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Estimating the Behavior of an Actual Market System with a Stream of Relations and Simulation Experiments

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Abstract

When a modeling process is applied to an actual commodity market in the real world, interactions over closely related commodities through the marketing channel should also be formulated into the model to reflect the information that exists in the whole market system, otherwise unreliable estimates and test statistics may be produced by ignoring those effects. Single-equation type model in this case tends to yield inefficient estimates, and sometimes biased and inconsistent, which will mislead us. A system of equation method to examine the structure of the imported commodity market system is developed and its empirical results are analyzed, then followed by some policy experiments and its implications.

1. Introduction

The published empirical works for estimation in business, economics and statistics reveal that many relationships between variables are of the single-equation type. However, the single-equation type of regression model does not explain the interdependencies that may exist between the explanatory variables themselves or how these explanatory variables are related to other variables. The cause and effect relationship in these models runs from a set of explanatory variables to a dependent variable, but there is no feedback relationship between the dependent variable and the explanatory variables. Such a unidirectional cause and effect relationship is not meaningful where there is a two-way, or simultaneous flow of influence among variables.

Models for estimation frequently involve a set of relationships designed to explain the behavior of certain variables. In such models the problem of estimating the parameters has special features that are not present when a model involves only a single relation. In particular, when a relation is a part of a system, some regressors are typically stochastic and correlated with the regression disturbance. Typical least squares estimators of the regression coefficient are inappropriate in this case, thus we are concerned with the problem of estimating equations that belong to a system of relations.

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In our real world, many variables of interest are interconnected stage by stage. A single equation may describe the interactions among variables at one stage. However, it is not sufficient to reflect the information that possibly exists and interacts through all stages within a same time interval. A commodity flow through various marketing stages is a good example. Different relations are supposed to exist at each marketing stage. The problem becomes more serious when several commodities are closely interrelated and move through the market stages in a similar fashion. Simultaneously lumping up the forces and effects that exist in the stream of relations into one system, we are able to obtain a more accurate picture of the system while reducing the chance of a partial and inefficient analysis.

Any estimation procedure for a single regression equation type, even for one commodity, in this case tends to yield asymptotically inefficient parameter estimates even if they yield consistent ones. The lack of asymptotic efficiency arises from two sources. First, all available information in description of the system of equations is not used in estimation. Second, an estimation procedure for a single-equation type does not account for the possible correlations in disturbance terms across equations. This deficiency can be overcome by estimating all the equations of the system simultaneously, in which the behavior of the variables is jointly determined. In such models, we may not estimate the parameters of a single equation without taking into account information provided by other equations in the system.

2. Issues

When the multilateral trade agreements at Urguay Round(UR) were under negotiation in 1993, agricultural field was probably the hottest area for us. As income goes up, demand for agricultural products sharply increases, which in turn raises agricultural imports and foreign dependency. Imports of grain commodities occupy a significant share of our imports, and foreign dependency of those commodities is expected to increase with the progress of trade liberization. Such large volume of the imports and high degree of foreign reliance are likely to make the supply unstable under the variations in the world grain market.

Three major imported grains are particularly important in our daily life. As such grain commodities that could be objects of government price policies, wheat, corn and soybeans are characterized to have great price variations without government market interference, strong import substitutional effects, and high price vulnerability. Since most of the domestic supply of these commodities are met by imports, unstable supply probably leads to price and political instabilities.

While gross domestic product, which is the national income from pure domestic sources, increased at the annual average rate of 9.36 percent in the 1970's, 8.2 percent in the 1980's, and 7.5 percent from 1990 to 1992, the total cost of wheat, corn, and soybean imports increased 5.6, 72.3, and 114.1 times in nominal dollar terms, respectively, from 1970 to 1992.

At the same time, the self-sufficiency levels for 1970-1992 period dropped from 15.4 percent to 0.02 percent for wheat, 18.9 percent to 1.2 percent for corn, and 86.1 percent to 12.2 percent for soybeans. Heavy usage of corn and soybeans for feed suggests an increasing demand for meat. Per capita annual meat consumption increased from 5.2kg in 1970 to 23.9kg in 1992. Those dramatic transitions are enough to attract our interest. We thus need to study the structure of the markets those commodities flow, and examine how these markets respond and adjust when there are variations in related variables. Such a macro-dimensional work in our reality has rarely appeared in the statistic field.

3. The Model

A system of markets such as production, imports, inventory levels, and disappearance for each commodity should be organized to utilize enough information. Accordingly, a system of equations is developed to describe the flow of the commodities through the whole marketing channel, then simultaneously analyzed as one system because the three commodities are the most important imported grains and closely related each other. The impacts of fluctuations in government policy and other variables of interest on each market level for each commodity can be analyzed, then corresponding magnitudes of market responses can be obtained.

In applied statistic field, most of the works that have employed simultaneous equation approaches for international commodity flows concentrate on export or import market levels. Some early examples are Goldstein and Khan (1978), Dunlevy (1980), and Geraci and Prewo (1982) etc. However, it is difficult to find the study that links international and domestic marketing stages.

3.1 Theoretical Model

Since the portion of domestic production for each commodity is negligible and presumed to have only minor effects on each market, it does not seem to be reasonable to include a production equation of each in the system. Instead, the annual domestic production level of each commodity is included as an explanatory variable in each appropriate equation. The model is thus composed of a set of nine equations, which are import, inventory, and disappearance equations for each of the three commodities to reflect the information available in the whole market.

Own import price, exchange rate, income level, domestic production, and current or carry-over stocks from the previous year are assumed to influence the level of imports. Many studies, including Murray and Ginman (1976), Goldstein and Kahn, Wilson and Takacs (1979), Chambers and Just(1981), Warner and Mordechai (1982), Backus (1986), Yamawaki (1986), and Dutton and Grennes (1988), have attempted to measure the effects of exchange rate fluctuations on prices and trade. Since we may respond differently to exchange rate adjustments from market price movements, it seems to be appropriate to include the exchange rate directly in an import equation to allow for the differential effects of exchange rate and price fluctuations. Thus exchange rate is included in each import equation as a separate regressor.

Inventories are an important factor, but often overlooked, as a major contributor to price stability. Stock policy and price policy are related, so a single general model is unlikely to explain stock-price relationships. Stock adjustment is a policy instrument and food security stocks are held as protection against variable domestic prices and import costs. For this reason stock equations are separately included in the model system.

$$
\begin{aligned}
Y_{11} &= f(X_{11},\ X_{21},\ N,\ F,\ P,\ Y_{21}) \\
Y_{12} &= f(X_{12},\ X_{22},\ N,\ F,\ P,\ Y_{22}) \\
Y_{13} &= f(X_{13},\ X_{23},\ N,\ F,\ P,\ Y_{23}) \\
Y_{21} &= f(X_{11},\ X_{21},\ D,\ Y_{31},\ P,\ LY_{21}) \\
Y_{22} &= f(X_{12},\ X_{22},\ X_{32},\ Y_{32},\ P,\ LY_{22}) \\
Y_{23} &= f(X_{13},\ X_{23},\ X_{33},\ Y_{33},\ P,\ LY_{23}) \\
Y_{31} &= f(X_{11},\ X_{21},\ N,\ P) \\
Y_{32} &= f(X_{12},\ X_{22},\ N,\ P) \\
Y_{33} &= f(X_{13},\ X_{23},\ N,\ P)
\end{aligned}
$$

where

Y_{11} : wheat imports, 1000MT
Y_{12} : corn imports, 1000MT
Y_{13} : soybean imports, 1000MT
Y_{21} : wheat stocks, 1000MT
Y_{22} : corn stocks, 1000MT
Y_{23} : soybean stocks, 1000MT
Y_{31} : wheat disappearance, 1000MT
Y_{32} : corn disappearance, 1000MT
Y_{33} : soybean disappearance, 1000MT
LY : Y but lagged one period
X_{11} : wheat import price, U.S. dollars per MT
X_{12} : corn import price, U.S. dollars per MT
X_{13} : soybean import price, U.S. dollars per MT
X_{21} : volume of wheat production, 1000MT
X_{22} : volume of corn production, 1000MT
X_{23} : volume of soybean production, 1000MT
X_{32} : government corn purchase price, won per 75Kg
X_{33} : government soybean purchase price, won per 75Kg
D : dummy variable for government wheat purchase
0 for 1970−1983, 1 for 1984−1992
F : foreign exchange rate
N : national income, won
P : annual population level, person

Stock adjustments affect trade flows and pose difficulties for estimation. Stocks may depend on various factors that determine the costs and benefits of holding stocks such as profits, storage costs, business taxes, and supply-demand conditions, whose data are largely unavailable. Potential problems may thus exist in estimating the stock equations. Carry-in stocks from the previous period, domestic production, and current disappearance are expected to influence current stocks.

Inventory level of a commodity adjusts as price of the commodity changes. Since government purchase is an important variable to influence the level of stock, the policy variables are included in corn and soybean stock equations. The government has dropped the wheat purchase program since 1984, accordingly the dummy variable is included to see the effect in the wheat stock equation. Stock equations thus can be separated, and direct estimation of those is then feasible.

There is a clear increasing trend in demand for each commodity with the increase in income. Income, price, and domestic production variables are thus supposed to influence the disappearance of each commodity. Based on the discussion above, the theoretical relationships are specified as follows.

More variables and relevant relationships will be considered in the estimating process while seeking for the final choice. In addition, the feed use of grains has sharply increased throughout the study period, so a meat consumption variable will be used as a proxy to capture this effect when necessary. Prices of other grains are also useful to reflect the cross price effect of potential competing commodities. We may need to examine the impact of the government purchase program, thus program variables, whether significant or not, will be considered unless it hurts the statistical fitness. Population level and other macro-variables are also expected to influence the activities at each market level and will be under consideration in the appropriate equations, whenever there is a room to improve the model.

3.2 Empirical Model Formulation and Data Handling

For empirical estimation, an unusual form of the model is constructed. A commodity market is designed in a recursive form in which each of the endogenous variables can be determined sequentially and a one period autoregressive term is tried in each equation, then each of those equations are assembled into a complete unit. The inclusion of the lagged endogenous variables implies a partial adjustment process. That is, the change in an endogenous variable is related to the difference between the value of the variable in period t and the value realized in period $t-1$.

Thus the formulation is able to capture the delayed response. An adjustment of the coefficient of the autoregressive term provides a simple means of changing the dynamic response of the endogenous variable, and is another method by which trend effects and built-in dynamic adjustments can be modified.

Accordingly, the model is formulated in a block recursive framework where a group of equations can be broken up into blocks of equations by market stages in such a way that equations across blocks are recursive. Knowledge of the endogenous variables in the first block allows the determination of the endogenous in the second block, then that in the third block.

In consequence, we attempt to develop a partial adjustment block recursive system of equations, which consists of nine behavioral equations with three identities, for the study and estimate it simultaneously to provide greater estimation efficiency. In such a model, the behavior of the variables is jointly determined, and the endogenous variables are simultaneously determined by an interrelated series of equations.

In the model, endogenous variables include imports, stocks, and disappearance of each commodity. Exogenous variables cover all other variables including lagged endogenous variables which are currently predetermined. A problem may arise whether import prices are considered to be exogenous or endogenous. Wu(1973), Hausman(1978), Attfield(1985,1991), and Thurman(1986) suggested various test statistics to identity the endogeneity of the right-hand-side variables.

We have been one of the major customers for the commodities under study. However we are not yet big enough to influence the international prices of those and have always been a price taker which is determined in the world market. The import price of each commodity is thus regarded as an exogenous variable.

Consistent data for the prices of the commodities at stock and disappearance market stages are widely unavailable for the study period, so import prices are used as proxy variables to serve to capture their own and cross effects in the model because most of the commodities domestically used are imported. On the other hand, each of Gross National Product(GNP), Gross Domestic Product(GDP), and disposable income(DI) are under consideration as an income variable. The problem is that the data for the price and income variables cannot be directly used in estimation. Before performing the estimation, those variables have to be made estimable by eliminating monetary or inflationary effect to account for the pure interactions among variables.

Various deflators considered to handle the problem are i)import price index, ii)agricultural import price index, iii)agricultural product price index, iv)wholesale price index, v)consumer price index, vi)producer price index, and vii)U.S. consumer price index. The current base year, which has the index value of 100 in 1990, is converted to 1985 base year to fit the estimation period, then the values of the above indices for the whole estimation period are adjusted in accordance with this.

Each of the indices is used to switchover the price and income data estimable. Thus a variety of price and income variables in 1985 constant price become available and ready to be estimated. For the foreign exchange variable, each of i)U.S. dollar, ii)Special Drawing Rights(SDR), iii)foreign reserve, and iv)exchange rate indices of those with 1985 value of 100 can be considered. As an alternative, both import prices and income could be deflated by the price index then adjusted by the exchange rate to be used for estimation. Each of those above are all under consideration.

In addition, various nondeflatable exogenous variables are included, whenever necessary and appropriate, in the relevant equations. As a result, numerous combinations of variables are applied to improve the model in the estimating process. A major problem arises in the scale of the study. In other words, the model can be estimated at a national-aggregate basis or at per capita basis. In the latter case, all current and lagged endogenous variables and some exogenous variables such as domestic production, income and meat consumption should be divided by the population level each year, then relevant variables are expected to be deflated before estimation. The choice depends upon the estimated results and statistical fitness.

What makes the estimation more complex is that we also need to convert or combine some of the predetermined variables into difference or ratio form to raise the statistical soundness and economic reasonableness at each estimation trial. Additionally, commodities in every field have their own characteristics for a certain period of time. Statistically nonsignificant variables for one time period may be significant in other time period, or vice versa.

Some theoretically or empirically important variables but statistically not significant for the study period are supposed to be on the relevant equation to reflect the reality. Therefore, the estimation is repeatedly performed to obtain the best possible outcome while accounting for all discussed above.

The data for population, meat consumption, production, imports, disappearance, stocks, import prices and government purchase price etc. are taken from Grain Policy Data 1988 and 1992, and Agricultural, Forestry and Fisheries Major Statistics 1987 and 1993 by the Department of Agriculture, Forestry and Fisheries. The raw data for macro-variables are from various issues of International Financial Statistics(IFS) yearbooks by IMF. However, IFS has no longer issued annual average won/SDR rates from 1991 yearbook, so the averages from quarterly end of period data are taken for the rest of the period(1991 and 1992). The study covers 1970-1992 period, the background era of UR in 1993, by using annual time series data.

3.3 Estimation and Validation of the Model

Two-stage least squares (2SLS) estimation, a single equation method for a system of equations, is first applied. In this case, a complete knowledge of the whole system is not required. We only need a listing of all predetermined variables and their sample values, so it is a limited information method. Then carrying the estimation a step further, three-stage least squares(3SLS) method is utilized to estimate the model as a single system because of the likelihood of cross-block correlation of disturbances. In the first stage, each endogenous variable $\mathbf{y}_i$ is regressed on all predetermined variables X to obtain estimates of the reduced form parameters, $\widehat{\boldsymbol{\pi}}_i = (X'X)^{-1}X'\mathbf{y}_i$. These in turn are used to get the predicted value of y_t as $\widehat{y}_i = X\,\widehat{\pi}_i = X(X'X)^{-1}X'\,y_i$. In the second stage the estimated covariance matrix is formed from the two stage least squares(2SLS) or GLS residuals. In the third stage, the covariance matrix is used to acquire 3SLS estimator.

Seemingly unrelated system of equation estimation, originally suggested by Zellner(1962), is not appropriate for the model because each of the stock equations has a corresponding disappearance, which is a current endogenous variable, on the right hand side.

SHAZAM program (1993) was used to seek for the best suitable model from candidates with various combinations and forms of variables, while eliminating statistical problems in the process of estimation. The best outcome by 3SLS method after repeated estimations was found to outperform those by 2SLS, and is reported here. The 2SLS estimator, although consistent, is in general not asymptotically efficient because it does not take into account the correlation of structural disturbances across equations.

$$
\begin{aligned}
WI_t &= f\,(WP_t,\ W_t,\ G_t, E_t,\ M_t,\ WS_{t-1},\ WI_{t-1})\\
CI_t &= f\,(CP_t,\ SP_t,\ GC_t,\ G_t, E_t,\ M_t,\ CS_{t-1},\ CI_{t-1})\\
SI_t &= f\,(SP_t,\ GS_t,\ G_t, E_t,\ M_t,\ SS_{t-1},\ SI_{t-1})\\
WS_t &= f\,(WP_t,\ W_t,\ D_t,\ WD_t,\ WS_{t-1})\\
CS_t &= f\,(CP_t,\ GC_t,\ CD_t,\ CS_{t-1})\\
SS_t &= f\,(SP_t,\ GS_t,\ S_t,\ I_t,\ SD_t,\ SS_{t-1})\\
WD_t &= f\,(WP_t,\ W_t,\ G_t,\ M_t,\ T_t,\ WD_{t-1})\\
CD_t &= f\,(WP_t,\ CP_t,\ G_t,\ M_t,\ CD_{t-1})\\
SD_t &= f\,(CP_t,\ SP_t,\ S_t,\ G_t,\ M_t,\ SD_{t-1})
\end{aligned}
$$

$$
\begin{aligned}
W_t + WI_t + WS_{t-1} &= WS_t + WD_t\\
C_t + CI_t + CS_{t-1} &= CS_t + CD_t\\
S_t + SI_t + SS_{t-1} &= SS_t + SD_t
\end{aligned}
$$

Endogenous variables include

WI_t = per capita wheat imports, Kg
CI_t = per capita corn imports, Kg
SI_t = per capita soybean imports, Kg
WS_t = per capita wheat stocks, Kg
CS_t = per capita corn stocks, Kg
SS_t = per capita soybean stocks, Kg
WD_t = per capita wheat disappearance, Kg
CD_t = per capita corn disappearance, Kg
SD_t = per capita soybean disappearance, Kg

Exogenous variablesinclude all lagged endogenous variables with

WP_t : wheat import price (U.S. dollar per metric ton) deflated by U.S. CPI(1985 = 100)
CP_t : corn import price (U.S.dollar per metric ton) deflated by U.S. CPI(1985 = 100)
SP_t : soybean import price (U.S.dollar per metric ton) deflated by U.S. CPI(1985 = 100)
W_t : per capita wheat production, Kg
C_t : per capita corn production, Kg
S_t : per capita soybean production, Kg
GC_t : government corn purchase price (1000 won per 75 Kg, 2nd class) deflated by Korean CPI (1985 = 100)
GS_t : government soybean purchase price (1000 won per 75 Kg, 2nd class) deflated by Korean CPI (1985 = 100)
D_t : dummy variable for government wheat purchase, 0 for 1970 − 1983, 1 for 1984 − 1992
G_t : per capita GDP, 1,000,000 won in 1985 price
E_t : won per SDR, period average
M_t : per capita meat consumption, Kg
I_t : interest rate, percent per annum, (deposit rates)
T_t : tax rate, percent

The program has finally selected twenty-three exogenous variables. All quantity and income variables were chosen as per capita basis rather than aggregate ones, thus data for import, stocks, disappearance, income, production, and consumption variables were adjusted by the population level for each year. Accordingly the theoretical model is modified and respecified as below.

Although a simultaneous equation estimation procedure is used to estimate all the model's coefficients, each estimated model can be evaluated by adopting the same criteria that are used in the construction and evaluation of single-equation regression models. In choosing the final model, a variety of criteria was used to evaluate the performance of each alternative specifications. We first decide whether the structural specification of the model is reasonable and whether the estimated coefficients make sense, besides the usual set of statistical tests.

In a multi-equation system, high statistical significance for some equations may have to be balanced against low statistical significance for other equations. It may be found that some of the equations fit the data well while others do not, so a judgement should be made regarding the overall statistical fit. Even if all the individual equations fit the data well and are statistically significant, we have no guarantee that the model as a whole reproduces the same data series closely when simulated. It is possible that some of the endogenous variables track the original data series closely while others not in an ex-post simulation.

Accordingly, we need to use specifications for some equations in the model that are less desirable from a statistical viewpoint but that improve the ability of the model to simulate well, thus we are forced to make some compromises by accepting some equations that do not have a particularly good statistical fit in order to build a complete structural model.

Another way used to evaluate the model is the fit of the individual variables in a simulation context. We hope the results of a simulation to match the behavior of the real world closely through the estimation period. Two methods are used to test the performance of the model, respectively, in quantitative and qualitative ways. One method to check the performance is to conduct a simulation in a quantitative way and examine how closely each endogenous variable tracks its corresponding actual data series. The other method is the turning point accuracy to check in a qualitative way how well the model simulates turning points in the actual data through the estimation period.

The quantitative measures used are root-mean-square error(RMSE) and RMS percent error. It is entirely possible for an equation that has a good statistical fit to have a poor simulation fit. It is for this reason that simulation error statistics are important criteria to evaluate the model while estimation statistics alone are not sufficient. In our model, finally selected, it is observed that simulated series closely track and reproduce the general long-run behavior of the actual data series, although some short-run fluctuations in the actual series are not correctly reproduced, which we call them turning points missed.

The ability to duplicate turning points or rapid changes in the original data is an important qualitative criterion for the evaluation of a model in a selecting procedure. Table 1 shows the number of turning points missed, out of 22, in the selected model. Soybean market is found to miss turning points most, whereas wheat market appears to miss them least. By market stages, stock market is found relatively poor as we might expect. The model as a whole, 23-24% of the total turning points are missed, which appears well acceptable. However, most of those points missed still closely reproduce the actual data as RMSE's and RMS percent errors show.

Table 1. Number of Turning Points missed

WI	CI	SI	WS	CS	SS	WD	CD	SD
2	8	6	8	6	9	5	6	8

In addition, the performances of the alternative models are again evaluated by altering the initial simulation period to test the model sensitivity. The simulations are begun from 1970 and from 1975 to search for the one that does not much matter in what year the simulations are begun. On the whole, the empirical model, which is the best that can be obtained, is as follows with t values in the parentheses.

3.4 Empirical Results

$$\begin{aligned} WI_t = \; & \underset{(1.896)}{27.821} \; \underset{(-1.991)}{-0.0507\, WP_t} \; \underset{(-1.547)}{-2.0614\, W_t} \; \underset{(3.092)}{+37.141\, G_t} \; \underset{(5.581)}{+0.0926\, E_t} \\ & \underset{(-4.173)}{-7.9627\, M_t} \; \underset{(3.156)}{+2.3818\, WS_{t-1}} \; \underset{(-1.484)}{-0.1834\, WI_{t-1}} \end{aligned}$$

$R^2 = 0.8186$ *RMS percent error* $= 0.1464$ *RMSE* $= 8.6593$

$$CI_t = \underset{(0.1706)}{2.9188} \underset{(-3.339)}{-0.1779\,CP_t} \underset{(1.532)}{+0.0407\,SP_t} \underset{(-1.165)}{-0.8385\,GC_t} \underset{(0.0081)}{+0.0947\,G_t}$$

$$\underset{(3.708)}{+0.0495\,E_t} \underset{(2.503)}{+5.1149\,M_t} \underset{(2.63)}{+1.4482\,CS_{t-1}} \underset{(-0.7257)}{-0.1074\,CI_{t-1}}$$

$R^2 = 0.9522$ *RMS percent error* $= 0.2669$ *RMSE* $= 10.0317$

$$SI_t = \underset{(-2.9)}{-5.7734} \underset{(-0.8826)}{-0.0038\,SP_t} \underset{(1.355)}{+0.0742\,GS_t} \underset{(-3.644)}{-7.0273\,G_t} \underset{(2.294)}{+0.0069\,E_t}$$

$$\underset{(5.746)}{+1.8246\,M_t} \underset{(-9.531)}{-3.5514\,SS_{t-1}} \underset{(7.308)}{+0.6594\,SI_{t-1}}$$

$R^2 = 0.9867$ *RMS percent error* $= 0.3907$ *RMSE* $= 1.1635$

$$WSt = \underset{(1.429)}{4.4095} \underset{(-2.06)}{-0.0136\,WP_t} \underset{(1.217)}{+\ 0.4328\,W_t} \underset{(1.12)}{+\ 1.8735\,D_t}$$

$$\underset{(2.279)}{+0.0816\,WD_t} \underset{(-0.4006)}{-0.0726\,WS_{t-1}}$$

$R^2 = 0.5789$ *RMS percent error* $= 0.3738$ *RMSE* $= 2.3303$

$$CS_t = \underset{(-1.141)}{-5.9712} \underset{(-1.4)}{-0.0197\,CP_t} \underset{(2.641)}{+0.5919\,GC_t} \underset{(0.6547)}{+0.0171\,CD_t} \underset{(2.129)}{+0.3898\,CS_{t-1}}$$

$R^2 = 0.7001$ *RMS percent error* $= 0.3083$ *RMSE* $= 2.642$

$$SS_t = \underset{(-1.175)}{-1.8408} \underset{(-1.066)}{-0.0021\,SP_t} \underset{(2.205)}{+0.0528\,GS_t} \underset{(1.132)}{+0.167\,S_t} \underset{(-0.5482)}{-0.0172\,I_t}$$

$$\underset{(0.6265)}{+0.0296\,SD_t} \underset{(-0.3644)}{-0.0507\,SS_{t-1}}$$

$R^2 = 0.6396$ *RMS percent error* $= 1.3063$ *RMSE* $= 0.9747$

$$WD_t = \underset{(2.82)}{85.367} \underset{(-2.902)}{-0.0897\,WP_t} \underset{(-1.972)}{-3.3619\,W_t} \underset{(0.8163)}{+13.703\,G_t} \underset{(-0.5661)}{-1.5118\,M_t}$$

$$\underset{(-0.4176)}{-0.6543\,T_t} \underset{(0.6492)}{+0.0953\,WD_{t-1}}$$

$R^2 = 0.6472$ *RMS percent error* $= 0.1968$ *RMSE* $= 11.1249$

$$CD_t = \underset{(1.129)}{16.582} \quad \underset{(-3.321)}{-0.2584\ CP_t} \quad \underset{(2.68)}{+0.1123\ WP_t} \quad \underset{(0.5462)}{+7.3616\ G_t}$$

$$\underset{(1.813)}{+4.2381\ M_t} \quad \underset{(1.491)}{+0.1915\ CD_{t-1}}$$

$$R^2 = 0.9528 \quad RMS\ percent\ error = 0.264 \quad RMSE = 9.9757$$

$$SD_t = \underset{(-0.6613)}{-2.4039} \quad \underset{(-1.43)}{-0.0076\ SP_t} \quad \underset{(1.037)}{+0.0117\ CP_t} \quad \underset{(1.311)}{+0.4767\ S_t} \quad \underset{(-2.889)}{-6.0639\ G_t}$$

$$\underset{(4.389)}{+1.3518\ M_t} \quad \underset{(7.256)}{+0.7687\ SD_{t-1}}$$

$$R^2 = 0.9692 \quad RMS\ percent\ error = 0.1255 \quad RMSE = 2.2073$$

The final model as a whole generally fits well and achieves a reasonable level of statistical significance with system $R^2 = 0.9993$ and $\chi^2 = 166.33$ with 54df. The signs of coefficients for most of the variables are in accord with a priori expectations. The model reasonably captures own and cross effects between variables, which are consistent with actual market situations.

In the model, most of the important variables are included to explain the forces that exist in the actual market. Some essential data for the stock equations, as mentioned earlier, were not available, which made the equations appear to perform relatively unsatisfactory. Even though proxy variables substituted for those, relevant variables might still be omitted in the specification of the equations. The important missing variables were probably storage cost, maintenance fee, and business tax for each inventory holders.

The omission of a relevant variable may yield a biased estimate of the true parameter in the statistical sense, and this bias, if exists, will not disappear as the sample size grows large, so that the omission of a variable from the true model yields inconsistent parameter estimates as well. The bias disappears only when omitted variable is uncorrelated with all the included independent variables, but zero covariances between the omitted variable and each independent variable might be unlikely with most of business and economic data.

Specification error problems were suggested by Theil, and discussed by Rao and Miller(1971), Kmenta (1986), and Pindyck and Rubinfeld(1991). As shown in Rao and Miller by using two variable model, when the included and omitted variables are correlated, .the actual variance of the included variable with omission will be less than the actual variance of the variable without omission even though the model is misspecified.

If we are willing to give up lack of bias as an important purpose, the omitted variable specification has some merit, which is especially true when omitted variables are thought to be uncorrelated with included variables. In reality, omissions of the relevant variables are common in business and economic analysis, and even in research reports to the government, due to unavailability or nonexistence of the consistent data required.

Another problem arises in soybean stock and wheat disappearance equations, which show slight signs of multicollinearity. We thus need to be cautious to interpret the results of those. Multicollinearity was examined from the checking of simple and partial correlation coefficients to the final stage of estimation. The problem was detected and mostly eliminated while running the program by adapting various combinations and forms of exogenous variables. However, the outcome is not able to be improved further without hurting statistical soundness and realistic economic relationships, otherwise specification error would be made, which causes more serious problems.

According to Pindyck and Rubinfeld, the lagged dependent variable sometimes provides the best means of imposing a lagged distribution on the equation, and this benefits may outweigh the associated statistical problems. Thursby and Thursby(1983) examined nine frequently used models of aggregate import demand for each of five advanced countries in an attempt to determine which of those generated unbiased or at least consistent and efficient estimates. It was found that models without lagged adjustments performed rather poorly, whereas those including dynamic behavior through lagged values of the dependent variable were frequently accepted. Haynes and Stone (1983) has also found a specification incorporating learning processes and delayed or lagged adjustment plausible.

In general, because of the interdependence between the stochastic disturbance term and the endogenous explanatory variables, a single equation method like OLS is inappropriate for the estimation of an equation in a system of simultaneous equations. There is one situation where OLS can be applied appropriately even in the context of simultaneous equations. This is the case of the recursive or casual models. Suppose market stages for one commidity has the following three-equation system where Y's and X's are the endogenous and exogenous variables, respectively.

$$Y_{1t} = \alpha_{10} + \beta_{13}X_{1t} + \beta_{14}X_{2t} + e_{1t}$$

$$Y_{2t} = \alpha_{20} + \beta_{21}Y_{1t} + \beta_{23}X_{1t} + \beta_{24}X_{2t} + e_{2t}$$

$$Y_{3t} = \alpha_{30} + \beta_{31}Y_{1t} + \beta_{32}Y_{2t} + \beta_{33}X_{1t} + \beta_{34}X_{2t} + e_{3t}$$

The same period disturbances in different equations are uncorrelated such that

$$cov(e_{1t}, e_{2t}) = cov(e_{1t}, e_{3t}) = cov(e_{2t}, e_{3t}) = 0$$

which is the assumption of zero contemporaneous correlation.

The first equation contains only the exogenous variables, which are uncorrelated with e_1 by the assumption of the classical OLS. The second equation contains Y_1 as an explanatory variable and e_1 which affects Y_1 is uncorrelated with e_2 by the assumption. By the same argument, in the third equation both Y_1 and Y_2 are uncorrelated with e_3. Since there is no interdependence among the endogenous variables, no simultanous equation problem exists in the structure of such systems. Thus OLS can be applied to each of the equations separately.

There exists some argument that one can use OLS to estimate simultaneous equation models as a standard of comparison, at least qualitatively, although it is generally inapplicable. Our model is formulated in a recursive framework, in fact seemingly block recursive formation, and thus OLS has also been applied. It is found that our model performs better than OLS in statistical and simulation context, but not much. It may happen that the results of the inappropriate application of OLS do not differ much from those by more sophisticated methods in many applications, in spite of the resulting OLS properties of biasedness and inconsistency.

3.5 Stability of the Model

Most of the estimation works tend to neglect the question of the stability. If an estimated model system is unstable, further analysis is meaningless. It should be realized that the existence of stability is, in fact, assumed in the process of estimation. The assumption that the predetermined variables in the system have finite variances as t increases also applies to the lagged endogenous variables. This assumption would be violated if the endogenous variables diverge without limit, and it would be difficult in proving the asymptotic properties of estimators if the assumption is not made.

One way of determining whether a system is stable or not is to refer to the concept of eigen values. Import and disappearance equations themselves are reduced forms. Transforming stock equations into reduced forms then arranging all equations by commodity lead to the following form.

$$\boldsymbol{y}_t + \boldsymbol{\Gamma}\, \boldsymbol{y}_{t-1} + \boldsymbol{\Psi}\, \boldsymbol{x}_t = \boldsymbol{v}_t$$

For wheat market as an example, $\boldsymbol{\Gamma}$ is a 3 by 3 coefficient matrix of lagged endogenous variables $\boldsymbol{\Psi}$ is a 3 by 7 coefficient matrix of exogenous variables, $\boldsymbol{y}_t$, $\boldsymbol{y}_{t-1}$ and $\boldsymbol{x}_t$ is 3 by 1, 3 by 1, and 7 by 1 variable vector respectively, and $\boldsymbol{v}_t$ is a 3 by 1 constant vector of reduced forms. Rearranging the above form yields

$$\boldsymbol{y}_t = -\boldsymbol{\Gamma}\, \boldsymbol{y}_{t-1} - \boldsymbol{\Psi}\, \boldsymbol{x}_t + \boldsymbol{v}_t$$

The rank of the coefficient matrix $-\boldsymbol{\Gamma}$ is 3 and three eigen values are obtained in wheat market. Applying same principles to corn and soybean markets, those eigen values corresponding to market stages of imports, stocks, and disappearance for each commodity are obtained as follows.

wheat : -0.1834, -0.0726, 0.0953
corn : -0.1074, 0.3898, 0.1915
soybeans : 0.6594, -0.0507, 0.7687

Since all eigen values are less than 1 in absolute value, the model is found stable.

4. Empirical Analysis

A foreign exchange variable in each import equation appears significant and has a positive sign, which looks unusual. Since the commodities are necessities, they are less sensitive to changes in exchange rate and imported whenever necessary within a year. In addition, import grew faster than exchange rate through the study period. Thus those results are possible.

As a potential competing food grain, the rice variable was attempted to be included in wheat import and disappearance equations to check a substitution effect. However, the inclusions hurt the statistical fits in repeated estimations, it was thus eliminated from the model.

Income appears to have strong negative effects on per capita soybean imports and disappearance, which also looks unusual. Demand for soybeans is largely a derived demand for beef. As income goes up, demand for beef also goes up. Time lag exists between production planning and actual realization in domestic beef production. Rapid growth in demand for beef might force to increase direct beef imports.

Imports, stock level, and disappearance of each commodity are found to decline as the price of the commodity goes up. This exactly reflects our reality. The levels of imports and disappearance for wheat and corn have moved together with those of income. The positive income effect of wheat appears to be relatively strong.

Each of wheat import and disappearance equations shows increasing imports and disappearance as the domestic wheat production level declines. On the other hand, the positive sign in wheat stock equation reflects that the domestic production is a contributing factor to the stock level. These are consistent with the trend we had for the study period.

Meat consumption variable allows us to analyze the cross effects between commodities. The negative relationship between meat consumption and wheat implies their substitutional relationship. The reverse is true for the other two commodities. The significantly positive relationships between meat and each of the other two clearly suggest the importance of both grains in feed use. Their strong complementary relationships have led the increases in imports and disappearances of corn and soybeans with the increase in meat consumption.

Government policy programs appear to be significant factors for corn and soybean stock levels but it is not the case for their import levels. Domestic wheat production and dummy variable for the government wheat policy show positive but not significant effects on wheat stock level. A potential problem may exist in soybean stock and wheat disappearance equations, as mentioned earlier, due to a multicollinearity problem. We are thus cautious about interpreting the magnitude of the effect of each variable in these equations.

The estimation result enables us to analyze the responsiveness of current endogenous variables with respect to changes in related predetermined variables. Our main interest lies in commodity imports, so the responses of import markets are calculated and evaluated at the mean levels of the predetermined variables of concern.

Commodity imports are not found responsive to changes in prices. This reflects the characteristics of agricultural products. A 10% increase in price leads to only 1%-4.5% reduction in imports in the short run and 1.5%-4.0% reduction in the long run. Corn appears relatively resposive to its price movement. On the other hand, wheat and soybean imports appear quite responsive to changes in income. Income effects are smallest in corn imports, but biggest in soybean imports.

Imports respond 3.8%-11.4% in the short run and 4.8%-11.1% in the long run when foreign exchange moves by 10%. Wheat and corn imports appear to be less responsive to changes of foreign exchange in the long run than in the short run. Soybean imports are three times more responsive to the fluctuations of foreign exchange in the long run. Corn is the least responsive commodity in average.

Corn imports are not responsive to a change in government policy. One percent increase in the government purchase price reduces corn imports about a quarter. Soybean imports are relatively responsive to the government purchase program. Soybeans still maintain over 12 percent in self-sufficiency, which may explain the relative responsiveness of soybean imports with respect to the change in government program.

10 percent increase in soybean price reduces its imports 1 percent in the short run and 3 percent in the long run, while increasing corn imports about 2 percent through time. Their substitutional effect in imports is found to be small. Wheat imports are responsive to meat consumption and their substitutional cross relationship is noticeable. Wheat imports are substituted by 15.8 percent in the short run and by 13.4 percent in the long run when meat consumption increases by 10 percent, which implies that wheat is the food grain. On the other hand, the relationships between meat consumption and other two grains appear to be complementary, which implies that corn, especially, is the feed grain.

5. Policy Experiments

We now use the model to perform some forecasting and policy experiments. The experiments permit us to forecast the effects of alternative conditions by formulating those conditions in terms of trajectories for the exogenous variables.

These experiments are the reproductions of the situations by means of a model for the purpose of examining especially various impacts on imports of each commodity. In each experiment we simulate the model 5 years into the future, beginning 1992. In particular, the following simulation experiments are performed.

EXPERIMENT 1.

we generate a forecast under the assumption that all the exogenous variables grow at their historical rates of growth.

EXPERIMENT 2.

Import price of each commodity shows high variations during the study period. It suggests a serious implications. This international price instability is transmitted to domestic price, which in turn makes the domestic price unstable. Wheat import price went up 6 times and moved down 16 times. Annual average increasing and decreasing rates are 43% and 14% respectively. Corn import price increased 7 times at the rate 23% and declined 15 times at the rate of 13%. Soybean import price increased 10 times at 17% and went down 12 times at 15%. The more serious is that those figures are measured in real terms, which are the pure rates after eliminating annual inflation rates.

Total annual average rate of change in import price for each commodity is quite small for the whole study period because of ups and downs. However, we always have chances to face such big price changes. Thus it is meaningful to investigate how imports of each commodity responds when annual average import price continues to increase or drop. Actual annual realization will be within this range.

Considering maximum, minimum, and recent rates of changes while other exogenous variables grow at the same rates as in experiment 1,

EXPERIMENT 2-1 : 20% increase in wheat import price on wheat imports.
18% increase in corn import price on corn imports.
17% increase in soybean import price on soybean imports.

EXPERIMENT 2-2 : 14% decrease in wheat import price on wheat imports.
14% decrease in corn import price on corn imports.
15% decrease in soybean import price on soybean imports.

EXPERIMENT 3.

In this experiment, we will examine the effects of government policy program. Government purchase price of corn increased 14 times and decreased 8 times during the study period. The price for soybeans moved up 15 times and moved down 7 times. When all other exogenous variables follow the same paths as in experiment 1,

EXPERIMENT 3-1 : 10% increase in corn purchase price on corn imports.
10% increase in soybean purchase price on soybean imports.

EXPERIMENT 3-2 : 6% decrease in corn purchase price on corn imports.
3% decrease in soybean purchase price on soybean imports.

EXPERIMENT 4.

This presents the effects of national income on imports. While all other exogenous variables grow as described in experiment 1, EXPERIMENT 4-1 : 10% increase in real gross domestic product on each imports.

EXPERIMENT 4-2 : 5% decrease in real gross domestic product on each imports.

EXPERIMENT 5.

This experiment provides the effects of changes in the annual average rates of foreign exchange on commodity imports when other exogenous variables have the time paths as in experiment 1. Foreign exchange rate increased 18 times and decreased 4 times for the study period. It involves two extreme rates of changes.

EXPERIMENT 5-1 : 9% increase in foreign exchange on commodity imports.

EXPERIMENT 5-2 : 6% decrease in foreign exchange on commodity imports.

EXPERIMENT 6.

Per capita meat consumption continued to go up. This experiment demonstrates the cross effects between meat consumption and each grain. It analyzes the effect of 10% increase in meat consumption on commodity imports, while other things are as in experiment 1.

The results of these experiments are presented in the tables below. Experiment 1 is included in all tables for comparison. All of the tables prove that the import price (experiment 2) is not the influential variable for each commodity imports, which is consistent with our real world and low short-run and long-run price responsiveness in import markets we have already obtained. Government policy variables (experiment 3) are also ineffective variables to change the levels of corn and soybean imports. This is probably because domestic production is only a minor portion of whole supply for each commodity.

Income variable (experiment 4) is dramatic in wheat imports. Wheat imports sensitively increase when income level goes up while sharply decline in the reverse case. Income elastic nature of wheat obtained before is confirmed. Income effect is small in corn imports. Historical path and income experiment for corn appear to move closely together. Soybean imports are relatively affected by changes in income. Foreign exchange effects (experiment 5) also show similar trends.

Meat consumption (experiment 6) gradually substitutes wheat imports as time goes. On the other hand, meat consumption and other two commodity imports are found to be complementary and thus move together. Those cross relationships have already been found.

An interesting finding is the increasing trend of corn imports and the decreasing trend of soybean imports in any cases. Corn imports appear to continue to increase no matter how the situation changes whereas soybean imports are found to increase for a while then sharply decline in all cases. The long-run trend in soybean imports looks unusual. This is probably because the figures given for the experiments are getting stronger as we move into distant future.

Knowledge of the relationships between endogenous and exogenous variables is important for policy decisions in response to changes in exchange rate, income, and import prices. Understanding those relationships and the sensitivity of endogenous variables with respect to changes in exogenous variables suggest policy guidelines.

When we consider the superior nature of wheat and the strong positive income effect on imports, it may imply that wheat is a necessity and should always be available for disappearance. Corn imports do not appear to be responsive to changes in the exchange rate and, especially, in income whereas they are most price responsive of all, which means that corn is affected most by the foreign price variations. It also suggests that price policy is relatively effective to control corn imports.

Table 2. Wheat imports

Year	EXP 1	EXP 2-1	EXP 2-2	EXP 4-1	EXP 4-2	EXP 5-1	EXP 5-2	EXP 6
1992	80.75355	80.75355	80.75355	80.75355	80.75355	80.75355	80.75355	80.75355
1993	90.14028	89.04254	91.03204	93.80183	74.73123	92.84016	77.44157	85.24935
1994	94.17576	91.94844	96.04683	101.4542	62.35946	99.49535	68.2362	84.43841
1995	99.64752	96.01651	102.406	111.2591	51.04372	108.0648	60.38613	84.09085
1996	105.3511	100.0305	108.9634	121.9633	39.37568	117.295	52.53542	83.06329
1997	111.5515	104.1903	115.998	133.942	27.56245	127.5189	44.90857	81.46946

Government corn purchase program is found not much effective in reducing imports. It may imply that the program is costly and suggest some changes in production and policy structures. The imports of soybeans are the most price unresponsive. This means that domestic soybean market is vulnerable to foreign and domestic price manipulations or variations. However, soybeans appear to be relatively advantageous to reduce foreign dependency.

6. Summary

The presence of simultaneity in a model causes least squares estimators to be inconsistent, so an alternative method must be used to estimate each equation in a model, in which the behavior of the variables is jointly determined. Simultaneous system of equation estimation method was applied to a model of multi-commodity and multi-market system, then empirical results were analyzed.

Table 3. Corn imports

Year	EXP 1	EXP 2-1	EXP 2-2	EXP 2-3	EXP 3-1	EXP 3-2	EXP 4-1	EXP 4-2	EXP 5-1	EXP 5-2	EXP 6
1992	153.9302	153.9302	153.9302	153.9302	153.9302	153.9302	153.9302	153.9302	153.9302	153.9302	153.9302
1993	166.328	162.939	168.5523	165.1797	164.7474	167.7653	166.3374	166.2887	167.7713	159.5399	169.4698
1994	181.8688	174.8894	186.3406	179.6015	178.6936	184.8502	181.8881	181.7884	184.8221	168.1123	188.3624
1995	198.6896	187.4738	205.1379	195.1966	193.7489	203.1578	198.7205	198.567	203.3934	177.9065	209.1323
1996	217.1845	201.0133	225.4273	212.363	210.2168	223.1062	217.229	217.0184	223.8892	189.2716	232.2124
1997	237.5339	215.5536	247.4327	231.2689	228.3448	244.8795	237.594	237.3227	246.5202	202.3603	257.869

Table 4. Soybean imports

Year	EXP 1	EXP 2-1	EXP 2-2	EXP 2-3	EXP 3-1	EXP 3-2	EXP 4-1	EXP 4-2	EXP 5-1	EXP 5-2	EXP 6
1992	30.12885	30.12885	30.12885	30.12885	30.12885	30.12885	30.12885	30.12885	30.12885	30.12885	30.12885
1993	35.12609	34.99643	35.23178	34.17986	35.44657	34.79561	34.43331	38.04158	35.32727	34.17986	36.24682
1994	35.71937	35.35332	35.82872	33.85606	36.61522	35.26773	33.75836	41.15532	36.28531	33.85606	38.89516
1995	31.55278	30.85513	31.58139	29.07313	33.24045	31.14572	27.81014	39.20326	32.62586	29.07313	37.62082
1996	21.59427	20.47317	21.46743	18.48138	24.27011	21.37179	15.58031	31.20639	23.30688	18.48138	31.3564
1997	4.042906	2.403773	3.689909	0.369587	7.895817	4.131373	-4.73555	15.39209	6.525219	0.369587	18.30981

Our model system appears to fit well and is statistically sound in spite of some minor shortcomings arising from data unavailability. The possible omission of relevant variables in stock equations due to data unavailablility might cause a statistical problem. Nevertheless those equations are still acceptable compared with many other research works. Including the autoregressive term in each equation looks to mitigate the problem.

The empirical results capture the important market forces that actually exist over the marketing channel and, the price effect, income effect, cross effect, exchange rate effect, and government policy effect are consistent with a priori expectations and actual market situations. The calculated market responsiveness was found to be confirmed by simulation results.

References

[1] Attfield, Clifford L.F. (1985). Homogeneity and Endogeneity in System of Demand Equations, *Journal of Econometrics*, 27. P197-209

[2] Attfield, Clifford L.F.(1991). Estimation and Testing When Explanatory Variables are Endogenous, *Journal of Econometrics*, 48. P395-408

[3] Backus, David (1986). The Canadian-U.S. Exchange Rate, *Review of Economics and Statistics*, 68. P628-637

[4] Chambers, Robert G., and Richard E. Just. (1981). Effects of Exchange Rate Changes on U.S. Agriculture : A Dynamic Analysis, *Ameri. J. of Agri. Econ,* Feb. P32-47

[5] Dunlevy, James A. (1980). A Test of the Capacity Pressure Hypothesis within a Simultaneous Equation Model of Export Performance, *Review of Economics and Statistics*, 62. P131-135

[6] Dutton, John and Thomas Grennes. (1988). *The Role of Exchange Rate in Trade Models in Elasticities in International Agricultural Trade*, edited by Carter, Colin A. and Walter H. Gardiner. Westview Press

[7] Geraci, Vincent J. and Wilfried Prewo (1982). An Empirical Demand and Supply Model of Multilateral Trade, *Review of Economics and Statistics*, 64. P432-441

[8] Goldstein, Morris, and Moshin S. Kahn. (1978). The Supply and Demand for Exports : A Simultaneous Approach, *Review of Economics and Statistics*, 60. May , P275-286

[9] Hausman, J. Y. (1978). Specification Tests in Econometrics, *Econometrica*, 46. P1251-1271

[10] Haynes, Stephen E. and Joe A. Stone (1983). Specification of Supply Behavior in International Trade, *Review of Economics and Statistics*, 65. P626-632

[11] IMF. *International Financial Statistics : Supplement on Trade Statistics*, (1982).

[12] IMF. *International Financial Statistics : Supplement on price Statistics.* Series #12, (1986).

[13] IMF. *International Financial Statiatics Year Book*, 1991-1993.

[14] Judge, George G., R. Carter Hill, William E. Griffiths, Helmut Lutkepohl, and Tsoung-Chao Lee. (1985) *The Theory and Practice of Econometrics*, 2nd Edition, John Wiley & Sons.

[15] Kmenta, J. (1986). *Elements of Econometrics*, New York, Macmillan

[16] Ministry of Agriculture, Forestry, and Fisheries : *Grain Policy Data*, Dept. of Grain Policy, 1988.4 and 1992.6.

[17] Ministry of Agriculture, *Forestry, and Fisheries: Agriculture, Forestry, and Fisheries Major Statistics*, 1987 and 1993.

[18] Murray, Tracy, and Peter J. Ginman. (1976) An Empirical Examination of Traditional Aggregate Import Demand Model, *Review of Economics and Statistics* 58, Feb. P75-80

[19] Pindyck, Robert S. and Daniel L. Rubinfeld. (1991). *Econometric Models and Economic Forecasts*, 3rd Edition, McGraw-Hill Book co.

[20] Rao, P. and R. L. Miller (1971). *Applied Econometrics*, Belmont, Calif : Wadsworth

[21] SHAZAM, *User's Reference Manual*, Version 7.0 (1993), McGraw-Hill.

[22] Theil, H. (1957). Specification Errors and the Estimation of Economic Relationships, *Review of the International Statistical Institute*, 25. P41-51

[23] Thurman, Walter N. (1986). Endogeneity Testing in a Supply and Demand Framework, *Review of Economics and Statistics*, 68. P638-646

[24] Thursby, Jerry and Marie Thursby (1983). How Reliable are Simple, Single Equation Specifications of Import Demand? *Review of Economics and Statistics*, 65. P120-128

[25] Warner, Dennis and Mordechai E. Kreinin (1982). Determinants of International Trade Flows, *Review of Economics and Statistics*, 64. P96-104

[26] Wilson John F and Wendy E. Takacs (1979). Differential Responses to Price and Exchange Rate Influences in the Foreign Trade of Selected Industrial Countries, *Review of Economics and Statistics*, 61. P267-279

[27] Wu, De-Min (1973). Alternative Tests of Independence between Stochastic Regressors and Disturbances, *Econometrica*, 41. P733-750

[28] Yamawaki, Hideki(1986). Export, Foreign Market Structure, and Profitability in Japanese and U. S. Manufacturing, *Review of Economics and Statistics*, 68. P618-627

[29] Zeller, A (1962). An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias, *J. Amer. Statist. Ass.* 57. P348-368