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The effects of exchange rate risk on agricultural imports of developing countries

Ligia María Soto-Urbina

To the Graduate Council:

I am submitting herewith a dissertation written by Ligia María Soto-Urbina entitled "The effects of exchange rate risk on agricultural imports of developing countries." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

Gregory K. Pompelli, Major Professor

We have read this dissertation and recommend its acceptance:

Larry VanTassell, William Park, Don Clark

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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THE EFFECTS OF EXCHANGE RATE RISK ON AGRICULTURAL IMPORTS OF DEVELOPING COUNTRIES

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Ligia María Soto-Urbina

August 1991

DEDICATION

To my Father

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ABSTRACT

Nominal and real exchange rate variability has been theoretically associated with increased risk that reduces the volume of internationally traded goods. This study examined the effects of nominal and real exchange rate variability on the volume of grains imported by developing countries.

A variant of Hooper and Kohlhagen's model was used to investigate nominal exchange risk. The model was modified to incorporate and test the effects of a budget constraint on import decisions in developing countries. It was assumed that unpredictable fluctuations of nominal exchange rates were the only source of uncertainty. It was shown that an increase in the nominal exchange rate uncertainty reduced the volume of imported grains, while a relaxation of the nominal budget constraint increased the quantity of imported grains.

The effects of real exchange rate uncertainty were examined by incorporating a budget constraint into the model developed by Cushman. The model assumed that both prices and exchange rates were random and, thus, the uncertain variable of the model was the real exchange rate. An increase in either the expected value of the real exchange rate or in the uncertainty associated with this variable led to a decline in the level of imported grains. However, a relaxation of the real budget constraint increased the quantity of imported grains.

The import demand models under nominal and real exchange rate uncertainty were estimated for quarterly quantities of wheat and corn imported by Brazil, and Trinidad and Tobago. In most cases, empirical results indicated that agricultural commodities were sensitive to either nominal or real exchange rate risk. The inclusion of a financial constraint proved to be important in the case of Trinidad and Tobago. In the case of Brazil, the results were far from conclusive, because the selected foreign exchange approximation did not accurately capture the expected positive effects of an increase in the level of foreign

exchange on the imported quantity. Despite this problem, the results indicate that nominal foreign exchange had a small but significant role in explaining Brazilian wheat imports.

To study the potential sources of real exchange rate variability, the model developed by Edwards was used. This model assumed that both monetary and real disturbances affected real exchange variability in the short-run, while only real shocks were relevant in the long-run.

Quarterly models of the potential sources of a short-run and a longer-run measure of the real effective exchange rate variability relevant for corn and wheat importers were developed for Brazil, and Trinidad and Tobago. For both countries, the empirical equations using the short-run measure of real exchange variability performed better than the equations using the long-wave measure. For Trinidad and Tobago, the results showed the influence of both monetary and real factors. In the case of Brazil, the results showed that monetary factors were the more influential factors determining volatility of the real exchange rate.

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Chapter 1

Introduction

Increased exchange rate variability has been associated theoretically with increased risk that negatively affects profits of firms and other agents engaged in international transactions. Several studies have noted that increased exchange rate risk would lead to reductions in the volume of traded goods, if agents are risk averse (Clark, Ethier, Hooper and Kohlhagen).

In the last decade, several authors have examined and tested the effects of exchange rate risk on trade among the developed countries (e.g., Hooper and Kohlhagen, Cushman (1983, 1988), Anderson and Garcia). Most of these studies have focused on total trade or on manufactured goods trade and empirical testing of the potential adverse effects of nominal and real exchange volatility has produced mixed results. Also, research on agricultural trade by developed countries is far from conclusive since few studies have been done and results are contradictory. For instance, one study found that nominal exchange rate risk had a small, but significant negative effect in the level of U.S. soybeans exports to other developed nations (Anderson and Garcia), while other study found no significant real exchange risk effects on total U.S. agricultural exports to major developed countries (Pick). On the other hand, another paper revealed that real exchange variability had adverse effects on total exports from the U.S. agricultural sector to major developed countries (Maskus).

The impact of exchange rate risk on international trade of developing countries has received scarce attention in the economic literature, with most studies focusing on the impact of real exchange rate fluctuations on export levels. For instance, Bautista showed evidence of adverse effects of real exchange rate variability on the level of total exports of the countries concerned. Diaz-Alejandro found that real exchange risk could be responsible for the decline in the level of agricultural exports in Colombia. Also, Coes showed evidence that a decline in real exchange rate risk was associated with an increase in the level of exports from Brazil. The effect of real bilateral exchange volatility on the level of total U.S. agricultural exports to Mexico, Brazil and South Korea was found to be significant by Pick.

Knowledge of the effect of nominal and real exchange rate risk on the demand for agricultural imports by developing countries, especially grains, is important because these countries constitute an important market for U.S. grain exporters. Examination of this phenomenon should take into account the economic situation of developing countries, which is characterized by severe financial constraints. Previous theoretical models of trade under uncertainty are considered inappropriate for investigating the impact of exchange rate risk on grain imports of developing countries, because they fail to reflect the financial constraints prevailing in many developing countries.

The distinction between nominal and real exchange rate uncertainty has been associated with the time framework considered by the researcher. The first type of risk has a very short-term nature and reflects the risk faced by individual traders as nominal exchange rate fluctuates within the contract period, but prices remain sticky. Thus, if the unit-value of an import transaction is fixed for the contract period in terms of a foreign currency against which the domestic currency fluctuates, exchange rate fluctuations result in smaller or larger profits than expected for the importer. If no method exists to insure against fluctuations, the importer will face risk to which a cost is attached (Lanyi and Suss). While this type of variability is relevant mainly within the currency-contract period, it could influence long-term decisions affecting the volume of imports (Clark). Since grains tend to be contracted and priced in U.S. dollars (Maggee and Rao), this type of risk can be associated with short-run fluctuations between the domestic currency and the U.S. dollar.

Another type of risk is associated with the effect of real exchange rate fluctuations on international transactions. This type of risk is assumed to be relevant for longer periods than the currency-contract-period. Outside the contract period, traders are expected to be concerned with fluctuations in both domestic and international price levels, as well as, fluctuations in nominal exchange rates. Unexpected real exchange rate movements or swings generate increased uncertainty about profit streams and this uncertainty is expected to affect short- and medium-term trade decisions (Wickham). In the short-run, real exchange rate risk could be expected to inhibit trade and in the longer-run it could be expected to to bias decision relating to the structure and level of output and investment (IMF). Most empirical studies have investigated the short-term effects of real exchange rate risk on international trade. Longer-term effects have received scarce attention in empirical research, chiefly because it is not an easy task to construct a measure capturing longer-term swings in the real exchange rate.

The empirical literature on the effects of short-run exchange risk has shown a lack of agreement on the way this type of risk is measured. The differences have stemmed from the way short-run risk is interpreted. Some researchers have assumed that this risk is reflected by the fluctuations between the domestic currency and the currency in which trade contracts are denominated (Hooper and Kohlhagen, Anderson and Garcia). Other researchers have assumed that traders have a longer-term planning horizon and their decisions are affected by the uncertainty about their profit streams generated by unexpected short- and medium-term exchange rate fluctuations. If exchange rate swings were assumed to be unrelated to underlying prices and cost differentials across countries, then short-run exchange risk could be measured by a nominal effective exchange rate (Akhtar and Hilton, Gotur). If, however, exchange rate fluctuations were assumed to have a role in changing prices of traded goods and costs, then short-run exchange risk could be measured by a real exchange rate (Wickham). Since the assessment of exchange rate risk has not been resolved, it is important to explore as many avenues as possible in the empirical investigation of the potential impact of short-term risk on the demand for imported grains by developing countries.

From a policy point of view, it is important to determine the main causes of exchange rate uncertainty. An understanding of these causes may help domestic authorities in designing policies aimed at reducing exchange rate risk. Research in this area has focused on the study of the main sources of real exchange variability. In theory, the long-run equilibrium real exchange rate depends on the behavior of real variables (Mussa). In the shorter-run, nevertheless, real exchange uncertainty is also affected by monetary disturbances. Edwards tested the role of variability in monetary and real factors in explaining real exchange variability in developing countries. He found that more unstable monetary policies were reflected in higher short-term exchange rate variability, whereas, more unstable real factors were responsible for higher longer-term exchange rate variability.

The general objective of this study is to specify and estimate the linkages between either nominal or real exchange rate risk and agricultural grain imports by developing countries under financial constraint. The potential role of monetary and real factors in explaining exchange rate variability is also investigated. Specific objectives are to:

1. Investigate the relationship between nominal and real exchange rate risk and the demand for imported grains by developing countries that face financial constraints.

2. Estimate the effect of nominal and real exchange rate uncertainty on the volume of grains imported by developing countries.

3. Estimate the effect of financial constraints on the quantity of grains imported by developing countries.

4. Investigate the main sources of real exchange variability.

Chapter 2

Literature Review

Since the collapse of the Bretton Woods' official parities and the advent of flexible exchange rates among the major industrial countries, there has been considerable theoretical work investigating the effects of exchange rate uncertainty on international trade. Also, there has been a substantial effort to empirically assess the effects of nominal and real exchange risk. Most of these studies have analyzed the effects of uncertainty on the flows of trade among industrial countries, and typically in terms of aggregate trade, manufactured goods trade, or agricultural trade. Those few studies devoted to studying the effects of exchange risk on trade of developing countries have dealt mostly with exports. This chapter provides a brief description of the main theoretical implications of exchange risks and their empirical tests, as well as, the possible sources of real exchange variability.

2.1 Theory and Empirical Evidence of the Impact of Exchange Rate Risk on Trade

Previous Theoretical Literature

Many models have been developed to explore the effect of nominal and real exchange rate uncertainty. Most theoretical contributions have shown this phenomenon has a negative impact on the volume of trade (Ethier, Clark, Hooper and Kohlhagen, Cushman (1983)). For instance, Ethier and Clark analyzed this phenomenon. For instance, Ethier and Clark theoretically analyzed the effects of nominal exchange risk as well as price uncertainty on the volume of trade. They evaluated the role of forward exchange markets in dealing with uncertainty. Hooper and Kohlhagen, however, did not allowed for price uncertainty as their model focused on the very short-run effects of nominal exchange uncertainty on both the price and volume of trade. Cushman (1983) developed a variant of Hooper and Kohlhagen's model which was designed to capture the effects of both price and exchange rate uncertainty on trade flows. Important details of these studies are discussed in turn.

Ethier examined the effects of nominal exchange rate uncertainty on merchant importers assuming the existence of well-developed forward exchange markets. He analyzed the role of financial markets as instruments to deal with exchange rate risk. He assumed that the future spot rate, R, was a random variable and the present forward exchange rate, R_f, reflected expectations concerning the value of R when payment was due. In this context, Ethier's study focused on the decisions the firm must make at the time of ordering, regarding both the volume, M, of goods to be imported and the amount of forward exchange cover to obtain, supposing that the price of imports was denominated in foreign currency and that the firm would receive and pay for the imports in ninety days.

Ethier assumed the firm was interested in maximizing profits in terms of domestic currency. He defined its profit function as

$$\pi(M, \alpha) = PM - V(M) - MQ[\alpha R_f + (1 - \alpha)R], \tag{2.1}$$

where α represented the proportion of the import bill for which cover was obtained; P represented the price which the firm received for its product in the domestic market; $V(M)$ was the cost of value-added by the firm which was assumed to be known with certainty as it was not affected by exchange risk; Q denoted the foreign price of imports which was assumed to be known when the contract was made; $MQ[\alpha R_f + (1 - \alpha)R]$ was the cost in terms of domestic currency at the end of the contract period. Ethier assumed that nominal exchange rate uncertainty affected the firm's profits through the domestic cost of its imports (if the import bill was not fully covered, i.e., $\alpha \neq 1$) and through the size of the domestic price, P, which the firm received for its output. The dependence of P on the exchange rate was given by

$$P = P^0 + \gamma(R - \bar{R})Q, \tag{2.2}$$

where P^0 was a constant, $1 \geq \gamma \geq 0$, and $\bar{R}$ was the expected value of R.

Ethier analyzed two cases. In the first case, he assumed that firms knew the relationship between their revenues and the future exchange rate. That is, he assumed that firms were able to predict how a change in exchange rate would affect the level of P. This assumption was reflected in the fact that γ was considered to be a constant known to the firm. Under this assumption, the firm would select M and α so as to maximize the expected utility of profit. The utility function assumed by Ethier was of the von Neumann-Morgenstern type and firms were assumed to be risk averse. The solution to the maximization problem showed that the volume of imports demanded was entirely independent of the firm's attitude toward risk, and that risk was relevant only to the choice of the amount of forward cover to obtain.[1] To the extent that the forward rate reflected the merchant's expectation concerning the future behavior of the spot rate, nominal exchange rate uncertainty influenced only the degree of forward cover and not the level of trade. In this model, the firm could adopt a riskless position by covering to the extent $\alpha = 1 - \gamma$ (then, it was not necessary to cover completely). This amount of cover removed nominal exchange risk entirely since the effect of a nominal exchange rate variation on the import bill was always matched by an equal and opposite effect on the proceeds of domestic sales. In other words, as price changes offset exchange rate movements, exchange risk was neutralized. If there were divergences between the forward rate and the future spot rate, the pattern of trade would have been inefficient, but this distortion would not have been due to nominal exchange rate uncertainty.

[1]This result is called the *separation theorem* and implies that any two firms with identical technologies, but with different attitudes toward risk and different probability beliefs will demand the same volume of imports. The risk coefficient is important only in determining the optimal proportion of the import bill to be hedged (Kawai and Zilcha).

Ethier's conclusions depended on the existence of a well-developed forward exchange market across a wide spectrum of maturities. Therefore, if traders would not have had access to this type of financial facility the effects of nominal exchange risk on trade could not be neutralized by using optimal covering.[2]

Ethier also studied the case when the typical firm was assumed to face both uncertainty about the future level of exchange rate and about the level of profits for any value of the exchange rate. This last type of uncertainty came from a lack of knowledge about how a change in the exchange rate would affect the domestic price of the product. This assumption was represented by letting γ to be a random variable, distributed independently of R. In this case, he found that the level of trade became sensitive to both price and exchange rate uncertainty. He also pointed out that nominal exchange rate changes would probably be negatively correlated with price changes so that an increase in nominal exchange rate risk would be at least partially offset by price changes. According to this variant of the theoretical model, if the forward rate had accurately reflected the merchant's expectations concerning the future spot rate, the firms' attitudes toward risk would have been reflected in a reduced level of trade and not at all in the proportion of forward cover. The more conservative the firm was, the lower the level of trade. In this case, the firm was unable to remove risk by using an optimal covering strategy. In fact, a riskless position was achieved, in this model, when the firm imported nothing, which would have entailed a certain loss if there had been fixed costs.

In summary, Ethier's theoretical model revealed that nominal exchange rate risk was not a source of concern when traders had well-developed forward markets. On the other hand, when the price of output was allowed to be random, nominal exchange rate affected adversely the level of trade. In this case, he was implicitly assuming that traders were negatively affected by a measure of real exchange rate variability.

[2]Black observes that most developing countries do not have forward markets. Also, financial alternatives to the forward market such as borrowing or lending foreign currencies are not always available in developing countries (Bacha)

Ethier's conclusion that nominal exchange rate risk did not affected trade volumes was challenged by Clark, who theoretically analyzed the effects of exchange rate uncertainty on the level of exports of a country. The divergence in Clark's results was achieved by assuming that the exporter had a planning horizon which was longer than the contract period, and, as a consequence, the exporter was unable to remove risk even in the presence of well-developed forward exchange markets.

The main assumption underlying Clark's analysis was that (p. 303)

> " ...the firm's willingness to engage in international trade depends on its assessment of the long-term prospects for profit in that activity. Such an assessment must take into account the firm's inability to predict with certainty the domestic value of its foreign sales."

The domestic value of the firm's foreign sales was assumed to be uncertain as a result of unpredictable exchange rate fluctuations. Consequently, the forward exchange market could be used to hedge particular transactions, but the entire stream of transactions which determines the profitability of the export activity could not be hedged. The variation in the forward rate was assumed to be a good measure of nominal exchange rate risk.

Clark developed a model of an exporting firm and considered two cases. In the first case, he assumed that the foreign price received by the exporter was constant. There was limited hedging as he assumed that there was a forward exchange market period for one maturity, e.g. ninety days, which was considerably shorter than the long-run planning horizon of the exporting firm. He also assumed a constant flow of exports over the long-run period which generated a constant revenue stream denominated in foreign currency, but a variable and unpredictable revenue stream denominated in domestic currency. This domestic stream of receipts had a short-run component which was certain because the domestic-currency equivalent of exports sales was assumed to be known ninety days before the foreign importer made payment. However, future export sales in domestic currency remained unpredictable.

The firm was assumed to decide on a level of exports which took the uncertainty of future receipts into account.

The firm's domestic-currency equivalent of profits, π, in any given ninety-day period was

$$\pi = fpq - C(q), \tag{2.3}$$

where q was the exported good, p was the foreign price of the exported good, f was the forward rate which was a random variable, and $C(q)$ was the total cost function. Profits were free from random disturbances in the first ninety-day period, but not in subsequent periods. The assumption was made that the firm wished to maximize the expected value of a quadratic utility function of profits. Using the results of the maximization problem, Clark deduced that the supply curve of risk-averse exporters would shift up and to the left when there was an increase in the variability of the forward exchange rate. Therefore, nominal exchange rate risk led to a decline in the volume of trade.

Clark also analyzed the case where perfect forward markets were assumed for any desired maturity and where the foreign price of the traded commodity was a random variable. He used the first assumption to demonstrate that the existence of these hedging opportunities would reduce, but not eliminate exchange rate risk in the long run if foreign exchange receipts could not be accurately predicted. In this case also, the volume of trade was reduced whenever there was an increase in the variability of the nominal exchange rate, *ceteris paribus*. The larger the variance in the forward rate, the larger was the variance of profits and, consequently, the larger were the risks associated with international transactions. However, the existence of perfect forward markets helped to alleviate these risks. Another important consequence of the underlying assumptions of the last case analyzed by Clark was that average profits depended on the covariance between the forward rate and the foreign price, which under normal circumstances was expected to be negative. Therefore, the larger the algebraic value of the covariance, the larger the expected value of profits would be. The reason was that the inverse relationship between these variables provided an offsetting mechanism since movements in one price were counterbalanced by movements in the opposite direction in the other price. In this case, Clark observed (p. 312)

> " ...that the amount by which an exporter will cover his expected earnings is very sensitive to the extent to which the foreign price and the exchange rate have an offsetting effect on his profits. The larger the negative covariance between these two variables, the less need there is to resort to the forward market to reduce the variability in earnings."

Clark was implicitly suggesting that the smaller the deviations from the purchasing-power parity law (PPP), the smaller the risk faced by the exporter.[3] This conclusion supported the use of a real exchange rate risk measure, when both prices and exchange rates were expected to be random.

Another important theoretical expansion of the implications of exchange rate fluctuations was developed by Hooper and Kohlhagen. They analyzed theoretically and empirically the impact of the risk associated with these fluctuations on both the volume and prices of trade. They assumed that traders had access to forward markets and that they hedged a proportion of their expected foreign credits or debits in this market. This proportion was invariant to the degree of risk associated with foreign exchange exposure.

Their theoretical model included both import demand and export supply sides of the market of traded goods. The demand and supply functions were derived for individual firms. These functions were then aggregated to derive market demand and supply to obtain reduced-form equation for market equilibrium price and quantity. Their model was also designed to capture differences in risk-bearing between importers and exporters.

[3]"The concept of purchasing-parity power is basically a notion that the exchange rate between the currencies of any pair of countries should equilibrate to a ratio of aggregate price indices for the two countries, or that the percentage change in the exchange rate should equal the difference between the percentage rates of inflation in the two countries" (Isard (p. 4))

The import demand for an individual firm was represented by a derived demand schedule, where imports were treated as inputs into the domestic production function. A two-period framework was assumed, in which the firm received orders for its domestic output and placed orders for its imported inputs in the first period, and in the second period it delivered and it was paid for its own output and received, and paid for its imports. The importer was assumed to be a price-taker in the import market.

The importer firm faced a domestic demand for its output, (Q), which was an increasing function of domestic money income (Y) and the price of other goods in the domestic economy (PD), and a decreasing function of the price (P), and nonprice rationing (CU) of its own output:

$$Q = aP + bPD + cY + dCU. \tag{2.4}$$

They assumed fixed input-output coefficients so that import demand was determined by the level of domestic output. The quantity of imports, q, needed to produce Q was equal to iQ, where i was the fixed input-output coefficient. Under this assumption, the firm's profits were

$$\pi = QP(Q) - UC \cdot Q - HP^{*}iQ, \tag{2.5}$$

where UC was the unit cost, P^{*} was the foreign price of imports, and H was a weighted average of the cost of foreign exchange to the importer. H depended on the currency in which the import contract was invoiced and the proportion of the import bill hedged in the forward market:

$$H = \beta(\alpha F + (1 - \alpha)R_1) + (1 - \beta)F. \tag{2.6}$$

β was the proportion of the import bill denominated in the exporter's currency, $(1 - \beta)$ was the proportion denominated in the importer's currency, F was the exchange rate in terms of the importer's currency per unit of the exporter's currency, and the random variable R_1 was the future spot exchange rate prevailing on the date of payment. Of the proportion denominated in foreign currency (β), the importer was assumed to hedge some constant proportion (α) in the forward market. Thus, the importer faced uncertainty when part of the contract was invoiced in the exporter's currency ($\beta \neq 0$) and when not all of the import bill denominated in the exporter's currency was covered forward ($\alpha < 1$).

Hooper and Kohlhagen assumed that the firm set the level of its output so as to maximize the expected utility of profits, which was an increasing function of its expected profits and a decreasing function of the standard deviation of those profits:

$$\max_q U = E\pi - \gamma(V(\pi))^{1/2}, \tag{2.7}$$

where E was an expected value operator, U was total utility, V was the variance operator, and γ was a relative measure of risk preference. Solving this maximization problem, the firm's import demand was determined from the first-order conditions:

$$q = \frac{i}{2}(aUC + bPD + cY + dCU) + \frac{ai^2}{2}P^*(EH + \gamma\delta\sigma_{R_1}), \tag{2.8}$$

where σ_{R_1} was the standard deviation of R_1. Using this equation they observed that an increase in exchange rate uncertainty *ceteris paribus* shifted the demand curve for importables downward.

Hooper and Kohlhagen assumed that the export supply side of the market consisted of one firm with monopoly power to control its market price. The exporter faced a downward sloping demand curve (q^*) aggregated over n identical competitive importers' demand functions.

$$q^* = nq = \frac{ni}{2}(aUC + bPD + cY + dCU) + \frac{nai^2}{2}P^*(EH - \gamma\delta\sigma_{R_1}). \tag{2.9}$$

In contrast with the importing firm, the exporting firm was assumed not to use imported inputs in production. Its profit function was

$$\pi^* = q^*P^*H^* - q^*UC^*, \tag{2.10}$$

where UC^* was the exporter's domestic unit-cost of production, and H^* was defined as

$$H^* = \beta + (1-\beta)F(\frac{\alpha^*}{F} + \frac{1-\alpha^*}{R_1}) = \beta + \alpha^*(1-\beta) + (1-\alpha^*)(1-\beta)\frac{F}{R_1}. \tag{2.11}$$

The exporter was assumed to sell some proportion (β) of its total output, q^*, at P^*, and some proportion $(1-\beta)$ at FP^* denominated in the importer's currency. The exporter was also assumed to hedge a constant proportion, α^*, of its foreign exchange exposure by selling forward exchange at the rate F. The remaining portion was converted to local currency at the future spot rate (R_1).

Again, the exporting firm was assumed to maximize the expected utility of profits which was an increasing function of expected profits (π^*) and a decreasing function of the standard deviation of profits:

$$\max_q U^* = E\pi^* - \gamma^*(V(\pi^*))^{1/2}, \tag{2.12}$$

where γ^* was a measure of the exporter's relative aversion to risk. This parameter was not constrained to be identical to the importer's risk coefficient. Therefore, the model allowed for differences in risk preferences between importers and exporters. The utility maximizing level of output was

$$q^* = \left(1/\frac{\partial P^*}{\partial q^*}\right)\left(\frac{UC^*}{EH^* - \gamma^*\delta^*\sigma_{1/R_1}} - P^*\right), \tag{2.13}$$

where σ_{1/R_1} was the standard deviation of the exchange rate $1/R_1$. In this case, an increase in exchange uncertainty reduced export supply at a given price.

From the market demand and supply functions, reduced-form equations were obtained for market equilibrium price and quantity:[4]

$$P^* = g(Y, CU, UC, UC^*, PD, EH, EH^*, \sigma_{R_1}, \sigma_{1/R_1}), \tag{2.14}$$

$$q^* = f(Y, CU, UC, UC^*, PD, EH, EH^*, \sigma_{R_1}, \sigma_{1/R_1}). \tag{2.15}$$

Equations 2.14 and 2.15 were used by Hooper and Kohlhagen to analyze the effects of an increase in the variance of the exchange rate. They found that (pp. 504–505)

[4]The exporter's risk variable, σ_{1/R_1}, was dropped during estimation due to its collinearity with the importer's risk variable, σ_{R_1}.

" . . .if traders are risk averse, an increase in exchange risk will unambiguously reduce the volume of trade whether the risk is borne by importers or exporters. However, [they] also found that the effect of an increase in exchange risk on the price of traded goods could be in either direction, depending upon who bears the risk. If importers bear the risk, the price will *fall* as import demand falls, whereas if exporters bear the risk, the price will rise as exporters charge an increasingly higher risk premium."

In contrast with Ethier and Clark, Hooper and Kohlhagen assumed that foreign exchange uncertainty was the only source of risk. Their model did not account for price uncertainty. This treatment of risk assumed that traders had a relatively short-term planning horizon, so that all variables except next period's exchange rate were known with certainty. However, if traders had a longer-term planning horizon and, consequently, were interested in the effects of nominal exchange uncertainty outside the contract period, this treatment of risk would have overstated the effects of exchange rate uncertainty on international transactions. In fact, the variance of profits obtained theoretically by Hooper and Kohlhagen was larger than the variance of profits that would have been obtained by a framework allowing for price uncertainty because in this case exchange risk would have been offset at least partially by price changes (Ethier, Clark).[5] The treatment of exchange rate uncertainty used by Hooper and Kohlhagen was expanded and modified by Cushman (1983). He developed a variant of their model in which the firm's utility was assumed to depend on real profits rather than nominal profits. The firm was subject to uncertain foreign and domestic price levels in addition to uncertain nominal exchange rates. However, since the firm's decisions

[5]Akhtar and Hilton argued that the belief that nominal measures of exchange rate risk would overstate exchange rate uncertainty was not well founded because it rested upon the assumption that only movements (unpredictable) in exchange rates which were not offset by changes in foreign prices relative to domestic prices would be relevant for measuring uncertainty: that is, uncertainty would be measured by deviations from PPP, which are believed to be lower than nominal exchange rate variability. Instead, they argued that given highly unpredictable nature of exchange rate changes and the lack of empirical support for purchasing-power parity over the medium run, the relationship between relative price movements and nominal exchange rates could not be determined, *ex ante*, in any reliable basis. Under these circumstances, , they believed that a nominal measure of variability would not probably overstate nominal exchange uncertainty.

were affected by changes in real variables rather than nominal variables, variations in the real exchange rate measured exchange risk.[6] In addition, the firm was assumed to have a planning horizon which was longer than the contract period. As Cushman better explained (1983, p. 47–48):

> " ...the firm is interested in the profitability of not only present, but also future contracts. Due to various lags, such future contracts will be affected by current production or investment decisions. However, hedging of these contracts may not be possible because either their values are not known or forward exchange is not available. Moreover, domestic and foreign price levels, as well as exchange rates, are uncertain for such future periods. Current uncertainty about these variables will therefore affect trade flows in these future periods."

To develop the model under the real profit assumption, Cushman assumed that all prices and wages within a country grew at one common inflation rate. Therefore, there was no risk from uncertain relative price changes domestically. He also assumed that export price grew at the inflation rate in the country of currency denomination. He still maintained Hooper and Kohlhagen's assumption of constant proportion of contracts denominated in each currency. Finally, he assumed that forward cover was either not available or not used because it could not eliminate risk in this situation (Ethier, Clark).

Since future real profits affected the firm's utility function, the firm's future profit function was deflated by the future domestic price level. Therefore, all variables were in real terms with respect to the domestic price level, except the real exchange rate which was

[6]Akhtar and Hilton argued that the validity of the choice of a real measure of exchange risk, when both prices and exchange rates are random, depends on whether there are no domestic substitutes for imported goods in production or consumption. If no domestic substitutes were available, an increase in the uncertainty about any of the three components of the real exchange rate (domestic prices, foreign prices, and nominal exchange rates) will increase uncertainty about costs and revenues, leading to a decline in imports. Also, if foreign and domestic inputs were easily substitutable, increased uncertainty about exchange rates or foreign prices would unambiguously reduce quantity of imports. However, the impact of increased domestic input price variability on import volume would be ambiguous if domestic substitutes were available for the imported input, because the resulting profit uncertainty could be limited by substituting foreign in place of domestic inputs.

given by the price of foreign currency times the ratio of foreign to domestic price levels. The firms' foreign currency denominated values were also in real terms. The importer's real foreign currency cost was:

$$(P_n^* q^*)/(X \cdot PD) = (P^* q^*)/R, \tag{2.16}$$

and the exporter's real foreign currency receipts were:

$$(X \cdot P_n q)/PD^* = R \cdot P \cdot q, \tag{2.17}$$

where

$X =$ future price of importer's currency in terms of exporter's currency,

$P_n, P_n^* =$ future nominal export price in importer's and exporter's currency, respectively,

$PD, PD^* =$ future importer's and exporter's price levels,

$q, q^* =$ export quantity, the prices of which were to be denominated in importer's and exporter's currency, respectively,

$R = (X \cdot PD^*)/PD =$ real exchange rate,

$P^* = P_n^*/PD^* =$ real export price in exporter's currency,

$P = P_n/PD =$ real export price in importer's currency.

Cushman also redefined the real export price, PX, as a weighted average of P and P^* such as

$$PX = \frac{P^*}{\beta(PD^*) + (1-\beta)(PD)(X)}, \tag{2.18}$$

where β and $(1-\beta)$ are currency-denomination weights.

Since all monetary variables were assumed to inflate at the same rate within countries, the firm faced uncertainty only about changes in the real exchange rate, R, for the exporter and $1/R$ for the importer. By ignoring uncertainty about other real variables, the firm would take its future real values as equivalent to its current real values. However, since the future real exchange rate was uncertain, Cushman assumed that R (or $1/R$) could be decomposed as follows: $R = R_0 \cdot \theta$, where R_0 was its current value level, and θ was the uncertain growth rate of R. Theta (θ) was assumed to be equal to the uncertain growth of the exchange rate times the uncertain relative inflation rates. Relative purchasing-power parity prevailed if $\theta = 1.0$. However, if $\theta \leq 1.0$ the exporter became less competitive, therefore real profits would decline for both the importer and the exporter.

Using the Hooper and Kohlhagen's utility model, Cushman derived the expected real exchange rate and its standard deviation. The exporter's expectation variable was given by $E\theta$ whereas the importer's by $1/E\theta$. The exporter's risk variable was $\sigma\theta$ whereas the importer's was $\sigma(1/\theta) \cong \sigma\theta$. If R or $E\theta$ increased, import demand and export supply would increase as both the exporter and the importer would perceive future trade as more profitable. On the other hand, if $\sigma\theta$ increased, import demand and export supply would decrease because increased future riskness would affect negatively the perception of future trade.

The reduced form equations for equilibrium price and quantity were

$$Q = f(Y, CU, UC, UC^*, R, E\theta, \sigma\theta) \tag{2.19}$$

and

$$PX = g(Y, CU, UC, UC^*, R, E\theta, \sigma\theta). \tag{2.20}$$

These equations differed from the Hooper and Kohlhagen's equations (see equations 2.14 and 2.15) in several aspects. The monetary variables Y, CU, UC, UC^*, were all in real terms, PD was an implicit variable because it was used as a deflator, EH and EH^* were substituted by R and $E\theta$, and σ_{R_1} was substituted by $\sigma\theta$. Also, while the quantity of exports, Q, remained the same, PX, was calculated as a weighted average of P and P^*.

Previous Empirical Literature

The theoretical models explained above hypothesized that nominal and real exchange rate risk would adversely affect trade flows. In the last decade several studies have tested this hypothesis. Primarily for the case of developed countries, these investigations have produced mixed results.

Hooper and Kohlhagen empirically tested their model for various U.S. and German trade flow cases for the period 1965–1975. They specified exchange risk as the average over thirteen weekly observations (in each quarter) of the absolute difference between the current spot exchange rate and the forward rate 90 days earlier.[7] Empirical results revealed that exchange risk had a significantly negative impact on the market price in cases where exchange risk was more likely borne by importers, that is, when trade was predominantly invoiced in the exporter's currency. In this case, as exchange risk increased import demand was depressed *ceteris paribus*, and market price was reduced. They also found a significantly positive impact on export price in cases where the exporter was most likely to face the bulk of the risk as his transactions were largely denominated in the importer's currency. However, they found no significant impact of exchange uncertainty on the volume of trade. They observed that this result may be attributable to relatively inelastic export supply and import demand in the short run. Additionally, they argued that this result may reflect substantial hedging by importers and exporters.

Cushman (1983) empirically tested his model for the same U.S. and German aggregated trade flows analyzed by Hooper and Kohlhagen, for the period 1965-1977. Empirically, he assumed that the expected value of theta ($E\theta$) could be approximated by the variable M,

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[7] Hooper and Kohlhagen (p. 500) argued that 'the major advantage of this variable, compared with the standard deviation of either the spot or the forward rate, is that under pegged but adjustable exchange rates it might better indicate the market's assessment of exchange risk during the period leading up to a parity change.' Additionally, they noted that this measure of exchange risk overstated the amount of risk in floating versus fixed rate periods. In fixed exchange periods, when governments have an active role in exchange markets, there are other closely related sources of exchange market uncertainty, such as expectations about exchange or capital controls and trade barriers that are likely to dominate exchange rate variance. These sources of risk were omitted because they are not easily quantifiable.

which was a four-quarter moving mean of theta where $\theta = 100(R_t/R_{t-1})$ and the fourth quarter was the current one. This variable would capture trader's expectations about the future behavior of the real exchange rate. Cushman (1983) assumed that expected real rate changes would eventually close purchasing-power parity (PPP) gaps. In the context of PPP theory, he argued, the relationship between M and $E\theta$ would be described by stabilizing expectations. Thus, if for several quarters θ were greater (less) than one, then the domestic currency would become relatively undervalued (overvalued) and therefore the expectation would be for a decrease (increase) in θ (a return in the direction of relative PPP). Thus, $1/M \cong E\theta$. The standard deviation of theta ($\sigma\theta$) was approximated by the variable S, which was a four-quarter moving standard deviation of theta ending in the current quarter. The results obtained by Cushman (1983) revealed that $E\theta$ affected positively (M affected negatively) trade quantity and price, usually with a lag. According to Cushman (1983) these lagged effects could be reflecting the effect of expectations on current planning with resulting lags on trade flows. Also, he argued, these lagged effects could support the notion that exchange rates affect trade flows in the long-run to a greater extent than in the short-run.

In contrast with Hooper and Kohlhagen, Cushman (1983) found significant evidence that exchange risk affected the volume of traded goods, while the effect on export price was negligible. According to Cushman (1983), his results would reflect the traditional notion of a relatively price elastic long-run curve, while Hooper and Kohlhagen's results would coincide with the theoretically assumed relatively price inelastic short-run curve.

Akhtar and Hilton analyzed the short-run impact of exchange rate volatility on the aggregated trade of manufactured goods of the United States and the Federal Republic of Germany. To avoid specification problems, the sample period (1974–1981) included only observations from the period of floating rates because the proxy for exchange risk under a fixed rate regime would not be appropriate under a flexible rate regime. They postulated a standard set of demand and price equations with each augmented to include the exchange rate risk variable. Exchange rate uncertainty was approximated by the standard deviation of the level of the daily nominal effective exchange rate during each quarter. They argued that this measure would be a lower bound for the true exchange rate risk because *ex post* variability would likely understate *ex ante* risk.[8] Their results showed significant adverse effects on German imports and exports and U.S. exports. Gotur, however, questioned these results, and tested the robustness of Akhtar and Hilton's empirical results by extending their theoretical framework to other countries, modifying the sample period, and correcting estimation techniques. Gotur concluded that these estimates did not provide conclusive evidence that exchange rate volatility has had a statistically significant effect on trade flows.

The International Monetary Fund (IMF) extended Cushman's (1983) analysis through 1982, including additional countries. The IMF estimated bilateral trade volume equations using a measure of real exchange rate uncertainty. Using observations for both the fixed and the flexible rate periods, the IMF found no significant impact of the real, bilateral, exchange rate variability on traded volume of seven industrial countries.

On the other hand, Thursby and Thursby found evidence supporting the proposition that both nominal and real exchange rate risk affected negatively the value of exports of twenty industrial countries, during the period 1973–1977. Also, the results obtained by Kenen and Rodrick indicated that short-term real effective exchange rate had a negative influence on the volume of manufactured imports of eleven industrial countries, during the period 1975–1984.

[8] Akhtar and Hilton considered that traditional measures of variability were likely to understate exchange risk because variability, which could only measured in the *ex post* sense, could frequently underestimate the *ex ante* uncertainty about the unpredictable behavior of exchange rate changes. Besides, Akhtar and Hilton (pp. 21–22) pointed out that "if exchange rate changes [were] unpredictable over the medium- to long-term, *potential* importers and exporters [could] not want to enter into long-term planning and contracts because of the perceived high uncertainty about costs and earnings. This type of exchange rate uncertainty [could] not be adequately represented by any measure of observed variability. Nor [could] such variability capture the adverse effects of exchange rate uncertainty on the efforts to establish and/or to expand foreign markets which [would] require long-term investment".

Conflicting evidence was found by Bailey, Tavlas and Ulan, who found that a measure of variability of the nominal effective exchange rate had not played an important role in explaining aggregate exports from seven major developed countries during 1973–1984. However, Cushman (1988) continued to find significant negative effects on U.S. aggregate imports flows. Using data solely for the floating period and including more observations, Cushman investigated again the impact of real exchange rate on six U.S. bilateral trade flows for 1974–1983. His study revealed also that results for the risk effects on U.S. export flows were less conclusive.

The effects of exchange rate risk on the U.S. agricultural sectoral trade were analyzed by Maskus who compared the effects of the bilateral real effective exchange rate risk on aggregate bilateral trade of U.S. major sectors of the economy (agriculture, manufactured goods, machinery,etc.), during the period 1974–1984. These results indicate that agricultural aggregate bilateral trade between the United States and four major industrial countries was negatively affected by real exchange rate uncertainty. Moreover, U.S. agricultural trade sector was more responsive to exchange rate volatility than other sectors of U.S. economy. According to Maskus agriculture's risk sensitivity could be associated with the higher degree of openness to international trade, as indicated by the proportion of imports and exports on the domestic agricultural output, and with the low level of concentration prevailing in agricultural industry, which would made it more susceptible to profit variability.

Anderson and Garcia also studied exchange rate risk effects on agricultural trade of developed countries from 1974 to 1985. This research focused on the investigation of the effects of short-term bilateral nominal exchange rate volatility on the volume of U.S. soybeans exports to three developed countries. The results showed evidence of the negative influence of nominal exchange rate risk in agricultural trade. Pick, on the other hand, did not find evidence that variability in the bilateral real exchange rate had played a significant role in explaining U.S. agricultural exports to seven developed countries, during the period 1978–1987. However, Pick's results revealed that U.S. agricultural exports to three developing countries were adversely affected by volatility in the bilateral real exchange rate.

Though scarce, studies of the impact of exchange rate uncertainty on international trade of developing countries have generally provided evidence of the harmful effects of exchange rate uncertainty. For instance, Díaz-Alejandro, using data for Colombia from the period 1955–1972, found that real effective exchange rate instability had quite harmful effects on all Colombian minor (non-traditional) exports.

Coes investigated the impact of real bilateral exchange rate uncertainty on the export coefficient of thirteen industrial and nine primary product sectors in Brazil, during the period 1957–1974. Coes argued that the adoption of the crawling peg in 1968 reduced real exchange rate uncertainty and contributed to the greater openness of the Brazilian economy after 1968. Empirical results confirmed this proposition, indicating that the reduction in uncertainty contributed significantly in explaining export expansion. Moreover, Coes found that the uncertainty proxy had a negative effect in seven of the nine primary product sectors, including exports of commodities such as corn, peanuts, and soybeans.

Bautista also studied the effects of real effective exchange rate variability on total and manufactured exports of a large number of developing countries, for the period 1974–1979. Though not conclusive, the results revealed that real exchange rate variability had a significant negative impact on export earnings in a large number of countries.

2.2 Alternative Measures of Exchange Rate Variability

The effects of exchange rate fluctuations on the volume of trade usually have been divided between short-run effects and longer-run effects. How to measure exchange rate variability has proved to be an unresolved issue. Different measures of exchange rate instability have been suggested in applied research to capture each type of risk, and these are discussed in turn.

The empirical literature has proposed two alternative ways of measuring short-run exchange risk. Some papers (Hooper and Kohlhagen, Anderson and Garcia, among others) have proposed the use of nominal exchange rates, while others (Cushman (1983, 1988), Coes, Maskus,etc.) have proposed the use of real exchange rates. This distinction has stemmed from the way short-run risk is understood.

Some proponents of a nominal measure have argued that the short-run effects of exchange risk would depend on the currency-denomination of contracts (Anderson and Garcia, Hooper and Kohlhagen). If trade contracts were typically denominated in one of the major currencies, then the unit-value of an individual transaction would remain fixed during the contract-period in terms of that foreign currency. In this case, individual traders would face the risk of changes in the domestic-currency value of receipts and payments, and therefore profits, if the domestic currency were not pegged to the foreign currency in which the contract was settled. Within the contract period, then, the most appropriate measure of exchange risk would be a measure of the variability in the bilateral exchange rate between the domestic currency and the foreign currency in which contracts are denominated.

Other proponents of a nominal measure of *short-term* exchange risk have argued that traders would not have a very short-term planning horizon, the contract period, but would be concerned with the effects of exchange rate fluctuations on their profit streams over medium- to longer-term periods. Outside the contract period, traders could face short- and medium- term exchange rate fluctuations that could contribute to generating uncertainty about profit streams. Also, exchange rate fluctuations would eventually be reflected in the prices of traded goods and would affect both the demand and supply of these goods (Gotur). For instance, Lipschitz has pointed out that even though world prices of some homogeneous commodities could be fixed daily in terms of U.S. dollars, a change in the bilateral rate (domestic currency per U.S. dollar) of a large exporter would undoubtedly affect the dollar price of that commodity. Thus, the price of traded goods would be determined by a group of currencies, often referred as *basquet*, including currencies of main exporters and importers of traded goods. In this case, the appropriate measure of short-run exchange risk would be an effective exchange rate rather than a bilateral exchange rate. Cushman (1986), also, pointed toward the use of an *effective* measure. He argued that the relative variability between more than two currencies could play a role in affecting the pattern of bilateral trade flows. Consider as an example the case of a potential importer of country A who could buy from countries B and C. If the domestic-currency fluctuations against country C were smaller than those against B, the relative risk of importing from country C , as compared to country B, would be reduced. Therefore, there would be changes in the geographical pattern of trade resulting from variations in relative exchange risk. These changes could be captured by a trade-weighted measure of exchange rate variability. If prices of traded goods and costs were expected to be relatively inflexible over the short-run period, a measure of nominal *effective* exchange rate variability would be considered appropriated to capture this type of risk (Wickham).[9] The variability in the nominal effective exchange rate would reflect uncertain changes in the competitiveness of domestic firms *vis-à-vis* the rest of the world that could be unrelated to price and cost differentials. These changes would be an important source of profit uncertainty for traders and import-competing activities. As mentioned above, Akhtar and Hilton proposed this type of measure when analyzing the short-term effects of exchange risk on the aggregate trade in manufactured goods of the United States and the Federal Republic of Germany. They assumed that traders have a medium-term planning horizon and assumed that nominal effective exchange rate changes were a good approximation, in the short-run, for real changes. They argued that due to the

[9]The effective exchange rate for a country could be defined as a weighted average of the bilateral exchange rates of the country's trading partners (Black). The effective exchange rate for an individual importer would include the bilateral exchange rates of the main exporters, weighted by the exporter's share on imports. Thus, for importing country i the relevant effective exchange rate could be defined as

$$EER = \sum_j w_{ij} R_{ij} \tag{2.21}$$

where R_{ij} is the bilateral rate between countries i and j and w_{ij} is j's share of i's imports ($\sum_j w_i = 1$).

highly unpredictable nature of exchange rate changes and the lack of support of purchasing-power parity over the medium run, most of the variability in the real exchange rate would come from variations in the nominal rate. They also pointed out that a nominal measure of risk is preferable to a real measure because the latter would introduce a bias as it would confuse exchange risk with other sources of risk such as domestic factors that could affect relative prices.

Proponents of a *real* measure of exchange rate risk in the *short run* have argued that it is difficult to isolate the role that exchange rate fluctuations would have in changing price of traded goods, and thus altering sales revenues relative to costs.[10] Therefore, they assumed that a better indicator of profit uncertainty in the short run would be a measure of the variability of exchange rate adjusted to take into account changes in the relevant prices and costs. Cushman (1983), for instance, devoted his attention to real exchange risk. He assumed, as explained in Section 2.1, that both prices and exchange rates were random. Expected real exchange rates changes were assumed stabilizing to close purchasing-power parity (PPP) gaps. The standard deviation of these expectations was used as a proxy for real exchange risk.

According to Lipschitz, the variance of the real effective exchange rate ($REER$) could be decomposed into that part due to changes in the effective exchange rate (EER) and that part due to changes in relative prices (RP) (or differential inflation) and a term representing the covariance between the two.[11]

$$Var(REER) = Var(EER) + Var(RP) + 2Cov(EER, RP). \tag{2.23}$$

[10] A real exchange rate has been usually defined as the domestic currency price of tradable goods divided by the price of nontradables goods. Due to the difficulty of isolating the price of tradable and nontradables goods, empirical research has assumed that the international price level reflects the price of tradable goods, while the domestic price level reflects the price of nontradables (Bautista).

[11] The real effective exchange rate could be expressed as

$$REER_i = \sum_j w_{ij}(R_{ij}P_j/P_i) \tag{2.22}$$

where R_{ij} is the bilateral rate between countries i and j, P_j would be an index of the price level in country j, P_i would be the index of the domestic price level in the home country, and w_{ij} is j's share of i's imports ($\sum_j w_i = 1$).

This formula showed that minimizing the variability in the nominal effective exchange rate did not necessarily reduce the risk faced by the importer of grains.[12] In this case, if the movements in the EER were large enough to offset changes in relative prices, which showed up as a large negative covariance term, the risk faced by importers would be reduced.

Medium- and longer-term exchange rate fluctuations were expected to be more significant than short-term exchange risk. Besides increasing costs through uncertainty, longer-term exchange rate swings could result in costly shifts of resources between economic activities in response to changing price incentives or to greater riskness perceived for the traded goods sector. Large and persistent variability in real exchange rates, besides involving serious adjustment costs, could be expected to bias decisions relating to the structure of and the level of output and to inhibit trade (IMF). In fact, empirical evidence presented by Perée and Steinherr suggested that medium-term exchange rate uncertainty affects adversely trade flows of most industrial countries and, therefore, may have non negligible effects on the allocation of resources. They constructed two measures of medium-term exchange rate uncertainty. One was a weighted function of the magnitude of past movements in nominal exchange rates and the current deviation of the exchange rate from *equilibrium*. The other depended on both the duration and the amplitude of misalignment from equilibrium exchange rate.[13] The major drawback of these measures was the calculation of the equilibrium exchange rate. In fact, the computation of the uncertainty proxies relied on the equilibrium rate of 1984 calculated by Williamson (1985) for some industrial countries. Since equilibrium is a rather elusive concept and the calculation of the equilibrium path over time is a complex task, these type of uncertainty measures could not be easily applied in empirical works for developing countries.

[12]To assume that a minimum variance of the $REER$ would reduce risk in trade did not imply that changes in the $REER$ were not desirable. In fact, the $REER$ level could be changed to promote payments adjustment.

[13]The nominal equilibrium exchange rate was consistent with the long-run equilibrium real exchange rate.

2.3 Sources of Real Exchange Rate Variability

Although it is important to test the potential adverse effects of exchange rate variability on the volume of agricultural trade by developing countries, from a policy point of view, what is really important is to understand the causes of exchange variability so as to design policies aimed at stabilizing the real exchange rate.

According to Edwards (1988), in developing countries real exchange behavior occupies a central role in policy evaluation and design. Therefore, economic authorities would be interested in detecting the sources of real exchange variability rather than the sources of nominal exchange variability. An empirical assessment of the main sources of real exchange rate risk would be useful to the extent that some sources are identified with domestic economic policies implemented by each individual country. As the sources of real variability are identified, economic authorities could design policies aimed at reducing exchange risk. If, however, real exchange rate movements were attributed to exogenous or structural factors, domestic authorities would have fewer opportunities to prevent these changes.

Theoretically, the long-run equilibrium real exchange rate is determined solely by real factors, the so-called *fundamentals* (Williamson (1985), Edwards (1988), Korteweg). In the short run, however, the real exchange rate is influenced by the behavior of both monetary and real factors (see for example Mussa, specifically section 1.6, pp. 37 – 43).

According to Williamson (1985), the long-run fundamental equilibrium real exchange rate could change as there are structural changes in economic performance of a country *vis-à-vis* the rest of the world. He broadly classified these real factors as either changes in underlying capital flows, or changes in the pattern of demand for, or conditions of supply of traded goods. An example of changes in capital flows could be the loss of credit-worthiness of a country in the international financial market. He also argued that changes in demand and supply which could have a perceptible influence on the long-run equilibrium real exchange rate could be classified in three categories. First, changes in differential productivity such as an increase in the productivity of a country relative to other countries would provoke a real appreciation. Second, the discovery and exploitation of new natural resources in a given country would permit real appreciation of its currency. Third, *permanent* exogenous changes in the terms of trade would lead to a change in the real exchange rate.[14]

Edwards (1988) constructed a model of real exchange determination in developing countries. A three goods economy (exportables, importables, and non-traded goods) was considered. A dual exchange rate regime was assumed. Also, residents of the country were assumed to hold domestic and foreign assets. According to this model, the most important *fundamentals* in determining the long-run equilibrium real exchange rate were the external terms of trade, the level and composition of government consumption, import tariffs, and capital flows. A worsening in the exogenous terms of trade generated by an increase in the international price of imports could result in either equilibrium real depreciation or real appreciation. The adverse terms of trade change would affect the equilibrium in the external sector, and if the price elasticity of import demand were sufficiently elastic, there would be a substitution in consumption away from traded goods and toward non-traded goods. If the income effect were dominated by the substitution effect, the increase in international reserves would lead to a real appreciation. If, on the other hand, the import price elasticity were not sufficiently elastic and the income effect were larger than the substitution effect a real depreciation would be expected.

Edwards (1988) pointed out that the most plausible outcome of an import tariff would be a real appreciation because tariffs have been usually used to alter the long-run resource allocation. A higher tariff would probably induce substitution in demand away from importables and into nontradables and the higher demand for nontradables would lead to a real appreciation. An increase in the ratio of government consumption of nontradables would result in a real exchange appreciation, whereas an exogenous increase in capital outflows would result in a real depreciation.

[14]The terms of trade is defined as the price of exports divided by the price of imports.

In the model developed by Edwards (1988), the short-run real exchange rate was influenced by both monetary and real factors. The model predicted that a monetary disturbance such as an unanticipated increase in the stock of domestic credit would lead to an overvaluation of the actual real exchange rate. That is, the actual real exchange rate would have appreciated relative to its long-run equilibrium value. The reason for this overvalued (lower) short-run exchange rate is that the increase in domestic credit above the growth of money demand would be translated into an excess demand for tradable goods, nontradable goods, and financial assets. This incipient excess demand would be reflected in a trade deficit, loss of international reserves, and higher prices for nontradables that would force a short-run real appreciation. The overvaluation was transitory because as the stock of international reserves was declining the supply of money was tending toward its initial level. As a result of declining prices of nontradables, the real exchange rate would depreciate continuously toward equilibrium.

Diverse theoretical models of real exchange rate determination have consistently showed that the main causes of short-run real exchange variability were monetary and real disturbances, while long-run variability in the real exchange rate could be attributed solely to real causes. These theoretical implications have been analyzed empirically. For instance, a descriptive study written by Korteweg shed light on the possible causes of real exchange variability for a group of OECD countries. Korteweg observed that both real and monetary shocks seemed to have contributed to increasing real exchange instability. Korteweg pointed out that differential growth rates of money per unit of output were an important factor explaining transitory fluctuations in the real exchange rate. However, real factors such as the discovery and exploitation of North Sea oil and the differential productivity growth among countries appeared to be key factors explaining variability in the real exchange rates. Korteweg argued that appropriated monetary policies may be implemented to correct monetary sources of instability. Nevertheless, movements in real exchange rates that result from diverging structural economic developments among countries would be rather difficult to prevent by economic policy.

De Grauwe and Rosiers investigated the impact of monetary disturbances on short-run real exchange rate variability. They extended the model developed by Aizenman to explain short-run deviations around PPP (purchasing-power parity). The model was a variant of the sticky-price model and assumed that exchange rates would adjust immediately to new information, while prices had a degree of flexibility which was a function of the magnitude of real exchange variability, which itself was a function of monetary disturbances. If real exchange variability was smaller than the transaction costs associated with the flow of traded goods that would equalize good prices across borders, prices would remain sticky. Otherwise, prices would become flexible and deviations from PPP would be reduced. The model therefore predicted that exchange rate variability would increase as the size of monetary disturbances increased. Still, if monetary instability became large enough relative to transaction costs, exchange rate variability would stop increasing. Also, the model predicted that the size of real exchange variability would decline with the degree of openness of a country, because more open economies would have lower costs of shipping goods across borders than protected economies.[15] Using cross-section data for 39 developed and developing countries for 1970 – 1982, they found evidence that monetary instability increased real exchange rate variability. The degree of openness, however, did not seem to affect real exchange variability in the short run.

Melvin and Bernstein, on the other hand, concentrated their research efforts on the investigation of the role of real factors on real exchange variability. They observed that the effect of real shocks on deviations from PPP was associated with the concentration of trade and the degree of openness. They argued that while real economic shocks will increase real exchange rate variability, the impact of such shocks will be less for more open economies

[15]The degree of openness represents the importance of international trade in the domestic economy and is thus an structural factor.

and for countries with a diversified trade. Using cross-section data for 87 countries, they found that the variability of a bilateral rate was positively influenced by an index of export concentration and negatively influenced by a measure of a country's degree of openness.

Researching other possible factors that lead to deviations from PPP, Stockman developed a theoretical model that explored the role of real and nominal disturbances on real exchange variability. According to his model, the nominal exchange rate system should be neutral with respect to variability of the real exchange rate. However, this proposition was not supported by the empirical evidence he found using data from a sample of 38 developed and developing countries. In fact, results showed that flexible exchange rate systems are associated with greater variability of real exchange rates. Yuravlivker also found that the nominal exchange rate policy of crawling-peg had affected positively real exchange rate variability in four South American countries.

Edwards (1987) found that both real and monetary disturbances affected real exchange variability. Rather than developing a specific model, he used the implications that have emanated from a number of models. Edwards (1987) pointed out that this approach allowed a more general set of possible determinants of real exchange variability to be included. The real or structural factors suggested by these models were 1) an openness index as suggested by Grauwe and Rosiers, and Melvin and Bernstein, 2) a variability index of the terms of trade as suggested by Mussa and Williamson (1985), who pointed out that the external terms of trade would affect real exchange movements, and 3) real productivity shocks measured by the variability of real GDP (gross domestic product) as suggested by Korteweg.[16] The monetary variables suggested by these models [17] were *a*) an index of money growth instability or alternatively an index of domestic credit growth instability (Mussa, Edwards (1988), Aizenman), *b*) an index of volatility of domestic inflation as suggested by

[16]Edwards (1987) pointed out that it was not clear whether growth variability was a genuine exogenous variable; nevertheless he included this variable in his empirical model and it was found not to be relevant in explaining real exchange variability.

[17]To avoid multicollinearity problems, the empirical model introduced just one of the alternative measures of monetary instability at the time and then omitted the ones which were not statistically significant.

Korteweg, c) the average level of domestic inflation as suggested by Aizenman among others, who argued that higher inflation levels would be translated into higher variability of the real exchange rate, and d) index of volatility of nominal exchange rate policy (Stockman, Yuravlivker). Using cross-section data for 30 developing countries over the period 1971 – 1984, Edwards (1987) analyzed the potential role of both monetary and real factors in explaining a short-run and a longer-run measure of real exchange rate variability. The short-run measure was computed using quarterly data, while the long-run measure was estimated using annual data. Edwards (1987) found that real or structural factors had played an important role in explaining long-run real exchange variability, the most important being the terms of trade. On the other hand, measures of monetary instability were not found to be significant in explaining long-run real variability, except for the instability of nominal exchange rate policy that played a marginal role. On the contrary, while monetary factors played a more important role in explaining short-run real exchange variability, real factors did not appear to be relevant.

Chapter 3

Methodology

The models developed here are variants of Hooper and Kohlhagen's model. They are based on the theory of the competitive firm under uncertainty and risk aversion. Firms are assumed to maximize the expected utility of profit and a von Neumann-Morgenstern utility function expresses the firm's attitude toward risk. For an importing firm facing uncertain future import costs caused by variability in exchange rates, the optimal level of imports deviates from the competitive solution. The firm imports less relative to the amount imported under certainty, and charges a higher domestic price.

A model developed to explore the effect of exchange rate risk on the demand for grains should take into account the economic situation of most developing countries, which is characterized by severe financial constraints. For a developing country under financial constraint, import capacity is limited by the availability of foreign exchange. Hence, individual importers of a given commodity such as grains are also bound by this constraint. Under this assumption, two models are constructed. The first model considers that importers have a short-term planning horizon. They are solely concerned with fluctuations in nominal exchange rates because both domestic and international prices are assumed to be relatively inflexible. The second model is a variant of the first model. In this case, the model is adapted to describe the economic behavior of an importer, who is preoccupied with the effects of uncertainty over the whole stream of future profits. The assumption of a longer-term planning horizon implies that the relevant source of risk is the variability in the real exchange rate as both domestic and international prices are also a source of risk. Additionally, a model that determines the potential sources of real exchange rate variability is specified.

3.1 Modeling Nominal Exchange Risk

The demand for grain imports is a derived demand, where imported grain is treated as an input in the domestic production function.[1] If the importing firm is assumed to sell all of its output domestically, the level of output, and therefore imports, is determined by the domestic demand for output, or processed grains.

For simplicity, the firm is assumed to face a linear domestic demand for processed grains (Q), which is an increasing function of domestic money income (Y), the price of import-competing goods (P^s), and a decreasing function of the price of processed grain (P).[2]

$$Q = a + bP + cP^s + dY. \tag{3.1}$$

Production technology is assumed fixed, so that import demand is determined by the level of domestic output or, equivalently, by the level of domestic demand for processed grains since it is assumed that equilibrium prevails in the domestic market.[3] Thus, if k is the fixed input-output coefficient and q is imports, then

$$Q = kq. \tag{3.2}$$

Each country faces a downward-sloping domestic demand for its output. However, the importing country is assumed to be a price-taker in the world grain market.

[1] According to Hooper and Kohlhagen (p. 486), 'this specification of import demand differs from the usual treatment of imports as a final demand which ignores the intermediate demand aspects of import determination. In [this] treatment, imported goods may range from material inputs to finished goods, where domestic value added may amount to as little as wholesale or retail distribution service.'

[2] The assumption of a linear functional form is adopted to simplify the derivation of the demand for imports.

[3] To assume fixed production technology implies that there is no substitutability among inputs and that the firm cannot obtain more output for a given quantity of input. In the case of grains, it makes sense to assume a constant productivity assumption, because production processes, in these traditional industries, are not very innovative. The no-substitutability implication of the assumption is accepted as a simplifying abstraction from reality.

If the focus is centered on the evaluation of the impact of exchange rate risk within the contract period, a two-period framework is assumed: in the first period the firm orders its imported input at a known price, and in the second period it receives and pays for the imported input in the exporter's currency. Thus, short-run uncertainty arises from movements in the nominal exchange rate during the contract period. To capture this type of risk, Anderson and Garcia suggest the use of nominal exchange rates because the decision to import is made under known prices and costs. Additionally, it is assumed that a forward exchange market is either not available or not used by importers in the developing country.

During the contract period, the degree to which the exchange rate affects trade depends mainly on how traded goods are invoiced. If imports are price-invoiced and contracted in the exporter's currency, a depreciation of the domestic currency *vis-à-vis* the foreign currency increases importer's cost of traded goods. Increased costs may induce a reduction in the imported quantity.[4] In fact, any sort of exchange rate fluctuations within the contract period increases costs and affects adversely the volume of trade (Hooper and Kohlhagen). In the case of grains, the price is invoiced in U.S. dollars and contracts are generally settled in U.S. dollars (Maggee and Rao). Therefore, the relevant measure of exchange rate variability within the contract period is concerned with fluctuations in the bilateral exchange rate between the domestic currency and the U.S. dollar. As a consequence, the impact of this type of risk on the level of agricultural imports depends heavily on domestic exchange rate policy. If the domestic currency is pegged to the U.S. dollar, contract-period exchange risk will be eliminated. However, if the nominal exchange rate is set based on a group of foreign currencies, the spot rate reflects the fluctuations among the currencies involved in the group; therefore, the bilateral rate between the domestic currency and the U.S. dollar will probably have some degree of variability.

If the importer is assumed to take into account the effects of exchange rate fluctuations outside the contract period that are not related to price and cost differentials across coun-

[4] Short-run prices do not fully adjust to offset currency appreciation or depreciation.

tries, the relevant measure of short-run nominal exchange rate risk is a nominal effective exchange rate variability measure. For an importer of grains, this effective measure will include the bilateral exchange rates of the main exporters of grains, weighted according to the share of imports coming from each exporter.

In summary, under the assumption that both international and domestic prices are relatively constant, the only source of uncertainty comes from fluctuations in the nominal exchange rate. In this case, the firm will be concerned with changes in its nominal profit. The firm's profit function in domestic currency units is defined as

$$\tilde{\Pi} = P(Q)Q - Cq - \tilde{R}P^{*}q, \tag{3.3}$$

where the variable with a tilde ($\tilde{}$) is a random variable and where $\tilde{\Pi}$ represents profits, Q is domestic output, $P(Q)$ is the domestic price of output, C is the unit cost of processing the imported grains, q is the quantity of grain imports, P^{*} is the U.S. dollar price of imports, and $\tilde{R}$ is the nominal exchange rate prevailing when payment is due. The exchange rate, $\tilde{R}$, is stochastic and assumed to be normally distributed with a mean of R and variance σ^2.

A developing country under a financial constraint cannot import as it wishes, rather a foreign exchange allotment binds the level of imports to be contracted each period. The government is assumed to assign a fixed share to each importer. Therefore, the amount of foreign exchange available to the importer each period varies directly with changes in the level of total foreign exchange (Kim). The budget constraint to the importer[5], in domestic currency, is

$$\tilde{R}P^{*}q \leq F, \tag{3.4}$$

where F is the foreign exchange allotment in domestic currency available at the end of the second period when the payment is due. The variable F is assumed to be known with certainty even though it is itself affected by fluctuations in the major currencies. This is a

[5]Kim developed a model of import demand for a developing country constrained by a foreign exchange allotment. Kim's framework of analysis is adopted and modified to capture the effects of uncertainty.

strong assumption, nevertheless, it seems justifiable if the country under study is assumed to follow an exchange rate policy designed to minimize the effects of foreign currency fluctuations on the current account of its balance of payments.[6] In this case, the effects of exchange uncertainty on the foreign exchange allotment variable will be neutralized.

If the variable F is considered uncertain, the relevant exchange rate would be an effective exchange rate which would differ from the exchange rate variable that affects the level of grain imports, either in the short or in the long run. The reason is that the importer holds a microeconomic view of the situation. He is only concerned with either the fluctuation in the U.S. dollar *vis-à-vis* the domestic currency, or with fluctuations in the exchange rates of the main exporters of the commodity that he imports. On the other hand, the level of foreign exchange reserves is affected by fluctuations in the exchange rates of all countries that import from and export goods and services to the developing country.[7] Hence, if F is assumed to be uncertain, the model should include two different measures of exchange rate variability, which are obviously highly correlated. In this case, it would be extremely difficult to disentangle the effect of exchange rate risk on importer behavior. Therefore, the approach to be followed in this research holds a microeconomic view of the situation , and assumes that a macroeconomic stabilization policy prevails in exchange rate management.

[6]Williamson (1982) argues that domestic exchange rate policy should aim at continuous internal balance and achieve external balance (that is, current account balance) on average over a medium term. The reason is that departures from external balance (that involve variations in reserves and/or foreign borrowing) cause negligible welfare costs, whereas departures from internal balance always involve welfare costs. (The appropriate definition of internal balance depends on the model of the economy. For instance, in the dependent economy, flexible price, full-employment model, internal balance is represented by a constant level of output of nontraded goods.) Despite these arguments, it has been observed that highly indebted countries have adopted as a key objective, even in the short run, the achievement of external balance (Grigsby and Pagoulatos). Therefore, it seems reasonable to suppose that these governments are very interested in minimizing the effects of foreign exchange fluctuations in their current account and consequently in their foreign exchange allotments.

[7]Foreign exchange reserves are affected by the same exchange risk that affects the current account, that is, all international transactions of goods and services. The reason is that the level of foreign reserves depends on the inflow of reserves brought about by exports and private transfers and by the outflow of reserves demanded by all imports. Also, the level of reserves depends on the level of foreign borrowing assumed each period, which is included in the capital account. However, the exchange rate risk that affects interest payments, in the current account, is a good indicator of the effects of exchange uncertainty on foreign borrowing. Therefore, a measure of the exchange rate variability that affects the current account can be seen as a good approximation of the risk burden faced by the foreign reserves allotment.

Based on the above assumption, the firm sets the level of its output so as to maximize its expected utility of profit subject to a budget constraint.[8]

The utility function, in the relevant range, is approximated by a negative exponential function

$$U(\tilde{\Pi}) = w - ve^{-\phi\tilde{\Pi}} \tag{3.5}$$

where U is total utility, with constants w, v, and ϕ, where v and ϕ exceed zero. As pointed out by Freund, this function is concave everywhere and indicates a conservative merchant. The constant ϕ represents the firm's aversion to risk and the larger the value of ϕ, the more conservative the firm.[9] If profits are assumed to be normally distributed, the maximization of the negative exponential utility function yields a decision rule that depends only on the first two moments of profit (Barry).[10] This decision rule is equivalent to a mean-standard deviation decision rule since both yield an identical efficient set (Hazell and Norton). The mean-standard deviation is widely used when analyzing exchange rate variability in trade (Hooper and Kohlhagen, Cushman, Anderson and Garcia). For an importing firm this decision rule is

$$\max_q E[U(\tilde{\Pi})] = \max_q E(\tilde{\Pi}) - \phi[Var(\tilde{\Pi})]^{1/2}, \tag{3.6}$$

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[8]The developing country' imports of grains may be contracted by public companies. In this case, as Anderson (p. 5) points out: 'Uncertainty for publicly owned companies can be incorporated into the firm's objective if it is assumed that individual shareholders exhibit uniform preferences about risk, are unable to manage risk, and rely instead on the firm to do so.'

[9]Tsiang noted that the negative exponential function is characterized by an absolute risk aversion coefficient that is invariant with an increase or decrease in wealth. This assumption is criticized because it does not reflect real world behavior, as empirical evidence is more consistent with a decreasing absolute risk aversion coefficient. Also, Tsiang observes that this type of function is not able to rationalize the demand for idle cash as an investment portfolio. Hooper and Kohlhagen (p. 487) argue that 'this drawback is not relevant in our case since the firm is not faced with the problem of allocating its wealth over a set of risky and riskless assets. More complicated functional forms of utility functions are not without their own undesirable characteristics and do not yield easily interpretable or econometrically estimable reduced form equations for our problem'. For instance, Tsiang observed that another widely used function, the constant elasticity utility function, has an absolute risk aversion that decreases with wealth; nevertheless, it has a serious defect as it is undefined or not real, or yields negative marginal utility for zero or negative wealth. Also, another possible choice,the quadratic utility function, is widely objected to because it has the property of increasing risk aversion.

[10]The assumption of normally distributed profits is widely used in mathematical programming, where it is assumed that the firm maximizes the expected utility of profits subject to restrictions on the amount of resources available. The truncated distribution of profits is overcome by letting the constraint vary so as to obtain a frontier of profit maximizing points. In the case under study, a similar approach is followed because the derived demand for grains is obtained by letting the budget constraint be variable.

subject of course to the budget constraint, and where E is the expected value operator, Var denotes variance and, ϕ is a measure of the firm's degree of absolute risk aversion.

In the problem under study, the left hand side of the budget constraint is also affected by exchange rate variability; therefore, under the chosen decision rule this constraint can be written as (see Paris):

$$E(\tilde{R})P^*q - \phi[Var(\tilde{R})]^{1/2} \leq F. \tag{3.7}$$

Equivalently, the maximization problem of the grain importing firm can be written using a Lagrangian function such as

$$\max_q E[U(\tilde{L})] = E[U[P(Q)Q - Cq - \tilde{R}P^*q + \lambda(F - \tilde{R}P^*q)]], \tag{3.8}$$

where λ is the lagrangian multiplier (Freund, Hazell and Scandizzo, Paris).

Using the chosen decision rule, it is possible to obtain the first and the second moments for the Lagrangian function, which, using the inverse of Equation 3.1, are:

$$E(\tilde{L}) = [(Q - a - cP^s - dY)/b]Q - Cq - RP^*q + \lambda(F - RP^*q) \tag{3.9}$$

and,

$$[Var(\tilde{L})]^{1/2} = (1 + \lambda)P^*q\sigma, \tag{3.10}$$

where σ is the standard deviation of the exchange rate. Thus, the firm's maximization problem can be stated as

$$\max_q L = [(Q - a - cP^s - dY)/b]Q - Cq - RP^*q + \lambda(F - RP^*q) - \phi[(1 + \lambda)P^*q\sigma]. \tag{3.11}$$

Since a fixed relationship is assumed between the imported input and the domestic output, maximizing with respect to output is equivalent to maximizing with respect to the raw input, grains. Then, substituting for q in equations 3.9 and 3.10, and, using the fixed production relationship given by Equation 3.2, Equation 3.11 is maximized with respect to

q (see appendix A for details). The Khun-Tucker conditions[11] are $q \geq 0$, and $\lambda \geq 0$, and

$$\frac{\partial L}{\partial q} = (2k^2 q - ak - ckP^s - dkY)/b - C - RP^* - \lambda RP^* - \phi(1+\lambda)P^*\sigma \leq 0 \qquad (3.12)$$

$$q\frac{\partial L}{\partial q} = 0 \qquad (3.13)$$

$$\frac{\partial L}{\partial \lambda} = F - RP^*q - \phi P^* q\sigma \geq 0 \qquad (3.14)$$

$$\lambda\frac{\partial L}{\partial \lambda} = 0 \qquad (3.15)$$

If $\lambda = 0$ and $q \geq 0$, the traditional maximization problem is faced by the firm because the financial constraint is not affecting importer's decisions. In this case, Equation 3.12 is used to solve for q as follows:

$$q = \frac{a - cP^s - dY}{2k} + \frac{(C + RP^* + \phi P^*\sigma)b}{2k^2}, \qquad (3.16)$$

where $a, c, d, k, \phi \geq 0$ and $b \leq 0$.

The effect of a change in the import price and exchange rate uncertainty on the quantity of imported grains is assessed by the following equations:

$$\frac{\partial q}{\partial RP^*} = \frac{b}{2k^2} \leq 0, \qquad (3.17)$$

$$\frac{\partial q}{\partial P^*\sigma} = \frac{b\phi}{2k^2} \leq 0. \qquad (3.18)$$

All other things being equal, an increase in the standard deviation of the exchange rate decreases the volume of imported grains for a risk averse importer ($\phi \geq 0$) as does an increase in the domestic price of grains.

If the international price of grains is assumed to be constant, the exchange rate elasticity and the exchange rate risk elasticity are:

$$\eta_{q,RP^*} = \frac{bRP^*}{2k^2 q} \leq 0, \qquad (3.19)$$

[11]The Khun-Tucker conditions are necessary and sufficient conditions for a maximum if the objective function is differentiable and concave in the nonnegative orthant, if each constraint function is differentiable and convex in the nonnegative orthant, and if the constraint qualification is satisfied. In the case under analysis, the utility function satisfies the first requirement, and the linear inequality constraint satisfies the second and third requirements (Chiang).

$$\eta_{q,P^*\sigma} = \frac{b\phi P^*\sigma}{2k^2q} \leq 0. \tag{3.20}$$

As long as $\phi\sigma \leq R$, a depreciation of the domestic currency, which raises the domestic currency cost of imported grains, has a stronger effect on the quantity imported than does an increase in the variation of the import price caused by an increase in exchange rate uncertainty.

If $\lambda \geq 0$ and $q \geq 0$, the Khun-Tucker conditions are used to solve for q (see Appendix A for a detailed solution), which becomes:

$$q = RP^*F + \phi P^*\sigma F. \tag{3.21}$$

The effect of a change in the budget constraint on the level of imported grains is

$$\frac{\partial q}{\partial F} = RP^* + \phi P^*\sigma \geq 0. \tag{3.22}$$

Thus, all other things being constant, an increase in the budget constraint will increase the demand for imports.

When the constraint binds the importer's decision, q is a function of the foreign exchange allotment, expected import price in domestic currency, and exchange rate risk. In this case, other variables do not affect the value of q. However, when the constraint does not bind the optimal choice of q, other variables have an important role in determining the level of imports. Before the decade of 1980 developing countries were not affected by chronic foreign exchange shortages, whereas in the 1980s these countries faced severe foreign exchange constraints. Therefore, a study of the determinants of the demand for imports based on time-series should assume that theoretically all variables are relevant to the choice of an optimal level of imports.[12] Consequently, a conditional reduced form of the demand for imports, q, is assumed in general terms as

$$q = q(P^s, Y, C, F, RP^*, \sigma). \tag{3.23}$$

[12] Kim introduced a foreign exchange constraint in the import decisions of a given country. When the constraint were binding the level of imports income and prices would not be determining variables. However, the author assumes that all variables contribute to the determination of the optimal level of imports.

Equation 3.23 assumes a linear approximation of the intrinsically nonlinear theoretical model.[13]

3.2 Modeling Real Exchange Risk

The model is now revised to accommodate an importer with a longer-term planning horizon, following Cushman's approach. Thus, the main assumption underlying the model is the idea that the importer has a planning horizon longer than the contract period. The firm is interested in the effect of uncertainty over the whole stream of future profits. There is a link between present production, marketing, or investment decisions and future profitability. The hypothesis of an extended planning horizon leads to the assumption that nominal exchange rates are not the only source of risk, but international as well as domestic price levels are random. The importer is thus interested in the behavior of both nominal exchange rates and price levels of the main exporters of the commodity he imports, as well as the behavior of domestic price levels.

According to the model, the firm's utility is assumed to depend on real rather than nominal *future* profits. All prices and wages within a country are assumed to grow at one common inflation rate. Therefore, there is no risk from uncertain relative price changes within a country. Besides, importing firms are assumed to believe that import price, in foreign currency, grows at a weighted average of the inflation rates prevailing in the major exporting countries. Forward cover is assumed either not available or not used.

[13]From equations 3.16 and 3.21, it can be deduced that Equation 3.23 is intrinsically nonlinear. Kmenta (p. 504) defines intrinsically nonlinear models as models that are not linear with respect to the variables as well as with respect to the parameters to be estimated. Previous empirical research on the effects of exchange risk on trade have assumed linear approximations of the nonlinear theoretical models (eg.,Hooper and Kohlhagen, Cushman (1983), Kenen and Rodrick). To linearize the model, nonlinear restrictions have been imposed on the parameters to be estimated. The parameters of the intrinsically nonlinear model, called restricted, were assumed to be nonlinear functions of other coefficients, called unrestricted. The regression equation that ignored restrictions was then a linear function. Additionally, most empirical work has not considered interaction terms in the regression equation, that is,the combined effect of two or more variables. This assumption was used as a mean of avoiding serious statistical problems. For an exception see Anderson and Garcia who considered interaction terms in a more simple model than the one developed in this section. Here, the assumptions assumed by the mainstream empirical research are adopted here and a linear approximation is specified with respect to the variables and parameters of the theoretical model, except for the import price variable.

The firm's future real profit function is obtained by deflating the firm's nominal future profit function with the future domestic price level, P_d. Therefore, all variables are in real terms with respect to the domestic price level, except the the importer's cost of imported inputs, in domestic currency, which also includes foreign price levels.

Redefining equations 3.3 and 3.4 in future values, and using the inverse of Equation 3.1, the real profit function and the real budget constraint, expressed in current values, are:

$$\tilde{\Pi}_r = ([Q - a - dY_r]/b)Q - C_r q - \tilde{Z}P_r^* q, \tag{3.24}$$

$$\tilde{Z}P_r^* q \leq F_r. \tag{3.25}$$

In this function, all variables are in real terms so that domestic variables are defined as: $Y_r = Y/P_d$, $C_r = C/P_d$, $F_r = F/P_d$. The variable P^s/P_d is dropped as an explicit variable because of the assumption that domestic prices grow at the same pace as the domestic price level. The real cost of imported grains is constructed as follows:

$$\tilde{Z}P_r^* q = \frac{P^* q(R)}{P_d} = \frac{P^* q(R)/P_d^*}{P_d/P_d^*} = P_r^* q(R)(\frac{P_d^*}{P_d}), \tag{3.26}$$

where where P_d^* is the exporter's future price level expressed as a weighted index of major's exporter's price levels, $P_r^* = P^*/P_d^*$ is thus the future real price of imports in exporter's currency, and $\tilde{Z} = R(P_d^*/P_d)$ is the future real effective exchange rate.[14]

Since all monetary variables are assumed to inflate at the same rate within countries, the firm ignores uncertainty from all domestic real variables and from the real price of imports, P_r^*. Under these circumstances, the firm takes its future real values as equivalent to its current real values. The only source of uncertainty, in this model, comes from changes in the future real exchange rate which, according to Cushman (1983), can be decomposed as follows: $\tilde{Z} = Z_0\tilde{\theta}$, where Z_0 is the current *known* level of $\tilde{Z}$ and $\tilde{\theta}$ is the *uncertain* growth rate of $\tilde{Z}$. Theta ($\tilde{\theta}$) represents the uncertain growth rate of the exchange rate

[14]Cushman (1983) used a bilateral measure of real exchange rate. Nevertheless, a real effective exchange rate is considered more appropriate in the present analysis, because this type of rate can capture the effects of fluctuations in the currencies of the major grain exporters on the price of grains (Lipschitz).

times the uncertain relative inflation rates and is thus the only uncertain variable of the model. Theta ($\tilde{\theta}$) shows unexpected fluctuations around the purchasing-power parity level of exchange rates, which induce variability on profit streams. If θ is equal to one the relative purchasing-power parity level is maintained. If θ is less than one the domestic currency is overvalued, the importer's real profits are increased and the volume of imports is increased. In contrast, when θ is greater than one the domestic currency is undervalued and the volume of imports is reduced. The variable $\tilde{\theta}$ is stochastic and is assumed to be normally distributed with $E(\tilde{\theta}) = \theta$ and variance σ_θ^2.

The utility function is approximated by Equation 3.5, and the firm sets the level of its output so as to maximize its expected utility of real profits subject to a real budget constraint. The Lagrangian function to be maximized is

$$\max_q E[U(\tilde{L})] = E[U[([Q - a - dY_r]/b)Q - C_r q - Z_0\tilde{\theta}P_r^* q + \lambda(F_r - Z_0\tilde{\theta}P_r^* q)]]. \quad (3.27)$$

The first and second moments of this Lagrangian function are:

$$E[\tilde{L}] = [(Q - a - dY_r)/b]Q - C_r q - Z_0\theta P_r^* q + \lambda(F_r - Z_0\theta P_r^* q) \quad (3.28)$$

and

$$[Var(\tilde{\Pi})]^{1/2} = (1 + \lambda)P_r^* q\sigma_\theta, \quad (3.29)$$

where σ_θ is the standard deviation of θ. Thus, the maximization problem can be stated as

$$\max_q L = [(Q - a - dY_r)/b] - C_r q - Z_0\theta P_r^* q + \lambda(F_r - Z_0\theta P_r^* q) - \phi(1 + \lambda)P_r^* q\sigma_\theta. \quad (3.30)$$

Substituting q into Equation 3.30 and using the fixed production technology assumption given by Equation 3.2, the Lagrangian equation is maximized with respect to q. The Kuhn-Tucker conditions are $q \geq 0$, and $\lambda \geq 0$, and

$$\frac{\partial L}{\partial q} = (2k^2 q - ak - dkY_r)/b - C_r - Z_0\theta P_r^* - \lambda Z_0\theta P_r^* - \phi(1 + \lambda)P_r^*\sigma_\theta \leq 0 \quad (3.31)$$

$$q\frac{\partial L}{\partial q} = 0 \quad (3.32)$$

$$\frac{\partial L}{\partial \lambda} = F_r - Z_0\theta P_r^* q - \phi P_r^* q\sigma_\theta \geq 0 \quad (3.33)$$

$$\lambda\frac{\partial L}{\partial \lambda} = 0 \quad (3.34)$$

If $\lambda = 0$ and $q \geq 0$, the traditional maximization problem is faced by the firm because the financial constraint is not affecting importer's decisions. In this case, Equation 3.31 is used to solve for q as follows:

$$q = \frac{a - dY_r}{2k} + \frac{(C_r + Z_0\theta P_r^* + \phi P_r^*\sigma_\theta)b}{2k^2}, \quad (3.35)$$

where $a, d, k, \phi \geq 0$ and $b \leq 0$.

The effect of a change in the real import price, in domestic currency, and exchange rate uncertainty on the quantity of imported grains is assessed by the following equations:

$$\frac{\partial q}{\partial Z_0\theta P_r^*} = \frac{b}{2k^2} \leq 0, \quad (3.36)$$

$$\frac{\partial q}{\partial P_r^*\sigma_\theta} = \frac{b\phi}{2k^2} \leq 0. \quad (3.37)$$

All other things being equal, an increase in the foreign price of imports (P_r^*) decreases the volume of imported grains. Also, if the current value of the real exchange rate (Z_0) or the expected value of the future exchange rate (θ) increase, *ceteris paribus*, future trade appears relatively less profitable to importers; therefore, import quantity declines. In a similar way, an increase (*ceteris paribus*) in the importer's risk variable (σ_θ), indicates enhanced future riskiness leading thus to a reduction in the volume of imported grains for a risk averse importer ($\phi \geq 0$).

If $\lambda \geq 0$ and $q \geq 0$, the Kuhn-Tucker conditions are used to solve for q (see Appendix A for detailed solution), which becomes:

$$q = F_r Z_0\theta P_r^* + \phi F_r P_r^*\sigma_\theta. \quad (3.38)$$

The effect of a change in the budget constraint on the level of imported grains is

$$\frac{\partial q}{\partial F_r} = Z_0\theta P_r^* + \phi P_r^*\sigma_\theta \geq 0. \quad (3.39)$$

Thus, all other things being constant, an increase in the budget constraint will increase the demand for imports.

From equations 3.35 and 3.38 an it is possible to solve for q, which in general terms is

$$q = q(Y_r, C_r, F_r, P_r^*, Z_0, \theta, \sigma_\theta,). \tag{3.40}$$

3.3 Modeling the Sources of Real Exchange Risk

To analyze the role of monetary and real factors in the explanation of real exchange variability the model specification proposed by Edwards (1987) is adopted here. The model assumes that real exchange variability is explained by both monetary and real disturbances. In a short-run framework, both monetary and real factors are expected to be accountable for fluctuations in the real exchange rate, while real disturbances are expected to be the dominant explanatory variables as the planning horizon is expanded. The model is thus specified, in general terms, as:

$$\log \sigma_\theta = \delta_0 + \sum_i \beta_i \log N_i + \sum_j \gamma_j \log T_j + \epsilon, \tag{3.41}$$

where σ_θ is real exchange variability, N_i represents monetary sources of real exchange variability, and T_j real sources of real exchange variability.

Two measures of real exchange variability are used. The first considers a relatively short-term planning horizon for the importer. The second measure, called ***long-wave***, expands the importer's planning horizon to capture short-term and medium-term exchange rate fluctuations. The real or structural variables included in the model are an approximation of openness of the economy (to capture the importance of international trade in the domestic economy) and volatility of the terms of trade.[15] The more open the economy the less will be the impact of real shocks on the real effective exchange rate variability. Terms of trade instability, on the other hand, is expected to enhance real effective exchange rate

[15]Edwards also proposed the coefficient of variation of real gross national product (GNP) growth as a proxy for real productivity growth that is expected to cause long-term swings in the real exchange rate.

fluctuations. The monetary variables are money supply growth instability, volatility of nominal exchange rate policy, and average level of domestic inflation. Disturbances in these monetary variables are expected to increase variability of the real exchange rate.

Chapter 4

Empirical Analysis

4.1 Empirical Model

The nominal and real models previously developed are estimated for quarterly quantities of wheat and corn imported by Trinidad and Tobago and Brazil using data from the first quarter of 1974 to the last quarter of 1987. Corn is a grain that can be produced by both importing countries. Wheat, however, can only be grown in Brazil.

The selection of countries and agricultural commodities investigated was limited by data availability. Despite this limitation, the selection of countries took into account different exchange rate regimes. This is appropriated in analyzing exchange rate risk because a country's exchange rate policy may be designed to reduce the effect of unpredictable external and internal disturbances on the domestic economy (Black). Therefore, the effects of exchange rate risk are influenced by the exchange rate policy adopted in each country. Brazil has maintained a pre-announced crawling peg to a basquet of major currencies, while Trinidad and Tobago has adopted, most of the time, a peg to the U.S. dollar.

The equations modeling the sources of real effective exchange rate risk in Brazil are estimated using data from the first quarter of 1974 to the fourth quarter of 1985, while the estimated equations for Trinidad and Tobago use data series starting the first quarter of 1974 and ending the second quarter of 1987.

4.1.1 Empirical Nominal Exchange Rate Risk Model

For empirical estimation the conditional reduced form of the demand for imports, Equation 3.23, is approximated by the following linear form

$$q = \alpha_0 + \alpha_1 Y + \alpha_2 P^s + \alpha_3 C + \alpha_4 F + \alpha_5 RP^* + \alpha_6 \sigma + \alpha_7 D_1 + \alpha_8 D_2 + \alpha_9 D_3 + e. \quad (4.1)$$

Equation 4.1 is considered to be a market import demand curve, derived by aggregating over the number of identical importing firms. The coefficients α_1, α_2, and α_4 are expected to be positive, while α_3, α_5, and α_6 are expected to be negative. Quarterly dummy variables are used to account for seasonal patterns.

Description of Variables and Data Employed

For purposes of this study the variable q stands for the quarterly imported volume (in 1000 metric tons) of either corn or wheat. The domestic income variable, Y, is approximated by the annual nominal gross domestic product (GDP) of each country. In a similar case, Anderson and Garcia approximated a quarterly Y by a trend variable. However, one problem associated with the use of a trend variable is the implicit assumption that GDP grows at constant rate over time. Therefore, for Brazil and Trinidad and Tobago quarterly data are generated from annual GDP using a method designed by Chow and Lin and applied by Bahmani-Oskooee in the estimation of a quarterly income series used in his trade model. This method obtains quarterly best linear unbiased estimates of an annual series with the help of quarterly series of related economic variables. Thus, the quarterly series to be estimated, Y, is regressed on the value of total imports, I.[1] Using annual observations the relationship $Y = c + dI_t + \epsilon_t$ is estimated. Then, using quarterly data for I, a quarterly series for Y is developed.

[1]Bahmani-Oskooee estimated quarterly series for real GDP using a quarterly index of the volume of total imports. In the case under study, however, total volume of imports was not available. Therefore, the value of imports was selected since it is a variable closely related to nominal GDP.

Since quarterly data series for the domestic price of substitutes (P^s) are not available, this variable was approximated by the international price, in domestic currency, of possible substitutes of wheat and corn. In the corn import demand equations, the price of substitutes, is either the international price of U.S. number 2 sorghum, f.o.b, in U.S dollars per metric ton, or international price of U.S. soybeans, f.o.b gulf ports, in U.S dollars per metric ton. In the wheat import demand equations, P^s is the price of U.S. number 2 long-grain rice, f.o.b Houston, in U.S dollars per metric ton.

The variable C is omitted from the empirical model because data series of the unit-cost of processing imported grains are not available for the countries under examination.

The variable foreign exchange allotment, F, is approximated by quarterly end-of-the period foreign exchange. Another approximation of F is the current capacity to import in a given country, which is defined as the sum of exports (f.o.b) and private transfers less debt service (Kim). For Trinidad and Tobago, quarterly data are not available to construct this variable. For Brazil, this variable is constructed using quarterly data of its balance of payments. Thus, F is the sum of the value of total exports of goods and services and net transfers less debits attributed to goods, services, and income. The latter component of F largely reflects debt service payments. A proxy for F is expected to affect import volume in a positive fashion. However, a negative relationship may occur if the country under investigation has implemented an external adjustment program, requiring a substantial reduction of imports while exports are expanded.[2] Koo argues that agricultural trade is more sensitive to these types of policies. For instance, countries like Brazil have heavily increased agricultural exports and reduced agicultural imports as much as possible by increasing production of domestically produced substitutes (Koo). Thus, the proxy of F

[2]According to Grigsby and Pagoulatos (p:1287), external debt difficulties for Latin American countries have induced debtor nations to implement adjustment programs designed at improving the current account of the balance of payments by improving trade balance and deferring interest payment. Trade balance has been improved by increasing exports and reducing imports (see also Dutton, Grennes,and Johnson). Interest payments have been reduced by rolling over short-term debt and transforming short-term debt to longer-term debt.

may be expected to negatively affect imports because an improvement in the level of foreign exchange may be taken as an indication of the imposition of an import-reducing policy.

The variable P^* is the international price of either wheat or corn. For wheat, P^* is approximated by the quarterly U.S. price of number 3, hard winter, ordinary protein wheat, f.o.b gulf ports, in U.S. dollars per metric ton. For corn, P^* is approximated by the quarterly U.S. price of number 2, yellow corn, f.o.b gulf ports, in U.S. dollars per metric ton.

The expected value of R is approximated for two different exchange rate measures. The first, R_1, is the next-quarter's bilateral nominal rate expressed as units of domestic currency per U.S. dollar. The second, R_2, is the next-quarter's nominal effective exchange rate, which is described by the following import-weighted index

$$R_{2i} = \sum_j w_{ij} R_{ij} \tag{4.2}$$

This index is the arithmetic average of the bilateral exchange rates, R_{ij}, between countries i and j relative to the selected base period, weighted by an approximation of the exporters' share, w_{ij}, in grain imports of the home country ($\sum_j w_i = 1$). Actual calculations of R_{ij} use exchange rates *vis-à-vis* the U.S. dollar, $R_{j\$}$, and rely on the relation $R_{ij} = R_{j\$}/R_{i\$}$. Two effective exchange rates are constructed for each importing country. One for corn and the other for wheat. The exporting countries (j) are the main exporters of either wheat or corn. In the case of corn, R_2 is constructed using series of bilateral quarterly exchange rates between the importing country and the United States, South Africa, Argentina, Thailand, and France. In the case of wheat, the exporting countries are United States, Canada, France, Argentina, and Australia. The proportion of i's imports coming from each exporter, w_{ij}, is approximated by the share of each exporter in world total exports of either corn or wheat.[3]

[3]The selected exporting countries sell more than two-thirds of global exports, therefore, to maintain the equality $\sum_j w_i = 1$, the original weights are normalized assuming that the selected countries are wholly responsible for global exports.

When the interest is centered on evaluating risk within the contract-period, the exchange rate variability, σ, is approximated by σ_1, which is is the absolute percentage change in quarter-to-quarter bilateral spot rates (R_1):

$$\sigma_1 = \mid \frac{R_{1,t} - R_{1,t-1}}{R_{1,t-1}} \mid . \tag{4.3}$$

This measure reflects period-to-period change. Additionally, σ_1 adjusts for trend, focusing on unpredictable rather than systematic movements of exchange rates (Lanyi and Suss, Gotur). If R is the effective exchange rate (R_2), then σ may be measured by σ_2, which is the absolute percentage change in quarter-to-quarter effective rates (monthly data to construct effective exchange rates are not available; therefore, it is not possible to calculate a standard deviation measure of σ within a quarter).

Finally, the seasonal dummy variable D_{i-1} is one if observation is from quarter i ($i = 2, 3, 4$); otherwise, D_{i-1} is zero.

Variables q and w_{ij} are published by the the Food and Agricultural Organization in *Monthly Bulletin of Statistics.* Variables Y, F, I, and series of monthly and quarterly end-of-the period exchange rates are published by the International Monetary Fund in *International Financial Statistics.* Variables P^* and P^s are published by the United States Department of Agriculture in *Foreign Trade of the United States* and *Rice Outlook and Situation Report.*

Estimation Procedure and Results

Following Hooper and Kohlhagen approach, all equations were first estimated with one-quarter lag on all of the explanatory variables. This specification was expected to reflect the two-period time framework underlying the theoretical nominal model, in which firms were assumed to place their orders for imports in one period and to receive the imported inputs and make payments in the next period. Equations were also estimated without lags, testing the possibility that firms could anticipate import determinants.[4] The 'best looking equation' criterion, based on correct and significant signs for the independent variables, was used to select a no lag or a one-quarter lag specification for the explanatory variables. In all cases, the presence of the best specification for Y did not improve the overall fit of the model; therefore, this variable was omitted from the equations.

Equations were initially estimated using ordinary least-squares (OLS). The Durbin-Watson test was used to detect the presence of autocorrelated disturbance terms. For $n = 54$ and $k = 7$, the lower and upper critical point at the 5% significance level are approximately 1.21 and 1.78. For all equations, the calculated Durbin-Watson was below the lower critical point, so that the hypothesis of no autoregression ($\rho = 0$) had to be rejected. In the presence of autocorrelation, the estimated variances of the OLS estimators are biased and t-ratios are not reliable (Kmenta). Therefore, equations were reestimated using the Yule-Walker procedure available in SAS. This procedure applies the Estimated Generalized Least Squares (EGLS) method, which uses all of the OLS residuals to estimate the error covariances across observations. This estimation procedure is often called Prais-Winsten two-step procedure (Kmenta, Judge et al.).

The presence of multicollinearity in the data set typically reduces the efficiency of the OLS estimates (Kmenta). To detect this problem, Belsley et al. propose some tests based on the magnitude of the condition number, condition indices, and variance proportions calculated for the data matrices (X). The severity of multicollinearity is revealed by the relative values of the eigenvalues of $X'X$. Since eigenvalues close to zero indicate exact collinearity, the smaller the eigenvalue the higher the degree of multicollinearity. The square root of the

[4] A polynomial distributed lag structure was specified on RP^* and σ. The search for the correct lag and order was based on two selection criteria, the Schwarz information criteria (SIC) and the Akaike information criteria (AIC). In general, lag coefficients were not significant. Moreover, lagged effects were not consistent with theoretical expectations, since all lagged coefficients did not exhibit the same sign. Coefficients with different signs may indicate an incorrect specification. Pick argued that lag specification and selection presents a problem when using short-run data, Under these circumstances, an unrestricted (one lag) lag specification was used. This type of approach seems to be more appropriate, because the nominal model is designed to capture fairly quick adjustments of a short-term nature in imported quantities.

ratio of the largest to the smallest of these eigenvalues is the condition number. If the calculated value of this statistic is between 5 to 10, weak linear dependencies exist among the explanatory variables, while moderate to strong relationships occur if the condition number exceeds 30 (Judge et al.). The number of large values for the condition indices, defined as the square root of the ratio of the largest eigenvalue to each of the other eigenvalues, provides an indication of the number of close dependencies among the explanatory variables. Finally, relatively large values for the variance proportion of the coefficients associated with any small eigenvalue reveal which are the collinear variables.

In general, collinearity was not found to be excessive. In particular, values around 3 for the condition number of Trinidad and Tobago's wheat and corn data indicated that multicollinearity was not an excessive problem. In Brazil, a condition number of 22 in the wheat data matrix that included the risk variable σ_1, revealed a moderate multicollinearity problem. The smallest eigenvalue, in this case, accounts for an important proportion of the variance of Y and RP^*. Also, the variance proportions related to another large condition index showed a close linear dependency between P^s and F. The wheat data matrix that included the risk variable σ_2, revealed a weak multicollinearity problem, as indicated by a condition number of 11. The variance proportions associated with the smallest eigenvalue showed again a close linear dependency between P^s and F. In Brazil, the corn data matrix that included the risk variable σ_1 revealed a stronger multicollinearity problem, as indicated by a condition number of 96. The smallest eigenvalue accounts for an important proportion of the variance of P^s and RP^* (using R_1). Also, the variance proportions related to another large condition index showed a near linear dependency between Y and F. The corn data matrix that included the risk variable σ_2, exhibited a weak multicollinearity problem, as indicated by a condition number of 13. The variance proportions associated with the smallest eigenvalue showed again a near linear dependency between Y and P^s. It is important to stress, however, that the variable of interest, σ, did not appear to be part of any collinear relationship with any other variable, and thus any insignificant sign could not be attributed to multicollinearity.

Summary statistics reported for each equation include the coefficient of determination (R^2), the coefficient of determination adjusted for degrees of freedom ($\overline{R}^2$), and the Durbin-Watson Statistic (DW). For equations corrected for autocorrelation, R^2 is calculated for the transformed regression and is a measure of the goodness of the fit of the corrected model and does not include the predictive power of the autocorrelated disturbances. To test the null hypothesis that each of the explanatory variables did not play any role in determining grain imports, the t test was used. Two confidence intervals were allowed: the conventional level of 95% and a 90% level. The narrow level of 90% is associated with lower levels of confidence, however, it was selected to warrant attention to variables that play a small role in grain import decisions.

Table 4.1 shows the results for the nominal case in Trinidad and Tobago. Since Trinidad and Tobago has maintained, most of the time, a peg to the U.S. dollar, importers are shielded against nominal exchange rate risk for dollar denominated contracts (measured by σ_1). However, a fixed parity to the U.S. dollar does not necessarily eliminate risk effects arising from fluctuations in the relevant nominal effective exchange rates. Therefore, the corn and wheat equations are estimated using R_2 as an approximation for the nominal effective exchange rate. The exchange risk variable is, thus, the standard deviation of R_2.

In the case of wheat, the coefficient for the price of substitutes (P^s) was significant at the 95% level. The coefficient for foreign exchange did not exhibit the expected positive sign.[5] The seasonal dummy variables were also significant, revealing a seasonal pattern with wheat imports increasing consistently from the second quarter to the fourth quarter. The effective price of wheat (RP^*) and the risk variable (σ_2) generated the expected negative sign, but their coefficients were not statistically significant.

[5]For Trinidad and Tobago, most cases showed a positive sign for the foreign exchange variable. Thus, it seems reasonable to suppose that the chosen approximation of F is accurately capturing the financial constraint. Therefore, it is assumed that F has a 'wrong' sign in the wheat equation.

Table 4.1: Nominal Model For Trinidad and Tobago: Corn and Wheat Import Demand Equations with σ_2.

Variable	Wheat	Corn
Constant	9.774	-3.572
	(0.72)	(-0.17)
P^s	25.465	16.001[a]
	(2.35)*	(0.53)
F	-21.600[a]	63.868*
	(-1.58)	(3.10)
D_1	25.155*	25.138*
	(5.96)	(3.92)
D_2	51.734*	43.366*
	(10.98)	(6.32)
D_3	74.484*	64.871*
	(17.77)	(10.48)
RP^*	-3.451	-5.831
	(-1.42)	(-0.52)
σ	-1.268	-6.540
	(-0.49)	(-1.28)
R^2	0.90	0.76
$\overline{R}^2$	0.89	0.73
DW	1.03	1.18

Notes: Unless otherwise noted, variables are not lagged,
t-ratios are in parentheses,
* indicates significant at the 95% level,
** indicates significant at the 90% level,
[a] one quarter lag.

In the case of corn, the coefficient of P^s generated the expected sign, but it was not significantly different from zero. The foreign exchange coefficient was positive, as expected, and played and important role in determining the volume of corn imports. The seasonal dummy variables were also significant, exhibiting a seasonal pattern similar to that of wheat imports since corn imports increased consistently from the second quarter to the fourth quarter. The effective price of wheat (RP^*) and the risk variable (σ_2) produced the expected negative sign, but their coefficients were not statistically significant.

The low t statistics associated with each of the estimated coefficients that were not significant were accompanied by rather high variances for the estimates. This problem, however, cannot be attributed to the presence of multicollinearity, as discussed above. Kmenta argues that low t values, resulting from large variances for the coefficients could also be the result of small dispersion of the explanatory variables, or a large error variance.

Table 4.2 shows the results for the nominal model in Brazil. The corn and wheat equations are estimated using two approximations for the the nominal exchange rate: R_1 and R_2. The exchange risk variable is thus the standard deviation of the alternative R_s.

The results for the corn equation using σ_1 as risk proxy indicated that the coefficient of P^s was positive and significantly different from zero at the 95% level. The foreign exchange coefficient was negative and played and important role in determining the volume of corn imports. As argued above, a negative sign for the coefficient of F could be the result of the adoption of an import-reducing policy by the Brazilian government, so as to improve the current account position and the level of foreign exchange available. Only two seasonal dummy variables were significant, indicating that corn imports were concentrated in the last two quarters of the year. The coefficient for the effective price of corn (RP^*) exhibited the expected negative sign and was significant at the 95% level. The risk variable (σ_1) generated the expected negative sign, but it did not play any significant role in explaining corn imports.

Table 4.2: Nominal Model For Brazil: Corn and Wheat Import Demand Equations with alternative σ_s.

Variable	Equations with σ_1		Equations with σ_2	
	Corn	Wheat	Corn	Wheat
Constant	115.764	793.463*	112.903	1142.424*
	(0.73)	(3.66)	(0.74)	(5.00)
P^s	49.620[a,]*	78.613	10.538[a,]*	58.465
	(2.65)	(0.84)	(2.98)	(1.14)
F	-11.959*	-52.292[a]	-11.962*	-103.315[a,]*
	(-2.63)	(-0.55)	(-2.71)	(-1.71)
D_1	68.941	757.591*	131.338	585.751*
	(0.60)	(4.63)	(0.81)	(3.48)
D_2	225.714**	1874.590*	220.810	1655.504*
	(1.76)	(10.19)	(1.58)	(8.53)
D_3	469.601*	2773.205*	481.134*	2588.318*
	(4.08)	(17.19)	(3.81)	(14.49)
RP^*	-3.658[a,]*	-2.510	-2.607	-1.185
	(-2.13)	(-1.10)	(-1.32)	(-1.46)
σ	-2.538[a]	55.802	-2.371	-1.361**
	(-0.66)	(0.76)	(-0.81)	(-1.71)
R^2	0.39	0.87	0.36	0.89
$\overline{R}^2$	0.30	0.85	0.27	0.87
DW	0.89	0.99	1.01	0.88

Notes: Unless otherwise noted, variables are not lagged,
t-ratios are in parentheses,
* indicates significant at the 95% level,
** indicates significant at the 90% level,
[a] one quarter lag,

The results for the corn equation using σ_2 as risk proxy showed that the coefficient of P^s was again positive and significantly different from zero at the 95% level. The foreign exchange coefficient was negative and significantly different from zero at the 95% level. In this case only one seasonal dummy variable was significantly different from zero, indicating that corn imports were concentrated in the last quarter. The effective price of corn (RP^*) and the risk variable (σ_2) generated the expected negative sign, but their coefficients were not significant in explaining corn imports.

The results for the wheat equation using σ_1 as risk proxy revealed that coefficient for P^s was positive, as expected, but it was not significantly different from zero. The foreign exchange coefficient was negative and was not statistically significant. The seasonal dummy variables were also significant, revealing a seasonal pattern with wheat imports increasing consistently from the second quarter to the fourth quarter. The effective price of wheat (RP^*) produced the expected negative sign. On the other hand, the risk variable (σ_1) did not generate the expected negative sign. The coefficients for both RP^* and σ_1 were not found to be significantly different from zero.

The results for the wheat equation using σ_2 as risk proxy revealed that the coefficient for P^s was positive, as expected, but it was not relevant in explaining wheat imports. The foreign exchange coefficient was negative and significantly different from zero at the 90% level. The seasonal dummy variables were also significant, revealing a seasonal pattern with wheat imports increasing consistently from the second to the fourth quarter. The nominal effective price of wheat (RP^*) produced the expected negative sign, but its coefficient was not significantly different from zero. The risk variable (σ_2) generated the expected negative sign and its coefficient was significantly different from zero at the 90% level.

In summary, the nominal model does not seem to adequately explain imports of wheat and corn in Trinidad and Tobago. In general, in the wheat equation the only variable significant variable was the price of substitutes and in the corn equation the only variable relevant was the foreign exchange proxy. In both cases, important economic explanatory variables such as the price of either corn or wheat were not found to be significant, revealing that imports were not explained by a nominal effective measure of RP^*. Additionally, nominal effective exchange risk was not found to be a source of concern for grain importers. In Brazil, the nominal model seemed to provide a good explanation for corn imports. The corn equation using σ_1 exhibited good results with most variables being significant at the 95% level. Results for the corn equation using σ_2 were similar, but the nominal effective measure of RP^* was significantly different from zero. Nominal risk, measured by either σ_1 or σ_2, was not found to be important in explaining Brazilian corn imports. On the other hand, results for both Brazilian corn equations showed that the nominal foreign exchange coefficient was found to be significant at the 95% level. In the case of Brazilian wheat imports, the equation using σ_2 produced better results than the equation using σ_1, and also exhibited significant, though small, coefficients for nominal risk and nominal foreign exchange.

4.1.2 Empirical Real Exchange Rate Risk Model

For empirical investigation the conditional reduced form of the demand for imports, as given by Equation 3.40, is approximated by the following linear form:

$$q = \alpha_0 + \alpha_1 Y_r + \alpha_2 C_r + \alpha_3 F_r + \alpha_4 Z_0 P_r^* + \alpha_5 \theta + \alpha_6 \sigma_\theta + + \alpha_7 D_1 + \alpha_8 D_2 + \alpha_9 D_3, \quad (4.4)$$

where α_1 and α_3 are expected to be positive and α_2, α_4, α_5, and α_6 are expected to be negative. D_1, D_2, and D_3 are quarterly dummy variables.

Description of Variables and Data Employed

To empirically evaluate the short-term effects of real exchange variability the substitute proxy variables suggested by Cushman (1983), M for θ and S for σ_θ, are included in

Equation 4.4. M is an approximation of the importer's estimate of the expected value of θ and is a four-quarter moving average of theta, where $\theta = 100(Z_t/Z_{t-1})$ and the fourth quarter of M is the current one. According to Cushman (1983), the coefficient of M has a sign opposite to that of the expected value of theta because of the hypothesis of stabilizing expectations. Thus, in the context of purchasing-power parity theory, if lagged M has been consistently low ($\theta \leq 1$), the domestic currency is overvalued and the expectation would be for an increase in θ toward purchasing parity level, and volume of imports in the current quarter would now be lower as a result of that expectation. Thus, $1/M \cong \theta$ and the coefficient of M is expected to be positive.[6]

S is an approximation of the importer's estimate of the standard deviation (or risk) of the random value of the future *change* in the real exchange rate (σ_θ) and is a four-quarter moving standard deviation of theta ending in the current quarter.[7] Variable S is expected to have a negative sign under risk aversion.[8]

The real effective exchange rate, Z, for importing country i is defined as

$$Z_i = \sum_j w_{ij}(R_{ij}P_j/P_i), \tag{4.5}$$

where R_{ij} is an index of the bilateral rate between countries i and j. P_j is an index of the price level in country j and P_i is the index of the domestic price level in the importing country. The share, w_{ij}, is j's share of i's imports ($\sum_j w_i = 1$). Two real effective exchange rates are constructed for each importing country. One for corn and the other for wheat. The exporting countries (j) are the main exporters of either wheat or corn. P_j is approximated

[6] A positive coefficient for M is also consistent with an adaptive expectations framework (Cushman (1988)). If current expectations are adaptive , then a low value of M would suggest further depreciation of Z so that current trade would be postponed.

[7] Rana points out that the standard deviation is not an appropriate measure of risk when exchange rates are not normally distributed. Brodsky, in the other hand, argues that the choice of an adequate measure of instability cannot be made on statistical grounds alone and that more intuitive meaningful economic considerations should prevail over statistical considerations. Moreover, he argued that, under the assumption of risk aversion, the standard deviation is an entirely consistent measure of variability.

[8] Lanyi and Suss argued that the use of a *moving* standard deviation would introduce an element of arbitrariness into the calculation because it would involve a decision about the length of the moving average. Also, they pointed out that the use of a moving average would understate the actual costs of exchange rate by smoothing the movements too much.

by the consumer price index of the exporting country and P_i is the consumer price index of the importing country. The proportion of i's imports coming from each exporter, w_{ij}, is approximated by the share of each exporter in world total exports of either corn or wheat. Series of consumer price indices are published by the Monetary Fund in *International Financial Statistics.*

The measures of the expected value and standard deviation of theta (M and S) suggested above have a relatively short-term frame of reference both from the point of view of exchange rate prediction and the firm's planning horizon for trade decisions. Thus, alternative measures of θ and σ_θ are constructed to reflect a medium-term planning horizon and are called here *long-wave* measures of risk.[9] The approximation of θ is M_l, which is defined as an eight-quarter moving average of recent quarterly changes in θ. M_l is expected to be positive. The proxy for σ_θ, S_l, is an eight-quarter moving standard deviation of recent quarterly percentage changes in the real exchange rate.

The real variables Y_r and F_r are constructed by deflating the nominal variables described in Section 4.1.1 with the domestic consumer price index. The variable $Z_0P_r^*$ was initially constructed using the real price of grains, in foreign currency, times the real effective exchange rate.[10] However, this variable specification did not provide good results. Therefore, $Z_0P_r^*$ was approximated by $(RP^*)/P_d$, which as explained above is equivalent to $Z_0P_r^*$ (see Equation 3.26). The variable P^* is the international price of either wheat or corn. The variable R is the relevant nominal effective exchange rate.

Estimation Procedure and Results

Cushman's approach was adopted when estimating corn and wheat equations with either S or S_l. This approach tests different lags for explanatory variables and selects lag speci-

[9]These measures do not reflect long-term swings in real exchange rates. They just reflect a medium-term planning horizon for the importer of grains and they are still considered as short-term measures of exchange risk.

[10]The real price of grains, in foreign currency, is deflated by a weighted average of the consumer price indices of the major exporting countries.

fication choosing the 'best looking equation', based on correct and significant signs for the independent variables.[11] Thus, for Y_r, F_r, and $Z_0 P_r^*$ either no lag, or different lags ranging from one-quarter lag up to five-quarters lag were allowed. In most cases, the presence of the best lag specification for Y did not improve the overall fit of the model (see appendix B); therefore, this variable was omitted from most equations. Once the lag-length was established for each of the non-risk variables, the lag search started for M or M_l, and S or S_l. In addition to alternative lags, one-quarter and two-quarters lead were tested for these variables. The imposition of a lead during estimation implicitly assumes that the importer has perfect foresight and expectations concerning changes in the real effective exchange rate (M or M_l) and real exchange rate risk (S or S_l) are correct. In Trinidad and Tobago, the real model provided good results when up to two-quarters lag were used. However, in Brazil the real model provided better results when lag lengths increased. Tables in appendix B report many of the lag specifications allowed for each case. These tables show a sample of the the range of possible outcomes that the application of Cushman's approach provide. From this sample, results were selected based on equations which as a whole had the most reasonable coefficients for the non-risk variables.

Equations were initially estimated using ordinary least-squares (OLS). The Durbin-Watson test was used to detect the presence of autocorrelated disturbance terms. In Trinidad and Tobago's cases ($k = 7$ and $n = 45, 46$, or 47), the lower and upper critical points at the 5% significance level are approximately 1.12 and 1.80. In Brazil's cases ($k = 7$ and $n = 43, 44$, or 45), the lower and upper critical points at the 5% significance level are approximately 1.09 and 1.81. Pindyck and Rubinfeld (p. 16) argue that the lower limit is more accurate to detect serial correlation than the upper limit, when the explanatory variables are likely to be autocorrelated, as in most time series data. Other authors support,

[11] Pick argues that despite the fact that Cushman's procedure is ad hoc, it provides a plausible way of observing alternative lag specification when using short-run data, because the lag structure which affects the dependent variable is not known for quarterly data.

instead, a more conservative strategy by choosing the upper limit. This conservative approach would cause the null to be rejected even if the value of the Durbin-Watson statistics is in the inconclusive region (Kmenta, Ostrom). However, when the two-step Prais-Winsten estimation procedure was employed to cases where calculated Durbin-Watson exceeded 1.55, the corresponding value of ρ was insignificant at the 5% level, as revealed by its t-statistics. Therefore, 1.55 was selected as the upper limit.

To detect the possible presence of multicollinearity, the condition number, condition indices, and variance proportions were calculated for the data matrices. These statistics revealed that multicollinearity was not a problem affecting the estimation process. In fact, the calculated values for the condition number were around 3 for all data sets, revealing very weak linear dependencies among the explanatory variables.

Equations exhibiting the results for Trinidad and Tobago are reported in Table 4.3. The results for the Trinidad and Tobago's corn equation with S as a measure of risk indicated that the coefficient for foreign exchange (F_r) was positive and significantly different from zero at the 95% level. The quarterly dummy variables showed significant seasonal patterns in corn imports, with higher import levels in the third and fourth quarter. In addition, the coefficient for the real corn price ($Z_0P_r^*$) was negative and significantly different from zero at the 95% level. The moving average of the change in the real effective exchange rate (M) generated the expected positive sign. Also the risk variable (S) produced the expected negative sign. However, coefficients for both M and S were not statistically significant in explaining corn import decisions. The corn equation estimated with the longer-term risk measure, S_l, exhibited a similar behavior to the equation estimated with S. In fact, F_r and $Z_0P_r^*$ were again the variables that affected the level of corn imports. Their coefficients, however, showed lower levels of significance (90%).

The results for the Trinidad and Tobago's wheat equation using S as risk proxy indicated that the coefficient for foreign exchange (F_r) was positive and significantly different from

Table 4.3: Real Model For Trinidad and Tobago: Corn and Wheat Import Demand Equation Results.

Variable	Equations with M and S		Equations with M_l and S_l	
	Corn	Wheat	Corn	Wheat
Constant	-40.372	-54.769	-72.794	-28.562
	(-0.41)	(-1.81)**	(-0.33)	(-0.42)
F_r	323.950*	122.452*	271.285**	102.417^{b,**}
	(2.20)	(3.13)	(1.79)	(1.66)
D_1	20.490*	-76.678*	21.027*	-78546*
	(2.98)	(-22.01)	(3.05)	(-18.20)
D_2	47.851*	-48.820*	48.010*	-52.231*
	(6.23)	(-14.23)	(6.21)	(-12.20)
D_3	70.480*	-20.943*	70.694*	-22.027*
	(10.15)	(-6.16)	(10.10)	(-5.23)
$Z_0P_r^*$	-54.679^{a,*}	-1.657	-44.721^{a,**}	-3.422
	(-2.01)	(-0.37)	(-1.65)	(-0.48)
M or M_l	0.549^a	1.553^{a,*}	5.576	3.313*
	(0.55)	(5.24)	(0.62)	(3.49)
S or S_l	-0.681	-1.046^{f,*}	-4.065	-1.783^{f,*}
	(-0.92)	(-5.20)	(-0.65)	(-2.70)
R^2	0.75	0.94	0.75	0.91
$\overline{R}^2$	0.71	0.93	0.71	0.89
DW	1.14	1.84	1.15	1.61

Notes: Unless otherwise noted, variables are not lagged,
t-ratios are in parentheses,
* indicates significant at the 95% level,
** indicates significant at the 90% level,
^{a} one quarter lag,
^{b} two quarters lag and,
^{f} one quarter lead.

zero at the 95% level. The seasonal dummy variables were significant, showing that wheat imports were higher in the third and fourth quarter. The coefficient for the real wheat price variable ($Z_0 P_r^*$) revealed the expected negative sign, but it was not significantly different from zero. The coefficient for M was consistent with the theoretical expectations. Moreover, this coefficient was found to be significantly different from zero at the 95% level. As expected, the risk variable (S) had highly significant adverse effects on Trinidad and Tobago's import volumes. The wheat equation estimated with the longer-term risk measure, S_l, exhibited a similar behavior to the equation estimated using S. In this case, however, the coefficient for F_r showed lower levels of significance (90%). The variables M_l and S_l played an important role in explaining the volume of wheat imports.

Equations exhibiting the results for Brazil are reported in Table 4.4. The results for the Brazilian corn equation with S as a measure of risk indicated that variable Y_r had a positive and significant influence and on imports. The coefficient for foreign exchange allotment (F_r) was negative, but it was not statistically significant. The quarterly dummy variables indicated significant seasonal patterns, with corn imports increasing consistently from the the second to the third quarter. In addition, the coefficient for real corn price ($Z_0 P_r^*$) was negative and significantly different from zero at the 90% level. The moving average of the change in the real effective exchange rate (M) generated the expected positive sign and was significantly different from zero at the 95% level. The risk variable (S) produced the expected negative sign. However, S did not play an important role in explaining corn import decisions. The Brazilian corn equation estimated with the longer-term risk measure, S_l, exhibited some interesting results. For instance, the coefficient for Y_r was positive, but it was no longer statistically significant. On the other hand, $Z_0 P_r^*$ and M_l were again important variables in determining the volume of corn imports. Additionally, the coefficient for the risk variable (S_l) was negative and significant at the 95% level, revealing that risk considerations became important as the importer of corn was allowed to have a longer-term planning horizon.

Table 4.4: Real Model For Brazil: Corn and Wheat Import Demand Equation Results.

Variable	Equations with M and S		Equations with M_l and S_l	
	Corn	Wheat	Corn	Wheat
Constant	-2420.914**	-355.921	517.561	2068.140
	(-1.71)	(-0.54)	(-0.25)	(1.42)
Y_r	$883.397^{b,*}$		464.198^{a}	
	(2.14)		(1.28)	
F_r	-2048.827	-1011.139^{e}	-1894.557	-1554.485^{d}
	(-1.59)	(-0.62)	(-1.52)	(-0.98)
D_1	-761.319*	768.320*	378.898**	-3014.433*
	(4.07)	(4.72)	(1.73)	(-19.03)
D_2	-720.928*	1866.977*	529.818*	-2198.981*
	(-3.46)	(11.09)	(2.45)	(-13.21)
D_3	-131.227	2979.866*	661.025*	-1089.979*
	(-0.72)	(19.32)	(4.31)	(-7.13)
$Z_0P_r^*$	$-413.398^{a,**}$	$-264.433^{c,**}$	-940.030*	$-218.209^{c,**}$
	(-1.80)	(-1.74)	(-2.12)	(-1.79)
M or M_l	$27.599^{f,*}$	$14.143^{d,*}$	34.482*	25.834*
	(2.57)	(2.61)	(2.17)	(2.02)
S or S_l	-8.318	-1.494^{b}	$-22.755^{c,*}$	-4.783^{f}
	(-1.29)	(-0.47)	(-2.64)	(-0.83)
R^2	0.41	0.92	0.47	0.93
$\overline{R}^2$	0.28	0.90	0.35	0.92
DW	1.44	0.84	1.13	0.70

Notes: Unless otherwise noted, variables are not lagged,
t-ratios are in parentheses,
* indicates significant at the 95% level,
** indicates significant at the 90% level,
[a] one quarter lag,
[b] two quarters lag and,
[c] three quarters lag and,
[d] four quarters lag and,
[e] five quarters lag and,
[f] one quarter lead.

The results for the Brazilian wheat equation using S as risk proxy indicated that the coefficient for foreign exchange allotment (F_r) was negative, but it was not significantly different from zero. The coefficient for the real wheat price variable ($Z_0P_r^*$) exhibited negative influences on wheat import quantities, and was significantly different from zero at the 90% level. The coefficient for M was consistent with the theoretical expectations. Moreover, this coefficient was found to be significantly different from zero at the 95% level. As expected, the risk variable (S) generated a negative sign, but this variable did not play any role in explaining wheat imports. The wheat equation estimated with the longer-term risk measure, S_l, exhibited a similar behavior to the equation estimated using S. The variables $Z_0P_r^*$ and M_l played an significant role in explaining the volume of wheat imports.

It is interesting to note that the real models estimated for Brazilian wheat imports performed better as the lag length increased. It seemed that the behavior of lagged explanatory variables could be affecting past domestic production (planting) decisions of wheat and thus current levels of wheat imports. The model may be capturing the substitution between domestic and imported wheat.

In summary, the real model seemed to explain imports of wheat and corn in Trinidad and Tobago well. In particular, variable F_r was important in determining both corn and wheat imports, while $Z_0P_r^*$ was just significant in explaining corn imports. Expected changes in the real effective exchange rate (M or M_l) and real effective exchange rate risk (S or S_l) were not statistically significant in determining corn imports. Since the real effective exchange rate relevant for corn has been heavily dominated by the U.S. dollar, these results could indicate that Trinidad and Tobago has been maintaining the bilateral (U.S. dollar *vis-à-vis* the domestic currency) real exchange rate relatively stable. In the case of Trinidad and Tobago's wheat imports, however, M (or M_l) and S (or S_l) played a major role in explaining the volume of imports. In the Brazilian equations, the real foreign exchange variable, F_r, did not play a statistically significant role in explaining grain imports. The real effective price of grains, $Z_0 P_r^*$, had a small but significant negative influence in both wheat and corn imports. Additionally, M was an important variable in the decision of importing both grains. In the case of wheat, real exchange rate risk was not significant. In the case of corn, however, the risk proxy S_l played a substantial role in determining corn imports.

4.1.3 Empirical Model of the Sources of Real Exchange Risk

The possible role of monetary and real factors in the explanation of real exchange variability is analyzed by estimating the log-linear specification proposed by Edwards (1987) which is[12]

$$\log \sigma_\theta = \delta_0 + \sum_i \beta_i \log N_i + \sum_j \gamma_j \log T_j + \epsilon, \tag{4.6}$$

where σ_θ is real exchange variability, N_i represents monetary sources of real exchange variability, and T_j real sources of real exchange variability.

Description of Variables and Data Employed

The two measures of real exchange variability used here are S and S_l, as defined previously in Section 4.1.2. The first measure considers a relatively short-term planning horizon for the importer. The second measure, called *long-wave*, expands the importer's planning horizon to capture short-term and medium-term real exchange rate fluctuations. As mentioned above, the long-wave is considered to be a short-term measure, chiefly because it can not capture long-term swings in the real exchange rate. Nevertheless, the long-wave measure is expected to be be more influenced by real shocks than the short-term measure.

The monetary variables, N_i, are approximated by alternative approximations of monetary or nominal disturbances. The approximations that provide a better explanation of the fluctuations in the real effective exchange rate are selected. Thus, money supply growth

[12]The model specification as well as the variables included in the empirical model are based on the model estimated by Edwards (1987).

instability (MS) is described by two proxies, which are expected to have a positive influence on real exchange rate variability: the standard deviation of either the rate of change (measured by quarterly percentage changes) of $M1$ or the rate of change of domestic credit (DC). Growth variability of $M1$ was selected as the better proxy for MS because it provided better results. Also, the effects of the volatility of domestic inflation (VP) on S or S_l were explored. However, VP was omitted because it did not provide a good explanation of real effective exchange rate instability.[13] The average level of domestic inflation (AP) is expected to influence positively real exchange rate volatility. This variable was approximated by an average of quarterly percentage changes in the level of domestic inflation, measured by the consumer price index (CPI). However, AP was omitted as it proved to be an unsatisfactory measure of monetary disturbances. Additionally, two alternative approximations of the volatility of nominal exchange rate policy, expected to be positive, are used: the standard deviation of the rate of devaluation of the nominal effective exchange rate (σ_2) and the standard deviation of the rate of devaluation of the domestic currency with respect to U.S. dollar (σ_1).[14] The proxy σ_2 was selected as it showed a more influential role on the dependent variable.

The real or structural variables included in the model, T_i, are an approximation of the openness of the economy (to capture the importance of international trade in the domestic economy) and volatility of the terms of trade.[15] The proxy for openness (OPE) is expected to generate a negative sign and is described by an average of quarterly percentage changes in the propensity to import, which is defined as the value of imports as a fraction of the gross domestic product (Y) in each quarter.[16] Finally, variability of the terms of trade

[13]Since VP is itself a function of money supply variability (Bairam), MS was omitted from the equations when VP was used as a proxy of monetary disturbances.

[14]The standard deviation of the bilateral rate between the domestic currency and the U.S. dollar is added by one in the case of Trinidad and Tobago, because the standard deviation of this bilateral exchange rate is zero for countries that maintain a fixed rate with respect to the U.S. dollar and it cannot be logged.

[15]Edwards also proposed the coefficient of variation of real income (Y_r) growth as a proxy for real productivity growth that is expected to cause long-term swings in the real exchange rate.

[16]To calculate propensity to import, quarterly Y is assumed to be equal to the annual mean.

(TOT), which is expected to show a positive sign, is defined as the standard deviation of quarterly percentage changes in the terms of trade. In the case of Trinidad and Tobago, the terms of trade series has some missing observations. Therefore, quarterly observations are generated using Chow and Lin's method. Quarterly observations for unit value of exports are estimated using quarterly observations of unit value of exports for oil-exporting countries. Quarterly observations for unit value of imports are estimated using quarterly observations of unit value of imports for small low-income developing countries.

Since S is a four-quarter moving standard deviation of relative changes in the real exchange rate, variability in the explanatory variables is defined also as a four-quarter moving standard deviation of quarterly changes in these variables. Additionally, openness and average level of domestic inflation are measured by a four-quarter moving average of quarterly changes in these variables. On the other hand, since S_l is defined as an eight-quarter moving standard deviation of quarterly changes in the real exchange rate, variability of independent variables is measured as an eight-quarter moving standard deviation of quarterly changes in these variables. Openness and average level of domestic inflation are measured by a four-quarter moving average of quarterly changes in these variables.

To construct all the proposed approximations for monetary and real disturbances, data was collected from *International Financial Statistics* as published by the International Monetary Fund.

Estimation Procedure and Results

Following Edwards (1987), all equations were first estimated with no lags for the independent variables. This specification implicitly assumed that either S or S_l were affected by anticipated (expected) disturbances or that the adjustments period of exchange risk to monetary and real shocks was shorter than one quarter. Equations were also estimated with a one-quarter lag specification on all of the explanatory variables. A one-quarter lag specification was expected to reflect the effect of past instability in the behavior of independent variables on the present behavior of real effective exchange rate variability. The 'best looking equation' criterion, based on correct and significant signs for the independent variables, was used to select a no lag or a one-quarter lag specification for the explanatory variables.

Equations were initially estimated using ordinary least-squares (OLS). The Durbin-Watson test was used to detect the presence of autocorrelated disturbance terms. In Trinidad and Tobago's cases ($k = 5$ and $n = 45$ or 52), the lower and upper critical points at the 5% significance level are approximately 1.24 and 1.68. In Brazil's cases ($k = 5$ and $n = 39$ or 45), the lower and upper critical points at the 5% significance level are approximately 1.13 and 1.69. For all equations, the calculated Durbin-Watson was below the lower critical point, so that the hypothesis of no autoregression ($\rho = 0$) had to be rejected. Therefore, equations were reestimated using the Yule-Walker procedure.

Multicollinearity was not a source of concern during the estimation process. In fact, values around 2 for the condition number of Trinidad and Tobago's data and values between 2 and 4 for Brazilian data indicated that the presence of collinear relations among the explanatory variables was not a problem.

Table 4.5 shows the results for Trinidad and Tobago's real exchange variability, S and S_l, relevant for corn and wheat importers. In the case of the dependent variable S associated with Trinidad and Tobago's corn imports, money supply disturbances (MS) have a positive and significant role in explaining the short-term measure of real effective exchange rate volatility. Also, the coefficient for instability in the rate of devaluation of the nominal effective exchange rate (σ_2) was positive and significant at the 95% level. The coefficient for variability of the terms of trade, TOT, revealed the expected positive sign and was significant at the 95% level. The coefficient for average openness (OPE), contradicting expectations, was positive and was not found to be significantly different from zero. In the case of the

Table 4.5: Trinidad and Tobago: Sources of Real Exchange Rate Variability for Corn and Wheat.

Variable	Dependent variable: S		Dependent variable: S_l	
	Corn	Wheat	Corn	Wheat
Constant	-5.957**	-4.566	4.223*	3.051*
	(-1.70)	(-0.94)	(3.56)	(2.32)
MS	53.931^{a,*}	46.827	-35.989*	-19.91
	(2.54)	(1.60)	(-2.09)	(-1.11)
σ_2	43.587*	65.611*	0.900	-0.539
	(3.99)	(5.81)	(0.52)	(-0.38)
TOT	42.881^{a,*}	57.466*	38.214^{a,*}	48.853^{a,*}
	(2.39)	(2.45)	(2.81)	(3.27)
OPE	87.188	30.292	8.397	7.699
	(1.19)	(0.31)	(1.36)	(1.11)
R^2	0.35	0.48	0.33	0.32
$\overline{R}^2$	0.29	0.43	0.26	0.25
DW	0.99	0.69	0.93	1.01

Notes: Unless otherwise noted, variables are not lagged,
t-ratios are in parentheses,
* indicates significant at the 95% level,
** indicates significant at the 90% level,
^{a} one quarter lag.

dependent variable S_l associated with Trinidad and Tobago's corn imports, results showed a contradictory negative effect for the coefficient of money supply disturbances, MS, which was found to have a significant role in explaining the long-wave measure of real exchange rate variability. The coefficient for volatility of the terms of trade, TOT, revealed the expected positive sign and was significant at the 95% level. Coefficients for the variables σ_2 and OPE were not found to be statistically different from zero.

In the case of the dependent variable S associated with Trinidad and Tobago's wheat imports, money supply instability (MS) had a positive, but not significant influence in explaining S. On the other hand, volatility in the rate of devaluation of the nominal effective exchange rate (σ_2) exhibited a highly significant positive effect on the short-term measure of real effective exchange rate volatility. The coefficient for TOT was also found to be positive and significant at significant at the 95% level. The coefficient for average openness (OPE) did not exhibit the correct sign and was significantly different from zero. In the case of the dependent variable S_l associated with Trinidad and Tobago's wheat imports, results did not produced the expected sign for money supply disturbances, MS; still, its coefficient was not found to be significant. Volatility of the terms of trade, TOT, generated the expected positive sign and its coefficient was significant at the 95% level. The coefficients for the variables σ_2 and OPE did not revealed the expected sign and were not found to be significantly different from zero. In summary, the equations modeling sources of Trinidad and Tobago's short-run real exchange variability performed better than the equations explaining the long-wave measure. As expected, the short-term equations showed the influence of both monetary and real factors. The long-wave equation for corn revealed that a real factor played a significant role. Unfortunately, results for this equation also indicate that the coefficient for MS exhibited the wrong sign and was statistically significant. The long-wave equation for wheat, on the other hand, revealed that a real factor, TOT, was the only significant variable. In general, it was observed that MS was significant only in the case of corn (generating the wrong sign when the dependent variable was S_l). The variable σ_2 was found to be significant only for the short-run equations. The coefficient of TOT was statistically significant in all cases estimated for Trinidad and Tobago. On the other hand, the coefficient for OPE was not found to be significant in any case.

Table 4.6 shows the results for Brazil's real exchange variability equations using S and S_l. In the case of the dependent variable S associated with Brazilian corn imports, the money supply disturbances coefficient (MS) exhibited the expected positive sign, but it was not statistically significant in explaining the short-term measure of real effective exchange rate volatility. On the contrary, the coefficient for instability in the rate of devaluation of the nominal effective exchange rate (σ_2) was positive and highly significant. The coefficient for variability of the terms of trade, TOT, revealed the expected positive sign, but it was not significantly different from zero. The real variable measuring the average openness (OPE) generated the expected sign, but it did not play an important role in explaining S. In the case of the dependent variable S_l associated with Brazilian corn imports, results showed a positive, but still insignificant effect of money supply disturbances (MS) on the long-wave measure of real exchange rate variability. As expected, σ_2 produced a positive sign and had the more influential role on determining S_l. Volatility of the terms of trade, TOT, and average openness, OPE, generated the expected sign, but their coefficients were not were not found to be significantly different from zero.

In the case of the dependent variable, S, associated with Brazilian wheat imports, money supply instability (MS) had a significant and positive influence. Volatility in the rate of devaluation of the nominal effective exchange rate (σ_2) had also a highly dominant positive effect on the short-term measure of real effective exchange rate volatility. The coefficients for the real variables TOT and OPE exhibited the expected signs, but they were not significantly different from zero. In the case of the dependent variable, S_l, associated with

Table 4.6: Brazil: Sources of Real Exchange Rate Variability for Corn and Wheat.

Variable	Dependent variable: S		Dependent variable: S_l	
	Corn	Wheat	Corn	Wheat
Constant	1.812	0.883	5.682*	1.704
	(0.62)	(0.42)	(2.13)	(1.36)
MS	7.772	21.969*	16.614	-5.357
	(0.66)	(2.55)	(0.81)	(-0.39)
σ_2	57.697*	77.427*	17.676*	38.273*
	(6.96)	(32.934)	(5.63)	(21.49)
TOT	1.272	1.681	-53.695[a]	-10.177[a]
	(0.15)	(0.27)	(-1.33)	(-0.49)
OPE	-18.906	-23.461	4.449	43.519*
	(-0.30)	(-0.52)	(0.14)	(2.23)
R^2	0.61	0.98	0.67	0.95
$\overline{R}^2$	0.57	0.97	0.63	0.94
DW	0.70	0.42	0.85	1.03

Notes: Unless otherwise noted, variables are not lagged,
t-ratios are in parentheses,
* indicates significant at the 95% level,
[a] one quarter lag.

Brazilian wheat imports, results showed the expected sign for the coefficient of money supply disturbances, MS, but it was not found to be significant. Again, volatility of the domestic nominal exchange rate policy, measured by σ_2, was the most significant factor in explaining the long-wave measure of real exchange variability relevant for wheat importers. Volatility of the terms of trade (TOT) produced an unexpected negative sign, but its coefficients was not significantly different from zero. Average openness (OPE) also revealed a contradictory sign, but unfortunately its coefficient was found to be significant at the 95% level.

In summary, the equations modeling sources of Brazilian short-run real exchange variability performed better than the equations explaining the long-wave measure. Both short-term and long-wave equations showed that monetary factors were mainly responsible for volatility of the real exchange rate. However, the long-wave equation for wheat was not solely dominated by monetary factors, because OPE, exhibiting the wrong sign, was found to be significant. In general, it was observed that MS was significant only in the case of wheat (generating the wrong sign when the dependent variable is S_l). The variable σ_2 was found to be highly significant in all cases. On the other hand, variable TOT was insignificant in all cases estimated for Brazil and produced the wrong sign when the dependent variable was S_l. Also, the coefficient for variable OPE was not found to be significantly different from zero in most cases. Unfortunately, when the dependent variable was the longer-run measure of the real effective exchange rate variability (S_l) relevant for Brazilian wheat importers, OPE showed a contradictory and significant positive effect.

Chapter 5

Conclusions

Nominal and real exchange rate variability has been theoretically associated with increased risk that would inhibit the volume of internationally traded goods. This research focused on the study of the effects of nominal and real exchange rate uncertainty on the volume of grains imported by developing countries.

A variant of Hooper and Kohlhagen's model was used to investigate nominal exchange risk. The model was, nevertheless, expanded to admit a budget constraint affecting import decisions in developing countries. This model assumed that unpredictable fluctuations of nominal exchange rates were the only source of uncertainty. The model showed that an increase in the expected value of the nominal exchange rates reduced the volume of imported grains, as did an increase in nominal exchange rate uncertainty. On the other hand, a relaxation of the nominal budget constraint increased the quantity of grain imports.

To study the impact of real exchange rate uncertainty, the model developed by Cushman was modified to include a budget constraint. This model assumed that both prices and exchange rates were random and, thus, the uncertain variable of the model was the real exchange rate. An increase in either the expected value of the real exchange rate or in the uncertainty associated with this variable led to a decline in the level of imported grains. However, a relaxation of the real budget constraint increased the quantity of imports.

To study the potential sources of real exchange rate variability, the model developed by Edwards was used. This model assumed that both monetary and real disturbances affected real exchange variability in the short-run, while only real shocks were relevant in the long-run.

The import demand models under nominal and real exchange rate uncertainty were estimated for quarterly quantities of wheat and corn imported by Brazil and Trinidad and Tobago. Quarterly models of the potential sources of the real effective exchange rate variability relevant for corn and wheat were developed for Brazil and Trinidad and Tobago.

In the case of Trinidad and Tobago, the empirical nominal equations for wheat and corn tended weakly to support the theoretical model. In Brazil the nominal equation provided a good explanation of corn imports. Regression results for the nominal case revealed that nominal exchange rate risk was not a source of concern for Trinidad and Tobago's grain importers, as well as, Brazilian corn importers. Nominal effective exchange rate risk, however, played a small but significant role in explaining Brazilian wheat imports. In the countries under investigation, corn import decisions were affected by the level of the financial constraint. Foreign exchange did not affect Trinidad and Tobago's wheat imports, while it played a small but significant role in determining Brazilian wheat imports.

The real model explained well the imports of wheat and corn in Trinidad and Tobago. Risk effects varied across commodities. Thus, real effective exchange rate risk had a significant adverse influence on Trinidad and Tobago's wheat imports, whereas it did not affect significantly the level of Trinidad and Tobago's corn imports. The expectation variable effects also varied across commodities in Trinidad and Tobago. In fact, expected changes in the real effective exchange rate were solely relevant in the case of wheat imports. Foreign exchange, on the other hand, was important in determining both corn and wheat imports. Results for the Brazilian real model also revealed that risk effects varied across commodities. Real effective exchange rate risk played a substantial role in determining corn imports, while it was not significant in the case of wheat imports. Nevertheless, expected changes in the real effective exchange rate were an important variable in the decision of importing both grains. On the other hand, the real foreign exchange variable did not play any major role in explaining grain imports.

When estimating the sources of real effective exchange rate variability, two measures of variability were used: one was a short-run measure, while the other was a long-wave measure that was expected to capture a longer-term planning horizon, but not long-term swings in the real effective exchange rate. For both countries, the empirical equations modeling sources of short-run real exchange variability performed better than the equations explaining the long-wave measure. In Trinidad and Tobago, the short-term equations showed the influence of both monetary and real factors. Volatility in the terms of trade was an important explanatory variable for the variability in the real effective exchange rate of both corn and wheat. Instability in the domestic nominal effective exchange rate policy money supply was also important in both cases. However, monetary disturbances only had an influential role in explaining variability of the real exchange rate for corn. In Trinidad and Tobago, the long-wave equation for corn revealed the important role played by instability in the terms of trade (TOT) as explanatory variable. Unfortunately, the coefficient for money supply disturbances, MS, exhibited the wrong sign and was statistically significant. The long-wave equation for wheat, on the other hand, revealed that a real factor (TOT) was the only significant variable. In the case of Brazil, results for both short-term and long-wave equations showed that monetary factors were the more influential factors determining volatility of the real exchange rate. Money supply volatility was significant in the case of of the short-run measure for wheat, while volatility in the domestic nominal effective exchange rate policy money supply was an important source of variability for the two measures of variability in both corn and wheat. Additionally, results showed that the long-wave equation for Brazilian corn was solely dominated by monetary factors, revealing the ***short-run nature*** of the selected long-wave measure. The long-wave wheat equation was also highly influenced by monetary factors, but unfortunately showed contradictory and significant signs for the measure of openness.

In most cases, empirical results indicated that agricultural commodities were sensitive to either nominal or real exchange rate risk. However, Trinidad and Tobago's corn imports were not affected by any of the measures of of risk. Since risk effects varied across agricultural commodities and countries, it would be interesting to study risk effects on a large number of developing countries and to include more agricultural commodities. These findings also stress the need to explore different models and measures of risk. Additionally, it would be interesting to research the relationship between the exchange rate policy adopted by any particular country and the type and magnitude of risk effects, if any, on the volume of the major agricultural imports, using a large sample of developing countries.

The inclusion of a financial constraint proved to be important in the case of Trinidad and Tobago. In Brazil, the selected foreign exchange approximations did not accurately captured the expected positive effects of an increase in the level of foreign exchange on imported quantity. Also, in some cases a nominal measure of foreign exchange performed better than a real measure, and viceversa. Thus, research could focus on the construction of more adequate foreign exchange approximations to better capture its effects on agricultural imports.

The important role of monetary disturbances in explaining short-term variability of the real effective exchange rates relevant for importers of wheat and corn stress the need to advocate the design and implementation, by economic authorities, of policies aimed at reducing money supply and nominal effective exchange rate policy instability. Finally, empirical findings for the long-wave measure of real exchange variability were far from conclusive and additional investigation of the longer-term sources of real exchange rate variability is recommended, perhaps with different approximations for the long-run measure and also for the monetary and real variables.

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APPENDICES

Appendix A

Derivation of Relevant Equations

The demand for domestic output is given by:

$$Q = a + bP + cPS + dY. \tag{A.1}$$

Therefore, the inverse demand is

$$P = (Q - a - cPS - dY)/b. \tag{A.2}$$

Substituting Equation A.2 into the Lagrangian equation to be maximized (see Equation 3.8), the following expression is obtained

$$\max_q E[U(\tilde{L})] = E[U[(Q - a - cPS - dY)/b]Q - UCq - \tilde{R}P^*q + \lambda(FE - \tilde{R}P^*q)], \tag{A.3}$$

The maximization of the assumed negative exponential utility function yields the following decision rule

$$\max_q E[U(\tilde{L})] = \max_q E(\tilde{L}) - \phi[var(\tilde{L})]^{1/2}, \tag{A.4}$$

where ϕ denotes the firm's degree of absolute risk aversion. Using the decision rule, it is possible to obtain the first and second moments of the Lagrangian function (Equation A.3), which are

$$E(\tilde{L}) = [(Q - a - cPS - dY)/b]Q - UCq - RP^*q + \lambda(FE - RP^*q) \tag{A.5}$$

and

$$[Var(\tilde{L})]^{1/2} = \sigma P^*q + \lambda\sigma P^*q = (1 + \lambda)\sigma P^*q, \tag{A.6}$$

where σ is the standard deviation of $\tilde{R}$. Thus, the firm's maximization problem can be stated as

$$\max L = [(Q-a-cPS-dY)/b]Q - UCq - \tilde{R}P^*q + \lambda(FE - \tilde{R}P^*q) - \phi[(1+\lambda)\sigma P^*q]. \quad \text{(A.7)}$$

Using the relationship $Q = qk$, Equation A.7 can be expressed in terms of q as

$$\max L = [(kq-a-cPS-dY)/b]kq - UCq - \tilde{R}P^*q + \lambda(FE - \tilde{R}P^*q) - \phi(1+\lambda)\sigma P^*q], \quad \text{(A.8)}$$

or

$$\begin{aligned} \max L \;=\; & [(kq)^2 - akq - ckqPS - dkqY)/b - \\ & UCq - \tilde{R}P^*q + \lambda(FE - \tilde{R}P^*q) - \phi(1+\lambda)\sigma P^*q]. \end{aligned} \quad \text{(A.9)}$$

The Khun-Tucker conditions for the maximization problem expressed by Equation A.9 are:

$$\frac{\partial L}{\partial q} = (2k^2q - ak - ckPS - dkY)/b - UC - RP^* - \lambda RP^* - \phi(1+\lambda)P^*\sigma \leq 0, \quad \text{(A.10)}$$

$$q\frac{\partial L}{\partial q} = 0, \quad \text{(A.11)}$$

$$\frac{\partial L}{\partial \lambda} = FE - RP^*q - \phi P^*q\sigma \geq 0, \quad \text{(A.12)}$$

$$\lambda\frac{\partial L}{\partial \lambda} = 0, \quad \text{(A.13)}$$

$$q \geq 0, \quad \text{(A.14)}$$

and

$$\lambda \geq 0. \quad \text{(A.15)}$$

If $\lambda \geq 0$ and $q \geq 0$, the traditional maximization problem is solved. In this case, from Equation A.10 it is possible to solve for q as follows

$$(2k^2q - ak - ckPS - dkY_r)/b - -UC - RP^* - \phi P^*\sigma = 0. \quad \text{(A.16)}$$

Therefore,

$$q = \frac{(ak + ckPS + dkY)b}{b2k^2} + \frac{(UC + RP^* + \phi P^* \sigma)b}{2k^2}, \tag{A.17}$$

or

$$q = (a + cPS + dY)/2k + [(UC + RP^* + \phi P^* \sigma)b]/2k^2. \tag{A.18}$$

If $\lambda \geq 0$ and $q \geq 0$, it is possible to find a solution for q using the Khun-Tucker conditions. First, Equation A.12 is solved in terms of q as follows:

$$q = \frac{FE}{RP^* + \phi P^* \sigma}. \tag{A.19}$$

To solve for the unknown λ, Equation A.19 is substituted into Equation A.10 as follows:

$$\begin{aligned} 2k^2 \frac{FE}{RP^* + \phi P^* \sigma}/b + (-ak - ckPS - dkY)/b - & \\ UC - RP^* - \phi P^* \sigma - \lambda RP^* - \phi \lambda P^* \sigma &= 0. \end{aligned} \tag{A.20}$$

Asssuming that

$$A = (-ak - ckPS - dkY)/b - UC - RP^* - \phi P^* \sigma, \tag{A.21}$$

Equation A.20 can be rewritten as

$$2k^2 \frac{FE}{RP^* + \phi P^* \sigma}/b + A - \lambda(RP^* + \phi P^* \sigma) = 0. \tag{A.22}$$

From Equation A.22 it is possible to solve for λ as follows:

$$\lambda = \frac{\frac{2k^2 FE}{RP^* + \phi P^* \sigma}/b + A}{RP^* - \phi P^* \sigma)}, \tag{A.23}$$

or

$$\lambda = (2k^2 FE)/b + \frac{A}{RP^* + \phi P^* \sigma}. \tag{A.24}$$

Substituting λ into Equation A.10 it is possible to solve for q as

$$\begin{aligned} (2k^2 q - ak - ckPS - dkY)/b - UC - RP^* - & \\ \phi P^* \sigma - \left[(2k^2 FE)/b + \frac{A}{RP^* + \phi P^* \sigma} \right] (RP^* + \phi P^* \sigma) &= 0. \end{aligned} \tag{A.25}$$

or

$$(2k^2q - ak - ckPS - dkY)/b - UC - RP^* - \phi P^*\sigma -$$
$$(2k^2FE)(RP^* + \phi P^*\sigma)/b - A \quad = \quad 0, \tag{A.26}$$

or, substituting A

$$(2k^2q)/b + (-ak - ckPS - dkY)/b - UC - RP^* -$$
$$\phi P^*\sigma - (2k^2FE)(RP^* + \phi P^*\sigma)/b -$$
$$(-ak - ckPS - dkY - UC - RP^* - \phi P^*\sigma) \quad = \quad 0, \tag{A.27}$$

which implies that

$$\frac{2k^2q}{b} = \frac{2k^2FE}{b}(RP^* + \phi P^*\sigma) \tag{A.28}$$

The solution for q is therefore:

$$q = \frac{2k^2bFE(RP^* + \phi P^*\sigma)}{2k^2b}, \tag{A.29}$$

or

$$q = FERP^* + FE\phi P^*\sigma. \tag{A.30}$$

Appendix B

Selected Results

Table B.1: Real model for Trinidad and Tobago: Corn Import Equations with S.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0P_r^*$	M	S	R^2	$\overline{R}^2$	DW	ρ
-118.750		351.925	20.080	47.955	70.241	−59.404[a]	1.374	-1.379	0.75	0.71	1.13	-0.428
(-0.70)		(2.25)	(2.93)	(6.28)	(10.18)	(-2.10)	(0.79)	(-1.07)				(-2.92)
43.973		285.647	20.971	47.813	70.473	−45.882[a]	-0.351	0.263[a]	0.75	0.71	1.15	-0.418
(0.46)		(1.99)	(3.02)	(6.16)	(10.04)	(-1.72)	(-0.36)	(0.37)				(-2.83)
-141.033		349.739[a]	23.968	50.864	75.714	−57.004[a]	1.565	-1.422	0.75	0.71	1.14	-0.426
(-0.79)		(2.08)	(3.42)	(6.47)	(10.61)	(-2.01)	(0.86)	(-1.07)				(-2.90)
-40.372		323.950	20.490	47.851	70.480	−54.769[a]	0.549[a]	-0.681	0.75	0.71	1.14	-0.422
(-0.41)		(2.20)	(2.98)	(6.23)	(10.15)	(-2.01)	(0.55)	(-0.92)				(-2.87)
-13.185		312.965	20.902	47.632	70.227	−52.506[a]	0.273[b]	-0.541	0.75	0.70	1.14	-0.419
(-0.14)		(2.11)	(2.96)	(6.07)	(9.92)	(-1.90)	(0.29)	(-0.78)				(-2.80)
-94.349	−19.474[b]	361.769	20.768	48.127	70.261	−58.172[a]	1.152	-1.227	0.75	0.70	1.18	-0.402
(-0.52)	(-0.22)	(2.19)	(2.83)	(5.93)	(9.74)	(-2.03)	(0.63)	(-0.91)				(-2.63)
-34.093	−31.951[b]	351.833	21.255	48.234	70.502	−54.454[a]	0.535[a]	-0.673	0.75	0.70	1.15	-0.415
(-0.32)	(-0.38)	(2.13)	(2.94)	(5.96)	(9.83)	(-1.95)	(0.52)	(-0.89)				(-2.74)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.
[a] One quarter lag
[b] Two quarters lag

Table B.2: Real Model for Trinidad and Tobago: Corn Import Equations with S_l.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0P_r^*$	M_l	S_l	R^2	$\overline{R}^2$	DW	ρ
30.747		354.533	-68.500	-47.079	-19.830	-43.750^a	0.944	-0.439^f	0.75	0.71	1.11	-0.430
(0.18)		(2.15)	(-9.65)	(-5.94)	(-2.82)	(-1.63)	(0.45)	(-0.31)				(-2.89)
68.978		345.506	-68.656	-47.275	-20.106	-45.947^a	0.173^a	-0.096^f	0.75	0.71	1.11	-0.433
(0.39)		(2.09)	(-9.65)	(-5.91)	(-2.84)	(-1.73)	(0.09)	(-0.08)				(-2.92)
-72.794		271.285	21.027	48.010	70.694	-44.721^a	5.576	-4.065	0.75	0.71	1.15	-0.421
(-0.33)		(1.79)	(3.05)	(6.21)	(10.10)	(-1.65)	(0.62)	(-0.65)				(-2.86)
-7.205		298.906	20.757	47.753	70.424	-49.197^a	0.946^a	-0.662	0.75	0.71	1.14	-0.425
(-0.04)		(1.92)	(3.01)	(6.17)	(10.07)	(-1.84)	(0.45)	(-0.47)				(-2.90)
-4.644		278.895^a	23.963	50.091	74.870	-46.039^a	0.635^a	-0.433	0.74	0.69	1.15	-0.421
(-0.03)		(1.69)	(3.36)	(6.29)	(10.33)	(-1.72)	(0.30)	(-0.29)				(-2.86)
12.901	-38.660^b	327.741	21.615	48.265	70.516	-49.490^a	0.915^a	-0.754	0.74	0.68	1.18	-0.405
(0.08)	(-0.45)	(1.95)	(2.96)	(5.91)	(9.72)	(-1.83)	(0.43)	(-0.52)				(-2.66)
84.824	-24.010^b	358.535	-68.730	-46.719	-19.994	-45.979^a	0.114^a	-1.144^f	0.74	0.68	1.15	-0.408
(0.48)	(-0.28)	(2.04)	(-9.24)	(-5.53)	(-2.71)	(-1.71)	(0.06)	(-0.11)				(-2.64)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.
[a] One quarter lag
[b] Two quarters lag
[f] One quarter lead

Table B.3: Real Model for Trinidad and Tobago: Wheat Import Equations with S.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0 P_r^*$	M	S	R^2	$\overline{R}^2$	DW	ρ
-31.956		115.487	-76.288	-49.244	-20.966	-4.275	1.307^b	-0.741^f	0.94	0.93	1.94	0.023
(-1.06)		(2.79)	(-20.48)	(-13.39)	(-5.80)	(-0.70)	(4.49)	(-3.74)				(0.13)
-54.769		122.452	-76.678	-48.820	-20.943	-1.657	1.553^a	-1.046^f	0.94	0.93	1.84	-0.019
(-1.82)		(3.13)	(-22.01)	(-14.23)	(-6.16)	(-0.37)	(5.24)	(-5.20)				(-0.11)
-35.048		125.731^a	-78.322	-49.974	-21.863	-3.629	1.337^b	-0.721^f	0.94	0.93	1.93	0.020
(-1.16)		(2.95)	(-21.45)	(-13.81)	(-6.16)	(-0.61)	(4.61)	(-3.68)				(0.12)
-122.516		44.422	26.447	54.756	81.451	-1.837	1.505^a	-0.829	0.89	0.87	1.18	-0.202
(-2.07)		(0.63)	(5.65)	(10.85)	(17.04)	(-0.23)	(2.54)	(-2.09)				(-1.27)
-121.818		46.505^a	26.983	55.204	82.249	-1.312	1.490^a	-0.815	0.89	0.87	1.19	-0.198
(-2.09)		(0.65)	(5.69)	(10.85)	(17.10)	(-0.17)	(2.57)	(-2.08)				(-1.25)
-124.300	11.077^a	34.980^a	26.811	55.163	82.362	-0.943	1.499^a	-0.819	0.89	0.87	1.19	-0.198
(-2.06)	(0.19)	(0.38)	(5.49)	(10.70)	(16.78)	(-0.12)	(2.54)	(-2.06)				(-1.23)
-32.942	4.030^a	111.743	-76.397	-49.366	-21.052	-4.072	1.311^b	-0.738^f	0.94	0.93	1.94	0.025
(-1.03)	(0.10)	(2.02)	(-19.50)	(-12.63)	(-5.61)	(-0.62)	(4.41)	(-3.65)				(0.15)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.
[a] One quarter lag
[b] Two quarters lag
[f] One quarter lead

Table B.4: Real Model for Trinidad and Tobago: Wheat Import Equations with S_l.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0P_r^*$	M_l	S_l	R^2	$\overline{R}^2$	DW	ρ
-12.055		84.187[a]	-79.624	-50.615	-22.584	1.815	3.065	−1.703[f]	0.91	0.89	1.62	-0.180
(-0.21)		(1.47)	(-18.32)	(-11.83)	(-5.34)	(0.33)	(3.26)	(-2.55)				(-1.11)
-28.562		102.417[b]	-78.546	-52.231	-22.027	-3.422	3.313	−1.783[f]	0.91	0.89	1.61	-1.188
(-0.48)		(1.66)	(-18.20)	(-12.20)	(-5.23)	(-0.48)	(3.49)	(-2.70)				(-1.15)
-21.707		98.212[b]	-78.509	-52.369	-22.480	4.757[a]	3.030	−1.603[f]	0.92	0.91	1.62	-0.192
(-0.37)		(1.61)	(-18.43)	(-12.32)	(-5.38)	(0.88)	(3.25)	(-2.45)				(-1.17)
-198.147		57.905[b]	24.862	54.700	81.974	-3.285	5.464[a]	-2.814	0.92	0.91	1.81	-0.054
(-3.52)		(1.01)	(5.68)	(12.87)	(19.14)	(-0.47)	(5.92)	(-4.27)				(-0.33)
-214.627		81.959[c]	25.097	53.179	81.993	-6.247	5.579[a]	-2.782	0.93	0.92	1.83	-0.045
(-3.59)		(1.31)	(5.76)	(12.07)	(19.06)	(-0.77)	(5.98)	(-4.26)				(-0.273)
-32.325	11.917[a]	90.816[b]	-78.755	-52.408	-22.210	-3.026	3.331	−1.780[f]	0.92	0.90	1.61	-0.189
(-0.52)	(0.26)	(1.18)	(-17.71)	(-11.94)	(-5.13)	(-0.41)	(3.45)	(-2.66)				(-1.14)
-212.611	−12.765[a]	96.716[c]	25.143	52.956	81.779	-6.906	5.589[a]	-2.791	0.93	0.91	1.83	-0.044
(-3.48)	(-0.26)	(1.14)	(5.69)	(11.65)	(18.45)	(-0.81)	(5.91)	(-4.21)				(-0.26)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.

[a] One quarter lag

[b] Two quarters lag

[c] Three quarters lag

[f] One quarter lead

Table B.5: Real Model for Brazil: Corn Import Equations with S.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0 P_r^*$	M	S	R^2	$\overline{R}^2$	DW	ρ
-1964.918	434.803[b]	-628.080	-627.984	-579.495	-196.312	−196.332[a]	18.800[f]	6.808	0.38	0.25	1.40	-0.290
(-1.43)	(0.97)	(-0.44)	(-3.20)	(-2.81)	(-1.06)	(-0.95)	(1.69)	(0.93)				(-1.80)
-2078.376	403.459[b]	-650.210	-624.736	-566.929	-205.326	−207.314[a]	20.532[f]	6.096[a]	0.37	0.23	1.34	-0.316
(-1.52)	(0.89)	(-0.45)	(-3.20)	(-2.74)	(-1.10)	(-0.99)	(1.93)	(0.83)				(-1.97)
-2420.914	883.397[b]	-2048.827	-761.319	-720.928	-131.227	−413.398[a]	27.599[f]	−8.318[c]	0.41	0.28	1.44	-0.271
(-1.71)	(2.14)	(-1.59)	(-4.07)	(-3.46)	(-0.72)	(-1.80)	(2.57)	(-1.29)				(-1.64)
-2503.163	843.784[b]	-2071.909	-769.811	-611.557	-101.748	-511.513	27.988[f]	−7.291[c]	0.39	0.25	1.45	-0.256
(-1.70)	(1.91)	(-1.56)	(-4.00)	(-2.81)	(-0.54)	(-1.37)	(2.56)	(-1.12)				(-1.54)
-2154.612	643.335[b]	−918.686[a]	-679.766	-740.744	-253.912	−430.371[a]	25.686[f]	−6.631[c]	0.37	0.23	1.36	-0.318
(-1.42)	(1.56)	(-0.62)	(-3.68)	(-3.02)	(-1.47)	(-1.65)	(2.30)	(-0.90)				(-1.95)
-2911.598	920.935[b]	-1691.466	-3.845	608.541	-747.618	−289.479[a]	23.206	−5.871[c]	0.39	0.25	1.58	-0.204
(-1.89)	(2.21)	(-1.30)	(-0.02)	(2.44)	(3.86)	(-1.21)	(2.14)	(-0.94)				(-1.24)
-1137.289	483.594[b]	-1557.832	29.978	458.291	673.553	−408.289[a]	12.613[a]	−6.516[c]	0.33	0.18	1.30	-0.344
(-0.80)	(1.16)	(-1.15)	(0.17)	(1.86)	(3.62)	(-1.65)	(1.17)	(-0.95)				(-2.17)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.

[a] One quarter lag
[b] Two quarters lag
[c] Three quarters lag
[f] One quarter lead

Table B.6: Real Model for Brazil: Corn Import Equations with S_l.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0P_r^*$	M_l	S_l	R^2	$\overline{R}^2$	DW	ρ
-3858.345	564.886[a]	-1329.369	335.275	465.550	614.482	-63.928	52.621	-15.498	0.38	0.25	1.21	-0.383
(-2.08)	(1.50)	(-0.96)	(1.39)	(1.96)	(3.70)	(-0.27)	(1.96)	(-1.09)				(-2.52)
-3370.420	481.569[a]	-785.490	260.028	393.305	577.158	-38.344	32.438	−3.265[a]	0.37	0.24	1.24	-0.369
(-1.74)	(1.29)	(-0.59)	(1.12)	(1.68)	(3.45)	(-0.14)	(1.74)	(-0.35)				(-2.41)
-517.561	464.198[a]	-1894.557	378.898	529.818	661.025	-940.030	34.482	−22.755[c]	0.47	0.35	1.13	-0.430
(-0.25)	(1.28)	(-1.52)	(1.73)	(2.45)	(4.31)	(-2.12)	(2.17)	(-2.64)				(-2.82)
-463.501	711.465[a]	-1828.134	-714.282	-178.606	-91.373	-842.813	33.589[f]	−20.368[c]	0.44	0.32	1.31	-0.338
(-0.18)	(1.88)	(-1.37)	(-4.26)	(-0.89)	(-0.52)	(-1.83)	(1.72)	(-2.39)				(-2.09)
944.133	407.855[a]	-2240.368	363.795	514.591	667.191	-786.100	27.371[d]	−26.494[c]	0.47	0.35	0.94	-0.525
(0.46)	(1.06)	(-1.79)	(1.59)	(2.32)	(4.32)	(-1.55)	(1.57)	(-2.73)				(-3.60)
-82.959	437.802[a]	-1786.649	310.686	465.784	617.907	−269.788[d]	31.914[d]	−23.628[e]	0.45	0.32	0.99	-0.500
(-0.04)	(1.13)	(-1.48)	(1.38)	(2.10)	(4.06)	(-1.10)	(1.83)	(-2.49)				(-3.37)
-1648.223	423.720[a]	−486.559[a]	229.827	366.107	589.805	-707.916	38.881	−19.002[c]	0.44	0.32	1.15	-0.416
(-0.79)	(1.12)	(-0.40)	(1.15)	(1.92)	(3.79)	(-1.62)	(2.40)	(-2.19)				(-2.71)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.
[a] One quarter lag
[c] Three quarters lag
[d] Four quarters lag
[f] One quarter lead

Table B.7: Real Model for Brazil: Wheat Import Equations with S.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0P_r^*$	M	S	R^2	$\overline{R}^2$	DW	ρ
-237.333		-972.380^b	744.986	1796.058	2908.609	-154.113^c	13.034^d	-1.118^b	0.92	0.90	0.76	-0.589
(-0.37)		(-0.71)	(5.05)	(9.59)	(20.058)	(-1.27)	(2.41)	(-0.38)				(-4.31)
-182.962		-1528.898^d	832.027	1953.219	2980.802	-144.279^c	12.793^d	-2.110^b	0.92	0.90	0.71	-0.583
(-0.29)		(-1.06)	(5.53)	(10.56)	(19.56)	(-1.22)	(2.43)	(-0.69)				(-4.24)
-1273.313		126.575^e	814.286	1869.678	2956.543	-265.211^c	18.128^d	4.623	0.93	0.92	0.78	-0.574
(-1.35)		(0.08)	(5.18)	(11.45)	(19.82)	(-1.77)	(2.76)	(1.16)				(-4.08)
-355.921		-1011.139^e	768.320	1866.977	2979.866	-264.433^c	14.143^d	-1.494^b	0.92	0.90	0.82	-0.548
(-0.54)		(-0.62)	(4.72)	(11.09)	(19.32)	(-1.74)	(2.61)	(-0.47)				(-3.82)
-433.606		-821.995^e	776.346	1867.322	2973.803	-253.636^c	14.230^d	-0.756^c	0.92	0.90	0.81	-0.552
(-0.68)		(-0.51)	(4.78)	(11.08)	(19.36)	(-1.67)	(2.55)	(-0.24)				(-3.86)
821.049		-259.001^e	793.707	1865.403	2955.238	-247.278^c	2.286^c	-0.961^b	0.90	0.88	0.81	-0.532
(0.99)		(-0.14)	(4.39)	(10.01)	(17.32)	(-1.44)	(0.36)	(-0.27)				(-3.66)
-40.916	-282.861^a	-1372.608^e	638.440	1774.368	2958.901	-307.271^c	15.521^d	-1.431^b	0.91	0.89	1.06	-0.439
(-0.04)	(-0.63)	(-0.83)	(2.62)	(7.89)	(17.18)	(-1.96)	(2.87)	(-0.43)				(-2.81)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.
[a] One quarter lag
[b] Two quarters lag
[c] Three quarters lag
[d] Four quarters lag
[e] Five quarters lag

Table B.8: Real Model for Brazil: Wheat Import Equations with S_l.

Expected Sign:	(+)	(+)				(−)	(+)	(−)				
Constant	Y_r	F_r	D_1	D_2	D_3	$Z_0P_r^*$	M_l	S_l	R^2	$\overline{R}^2$	DW	ρ
2068.140		−1554.485[d]	-3014.433	-2198.981	-1089.979	−218.209[c]	25.834	−4.783[f]	0.93	0.92	0.70	-0.603
(1.42)		(-0.98)	(-19.03)	(-13.21)	(-7.13)	(-1.79)	(2.02)	(-0.83)				(-4.40)
1114.993		−2571.194[d]	-3052.511	-2213.921	-1089.569	−233.866[c]	27.287[c]	1.541[f]	0.92	0.90	1.04	-0.423
(0.81)		(-1.60)	(-17.81)	(-12.38)	(-6.62)	(-2.09)	(2.64)	(0.31)				(-2.72)
-1661.634		−1661.974[d]	834.952	1952.198	2974.128	−194.124[c]	23.708[c]	1.344[b]	0.91	0.89	0.87	-0.492
(-1.36)		(-1.14)	(5.16)	(9.95)	(18.17)	(-1.59)	(1.83)	(0.25)				(-3.34)
-1809.507		−1471.502[d]	823.463	1940.750	2965.698	−184.548[c]	22.996[c]	2.704[a]	0.91	0.89	0.89	-0.488
(-1.45)		(-0.97)	(5.04)	(9.83)	(18.03)	(-1.51)	(1.90)	(0.53)				(-3.30)
-1715.322		−539.122[e]	788.037	1866.638	2959.198	−283.440[c]	22.540[c]	1.982[b]	0.91	0.89	0.97	-0.458
(-1.37)		(-0.33)	(4.44)	(10.14)	(17.50)	(-1.71)	(1.73)	(0.34)				(-3.00)
-2302.526	−306.014[b]	−1211.157[d]	-2948.529	-2121.596	-1139.111	−236.051[c]	27.172	−5.264[f]	0.92	0.90	0.87	-0.536
(1.53)	(-0.66)	(-0.72)	(-15.38)	(-10.06)	(-6.59)	(-1.92)	(2.09)	(-0.88)				(-3.65)
1475.462	−402.372[b]	−2153.45[d]	-2967.232	-2110.836	-1149.982	−260.750[c]	28.371[c]	0.988[f]	0.91	0.89	1.15	-0.382
(1.01)	(-0.89)	(-1.28)	(-14.87)	(-9.76)	(-6.35)	(-2.27)	(2.81)	(0.20)				(-2.37)

Notes: All variables are not lagged unless otherwise noted; t-ratios are in parentheses.
[a] One quarter lag
[b] Two quarters lag
[c] Three quarters lag
[d] Four quarters lag
[e] Five quarters lag
[f] One quarter lead

Appendix C

Selected Data

Table C.1: Foreign Exchange for Brazil and Trinidad Tobago (in millions of U.S. dollars).

Year[a] [b]	Quarter	Brazil	Trinidad Tobago
1974	1	6150.0	51.1
1974	2	6130.0	88.5
1974	3	5315.0	244.4
1974	4	4874.0	374.9
1975	1	4097.0	336.3
1975	2	3398.0	389.3
1975	3	3387.0	498.2
1975	4	3653.0	720.2
1976	1	3166.0	641.9
1976	2	3305.0	901.6
1976	3	4175.0	890.0
1976	4	6101.0	972.5
1977	1	5375.0	917.4
1977	2	5253.0	996.9
1977	3	5539.0	1200.0
1977	4	6787.0	1433.4
1978	1	6795.0	1383.2
1978	2	7644.0	1511.8
1978	3	9550.0	1614.1
1978	4	11406.0	1744.0
1979	1	10550.0	1624.1
1979	2	9489.0	1668.4
1979	3	8674.0	1647.5
1979	4	8342.0	2047.0
1980	1	6185.0	1876.6
1980	2	4825.0	1834.5
1980	3	4534.0	2157.7
1980	4	5042.0	2654.1
1981	1	4749.0	2397.0
1981	2	4496.0	2559.9
1981	3	4759.0	2798.0
1981	4	5888.0	3196.7
1982	1	5594.0	2932.3
1982	2	5428.0	2991.7
1982	3	3714.0	2851.3
1982	4	3641.0	2892.8

[a]Source: International Monetary Fund, *International Financial Statistics*, various issues.
[b]End of the period foreign exchange.

Table C.1 Continued.

Year	Quarter	Brazil	Trinidad Tobago
1983	1	3389.0	2413.1
1983	2	3758.0	2291.5
1983	3	3853.0	1972.5
1983	4	4355.0	1881.5
1984	1	5618.0	1568.7
1984	2	7570.0	1436.0
1984	3	9233.0	1253.3
1984	4	11507.0	1131.3
1985	1	10660.0	816.7
1985	2	10758.0	799.5
1985	3	10886.0	640.1
1985	4	10604.0	873.5
1986	1	8970.0	573.9
1986	2	9225.0	531.4
1986	3	7686.0	301.0
1986	4	5803.0	242.8
1987	1	3916.0	225.3
1987	2	4499.0	216.6
1987	3	6090.0	119.7
1987	4	6299.0	112.6

Table C.2: Consumer Prices Indices of Selected Countries (1985 = 100).

Year[a]	Quarter	U.S.A.	France	Australia	South Africa	Thailand	Canada
1974	1	43.89	32.57	33.05	24.73	44.01	39.58
1974	2	45.15	33.92	34.39	25.50	47.23	40.92
1974	3	46.55	35.04	36.17	26.63	47.92	42.16
1974	4	47.90	36.16	37.51	27.51	48.61	43.31
1975	1	48.75	37.13	38.86	28.43	48.56	44.23
1975	2	49.50	38.05	40.24	29.26	49.35	45.19
1975	3	50.60	38.86	40.52	30.06	49.60	46.76
1975	4	51.40	39.71	42.79	30.71	50.29	47.72
1976	1	51.90	40.68	44.05	31.45	50.98	48.32
1976	2	52.55	41.64	45.19	32.55	51.13	49.06
1976	3	53.35	42.57	46.16	33.47	51.38	49.79
1976	4	53.95	43.69	48.96	34.18	52.57	50.53
1977	1	54.91	44.34	50.06	35.16	53.11	51.63
1977	2	56.11	45.73	51.24	36.22	55.04	52.83
1977	3	56.91	46.81	52.25	37.23	56.47	53.98
1977	4	57.56	47.70	53.47	37.85	57.07	55.13
1978	1	58.51	48.43	54.16	38.65	57.76	56.18
1978	2	60.06	49.82	55.30	39.27	59.49	57.52
1978	3	61.46	51.13	56.35	41.38	60.58	58.99
1978	4	62.66	52.22	57.61	42.09	61.42	59.91
1979	1	64.27	53.37	58.63	43.15	61.81	61.29
1979	2	66.47	54.84	60.17	44.40	63.74	62.90
1979	3	68.67	56.65	61.55	47.06	67.25	64.09
1979	4	70.67	58.24	63.42	48.01	70.07	65.61
1980	1	73.42	60.47	64.80	48.99	74.03	67.03
1980	2	76.08	62.37	66.59	50.59	78.68	68.92
1980	3	77.48	64.37	67.84	52.81	80.06	70.89
1980	4	79.53	66.15	69.27	55.24	81.99	72.87
1981	1	81.63	68.12	70.93	56.81	85.06	75.22
1981	2	83.53	70.35	72.47	58.20	88.52	77.56
1981	3	85.94	72.96	74.02	61.10	89.51	79.86
1981	4	87.13	75.30	77.05	63.14	91.50	81.82
1982	1	87.89	77.45	78.39	64.95	92.21	83.92
1982	2	89.19	79.86	80.27	67.70	93.08	86.50
1982	3	90.88	80.94	83.09	69.73	93.31	88.32
1982	4	91.11	82.46	85.50	72.07	94.65	89.72
1983	1	91.03	84.61	87.38	74.25	94.33	90.28
1983	2	92.18	87.02	89.26	76.22	96.46	91.54
1983	3	93.26	88.85	90.80	77.93	97.80	93.07
1983	4	94.10	90.56	92.95	79.80	98.50	93.85

[a]Source: International Monetary Fund, *International Financial Statistics*, various issues.

Table C.2 Continued.

Year	Quarter	U.S.A.	France	Australia	South Africa	Thailand	Canada
1984	1	95.09	92.08	92.55	81.83	97.25	94.96
1984	2	96.17	93.79	92.75	84.79	97.88	95.80
1984	3	97.24	95.38	93.96	87.38	97.64	96.64
1984	4	97.93	96.71	95.30	90.19	97.64	97.34
1985	1	98.54	98.04	96.64	94.08	98.58	98.46
1985	2	99.77	99.81	98.93	98.44	99.84	99.58
1985	3	100.46	100.76	101.14	101.61	100.47	100.49
1985	4	101.38	101.39	103.15	105.92	101.02	101.40
1986	1	101.60	101.50	106.00	112.10	100.90	102.70
1986	2	101.30	102.20	107.00	115.80	101.70	103.50
1986	3	102.10	102.90	110.00	120.80	102.10	104.70
1986	4	102.60	103.50	113.00	125.80	102.70	105.80
1987	1	103.80	104.80	116.00	130.50	102.70	106.80
1987	2	105.10	105.70	117.00	135.40	103.70	108.30
1987	3	106.30	106.30	119.00	140.10	105.00	109.50
1987	4	107.20	106.80	121.00	144.80	106.00	110.30

Table C.3: Consumer Prices Indices of Latin American Countries (1985 = 100).

Year[a] [b]	Quarter	Brazil	Trinidad Tobago	Argentina
1974	1	0.0912	24.07	0.000107
1974	2	0.1009	25.56	0.000114
1974	3	0.1066	26.59	0.000123
1974	4	0.1120	27.81	0.000142
1975	1	0.1195	29.45	0.000169
1975	2	0.1269	30.03	0.000217
1975	3	0.1369	30.76	0.000402
1975	4	0.1464	31.43	0.000587
1976	1	0.1629	32.50	0.000940
1976	2	0.1808	32.95	0.001761
1976	3	0.1961	33.90	0.002080
1976	4	0.2116	35.17	0.002710
1977	1	0.2358	36.21	0.003540
1977	2	0.2611	37.06	0.004320
1977	3	0.2807	38.00	0.005490
1977	4	0.3026	39.07	0.007320
1978	1	0.3276	39.98	0.009600
1978	2	0.3576	40.86	0.012480
1978	3	0.3935	42.02	0.015300
1978	4	0.4208	42.90	0.019560
1979	1	0.4686	44.42	0.025830
1979	2	0.5211	46.10	0.032100
1979	3	0.5984	48.87	0.041130
1979	4	0.7013	50.75	0.048710
1980	1	0.8219	53.25	0.057710
1980	2	0.9432	54.25	0.068470
1980	3	1.1102	56.60	0.078550
1980	4	1.3100	59.33	0.091930
1981	1	1.6267	61.55	0.105200
1981	2	1.9381	62.50	0.129500
1981	3	2.3454	64.64	0.167100
1981	4	2.6936	66.76	0.204700
1982	1	3.2126	69.05	0.260300
1982	2	3.8552	70.11	0.298100
1982	3	4.6295	72.18	0.427900
1982	4	5.3380	73.80	0.620000
1983	1	6.6820	80.39	0.897400
1983	2	8.4900	82.23	1.231900
1983	3	11.4000	84.30	1.876400
1983	4	14.6600	85.47	3.123100

[a]Source: International Monetary Fund, *International Financial Statistics*, various issues.
[b]End of the period exchange rates expressed as units of domestic currency per U.S. dollar.

Table C.3 Continued.

Year	Quarter	Brazil	Trinidad Tobago	Argentina
1984	1	19.2100	28.500	4.905300
1984	2	25.0800	34.270	8.119700
1984	3	33.4600	40.560	14.169300
1984	4	44.5800	48.530	24.610000
1985	1	61.9700	64.730	44.863000
1985	2	79.5000	87.830	92.250000
1985	3	109.3500	116.780	126.940000
1985	4	149.1800	130.660	135.950000
1986	1	225.2400	148.000	148.000000
1986	2	243.4400	167.000	167.000000
1986	3	249.0000	187.000	202.000000
1986	4	264.0000	210.000	243.000000
1987	1	365.0000	246.000	293.000000
1987	2	643.0000	292.000	344.000000
1987	3	935.0000	352.000	459.000000
1987	4	1290.0000	432.000	663.000000

Table C.4: Quarterly Exchange Rates of Latin American Countries.

Year[a,b]	Quarter	Brazil	Trinidad Tobago	Argentina
1974	1	0.0065	2.0050	0.00000050
1974	2	0.0068	2.0080	0.00000050
1974	3	0.0071	2.0580	0.00000050
1974	4	0.0074	2.0439	0.00000050
1975	1	0.0077	1.9925	0.00000100
1975	2	0.0081	2.1838	0.00000260
1975	3	0.0085	2.3519	0.00000364
1975	4	0.0091	2.3721	0.00000609
1976	1	0.0099	2.5056	0.00001402
1976	2	0.0108	2.4000	0.00001402
1976	3	0.0114	2.4000	0.00001402
1976	4	0.0123	2.4000	0.00002745
1977	1	0.0131	2.4000	0.00003365
1977	2	0.0144	2.4000	0.00003905
1977	3	0.0150	2.4000	0.00004375
1977	4	0.0161	2.4000	0.00005975
1978	1	0.0169	2.4000	0.00007210
1978	2	0.0180	2.4000	0.00007885
1978	3	0.0193	2.4000	0.00008665
1978	4	0.0209	2.4000	0.00010035
1979	1	0.0231	2.4000	0.00011565
1979	2	0.0257	2.4000	0.00013165
1979	3	0.0298	2.4000	0.00014725
1979	4	0.0425	2.4000	0.00016185
1980	1	0.0468	2.4000	0.00017475
1980	2	0.0523	2.4000	0.00018545
1980	3	0.0576	2.4000	0.00019335
1980	4	0.0655	2.4000	0.00019925
1981	1	0.0765	2.4000	0.00024000
1981	2	0.0914	2.4000	0.00045000
1981	3	0.1086	2.4000	0.00058000
1981	4	0.1278	2.4000	0.00072000
1982	1	0.1482	2.4000	0.00116000
1982	2	0.1732	2.4000	0.00157000
1982	3	0.2072	2.4000	0.00390000
1982	4	0.2527	2.4000	0.00485000
1983	1	0.4175	2.4000	0.00673000
1983	2	0.5430	2.4000	0.00888000
1983	3	0.7380	2.4000	0.01308000
1983	4	0.9840	2.4000	0.02326000

[a] Source: International Monetary Fund *International Finance Statistics*, various Issues

[b] End of the period exchange rates expressed as units of domestic currency per U.S. dollar.

Table C.4 Continued.

Year	Quarter	Brazil	Trinidad Tobago	Argentina
1984	1	1.3350	2.4000	0.03272000
1984	2	1.7280	2.4000	0.05124000
1984	3	2.3290	2.4000	0.09179000
1984	4	3.1840	2.4000	0.17874000
1985	1	4.4500	2.4000	0.34274000
1985	2	5.9800	2.4000	0.80050000
1985	3	7.8250	2.4000	0.80050000
1985	4	10.4900	3.6000	0.80050000
1986	1	13.8400	3.6000	0.80100000
1986	2	13.8400	3.6000	0.89100000
1986	3	13.8400	3.6000	1.06900000
1986	4	14.9000	3.6000	1.25700000
1987	1	22.1400	3.6000	1.54000000
1987	2	43.3800	3.6000	1.80000000
1987	3	51.2800	3.6000	2.63000000
1987	4	72.2500	3.6000	3.75000000

Table C.5: Quarterly Exchange Rates of Selected Countries.

Year[a] [b]	Quarter	France	Australia	South Africa	Thailand	Canada
1974	1	4.8644	1.4880	1.4900	20.375	0.9724
1974	2	4.8229	1.4880	1.5000	20.375	0.9722
1974	3	4.7413	1.3100	1.4300	20.375	0.9858
1974	4	4.4445	1.3270	1.4501	20.375	0.9912
1975	1	4.2155	1.3537	1.4900	20.375	1.0032
1975	2	4.0400	1.3258	1.4000	20.375	1.0306
1975	3	4.5358	1.2560	1.1500	20.375	1.0252
1975	4	4.4855	1.2571	1.1500	20.400	1.0164
1976	1	4.6690	1.2486	1.1500	20.400	0.9842
1976	2	4.7403	1.2356	1.1500	20.400	0.9686
1976	3	4.9269	1.2373	1.1500	20.400	0.9732
1976	4	4.9698	1.0864	1.1500	20.400	1.0092
1977	1	4.9693	1.1031	1.1500	20.400	1.0586
1977	2	4.9193	1.1155	1.1500	20.400	1.0599
1977	3	4.9033	1.1076	1.1500	20.400	1.0734
1977	4	4.7050	1.1414	1.1500	20.400	1.0944
1978	1	4.5805	1.1431	1.1500	20.400	1.1322
1978	2	4.5015	1.1475	1.1500	20.400	1.1245
1978	3	4.3310	1.1566	1.1500	20.200	1.1831
1978	4	4.1800	1.1505	1.1500	20.390	1.1860
1979	1	4.2970	1.1182	1.1823	20.425	1.1606
1979	2	4.2850	1.1211	1.1797	20.425	1.1678
1979	3	4.1005	1.1298	1.2071	20.400	1.1606
1979	4	4.0200	1.1055	1.2094	20.425	1.1681
1980	1	4.4785	1.0831	1.2348	20.425	1.1914
1980	2	4.0870	1.1576	1.2989	20.405	1.1510
1980	3	4.1995	1.1690	1.3274	20.488	1.1705
1980	4	4.5160	1.1807	1.3416	20.630	1.1947
1981	1	4.9580	1.1684	1.2525	20.700	1.1868
1981	2	5.7175	1.1480	1.1315	21.000	1.2005
1981	3	5.5670	1.1414	1.0474	23.000	1.2068
1981	4	5.7480	1.1279	1.0454	23.000	1.1859
1982	1	6.2420	1.0503	0.9500	23.000	1.2303
1982	2	6.8290	1.0223	0.8748	23.000	1.2930
1982	3	7.1380	0.9493	0.8667	23.000	1.2363
1982	4	6.7250	0.9806	0.9291	23.000	1.2294
1983	1	7.2695	0.8629	0.9135	23.000	1.2339
1983	2	7.6375	0.8745	0.9149	23.000	1.2273
1983	3	8.0090	0.8965	0.9065	23.000	1.2323
1983	4	8.3475	0.8925	0.8184	23.000	1.2444

[a]Source: International Monetary Fund, *International Financial Statistics*, various issues.
[b]End of the period exchange rates expressed as units of domestic currency per U.S. dollar.

Table C.5 Continued.

Year	Quarter	France	Australia	South Africa	Thailand	Canada
1984	1	7.9800	0.9350	0.8093	23.000	1.2765
1984	2	8.5445	0.8613	0.7380	23.000	1.3194
1984	3	9.2840	0.8330	0.5988	23.000	1.3180
1984	4	9.5920	0.8278	0.5038	27.150	1.3214
1985	1	9.4270	0.7051	0.5250	27.550	1.3670
1985	2	9.3170	0.6655	0.5080	27.420	1.3587
1985	3	8.1525	0.7077	0.3905	26.300	1.3710
1985	4	7.5610	0.6809	0.3910	26.650	1.3975
1986	1	7.1325	0.7119	0.4750	26.470	1.3973
1986	2	7.0115	0.6772	0.4045	26.300	1.3867
1986	3	6.6220	0.6274	0.4495	26.070	1.3885
1986	4	6.4550	0.6648	0.4580	26.130	1.3805
1987	1	6.0130	0.7053	0.4955	25.870	1.3051
1987	2	6.1055	0.7203	0.4889	25.840	1.3312
1987	3	6.1180	0.7194	0.4817	25.830	1.3091
1987	4	5.3400	0.7225	0.5182	25.070	1.2998

Table C.6: International Prices of Wheat and Corn ($/mt).

Year[a] [b]	Quarter	Wheat	Corn
1974	1	194.33	126.37
1974	2	157.26	116.53
1974	3	170.49	141.33
1974	4	185.92	148.81
1975	1	145.50	123.22
1975	2	127.50	120.86
1975	3	159.84	123.22
1975	4	143.67	110.62
1976	1	153.58	114.56
1976	2	146.61	123.62
1976	3	121.62	119.68
1976	4	107.66	105.11
1977	1	109.13	109.44
1977	2	94.06	96.45
1977	3	102.15	81.49
1977	4	116.84	100.39
1978	1	126.03	110.23
1978	2	129.34	110.62
1978	3	133.75	96.45
1978	4	138.89	101.57
1979	1	142.57	111.81
1979	2	167.18	123.22
1979	3	178.57	120.47
1979	4	184.09	120.86
1980	1	168.00	114.00
1980	2	159.00	115.00
1980	3	182.00	144.00
1980	4	188.00	151.00
1981	1	176.00	144.00
1981	2	170.00	139.00
1981	3	173.00	122.00
1981	4	174.00	110.00
1982	1	170.00	116.00
1982	2	152.00	115.00
1982	3	155.00	102.00
1982	4	161.00	107.00
1983	1	167.00	124.00
1983	2	151.00	136.00
1983	3	157.00	151.00
1983	4	153.00	144.00

[a]Source: International Monetary Fund, *International Financial Statistics*, various issues.

[b]Price of wheat U.S. # 3, hard winter, ordinary protein, f.o.b. vessel, and gulf ports. Price of corn U.S. # 2 yellow, f.o.b. vessel, and gulf ports.

Table C.6 Continued.

Year	Quarter	Wheat	Corn
1984	1	155.00	149.00
1984	2	151.00	147.00
1984	3	157.00	135.00
1984	4	150.00	117.00
1985	1	146.00	122.00
1985	2	134.00	117.00
1985	3	128.00	103.00
1985	4	139.00	111.00
1986	1	136.00	101.00
1986	2	107.00	106.00
1986	3	104.00	67.00
1986	4	109.00	74.00
1987	1	116.00	73.00
1987	2	110.00	82.00
1987	3	114.00	74.00
1987	4	126.00	84.00

Table C.7: Corn and Wheat Exporter's Share (%).

Year[a,b]	Qtr	Corn					Wheat				
		SAF[c]	USA[d]	ARG[e]	THA[f]	FRA[g]	CAN[h]	USA	ARG	FRA	AUS[i]
1974	1	1.59	67.44	7.11	7.22	12.18	13.57	45.00	1.98	13.78	11.95
1974	2	3.79	67.50	9.36	4.52	9.81	16.07	38.78	1.93	14.42	14.20
1974	3	4.23	65.41	10.50	4.45	9.15	16.48	39.56	1.71	13.59	12.55
1974	4	4.59	63.40	11.73	4.80	8.14	16.92	41.77	2.87	12.27	12.07
1975	1	6.23	74.05	5.67	4.82	1.90	3.93	50.34	5.10	8.29	17.98
1975	2	5.98	64.45	10.57	3.48	4.57	16.55	41.80	2.92	10.36	15.61
1975	3	6.65	61.79	9.92	3.49	5.86	15.77	45.87	2.35	10.73	13.44
1975	4	6.29	65.47	7.60	4.05	4.99	15.05	51.11	2.40	8.56	11.57
1976	1	5.60	72.56	2.44	5.08	4.61	13.99	41.96	8.66	12.36	11.68
1976	2	4.43	71.69	4.27	3.52	5.69	16.07	38.96	6.98	14.13	12.02
1976	3	4.26	70.72	4.92	3.35	4.40	16.49	42.38	5.15	12.43	12.24
1976	4	3.59	71.68	4.98	3.86	3.31	16.89	42.16	5.01	11.65	12.61
1977	1	1.99	76.30	4.20	4.07	1.41	17.42	31.16	20.42	8.06	12.18
1977	2	1.86	72.43	9.43	2.91	1.19	19.46	33.33	14.91	8.53	13.02
1977	3	2.77	70.23	10.64	3.22	0.91	20.84	35.74	10.31	8.54	13.39
1977	4	3.33	71.03	9.60	2.66	1.53	21.32	35.60	8.42	8.84	14.42
1978	1	4.78	76.70	2.90	1.69	4.64	13.37	42.65	7.46	8.46	16.25
1978	2	3.82	74.04	8.69	1.53	4.63	16.76	45.02	3.93	8.65	14.66
1978	3	3.92	73.92	10.21	1.76	3.46	19.25	46.44	2.59	8.60	12.04
1978	4	4.11	73.62	8.65	2.87	3.70	19.88	46.97	2.21	8.81	10.60
1979	1	5.61	75.95	3.76	4.12	5.46	12.23	34.40	12.31	12.38	12.13
1979	2	3.57	74.34	10.71	2.25	4.83	13.15	36.18	8.43	12.85	12.42
1979	3	2.74	76.65	10.18	1.99	3.96	14.88	42.06	6.48	10.69	13.07
1979	4	2.84	78.18	7.86	2.62	4.04	15.13	43.18	5.53	9.37	15.15
1980	1	4.48	82.94	1.34	3.18	4.25	10.81	33.93	14.49	13.02	18.94
1980	2	4.54	79.34	4.82	2.09	4.98	16.93	35.29	8.21	13.31	17.80
1980	3	4.43	79.53	5.22	2.33	4.08	18.88	39.95	5.58	12.15	15.47
1980	4	4.17	79.33	4.43	2.73	3.99	19.15	40.86	5.12	11.30	14.13
1981	1	4.39	83.05	1.46	2.03	3.20	10.91	42.14	10.14	13.33	13.97
1981	2	4.60	74.38	9.98	2.03	3.04	14.18	42.19	6.21	14.95	12.39
1981	3	5.58	68.28	14.37	2.46	3.01	15.58	46.62	4.86	14.09	10.69
1981	4	5.55	69.15	11.55	3.22	2.97	16.57	46.97	4.02	13.68	9.66

[a] Source: Food and Agriculture Organization. *Monthly Bulletin of Statistics.*
[b] Exporter's share is each country's share of total exports of wheat and corn.
[c] South Africa.
[d] United States of America.
[e] Argentina.
[f] Thailand.
[g] France.
[h] Canada.
[i] Australia.

Table C.7 Continued.

Year	Qtr	Corn					Wheat				
		SAF	USA	ARG	THA	FRA	CAN	USA	ARG	FRA	AUS
1982	1	4.31	76.95	1.74	5.94	4.38	10.38	43.46	12.07	11.11	13.33
1982	2	2.68	73.55	9.18	3.76	4.10	15.74	44.69	6.39	9.69	14.07
1982	3	5.44	70.24	8.66	3.51	4.41	18.43	45.26	4.54	9.49	12.78
1982	4	5.74	70.26	7.50	4.02	4.57	19.73	41.63	3.90	11.03	12.71
1983	1	0.12	76.94	4.69	2.39	6.06	12.36	40.25	18.01	11.61	8.10
1983	2	0.23	70.71	9.89	2.43	6.61	19.32	38.58	12.89	12.54	6.17
1983	3	0.30	68.42	11.51	2.77	7.11	21.82	38.35	10.94	13.08	6.19
1983	4	1.88	69.11	9.47	3.81	6.46	21.59	38.03	10.08	13.27	6.38
1984	1	0.12	78.67	4.20	3.27	5.69	10.54	33.50	17.74	10.71	14.49
1984	2	0.07	70.62	10.63	2.74	8.36	17.14	34.13	12.18	10.71	13.89
1984	3	0.06	69.81	10.58	3.44	7.93	19.80	37.81	8.06	11.15	13.52
1984	4	0.05	71.18	8.07	4.56	7.62	18.91	38.00	6.55	12.11	13.60
1985	1	0.26	72.77	3.57	3.27	6.41	9.74	27.45	19.82	16.38	13.95
1985	2	0.40	64.64	13.31	2.63	6.04	14.06	25.00	14.09	17.38	17.78
1985	3	0.44	61.42	13.18	3.25	6.15	15.91	26.30	11.49	16.64	17.30
1985	4	0.57	63.23	10.12	3.94	6.38	17.70	25.86	9.99	17.66	15.99
1986	1	1.27	61.96	5.22	8.37	8.42	11.22	23.40	11.25	18.41	21.14
1986	2	2.88	44.05	17.90	6.29	9.27	14.23	23.74	8.08	16.24	21.77
1986	3	3.16	42.75	16.44	5.86	10.27	15.47	29.42	5.67	14.66	20.24
1986	4	3.12	47.05	12.87	6.91	10.07	18.18	27.98	4.58	15.23	18.91
1987	1	1.60	64.48	4.06	4.14	12.41	16.24	21.73	12.87	15.47	14.91
1987	2	2.26	62.82	9.40	2.73	10.26	20.79	24.28	7.88	14.76	15.71
1987	3	3.36	63.66	7.53	3.13	9.57	20.59	30.32	5.44	13.90	15.83
1987	4	3.71	64.68	6.30	2.57	9.97	22.09	30.57	4.18	14.19	15.21

Table C.8: Corn and Wheat Imports (1000 mt).

Year[a]	Qtr	Corn		Wheat	
		TRI[b]	BRA[c]	TRI	BRA
1974	1	15.4	0.7	32.5	668.4
1974	2	31.4	1.5	59.7	1056.7
1974	3	47.8	2.3	78.8	1729.6
1974	4	62.6	3.3	81.7	2399.2
1975	1	13.5	0.5	37.2	142.0
1975	2	41.0	1.0	72.3	333.8
1975	3	60.3	1.5	77.1	1356.0
1975	4	78.0	2.1	104.9	2097.9
1976	1	17.4	1.2	38.9	987.2
1976	2	30.8	1.3	63.7	1958.4
1976	3	55.2	1.3	86.4	2947.1
1976	4	68.6	1.5	114.0	3428.1
1977	1	20.5	0.1	10.5	674.5
1977	2	35.8	0.1	55.3	1457.9
1977	3	61.6	0.3	82.8	2264.8
1977	4	67.0	0.6	101.1	2624.1
1978	1	16.7	0.2	31.2	715.7
1978	2	48.1	0.2	55.3	1936.4
1978	3	62.7	554.0	80.5	3261.3
1978	4	72.6	1262.1	102.0	4334.8
1979	1	32.7	237.2	24.2	978.5
1979	2	61.8	353.1	49.1	1694.0
1979	3	83.3	601.2	75.2	2732.6
1979	4	96.2	1525.9	100.6	3654.6
1980	1	25.2	413.3	36.4	1432.9
1980	2	46.7	487.3	58.6	2238.8
1980	3	72.8	815.9	89.6	3441.5
1980	4	97.1	1594.0	115.8	4755.1
1981	1	34.4	799.4	29.5	1038.3
1981	2	61.6	901.9	54.3	1738.3
1981	3	150.0	902.0	66.6	3276.5
1981	4	167.3	902.0	97.8	4360.0

[a]Source: Food and Agriculture Organization. *Monthly Bulletin of Statistics.*
[b]Trinidad Tobago.
[c]Brazil.

Table C.8 Continued.

Year	Qtr	Corn		Wheat	
		TRI	BRA	TRI	BRA
1982	1	28.6	0.0	22.6	961.1
1982	2	54.5	0.0	46.1	2020.1
1982	3	85.3	0.0	74.6	3206.7
1982	4	115.8	0.0	98.4	4223.8
1983	1	17.5	50.0	26.1	724.0
1983	2	34.0	100.0	45.1	1651.4
1983	3	50.0	150.0	81.6	2997.4
1983	4	62.9	213.1	86.1	4182.0
1984	1	52.5	220.6	34.1	1211.3
1984	2	75.6	253.5	55.2	1994.5
1984	3	105.9	253.5	88.1	3341.4
1984	4	120.9	253.6	97.6	4867.6
1985	1	10.0	188.4	6.2	1174.2
1985	2	30.1	188.4	40.7	2275.2
1985	3	31.1	188.4	40.7	3242.2
1985	4	75.7	262.2	78.6	4041.4
1986	1	15.0	1027.7	15.0	700.6
1986	2	37.7	1297.6	46.2	852.8
1986	3	42.0	1719.2	90.0	1491.7
1986	4	93.8	2423.6	123.4	2255.1
1987	1	15.0	175.0	19.9	800.0
1987	2	38.0	350.0	44.8	1200.0
1987	3	43.0	575.0	90.0	1700.0
1987	4	97.9	871.2	153.3	2748.6

Appendix D

Data Preparation Program

The program listed in this appendix is meant to be used as guideline for the reader. It shows how the variables were constructed.

```
c***********************************************************************
c
c        Program: ERRAIDC --- Exchange Rate Risk in Agriculture
c                 Imports of Developing Countries
c
c                      Ligia Maria Soto-Urbina
c
c                       PhD dissertation
c
c                 Department of Agricultural Economics
c
c                 University of Tennessee, Knoxville
c
c                          June 1991
c
c*********************************************************************
c  Subroutines:
c               INPUT  : read input data
c               REX1   : calculation of real and nominal effective
c                          exchange rates
c               VAR1   : calculation of nominal mean-standard deviation
c               VARLS  : calculation of real mean-standard deviation
c               DISINP : disspla graphs of input data
c               DISPLA : disspla graphs of exchange rates
c               OUTPUT : prints data
c
c*********************************************************************
c  Notes: 1. Files: TB.DAT -- Input data of tables 1 trough 9 in Appendix B.
c                    ERRAIDC.FOR -- Fortran source program.
c                    OUTTB.DAT -- General output file.
c                    OUTIN.DAT -- Output of the TB.DAT file.
c                    IMAGEN.IMP -- Graphs output file.
c         2. Variables in commons t1 through t9 represents data in
c            tables 1 through 9 in Appendix B.
```

```
c           3. This program performs data manipulation and other
c              calculations with the main purpose of preparing
c              input data for SAS.
c           4. Variables are associated with countries with the
c              following suffixes:
c              br = Brasil,    tt = Trinidad Tobago,

c              au = Australia, ca = Canada,       fr = France,
c              ar = Argentina, sa = South Africa, ta = Thailand.
c
c**********************************************************************
        integer in1/5/,out/6/,outin/10/,t9mon
       common /t0/date1(60),date2(60),iear(60),iqtr(60)
       common /t1/t1br(60),t1tt(60)
       common /t2/t2us(60),t2fr(60),t2au(60),t2sa(60),t2ta(60),t2ca(60)
       common /t3/t3br(60),t3tt(60),t3ar(60)
       common /t4/t4br(60),t4tt(60),t4ar(60)
       common /t5/t5fr(60),t5au(60),t5sa(60),t5ta(60),t5ca(60)
       common /t6/wheat(60),corn(60)
       common /t7/t7sac(60),t7usc(60),t7arc(60),t7tac(60),t7frc(60),
     *           t7caw(60),t7usw(60),t7arw(60),t7frw(60),t7auw(60)
       common /t8/t8ttc(60),t8brc(60),
     *           t8ttw(60),t8brw(60)
       common /t9/t9mon(180),t9tt(180),t9br(180)
       common /rx1/
     *exsa(60),exar(60),exta(60),exfr(60),exau(60),exca(60),exus(60),
     *brerc(60),brerw(60),trerc(60),trerw(60),
     *beffc(60),beffw(60),teffc(60),teffw(60)
       common /rx2/ prw(60),prc(60),bf(60),pf(60),tf(60)
       common /var/
     *br1(60),bsr1(60),bsr2(60),br2(60),
     *bsr3c(60),br3c(60),bsr3w(60),br3w(60),
     *tsr3c(60),tr3c(60),tsr3w(60),tr3w(60)
       common /lsc/
     *bws(60),bwm(60),bwml1(60),bwsl1(60),bwsl2(60),
     *bcs(60),bcm(60),bcml1(60),bcsl1(60),bcsl2(60),
     *tws(60),twm(60),twml1(60),twsl1(60),twsl2(60),
     *tcs(60),tcm(60),tcml1(60),tcsl1(60),tcsl2(60),
     *bwml2(60),bcml2(60),twml2(60),tcml2(60)
       common /displa/ idis,ivt240,it1,it2,it3,it4,it5,it6,it7,it8,
     *                it9,it10,it11
        open (unit=5,file='tb.dat',status='old')
        open (unit=6,file='outtb.dat',status='new')
        open (unit=10,file='outin.dat',status='new')
c*********disspla
c
c      Data for graphical output
c
c      idis   < 0 no graphs are created
c      ivt240 < 0 graph output in IMAGEN.IMP file
c             > 0 graph output in VT240 terminals
c      negative argument means that that particular
```

```
c      graph will not be generated.
c
       idis   = -1
       ivt240 = -1
      it1  = -1
      it2  = -1
      it3  = -1
      it4  = -1
      it5  = -1
      it6  = -1
      it7  = -1
      it8  = -1
      it9  = -1
      it10 = 1
      it11 = 1

c*********disspla
       call input(in1,outin)
       call rex1(in1,out)
       call var1(out)
       call varls(out,brerw,bws,bwm,bwml1,bwsl1,bwsl2,bwml2)
       call varls(out,brerc,bcs,bcm,bcml1,bcsl1,bcsl2,bcml2)
       call varls(out,trerw,tws,twm,twml1,twsl1,twsl2,twml2)
       call varls(out,trerc,tcs,tcm,tcml1,tcsl1,tcsl2,tcml2)
       call output(out)
       stop
       end
c***********************************************************************
c
       subroutine input(in1,out)
c
c
c***********************************************************************
       integer out,t9mon
       dimension title(20)
      common /t0/date1(60),date2(60),iear(60),iqtr(60)
      common /t1/t1br(60),t1tt(60)
      common /t2/t2us(60),t2fr(60),t2au(60),t2sa(60),t2ta(60),t2ca(60)
      common /t3/t3br(60),t3tt(60),t3ar(60)
      common /t4/t4br(60),t4tt(60),t4ar(60)
      common /t5/t5fr(60),t5au(60),t5sa(60),t5ta(60),t5ca(60)
      common /t6/wheat(60),corn(60)
      common /t7/t7sac(60),t7usc(60),t7arc(60),t7tac(60),t7frc(60),
     *          t7caw(60),t7usw(60),t7arw(60),t7frw(60),t7auw(60)
      common /t8/t8ttc(60),t8brc(60),
     *          t8ttw(60),t8brw(60)
      common /t9/t9mon(180),t9tt(180),t9br(180)
      common /displa/ idis,ivt240,it1,it2,it3,it4,it5,it6,it7,it8,
     *               it9,it10,it11
c********
c   Read T0 (read proper time variable e.g. year, quarter etc)
c   Read title and variables name
```

```
c
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
c
      do 500 i=1,60
      read(in1,*) date1(i),date2(i),iear(i),iqtr(i)
      write(out,*) date1(i),date2(i),iear(i),iqtr(i)
  500 continue
c********
c   Read T1
c   Read title and variables name
c
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
c
      do 501 i=1,60
      read(in1,*) id1,id2,t1br(i),t1tt(i)
      write(out,*) id1,id2, t1br(i),t1tt(i)
  501 continue
c********
c   Read T2
c   Read title and variables name

c
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
c
      do 502 i=1,60
     read(in1,*)id1,id2,t2us(i),t2fr(i),t2au(i),t2sa(i),t2ta(i),t2ca(i)
     write(out,*)id1,id2,t2us(i),t2fr(i),t2au(i),t2sa(i),t2ta(i),
    *t2ca(i)
  502 continue
c********
c   Read T3
c   Read title and variables name
c
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
                 read(in1,1010)(title(i),i=1,20)
                 write(out,1020)(title(i),i=1,20)
c
      do 503 i=1,60
      read(in1,*) id1,id2, t3br(i),t3tt(i),t3ar(i)
      write(out,*) id1,id2, t3br(i),t3tt(i),t3ar(i)
  503 continue
c********
```

```
c   Read T4
c   Read title and variables name
c
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
      do 504 i=1,60
      read(in1,*) id, id, t4br(i),t4tt(i),t4ar(i)
      write(out,*) id1,id2, t4br(i),t4tt(i),t4ar(i)
  504 continue
c********
c   Read T5
c   Read title and variables name
c
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
c
      do 505 i=1,60
      read(in1,*) id1,id2,t5fr(i),t5au(i),t5sa(i),t5ta(i),t5ca(i)
      write(out,*) id1,id2, t5fr(i),t5au(i),t5sa(i),t5ta(i),t5ca(i)
  505 continue
c********
c   Read T6
c   Read title and variables name
c
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
c
      do 506 i=1,60
      read(in1,*) id1,id2,wheat(i),corn(i)
      write(out,*) id1,id2, wheat(i),corn(i)
  506 continue
c********
c   Read T7

c   Read title and variables name
c
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
c
      do 507 i=1,60
     read(in1,*)id1,id2,t7sac(i),t7usc(i),t7arc(i),t7tac(i),t7frc(i),
     *                t7caw(i),t7usw(i),t7arw(i),t7frw(i),t7auw(i)
     write(out,*)id1,id2, t7sac(i),t7usc(i),t7arc(i),t7tac(i),
     *t7frc(i),t7caw(i),t7usw(i),t7arw(i),t7frw(i),t7auw(i)
```

```
 507  continue
c********
c   Read T8
c   Read title and variables name
c
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
c
       do 508 i=1,60
      read(in1,*)id1,id2, t8ttc(i),t8brc(i),
     *           t8ttw(i),t8brw(i)
      write(out,*)id1,id2, t8ttc(i),t8brc(i),
     *           t8ttw(i),t8brw(i)
 508  continue
c********
c   Read T9
c   Read title and variables name
c
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
                  read(in1,1010)(title(i),i=1,20)
                  write(out,1020)(title(i),i=1,20)
c
       do 509 i=1,180
      read(in1,*)t9mon(i),t9tt(i),t9br(i),
      write(out,*) t9mon(i),t9tt(i),t9br(i)
 509  continue
 1010 format(20a4)
 1020 format(' ',20a4)
c234567
      if(idis.lt.0) return
      call disinp
      return
      end
c**********************************************************************
c
       subroutine rex1(in1,out)
c
c    Calculation of Real and Nominal Effective Exchange Rates
c**********************************************************************
       integer out,t9mon
      common /t1/t1br(60),t1tt(60)
      common /t2/t2us(60),t2fr(60),t2au(60),t2sa(60),t2ta(60),t2ca(60)
      common /t3/t3br(60),t3tt(60),t3ar(60)
      common /t4/t4br(60),t4tt(60),t4ar(60)
      common /t5/t5fr(60),t5au(60),t5sa(60),t5ta(60),t5ca(60)
      common /t6/wheat(60),corn(60)
      common /t7/t7sac(60),t7usc(60),t7arc(60),t7tac(60),t7frc(60),
     *           t7caw(60),t7usw(60),t7arw(60),t7frw(60),t7auw(60)
```

```
       common /rx1/
     *exsa(60),exar(60),exta(60),exfr(60),exau(60),exca(60),exus(60),
     *brerc(60),brerw(60),trerc(60),trerw(60),
     *beffc(60),beffw(60),teffc(60),teffw(60)
      common /rx2/ prw(60),prc(60),bf(60),pf(60),tf(60)
      common /displa/ idis,ivt240,it1,it2,it3,it4,it5,it6,it7,it8,
     *                it9,it10,it11
c*******
c
c     Corn and wheat exporter's share (COMMON t7)are normalized.
c     r1 is the sum of each element of the vectors.
c
      do 10 i=1,60
      r1= t7sac(i) +t7usc(i)+t7arc(i) + t7tac(i) + t7frc(i)
      t7sac(i) = t7sac(i)/r1
      t7usc(i) = t7usc(i)/r1
      t7arc(i) = t7arc(i)/r1
      t7tac(i) = t7tac(i)/r1
      t7frc(i) = t7frc(i)/r1
   10 continue
c
      do 30 i=1,60
      r1 = t7caw(i)+ t7usw(i)+t7arw(i)+t7frw(i)+t7auw(i)
      t7caw(i) = t7caw(i)/r1
      t7usw(i) = t7usw(i)/r1
      t7arw(i) = t7arw(i)/r1
      t7frw(i) = t7frw(i)/r1
      t7auw(i) = t7auw(i)/r1
   30 continue
c
c     To construct real effective exchange rate (RER) for Brasil.
c     Bilateral exchange rate indices.
c      (base dec. 1985)
c
      bbsa = 10.49 * 0.3910
      bbar = 10.49 / 8.0050
      bbta = 10.49 / 26.650
      bbfr = 10.49 / 7.5610
      bbau = 10.49 * 0.6809
      bbca = 10.49 / 1.3975
      bbus = 10.49
c
c     Bilateral  indices
c
      do 50 i=1,60
      exsa(i) = ((t4br(i) * t5sa(i)) / bbsa) *100
      exar(i) = ((t4br(i) / t4ar(i)) / bbar) *100
      exta(i) = ((t4br(i) / t5ta(i)) / bbta) *100
      exfr(i) = ((t4br(i) / t5fr(i)) / bbfr) *100
      exau(i) = ((t4br(i) * t5au(i)) / bbau) *100
      exca(i) = ((t4br(i) / t5ca(i)) / bbca) *100
```

```
      exus(i) = ( t4br(i)/bbus) *100
  50  continue
c
c     Corn and wheat RER for Brasil.
c
      do 60 i=1,60
      r1 = exus(i)*(t2us(i)/t3br(i))
      r2 = exar(i)* (t3ar(i)/t3br(i))
      r3 = exfr(i)* (t2fr(i)/t3br(i))
c
      c1 =  exsa(i)*(t2sa(i)/t3br(i))*t7sac(i)
      c2 =  exta(i)*(t2ta(i)/t3br(i))*t7tac(i)
c
      w1 =  exca(i)*(t2ca(i)/t3br(i))*t7caw(i)

      w2 =  exau(i)*(t2au(i)/t3br(i))*t7auw(i)
c
      c3 = r1*t7usc(i)
      c4 = r2*t7arc(i)
      c5 = r3*t7frc(i)
c
      w3 = r1*t7usw(i)
      w4 = r2*t7arw(i)
      w5 = r3*t7frw(i)
c
      brerc(i) = c1 + c2 + c3 + c4 + c5
      brerw(i) = w1 + w2+ w3+ w4+ w5
  60  continue
c
c     Nominal Effective Rates (ER) for corn Brasil.
c
      do 65 i=1,60
      c1 = exsa(i) * t7sac(i)
      c2 = exar(i) * t7arc(i)
      c3 = exta(i) * t7tac(i)
      c4 = exfr(i) * t7frc(i)
      c5 = exus(i) * t7frc(i)
c
c     Nominal effective rates for wheat Brasil.
c
      w1 = exca(i) * t7caw(i)
      w2 = exar(i) * t7arw(i)
      w3 = exau(i) * t7auw(i)
      w4 = exfr(i) * t7frw(i)
      w5 = exus(i) * t7usw(i)
c
      beffc(i) = c1+ c2+ c3+ c4+ c5
      beffw(i) = w1+ w2+ w3+ w4+ w5
  65  continue
c
c
c     Corn and wheat RER for Trinidad Tobago.
```

```
c
      do 100 i=1,60
      r1 = exus(i)* ( t2us(i)/t3tt(i))
      r2 = exar(i)* (t3ar(i)/t3tt(i))
      r3 = exfr(i)* (t2fr(i)/t3tt(i))
c
      c1 =  exsa(i)* (t2sa(i)/t3tt(i))*t7sac(i)
      c2 =  exta(i)* (t2ta(i)/t3tt(i))*t7tac(i)
c
      w1 =  exca(i)* (t2ca(i)/t3tt(i))*t7caw(i)
      w2 =  exau(i)* (t2au(i)/t3tt(i))*t7auw(i)
c
      c3 = r1*t7usc(i)
      c4 = r2*t7arc(i)
      c5 = r3*t7frc(i)
c

      w3 = r1*t7usw(i)
      w4 = r2*t7arw(i)
      w5 = r3*t7frw(i)
c
      trerc(i) = c1+ c2+ c3+ c4+ c5
      trerw(i) = w1+ w2+ w3+ w4+ w5
  100 continue
c
c     Nominal effective rates for corn Trinidad Tobago.
c
      do 105 i=1,60
      c1 = exsa(i) * t7sac(i)
      c2 = exar(i) * t7arc(i)
      c3 = exta(i) * t7tac(i)
      c4 = exfr(i) * t7frc(i)
      c5 = exus(i) * t7usc(i)
c
c     Nominal effective rates for wheat Trinidad.
c
      w1 = exca(i) * t7caw(i)
      w2 = exar(i) * t7arw(i)
      w3 = exau(i) * t7auw(i)
      w4 = exfr(i) * t7frw(i)
      w5 = exus(i) * t7usw(i)
c
      teffc(i) = c1+ c2+ c3+ c4+ c5
      teffw(i) = w1+ w2+ w3+ w4+ w5
  105 continue
c
c    Calculation of  real price of corn and wheat (wheighted deflators)
c    and foreign exchange allotment in domestic currency(fe*ex)
c
      do 110 i=1,56
      prw(i) = wheat(i)/ (t7caw(i)*t2ca(i)+t7usw(i)*t2us(i)+
     *t7arw(i)*t3ar(i)+t7frw(i)*t2fr(i)+t7auw(i)*t2au(i))
```

```
      prc(i) = corn(i)/ (t7usc(i)*t2us(i)+t7arc(i)*t3ar(i)+
     *t7tac(i)*t2ta(i)+t7frc(i)*t2fr(i)+t7sac(i)*t2sa(i))
      bf(i) = t1br(i)*t4br(i)
      pf(i) = t1pe(i)*t4pe(i)
      tf(i) = t1tt(i)*t4tt(i)
 110  continue
      return
      end
c***********************************************************************
c
       subroutine var1(out)
c
c  Calculation of Nominal Mean-Standard Deviation
c
c***********************************************************************
       integer out,t9mon
      common /t4/t4br(60),t4tt(60),t4ar(60)

      common /t9/t9mon(180),t9tt(180),t9br(180)
      common /rx1/
     *exsa(60),exar(60),exta(60),exfr(60),exau(60),exca(60),exus(60),
     *brerc(60),brerw(60),trerc(60),trerw(60),
     *beffc(60),beffw(60),teffc(60),teffw(60)
      common /displa/ idis,ivt240,it1,it2,it3,it4,it5,it6,it7,it8,
     *                it9,it10,it11
      common /var/
     *br1(60),bsr1(60),bsr2(60),br2(60),
     *bsr3c(60),br3c(60),bsr3w(60),br3w(60),
     *tsr3c(60),tr3c(60),tsr3w(60),tr3w(60)
      dimension dif(60)
c*********************
c  Brasil
c*********************
c    Mean of monthly differences of bilateral exchange rates.
c
       do 100 i=2,168
       dif(i)= t9br(i)/t9br(i-1)*100.
  100  continue
       ic=0
       do 110 i=4,168
       ic=ic+1
       if (ic.lt.3) go to 110
       j=i/3
       ic=0
       br1(j) = (dif(i)+dif(i-1)+dif(i-2))/3.
  110  continue
c
c    Standard deviation of monthly diff.
c
       ic=0
       do 120 i=4,168
       ic=ic+1
```

```
      if (ic.lt.3) go to 120
      ic=0
      j=i/3
      qr1= br1(j)**2
      sdr= dif(i)**2+dif(i-1)**2+dif(i-2)**2
      temp= (1./(3.-1.))*(sdr -3.*qr1)
      bsr1(j) = sqrt(temp)
  120 continue
c
c      Absolute percentage changes in bilateral rates(sr2)
c      and mean for the quarter (r2 = expected value)
c      Absolute percentage changes in effective exchange
c      rates (sr3c and sr3w) and mean for the quarter
c      (r3c,r3w = expected value)
c
      do 130 i=2,56
c      write(out,690) t4br(i),t4br(i-1),beffc(i),beffc(i-1),
c     *beffw(i),beffw(i-1)
c 690  format(' ',6(2x,1pe12.5))
      bsr2(i) = abs(t4br(i)-t4br(i-1))/t4br(i-1)
      br2(i) =  t4br(i)
      bsr3c(i) = abs(beffc(i)-beffc(i-1))/beffc(i-1)
      br3c(i) = beffc(i)
      bsr3w(i) = abs(beffw(i)-beffw(i-1))/beffw(i-1)
      br3w(i) = beffw(i)
  130 continue

c*********************
c  Trinidad Tobago
c***************
c      Absolute percentage changes in effective exchange
c      rates (sr3c and sr3w) and mean for the quarter(r3c,r3w)
c
      do 330 i=2,56
      tsr3c(i) = abs(teffc(i)-teffc(i-1))/teffc(i-1)
      tr3c(i) = teffc(i)
      tsr3w(i) = abs(teffw(i)-teffw(i-1))/teffw(i-1)
      tr3w(i) = teffw(i)
  330 continue
      return
      end
c***********************************************************************
c
      subroutine varls(out,work,ws,wm,wml1,wsl1,wsl2,wml2)
c
c   Calculation of Real Mean-Standard Deviation
c
c***********************************************************************
      integer out,t9mon
     dimension work(60),ws(60),wm(60),wml1(60),wsl1(60),wsl2(60),
    *theta(56),x(60),x2(60),wml2(60)
c*******
```

```
c  Real measures of variability
c*******
c Quarterly differences in real ex. (theta)
c
      do 700 i=2,56
      theta(i) = (work(i)/work(i-1))*100.
  700 continue
c
c  Four-quarter moving mean and stand.deviation of theta
c
      do 710 i=5,56
      wm(i) = (theta(i)+theta(i-1)+theta(i-2)+theta(i-3))/4.
      s = (theta(i)**2)+(theta(i-1)**2)+(theta(i-2)**2)+
     *(theta(i-3)**2)
      temp = 1./(4.-1.)*(s- 4.*wm(i)**2)
      ws(i) = sqrt(temp)
  710 continue
c
c  Eight-quarter moving mean and stand.deviation of theta
c
      do 715 i=9,56
      wml1(i) = (theta(i)+theta(i-1)+theta(i-2)+theta(i-3)+
     *theta(i-4)+theta(i-5)+theta(i-6)+theta(i-7))/8.
      s = theta(i)**2+theta(i-1)**2+theta(i-2)**2+
     *theta(i-3)**2+theta(i-4)**2+theta(i-5)**2+
     *theta(i-6)**2+theta(i-7)**2
      temp = 1./(4.-1.)*(s- 4.*wml1(i)**2)
      wsl1(i) = sqrt(temp)
  715 continue
c
c   Error of trend equation(eight-quarter moving)
c
c    Trend variable
c
      sum1=0.
      sum2=0.
      do 720 i=1,8
      x(i) = i
      x2(i) = x(i)*x(i)
      sum1= sum1 + x(i)
      sum2 = sum2 + x2(i)
 720  continue

c
c    Regression y= a+bx (x=trend, y=rer)
c
      ic=o
      do 730 i=8,56
      sumy = work(i)+work(i-1)+work(i-2)+work(i-3)+work(i-4)+
     *work(i-5)+work(i-6)+work(i-7)
      sumxy = (x(8)*work(i)) + (x(7)*work(i-1)) +
     *(x(6)*work(i-2))+ (x(5)*work(i-3)) + (x(4)* work(i-4)) +
```

```
     *(x(3)*work(i-5)) + (x(2)*work(i-6)) + (x(1)*work(i-7))
      b=(8.* sumxy-sum1*sumy)/(8.*sum2-sum1*sum1)
      a=(sum2*sumy-sumxy*sum1)/(8.*sum2 - sum1*sum1)
      sum=0
      do 740 j=1,8
      k=8-j
      sum = sum + (work(i-k) -a - b*x(j))**2
  740 continue
      wsl2(i) = sqrt(sum/(8.-2.))
  730 continue
c
c   Mean using long-term estimate of Z
c    wml2 = Z(trend)/Zt
c
c    Trend variable

      sum1=0
      sum2=0
      do 750 i=9,56
      x(i) = i
      x2(i) = x(i)*x(i)
      sum1= sum1 + x(i)
      sum2 = sum2 + x2(i)
 750  continue
c
c    Regression y= a+bx (x=trend, y=rer)
c
      ic=0
      sumy=0.
      sumxy=0.
      do 760 i=9,56
      sumy = sumy + work(i)
      sumxy = sumxy + x(i)*work(i)
      b=(48.* sumxy-sum1*sumy)/(48.*sum2-sum1*sum1)
      a=(sum2*sumy-sumxy*sum1)/(48.*sum2 - sum1*sum1)
  760 continue
      do 761 i=9,56
      zhat = a + b*x(i)
      wml2(i) = zhat/work(i)
  761 continue
      return
      end
c*********************************************************************
c
       subroutine output(out)
c
c
c*********************************************************************

      integer out,t9mon
      common /t0/date1(60),date2(60),iear(60),iqtr(60)
      common /t1/t1br(60),t1tt(60)
```

```
      common /t2/t2us(60),t2fr(60),t2au(60),t2sa(60),t2ta(60),t2ca(60)
      common /t3/t3br(60),t3tt(60),t3ar(60)
      common /t4/t4br(60),t4tt(60),t4ar(60)
      common /t5/t5fr(60),t5au(60),t5sa(60),t5ta(60),t5ca(60)
      common /t6/wheat(60),corn(60)
      common /t7/t7sac(60),t7usc(60),t7arc(60),t7tac(60),t7frc(60),
     *           t7caw(60),t7usw(60),t7arw(60),t7frw(60),t7auw(60)
      common /t8/t8ttc(60),t8brc(60),
     *           t8ttw(60),t8brw(60),
      common /t9/t9mon(180),t9tt(180),t9br(180)
      common /rx1/
     *exsa(60),exar(60),exta(60),exfr(60),exau(60),exca(60),exus(60),
     *brerc(60),brerw(60),trerc(60),trerw(60),
     *beffc(60),beffw(60),teffc(60),teffw(60)
      common /rx2/ prw(60),prc(60),bf(60),pf(60),tf(60)
      common /var/
     *br1(60),bsr1(60),bsr2(60),br2(60),
     *bsr3c(60),br3c(60),bsr3w(60),br3w(60),
     *tsr3c(60),tr3c(60),tsr3w(60),tr3w(60)
      common /lsc/
     *bws(60),bwm(60),bwml1(60),bwsl1(60),bwsl2(60),
     *bcs(60),bcm(60),bcml1(60),bcsl1(60),bcsl2(60),
     *tws(60),twm(60),twml1(60),twsl1(60),twsl2(60),
     *tcs(60),tcm(60),tcml1(60),tcsl1(60),tcsl2(60),
     *bwml2(60),bcml2(60),twml2(60),tcml2(60)
      common /displa/ idis,ivt240,it1,it2,it3,it4,it5,it6,it7,it8,
     *                it9,it10,it11
c
c  Real Effective Exchange Rates (B,T, and for corn and wheat)
c
      write(out,604)
  604 format('1','Real effective exchange rates',/,
     *'    brerc    ','    brerw    ',
     *'   trerc    ','   trerw   ')
      do 350 i=1,60
      write(out,404) brerc(i),brerw(i),
     *trerc(i),trerw(i)
  350 continue
  404 format(' ',4(2x,1pe10.4))
c
c Effective Exchange Rates (B,T, and for corn and wheat)
c
      write(out,506)
  506 format('1','Effective exchange rates',/,
     *'    beffc    ','    beffw    '
     *'   teffc    ','   teffw   ')
      do 355 i=1,60
      write(out,404) beffc(i),beffw(i),
     *teffc(i),teffw(i)
  355 continue
c
```

```
c  1.a) To write variables for nominal model: Brasil (corn)
c
      write(out,605)
 605  format('1','Brasil: nominal variables for corn1',/,3x,'date',
     *6x,'t8brc',11x,'t3br',7x,'bf',11x,'cpri')

      do 410 i=2,56
      write(out,610) date1(i),t8brc(i),t3br(i),bf(i),corn(i)
  410 continue
 610  format(' ',2x,f4.1,4x,f6.1,7x,f10.4,2x,1pe11.4,4x,0pf7.2)
c
      write(out,615)
 615  format('1','Brasil: nominal variables for corn2',/,3x,'date',
     *4x,'br1',9x,'br2',9x,'br3c',8x,'bsr1',8x,'bsr2',8x,'bsr3c')
      do 415 i=2,56
      write(out,620) date1(i),br1(i),br2(i),br3c(i),bsr1(i),
     *bsr2(i),bsr3c(i)
 415  continue
 620  format(' ',2x,f4.1,6(2x,1pe10.4))
c
c  1.b) To write variables for nominal model: Brasil (wheat)
c
      write(out,625)
 625  format('1','Brasil: nominal variables for wheat1',/,3x,'date',
     *3x,3x,'t8brw',11x,'t3br',7x,'bf',10x,'wpri')
      do 420 i=2,56
      write(out,630) date1(i),t8brw(i),t3br(i),bf(i),wheat(i)
  420 continue
 630  format(' ',2x,f4.1,6x,f6.1,4x,f10.4,2x,1pe11.4,4x,0pf7.2)
c
      write(out,635)
 635  format('1','Brasil: nominal variables for wheat2',/,3x,'date',
     *4x,'br1',9x,'br2',9x,'br3w',8x,'bsr1',8x,'bsr2',8x,'bsr3w')
      do 425 i=2,56
      write(out,640) date1(i),br1(i),br2(i),br3w(i),bsr1(i),
     *bsr2(i),bsr3w(i)
 425  continue
 640  format(' ',2x,f4.1,6(2x,1pe10.4))
c
c  2.a) To write variables for nominal model: Trinidad (corn)
c
      write(out,685)
 685  format('1','Trinidad: nominal variables for corn1',/,3x,
     *'date',8x,'t8tc',9x,'t3tt',7x,'tf',11x,'cpri')
      do 450 i=2,56
      write(out,690) date1(i),t8ttc(i),t3tt(i),tf(i),corn(i)
  450 continue
 690  format(' ',2x,f4.1,6x,f6.1,4x,f10.4,2x,1pe11.4,4x,0pf7.2)
c
      write(out,700)
 700  format('1','Trinidad: nominal variables for corn2',/,3x,
     *'date',3x,'t4tt',3x,'tr3c',6x,'tsr3c')
```

```
      do 455 i=2,56
      write(out,710) date1(i),t4tt(i),tr3c(i),tsr3c(i)
 455  continue
 710  format(' ',2x,f4.1,3x,f6.4,2(2x,1pe10.4))
c
c  1. To write variables for nominal model: Trinidad (wheat)
c
      write(out,715)
 715  format('1','Trinidad: nominal variables for wheat1',/,3x,
     *'date',8x,'t8tw',9x,'t3tt',7x,'tf',11x,'wpri')
      do 460 i=2,56
      write(out,720) date1(i),t8ttw(i),t3tt(i),tf(i),wheat(i)
  460 continue
 720  format(' ',2x,f4.1,6x,f6.1,4x,f10.4,2x,1pe11.4,4x,0pf7.2)
c
      write(out,725)
 725  format('1','Trinidad: nominal variables for wheat2',/,3x,
     *'date',3x,'t4tt',3x,'tr3w',4x,'tsr3w')
      do 465 i=2,56
      write(out,730) date1(i),t4tt(i),tr3w(i),tsr3w(i)
 465  continue
 730  format(' ',2x,f4.1,3x,f6.4,2(2x,1pe10.4))
c******************************
c  Variables for real model: Brasil
c*******************************c
c Brasil: corn
c
      write(out,735)
 735  format('1','Brasil: real variables for corn1',/,3x,'date',
     *6x,'t8brc',11x,'t3br',7x,'bf',12x,'prc',7x,'brerc')
      do 470 i=9,56
      write(out,740) date1(i),t8brc(i),t3br(i),bf(i),prc(i),
     *brerc(i)
  470 continue
 740  format(' ',2x,f4.1,4x,f6.1,7x,f10.4,2x,1pe11.4,4x,0pf7.2,
     *3x,1pe10.4)
c
      write(out,745)
 745  format('1','Brasil: real variables for corn2',/,3x,'date',
     *4x,'bcm',9x,'bcml1',9x,'bcml2',8x,'bcs',8x,'bcsl1',7x,'bcsl2')
      do 475 i=9,56
      write(out,750) date1(i),bcm(i),bcml1(i),bcml2(i),bcs(i),
     *bcsl1(i),bcsl2(i)
 475  continue
 750  format(' ',2x,f4.1,6(2x,1pe10.4))
c
c   Brasil: wheat
c
      write(out,755)
 755  format('1','Brasil: real variables for wheat1',/,3x,'date',
     *3x,3x,'t8brw',11x,'t3br',7x,'bf',11x,'prw',7x,'brerw')
```

```
      do 480 i=9,56
      write(out,760) date1(i),t8brw(i),t3br(i),bf(i),prw(i),
     *brerw(i)
  480 continue
 760  format(' ',2x,f4.1,6x,f6.1,4x,f10.4,2x,1pe11.4,4x,0pf7.2,
     *3x,1pe10.4)
c
      write(out,765)
 765  format('1','Brasil: real variables for wheat2',/,3x,'date',
     *4x,'bwm',9x,'bwml1',9x,'bwml2',8x,'bws',8x,'bwsl1',7x,'bwsl2')
      do 485 i=9,56
\begin{verbatim}
\begin{verbatim}
      write(out,770) date1(i),bwm(i),bwml1(i),bwml2(i),bws(i),
     *bwsl1(i),bwsl2(i)
 485  continue
 770  format(' ',2x,f4.1,6(2x,1pe10.4))
c**********
c     Variables for real model: Trinidad
c***************
c    Trinidad: corn
c
      Write(out,815)
 815  format('1','Trinidad: real variables for corn1',/,3x,'date',
     *3x,'t4tt',3x,'t8ttc',3x,'t3tt',3x,'tf',3x,'prc',3x,'trerc')
      do 510 i=9,56
      write(out,820) date1(i),t4tt(i),t8ttc(i),t3tt(i),tf(i),
     *prc(i),trerc(i)
  510 continue
 820  format(' ',2x,f4.1,3x,f6.4,2x,f6.1,3x,f10.4,2x,1pe11.4,3x,
     *0pf7.2,2x,1pe10.4)
c
      write(out,825)
 825  format('1','Trinidad: real variables for corn2',/,3x,'date',
     *4x,'tcm',9x,'tcml1',9x,'tcml2',8x,'tcs',8x,'tcsl1',7x,'tcsl2')
      do 515 i=9,56
      write(out,830) date1(i),tcm(i),tcml1(i),tcml2(i),tcs(i),
     *tcsl1(i),tcsl2(i)
 515  continue
 830  format(' ',2x,f4.1,6(2x,1pe10.4))
c
c   Trinidad: wheat
c
      Write(out,835)
 835  format('1','Trinidad: real variables for wheat1',/,3x,'date',
     *3x,'t4tt',3x,'t8ttw',4x,'t3tt',4x,'tf',4x,'prw',4x,
     *'trerw')
      do 520 i=9,56
      write(out,840) date1(i),t4tt(i),t8ttw(i),t3tt(i),tf(i),
     *prw(i),trerw(i)
  520 continue
```

```
 840  format(' ',2x,f4.1,3x,f6.4,2x,f6.1,3x,f10.4,2x,1pe11.4,3x,
     *0pf7.2,2x,1pe10.4)
c
      Write(out,845)
 845  format('1','Trinidad: real variables for wheat2',/,3x,'date',
     *4x,'twm',9x,'twml1',9x,'twml2',8x,'tws',8x,'twsl1',7x,'twsl2')
      do 525 i=9,56
      write(out,850) date1(i),twm(i),twml1(i),twml2(i),tws(i),
     *twsl1(i),twsl2(i)
 525  continue
 850  format(' ',2x,f4.1,6(2x,1pe10.4))
      return
      end
c***********************************************************************
c
      subroutine disinp
c
c
c      This subroutine produces disspla graphics of the
c      9 tables in Appendix B.
c***********************************************************************
c       integer in1/1/,in2/2/,out/6/,quarter,year
       integer out,t9mon
\begin{verbatim}
\begin{verbatim}
      common /t0/date1(60),date2(60),iear(60),iqtr(60)
      common /t1/t1br(60),t1tt(60)
      common /t2/t2us(60),t2fr(60),t2au(60),t2sa(60),t2ta(60),t2ca(60)
      common /t3/t3br(60),t3tt(60),t3ar(60)
      common /t4/t4br(60),t4tt(60),t4ar(60)
      common /t5/t5fr(60),t5au(60),t5sa(60),t5ta(60),t5ca(60)
      common /t6/wheat(60),corn(60)
      common /t7/t7sac(60),t7usc(60),t7arc(60),t7tac(60),t7frc(60),
     *           t7caw(60),t7usw(60),t7arw(60),t7frw(60),t7auw(60)
      common /t8/t8ttc(60),t8brc(60),
     *           t8ttw(60),t8brw(60)
      common /t9/t9mon(180),t9tt(180),t9br(180),
      common /displa/ idis,ivt240,it1,it2,it3,it4,it5,it6,it7,it8,
     *                it9,it10,it11
      write(5,201)
201   format(' Starting plot')
      if(ivt240.gt.0) go to 10
      call IMAGEN
      go to 11
 10   call vt240
 11   continue
      if(it3.lt.0) go to 304
c
c      tb3
c
       call complx
```

```
      call nobrdr
      call area2d(7.0,9.0)
      xaxis = 7.0
      yaxis = 9.0
      call xname('Year ',100)
      call xintax
      call yaxang(0.)
      call thkfrm(0.01)
      call frame
      call xticks(3)
      call graf(1973.0,3.,1990., 0.,8.,60.)
      yipc = yaxis/(alog10(30000./.0001))
      call ylgaxs(.0001,yipc,yaxis,'Consumer Prices Indices
     * --- 1985 = 100 $',100,0.,0.)
      call spline
      call leglin
      call lines('Brazil $',idleg,1)
      call lines('Peru   $',idleg,2)
      call lines('Trinidad Tobago $',idleg,3)
      call lines('Argentina $',idleg,4)
      call dot
      call curve(date2,brcp,60,0)
      call dash
      call curve(date2,pecp,60,0)
      call chndot
      call curve(date2,ttcp,60,0)
      call chndsh
      call curve(date2,arcp,60,0)
      call reset('chndsh')
      call legnam(' ',1)
      call legend(idleg,4,0.5,6.5)
c      call ynonum
c      call ylgaxs(.0001,yipc,8.0,' $',100,6.,0.)
c      call reset('ynonum')
      call endpl (1)
 304  if(it4.lt.0) go to 305
 305  return
\begin{verbatim}
\begin{verbatim}
      end
c*********************************************************************
c
      subroutine displa1
c
c
c     This subroutine produces disspla graphics of the
c     real effective rates and
c     for Brazil, Peru, and Trinidad Tobago.
c
c*********************************************************************
      common /t0/date1(60),date2(60),iear(60),iqtr(60)
```

```
        common /rx1/
     *exsa(60),exar(60),exta(60),exfr(60),exau(60),exca(60),exus(60),
     *brerc(60),brerw(60),prerc(60),prerw(60),trerc(60),trerw(60),
     *beffc(60),beffw(60),peffc(60),peffw(60),teffc(60),teffw(60)
      common /displa/ idis,ivt240,it1,it2,it3,it4,it5,it6,it7,it8,
     *                it9,it10,it11
        if(ivt240.gt.0) go to 10
        call imagen
        go to 11
 10     call vt240
c************************
c       Brazil
c
 11     if(it10.lt.0) go to 311
        call complx
        call nobrdr
        call page(11.,8.5)
        call physor(1.7,2.5)
        call area2d(2.5,4.0)
        xaxis = 2.5
        yaxis = 4.0
        call xname('Year ',100)
        call yname('Real Effective Exchange Rate ',100)
        call xintax
        call frame
        call graf(1973.0,4.,1990., 0.,100.,300.)
        call xticks(4)
        call spline
        call lines('Corn $',idleg,1)
        call lines('Wheat $',idleg,2)
        call leglin
        call curve(date2,brerc,60,0)
        call dot
        call curve(date2,brerw,60,0)
        call reset('dot')
        call legnam('Brazil ',100)
        call legend(idleg,2,0.5,3.0)
        call endgr (1)
c***************
c       Peru
c
        call complx
        call nobrdr
        call page(11.,8.5)
        call physor(4.6,2.5)
        call area2d(2.5,4.0)
        xaxis = 2.5
        yaxis = 4.0
        call xname('Year ',100)
        call yname(' ',1)

        call ynonum
```

```
      call xintax
      call frame
      call graf(1973.0,4.,1990., 0.,100.,300.)
      call xticks(4)
      call spline
      call lines('Corn $',idleg,1)
      call lines('Wheat $',idleg,2)
      call leglin
      call curve(date2,prerc,60,0)
      call dot
      call curve(date2,prerw,60,0)
      call reset('dot')
      call legnam('Peru ',100)
      call legend(idleg,2,0.5,3.0)
      call endgr (2)
c***************
c     Trinidad Tobago
c
      call complx
      call nobrdr
      call page(11.,8.5)
      call physor(7.5,2.5)
      call area2d(2.5,4.0)
      xaxis = 2.5
      yaxis = 4.0
      call xname('Year ',100)
      call yname(' ',1)
      call ynonum
      call xintax
      call frame
      call graf(1973.0,4.,1990., 0.,100.,300.)
      call xticks(4)
      call spline
      call lines('Corn $',idleg,1)
      call lines('Wheat $',idleg,2)
      call leglin
      call curve(date2,trerc,60,0)
      call dot
      call curve(date2,trerw,60,0)
      call reset('dot')
      call legnam('Trinidad Tobago ',100)
      call legend(idleg,2,0.5,3.0)
      call endgr (3)
      call endpl (2)
c************************
 311  if(it11.lt.0) return
c************************
c     Brazil
c
      call complx
      call nobrdr
```

```
      call page(11.,8.5)
      call physor(1.7,2.5)
      call area2d(2.5,4.0)
      xaxis = 2.5
      yaxis = 4.0
      call xname('Year ',100)
c      call yname('Nominal Effective Exchange Rate ',100)
      call xintax
      call frame
      call yaxang(0.)

      call graf(1973.0,4.,1990., 0.,60.,60.)
      call reset('ynonum')
      yipc = yaxis/(alog10(100000000./.1))
      call ylgaxs(.1,yipc,yaxis,'Nominal Effective Exchange Rate
     * $',100,0.,0.)
      call xticks(4)
      call spline
      call lines('Corn $',idleg,1)
      call lines('Wheat $',idleg,2)
      call leglin
      call curve(date2,beffc,60,0)
      call dot
      call curve(date2,beffw,60,0)
      call reset('dot')
      call legnam('Brazil ',100)
      call legend(idleg,2,0.5,3.0)
      call endgr (1)
c***************
c     Peru
c
      call complx
      call nobrdr
      call page(11.,8.5)
      call physor(4.6,2.5)
      call area2d(2.5,4.0)
      xaxis = 2.5
      yaxis = 4.0
      call xname('Year ',100)
c      call yname(' ',1)
      call ynonum
      call xintax
      call frame
      call graf(1973.0,4.,1990., 0.,100.,300.)
      call yaxang(0.)
      call ylgaxs(.1,yipc,yaxis,' $',1,0.,0.)
      call xticks(4)
      call spline
      call lines('Corn $',idleg,1)
      call lines('Wheat $',idleg,2)
      call leglin
      call curve(date2,peffc,60,0)
```

```
      call dot
      call curve(date2,peffw,60,0)
      call reset('dot')
      call legnam('Peru ',100)
      call legend(idleg,2,0.5,3.0)
      call endgr (2)
c***************
c     Trinidad Tobago
c
      call complx
      call nobrdr
      call page(11.,8.5)
      call physor(7.5,2.5)
      call area2d(2.5,4.0)
      xaxis = 2.5

      yaxis = 4.0
      call xname('Year ',100)
c      call yname(' ',1)
      call ynonum
      call xintax
      call frame
      call graf(1973.0,4.,1990., 0.,100.,300.)
      call yaxang(0.)
      call ylgaxs(.1,yipc,yaxis,' $',1,0.,0.)
      call xticks(4)
      call spline
      call lines('Corn $',idleg,1)
      call lines('Wheat $',idleg,2)
      call leglin
      call curve(date2,teffc,60,0)
      call dot
      call curve(date2,teffw,60,0)
      call reset('dot')
      call reset('ynonum')
      call legnam('Trinidad Tobago ',100)
      call legend(idleg,2,0.5,3.0)
      call endgr (3)
      call endpl (3)
      call donepl
c***************
      continue
      return
      end
```

VITA

Ligia María Soto Urbina was born in San José, Costa Rica on May 3, 1957. In 1979 she received her B.S. degree in Agricultural Economics from the Universidad de Costa Rica and in 1984 she received her M.S. degree in Economics from the Universidade de São Paulo. She started to work in 1985 for the Consórcio Nacional de Engenheiros Consultores in the economic evaluation of engineering projects. In 1987 she started her work toward the Ph.D. degree in Agricultural Economics at the University of Tennessee, Knoxville.