1 and β_1 may be estimated by the standard LIML procedure.

The Bayesian procedure, on the other hand, is to derive first the joint marginal posterior pdf for t^* and η and the posterior means computed by using a numerical integration procedure. Once the estimated posterior means of t^* and η are obtained one may estimate γ_1 and β_1 conditionally on them by the two-stage least squares procedure.

4.3 Critical Assessment of Structural Change Models

Structural change models are appropriate when the coefficients of an otherwise properly specified relationship are different for some sample subsets, i.e., the sample data cannot be pooled. In such cases estimation of models that disregard this fact will not represent the true existing economic structure and may not be appropriate for forecasting.

The second justification of structural change models is that econometric models are necessarily abstractions from and simplifications of reality. The adopting of classical linear models may imply misspecification that cause coefficients of the model to apparently vary across the sample even though the true underlying structure is not changing. Important types of misspecifications which may arise include omitted variables, proxy variables, aggregate data and nonlinearities.

Important variables can be omitted because of inadequate theoretical frameworks, unavailable data or simply the desire for simplicity. These types of excluded data often are related to structural changes that result from taste evolution, technological developments, changes in institutional arrangements etc. If the excluded variables are related to those included, as is often the case with time series, then the effects of included variables can be expected to change with time.

Proxy variables on the other hand are often employed in the construction of econometric models when there are data limitations. These proxy variables are invariably introduced into dynamic representations which involve expectations formation patterns. In most cases these and other types of proxies detect only partial changes in the levels of economic stimuli which they intend to measure. It is also expected that relationships between the true variable and its proxy will change over time. It is clear then that changes in the true variables which measure the actual economic stimuli induce instability in the estimated coefficients for the proxy variables.

Parameter instability for aggregated data is due to the fact that aggregate data are measured by weighting the relative importance of the heterogeneous sets of microunits. As long as these weights remain constant the parameters in the estimated aggregate equation will remain constant. But with time series economic data the weights can be expected not to remain constant such that parameter effects associated with the aggregate variables will change across time (Zellner).

Another source of parameter variation may come about because of inappropriate functional forms. For example, in order to avoid nonlinear equations a Taylor series expansion around the mean is usually employed. In this case the assumption of constant parameters for the simplified equation is reasonable only if the observed explanatory variables remain within some narrow range of the means. However, the secular evolution of time series strongly reject this assumption of narrow sample ranges and should motivate a varying parameter structure.

Although modelling a changing economic structure by permitting the response parameters to vary over observations may be a realistic approach, the chances for misspecification are many (Judge et al.). For example, models with random but not systematically varying parameters force recognition of another source of estimation and forecasting inacurracy such that the quality of statistical results cannot be overstated. It is also possible to forecast the dependent variable more accurately by letting parameters vary systematically with trend variables, but this may not reveal the nature of the actual structural change.

Another difficulty with varying parameter models e.g. Kalman Filter and Cooley-Prescott presume that the researchers can specify the relative variability of the parameters by assuming known covariance matrices. When ignorance of such variability is existent the practical application of these models becomes a problem.

The nature of most varying parameter formulations induces heteroskedastic structure of the error terms in the estimable equations. Also the nature of the present estimation procedures to take into account this heteroskedastic structure does not guarantee nonnegativity property of the error variance. This calls for other procedures involving application of inequality estimators or ridge regressions. Ridge regression approach is where a priori information is incorporated into the estimation procedure in order to force the negative variance estimates toward zero. However, these approaches can achieve the desired results if the a priori information including the direction of the inequality constraint is available and correct.

Other approaches like the spline functions assume data uniformity throughout the observed range. If this assumption is violated the function can take on spurious curvatures through the sparse sections of the data. Spline functions are also closely tied to the observed sample and may prove to be of limited usefulness in econometric models designed for forecasting and related purposes (Suits et al.).

Despite all the inherent difficulties just stated the fact remains that inferences from statistical models about economic processes can only be as good as the theoretical and institutional knowledge of the economic structure on which the model is based (Judge et al.). The relevant issue then is whether the recognition of varying parameters will provide accurate and implementation benefits that outweigh the additional complexities of their formulation.

The current study will be modeled along the same line as the Subotnik et al. model but with statistical modifications that allow some parameters to change over time. In order for the current parameter variation specification to be in line with the general representation of equation (7), $\delta_0 = 1$, $\delta_1 = 0$, $\epsilon_t = 0$, X_{t-1} and Z_t^* are replaced by quarterly time trend and quarterly soymeal exported by Brazil respectively.

In addition to varying some parameters the model developed for the current study will consider simultaneous relationships. In this model parameter changes are assumed to be quarterly, whereas in the Goldfeld et al. presentation, structural shift is at point i which may be endogenously determined within the system. In the following chapter the theoretical model is discussed and the methodology applied in this study is detailed in later sections.

CHAPTER 5

APPROACH AND METHODOLOGY

5.1 Structure of the Soybean Complex

The soybean industry is highly complex and may be considered as a series of interrelated markets. In the soybean sector, price of beans, meal and oil result from an interplay of demand forces, supply forces as well as government programs. Several features of the soybean markets are noted for shaping the way in which the above mentioned forces interact: (a) multiple-market outlets for beans, meal and oil. These outlets include crushing, export, storage, domestic utilization and seed; (b) joint-product aspects of soymeal and soyoil. The supplies of soymeal and soyoil are tightly linked to each other and to the quantity of soybeans crushed domestically; (c) interdependence of soybeans and soybean products with larger economic sectors. Soymeal is one of the several high-protein feed products in the livestock sector. Soyoil is one of the many edible vegetable oils in the fats and oils complex. On the other hand, soybeans themselves are one of the competing oil-bearing products; (d) simultaneous determination of product prices and market flows within each quarter. This simultaneity is ensured by the joint-product and multiple-market aspects of the soybean sector. Figure 2 below produces a diagramatic review of the U.S. soybean sector while Figure 3 is an illustration of an aggregate supply and demand model of the world.

With reference to Figure 2 total demand for soybean meal at wholesale level is the horizontal summation of the derived demands for meal in the U.S. and for meal exports to foreign nations. The total wholesale demand for soybean oil is also the horizontal summation of the derived demands for oil in the U.S. and for export to foreign nations. The demand for oil stocks is regarded as part of the U.S. domestic demand. The export demand for oil is made up of two parts (1) the perfectly inelastic demand representing the administratively determined PL480 concessional sales and (2) demand for exports through the commercial trade channels.

The meal production and oil production are locked together through technically fixed crushing yields of meal and oil. When the meal and oil demand functions are added together vertically they form the average revenue function (given by R in figure 2) in the crushing sector. Each 60 pound bushel of soybeans crushed yields about 11 pounds of oil and 48 pounds of meal and by subtracting the crushing and handling spread (w) from the average revenue function the farm-level demand for soybeans for crushing is obtained.

The total farm-level demand for soybeans is the horizontal summation of crushing demand, export soybean demand and domestic commercial soybean stocks. The price of soybeans necessarily affects the positioning of the demands for meal and oil. However, in the real world the entire system moves towards

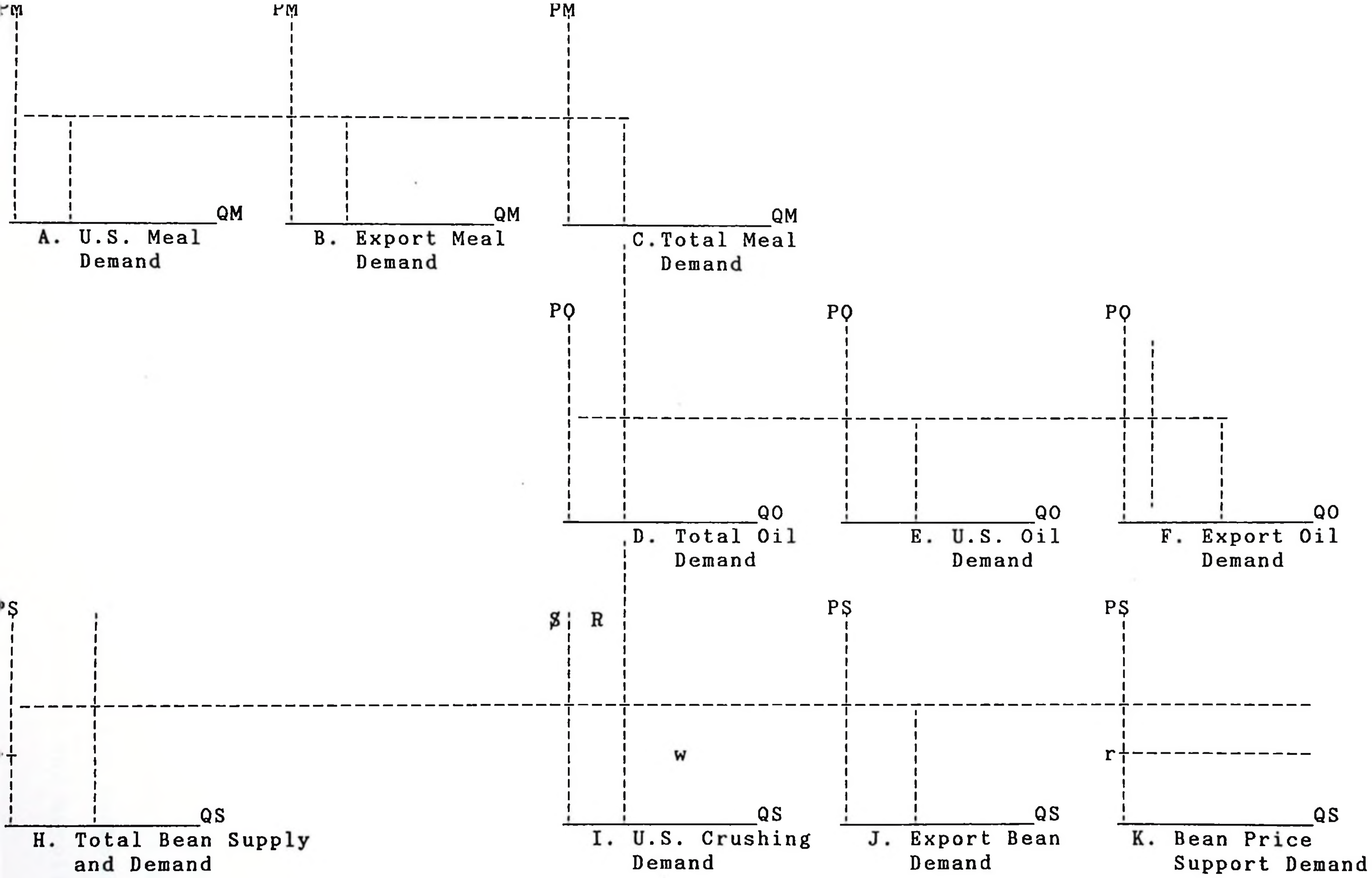

FIGURE 2: SIMPLIFIED GRAPHIC MODEL OF THE U.S. SOYBEAN DEMAND BLOCK

equilibrium in a simultaneous manner with all the sectors interacting.

The linkages between the U.S. soybean industry and the world market and among soybeans and soybean products are represented graphically in Figure 3. In this figure the soybean, soymeal and soyoil markets are represented by the top, middle and bottom rows respectively. The supply of soybeans, a function of lagged relative prices, is considered as given in any given period. This is illustrated by the vertical supply curve (QSP). The U.S. total demand for soybeans (QSD) is the horizontal summation of the U.S. demands for soybeans for crushing (QSCR) and storage (QSS).

The excess supplies of soybeans from the U.S. (QSEX) and Brazil and Argentina (QSEXB) are added horizontally to obtain the world excess supply of soybeans schedule (QSEXW). When the domestic demand relations of importing countries are summed horizontally the world excess demand (QSDW) results since it is assumed these countries do not supply soybeans domestically. The world soybean price (PSW) and volumes of trade are determined by the simultaneous interaction of the world excess supply (QSEXW) and demand (QSDW). In turn these world prices feed back into the domestic markets of exporting and importing countries to determine the volume of soybeans demanded domestically. When the amounts of soybeans to be crushed are determined, the domestic supplies of soymeal and soyoil (QMP and QOS in the U.S.) are fixed since the rates of extraction are technologically determined. The excess supplies of soymeal and soyoil from

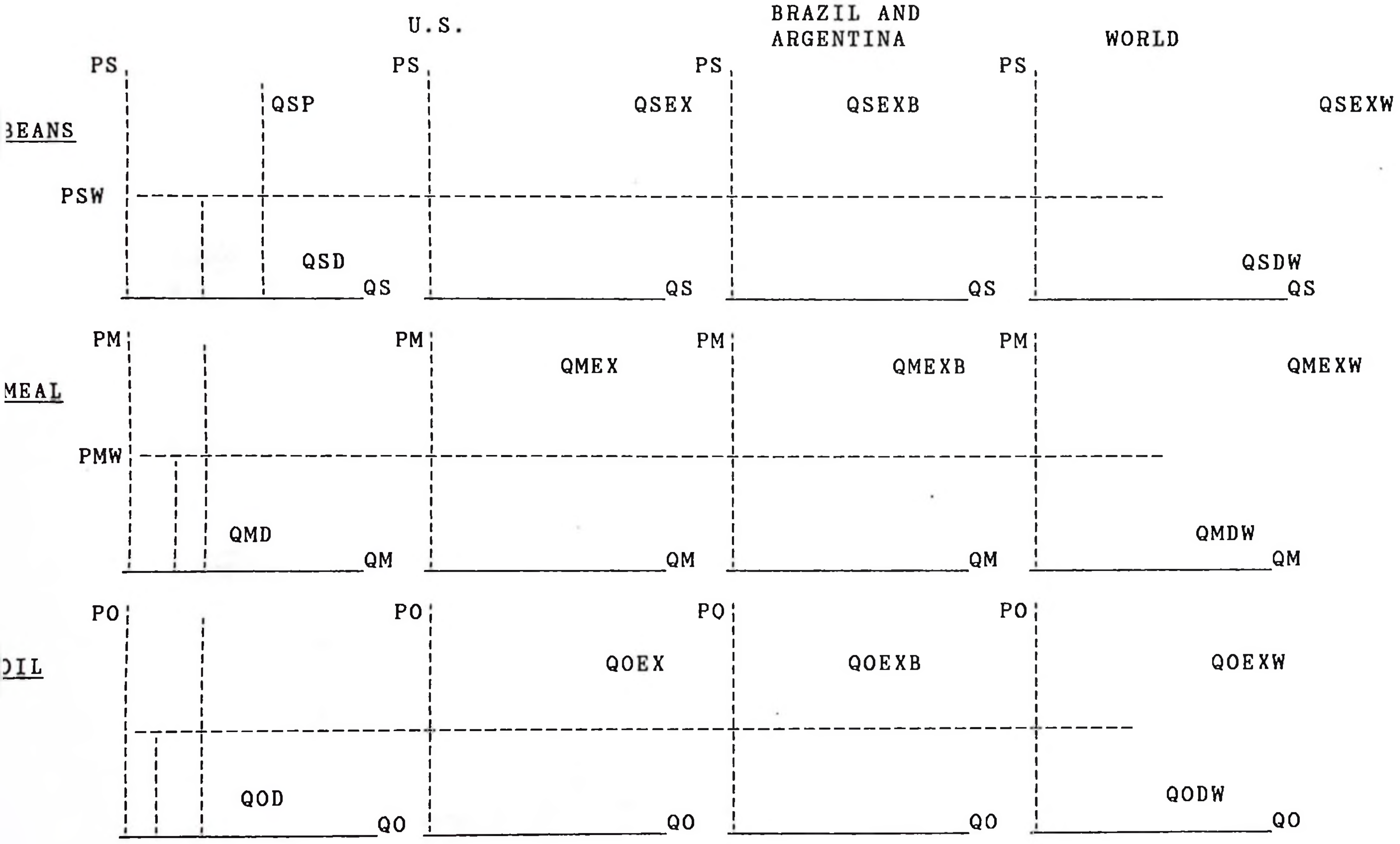

FIGURE 3: SIMPLIFIED GRAPHIC MODEL OF THE AGGREGATE WORLD EXPORT MARKETS FOR SOYBEANS, SOYMEAL AND SOYOIL

the U.S. (QMEX and QOEX) and Brazil and Argentina (QMEXB and QOEXB) and the excess demand for soymeal and soyoil by the importing countries (QMDW and QODW) are derived from the respective domestic supply and demand schedules for each commodity.

The world excess supplies of soymeal and soyoil (QMEXW and QOEXW) interact simultaneously with the world excess demands for soymeal and soyoil to produce the world prices (PMW for soymeal and POW for soyoil) and the volume of trade in each commodity. As these prices feed back into domestic markets the volume of soymeal and soyoil demanded are determined.

The present framework has one drawback of ignoring the interdependence of the markets for all oilseeds, meals and oils. In the real world quantities and prices of soybeans, soymeal and soyoil are determined simultaneously with those of other oilseeds, meals and oils. However the task of empirically estimating such a huge detailed model is beyond the scope of the current study.

5.2 Theoretical Model

The model of the U.S. soybean economy illustrated in the two graphs above is presented algebraically below. It consists of 25 equations, 12 of which are structural equations whose coefficients are estimated simultaneously for the crop years 1964/65 - 1980/81 using quarterly data. The equations and definition of variables used are given below.

5.2.1 Soybean Stock Demand

The structural equation to explain the demand for soybean stocks is given by

$$QSS^{1} = f(D1, \ldots, D3, QSS_{-1}, QSP, D1*(FPS-PS), \ldots, D4*(FPS-PS), D1*PS, \ldots, D4*PS)$$

where

QSS – (endogenous) quarterly ending stocks of soybeans, mil. bu.

D_i – (exogenous) quarterly dummy equal to 1 in quarter i and 0 otherwise, i = 1, 2, 3, 4 with October - December as the first quarter.

QSS_{-1} – (predetermined) lagged quarterly ending stocks of soybeans.

FPS – (endogenous) quarterly futures price of soybeans quoted for next quarter. The futures price was computed as an average of the daily quotations of futures prices during the last month of that quarter pertaining to delivery in the last month of the next quarter. However since there are no June delivery contracts, March prices for July delivery were used in the second crop year quarter. The procedure which also applies to soyoil and soymeal futures prices is explained below:

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[1] Two stock equations are considered, namely on-farm and off-farm.

Quarter	Future Prices
October – December	December prices for March delivery
January – March	March prices for July delivery
April – June	June prices for September delivery
July – September	September prices for December delivery

PS – (endogenous) quarterly price of soybeans , $ per bu.

QSP – (exogenous in the demand block) quantity of soybeans produced in the U.S.(used in the first quarter only), mil. bu.

As the price of soybeans (PS) increases more soybeans would be expected to be supplied for use and stocks would be depleted. The variable measuring the difference between futures and spot prices is included to account for the speculative demand of the suppliers of storage. The higher the value of this variable the more the amount of stocks held for future resale.

The quantity of soybeans produced occurs in the model as a shifter only in the first quarter of each crop year. It is during this period when capacity constraints in transportation and storage are most likely to become a bottleneck between inventory holders and users. The higher the quantity of soybeans produced the higher the level of stocks held.

The demand for ending commercial stocks also depends on the availability of stocks at the beginning of each quarter. The Nerlovian partial adjustment mechanism as applied in this study illustrates this idea.

$QSS_i^* = \alpha_0 + Z\beta + e_i \quad i=1,2,3\ 4$

but only some fixed fraction (γ) of the desired adjustment is accomplished in one period:

$QSS_i - QSS_{i-1} = \gamma(QSS_i^* - QSS_{i-1}), \quad 0 < \gamma < 1$

where

QSS_i^* = desired ending stocks; QSS_i = actual ending stocks in quarter i and Z is a row vector of explanatory variables in the same quarter. When the two relationships are combined the following equation results:

$QSS_i = \gamma\alpha_0 + Z\gamma\beta + (1-\gamma)QSS_{i-1} + \gamma e_i.$

Note that the new error term is a constant multiple of e_i and maintains the same property of autocorrelation. In the context of the quarterly model long-run equilibrium implies $QSS_i(t)=QSS_i(t-1)$, where t is the crop year. When long-run equilibrium is achieved, ending stocks for the same quarter do not change from year to year.

5.2.2 Soyoil Stock Demand

The structural equation to explain the demand for soyoil stocks is specified as follows:

$QOS = f(D1,D2,D3,QOS_{-1},QSCR,D1*(FPO-PO),....D4*(FPO-PO),$
$D1*PO,...D4*PO)$

where

QOS - (endogenous) quarterly ending stocks of soyoil, mil. lbs.

QOS_{-1} – (predetermined) lagged quarterly ending stocks of soyoil

QSCR – (endogenous) quarterly quantity of soybeans crushed, mil. bu.

FPO – (endogenous) futures price of soyoil quoted for next quarter, ¢/lb.

PO – (endogenous) quarterly average price of soyoil, ¢/lb.

The variable measuring the difference between futures and spot prices (FPO - PO) is included to capture the speculative motives of holding stocks and is expected to affect the dependent variable positively. The effect of the spot price (PO) is expected to be negative since as price rises more quantities of soyoil are sold and less stocks are held.

The expected positive effect of the quantity of soybeans crushed is comparable to the effect of the quantity of soybeans produced on soybean stocks. But inventory holders are less flexible with soyoil stocks than with soybean stocks. This is because unprocessed raw soybeans have more market alternatives which are also growing more rapidly than those for soyoil. The lagged dependent variable is included to capture the adjustment process between the desired and the actual level of stocks held. It is expected to have a positive effect.

5.2.3 Domestic Soymeal Demand

The domestic demand for soymeal is explained by the following structural equation:

$$QMD = f(D1, D2, D3, PM, MCU, PLI, PF/PM, T1)$$

where

QMD – (endogenous) quarterly quantity of soymeal demanded domestically, 1000 short tons

PM – (endogenous) quarterly price of soymeal, $/ton

MCU – (exogenous) quarterly quantity of meal consuming units, see Appendix 1 for detailed calculations

PLI – (exogenous) quarterly index of livestock prices received by farmers, 1967 = 100

PF – (exogenous) quarterly price of fishmeal, $/ton

T1 – (exogenous) quarterly time trend

The explanatory variables used here mainly originate in the feed-livestock sector. The own price (PM) is expected to have a negative effect. The effect of livestock (hogs, cattle and poultry) production is similar to the population effect in any demand relationship. This means the variable measuring the meal consuming units (MCU) is expected to have a positive effect on the quantity of soymeal consumed. Also as the price of livestock increases farmers would be motivated to produce more animals. In the process of trying to produce more animals the demand for feedstuffs would be increased so that the livestock price index (PLI) is expected to have a positive sign. The time trend is included as proxy for the technological changes in livestock feeding practices.

The ratio of U.S. fishmeal price to soymeal price was included to capture the effect of changing relative prices of close substitutes. This variable is expected to have a positive effect. Because of computational constraints this ratio and other ratios in this study were approximated using linear terms in a Taylor's series expansion. The Taylor's series expansion evaluated at the means of X and Y is given by

$$X/Y=\alpha_0+\alpha_1 X-\alpha_2 Y+\mu$$

where

α_0 = mean of X/mean of Y

α_1 = 1/mean of Y

α_2 = mean of X/mean of Y^2

5.2.4 Soyoil Demand

The structural equation to explain the demand for soyoil is specified as

$$QOD=f(D1,D2,D3,PO,Y,POS/PO)$$

where

QOD	–	(endogenous) quarterly quantity of soyoil consumed, mil. lbs.
PO	–	(endogenous) quarterly price of soyoil, ¢/lb.
Y	–	(exogenous) quarterly deflated U.S. disposable income per capita, $.
POS	–	(exogenous) quarterly simple average price of corn oil, peanut oil and cottonseed oil, ¢/lb.

The disposable income per capita was included to account for changes in both population and individual incomes which reflect overall demand growth for vegetable-oil-using products. This variable together with the relative average price of substitutes are expected to have positive effects on the dependent variable.

5.2.5 Crushing Demand

The crushing demand for soybeans is explained by the following equation:

QSCR=f(D1,D2,D3,MCU,CMS,(FPO-PO),(FPM-PM),DV69,DV73)

where

QSCR - (endogenous) quarterly quantity of soybeans crushed, mil.bu.

CMS - (exogenous) quarterly crushing margin for soybeans, ¢/bu.

FPM - (exogenous) futures price of soymeal quoted for next quarter, $/ton

DV69 - (exogenous) U.S. dock strikes, 1969(1) = 1

DV73 - (exogenous) U.S. soybean exports embargo, 1973(3) = 1

D1, D2, D3, MCU, PO, PM, FPO are as explained earlier.

A greater proportion of the crushed soybeans is made up of soymeal which is an important component in animal feedstuffs for its protein content. Thus as more livestock (MCU) are produced more quantities of soybeans would be crushed to produce higher amounts of soymeal. The crushing margin (CMS) on the other hand indicates the profitability of the crushing industry. The higher the profits the stronger the motivation to crush more soybeans. The variable measuring the difference between the futures price and spot price reflects the speculative motives of the crushers. The crusher's demand for soybeans arises because the products of soybean processing, soymeal and soyoil, can be sold into various end-use markets. Since for storable commodities the basis should cover storage and handling charges including profit, the coefficients associated with the respective bases are expected to be positive.

5.2.6 Current Supply for Use

The structural equations for the current supply for use of soybeans and soybean products are given by:

$PS = f(D1,D2,D3,FPS,CSS,DV69,DV73)$

$PM = f(D1,D2,D3,FPM,CSM,DV69,DV73)$

$PO = f(D1,D2,D3,FPO,CSO,DV74)$

where

CSS - (endogenous) commercial supply of soybeans , mil.bu.

CSM - (endogenous) commercial supply of soymeal, 1000 short tons

CSO - (endogenous) commercial supply of soyoil, mil. lbs.

DV74 - (exogenous) dummy for highest soyoil price, 1974 (3) = 1

One of the conditions of profit maximization for any agent involved in production is that:

$C(S)=FP-P$

where

$C(S)$ is the marginal cost of carrying stocks (S) of a given production input and (FP-P) is the respective price basis of the input. Let X be the amount of the input supplied for current use in the production of livestock and other consumption such that $X=S_{t-1}-S$. From the profit maximizing condition considered above:

$$C(S_{t-1}-X)=FP-P$$

so that

$$X=f(FP-P,S_{t-1})$$

is the equation of supply for current use. The supply relation for current utilization is specified for estimation with price of the input (P) on the left-hand side. The sign on the futures price is expected to be positive since this price may be used as the expected price of subsequent future cash price. On the other hand as the quantity supplied for current use increases the price decreases and the sign on the commercial supply variable is expected to be negative. The variables measuring commercial supplies in this study are defined as follows:

CSS = total quantity of soybeans stored at the end of the quarter + quantity exported + quantity crushed

CSM = ending stocks + soymeal exports + soymeal consumed domestically

CSO = ending stocks of oil + soyoil exports + soyoil consumed domestically

5.2.7 Soybean Export Demand

The export demand for soybeans is explained by the following structural equation.

QSEXW = f(D1,D2,D3,DSDR,WPC,MCUF,VALUE,PS/DSDR)

where

QSEXW - (endogenous) quarterly total soybean exports of the U.S., Brazil and Argentina less USSR imports, 100 MT.

DSDR - (exogenous) quarterly quotation of dollars per Special Drawing Rights (SDR)

WPR - (exogenous) quarterly weighted price of corn = $(1-f_1)*PC*39.3679/DSDR+f_1*EPC*DECU/DSDR$

PC - (exogenous) quarterly price of corn in the U.S., \$/bu.

EPC - (exogenous) EC quarterly corn threshold price, European Currency Units (ECU) per MT

DECU - (exogenous) dollars per ECU

f_1 - ratio of quantity of soybeans imported by the EC from the U.S. to the total quantity of soybeans exported by the U.S., Brazil and Argentina

MCUF - (exogenous) meal consuming animal units in EC, Japan and Canada

VALUE - (endogenous) quarterly value of a bushel of soybeans crushed in the U.S divided by DSDR

= $\{(PO/100)*11.0+48*(PM/2000)\}/DSDR$

where 39.3679 = number of bushels per metric ton; 11.0 and 48 are average rates of extraction of soyoil and soymeal per bushel of soybeans crushed. In order to have units of VALUE in dollars per lb. the prices of soyoil and soymeal are divided by 100 and 2000 respectively.

As the U. S. soybean and soybean products prices decline foreign demand for these products trend to increase. But the strengthening of the dollar against foreign currencies partially offsets the impact of the decline of the U.S. domestic farm prices. The SDR rate expressed in U.S. dollars was included as proxy for a composite exchange rate. The sign of this variable is expected to be positive. As was stated earlier, the effect of the livestock production variable is similar to the population effect in the demand relationship. Thus the sign associated with MCUF is expected to be positive.

Although corn and soymeal may not be perfect substitutes they supplement each other in terms of the provision of energy and protein respectively. An increase in the EC threshold price of corn (EPC) makes soymeal a relatively less expensive feed ingredient in the EC. However since Japan does not have a similar policy on corn as the EC and is a significant importer of soybeans it was decided to include the price of corn as a weighted average of U.S. corn and EC corn threshold price.

West Germany and the Netherlands export soymeal and soyoil to other EC member countries. One might argue that an increase in crushing profitability would encourage these countries to import greater quantities of soybeans. Most foreign data were not readily available and the value of the U.S. bushel of soybeans crushed divided by SDR was used as proxy for foreign crusher's profitability. The sign on this variable is expected to be positive.

5.2.8 Soymeal Export Demand

The export demand for soymeal is explained by the following structural equation:

QMEXW = f(D1,D2,D3,MCUF,WPM,T,PFE/PM,QFE)

where

QMEXW - (endogenous) quarterly soymeal exports of the U.S., Brazil and Argentina

WPM - (endogenous) quarterly weighted price of soymeal

= $(1-f_2)$*PM*1.102311/DSDR+f_2*PME*10/DSDR

QFE - (exogenous) quantity of feedgrains produced in the EC, Japan and Canada, mil. MT

T - (exogenous) time trend in quarters

PME - (exogenous) European quarterly import price of soymeal, $/100 kg.

PFE - (exogenous) European quarterly import price of fishmeal, $/100 kg.

f_2 = ratio of quantity of soymeal imported by the EC from the U.S. to the total quantity of soymeal exported by the U.S., Brazil and Argentina

The import price of soymeal was available only at the European ports and it was decided to include a weighted average price of soymeal (WPM) in order to also account for the Japanese response to the variability of soymeal price. The weighted price of soymeal is expected to have a negative sign.

The production of feedgrains (QFE) is a measure of how the degree of self-sufficiency in the EC affects the importation of soymeal. The higher the quantity of feedgrains (oats, corn and sorghum) produced the less quantity of soymeal imported.

The ratio of fishmeal price to soymeal price measures the competing effects of other oilseed-meals. The larger the ratio the higher the amount of soymeal imported.

A variable to reflect changes in livestock-feeding practices could not be found and a time trend (T) is used as a fair approximation for it. The time trend is also presumed to capture changes in the processing technology.

The export section of this study excluded the oil export demand. The main reason for exclusion is that PL480 concessional exports dominate U.S. foreign oil trade and quarterly data for these exports were not readily available. The other reason for exclusion is that much of U.S. oil trade through commercial channels is with developing countries whose data are not readily available. The third factor for exclusion is that normally the crushing of soybeans is derived from soymeal such that soyoil is mainly a by-product.

5.2.9 Soybean Production

In order to perform long-range forecasting it is important that soybean production be incorporated and determined within the system. The yield of soybeans per acre is assumed exogenous to the system. The acreage response equation is presented below:

$$\begin{aligned} ACS_t = {} & \gamma_0 + \gamma_1 T2 + \gamma_2 (D1*PSL)_t + \gamma_3 (D1*PCL/PSL)_t + \gamma_4 ACS_{t-1} + \\ & \gamma_5 (D1*PCS/PSS)_t + e_t , \qquad t = 1, 2, \ldots T \end{aligned}$$

where

ACS – (endogenous) annual acreage of soybeans, mil. acres.

T2 – (exogenous) time trend in years

PSL – (exogenous) lagged price of soybeans, \$/bu.

PCL – (exogenous) lagged price of corn once, \$/bu.

PCS – (exogenous) corn price support, \$/bu.

PSS – (exogenous) soybean price support, \$/bu.

ACS_{t-1} – (exogenous) lagged acreage of soybeans.

Since our main interest is to estimate soybean production for the quarterly model this variable can be calculated as the product of acreage and yield per acre. However, because of computational constraints a linearized version of this identity is employed (Houck et al.). Using a Taylor series expansion in the neighborhood of the means the following linear version of soybean production is obtained:

$$
\begin{aligned}
QSP &= YLD * ACS \\
&\doteq \beta_0 + \beta_1 YLD + \beta_2 T2 + \beta_3 D1*PSL + \beta_4 ACS_{-1} + \beta_5 D1*PCL/PSL + \\
&\quad \beta_6 D1*PCS/PSS + V
\end{aligned}
$$

where

YLD – (exogenous) yield of soybeans per acre.

The aggregate supply function just defined is a horizontal summation of the six regional supply functions. The five main regions include, the Lake States, the Corn Belt, the Plains States, the Delta States and the Atlantic State.

The supply of soybeans (QSP) is determined within the supply block for a given year t and enters the demand block as predetermined to influence the level of soybean price (PS) for that crop year. This price of soybeans then influences the supply block in the following crop year t + 1 through a lagged relationship. This produces a new supply in crop year t + 2 which enters the demand block and the process continues. This process of action and reaction between demand and supply blocks is illustrated in Figure 4.

The ratio of corn price to soybean price (PCL/PSL and PCS/PSS) are included to account for the competing effects of corn and other related agricultural crops. Since these crops compete for production resources the coefficients on the variables are expected to have negative signs. The variable measuring time trend (T2) is included to account for changes in production technology and its effect is expected to be positive. The own lagged price (PCL) is used to reflect the expectations of producers. This assumes the market prices ruling at the time production decisions are made will prevail until harvest time. In order to link the annual production to the quarterly model the quarterly prices need to be joined to the crop year average price. This is accomplished by calculating a simple average of the four estimated quarterly prices just before the time production decisions are made. It is expected this variable will have a positive effect.The physical and technical relationship contained within the model include the following:

QOP = 11*QSCR

CSO = QOD+QOS+QOEX

QMP = 24*QSCR

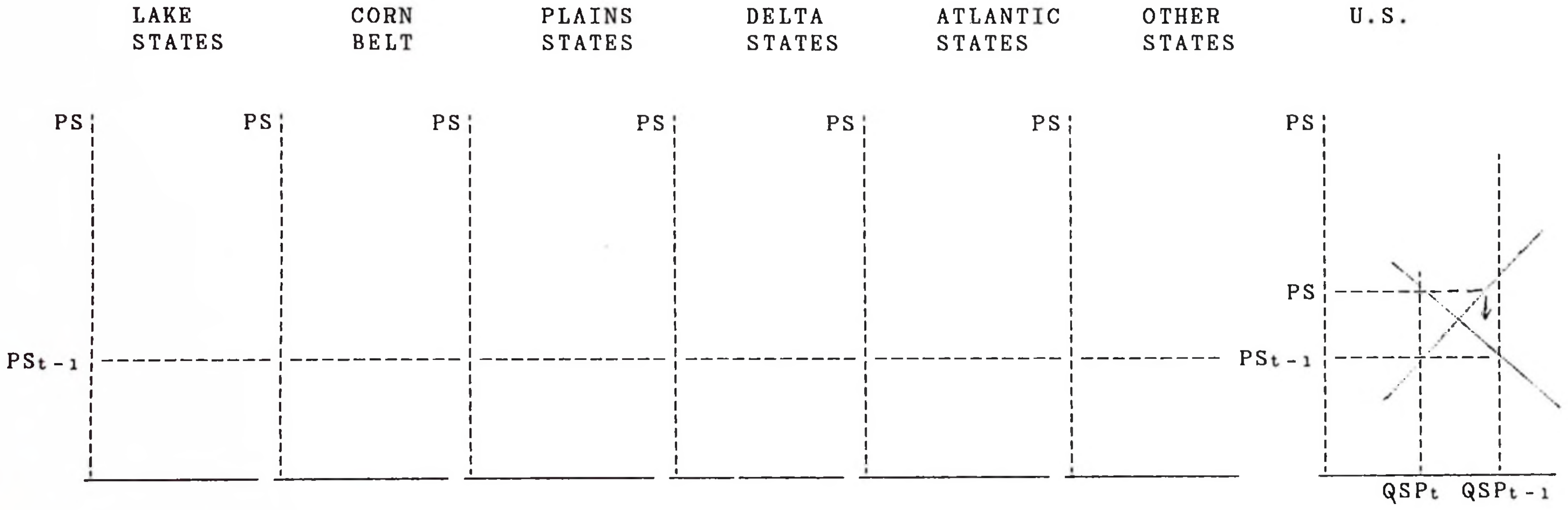


FIGURE 4: MODEL DEPICTING AGGREGATION OF REGIONAL SUPPLY FUNCTIONS

$CSM = QUMD+QMS+QMEX$

$BPS = FPS-PS$

$QSEXW = QSEX+QSEXB-QSSOV$

$CSS = TQSS+QSZEX+QSCR$

$QMEXW = QMEX+QMEXB$

$BPM = FPM-PM$

$BPO = FPO-PO$

$QMP = QMD+QMS+QMEX-QMS_{-1}$

$QSP+TQSS_{-1} = QSCR+TQSS+QSEX$

$QOP = QOD+QOS+QOEX-QOS_{-1}$

where

BPS – (endogenous) quarterly soybean price basis

QOP – (endogenous) quarterly quantity of soyoil produced, mil.lbs.

BPO – (endogenous) quarterly soyoil price basis

QMP – (endogenous) quarterly quantity of soymeal produced, 1000 tons

BPM – (exogenous) quarterly soymeal price basis

QSEX – (endogenous) quarterly quantity of soybeans exported from U.S., mil. bu.

QSSOV – (exogenous) total soybean imports by the Soviet Union

QMEX – (endogenous) quarterly quantity of soymeal exported from U.S., 1000 tons

QSEXB – (exogenous) total quarterly soybeans exported by Brazil and Argentina

TQSS - (endogenous) total quarterly ending stocks of soybeans, mil. bu.

QMEXB - (exogenous) total quarterly soymeal exported by Brazil and Argentina

QOEX - (exogenous) quarterly quantity of soyoil exported from U.S., mil. lbs.

QSCR, QSP, CSS, CSM, CSO, QMEXW, QSEXW, QMD, QMS, QOD and QOS are as defined above.

QOP and QMP mean that soyoil and soymeal production in each quarter depend upon the amount of soybeans crushed and average yields of oil and meal per bushel. The latter is fixed by technological considerations at 11 pounds of soyoil and 48 pounds of meal. Since the quantity crushed is measured in bushels, the quantity of soyoil produced is obtained simply as a product of yield per bushel and bushels crushed. On the other hand the quantity of soymeal produced is measured in 1000 short tons such that necessary adjustments are required. These adjustments are such that QMP = 48 x QSCR x 1000/2000 = 24 x QSCR.

The last three identities are market clearing identities which ensure that total demand for beans, meal and oil in all outlets will be equivalent to total supplies for each quarter.

5.3 Simultaneous Specification

The procedure for simultaneous specification is as suggested by Gordon Rausser et al. Consider a G simultaneous equation system given by

$Y\Gamma + X\theta = \mu$

where

Y is a TxG matrix of T observations on G endogenous variables; Γ is a conformable GxG parameter matrix; X is a TxK matrix of sample values of predetermined variables; θ is the corresponding KxG parameter martix and μ is the matrix formed by the T disturbance vectors of G equations. It is assumed that the row vectors corresponding to values for the G disturbances associated with a particular observation have expectation zero and are only contemporaneously correlated, i.e.

1. $E(\underline{\mu}_t')=\underline{0}'$ and $E(\underline{\mu}_t\underline{\mu}_{t}')=\Sigma$ for $t=t'$, 0 otherwise

where $\underline{\mu}_t'$ is the t^{th} row vector from μ . It is also assumed that X is of full rank and Γ is non-singular.

To introduce the variational parameter specification and sticking to the exclusion restriction i.e. setting each of the n elements along the principal diagonal of the Γ matrix equal to -1, the g^{th} equation can be expressed as

2. $\underline{y}_g = Y_g\underline{\gamma}_g + X_g\underline{\theta}_g + \underline{\mu}_g$

where $\underline{y}_g$ is a vector of T observations on the endogenous variable selected for normalization; Y_g and X_g are matrices of T observations on the included endogenous (less the one selected for normalization) and predetermined variables respectively; $\underline{\gamma}_g$ and $\underline{\theta}_g$ are the appropriate parameter vectors and $\underline{\mu}_g$ is the Tx1 vector of structural disturbances.

Now define the matrix

3. $S_g=(Y_g \quad X_g)$ and the vector

4. $\underline{\beta}_g=(\underline{\gamma}_g \quad \underline{\theta}_g)$

Thus equation 2 can be written as

5. $\underline{y}_g = S_g \underline{\beta}_g + \underline{\mu}_g$

and so the G equations in the system could be expressed as

6. $\underline{y} = S\underline{\beta} + \underline{\mu}$

where the following stacking and partitioning conventions have been employed:

$\underline{y}' = (\underline{y}_1' \ldots . \underline{y}_G')$

$\underline{\mu}' = (\underline{\mu}'_1 \ldots \underline{\mu}'_G)$

$\underline{\beta}' = (\underline{\beta}'_1 \ldots \underline{\beta}'_G)$

$$S = \begin{matrix} S_1 & & & \\ & S_2 & & \\ & & \ddots & \\ & & & S_G \end{matrix}$$

Thus the previous assumptions on the structural disturbances imply

7. $E(\underline{\mu}) = \underline{0}$ and $E(\underline{\mu}\;\underline{\mu}') = \Sigma \otimes I$

By first subscripting the vector β, the variational parameter specification for the t^{th} observation in equation g is

8. $y_{gt} = S_{gt} \underline{\beta}_{gt} + \mu_{gt}$

Similarly for the g^{th} equation we have

9. $\underline{y}_g = S^d_g \underline{\beta}_g + \underline{\mu}_g$

where $S^d_g = \mathrm{diag}(S_{gt})$ is a $T\mathrm{x}(T\mathrm{x}g^*)$ matrix.

$\underline{\beta}_g' = (\underline{\beta}'_{g1} \ldots \underline{\beta}'_{gT})$; $\underline{\beta}_{gt}$ is a $g^*\mathrm{x}1$ vector of parameter values implied by the variational structure on the g* included right-hand side endogenous and predetermined variables. $\underline{y}_g$ and $\underline{\mu}_g$ are each T component vectors.

Let

10. $\underline{\beta}_{gt} = \underline{\beta}_{g0} + \underline{Z}'_{gt}\underline{\alpha}_{gt} + \underline{e}_{gt}$

where $\underline{Z}_{gt}$ is a column vector of exogenous variables and $\underline{\alpha}_{gt}$ are parameters representing the outside effect of $\underline{Z}_{gt}$ on $\underline{\beta}_{gt}$. When the effect is not present, $\underline{\beta}_{gt}$ is random with mean $\underline{\beta}_{g0}$ and error $\underline{e}_{gt}$. In the most special case when the variance of $\underline{e}_{gt}$ is zero and the effects of $\underline{Z}_{gt}$ are not present, $\underline{\beta}_{gt}$ is constant as in the usual regression analysis formulation.

For the above formulation the generalized version of the variational parameter for the g^{th} equation is given by:

11. $\underline{\beta}_g = (1\otimes\underline{\beta}_{g0}) + Z_g\underline{\alpha}_g + \underline{e}_g$ where $\underline{\beta}_{g0}$ is a g^*x1 vector representing the mean value of $\underline{\beta}_{gt}$ for zero values of Z_{gt}; 1 is a T component of ones; $\underline{e}'_g = (\underline{e}'_{g1}\ldots\underline{e}'_{gt})$ and

$$Z_g = \begin{matrix} I_{g*}\otimes\underline{Z}_{g1} \\ \\ I_{g*}\otimes\underline{Z}_{gT} \end{matrix}$$

is a Tg*xmg* matrix; $Z_{gt} = (Z_{g1t}\ldots\ldots Z_{gmt})$. Here m is the number of exogenous variables (less the constant) influencing the structural coefficients.

Combining 9 and 11 we get

12. $\underline{y}_g = S_g\underline{\beta}_{g0} + \underline{S}^d_g Z_g\underline{\alpha}_g + (S^d_g\underline{e}_g + \underline{\mu}_g)$

where

$$S_g = \begin{matrix} S'_{g1} \\ \\ S'_{gT} \end{matrix}$$

By letting

13. $S^+_g = (S_g \quad S^d_g Z_g)$

14. $\underline{\beta}_g^+ = (\underline{\beta}_{g0}' \quad \underline{\alpha}_g)$

15. $\underline{\mu}_g^+ = (S_g^d \underline{e}_g + \underline{\mu}_g)$

the equation with the structure for the variational parameters imposed is

16. $\underline{y}_g = S_g^+ \underline{\beta}_g^+ + \underline{\mu}_g^+$

The dimension of the parameter vector is now $g^* + j_g$ with j_g determined by the number of extraneous variables.

Identification

The nature of the identification problem introduced by the varying parameter structure is suggested by the expanded number of variables in S_g^+. The source of identifiability complication is the extraneous variables Z_g and the parameters that must be estimated on the new endogenous variables. If S_g^d is partitioned as $(Y_g^d \quad X_g^d)$ then the equations identifying the new endogenous variables are

17. $Y_g^d Z_g = Y_g^*$

where S_g^d and Z_g have been so defined that the first j_{g1} variables corresponding to the parameter vector $\underline{\alpha}_g$ are products of the extraneous variables with the included endogenous variables. Thus, the condition for the g^{th} reparameterized equation to be identified is $g_\theta + j_{g2} \geq g + j_{g1}$ where g denotes the number of right-hand-side endogenous variables included in the constant parameter version of equation g; g_θ denotes the number of included exogenous variables. Therefore $g^* = g + g_\theta$. This also assumes that the rank of the expanded set of predetermined variables is equal to $g_\theta + j_{g2}$ and that the non-linear identities associated with j_{g1} equations defining Y_g^* have been added to the simultaneous system. The j_{g1} equations can be added to the system without destroying the basic linearity by using a first-order Taylor's series expansion of expression 17. The expansion is to be taken at the means and the resulting expression is similar to $\bar{X}Y + \bar{Y}X - \overline{XY}$ which is a linear approximation of XY.

The difficulty with the specification just given is that the composite error term $\underline{\mu}_g^+$ is heteroskedastic. To deal with it one has to estimate various variance components, but in practice there is no guarantee that all of these components will be nonnegative as expected. Another problem is that there are no readily available computational routines to deal with this type of heteroskedasticity in a simultaneous system.

The operational complexities of the above formulation has prompted this study to consider the error term $\underline{e}_g$ as zero in the varying parameter specification. According to this specification equation (11) becomes

18. $\underline{\beta}_g = (1 \otimes \underline{\beta}_{g0}) + Z_g \underline{\alpha}_g$

(15) changes to

19. $\underline{\mu}_g^+ = \underline{\mu}_g$

and (16) the structural equation with the variational parameters imposed becomes

20. $\underline{y}_g = S_g^+ \underline{\beta}_g^+ + \underline{\mu}_g^+$

Though the estimate of $\underline{\beta}_g^+$ is still unbiased it is inefficient relative to the <u>appropriate</u> Aitken estimator. But the possibility of nonnegativity for some variance components makes this appropriate Aitken estimator suspect. It is also important to note that the specification given by (18) is not entirely new but is a modification of the Goldfeld and Quandt switching regression model. The difference is that in the latter the switch occurs after one time whereas in this model it occurs every quarter.

It is an accepted fact that the growth of Brazilian production and export of soybeans and soybean products has eroded the U.S. dominance of the world soybean market. While Brazil produced less than 1 percent in the early 1960's its soybean production has grown to over 15 percent of the world production and by 1977 it exported more soymeal and about the same amount of soyoil as the U.S. (Williams, W.G. and R.L.Thompson). Williams et al. also state that despite the increased production and exports Brazilian policies towards its soybean industry have failed to achieve the intended results. It is argued that these policies have largely benefited the U.S. by boosting world prices of soybeans and lowering those of soybean products. As a consequence the U.S. has increased production, use and exports of soybeans and soybean products (Williams et al.)

The fact that Brazil is a competitor in the world market and with policies that can influence the domestic market of the U.S. has prompted this study to consider the Brazilian soymeal exports as one of the explanatory variables in the varying parameter specification. Also since the parameter coefficients are hypothesized to change over time, time trend constituted the second explanatory variable. The time trend hopefully will account for improvements in processing techniques, changing tastes and composition of feedstuffs. The use of calendar time to explain β_g can be justified in the same way as when time-trend variables are included in regression models. These variables act as surrogates for all the unknown time-related dynamic forces within the economy (Singh, Nagar, Choudry and Raj). Thus the inclusion of the time trend within this framework acts as a proxy for the error term in the variational parameter specification.

When the Brazilian soymeal exports and time trend are substituted the varying parameter specification becomes

$$\beta_g = \beta_{g0} + \underline{\alpha}_1 QMEXBR + \underline{\alpha}_2 T1$$

where

QMEXBR = quarterly quantity of soymeal exported by Brazil, 1000 MT

T1 = quarterly time trend

When the effects of QMEXBR and T1 are not present i.e. $\alpha_1 = \alpha_2 = 0$, β_g is constant (β_{g0}) as in the usual regression analysis formulation. The effects of QMEXBR stem from a combination of production, exports and government policies such that the sign on α_1 may not be specified a priori. Also the nature of the role played by T1 does not guarantee any prior specification of the expected sign of α_2. However the expected sign of the varying parameter β_g is known a priori according to economic theory.

5.4 Multicollinearity, Autocorrelation and Data Problems

It is a fact that the non-experimental nature of the social science discipline encounters many problems in attempting to apply empirical methods to examine economic hypotheses. The most common problem encountered when using data that is passively generated is multicollinearity. Some of the consequences of this collinearity include the following:

a) precise estimates of the separate effects may be very difficult to get. This lack of precision is manifested by the existence of large sampling errors that follow from the large sampling variances of the estimated coefficients

b) estimates of coefficients may be very sensitive to the addition or deletion of a few observations or the deletion of an apparently insignificant variable

c) despite the difficulties encountered in isolating the effects of individual variables from such a sample accurate forecasts may still be possible even outside the sample (Judge et al.)

Conceptually the regressions selected for the varying parameter model are expected to pose more multicollinearity problems than those chosen for the fixed parameter model. This is because the variables whose coefficients are assumed to vary are included in a given equation together with the same variables multiplied by the time trend and Brazilian soymeal exports.

Autocorrelation is naturally expected because the data used are time series. However, because of the smallness of the sample size no attempt other than the varying parameter model specification will be made to account for autocorrelation.

In the real world Brazilian data should be endogenized along with their counterpart data of the U.S. For the current study this is not possible because relevant data on the Brazilian soybean industry e.g. prices, stocks, policy variables and domestic utilization, etc. are not readily available.

Most of the U.S. data are available but PL480 soyoil exports are not available on a quarterly basis. Also most of the relevant foreign data are not available on a quarterly basis.

Also the data used in the statistical estimation will not be deflated because data in the time series framework are more natural. When data are in their natural setting (i.e. nominal data), it is more appropriate for forecasting purposes after which suitable policies can be determined to deal with inflationary problems.

CHAPTER 6

THE STATISTICAL MODEL AND RESULTS

There are several estimation methods that can be used to estimate a system of simultaneous equations that were specified in the last chapter. In this study structural coefficients were obtained using ordinary least squares (OLS), two-stage least squares (2SLS) and three-stage least squares (3SLS). Since two-stage least squares is a limited information method, 3SLS may be expected to produce more efficient estimates than the 2SLS (Zellner and Theil). But it should be noted that the efficient results of 3SLS depend upon the correct specification of the complete system. However, as is typical of most economic models there might be reasons to suspect that not all the relationships specified are stated correctly (Houck et al.). Hence results of both the 2SLS and 3SLS methods are presented, but the reported results will be based on 2SLS estimates.

6.1 Selection of Variables

The variables in the final estimation were maintained based on the consistency of signs with the theoretical expectations. The same type of variables were considered in the fixed and varying parameter models in order to make model comparison more meaningful.

It was stated in the previous chapter that varying coefficient models are appropriate when sample data cannot be pooled and when fixed coefficient models suffer from misspecifications caused by omitted variables, proxy variables, aggregate data and non-linear relationships. This is the reason why both the endogenous and exogenous variables were examined for incorporation into the varying parameter model.

The explanatory variables with varying parameters were selected for the preliminary regression analysis by examination of the plots of each explanatory variable against the left-hand side endogenous variable. The variables for which the graphed plots did not fall in a straight band were considered in the preliminary analysis as being associated with varying coefficients. The variables with varying coefficients were maintained for further analysis based on the consistency of signs with expectations. Let the equation of the varying coefficient be specified as $\beta=\alpha_0+\alpha_1 \text{T1}+\alpha_2 \text{QMEXBR}$, where T1 and QMEXBR are time trend and quarterly soymeal exports by Brazil respectively. The first test of consistency is that the sign of the constant term (α_0) be the same as the theoretically expected sign of β. When α_0 and α_1 have opposite signs from α_2 the procedure of finding the consistent sign of β involves plugging into the equation of β the maximum value of QMEXBR and the corresponding value of T1 and vice versa. If both α_1 and α_2 have signs different from α_0 the search for the consistent sign involves using the maximum and corresponding values of T1 and QMEXBR alternately. The identification of both models by order condition are given in Appendix C.

6.2 Discussion of Results

6.2.1 The Soybean Stock Demands

The commercial soybean stocks were differentiated according to location, on-farm and off-farm. The ending stocks for the third and fourth quarters were obtained by subtracting the amount of soybeans exported and crushed in June and September from the June 1 and September 1 stocks.

Both types of stocks are expected to be influenced by soybean basis, price of soybeans, quantity of soybeans produced and quantity of soybeans stored in the previous quarter.

The econometric results for the soybean stock demands are given in Tables 3 and 4. No price effects could be estimated in the first quarter for both the fixed and varying parameter equations. Perhaps the price effects are overshadowed by the new soybean crop produced in the first quarter. The price effects were also non-significant in the second quarter, but statistically significant in the third and fourth quarters.

The adjustment responses in the fixed parameter model specification are given by 0.73 and 0.65 for off-farm and on-farm stock demands respectively. On the other hand, the coefficient of 0.99 associated with the off-farm lagged stocks may appear as not making sense in the varying parameter model. However in the context of a varying parameter model it represents a constant term which, when combined with the coefficients of time trend and Brazilian soymeal exports, gives the total effect of the lagged stocks. It is the total rather than the

TABLE 3: STATISTICAL RESULTS OF U. S. DEMAND FOR OFF-FARM STOCKS (OFFQSS)
(t-statistics in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Fixed	Varying	Fixed	Varying	Fixed	Varying
Constant	-37.64 (-2.00)	-101.98 (-5.00)	-19.26 (-1.15)	-98.18 (-4.64)	-23.45 (-1.60)	-107.45 (-6.13)
D1	113.27 (3.78)	168.94 (5.92)	101.12 (3.27)	166.03 (5.72)	116.18 (4.52)	174.70 (7.04)
OFFQSS$_{-1}$	0.73 (23.94)	1.00 (14.44)	0.73 (21.71)	0.99 (13.89)	0.75 (26.91)	1.02 (17.46)
D2*(FPS-PS)	28.74 (1.41)	46.29 (2.51)	4.36 (0.14)	40.67 (1.80)	-15.05 (-0.57)	25.86 (1.38)
D3*PS	-11.83 (-5.86)	-6.52 (-3.13)	-13.72 (-5.97)	-7.01 (-3.14)	-15.23 (-7.52)	-7.42 (-4.0)
D4*PS	-9.79 (-4.0)	-0.25 (-0.83)	-12.50 (-4.64)	-0.92 (-0.29)	-12.57 (-5.29)	-0.21 (-0.08)
QSP	0.32 (17.35)	0.33 (20.33)	0.32 (16.98)	0.33 (20.22)	0.31 (19.15)	0.33 (22.85)
T1*OFFQSS$_{-1}$		-0.0047 (-2.68)		-0.0044 (-2.45)		-0.00397 (-2.66)
QMEXBR*OFFQSS$_{-1}$		0.00003 (0.95)		0.000028 (0.83)		0.0000089 (0.32)
	$\bar{R}^2$=0.98 D·W=1.50 h=2.13	$\bar{R}^2$=0.98 D·W=1.77 h=1.16				

TABLE 4: STATISTICAL RESULTS OF U. S. DEMAND FOR ON-FARM STOCKS (ONQSS)

(t-statistics in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Fixed	Varying	Fixed	Varying	Fixed	Varying
Constant	-20.48 (-1.56)	-6.69 (-0.31)	-18.32 (-1.37)	7.88 (0.35)	-19.14 (-1.73)	11.43 (0.70)
D1	-78.54 (-2.51)	-93.31 (-2.87)	-80.05 (-2.54)	-105.54 (-3.18)	-99.23 (-4.66)	-94.28 (-4.02)
D2*PS	-0.83 (-0.18)	-0.37 (-0.08)	-2.23 (-0.43)	-2.30 (-0.5)	-0.47 (-0.12)	-3.65 (-1.08)
D3*PS	-9.02 (-2.92)	-10.11 (-2.95)	-10.79 (-3.26)	-10.70 (-3.02)	-10.99 (-4.35)	-10.61 (-4.03)
D4*PS	-7.19 (-2.64)	-7.85 (-2.02)	-7.59 (-2.09)	-10.09 (-2.50)	-6.84 (-3.05)	-10.92 (-3.72)
ONQSS_{-1}	0.65 (14.99)	0.66 (6.44)	0.66 (13.64)	0.59 (5.45)	0.66 (19.13)	0.56 (7.55)
QSP	0.42 (21.06)	0.43 (23.05)	0.42 (20.87)	0.43 (22.71)	0.44 (30.19)	0.41 (29.87)
T1*ONQSS_{-1}		-0.0044 (-1.72)		-0.0033 (-1.26)		-0.0031 (-1.66)
QMEXBR*ONQSS_{-1}		0.00013 (3.00)		0.00012 (2.76)		0.00012 (3.93)
	$\bar{R}^2=0.98$ D·W=1.79 h=0.93	$\bar{R}^2=0.98$ D·W=1.79 h=1.61				

partial effects of the lagged stocks that is important for forecasting and policy making purposes.

The coefficients of 0.3 and 0.4 associated with soybean production in the off-farm and on-farm equations were similar for both models. The elasticities of soybean production were respectively calculated as 0.33 and 0.57. Thus, although the level of on-farm stocks is lower than that of off-farm stocks, the former stocks are relatively more responsive to soybean production.

The interpretation of the price elasticity of demand for stocks is somewhat more complex. As an illustration the behavioral stock equations are written in a schematic form as follows:

$$S(1) = \alpha_0 + \alpha_1 PS(1) + \alpha_2 S(4)$$

$$S(2) = \delta_0 + \delta_1 PS(2) + \delta_2 S(1)$$

$$S(3) = \gamma_0 + \gamma_1 PS(3) + \gamma_2 S(2)$$

$$S(4) = \beta_0 + \beta_1 PS(4) + \beta_2 S(3)$$

Evaluation of α_1, δ_1, γ_1, and β_1 at the data means yields the straight forward short-run (immediate impact) price elasticities. On the other hand the long-run elasticities when lags are involved are more difficult to obtain. The long-run equilibrium in the quarterly model does not imply that $S(i)=S(i-1)$ but rather that $S(i)_t=S(i)_{t-1}$. This is because the structural equations, including those of stocks, may differ from quarter to quarter (Subotnik et al.). If we assume the price change is sustained in all quarters for an indefinite period, the long-run elasticities can be developed from the following derivatives:

$$\partial S(1)/\partial PS=\alpha_1+\alpha_2\,\partial S(4)/\partial PS$$

$$\partial S(2)/\partial PS=\delta_1+\delta_2\,\partial S(1)/\partial PS$$

$$\partial S(3)/\partial PS=\gamma_1+\gamma_2\,\partial S(2)/\partial PS$$

$$\partial S(4)/\partial PS=\beta_1+\beta_2\,\partial S(3)/\partial PS$$

By repeated substitutions the above expressions become:

$$\partial S(1)/\partial PS=\{\alpha_1+\alpha_2(\beta_1+\beta_2(\gamma_1+\gamma_2\delta_1))\}/(1-\beta_2\gamma_2\delta_2\alpha_2)$$

$$\partial S(2)/\partial PS=\{\delta_1+\delta_2(\alpha_1+\alpha_2(\beta_1+\beta_2\gamma_1))\}/(1-\beta_2\gamma_2\delta_2\alpha_2)$$

$$\partial S(3)/\partial PS=\{\gamma_1+\gamma_2(\delta_1+\delta_2(\alpha_1+\alpha_2\beta_1))\}/(1-\beta_2\gamma_2\delta_2\alpha_2)$$

$$\partial S(4)/\partial PS=\{\beta_1+\beta_2(\gamma_1+\gamma_2(\delta_1+\delta_2\alpha_1))\}/(1-\beta_2\gamma_2\delta_2\alpha_2)$$

In the constant coefficient model for both the off- and on-farm stock, $\alpha_2=\delta_2=\gamma_2=\beta_2$. On the other hand $\alpha_1=\delta_1=0$ in the off-farm stock equation and $\alpha_1=0$ in case of the on-farm stocks.

In the case of the varying coefficient model, long-run elasticities are even more difficult to obtain because of the presence of multiplicative terms involving the lagged stocks. However, similar to the previous situation, the behavioral stock equations are written in the schematic form as follows:

$$S(1)=\alpha_0+\alpha_1 PS(1)+\alpha_2 S(4)+\alpha_3 T1*S(4)+\alpha_4 QMEXBR*S(4)$$

$$S(2)=\delta_0+\delta_1 PS(2)+\delta_2 S(1)+\delta_3 T1*S(1)+\delta_4 QMEXBR*S(1)$$

$$S(3)=\gamma_0+\gamma_1 PS(3)+\gamma_2 S(2)+\gamma_3 T1*S(2)+\gamma_4 QMEXBR*S(2)$$

$$S(4)=\beta_0+\beta_1 PS(4)+\beta_2 S(3)+\beta_3 T1*S(3)+\beta_4 QMEXBR*S(3)$$

Taking derivatives with respect to PS with $\partial QMEXBR/\partial PS=\partial T1/\partial PS=0$ and with repeated substitutions we get:

$$\partial S(1)/\partial PS=\{\alpha_1+\beta_1 D1+\gamma_1 D1D4+\delta_1 D1D3D4\}/(1-D1D2D3D4)$$

$$\partial S(2)/\partial PS=\{\delta_1+\alpha_1 D2+\beta_1 D1D2+\gamma_1 D1D2D4\}/(1-D1D2D3D4)$$

$$\partial S(3)/\partial PS=\{\gamma_1+\delta_1 D3+\alpha_1 D2D3+\beta_1 D1D2D3\}/(1-D1D2D3D4)$$

$$\partial S(4)/\partial PS=\{\beta_1+\gamma_1 D4+\delta_1 D3D4+\alpha_1 D2D3D4\}/(1-D1D2D3D4)$$

where

$$D1 = \alpha_2 + \alpha_3 * T1 + \alpha_4 * QMEXBR$$

$$D2 = \delta_2 + \delta_3 * T1 + \delta_4 * QMEXBR$$

$$D3 = \gamma_2 + \gamma_3 * T1 + \gamma_4 * QMEXBR$$

$$D4 = \beta_2 + \beta_3 * T1 + \beta_4 * QMEXBR$$

Also like in the fixed coefficient model $\alpha_2 = \delta_2 = \gamma_2 = \beta_2$, $\alpha_1 = \delta_1 = 0$ for the off-farm stocks and $\alpha_1 = 0$ for the on-farm stocks.

Table 5 contains the short and long-run elasticities for the constant and varying coefficient models. In order to simplify the interpretation of the long-run varying price elasticities, the calculations were based on the quarterly mean values of the variables influencing the varying coefficients. These mean values were taken at four equally spaced periods of the sample starting with 1965/66 crop year. These different time periods were 1965/66 - 1968/69, 1969/70 - 1972/73, 1973/74 - 1976/77 and 1977/78 -1980/81.

The calculated elasticities for the off-farm stock equation, indicate that the short-run basis elasticity (0.0012)from the fixed parameter model is considerably more inelastic than that calculated from the varying parameter model (0.011). However, the short-run own price elasticities from the varying parameter model are less elastic than those obtained from the fixed parameter model. The long-run fixed elasticities are more elastic than the short-run fixed elasticities. On the other hand, the long-run varying elasticities (both basis and own price) becomes more inelastic over time with the tendency to diverge away from the long-run fixed elasticities.

TABLE 5: SHORT-RUN AND LONG-RUN PRICE ELASTICITIES OF DEMAND FOR SOYBEAN STOCKS.

(i) Off-farm location.

		2nd Quarter[1]		3rd Quarter		4th Quarter	
Short-run:	Fixed	0.0012		-0.05		-0.05	
	Varying	0.011		-0.03		-0.004	
Long-run:	Fixed	0.016		-0.11		-0.12	
	Varying	0.047[a]	T1 = 12 QMEXBR = 40	-0.139[a]	T1 = 13 QMEXBR = 50	-0.116[a]	T1 = 14 QMEXBR = 58
		0.025[b]	T1 = 28 QMEXBR = 198	-0.072[b]	T1 = 29 QMEXBR = 377	-0.063[b]	T1 = 30 QMEX = 288
		0.019[c]	T1 = 44 QMEXBR = 816	-0.056[c]	T1 = 45 QMEXBR = 1181	-0.048[c]	T1 = 46 QM = 1163
		0.017[d]	T1 = 60 QMEXBR = 2036	-0.046[d]	T1 = 61 QMEXBR = 1996	-0.036[d]	T1 = 62 QM = 1376

[1] These elasticities reflect the influence of Basis on stocks.

[a] Time period is 1965/66-1968/69.

[b] Time period is 1969/70-1972/73.

[c] Time period is 1973/74-1976/77.

[d] Time period is 1977/78-1980/81.

TABLE 5 (continued): SHORT-RUN AND LONG-RUN PRICE ELASTICITIES OF DEMAND FOR SOYBEAN STOCKS.

(ii) On-farm location.

		2nd Quarter	3rd Quarter	4th Quarter
Short-run:	Fixed	-0.011	-0.06	-0.04
	Varying	-0.012	-0.05	-0.05
Long-run:	Fixed	-0.053	-0.09	-0.10
	Varying	-0.04[a] T1 = 12 QM = 40	-0.077[a] T1 = 13 QM = 50	-0.093[a] T1 = 14 QM = 58
		-0.035[b] T1 = 28 QM = 198	-0.075[b] T1 = 29 QM = 377	-0.089[b] T1 = 30 QM = 288
		-0.038[c] T1 = 44 QM = 816	-0.085[c] T1 = 45 QM = 1181	-0.097[c] T1 = 46 QM = 1163
		-0.055[d] T1 = 60 QM = 2036	-0.088[d] T1 = 61 QM = 19996	-0.093[d] T1 = 62 QM = 1376

[a] Time period is 1965/66-1968/69.
[b] Time period is 1969/70-1972/73.
[c] Time period is 1973/74-1976/77.
[d] Time period is 1977/78-1980/81.

The calculated elasticities for the on-farm stock equation indicate that the short-run elasticities from the fixed parameter model were almost identical to short-run elasticities from the varying parameter model. The long-run fixed elasticities are more elastic than the short-run fixed elasticities. On the other hand, the long-run varying elasticities also maintained almost the same degree of elasticity over the sub-samples but with very modest tendency to become more elastic. The long-run varying elasticity in the fourth quarter demonstrated a slightly more elastic response. In general the long-run varying elasticities have tended to converge towards the long-run fixed elasticities.

6.2.2 Soyoil Stock Demand

The soyoil ending inventory (QOS) was specified to depend on own price (PO), soyoil price basis (FPO-PO), quantity of soybeans crushed (QSCR) and beginning stocks of soyoil (QOS_{-1}).

The results of the soyoil inventory relationships are given in Table 6. The soyoil price basis does not seem to significantly affect the amount of soyoil stocks held in the constant parameter model specification. On the other hand, soyoil price basis affects significantly the soyoil stock demand in the first quarter in the varying parameter specification. The empirical results indicate that the adjustment process seems faster in the constant parameter model but tends to become more rapid in the varying parameter model specification following the increase in Brazilian soymeal exports. In the soyoil stock relationships the influence of soybeans crushed is assumed

TABLE 6: STATISTICAL RESULTS OF U.S. DEMAND FOR SOYOIL STOCKS (QOS)
(t-statistic in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant term	-162.92 (-2.70)	-222.95 (-1.26)	-152.64 (-2.46)	-67.10 (-0.34)	-145.10 (-2.48)	-158.42 (-1.22)
QSCR	2.16 (5.52)	3.08 (2.26)	1.99 (4.59)	1.95 (1.30)	1.90 (4.82)	2.72 (2.74)
QOS_{-1}	0.79 (15.14)	0.69 (4.85)	0.82 (12.66)	0.68 (4.64)	0.82 (14.36)	0.66 (7.14)
D1*(FPO-PO)	27.21 (1.16)	56.19 (2.14)	10.28 (0.33)	64.09 (2.03)	3.23 (0.12)	54.86 (2.80)
D2*(FPO-PO)	31.44 (2.10)	36.31 (2.45)	18.96 (0.52)	33.25 (1.61)	9.83 (0.31)	56.65 (4.35)
D3*PO	-4.86 (-2.72)	-5.42 (-3.02)	-5.45 (-2.77)	-5.95 (-3.06	-6.07 (-3.48)	-4.79 (-3.75)
D4*PO	-7.06 (-4.03)	-5.50 (-2.63)	-7.91 (-4.13)	-7.53 (-3.28)	-5.58 (-3.28)	-4.70 (-3.20)
T1*QSCR		0.016 (0.68)		0.026 (1.04)		0.026 (1.60)
QMEXBR*QSCR		-0.00095 (-1.77)		-0.00093 (-1.59)		-0.0012 -3.16
T1*QOS_{-1}		-0.0067 (-1.33)		-0.0061 -1.17		-0.0083 (-2.54)
QMEXBR*QOS_{-1}		0.00028 (2.34)		0.00026 (2.03)		0.00032 (4.12)
	$\bar{R}^2=0.92$ D·W=1.46 h=2.50	$\bar{R}^2=0.93$ D·W=1.38				

comparable to the effect of soybean production in the soybean stock equation. For every bushel (60 pounds) of soybeans crushed 11 pounds of soyoil are produced. When the effect of this variable is allowed to vary each unit change in time trend and Brazilian soymeal exports tend to increase and decrease it by 0.026 and 0.00093 units respectively.

The short-run and long-run elasticities are presented in Table 7. The long-run elasticities were calculated in the same way as the soybean stocks.

While the short-run basis elasticity from the varying parameter model are more elastic than those from the fixed parameter model, the short-run own price elasticities from both models are almost identical. On a comparative basis, the long-run fixed elasticities are much more elastic than the short-run elasticities. The long-run varying elasticity results are mixed. They show a tendency of becoming more elastic in the second and third quarters and tend to remain rather constant in the first and fourth quarters over the four sub-periods. In general while the long-run varying own price elasticity converged toward the long-run fixed price elasticity the long-run varying soyoil basis elasticity became more elastic than the fixed elasticity in the 1977/78 - 1980/81 sub-period.

6.2.3 Soymeal Domestic Demand

The demand for U.S. soymeal is a derived demand and was specified to be influenced by own price of soymeal (PM), the number of soymeal consuming units (MCU), the livestock price

TABLE 7: SHORT-RUN AND LONG-RUN ELASTICITIES OF DEMAND FOR SOYOIL STOCKS

		1st Quarter[1]		2nd Quarter		3rd Quarter		4th Quarter	
Short-run:	Fixed	-0.0016		-0.0007		-0.0292		-0.0441	
	Varying	-0.010		-0.0012		-0.032		-0.042	
Long-run:	Fixed	-0.013		-0.00362		-0.112		-0.126	
	Varying	-0.014[a]	T1 = 11 QMEXBR=43	-0.0032[a]	T1 = 12 QMEXBR=40	-0.048[a]	T1 = 13 QMEXBR=50	-0.073[a]	T1 = 14 QMEXBR=58
		-0.012[b]	T1 = 27 QMEXBR=174	-0.0028[b]	T1 = 28 QMEXBR=198	-0.047[b]	T1 = 29 QMEXBR=377	-0.068[b]	T1 = 30 QMEXBR=288
		-0.012[c]	T1 = 43 QMEXBR=553	-0.0032[c]	T1 = 44 QMEXBR=816	-0.06[c]	T1 = 45 QMEXBR=1181	-0.087[c]	T1 = 46 QMEXBR=1163
		-0.014[b]	T1 = 60 QMEXBR=1162	-0.0065[d]	T1 = 60 QMEXBR=2036	-0.10[d]	T1 = 61 QMEXBR=1996	-0.079[d]	T1 = 62 QMEXBR=1376

[1] The calculated elasticities in the first and second quarters refer to soyoil price basis elasticities. They are negative because the sample period average values of the price basis were negative.

[a] Time period is 1965/66-1968/69.

[b] Time period is 1969/70-1972/73.

[c] Time period is 1973/74-1976/77.

[d] Time period is 1977/78-1980/81.

index (PLI), the relative price of competing protein meals used in livestock feed (PF/PM) and the time trend.

The statistical estimates of the soymeal domestic demand are summarized in Table 8. The response of demand to the change in relative price of competing protein is appreciably greater in the fixed parameter model than in the varying parameter model. The response of demand to the index of livestock price is almost the same in both models. The linear quarterly time trend indicates that the domestic soymeal demand has been expanding by 84000 tons per year over the study period.

The relevant elasticities associated with soymeal demand are given in Table 9. The fixed own price elasticity of -0.112 is more inelastic than those found by Houck (-0.17) and Meyers (-0.22). The varying parameter model specification indicates that soymeal price elasticity became more elastic over the sub-periods up to the 1976/77 crop year. This elasticity varied from -0.18 in the 1965/66 - 1968/69 period to -0.26 in the 1973/74 - 1976/77 sub-period and then became relatively inelastic (-0.22) in the 1977/78 - 1980/81 period. The sub-period price elasticities calculated from the varying parameter model were more elastic than those from the fixed parameter model.

The meal consuming units elasticity of demand for soymeal was calculated as 0.84 from the fixed parameter model. The varying meal consuming units elasticity was more inelastic than the fixed elasticity but indicated a slight trend towards a more elastic response.

TABLE 8: STATISTICAL RESULTS OF U.S. DOMESTIC DEMAND FOR SOYMEAL (QMD)
(t-statistic in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Fixed	Varying	Fixed	Varying	Fixed	Varying
Constant	-1189.00 (-1.31)	-354.59 (-0.38)	-1225.90 (-1.31)	512.38 (0.48)	-1265.10 (-1.40)	800.49 (1.39)
D1	639.21 (5.67)	617.32 (5.52)	625.25 (5.41)	632.00 (4.72)	668.48 (5.80)	581.30 (7.03)
D2	425.18 (3.32)	436.48 (3.40)	413.46 (3.16)	447.12 (3.09)	459.22 (3.55)	370.57 (4.26)
D3	230.96 (2.14)	256.88 (2.34)	231.01 (2.10)	270.96 (2.29)	259.48 (2.37)	201.15 (2.82)
PM	-1.60 (-1.51)	-1.13 (-1.07)	-2.89 (-2.03)	-6.1491 (-3.48)	-4.32 (-3.94)	-4.03 (-4.21)
MCU	0.012 (3.34)	0.0086 (2.36)	0.012 (3.21)	0.0058 (1.38)	0.0012 (3,33)	0.0054 (2.41)
PF/PM	48.93 (0.38)	22.95 (0.18)	96.82 (0.66)	9.75 (0.069)	162.18 (1.12)	31.42 (0.44)
PLI	4.89 (2.31)	4.54 (2.01)	5.89 (2.57)	5.55 (2.24)	4.69 (2.21)	3.29 (2.68)
T1	20.63 (4.00)		21.08 (4.01)		27.59 (5.41)	
QMEXBR*PM		-0.0008 (-1.59)		0.00062 (0.28)		-0.0019 (-1.72)
T1*MCU		0.00011 (4.32)		0.00015 (4.70)		0.00013 (7.57)
QMEXBR*MCU		0.0000013 (1.43)		-0.0000011 (-0.54)		0.0000016 (1.57)
	R² =0.85	R² =0.86				
	D·W=1.11	D·W=1.57				

TABLE 9: DIRECT PRICE AND MEAL CONSUMING UNITS ELASTICITY OF DEMAND FOR SOYMEAL

	Fixed Parameter Model	Varying Parameter Model
Price of Soymeal (PM)	-0.112	-0.18[a] QMEXBR=48
		-0.21[b] QMEXBR=259
		-0.26[c] QMEXBR=923
		-0.22[d] QMEXBR=1643
Meal Consuming Units	0.84	0.63[a] T1=13 QMEXBR=48
		0.73[b] T1=29 QMEXBR=259
		0.80[c] T1=45 QMEXBR=928
		0.74[d] T1=61 QMEXBR=1643

[a] Time period is 1965/66 - 1968/69
[b] Time period is 1969/70 - 1972/73
[c] Time period is 1973/74 - 1976/77
[d] Time period is 1977/78 - 1980/81

6.2.4 Soyoil Domestic Demand

The domestic demand for soyoil faced by processors is also a total of several derived demand functions. In this study the quantity of soyoil demanded domestically was expressed as a function of price of soyoil (PO), personal disposable income (Y) and prices of substitutable vegetable oils (POS).

The estimated statistical results are presented in Table 10 while elasticities are summarized in Table 11. The fixed own price elasticity of -0.06 is consistent with the results found by Meyers but it is slightly more inelastic than that calculated by Beeson (-0.09). The calculations from the varying parameter model indicate that the soyoil price elasticity tended to become more elastic until 1977 and thereafter became relatively inelastic. The varying elasticity changed from -0.04 in the 1965/66 - 1968/69 period to -0.15 in the 1973/74 - 1976/77 period and then to -0.12 in 1977/78 - 1980/81 period.

TABLE 10: STATISTICAL RESULTS OF U.S. DOMESTIC DEMAND FOR SOYOIL (QOD)
(t-statistic in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant term	-1659.16 (-8.96)	687.37 (1.10)	-1717.87 (-8.26)	735.46 (1.14)	-1746.30 (-9.53)	839.28 (2.05)
Income	0.86 (15.69)	0.10 (0.49)	0.87 (15.53)	.077 (0.34)	0.86 (17.59)	0.018 (0.12)
POS	89.31 (1.01)	86.12 (1.06)	126.84 (1.16)	91.42 (0.95)	154.06 (1.61)	74.72 (1.22)
PO	-6.05 (-1.67)	-7.70 (-0.72)	-6.24 (-1.69)	-4.79 (-0.40)	-4.85 (-1.53)	3.72 (0.49)
Tl x PO		0.053 (0.19)		-0.027 (-0.084)		-0.15 (-0.76)
QMEXBR x PO		-0.0048 (-2.26)		-0.0048 (-2.22)		-0.0059 (-3.67)
Tl x INCOME		0.0046 (2.51)		0.0050 (2.41)		0.0057 (4.38)
	$\bar{R}^2 = 0.90$ D·W = 1.22	$\bar{R}^2 = 0.91$ D·W = 1.61				

TABLE 11: DIRECT PRICE AND INCOME ELASTICITIES OF DEMAND FOR SOYOIL

	Fixed Parameter Model	Varying Parameter Model
Price of Soyoil (PO)	-0.06	-0.04[a] T1=13 QMEXBR=48
		-0.05[b] T1=29 QMEXBR=259
		-0.15[c] T1=45 QMEXBR=923
		-0.12[d] T1=61 QMEXBR=1643
Average Price of Other Oils (POS)	0.1	0.07
Income	2.0	0.37[a] T1=13
		0.49[b] T1=29
		0.68[c] T1=45
		0.75[d] T1=61

[a] Time period is 1965/66 - 1968/69
[b] Time period is 1969/70 - 1972/73
[c] Time period is 1973/74 - 1976/77
[d] Time period is 1977/78 - 1980/81

The fixed income elasticity was estimated to be 2.0 while the varying income elasticity was found to be inelastic over the entire sample period. However, the varying income elasticity of demand for soyoil became more elastic over the sub-period by varying from 0.37 in the 1965/66 - 1968/69 period to 0.75 in the 1977/78 - 1980/81 period. The parameter for the substitute oils was not specified as varying over time. However, the calculated cross-price elasticities of 0.1 and 0.07 from the fixed and varying parameter models respectively were more inelastic than that found by Beeson (0.307).

6.2.5 U.S. Soybean Crushing Demand

The U.S. quantity of soybeans crushed (QSCR) was found to depend on current crushing margin for soybeans (CMS), the meal consuming units (MCU) and the soybean products price basis

(FPM-PM). While the crushing margin was included to account for current profitability, the basis variables were to account for speculative profitability motives of the crushers. However in the preliminary estimation the effect of the soyoil price was not consistent with economic theory and was eliminated from the equation.

The main reason for including this equation in the analysis is because the U.S. does not import soyoil nor soymeal such that the soybeans crushed are the main source of supply of soyoil and soymeal. Since crushing is part of the domestic utilization of soybeans, endogenizing this variable was assumed to also help constrain the estimation of soyoil and soymeal prices. Proper estimation of soybean product prices will in turn determine if it is more profitable to crush the beans domestically or to export raw beans to overseas crushers.

The results of the estimated effects are represented in Table 12. Despite large "t" values the equation explained only 46 percent of the variation in crush in the constant coefficient model specification. On the other hand, 90 percent of the variation in crush was explained by the equation in the varying coefficient model specification. Also the Durbin-Watson statistics were quite different, with the statistic of the varying coefficient model twice as big as that from the fixed parameter model.

The calculated elasticities are summarized in Table 13.

TABLE 12: STATISTICAL RESULTS OF U.S. SOYBEAN CRUSHING DEMAND (QSCR)
(t-statistic in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant Term	-445.89 (-4.48)	-104.19 (-2.16)	-426.37 (-3.89)	-111.87 (-2.27)	-288.97 (-3.11)	-49.29 (-2.01)
D1	63.18 (4.51)	45.84 (7.98)	53.09 (3.37)	48.99 (7.66)	43.50 (3.28)	39.12 (10.15)
D2	81.39 (5.32)	55.53 (8.07)	75.13 (4.42)	55.46 (7.90)	59.33 (4.12)	42.07 (10.28)
D3	54.98 (4.10)	37.01 (6.04)	57.01 (3.86)	38.20 (6.06)	41.94 (3.37)	26.57 (7.24)
CMS	0.37 (1.61)	0.57 (1.67)	0.67 (2.47)	0.60 (1.73)	0.56 (2.61)	0.44 (2.89)
MCU	0.0024 (6.04)	0.00077 (3.77)	0.0023 (5.24)	0.00081 (3.85)	0.0018 (4.82)	0.00059 (5.84)
FPM-PM	0.71 (3.48)	0.28 (2.95)	1.44 (4.29)	0.43 (3.11)	1.56 (5.66)	0.40 (6.26)
T1 x MCU		0.000011 (6.45)		0.000010 (5.99)		0.0000096 (11.36)
QMEXBR x MCU		-0.00000013 (-2.72)		-0.00000013 (-2.73)		-0.000000084 (-3.47)
T1 x CMS		-0.025 (-2.08)		-0.025 (-2.00)		-0.018 (-3.33)
QMEXBR x CMS		0.00099 (2.79)		0.0011 (2.92)		0.00070 (4.29)
	$\bar{R}^2=0.46$	$\bar{R}^2=0.90$				
	D·W=0.66	D·W=1.32				

TABLE 13: ELASTICITIES OF SOYBEAN CRUSHING DEMAND

	Fixed Parameter Model	Varying Parameter Model
Soymeal Basis(FPM-PM)	0.0033	0.000996
Meal Consuming Units (MCU)	2.86	1.16[a] T1=13 QMEXBR=48
		1.33[b] T1=29 QMEXBR=259
		1.44[c] T1=45 QMEXBR=928
		1.50[d] T1=61 QMEXBR=1643
Crushing Margin (CMS)	0.09	0.05[a] T1=13 QMEXBR=48
		0.02[b] T1=29 QMEXBR=259
		0.07[c] T1=45 QMEXBR=928
		0.12[d] T1=61 QMEXBR=1643

[a] Time period is 1965/66 - 1968/69
[b] Time period is 1969/70 - 1972/73
[c] Time period is 1973/74 - 1976/77
[d] Time period is 1977/78 - 1980/81

The elasticity of crushing margin (0.09) calculated from the fixed parameter model is more than that obtained by Meilke (0.037). On the other hand, the elasticity calculated from the varying parameter model was 0.05 in the 1965/66 - 1968/69 period and decreased to 0.02 in the 1969/70 - 1972/73 period. The elasticity increased again after the 1969/70 - 1972/73 period and reached 0.12 in the 1977/78 - 1980/81 period.

The elasticity of soymeal basis calculated from the fixed parameter model is about three times bigger than the elasticity obtained from the varying parameter model. These elasticities (0.0033 and 0.000996) are extremely inelastic. The elasticity of soymeal consuming units (2.86) calculated from the fixed parameter model is relatively more elastic than the changing elasticity from the varying parameter model. The varying elasticity of meal consuming units became more elastic though moderately and increased from 1.16 in the 1965/66 - 1968/69 period to 1.50 in the 1977/79 - 1980/81 period.

6.2.6 Current Supplies of Soybeans, Soyoil and Soymeal for Use

Tables 14, 15 and 16 contain the empirical results of the supply relations for current utilization of soybeans, soyoil and soymeal. All three relations were specified for estimation with the respective product prices on the left-hand side. There were no seasonal characteristics found.

The calculated elasticities relating to futures prices and supplies of respective commodities are given in Table 17. The three calculated elasticities of futures price to the respective cash prices are very close to unity confirming the theoretically held concept that the futures price and cash prices move together. In this sense the futures price can be used to forecast subsequent future cash prices. While the coefficient associated with the commercial supply of soybeans may be interpreted as the estimate of the slope of the marginal cost function for holding stocks, the coefficients of soyoil and soymeal supply variables may not quite fit such a definition. The reason being that the quantity of soyoil and soymeal supplied in a given quarter is equal to last quarter's ending stock plus quantities produced in a given quarter, whereas for soybeans no more new production is possible after the first quarter. The fixed price flexibilities are -0.128, -0.231 and -0.54 for soybeans, soyoil and soymeal respectively. This indicates that the three commodity prices are not very respon-

TABLE 14: STATISTICAL RESULTS OF U.S. CURRENT SUPPLY OF BEANS FOR USE (PS)

(t-statistics in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant Term	0.29 (1.32)	1.14 (2.98)	0.17 (0.77)	0.44 (1.03)	0.18 (0.84)	0.45 (1.32)
FPS	0.95 (24.69)	0.84 (15.30)	1.02 (24.39)	0.98 (15.20)	1.02 (26.07)	0.94 (18.54)
CSS	-0.00097 (-1.60)	-0.0033 (-2.79)	-0.0015 (-2.29)	-0.0020 (-1.52)	-0.0015 (-2.60)	-0.0021 (-2.10)
Tl x CSS		0.000036 (1.53)		0.0000055 (0.21)		0.000031 (1.51)
QMEXBR x CSS		0.00000025 (0.61)		0.00000027 (0.62)		-0.00000032 (-0.91)
	$\bar{R}^2=0.92$	$\bar{R}^2=0.93$				
	D·W=1.97	D·W=1.88				

TABLE 15: STATISTICAL RESULTS OF U.S. CURRENT SUPPLY OF SOYMEAL FOR USE (PM)
(t-statistics in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant Term	33.78 (2.88)	62.45 (2.06)	40.15 (3.22)	28.34 (0.84)	51.04 (5.17)	51.83 (2.53)
FPM	1.11 (15.32)	1.04 (10.65)	1.24 (15.30)	1.22 (11.05)	1.15 (18.98)	1.27 (18.53)
CSM	-0.010 (-2.87)	-0.018 (-2.10)	-0.015 (-3.83)	-0.011 (-1.13)	-0.015 (-5.16)	-0.020 (-3.36)
Tl x CSM		0.00011 (0.93)		-0.000033 (-0.25)		0.000023 (0.29)
QMEXBR x CSM		-0.00000051 (-0.33)		0.000000079 (0.050)		0.00000026 (0.26)
	$\bar{R}^2=0.86$	$\bar{R}^2=0.86$				
	D·W=1.51	D·W=1.45				

TABLE 16: STATISTICAL RESULTS OF U.S. CURRENT SUPPLY OF SOYOIL FOR USE (PO)
(t-statistic in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant Term	3.32 (3.51)	12.08 (4.39)	3.18 (3.30)	9.02 (3.00)	2.70 (2.92)	11.40 (4.46)
FPO	1.00 (20.32)	0.88 (16.26)	1.06 (20.27)	0.95 (16.14)	1.03 21.54	0.91 (17.75)
CSO	-0.0010 (-2.30)	-0.0057 (-4.06)	-0.0014 (-2.89)	-0.0044 (-2.86)	-0.00098 (-2.30)	-0.0055 (-4.21)
T1 x CSO		0.000072 (3.89)		0.000053 (2.63)		0.000065 (3.81)
QMEXBR x CSO		-0.00000058 (-2.67)		-0.00000051 (-2.26)		-0.00000046 (-2.28)
	$\bar{R}^2=0.91$	$\bar{R}^2=0.93$				
	D.W=1.63	D.W=1.83				

TABLE 17: FUTURES PRICE ELASTICITIES AND SUPPLY FLEXIBILITIES OF SOYBEANS, SOYOIL AND SOYMEAL

Elasticity/Flexibility	Fixed parameter Model	Varying Parameter Model		
Soybeans:				
Futures Price Elasticity	1.09	1.05		
Soybean Supply Price Flexibility	-0.128	-0.46[a]	T1=13	QMEXBR=48
		-0.36[b]	T1=29	QMEXBR=259
		-0.22[c]	T1=45	QMEXBR=928
		-0.17[d]	T1=61	QMEXBR=1643
Soyoil:				
Futures Price Elasticity	1.04	0.93		
Soyoil Supply Price Flexibility	-0.231	-0.77[a]	T1=13	QMEXBR=48
		-0.62[b]	T1=29	QMEXBR=259
		-0.30[c]	T1=45	QMEXBR=928
		-0.37[d]	T1=61	QMEXBR=1643
Soymeal:				
Futures Price Elasticity	1.24	1.22		
Soymeal Supply Price Flexibility	-0.54	-0.52[a]	T1=13	QMEXBR=48
		-0.48[b]	T1=29	QMEXBR=259
		-0.41[c]	T1=45	QMEXBR=928
		-0.44[d]	T1=61	QMEXBR=1643

[a] Time period is 1965/66-1968/69

[b] Time period is 1969/70-1972/73

[c] Time period is 1973/74-1976/77

[d] Time period is 1977/78-1980/81

sive to their respective quantities supplied though soymeal price is relatively more flexible. The flexibilities calculated from the varying parameter model indicate that as trend and Brazilian soymeal exports increase overtime, soybean flexibilities become more inelastic while price flexibilities of soyoil and soymeal tended to become more inelastic to 1977 and then became relatively more elastic. These results generally confirm those obtained for the soyoil and soymeal domestic demands.

6.2.7 Aggregate Soymeal Exports

Table 18 contains the empirical results of the estimated soymeal export equation. The aggregate soymeal exports were specified to be influenced by meal consuming animal units (MCUF) in major importing nations (Japan and the EC), the quantity of feedgrains (QFP) produced in the major importing countries, the weighted price of soymeal (WPM), the relative price of substitutable high protein feed (IPF/IPM) and the time trend (T1) to account for changing technology and feeding methods.

Several combinations of the varying coefficients were tried, but none of them gave satisfactory results and the varying coefficients were ruled out in this equation. The exchange rate by itself in terms of dollars per SDR had wrong signs in the preliminary and it was included only indirectly in the calculation of the weighted price of soymeal.

The production of feedgrains does not seem to significantly affect the importation of soymeal in an economic sense given the size of its coefficients. As the quantity of feedgrains

TABLE 18: STATISTICAL RESULTS OF AGGREGATE SOYMEAL EXPORTS (QMEXW)

(t-statistic in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant Term	-860.41	-860.41	-817.50	-868.28	-780.00	-510.02
	(-0.72)	(-0.72)	(-0.68)	(-0.73)	(-0.79)	(-0.80)
T1	52.76	52.76	53.42	52.63	49.31	54.33
	(9.18)	(9.18)	(9.13)	(9.03)	(10.14)	(15.47)
MCUF	0.0030	0.0030	0.0028	0.0030	0.00495	0.0017
	(0.35)	(0.35)	(0.33)	(0.35)	(0.70)	(0.37)
IPF/IPM	316.35	316.35	315.39	316.53	188.63	203.75
	(2.35)	(2.35)	(2.34)	(2.35)	(1.73)	(3.01)
WPM	-1.32	-1.32	-1.61	-1.26	-1.26	-1.37
	(-0.87)	(-0.87)	(-1.02)	(-0.80)	(-0.94)	(-1.54)
QFP	-0.0035	-0.0035	-0.0035	-0.0035	-0.0046	-0.0036
	(-2.04)	(-2.04)	(-2.05)	(-2.04)	(-3.18)	(-3.74)
	$\bar{R}^2=0.83$	$\bar{R}^2=0.83$				
	D·W=1.65	D·W=1.65				

TABLE 19: STATISTICAL RESULTS OF AGGREGATE SOYBEAN EXPORTS (QSEXW)
(t-statistic in parenthesis)

Explanatory Variable	OLS		2SLS		3SLS	
	Constant	Systematic	Constant	Systematic	Constant	Systematic
Constant Term	-135251.88 (-8.96)	-37516.83 (-2.23)	-137161.77 (-8.73)	-34574.29 (-2.02)	-126038.20 (-9.27)	-21652.14 (-2.11)
D1	16418.50 (6.01)	17270.27 (8.82)	16509.89 (6.00)	17304.82 (8.76)	13265.62 (5.43)	15565.78 (10.32)
D2	6193.35 (2.30)	7335.03 (3.79)	6427.74 (2.36)	7523.50 (3.85)	3416.45 (1.43)	6353.50 (4.49)
D3	9914.80 (3.71)	10260.17 (5.37)	10120.99 (3.76)	10441.39 (5.41)	8526.98 (3.57)	7759.65 (5.67)
DSDR	51329.93 (2.77)	40862.19 (3.07)	47288.97 (2.46)	39744.88 (2.91)	52327.50 (3.38)	33516.07 (4.24)
WPC	47.44 (3.08)	17.04 (1.45)	48.41 (3.12)	16.12 (1.36)	34.47 (2.78)	16.22 (2.62)
PS/DSDR	-2948.76 (-0.93)	-10952.51 (4.38)	-5396.14 (-1.41)	-13446.17 (-4.83)	-8140.58 (2.62)	-13111.76 (-8.21)
VALUE	4803.37 (1.65)	3784.66 (1.82)	7277.19 (2.08)	5504.72 (2.39)	9455.44 (3.29)	6043.59 (4.30)
MCUF	0.63 (4.43)	0.15 (1.22)	0.67 (4.57)	0.14 (1.15)	0.59 (4.89)	0.087 (1.21)
T1*PS/DSDR		151.22 (7.57)		160.47 (7.75)		159.29 (12.49)
	$\bar{R}^2=0.82$ D·W=1.05	$\bar{R}^2=0.91$ D·W=1.59				

and from the estimated results, soybean exports would increase by about 4.7 million metric tons per one unit increase in this variable.

The calculated elasticities of soybean export demand are given in Table 20. The calculated own price elasticity is -0.58 in the fixed parameter model compared to -2.0, -0.54 and -0.07 computed by Meyers, Houck and Beeson respectively. The time varying elasticity has tended to become more inelastic over time. It was -1.59 in the period 1965/66 - 1968/69 and has steadily become more inelastic to -0.35 in the 1977/78 - 1980/81 period.

TABLE 20: ELASTICITIES OF SOYBEAN EXPORT DEMAND

	Fixed Parameter Model	Varying Parameter Model
Soybean Price (PS/DSDR)	-0.58	-1.59[a] Tl=13 -0.96[b] Tl=29 -0.71[c] Tl=45 -0.35[d] Tl=61
Value of Bushel of Soybeans Crushed (VALUE)	0.85	0.64
Consuming Animal Units (MCUF)	2.63	0.55
Weighted Corn Price (WPC)	0.14	0.05

[a] Time period is 1965/66 - 1968/69
[b] Time period is 1969/70 - 1972/73
[c] Time period is 1973/74 - 1976/77
[d] Time period is 1977/78 - 1980/81

Since demand for soybeans is derived from the demand functions of soyoil and soymeal it is most likely that the profitability from crushing beans may override any soybean price changes. In fact, the elasticity of 0.851 of the value of a bushel crushed is more elastic than the own price elasticity calculated from the fixed parameter model. Also in the varying parameter model the elasticity of the value of each bushel crushed calculated as 0.643 will eventually be more elastic than the varying own price elasticity. The meal consuming animal units elasticity was calculated as 2.63 and 0.55 in the fixed and varying parameter models respectively. The elasticities found by Beeson and Meyers for the same variable are 4.42 and 1.4. The study's calculated elasticities are relatively more elastic than those calculated in the soymeal export equation. The calculated cross-price elasticity of corn is 0.137 and 0.046 in the fixed and varying parameter models respectively.

6.2.9 U.S. Soybean Production

In this study the soybean yields per acre were exogenous to the system and soybean production was equal to yield times the acreage planted. But due to computational constraints the linearized version of the resulting product was employed using a Taylor series expansion in the neighborhood of the means. The obtained linear version of soybean production is thus a function of lagged price of soybeans (PSL), lagged acreage of soybeans (ACS_{t-1}), time trend (T2), relative price of corn (PCL/PSL) and finally the annual yield of soybeans per acre (YLD). In the preliminary estimation neither production nor acreage responded well to support prices. This may not be too surprising since soybean market prices have generally been above the support rates and no acreage restriction programs have been applied to soybeans.

The lagged price of soybeans will generally be taken to mean the market ruling price before the production decisions are taken. In order to link the annual production to the quarterly model, the quarterly prices need to be joined to the crop year average price. An attempt was made to calculate the crop year price as a weighted average of the four estimated quarterly prices with weights given by the proportion of the quarterly utilization relative to the crop year total. However the weighted price came up with wrong negative signs and it was decided to simply use the simple average of the four estimated quarterly prices. The included quarterly prices were the second quarter price in a given year through to third quarter price in the preceding year.

Attempts to vary some coefficients were frustrated by the fact that at each attempt some variables changed their expected signs. It was then decided to estimate this equation without any varying coefficient.

The statistical estimates of the U.S. production of soybeans are summarized in Table 21. The soybean yield variable is very significant indicating that any big breakthrough in soybean yield rates will dominate the quantity of soybeans produced. The lagged acreage planted with soybeans is included to capture the historical planting behavior of farmers. The sign of its estimated coefficient is positive, as expected, and indicates that a one million increase in acreage planted the

TABLE 21: STATISTICAL RESULTS OF THE U.S. PRODUCTION OF SOYBEANS (QSP)
(t-statistics in parenthesis)

Explanatory Variable	Estimated Coefficient
Constant term	-0.68 (-0.13)
PSL	7.55 (0.71)
YLD	48.09 (18.35)
PCL/PSL	-1573.52 (-11.34)
ACS	8.18 (2.29)
T2	31.97 (5.92)

$\bar{R}^2 = 0.997$

D·W = 1.999

previous year would increase soybean output by about 8 million bushels. The own lagged price elasticity of 0.02 seems very inelastic. However, the cross price elasticity of corn is very elastic relative to own price elasticity such the effect of corn price may overshadow the impact of own price.

6.3 Model Validation

In order to validate the quarterly soybean model the equations estimated were combined and simulated over the historical period and for a four quarter period outside the estimation period. Since the most recent past may better reflect the future than the distant past the historical period covered 35 quarters of sample data beginning with the second quarter of 1972/73. The out-of-sample forecasting covered four consecutive quarters beginning with the first quarter of 1981/82.

Dynamic simulation was made possible by applying the SAS SIMLIN procedure which uses the lagged values of the predicted endogenous variables. The SIMLIN procedure requires that the number of equations be the same as the number of endogenous variables in the system. Suppose that there are g endogenous variables (Y_t), ℓ lagged endogenous variables (Y_t^L), and k exogenous variable (X_t) including the intercept. Then there are g structural equations in the system that are written:

$$Y\Gamma = Y^L C + XB$$

where Γ is assumed to be nonsingular. Γ, C and B are matrices of coefficients associated with endogenous, lagged endogenous and exogenous variables respectively. First, the SIMLIN procedure computes reduced-form coefficients by post-multiplying by Γ^{-1}:

$$Y=Y^{L}C\Gamma^{-1}+XB\Gamma^{-1}$$

The dynamic simulation begins with predicted values being fed into lagged endogenous terms until the end of the data set. The out of sample forecasting covered four consecutive quarters beginning with the first quarter of 1981/82. All exogenous variables are assigned their values in the forecasting exercise.

The statistics of fit are given in Tables 22 and 23 for historical simulation and out of sample forecasting respectively. They include root mean squared error (RMSE) and root mean squared percentage error (RMSPE). These statistics are calculated from the following expressions:

$$\text{RMSE} = \sqrt{\frac{1}{T}\Sigma(\hat{Y}_t - Y_t)^2}$$

$$\text{RMSEP} = \sqrt{\frac{1}{T}\Sigma\{(\hat{Y}_t - Y_t)/Y_t\}^2} \quad \text{x } 100$$

where T is the total number of observations. The smaller the value of the calculated statistic, the better the fitted model.

Since the RMSE and RMSPE move together in the same direction only the latter will be discussed. The historical simulations of both the fixed and varying parameter models indicate that the varying parameter model predicted the mean levels of the endogenous variables better than the fixed parameter model. In both models the on-farm stocks were predicted worst with a RMSPE of 113 and 315 for the varying and fixed parameter models respectively. On the other hand, the soybean crushings

TABLE 22: VALIDATION OF THE QUARTERLY SOYBEAN MODELS
1972/73(2) - 1980/81(4)

Endogenous Variables	Behavioral Equations	
	Varying	Fixed
	RMSPE	RMSPE
Off-farm soybean stocks	93.44	266.05
On-farm soybean stocks	112.91	315.29
Soyoil stocks	33.97	57.47
Soyoil demand	11.29	19.00
Soymeal demand	8.68	8.60
Soybean crush	7.43	15.88
Aggregate soybean export	24.20	33.62
Aggregate soymeal export	20.93	31.53
U.S. soybean export	31.27	49.05
U.S. soymeal export	36.00	51.63
U.S. soybean price	21.90	118.55
U.S. soymeal price	9.93	13.11
U.S. soyoil price	38.53	97.56

TABLE 23: OUT OF SAMPLE FORECASTING 1981/82(1)-1981/82(4)

Endogenous Variables	Behavioral Equations	
	Varying	Fixed
	RMSPE	RMSPE
Off-farm soybean stocks	23.85	102.73
On-farm soybean stocks	35.38	74.41
Soyoil stocks	25.04	27.61
Soyoil demand	17.93	14.49
Soymeal demand	10.85	9.46
Soybean crush	12.68	13.11
Aggregate soybean export	27.87	25.53
Aggregate soymeal export	8.44	9.57
U.S. soybean export	32.62	29.20
U.S. soymeal export	21.88	30.71
U.S. soybean price	38.02	82.91
U.S. soymeal price	22.01	28.83
U.S. soyoil price	104.18	102.05

were best predicted in the varying parameter model while the soymeal demand predictions were best in the fixed parameter model.

Also, besides the soybean stock equations in the varying parameter model, all other behavioral equations have RMSPE's below 39. On the other hand, of the thirteen behavioral equations, including U.S. soybean and soymeal export equations in the fixed parameter model, eight have RMSPE's above 49 with three of these actually above 100. While a value of RMSPE equal to zero indicates perfect prediction a value of 100 means that the predicted values were, on average, twice the actual values.

Also, besides having larger historical simulation prediction errors, the fixed parameter model predicted some negative values for soyoil and soybean prices, soyoil stock and U.S. soybean export demand equations. There were no negative predicted values for the varying parameter model.

The results of the out of sample forecasting were mixed. The varying parameter model outforecasted the fixed parameter model in all the stock equations, soymeal exports, soybean crushings, soybean and soymeal prices. The best forecasts by the fixed parameter model included soymeal and soyoil demand, soybean exports and soyoil price. However, the forecasting performance of the latter model is suspect since one of the forecasted soyoil price values was negative. Also it should be remembered that the out of sample forecasts were limited in number. Hence these results for assessing the predictive performance of the models must be viewed as tentative.

Another measure of goodness of fit considered in the study included turning point errors. Turning points can be important because many economic time series exhibit positive serial correlation such, that for a model to be superior to a simple time trends model, it must predict turning points.

A turning points simulation has four possible outcomes: A turning point exists and the model either predicts or does not predict it; or, no turning point exists and the model either predicts or does not predict one. These four possibilities are illustrated in the diagram below:

		PREDICTED	
		Turning Point	No Turning Point
ACTUAL	Turning Point	f_{11}	f_{12}
	No Turning Point	f_{21}	f_{22}

Turning point forecasting will be perfect if $f_{12}=f_{21}=0$ i.e. there are no turning point errors. A measure of turning point error is usually provided by expressing the errors in proportional terms. Thus, a turning point error is defined as:

$$\text{TP error} = (f_{12}+f_{21})/(f_{11}+f_{12}+f_{21}+f_{22})$$

A measure of error due to turning points missed is:

$$TP_M \text{ error} = f_{12}/(f_{11}+f_{12})$$

A measure of error due to falsely predicting turning points is:

$$TP_F \text{ error} = f_{21}/(f_{11}+f_{21})$$

These measures range between zero and one; small values indicate good turning point simulations.

On a comparative basis the varying parameter model performed better in correctly predicting the turning points except for soyoil stocks, soyoil demand, soymeal demand and U.S. soybean exports, as depicted in Table 24. However some of the turning points for the equations where the fixed parameter model outperformed the varying parameter model are negative which invalidates its predicting ability.

Both models predicted perfectly the turning points for the off-farm and on-farm soybean stocks because all turning point errors were equal to zero. The graphs in Appendix B demonstrate the relationship between the actual and predicted values.

TABLE 24: TURNING POINT ERRORS OF THE QUARTERLY ECONOMETRIC MODELS 1972/73(2) - 1980/81(4)

Variable	TP error		TP_m error		TP_f error	
	Varying	Fixed	Varying	Fixed	Varying	Fixed
Off-farm stocks	0	0	0	0	0	0
On-farm stocks	0	0	0	0	0	0
Soyoil stocks	0.40	0.26	0.44	0.29	0.44	0.33
Soyoil demand	0.34	0.29	0.19	0.24	0.32	0.24
Soymeal demand	0.31	0.26	0.32	0.18	0.21	0.22
Soybean crush	0.26	0.40	0.07	0.42	0.38	0.50
Soybean price	0.31	0.49	0.29	0.33	0.33	0.48
Soymeal price	0.20	0.49	0.21	0.46	0.27	0.61
Soyoil price	0.31	0.40	0.14	0.29	0.31	0.45
Aggregate Soybean exports	0.14	0.20	0.06	0.13	0.10	0.10
Aggregate soymeal exports	0.49	0.62	0.38	0.50	0.52	0.62
U.S. soybean exports	0.46	0.28	0.35	0.22	0.48	0.30
U.S. soymeal exports	0.29	0.49	0.33	0.43	0.25	0.53

TABLE 24: TURNING POINT ERRORS OF THE QUARTERLY ECONOMETRIC MODELS 1972/73(2) - 1980/81(4)

Variable	TP error		TP_m error		TP_f error	
	Varying	Fixed	Varying	Fixed	Varying	Fixed
Off-farm stocks	0	0	0	0	0	0
On-farm stocks	0	0	0	0	0	0
Soyoil stocks	0.40	0.26	0.44	0.29	0.44	0.33
Soyoil demand	0.34	0.29	0.19	0.24	0.32	0.24
Soymeal demand	0.31	0.26	0.32	0.18	0.21	0.22
Soybean crush	0.26	0.40	0.07	0.42	0.38	0.50
Soybean price	0.31	0.49	0.29	0.33	0.33	0.48
Soymeal price	0.20	0.49	0.21	0.46	0.27	0.61
Soyoil price	0.31	0.40	0.14	0.29	0.31	0.45
Aggregate Soybean exports	0.14	0.20	0.06	0.13	0.10	0.10
Aggregate soymeal exports	0.49	0.62	0.38	0.50	0.52	0.62
U.S. soybean exports	0.46	0.28	0.35	0.22	0.48	0.30
U.S. soymeal exports	0.29	0.49	0.33	0.43	0.25	0.53

CHAPTER 7

SUMMARY AND CONCLUSIONS

The main objective of the current study is to develop an appropriate econometric model of the U.S. soybean industry in order to examine the effect of changes in various demand and supply variables on prices, storage, utilization and processing levels of soybeans, soyoil and soymeal. The constructed model involves varying some of the response coefficients with respect to time and Brazilian quarterly soymeal exports. In order to be able to assess the performance of the varying parameter model the classical fixed parameter model is also developed.

Although the U.S. is by far still the largest supplier of soybeans and soybean products the recent expansion of soybean production in South America, especially Brazil, is continually eroding the dominance of the U.S. in the world soybean market. The accelerated economic progress has also contributed towards changes in dietary habits which has in turn increased demand for soybeans and soybean products. These changes include consumption of more meat and poultry, processed salads and cooking oils as well as improved animal feedstuffs in terms of the protein content.

On the other hand, some factors are noted which lead to a slow down in demand. These factors, among others, include attainment of optimum usage of soymeal, increased supplies of other vegetable oils, especially palm oil, and tendency of traditional importers to look for alternative suppliers when the U.S. imposes restrictive export policies like trade embargoes. However, the use of soybean oil could be increased since it is among the potential supplements to the petroleum-based fuel.

With the above background in mind the study began by first, looking at the major markets of U.S. soybeans and soymeal. These markets are essentially Japan and the European Community (EC). The developments in livestock production, economic growth and cereal support price policies, especially in the EC, greatly influence the rate of growth in demand for U.S. soybeans and soybean products. The changed Japanese consumption of livestock products, which almost quadrupled between 1964 and 1980, has mainly been due to the increased family income, prices of livestock products and substitutes, changing cultural and religious values as well as urbanization. Soybeans are also used as food in the diet of the Japanese. The Common Agricultural policy of the EC has also greatly contributed to growth in farm production. Though the European climate is not conducive to soybean production, attainment of self-sufficiency in other feedstuffs could substantially reduce the amounts of soybeans and soymeal imported due to the supplementality of these items in the animal feed compound. However, although the policy is beneficial to the European farmers, it has generated an economy of artificially high food prices and costly farm surpluses.

The study then reviewed the literature on the soybean industry complex. While many past works have concentrated on annual studies, virtually no study has considered varying parameters for the soybean industry models. Many earlier studies were designed along the lines of the Subotnik et al. study. Many studies have acknowledged the importance of the entry of Brazil into the world soybean industry, but activities by Brazil are taken as predetermined because of the unavailability of relevant data to endogenize some of these activities.

The study then reviewed the current structural change models. The study has found that many of these models deal with single equations and very few are empirical. Also most of these theoretically explained structural change models are not all that easy to apply empirically due to the assumed prior knowledge, especially as regards the variability of the error terms. Goldfeld et al. considered the simultaneous structural change models and explained the endogenization of the structural change point. However, the computational difficulties involving the maximization of the log-likelikhood function, conditional on the structural change index, complicates the empirical work.

Despite difficulties that exist, there are several factors that indicate under what circumstances structural change models might be most appropriate. First is the situation where the coefficients of a properly specified model relationship differ for some sample subsets, e.g. when sample data cannot be pooled. In this case, classical fixed parameter models may not represent the accurate existing economic structure and, as a result, forecasts may not be appropriate.

The application of varying parameter models are also justified by the fact that the econometric models are abstractions from and simplifications of reality. Thus, although coefficients may not be varying in the real world, the application of classical linear models may induce them to do so because of the implied misspecification. The important types of misspecifications include omitted variables, proxy variables, aggregate data and nonlinearities.

After reviewing the relevant literature, the economic relationships within the soybean industry are described. The demand for soybeans is derived from the demand for its products namely soymeal and soyoil. Several of the relationships considered in this study constitute the demand block of the soybean industry. These mainly include: storage demand for soybeans, soyoil and soymeal; crush demand for soybeans; export demand for soybeans, soyoil and soymeal; domestic demand for soybean meal and soybean oil. In a quarterly model, production happens only once a year and, in the empirical model, it occurs only in the first quarter. The endogenization of soybean production is important when long-run forecasts of price and other demand activities are required. Within a year production is known in the first quarter and could be regarded as exogenous in the subsequent quarters. However, for forecasting beyond four quarters, endogenization of the production activity becomes extremely important. This is so because of lagged prices determining current production and current demand conditions determining the current market price. The interaction of respective supplies and demands determine the respective equilibrium price. In a quarterly model perspective equilibrium conditions are attained when last year's stocks in quarter i do not differ much from current stocks in quarter i. In this study the soybean and soyoil futures prices were considered as determined within the system. This is because of the existence of two types of economic agents in the futures markets. The agents are divided among those who carry stocks into period t and high-cost agents who do not carry stocks into period t but are still involved in the market of a given commodity. These high-cost agents, after some level of the price basis, hold less stocks and satisfy their needs for future inventory by buying contracts for forward delivery.

Since very few relevant quarterly studies have been done on soybeans a theoretical conversion from annual to a quarterly framework was developed following Subotnik et al. This essentially involves including stocks which, after the harvest season, are the only source of supply of soybeans.

In the empirical estimation the soymeal stocks and soyoil export equations are not considered. The reason for excluding soymeal stocks is that soymeal is a perishable commodity and moves into animal feeding soon after being produced. The soyoil export equation is not considered because of the data problems, especially unavailability of PL480 data on a quarterly basis. The PL480 concessional exports constitute a high percentage of the U.S. soyoil exported.

The export equations of soybeans and soymeal are considered on an aggregate basis. The world soybean trade is taken as the sum of the U.S. exports, Brazil exports, Argentina exports less the Soviet soybean imports. The Soviet imports are subtracted because they are mainly policy determined and not a function of supply and demand conditions in the world market. The world trade in soymeal is also taken as the sum of U.S., Brazil and Argentina exports. The reason for considering aggregate rather than separate U.S. exports is that the interaction of excess supplies of the U.S., Brazil and Argentina along with excess demands of the rest of the world help to determine the world market price of soybeans and soymeal. The international price feeds back into the economics of individual countries to determine supply and demand activities in these countries. However, in the absence of an appropriate international price and given the strength of the dollar in international transactions, the price of the U.S. soybeans divided by SDR's per dollar is used as the most appropriate proxy. On the other hand, the price of meal in the soymeal export equation is weighted by proportions of soymeal imported by the EC and Japan. This is necessary because Japan only started importing soymeal after 1972 and its imports are very moderate. The exports by Brazil and Argentina are regarded as exogenous because no other variables from the two countries are available on a quarterly basis.

The simultaneous specification of the varying parameter model is developed, based on Gordon Rausser et al. The varying parameter model specification implies that some of the model's coefficients to be estimated are also dependent on some other variable. When varying parameters are incorporated into the system, new variables are formed which are multiples of the initial equations's explanatory variable with variables determining the varying parameters. Because of computational constraints the resulting endogenous products are linearized by simply regressing them on their respective multiplicands.

In this study a simple version of the varying parameter model is specified by simply considering the time varying parameters as dependent on time trend and Brazilian soymeal exports. The time trend is essentially included to account for changing technology in production and processing, changing tastes and living standards as well as representing excluded time-related dynamic forces within the economy. The inclusion of Brazilian soymeal exports can be justified by the fact that Brazil is an important competitor in the world soybean market and its policies on soybean production and marketing significantly influence the domestic soybean market of the U.S.

Structural change is evident when the dependent variable responds differently to a per unit change in explanatory variables over time. Evidence of structural change is provided by the interaction of terms between time and explanatory variables and between the level of Brazilian soymeal exports and explanatory variables. To provide additional evidence in structural change, time varying elasticities are calculated for four equally spaced sub-periods of the sample. The sub-periods are 1965/66 - 1968/69, 1969/70 - 1972/73, 1973/74 - 1976/77 and 1977/78 - 1980/81.

The results indicate that structural change occurred in almost all the sectors of the soybean complex but in varying degrees. The most dramatic evidence of structural change occurred in the soybean crushing, aggregate soybean exports demands and the supply of soyoil for use sectors. Modest evidence of structural change was present in the off-farm soybean stock demand, domestic demand for soymeal, domestic demand for soyoil, supply of soybeans and soymeal for use. By contrast there appeared to be no indication of structural change for the soyoil stock and on-farm soybean stock demands. The evaluation of the forecasting performance based on the historical simulation of the models tended to support this assessment of the degree and location of structural change.

Comparison of the elasticities for the sub-periods provide some insight into the changing responsiveness of various dependent variables to changes in explanatory variables over time. The results were mixed across equations in the soybean complex. In general terms, the off-farm soybean demand, aggregate soybean exports, soybean and soybean product prices tended to evidence a pattern of more inelastic price and quantity elasticities in recent years. However, several components of the soybean complex, soybean crush demand, domestic demand for soymeal and soyoil, showed the opposite pattern. In addition, the on-farm stock and soyoil stock demand components had relatively constant elasticities for almost the entire sample period.

Further analysis of elasticities revealed several interesting patterns. The elasticities from the varying parameter models for off-farm stock demand, domestic soymeal and soyoil demand, soybean crushing demand seemed to diverge from the fixed price elasticities. On the other hand, the varying price elasticity of soybean export demand seemed to converge on the price elasticity from the fixed parameter model.

Assessment of the forecasting performance of the varying parameter and fixed parameter models was performed. This assessment was based on percent root mean squared prediction error and turning point error analysis. Within the data used in estimation, the varying parameter model consistently outperformed the fixed parameter model by generating smaller percent root mean squared errors and fewer turning point errors. The most dramatic improvements in prediction accuracy were evidenced in the soybean stock equations and soybean and soyoil price equations. In the out of sample forecasts, the results of the prediction performances were mixed, with the fixed parameter model forecasting marginally better for certain equations. However, the varying parameter model still demonstrated rather significant improved forecasting accuracy for soybean stock and soymeal price relationships. The results from the out of sample forecasting should be viewed as a tentative assessment of the varying parameter model's accuracy because of the limited number of observations used in the test.

The implications of the research are varied for policy makers and market participants alike. Given that structural change has occurred, it is important that econometric representation of this sector take this into account. If structural change is not considered, forecasting will be impaired and elasticity estimators used in policy decisions will be inaccurate. This is important because incorrect forecasts and elasticity estimates can lead to inappropriate market and policy decisions. Results of the research also raise the question of the potential importance of structural change in other agricultural sectors and suggest the need for a systematic assessment of this possibility.

In terms of specific actions in the soybean complex the elasticity estimates for the export equation indicate that this sector is becoming more insensitive to price changes. This suggests that stimulation of exports will more likely occur with credit and government programs and policies designed to shift export demand rather than with marginal changes in costs or prices in the market.

7.1 Model Assessment and Recommendations

It seems appropriate at this time to point out that an attempt has been made to model the soybean market using time varying parameters. Improvement of the model will be required, since it is apparent from the prediction results, that the varying parameter model in its present form does not completely dominate the forecasting ability of the fixed parameter model.

At least four points are evident. First, not all the varying parameters need be functions of time and Brazilian soymeal exports only. It is quite in order for variables influencing the effects of the explanatory variables to differ within and across equations, depending on the specific situation and type of equation.

The second point concerns the level and direction of the influence on the varying parameter. If the sign of the variable affecting the parameter is different from the sign of the parameter, the model, as specified here, does not guarantee that a given parameter will not eventually change the theoretically accepted sign. The remedy is to incorporate constraints that ensure preservation of the expected sign. This may be especially important when time trend variable is used.

The third point concerns the variance of the error terms in the varying parameter model. As was stated earlier, the heteroskedastic error term, due to the varying parameters being associated with endogenous variables, was regarded as zero. The reason for exclusion is because of complications in estimating its various components. It is recommended that future research take these heteroskedastic errors into account in order to obtain relatively more efficient estimates as well as more reliable forecasts. Since forecast errors have variances that are bigger than those within the sample period, it is possible that the disregard of heteroskedasticity may be the reason why the varying parameter model did not do as well in the out of sample forecasting as it did in the historical simulation.

Another important point to consider, in future studies, is the values of exogenous variables used for out of sample forecasting. In this study all the exogenous variables were set at their actual values since these were known at the time of making sample simulations. This was necessitated by the anticipated problems of forecasting exogenous variables. However, using actual values is technically wrong because these values are not known in the actual operation of the model. The only true test of validity involves using the two contrasting models in an actual forecasting environment. The historical tracking provides some preliminary validation but, the impressions gathered from it can increases one's confidence as it did in the case of the varying parameter model.

The varying parameter model specified here could be applied to other commodities with appropriate respecifications as mentioned above. However, it may be impractical to correct for autocorrelation, heteroskedasticity, simultaneity and multicollinearity within the framework of one model.

APPENDIX A

CALCULATION OF MEAL CONSUMING ANIMAL UNITS

The meal consuming animal units index (MCU) is the sum of the following livestock groups weighted by the factor in parentheses according to calculations by T. Hieronymus.

Dairy Cows (2.9022)

Source: Cattle, USDA

First Quarter - average of July 1 and January 1

Second Quarter - milk cows on farms January 1

Third Quarter - average of January 1 and July 1

Fourth Quarter - milk cows on farms July 1

Cattle on Feed (1.7264)

Source: 23 states, Cattle on Feed, USDA

First through Fourth Quarter - cattle on feed at the beginning of the quarter

Other Beef Cattle (0.5274)

Source: Cattle, USDA

First Quarter - beef cows that have calved + heifer replaements over 500 lbs., average of July 1 and January 1

Second Quarter - beef cows and heifer replacements, January 1

Third Quarter - beef cows and heifer replacements, average of January 1 and July 1

Fourth Quarter - beef cows and heifer replacements, July 1

Layers on Hand (0.1626)

Source: Eggs, Chickens and Turkeys, USDA

First through Fourth Quarter - number of layers on hand at the beginning of the quarter

Broilers (0.0535)

Source: Eggs, Chickens and Turkeys, USDA

First Quarter - Broiler-type chicks hatched, Sept + Oct + Nov

Second Quarter - Broiler-type chicks hatched, Dec + Jan + Feb

Third Quarter - Broiler-type chicks hatched, Mar + Apr + May

Fourth Quarter - Broiler-type chicks hatched, Jun + Jul + Aug

Turkeys (0.5254)

Source: Eggs, Chickens and Turkeys, USDA

First Quarter - turkey poults hatched, all breeds, Jun + Jul + Aug

Second Quarter - turkey poults hatched, all breeds, Sept + Oct + Nov

Third Quarter - turkey poults hatched, all breeds, Dec + Jan + Feb

Fourth Quarter - turkey poults hatched, all breeds, Mar + Apr + May

Hogs (1.0000)

Source: Hogs and Pigs, USDA

First Quarter - all hogs and pigs, 14 states, September 1

Second Quarter - all hogs and pigs, 14 states, December 1

Third quarter - all hogs and pigs, 14 states, March 1

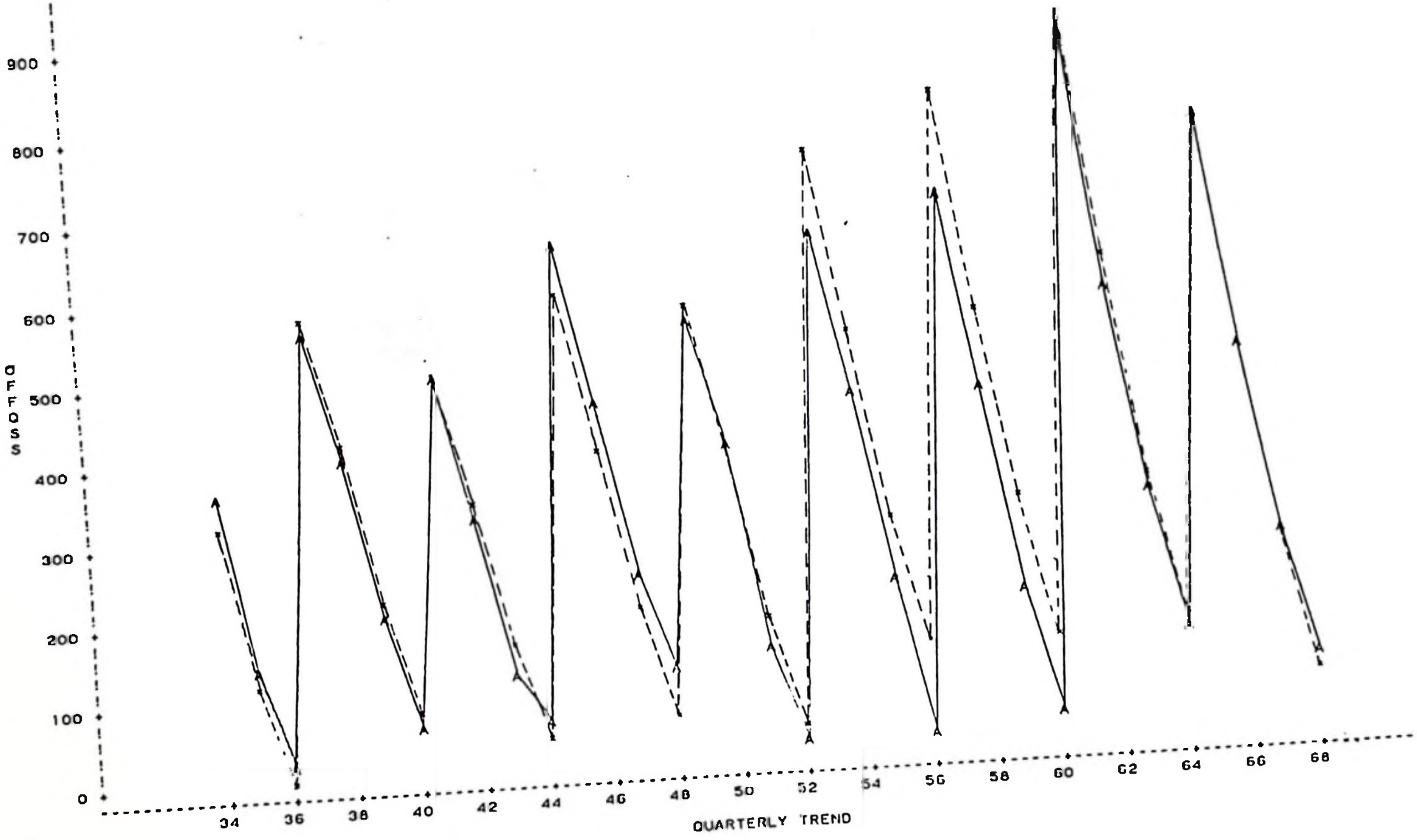
Fourth Quarter - all hogs and pigs, 14 states, June 1

APPENDIX B

GRAPHS OF PLOTTED ACTUAL AND PREDICTED VALUES OF SOME ENDOGENOUS VARIABLES

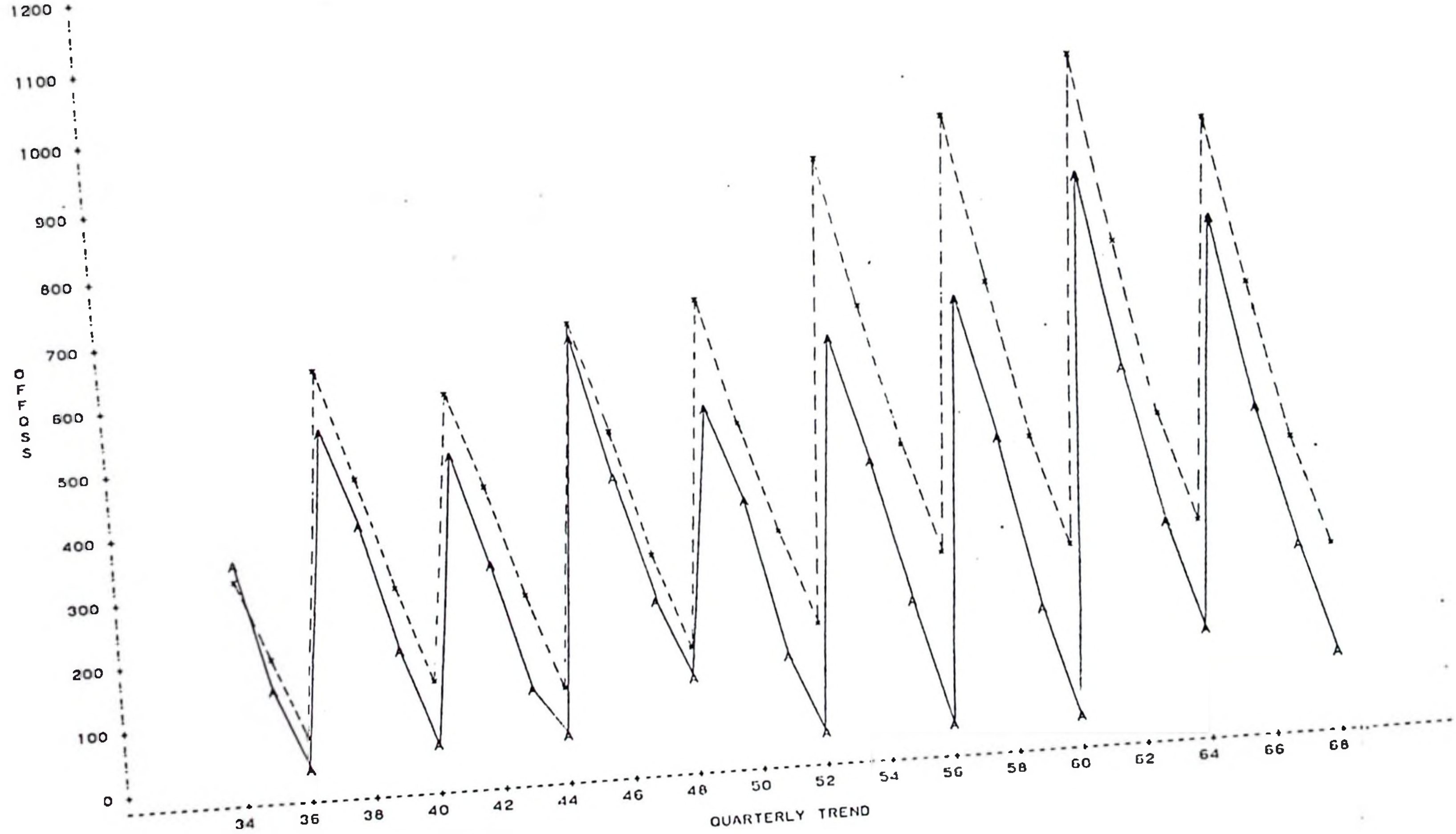
.....VARYING PARAMETER MODEL.....

PLOT OF X57*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P57*X1   SYMBOL USED IS *



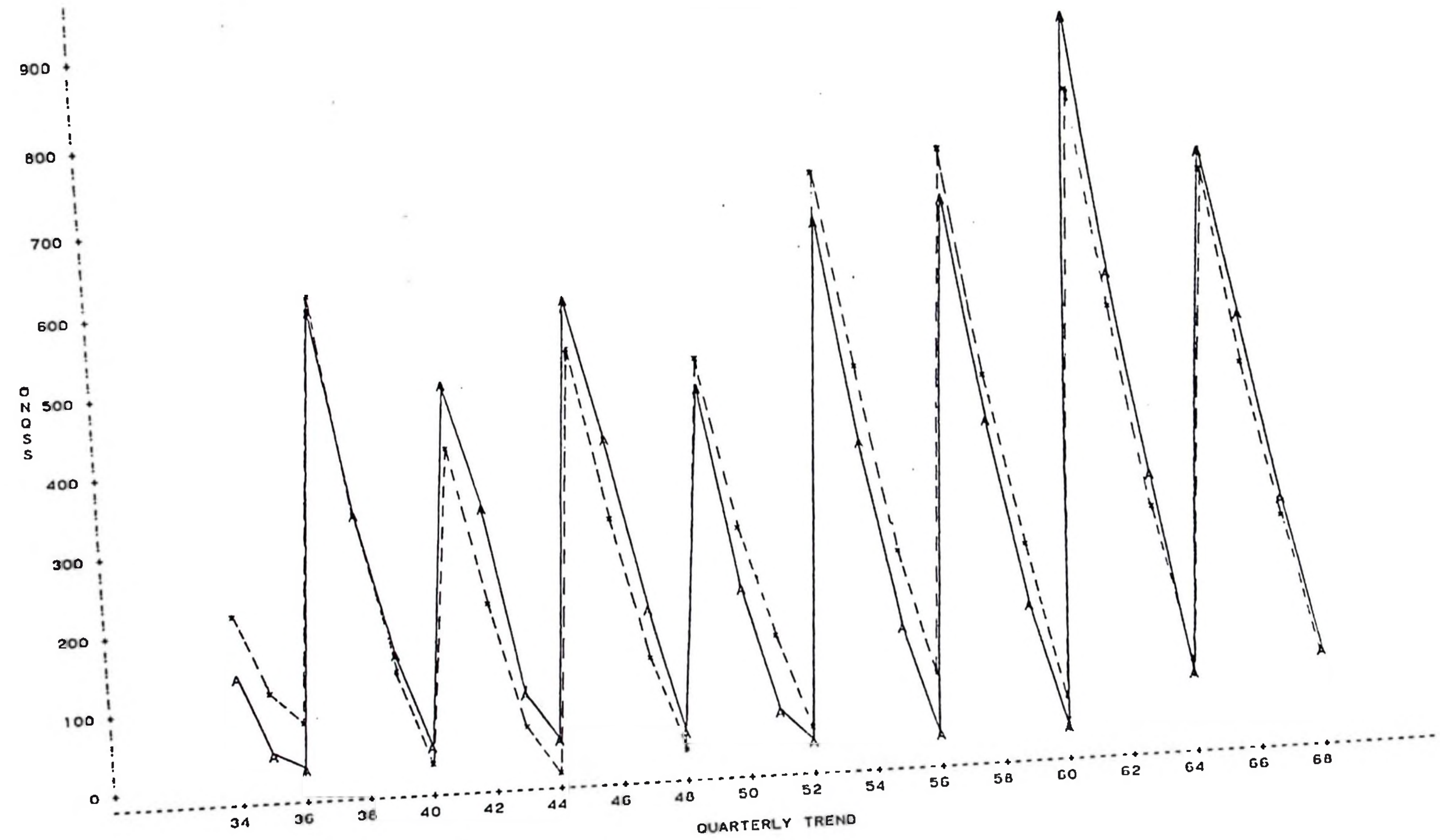
.....FIXED PARAMETER MODEL.....

PLOT OF X57*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P57*X1   SYMBOL USED IS *



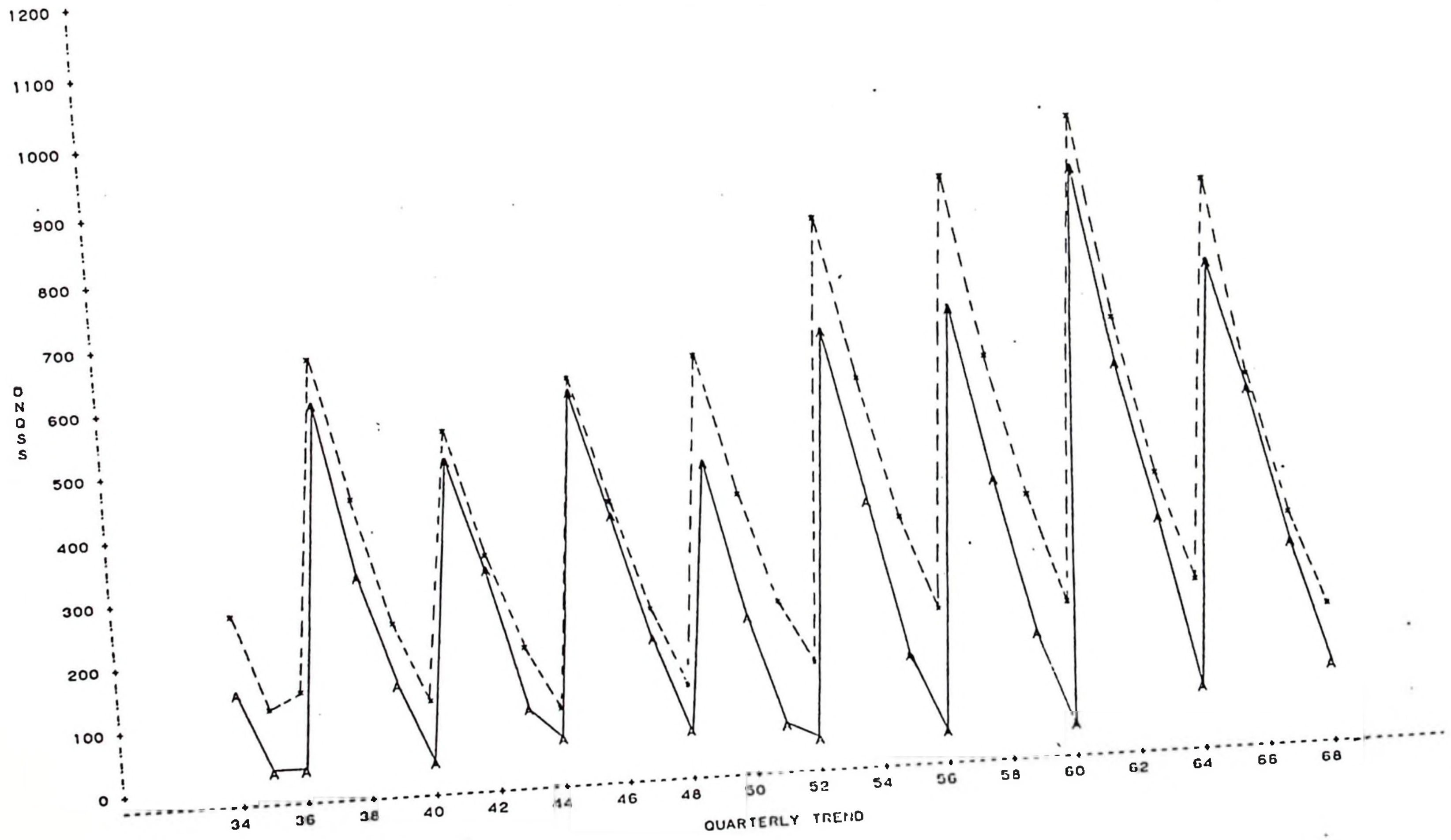
.....VARYING PARAMETER MODEL.....

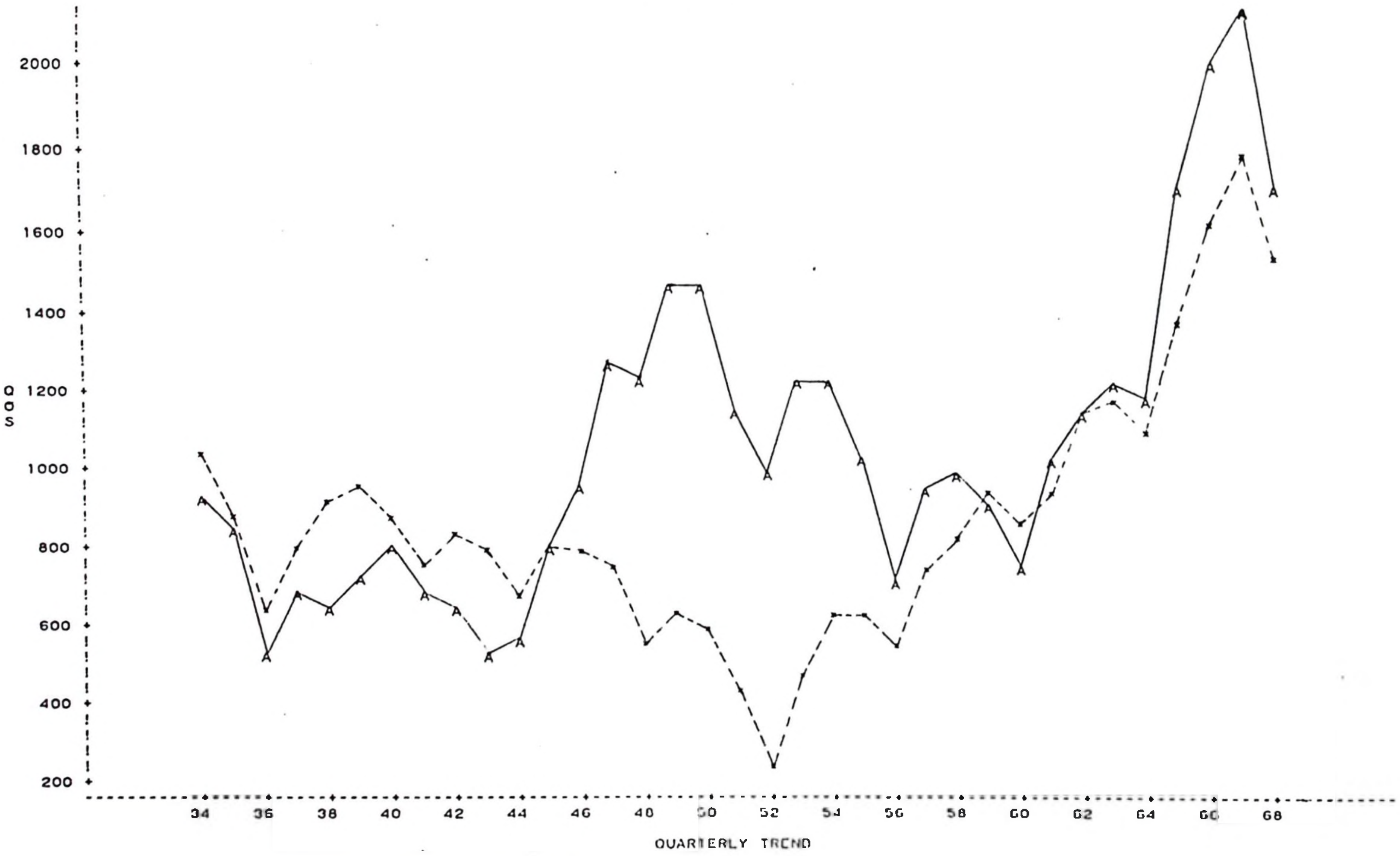
PLOT OF X58*X1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P58*X1 SYMBOL USED IS *



.....FIXED PARAMETER MODEL.....

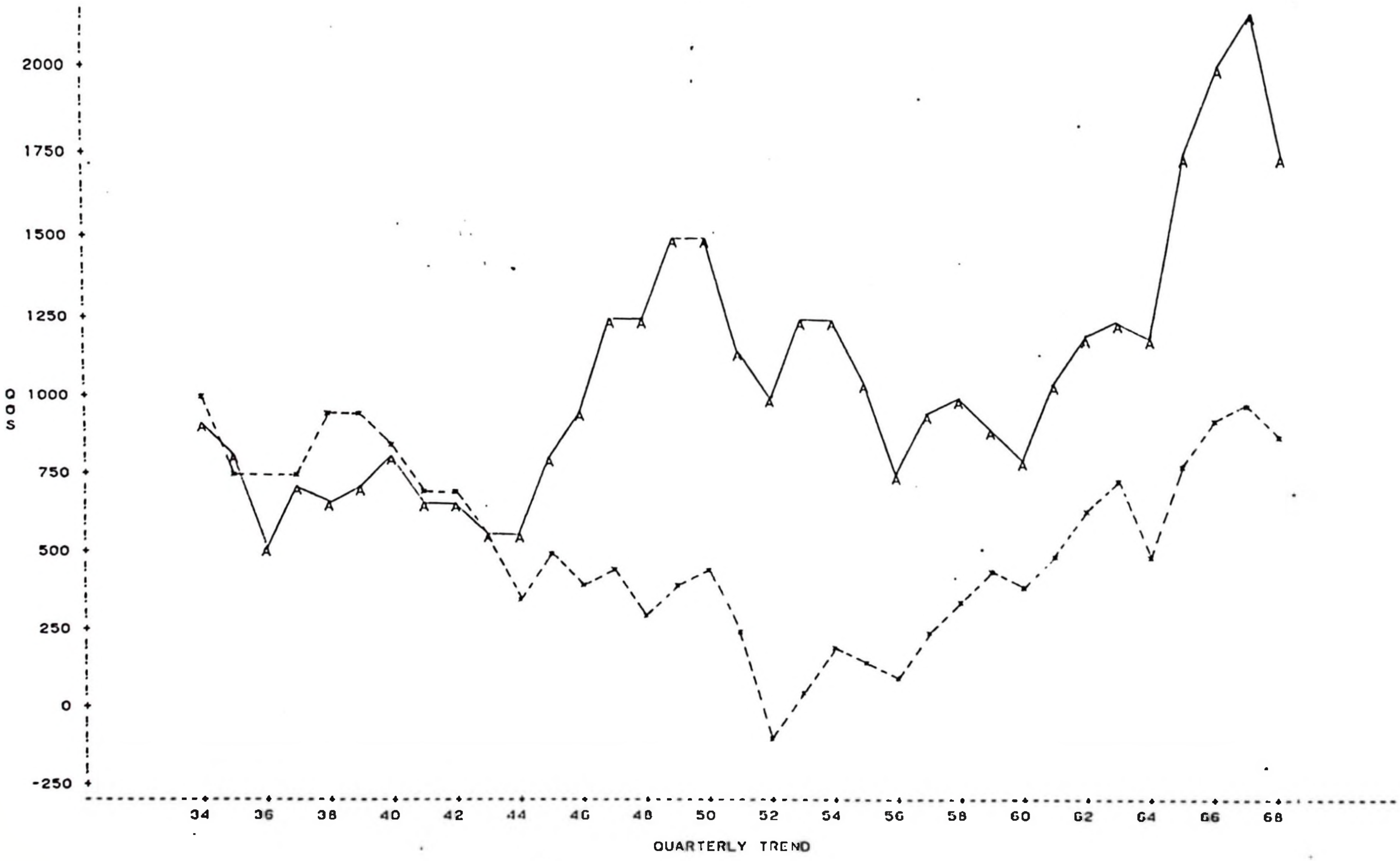
PLOT OF X58*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P58*X1   SYMBOL USED IS *





.....VARYING PARAMETER MODEL.....

PLOT OF X3*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P3*X1   SYMBOL USED IS *

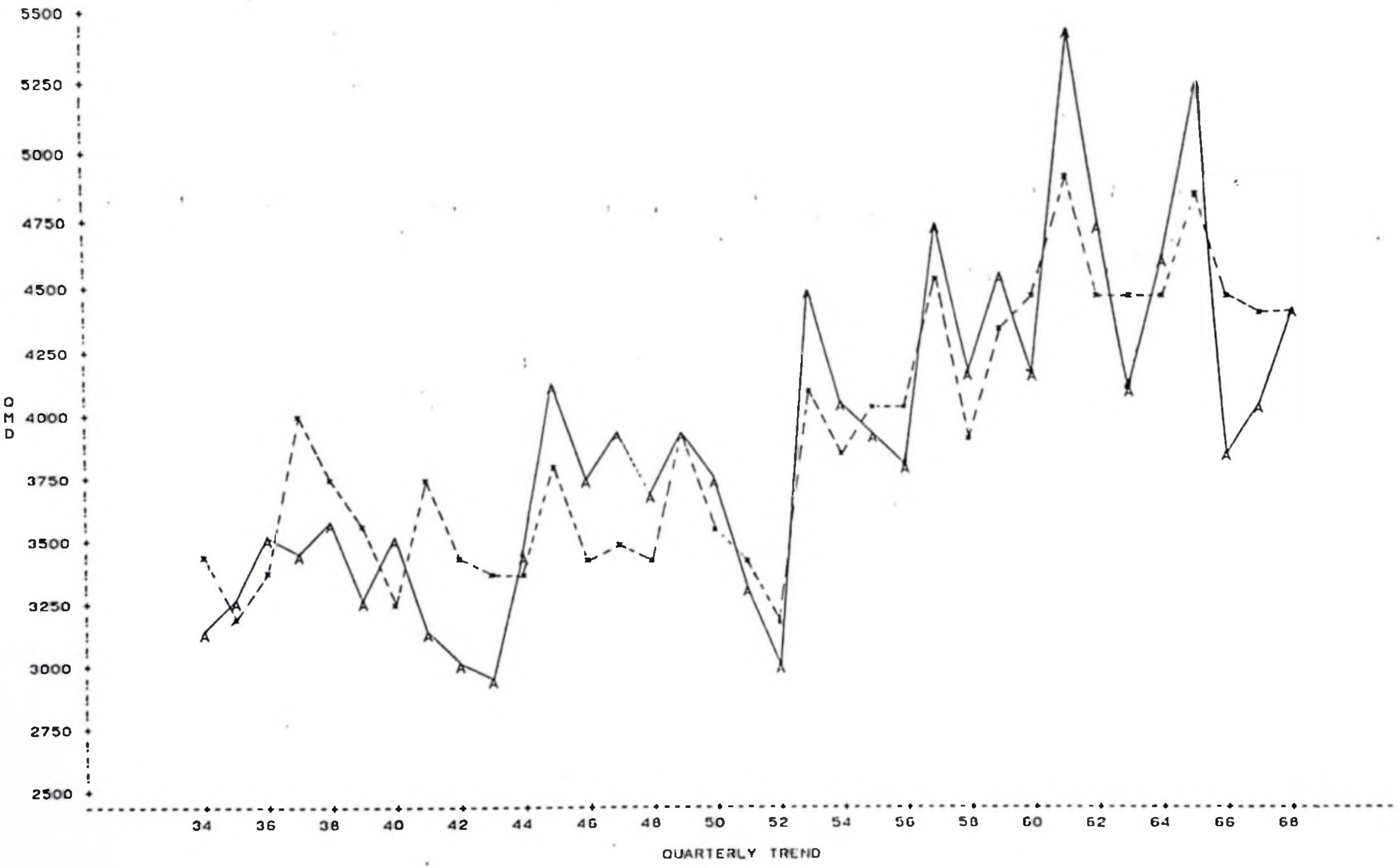


.....FIXED PARAMETER MODEL.....

PLOT OF X3*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P3*X1   SYMBOL USED IS *

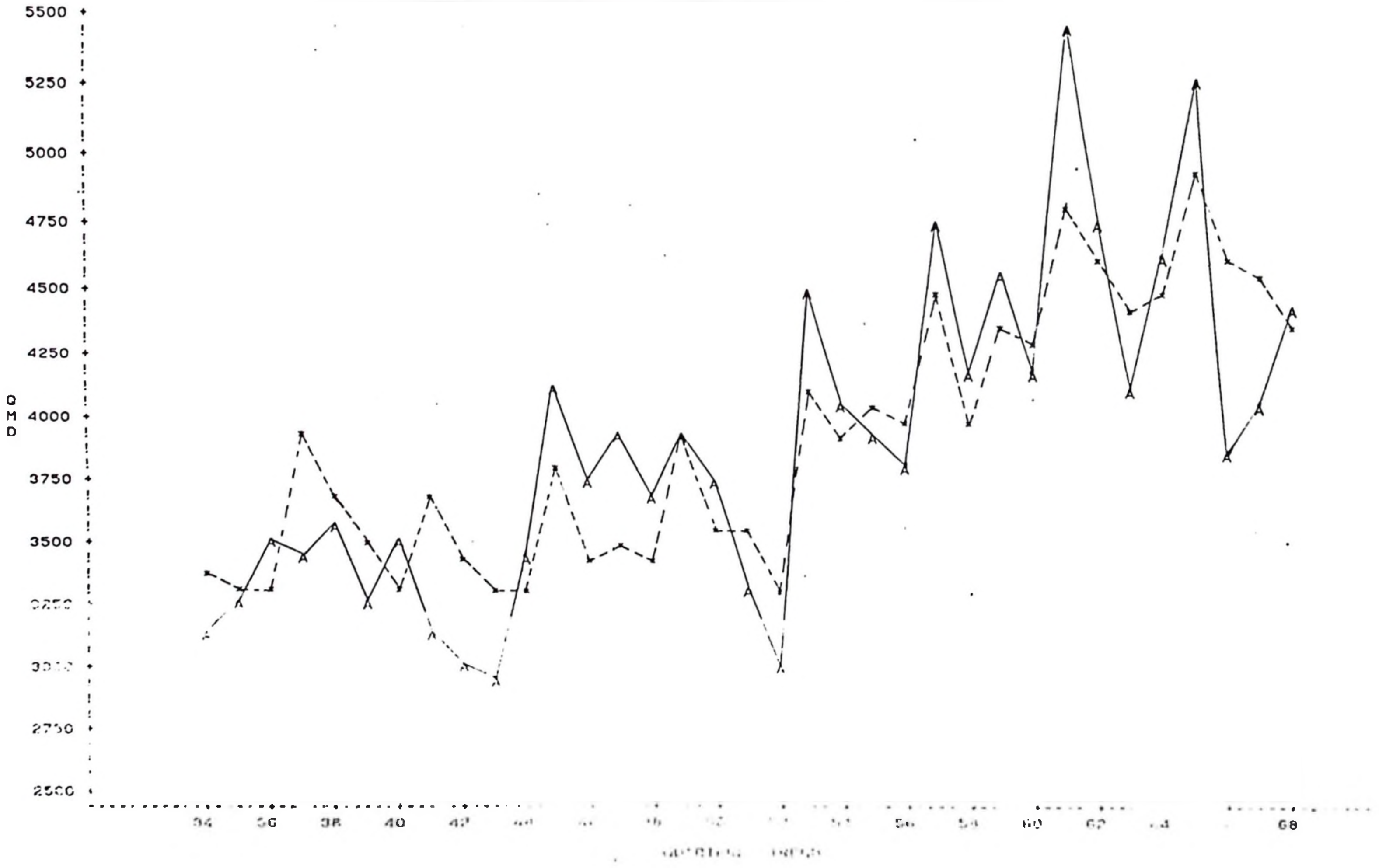
.....VARYING PARAMETER MODEL.....

PLOT OF X48*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P48*X1   SYMBOL USED IS *



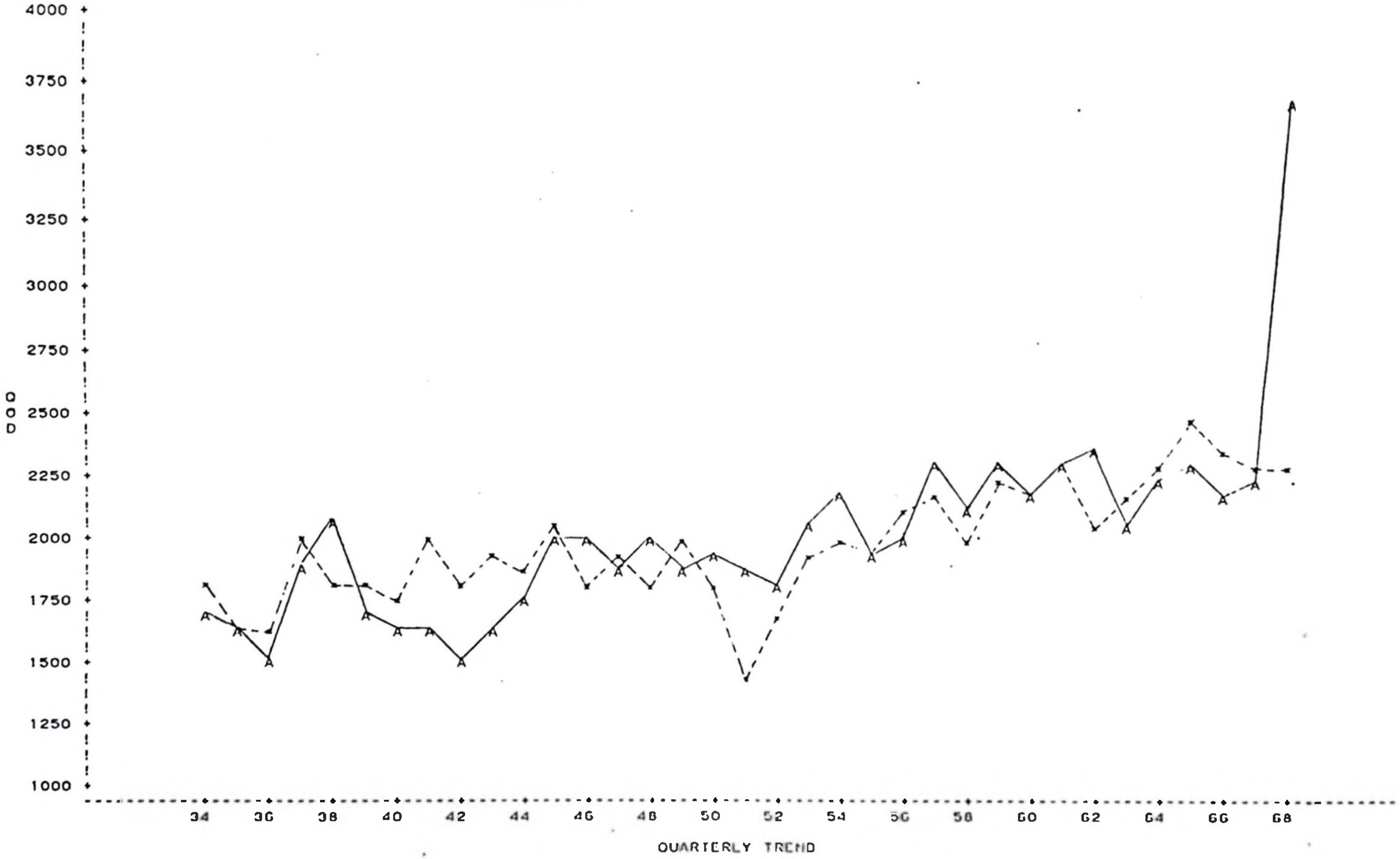
.....FIXED PARAMETER MODEL.....

PLOT OF X48*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P48*X1   SYMBOL USED IS *



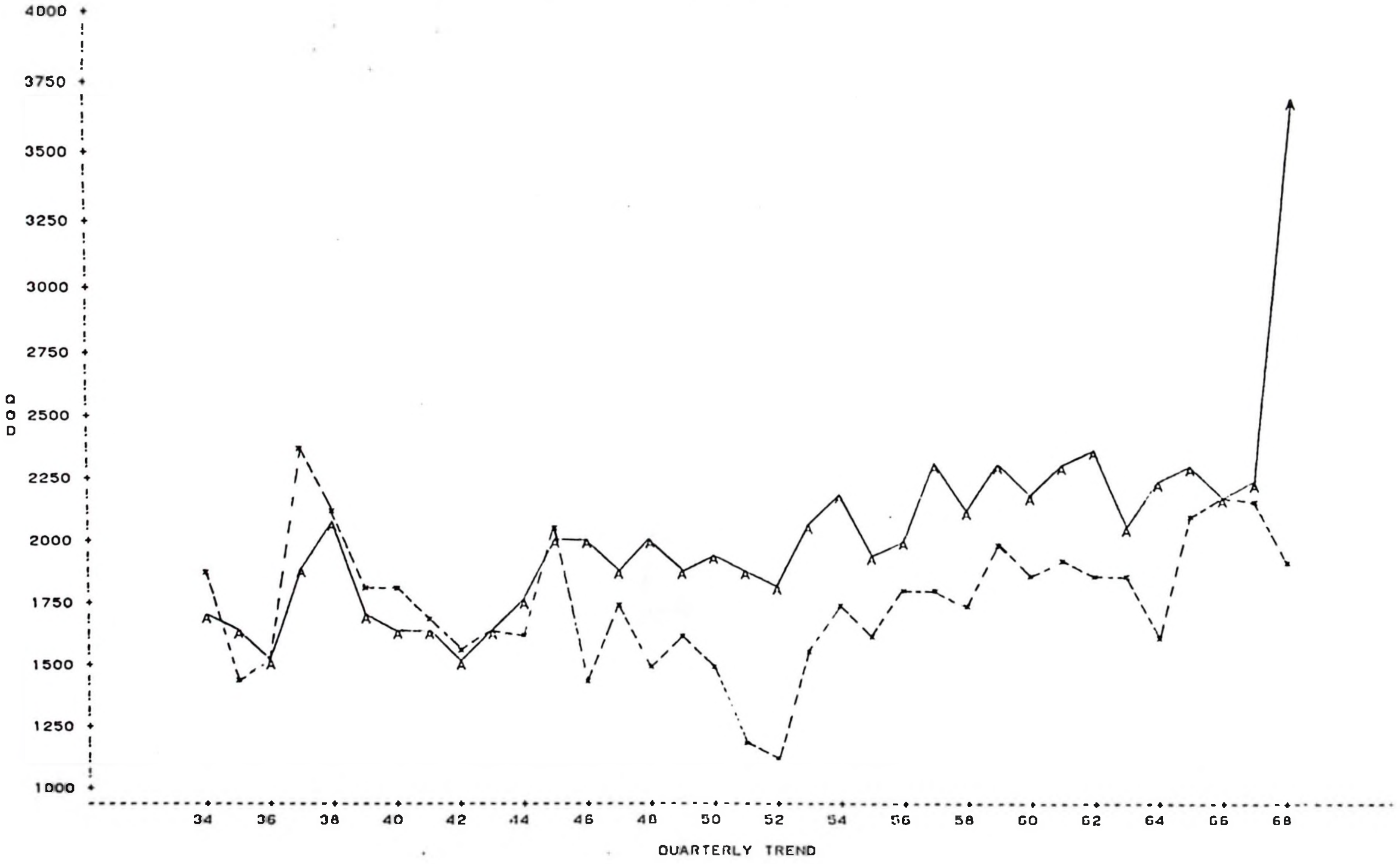
.....VARYING PARAMETER MODEL.....

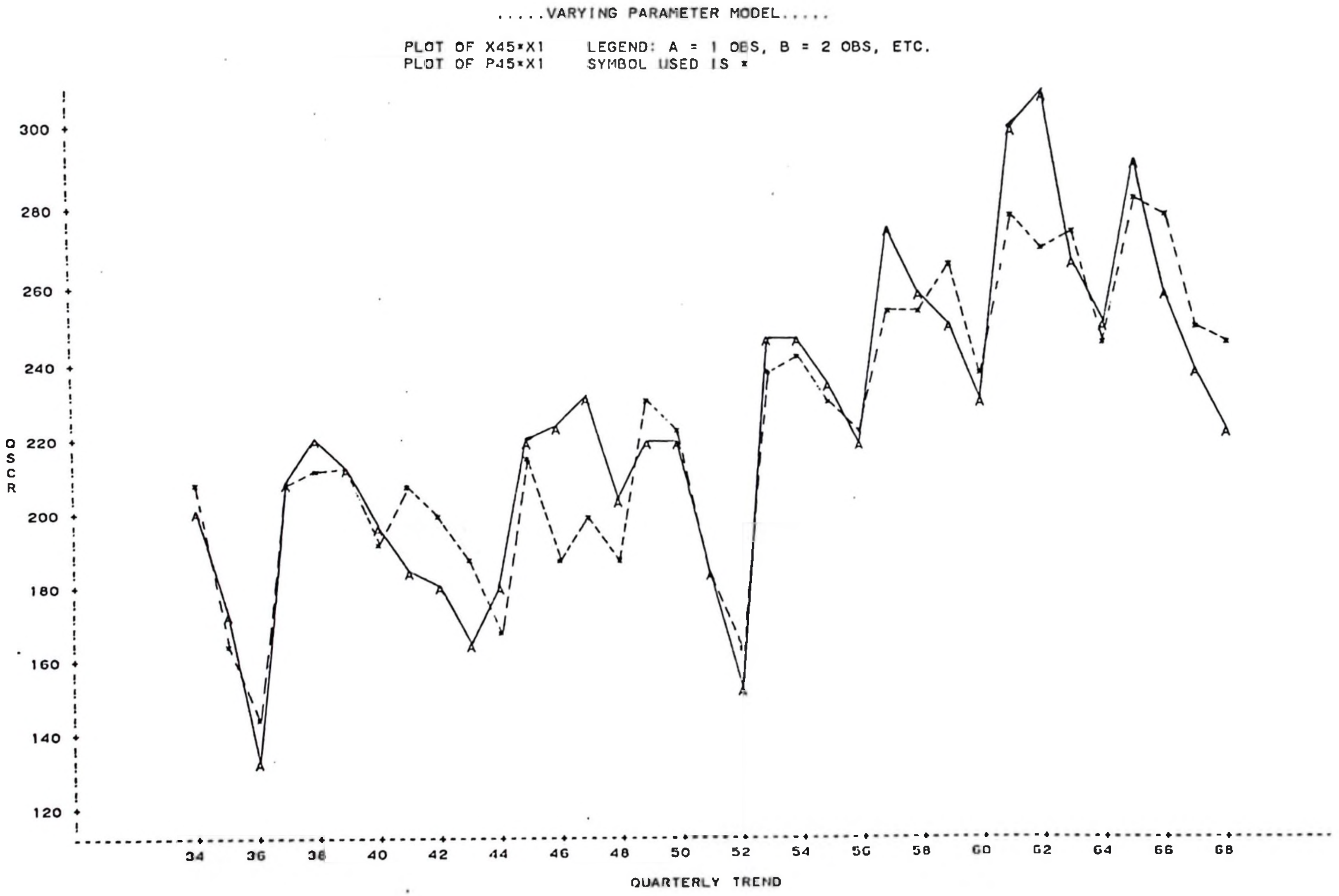
PLOT OF X43*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P43*X1   SYMBOL USED IS *



.....FIXED PARAMETER MODEL.....

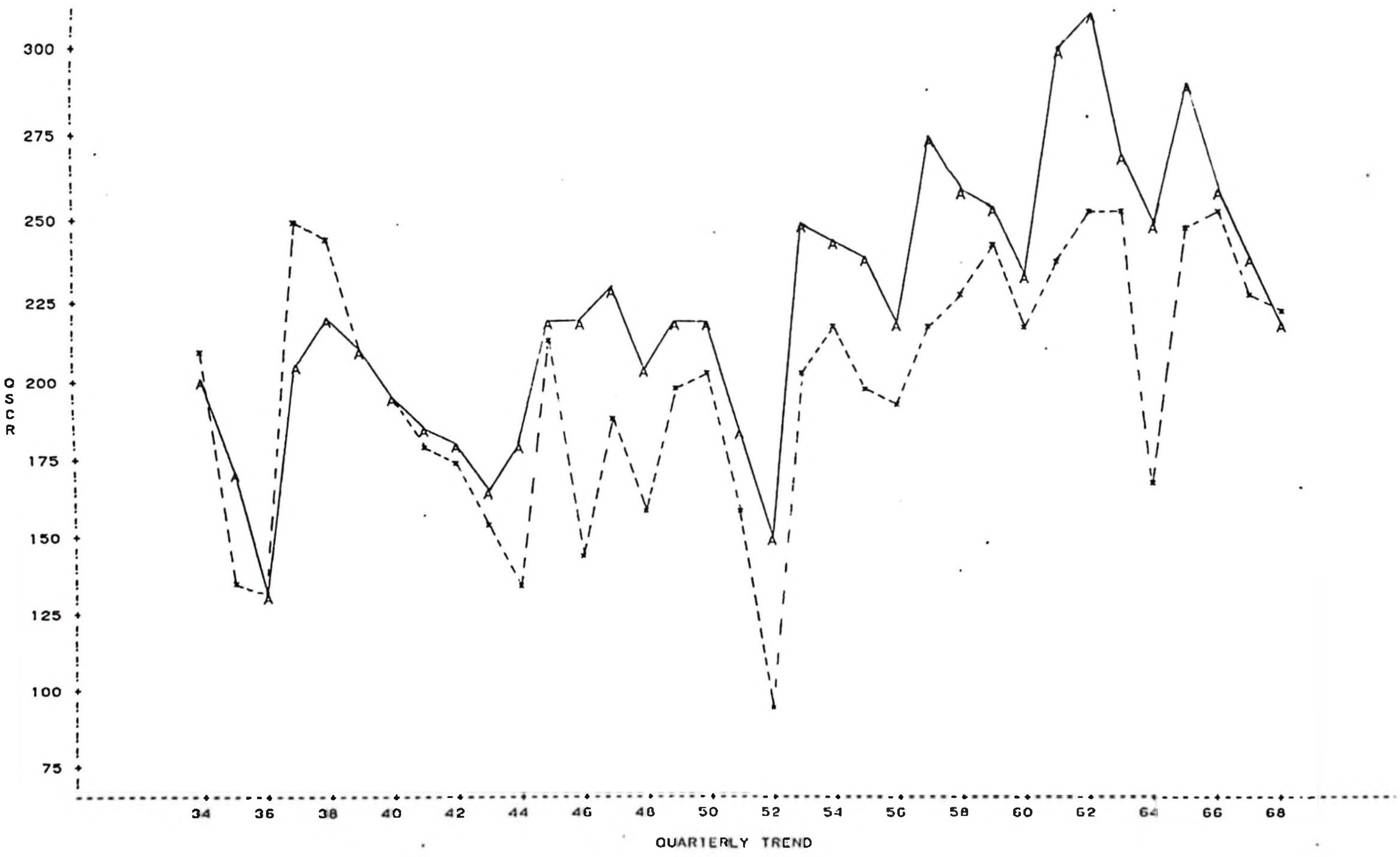
PLOT OF X43*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P43*X1   SYMBOL USED IS *




.....VARYING PARAMETER MODEL.....
PLOT OF X45*X1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P45*X1 SYMBOL USED IS *
QSCR
300
280
260
240
220
200
180
160
140
120
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
QUARTERLY TREND

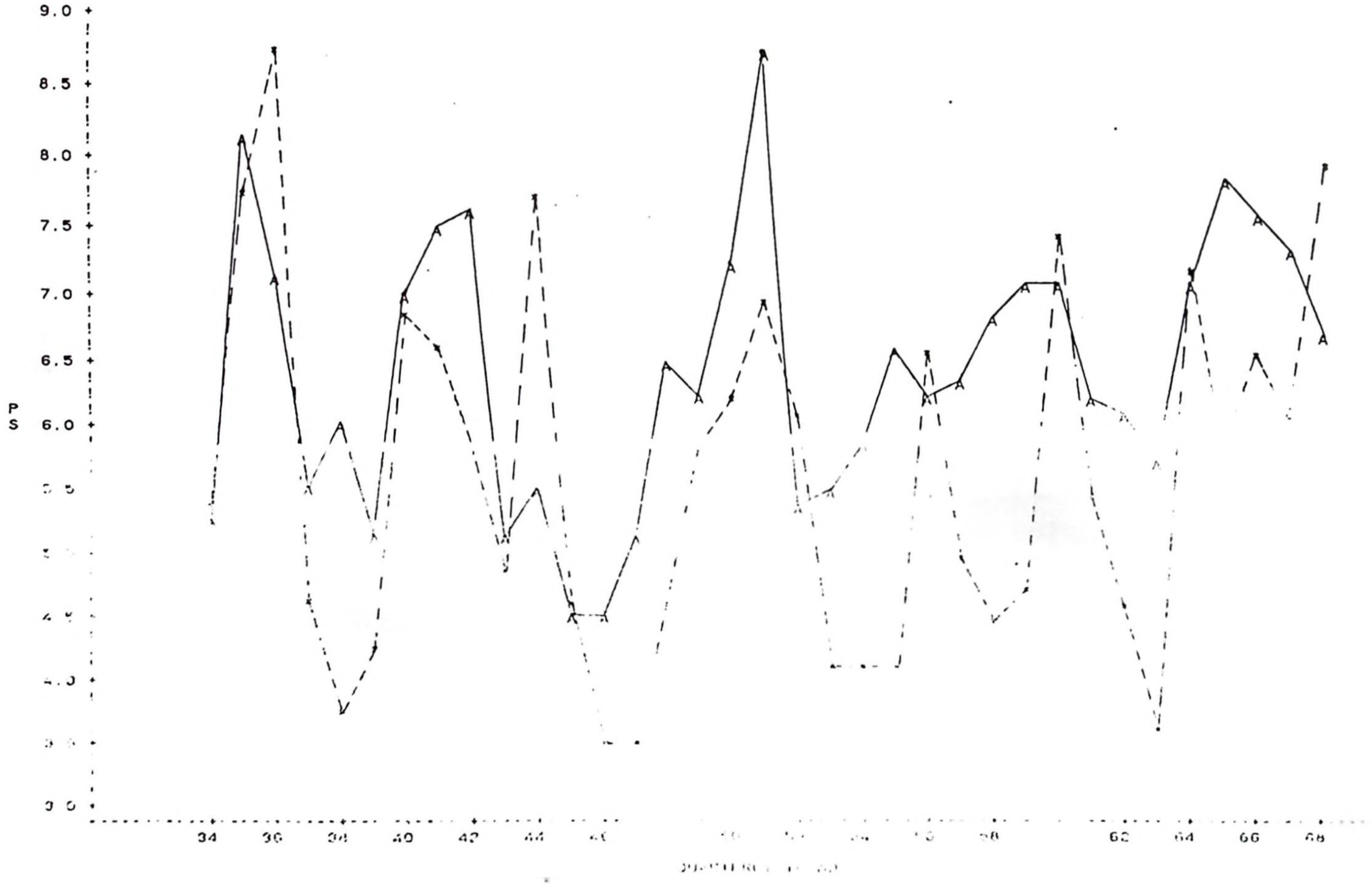
.....FIXED PARAMETER MODEL.....

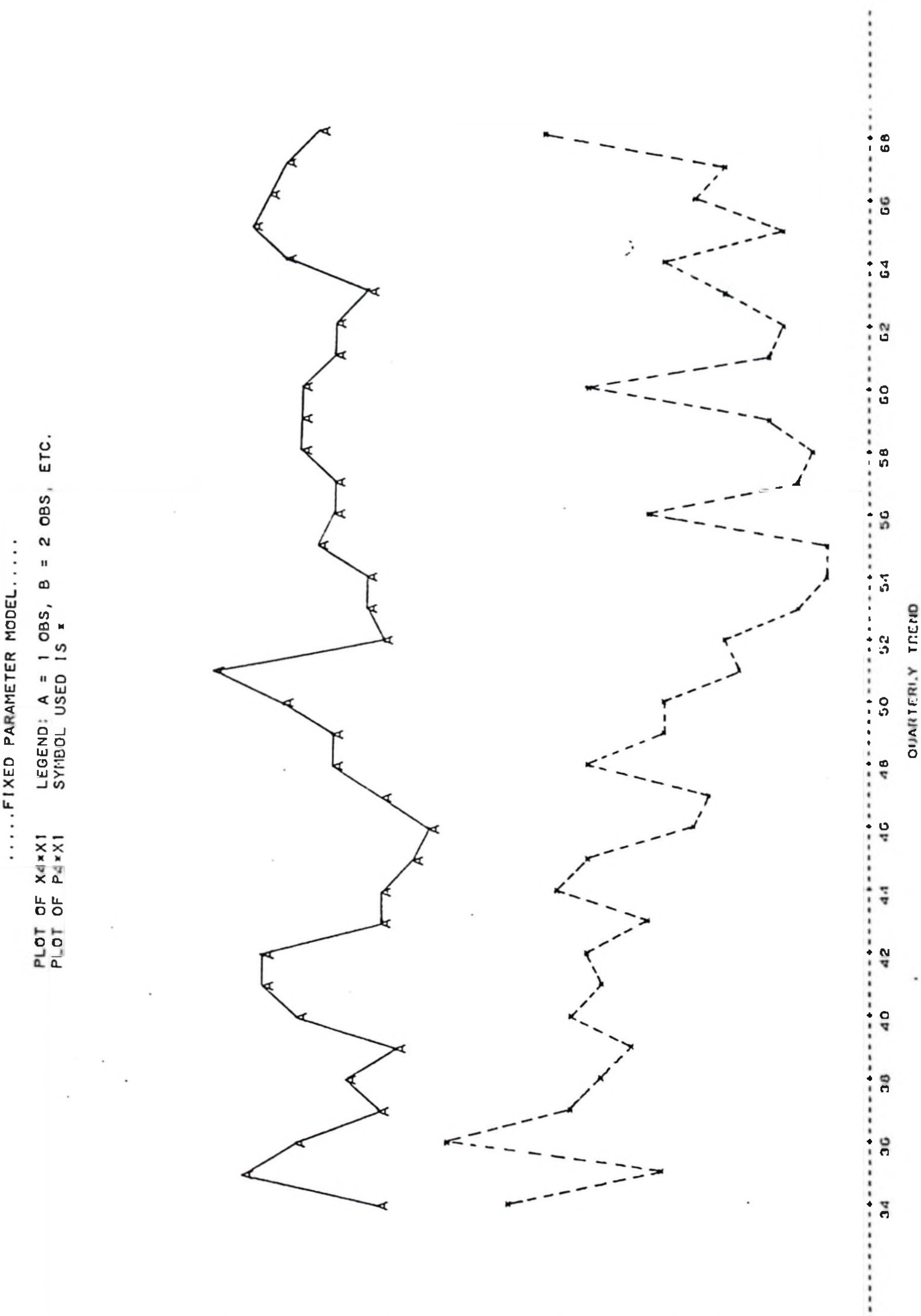
PLOT OF X45*X1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P45*X1 SYMBOL USED IS *



.....VARYING PARAMETER MODEL.....

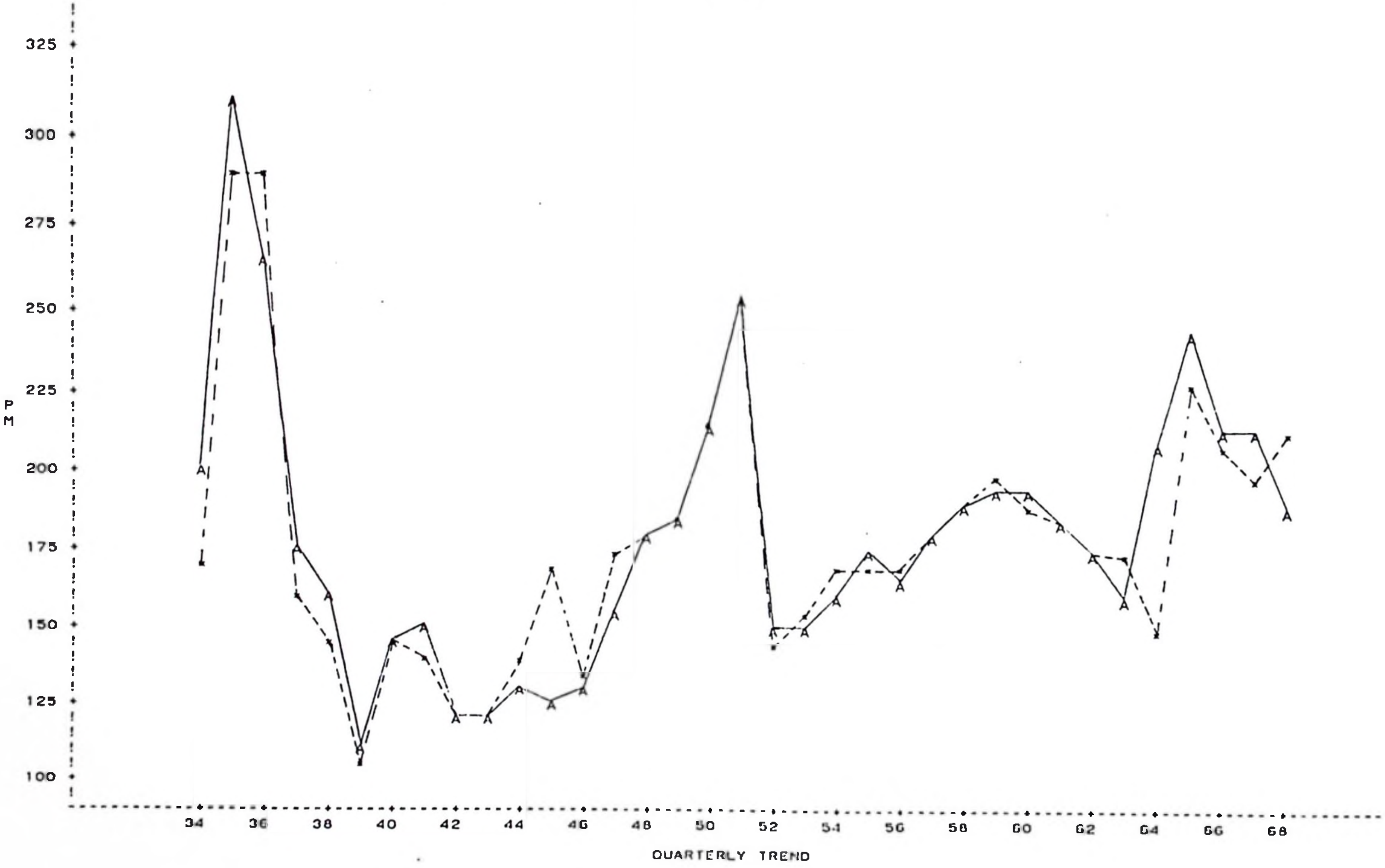
PLOT OF X4*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P4*X1   SYMBOL USED IS *




......FIXED PARAMETER MODEL......
PLOT OF X4*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P4*X1   SYMBOL USED IS *
P
S
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
QUARTERLY TREND

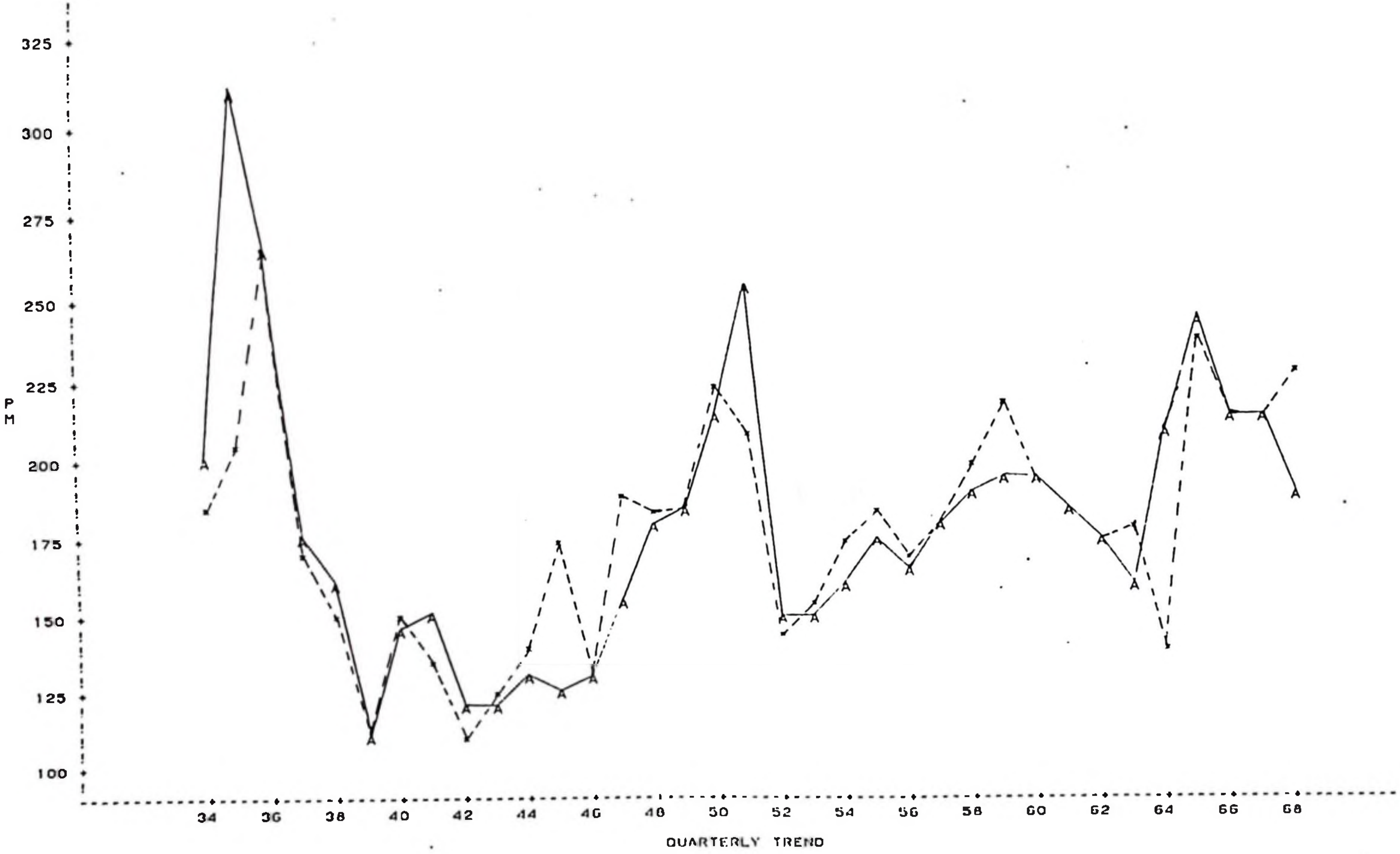
.....VARYING PARAMETER MODEL.....

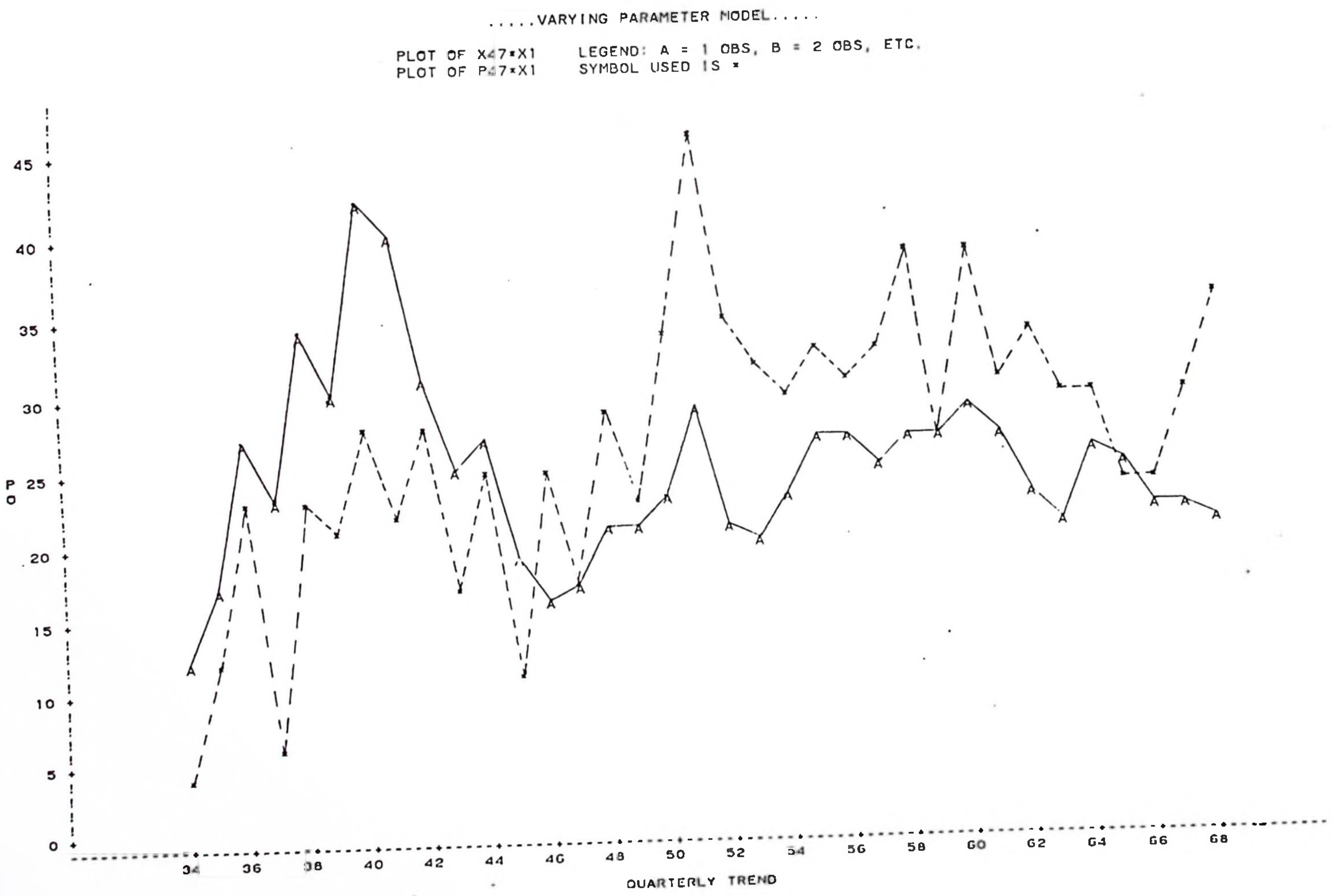
PLOT OF X49*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P49*X1   SYMBOL USED IS *

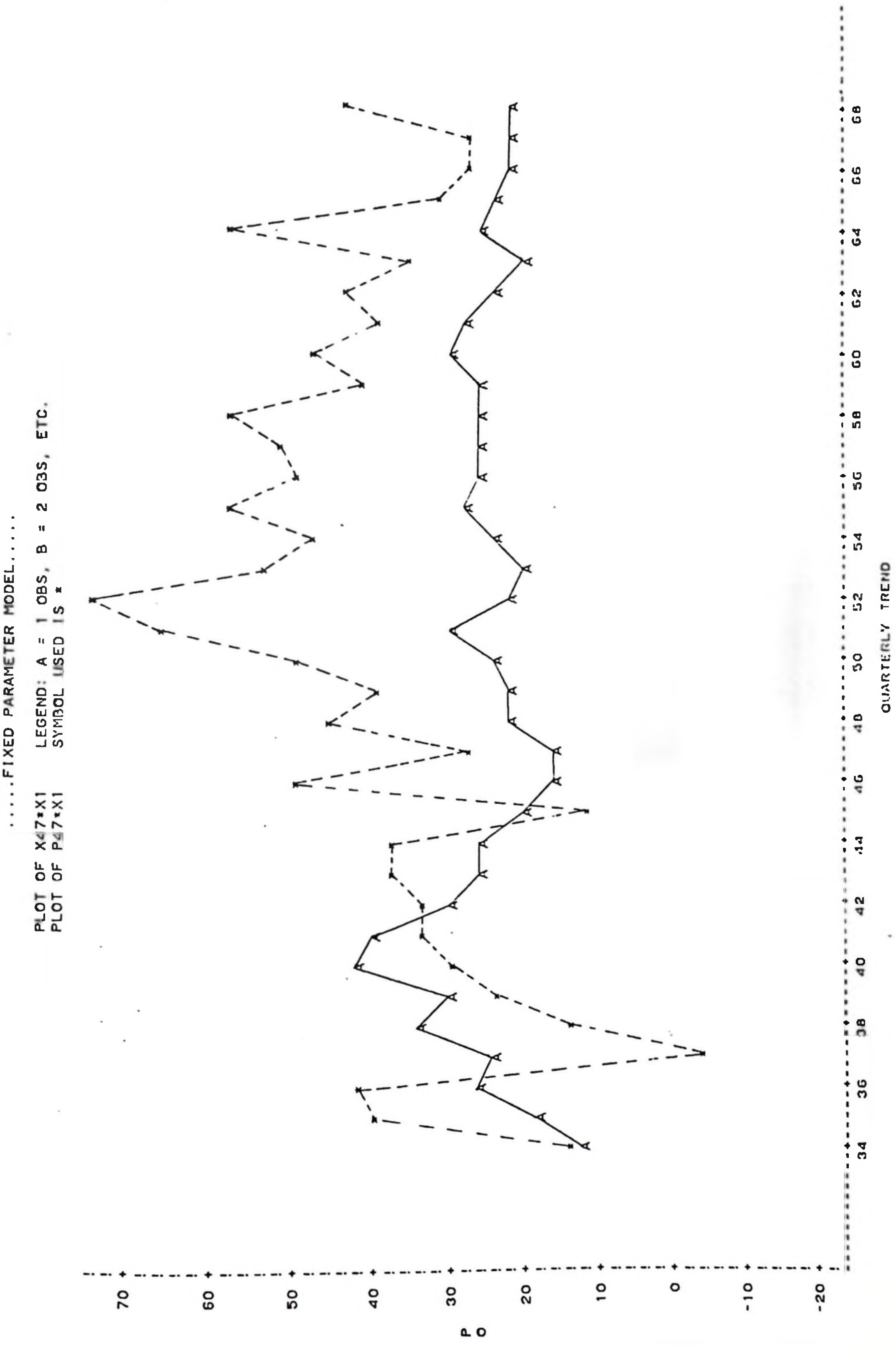


.....FIXED PARAMETER MODEL.....

PLOT OF X49*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P49*X1   SYMBOL USED IS *

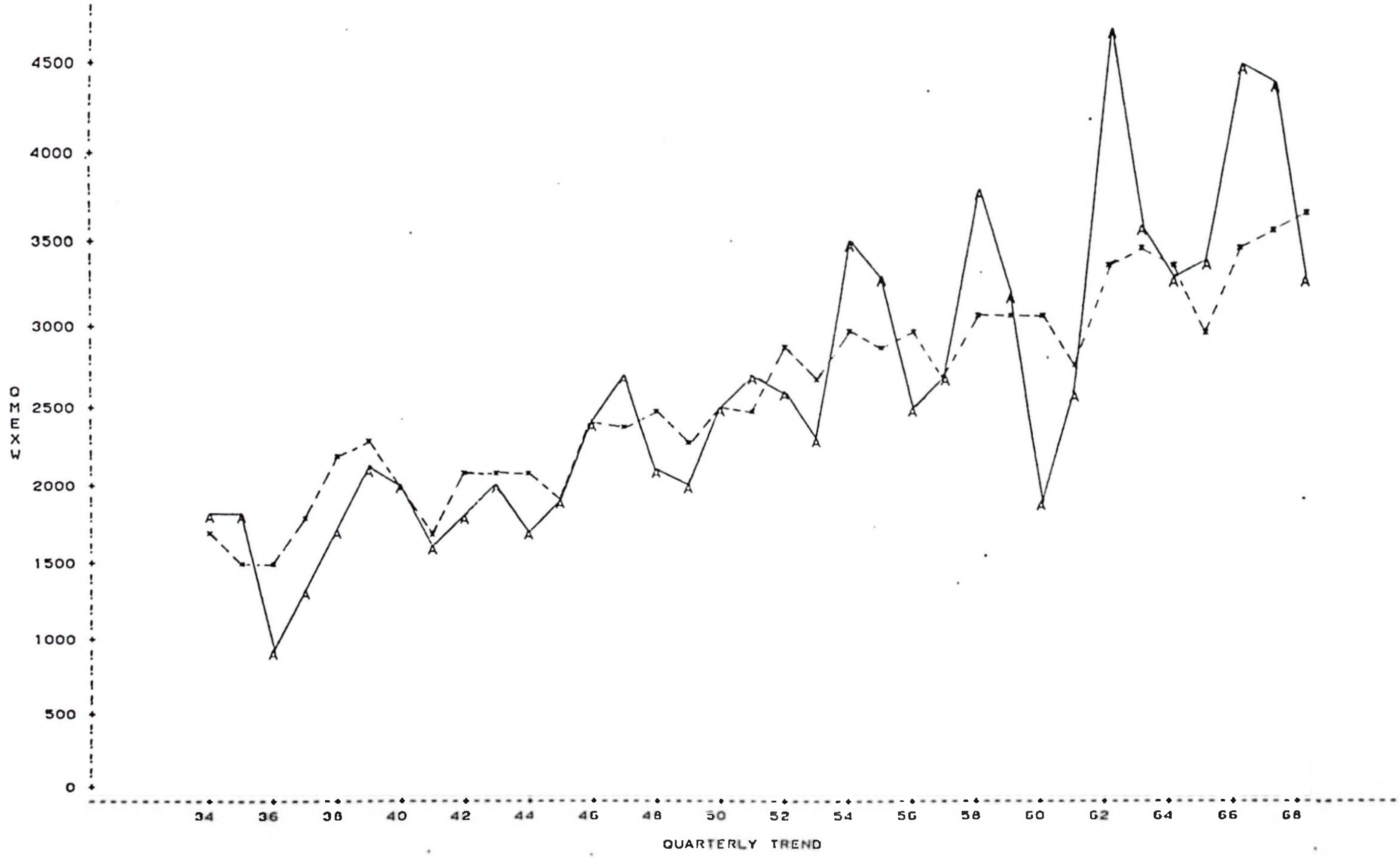



.....VARYING PARAMETER MODEL.....
PLOT OF X47*X1
PLOT OF P47*X1
LEGEND: A = 1 OBS, B = 2 OBS, ETC.
SYMBOL USED IS *
P
O
0
5
10
15
20
25
30
35
40
45
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
QUARTERLY TREND


.....FIXED PARAMETER MODEL.....
PLOT OF X47*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P47*X1   SYMBOL USED IS *
P
O
70
60
50
40
30
20
10
0
-10
-20
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
QUARTERLY TREND

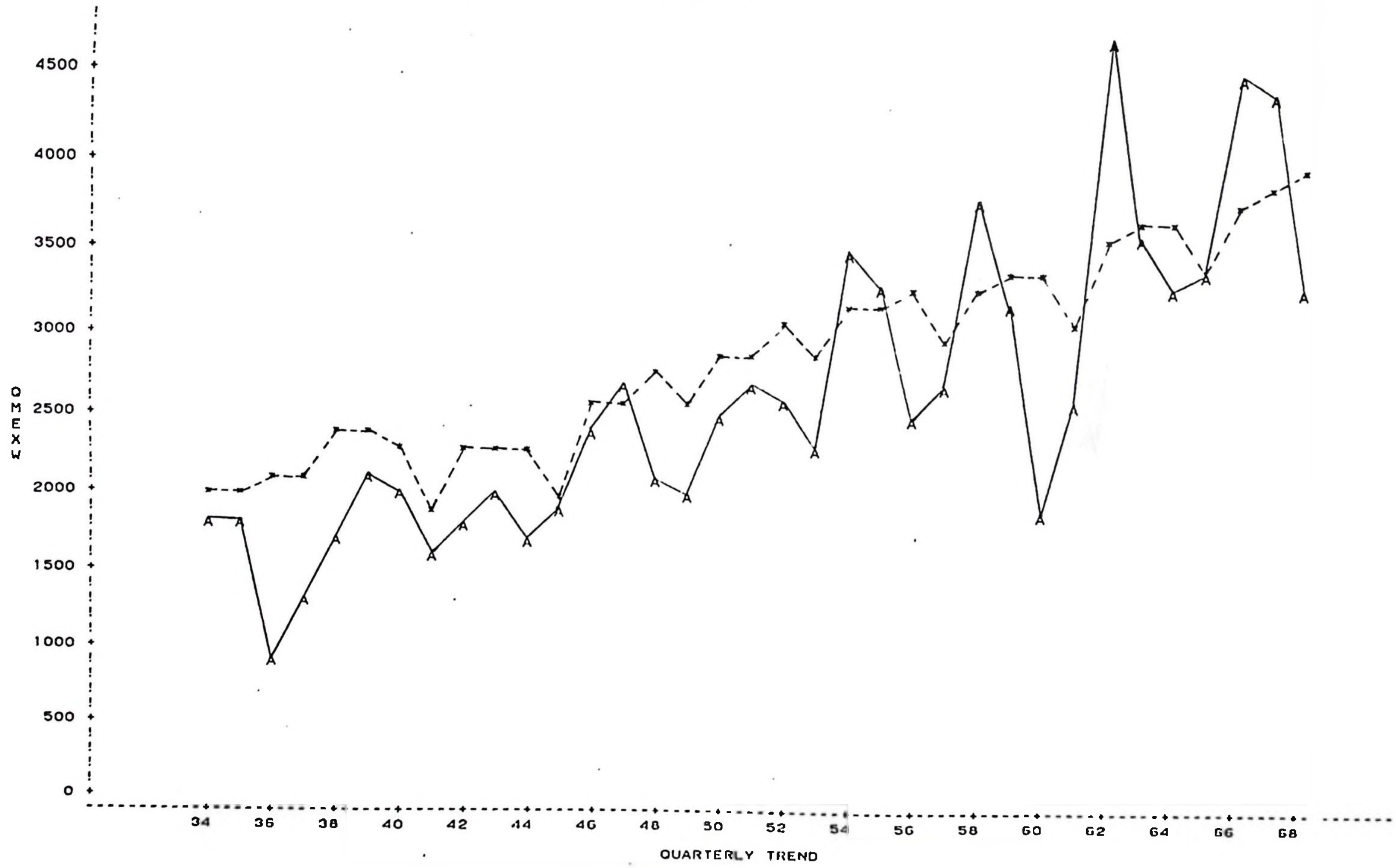
.....VARYING PARAMETER MODEL.....

PLOT OF X78*X1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P78*X1 SYMBOL USED IS *



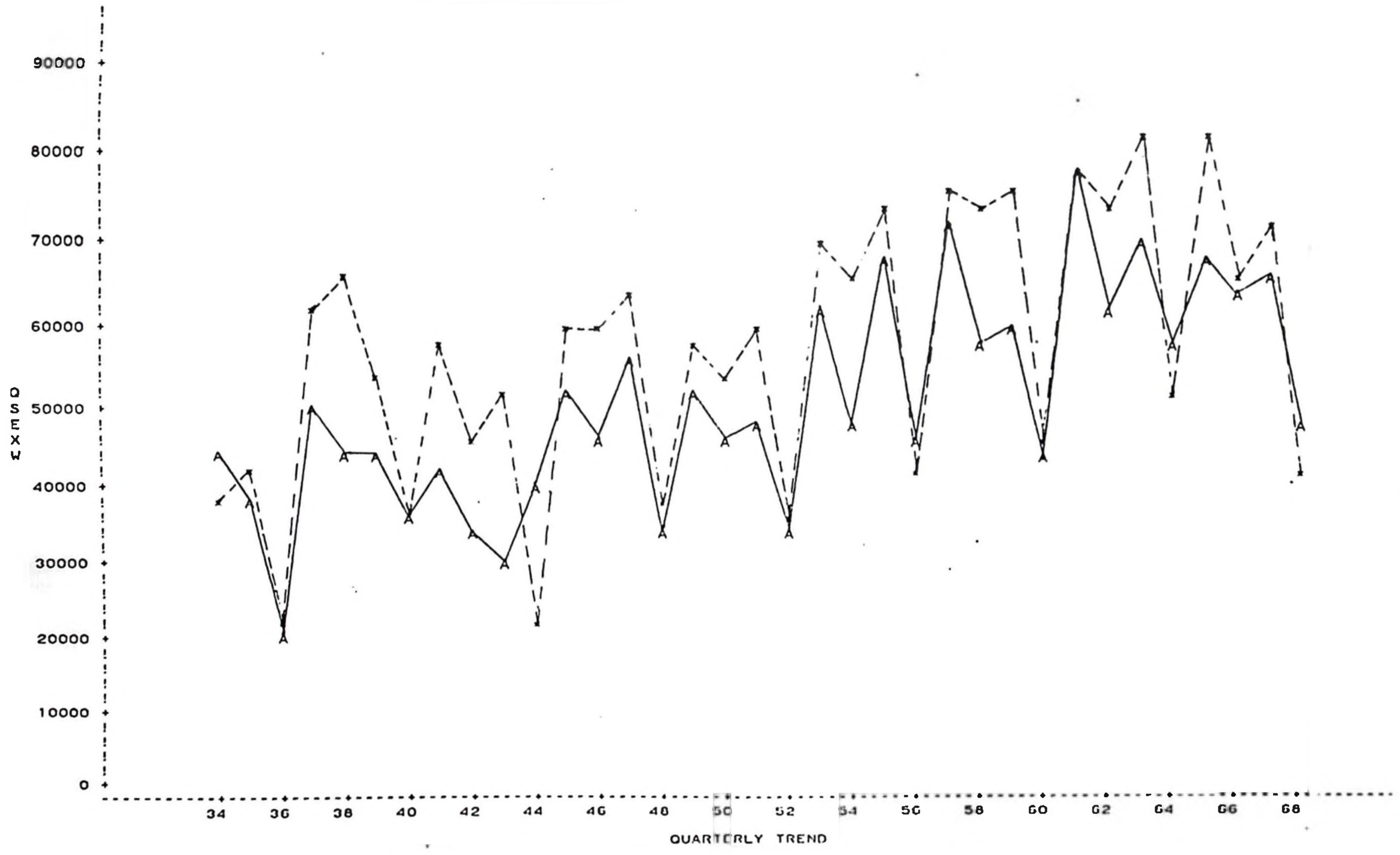
.....FIXED PARAMETER MODEL.....

PLOT OF X78*X1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P78*X1 SYMBOL USED IS *



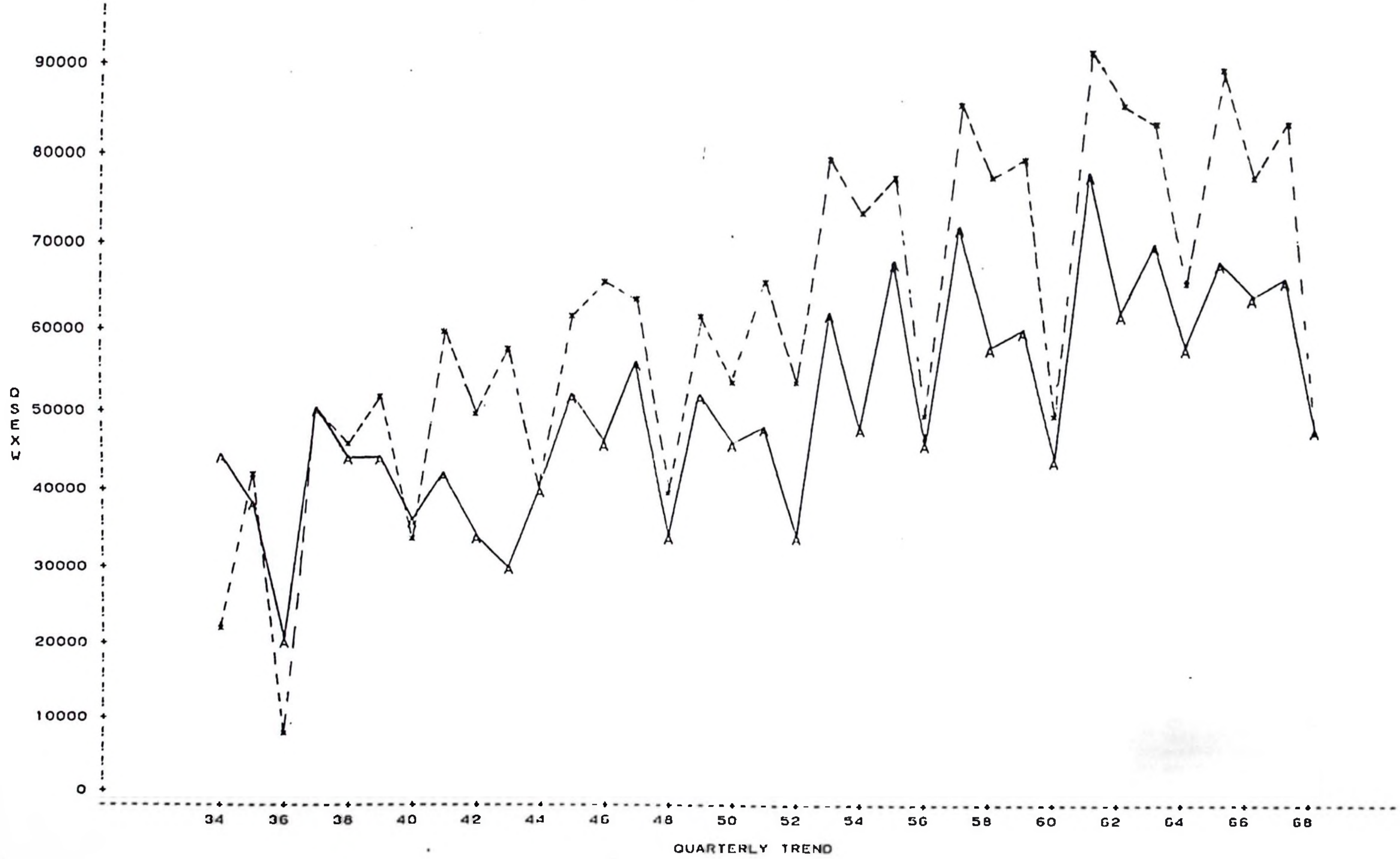
.....VARYING PARAMETER MODEL.....

PLOT OF X77*X1   LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P77*X1   SYMBOL USED IS *



.....FIXED PARAMETER MODEL.....

PLOT OF X77*X1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF P77*X1 SYMBOL USED IS *



APPENDIX C

IDENTIFICATION OF THE SYSTEM EQUATIONS BY ORDER CONDITION:

Off-farm soybean stocks

(i) Fixed Parameter Model

Total endogenous vbls[1] included less 1 = 4

Total exogenous vbls excluded = 38 - 3 = 35 > 4

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 4

Total exogenous vbls excluded = 55 - 5 = 50 > 4

Therefore equation is overidentified

On-farm soybean stocks

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 4

Total exogenous vbls excluded = 38 - 3 = 35 > 4

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 4

Total exogenous vbls excluded = 55 - 5 = 50 > 4

Therefore equation is overidentified

---

[1] vbls means variables

Soyoil stocks

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 5

Total exogenous vbls excluded = 38 - 2 = 36 > 5

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 7

Total exogenous vbls excluded = 55 - 4 = 51 > 7

Therefore equation is overidentified

Soymeal demand

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 2

Total exogenous vbls excluded = 38 - 7 = 31 > 2

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 3

Total exogenous vbls excluded = 55 - 9 = 46 > 3

Therefore equation is overidentified

Soyoil demand

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 2

Total exogenous vbls excluded = 38 - 2 = 36 > 2

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 4

Total exogenous vbls excluded = 55 - 3 = 52 > 4

Therefore equation is overidentified

Soybean crushing demand

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 1

Total exogenous vbls excluded = 38 - 6 = 32 > 1

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 1

Total exogenous vbls excluded = 55 - 10 = 45 > 1

Therefore equation is overidentified

Current supply of soybeans and soyoil

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 2

Total exogenous vbls excluded = 38 - 1 = 37 > 2

Therefore equations are overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 4

Total exogenous vbls excluded = 55 - 4 = 54 > 4

Therefore equations are overidentified

Current Supply of soymeal

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 1

Total exogenous vbls excluded = 38 - 2 = 36 > 1

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 3

Total exogenous vbls excluded = 55 - 2 = 53 > 3

Therefore equation is overidentified

Aggregate soymeal exports

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 1

Total exogenous vbls excluded = 38 - 5 = 33 > 1

Therefore equation is overidentified

Aggregate soybean exports

(i) Fixed Parameter Model

Total endogenous vbls included less 1 = 2

Total exogenous vbls excluded = 38 - 7 = 31 > 2

Therefore equation is overidentified

(ii) Varying Parameter Model

Total endogenous vbls included less 1 = 3

Total exogenous vbls excluded = 55 - 7 = 48 > 3

Therefore equation is overidentified

APPENDIX D

DATA SOURCES

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Chicago Board of Trade, Statistical Annual Digest.

Eurostatistics, Statistical Office of the European Communities.

FAO, FAO Monthly Bulletin of Statistics.

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USDA, Fats and Oils Situation, ERS.

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VITA

Jeremiah Boniface Ishengoma Rugambisa was born on June 2, 1952 in Bukoba, Tanzania. He completed his secondary school education at Pugu Secondary School in December 1972 before joining the University of Dar es Salaam in July 1973. He graduated from the University of Dar es Salaam in April 1976 with a Second Class Upper Division Honors Degree and was employed as a Tutorial Assistant at the then Faculty of Agriculture, Forestry and Veterinary Science at Morogoro. His major fields of concentration at the University were statistics and economics.

In July 1976 he was granted a study leave and left for the Institute of Economics at Boulder, Colorado to take a [month and a half crash] course in economics and statistics. He was later admitted at the University of Wisconsin at Madison and received a Masters Degree (Agricultural Economics) in May 1978.

Before receiving the Masters Degree he visited CIMMYT in Mexico for three months in order to observe and get acquainted with the general activities of the center. After the short visit he was admitted at Michigan State University at East Lansing to take, among others, a course in Research Methods. He returned to Tanzania in May 1978 to resume his teaching/research appointment.

In August 1981 he was admitted at the University of Illinois at Urbana-Champaign to pursue Ph.D studies in the department of Agricultural Economics. His two major fields of study were Agricultural Marketing and Agricultural Prices and Quantitative Economics. He is a member of the American Agricultural Economics Associating and the Tanzania Agricultural Economics Society. Upon completion of his Ph.D studies he expects to return to his mother country to teach and conduct research at Sokoine University of Agriculture.