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SOME WORLD MACROECONOMIC DETERMINANTS OF STORABLE, INTERNATIONALLY-TRADED AGRICULTURAL COMMODITY PRICES

Emilio Pagoulatos, Azzeddine Azzam, and Motoichiro Kitazawa*

In contrast to the relative stability of the preceding two decades, world commodity prices over the 1970's and early 1980's were characterized by a high degree of variability and a remarkably high degree of confluence across a large number of primary commodities (Bond, Crowley, and Vlastuin). High price volatility and an unusually high degree of synchronization in price movements among commodity groups have been especially noticeable for such internationally traded agricultural commodities as wheat, corn, and soybeans during the same period (Pagoulatos, Azzam, and Kitazawa). The synchronous price movements of various commodities since 1970 suggest the hypothesis of "a common cause" that creates strong linkages among the commodities affected. This hypothesis received some support from empirical studies that observed a high positive correlation among the residuals from individual commodity market models (e.g. Bosworth and Lawrence 1982), and from studies that have found traditional factors alone, such as the level of income, inventories, and production, unable to explain commodity price movements in the 1970's (e.g. Hwa (1979)).

The methodological problems in specifying, estimating, and simulating commodity models in international market analysis during a period of instability of commodity prices have been examined by Labys (1975). He suggests that including monetary factors and integrating speculative phenomena could improve the forecasting ability of international commodity market models. Specifically, he proposes considering the effect of exchange rate fluctuations on price formation and the existence of relations between price movements and futures trading. Several economists have began to include macroeconomic factors and futures markets in the analysis of markets for storable internationally-traded commodities (Lawrence and Lawrence; Grilli and Yang; Bond, Crowley and Vlastuin; Bond, Vlastuin, and Crowley; Thompson, Barnett and Bessler, Wailes and Suwanakul; Bond; and Kawai). The underlying view is that world commodity price instability has increasingly become a by-product of unstable monetary and other macroeconomic policies transmitted via flexible exchange rates in the presence of a well-integrated world capital market [Dornbusch (1983, 1985); McCalla; Pagoulatos; Schuh (1976,1981); Stallings]. Furthermore, the futures market can be viewed as providing an important facility for distributing commodity demand and supply from one period to the next and, hence, may have the potential to reduce price fluctuations over time (Kawai).

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The objective of this study is to investigate the role of global macroeconomic factors in explaining the price behavior of internationally-traded agricultural commodities. The paper applies the approach suggested by Kawai and Bond to analyze the world price determination process of three storable commodities -- corn, wheat, and soybeans -- by explicitly taking into account the role of futures markets. The operational model, developed in the following section, is similar to the theoretical portfolio model suggested by Bond, but is intended to give empirical content to some of the major determinants of the three commodity prices suggested by the theory. Similar to Bond's formulation, the model is short-run, demand oriented and considers the simultaneous determination of spot and futures prices. However, similar to Chu and Morrison (1986), we apply the portfolio model of commodity stock demand to a single aggregate international commodity market. We, therefore, abstract from interest rate differentials, reserve currencies and a number of other portfolio aspects of international markets.

The organization of the paper is as follows. Section I presents the structural model used to derive the commodity price equation. The econometric results and simulations are discussed in Section II, and Section III presents the conclusions. The Appendix at the end of the paper describes the variables and data sources.

I Model Specification

This section presents a simple world market model of a storable agricultural commodity that explicitly accounts for the presence of commodity futures. Following Bond, the model consists of relationships describing consumer and inventory demand and the supply of and demand for futures contracts. The model also reflects the working of a competitive international commodity market in which the commodity price is quoted in dollars and consumption is synonymous with the quantity traded in the world market. All variables are in real terms. In addition, the following assumptions are made regarding futures markets: 1) a futures contract is settled by actual delivery of the commodity; 2) a futures market reopens every period and delivery takes place only once in each period; 3) all inventories of the commodity are hedged.[1] Finally, the model is short-run in nature; therefore, the supply of the commodity is treated as exogenous, and the interest rate is assumed not to affect other macroeconomic variables such as industrial production.

Consumer Demand

The quantity of the commodity consumed by importing countries, C_t, is a negative function of the real spot price of the commodity (with real price defined as the ratio of the nominal price to a certain deflator), P_t, a positive function of the real price of substitute commodities, S_t, a negative function of the real dollar exchange rate (relative to consuming countries' currencies), X_t, a positive function of real aggregate economic activity in consuming (importing) countries, Y_t:

(1) $C_t = -aP_t + bS_t - cX_t + dY_t$

This specification is similar to that used by Chu and Morrison (1984) in deriving a price equation for internationally-traded commodities and can also be considered as an import demand function for the commodity.

Inventory Demand

Following Kawai and Bond, the level of inventory demand depends positively on the difference between the marginal return on stockholding, $R(f)'_t$, and the *ex ante* real interest rate, r_t:[2]

(2) $I_t = e\left[R(f)'_t - r_t\right]$

The Supply of Futures Contracts

Since for every unit of the commodity that is hedged there is a forward contract supplied, the supply of contracts by inventory dealers, B_t, will be equal to the level of inventory demanded in equation (2); therefore,

(3) $B_t = e\left[R(f)'_t - r_t\right]$.

The Demand for Futures Contracts

The quantity of contracts demanded by speculators, G_t, is a positive function of anticipated profit on each futures contract purchased:

(4) $G_t = f\,(P^e_{t+1} - F_t)$,

where P^e_{t+1} is the real spot price expected to prevail at time t+1, and F_t is the current real price of the futures contract. For simplicity, we adopt the adaptive expectations hypothesis and assume that the expectations of P^e_{t+1} are revised in proportion to the error associated with the previous level of expectations, i.e.

(5) $$P^e_{t+1} = P^e_t + \lambda(P_t - P^e_t) + \Sigma_k\, \phi_k\, D_{kt}$$

The variables D_{kt} (for k = 1, 2, 3) are included to account for seasonal variations in the formation of price expectations.[3]

Equilibrium Conditions

To close the model, we introduce equilibrium conditions for the futures and spot markets, respectively:

(6) $B_t = G_t$, and

(7) $C_t + I_t = I_{t-1} + Q_t$

where Q_t is the exogenously determined supply available at time t.

Price Determination

By substituting the relevant relationships into equations (6) and (7), solving simultaneously for P_t and F_t, and expressing the results as a forward premium, we obtain a reduced-form equation[4]

$$(8) \qquad P_t - F_t = \eta_0 + \eta_1 (I_{t-1} + Q_t) + \eta_2 S_t + \eta_3 X_t + \eta_4 Y_t$$
$$+ \eta_5 P_{t-1} + \eta_6 F_{t-1} + \eta_7 r_t + \eta_8 r_{t-1} + \eta_9 D_{1t}$$
$$+ \eta_{10} D_{2t} + \eta_{11} D_{3t}$$

where the expected signs are:

$$(\eta_2, \eta_4, \eta_5, \eta_8) > 0$$

and

$$(\eta_1, \eta_3, \eta_6, \eta_7) < 0.$$

Equation (8) identifies major variables affecting real spot commodity prices. Given the real futures price, an increase in current supply depresses spot prices. An increase in the real price of substitutes or income influences commodity prices positively. An appreciation of the dollar vis-a-vis the currencies of consuming countries has a negative impact on the price of the commodity. A rise in the current spot price relative to the current futures price, by narrowing the forward premium, results in less carryover, thus raising spot prices at time t + 1. On the other hand, a rise in the current futures price relative to the spot price creates the prospect of excess supply at period t+1, thus depressing spot prices at t + 1. A rise in current real interest rates, by making hedged stocks less profitable than financial instruments, depresses prices at time t, and raises them at t + 1 as less carryover takes place from period t to period t + 1.

II Empirical Results

In this section the commodity price model (8) is estimated as a group of seemingly unrelated equations with quarterly data for wheat, corn, and soybeans over the 1967I - 1983IV sample period.[5] There are reasonable grounds a priori to expect contemporaneous covariance given the speculative and portfolio aspects of demand for the three commodities.

Because the theoretical model implies the estimated coefficients for P_{t-1} and r_{t-1} should turn out to be the same (see equation 8), we imposed this restriction on the model. The overidentifying nonlinear restrictions of the model make it impossible to recover unique values of the restricted parameters in the structural model. This implies that we cannot directly test for the adaptive expectations hypothesis, since λ is not equal to the coefficient on P_{t-1} (i.e., $1 - \eta_5$) , except when $\frac{\Omega}{ae} = 1$ (which is true only in the unlikely situation of $f = 0$).[6]

Furthermore, examination of the correlation matrix indicated strong collinearity between lagged futures prices and lagged spot prices, industrial production and real exchange rates. To mitigate the effect of the collinearity, we transformed futures prices and industrial production into first differences.

Finally, since estimation was conducted with data prior to the introduction of the flexible exchange rate regime, we allowed for the slope parameter of the real exchange rate to change during the flexible exchange rate period (1973II - 1983IV). The intercept term and the slopes of the other parameters were assumed to be invariant through the estimation period.

The final specification of the estimated reduced-form commodity price equation may, therefore, be written as follows:

$$(9)\quad P_t = \theta_0 + \theta_1 \Delta F_t + \theta_2 (I_{t-1} + Q_t) + \theta_3 S_t + \theta_4 X_t + \theta_5 X_t \cdot DUM_t + \theta_6 \Delta Y_t + \theta_7 P_{t-1} + \theta_8 r_t + \theta_7 r_{t-1} + \theta_9 D_{1t} + \theta_{10} D_{2t} + \theta_{11} D_{3t} + v_t$$

where Δ = change, and v_t is a random error term. The expected signs are:

$(\theta_2, \theta_4, \theta_8) < 0$, and

$(\theta_3, \theta_6, \theta_7) > 0.$

Table 1 summarizes the results of estimation of the real price equation (9) for the three commodities. The real domestic price of substitutes variable, S_t, turned out negative and highly insignificant in all three equations and was dropped. The computed Durbin h statistic indicates absence of autocorrelation in all three equations.

Generally speaking, the results are good; most explanatory variables exhibit the theoretically-expected sign and are statistically significant. The supply variable in the wheat equation had the wrong sign but the coefficient was statistically insignificant. The overall results underscore the importance of all but the supply variables in determining relative commodity price movements. The lack of significance of the supply variables may be associated with the data limitations due to unavailability of quarterly production figures and stocks for countries other than the United States. Finally, the coefficients on lagged real prices indicate that adjustment of quarterly prices to equilibrium values is gradual.

The interpretation of the coefficient on the first difference of futures price is best understood if we look at the impact of a negative percentage decrease of this variable. A negative percentage decrease implies a wider forward premium in period t - 1. This induces the holding of inventories to period t, which, when released depress commodity prices. The negative and significant coefficient on the real value of the importer dollar exchange rate confirms our prior notion on its impact on real commodity prices. The presence of a negative and significant coefficient for the real exchange rate variable indicates that changes in the dollar exchange rate affect the nominal prices of agricultural commodities by more than those of nonagricultural goods. Therefore, a real dollar exchange rate appreciation results, ceteris

Table 1. Seemingly Unrelated Regression Results of Price Equation (9)

Independent Variables:	Wheat	Corn	Soybeans
Constant	1.80 (2.44)	2.83 (4.70)	2.83 (6.71)
ΔF_t	.550 (4.89)	.580 (5.23)	.784 (7.24)
$(I_{t-1} + Q_t)$	.025 (.328)	-.063 (1.45)	-.002 (.220)
X_t	-.556 (6.05)	-.537 (6.37)	-.670 (7.15)
$X_t \cdot DUM_t$	.039 (4.27)	.028 (3.55)	.038 (4.33)
ΔY_t	3.36 (2.92)	1.62 (1.46)	1.78 (1.60)
P_{t-1}	.553 (10.76)	.454 (8.39)	.412 (6.48)
r_t	-.382 (5.73)	-.339 (5.29)	-.310 (4.48)
r_{t-1}	.553 (10.76)	.454 (8.39)	.412 (6.48)
$D1_t$	.033 (.476)	-.314 (1.37)	-.003 (.043)
$D2_t$	-.014 (.225)	-.049 (.681)	.032 (.702)
$D3_t$	-.034 (.146)	.041 (.852)	.050 (.601)

Asymptotic t-values in parentheses.

paribus, in a decline of the purchasing power of agricultural commodities in terms of nonagricultural products.

It is perhaps surprising that the coefficient on the slope shifter designed to capture the effect of exchange rates on agricultural prices during the flexible exchange rate period is positive and statistically significant. Our prior notion was that the dampening effect of a real dollar appreciation on relative commodity prices would be accentuated by the introduction of flexible exchange rates. There are two plausible explanations, however, for the positive slope shifter coefficient [Labys (1975), Van Duyne, and Cooper and Lawrence]. First, the breakdown of the fixed exchange rate regime may have led investors to substitute real assets (including commodities) for foreign currencies in their portfolios, as the perceived risk of holding foreign currencies increased. Second, financial instruments became less attractive as a hedge against inflation than commodities, as inflation expectations increased during the 1970's.

The results also indicate the importance of the real interest rate in affecting real prices. The negative and significant coefficient on the real interest rate confirms our prior expectation about the impact of this variable on relative prices through stock behavior. The three estimated equations also confirm the expected positive effect of industrial growth (a measure of the business cycle in industrial countries) on relative prices. However, that impact is only significant in the relative wheat price equation. This is not an unexpected result, given the nature of the demand for the three commodities. As inputs into livestock production, corn and soybeans may be affected by rising income only through longer lags. Wheat demand, on the other hand, may be affected instantaneously by rising income because of direct human consumption.

Comparison of our present study to other studies is rather difficult. None of the studies on commodity prices reviewed took explicit account of futures prices in explaining relative commodity price movements. Besides, some researchers used real prices, others used nominal prices. Moreover, none of the reviewed work considered corn, wheat, and soybeans as such. Nonetheless, the results in our study are consistent with recent studies on aggregate commodity prices [Hwa (1981), Grilli and Yang, Bosworth and Lawrence, and Chu and Morrison (1984, 1986)].

Having estimated the model, we next assessed the contribution made by each of the main exogenous variables to the variability of the three real commodity prices. To do so, we simulated the three prices under the assumption that one of the exogenous variables has been completely stabilized at its long-term trend. The rest of the variables assume their historical values. The measure of variability is the standard deviation of the simulated price series over the period 1973II - 1983IV.

The results are reported in Table 2. The principal finding is that from the set of exogenous variables examined, the real exchange rate stands out as the dominant source of the variability in prices. Stabilization of exchange rates would have reduced the standard deviation of wheat, soybean, and corn prices by 37 percent (.291 to .183), 69 percent (.293 to .090), and 48 percent (.269 to .140), respectively. The results also show that had all exogenous variables been fully stabilized around their long-term trends, the variability in the three prices would have been reduced by 42 percent, 62 percent, and 53

Table 2. Sources of Real Commodity Price Instability

(Sample Period: 1973II - 1983IV)

Item	Commodity		
	Wheat	Soybeans	Corn
	SD[a]	SD[a]	SD[a]
Actual	.291	.293	.269
Simulated[b]	.272	.261	.237
Simulated[c]			
1) Exchange Rates	.183	.090	.140
2) Supply	.274	.261	.253
3) Interest Rates	.293	.286	.252
4) Income	.280	.260	.239
5) 1 - 4	.169	.111	.124

[a] Standard deviation

[b] Simulation based on historical value of exogenous variables

[c] Historical values of each exogenous variable were replaced by their long-term trend. This was accomplished by regressing the log of the exogenous variable on the linear time trend.

percent, respectively.

The general conclusion from the above results, in light of our model specification, is that exchange rate fluctuations have been the major factor underlying world commodity prices since the advent of the flexible exchange rate regime. This qualitative result is consistent with other findings in the literature [e.g., Chu and Morrison (1986)], though their analysis considered aggregate rather than individual commodity price movements. Similar results have been recently reported by Orden with reference to U.S. agriculture.

The fact that the rest of the exogenous variables show little contribution to the overall variability of prices does not diminish their importance -- as this may be related to the short-run demand-oriented nature of the structural model used for the analysis. Take the exogenous supply variable, for example. We recognize that it is critical to distinguish carefully between random exogenous supply shifts, and output changes brought about by price expectations. This implies that part of the supply response is endogenous to the model. Furthermore, it just may be that the full effects of interest rates and income are not visible in a short-run model. Consideration of a longer time unit, say a year, may alter the order of importance of the variables in affecting commodity price variability.

III Conclusions

World commodity price movements since the early 1970's have been characterized not only by a higher degree of instability relative to the preceding two decades, but by a remarkable confluence in price movements across diverse commodity groups. The major structural changes which took place during the early 1970's in the world economic environment such as the floating rate system suggest that emphasis should be placed on the linkage between world commodity price instability and world macroeconomic factors.

This study focuses upon the linkage between world macroeconomic factors and primary commodity prices in international markets by explicitly accounting for the role of futures prices in stockholding behavior. The empirical analysis is carried out with quarterly data of three storable, internationally-traded agricultural commodities: wheat, corn, and soybeans. A reduced-form relative price equation is derived from a global market model that combines both futures and current markets along the lines suggested by Bond and Kawai, and is estimated over the 1967I - 1983IV period. The empirical findings provide evidence that world macroeconomic factors do have an important influence on relative price movements for individual internationally-traded agricultural commodities.

More specifically, the empirical analysis indicates that the cyclical movements of real agricultural commodity prices are readily explainable by such factors as the real importer dollar exchange rate, the real three-month Eurodollar interest rate, and changes in futures prices and the business cycle in industrial countries. The simulation results further suggest that the real exchange rate has been the single most important source of real agricultural price variability since the advent of the flexible exchange rate regime.

The empirical part of our model can be improved in a number of ways. First, the dynamics of price expectations should be given more attention than has received in this paper. Second, greater emphasis should be placed in accounting for supply-side and policy factors underlying the fluctuation of world agricultural commodity prices. Finally, better estimates of quarterly world supplies and stocks for agricultural commodities are needed for a more complete understanding of market behavior.

In conclusion, this study serves as a reminder of the necessity to think more globally in setting agricultural policy price objectives and in forecasting agricultural prices. Since the results of this study provide evidence that international commodity market instability is to a large extent caused by world macroeconomic factors, such policies as commodity agreements, reductions of trade barriers, food security schemes, and gov-ernment schemes to purchase and hold stocks alone will be inadequate to dampen price fluctuations or adjust price levels. Therefore, it is essential to clearly understand the linkage between world macroeconomic forces and agricultural commodity markets for the purpose of establishing appropriate agricultural policy alternatives.

FOOTNOTES

1. The assumption that all stocks are hedged is probably unrealistic for internationally-traded commodities. The proper approach would be to add a relationship describing the nonspeculative demand for commodity inventories. However, since the nonspeculative component of inventory demand is a function of the real interest rate and the total flow demand for the commodity, its exclusion from our model does not affect the final reduced form equation for the commodity price.

2. The marginal return to stock holding is defined by Bond as follows:

$$R_t = (P_{t+1} - P_t)\ I_t - H(I_t)$$

where: R_t = total one period return to stock holding.

P_{t+1} = price of commodity in period t + 1.

I_t = inventory of commodity during period t.

$H(I_t)$= cost of storing I for one period.

Following Kawai (1983), the cost function of holding inventories is described in a nonlinear form as:

$$H(I_t) = 1/2\ h\ (I_t)^2 \qquad h > 0$$

where: h = holding cost coefficient.

The marginal return to stock holding over the interval (t, t + 1) is in turn defined as the first derivative of R_t with respect to I_t:

$$R'_t = P_{t+1} - P_t - h$$

Defining F_t as the futures contract price during period t for delivery at t + 1, the marginal return to hedged stock, $R(f)'_t$, is finally determined as:

$$R(f)'_t = F_t - P_t - h$$

3. An alternative hypothesis is that of rational expectations. Under this hypothesis, however, it would be necessary to generate expectations of all the exogenous variables in the system. Rather than following the conventional ad hoc schemes of doing so, we chose to work with the computationally simpler adaptive expectations hypothesis.

4. An appendix containing the derivations is available upon request.

5. The sample size was dictated by data availability for all relevant variables.

6. However, note that since $d\lambda/d\eta_5 < 0$, the value of λ decreases as η_5 increases.

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Appendix A = Variable Definitions, Data Sources and Data Set

The variables in equation (8) in the text are defined as follows:

P_t = Real price indices of wheat, corn, and soybeans. The wheat price index is for the U.S. No. 2 hard red winter, f.o.b. Gulf ports, ordinary protein, export price base. The corn price is for the U.S. No. 2 yellow, f.o.b. Gulf ports, export price base. The soybean price is for the U.S. c.i.f. Rotterdam. The three prices were deflated by the consumer price index for 21 industrial countries. The countries are: the United States, Canada, Australia, Japan, New Zealand, Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. Source: International Financial Statistics (International Monetary Fund, Washington), various issues.

F_t = Real futures prices of wheat, corn, and soybeans. The futures prices of wheat, corn, and soybeans on a quarterly basis are obtained as an average of weekly futures-closing-prices delivered the subsequent quarter. The wheat futures price is for hard winter wheat at Kansas City. The corn futures price if for Chicago no. 2 yellow. The soybean futures price is for soybeans at Chicago. The three prices were deflated by the consumer price index for 21 industrial countries. Source: Grain Market News (Consumer and Marketing Service, USDA, Washington); Statistical Annual: Chicago Board of Trade (Board of Trade, Chicago) various issues.

I_{t-1} = Carry-over stock of wheat, corn and soybeans from the previous quarter. Since quarterly data on carry-over stock at the global level are not available, quarterly data of the U.S. stocks of the three commodities are used as proxies. Source: Wheat Situation (ERS, USDA, Washington); Feed Situation (Economics, Statistics, and Cooperatives Service, USDA, Washington); Stocks of Soybeans in All Positions (Crop Reporting Board, USDA, Washington).

Q_t = World production of wheat, corn and soybeans. Production of major producing countries of three commodities was allocated on a quarterly data basis by using the world harvesting calendar. Source: FAO Production Yearbook (Food and Agriculture Organization of The United Nations, Rome), various issues.

S_t = Real domestic prices of substitutes in consuming countries. Because of the paucity of information on this variable, we used a weighted average of the wholesale price indices for nine consuming countries: Belgium, Canada, England, France, Germany, Italy, Japan, Netherlands, and Spain. The weights are the same used in constructing the bilateral dollar effective exchange rate (X_t). Source: I.M.F., International Financial Statistics, various issues.

X_t = Index of the real effective bilateral U.S. dollar exchange rate at time (quarter) t defined as:

$$\text{Index}_t = 100 \exp \sum_{i=1}^{n} w_i \log_e \left(E_{it} \cdot \frac{DF_{ust)}}{DF_{it}}\right)$$

Where E_{it} = (Base period exchange rate of currency i)/(Exchange rate of currency i at time t), with all exchange rates expressed in U.S. cents per unit of foreign currency; DF_{ust} and DF_{it} are indices of consumer price levels at time t for the United States and country i respectively; and w_i represents the share of the ith country in U.S. exports of each of the three commodities (1972-1976 average). The data were obtained from the I.M.F., International Financial Statistics tape. The bilateral weights w_i used for computing the trade-weighted indices for the three agricultural commodities are given below.

COUNTRIES	WHEAT	CORN	SOYBEANS
W. Germany	.220	.1732	.149
Japan	.139	.2900	.290
France	.049	.0384	.031
England	.120	.0546	.025
Canada	--	.0341	.039
Italy	.139	.1231	.077
Netherlands	.285	.1807	.251
Belgium	.041	.0260	.028
Spain	.007	.0799	.110

Y_t = Index of industrial production for the 18 major industrial countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom and the United States). Seasonally adjusted industrial production indices are averaged for the 18 countries (base year 1975 = 100). Source: I.M.F., International Financial Statistics, various issues.

r_t = Real world interest rates. The three-month London Eurodollar interest rate is used as a proxy for the nominal world interest rate. The three-month London Eurodollar interest rate minus the expected world inflation rate, is used as the real world interest rate. The expected inflation rate was calculated as the difference between the inflation rates in the two preceding quarters. The weighted average of the consumer price index in 21 industrial countries was used to generate the world inflation rate. Sources: Bank of England Quarterly Bulletin (Bank of England, London); International Financial Statistics (International Monetary Fund, Washington); OECD Financial Statistics (OECD, Paris); Federal Reserve Bulletin (Board of Governors of the Federal Reserve System, Washington), various issues.

DUM_t = Dummy for the flexible exchange rate period. Takes the value of 1 for 1973II - 1983IV, and the value of 0 for 1967I - 1973I.

D_{it} = Seasonal dummy variables for quarters 1, 2, and 3 respectively.