NBER WORKING PAPER SERIES

REAL EXCHANGE RATES AND RELATIVE PRICES: AN EMPIRICAL INVESTIGATION

Charles Engel

Working Paper No. 4231

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 1992

I would like to thank Jon Faust, Jeffrey Frankel, Craig Hakkio, Jim Hamilton, Dale Henderson, Alan Stockman and two anonymous referees for useful suggestions. Carol Manthey provided excellent research assistance. The first draft of the paper was written while I was a Visiting Scholar at the Federal Reserve Bank of Kansas City. The views expressed in this paper are not necessarily shared by the Federal Reserve Bank of Kansas City or the Federal Reserve System. This paper is part of NBER's research programs in International Finance and Macroeconomics and International Trade and Investment. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Paper #4231
December 1992

REAL EXCHANGE RATES AND RELATIVE PRICES: AN EMPIRICAL INVESTIGATION

ABSTRACT

This paper uncovers a striking empirical regularity: the consumer price of a good relative to a different good within a country tends to be much less variable than the price of that good relative to a similar good in another country. This fact seems to hold for all goods except very simple, homogeneous products. Models of real exchange rates are likely to have predictions regarding this relation, so this fact may provide a useful gauge for discriminating among models.

Charles Engel
Department of Economics
University of Washington
Seattle, WA 98195
and NBER

A criterion for judging general equilibrium macroeconomic models is whether the predictions of the model are consistent with the moments of the macroeconomic data. This paper sets out to document a striking empirical regularity: in the major industrialized countries, the volatility of the consumer price of a good relative to another good within the same country tends to be much lower than the volatility of the price of that good relative to the same good in another country.[1] For example, the price of a wool shirt relative to a bottle of wine in the United States is more volatile than the price of a wool shirt in the United States relative to the price of a wool shirt in Canada.

This paper does not gauge any specific models according to their ability to match this empirical moment.[2] But, it is likely that many macro models which generate an explanation for short-run real exchange rate variability will also produce predictions concerning the volatility of these relative prices. By way of motivation, consider the textbook discussions of why purchasing power parity does not hold (which is equivalent to discussing why the real exchange rate is not constant). Caves, Frankel and Jones (1990, ch. 18) and Krugman and Obstfeld (1991, ch. 15) both offer four explanations for the failure of PPP:

1) Barriers to trade such as tariffs and transportation costs.

2) Different consumption preferences across countries.

3) The presence of non-traded goods in consumer price indexes.

4) Prices which are sticky in terms of the currency in which the good is consumed.

Now consider two simple examples of the real exchange rate. In the first, there are two goods which are consumed in each country and are traded. However, the weights in

---

1 The precise meaning of "volatility" will be defined later.

2 The conclusions section of the paper suggests a range of models that might be consistent with this fact.

the CPIs differ because of different tastes. Then, in the home country, letting lower case p refer to the natural log of prices, the consumer price index can be written as:[3]

$$p = \alpha p_1 + (1-\alpha)p_2.$$

In the foreign country:

$$p^* = \beta p_1^* + (1-\beta)p_2^*.$$

Letting s denote the log of the domestic currency price of foreign currency, the real exchange rate can be written as

$$p\text{-}s\text{-}p^* = \alpha(p_1\text{-}s\text{-}p_1^*) + (1-\alpha)(p_2\text{-}s\text{-}p_2^*) + (\beta-\alpha)(p_1^*-p_2^*).$$

If nominal goods prices were sticky, the third term to the right of the equal sign would have zero variance, and thus would not contribute to the variability of the real exchange rate. The first two terms could fluctuate because the nominal exchange rate could change, and would thus explain all of the real exchange rate volatility in such a model. A model which emphasized the role of barriers to trade in leading to the failure of the law of one price might again focus on the volatility of the first two terms in its explanation of why PPP fails. On the other hand, one could construct a model in which the law of one price holds, so that the first two terms are identically zero. That model would rely on different consumption tastes ($\beta \neq \alpha$) and volatility of the third term to explain changes in the real exchange rate.

In the second example, let each country consume a traded good and a non-traded good. With obvious notation, we have:

$$p = \alpha p_T + (1-\alpha)p_N.$$

$$p^* = \beta p_T^* + (1-\beta)p_N^*.$$

The real exchange rate is given by:

$$p\text{-}s\text{-}p^* = p_T\text{-}s\text{-}p_T^* + (1-\alpha)(p_N-p_T) - (1-\beta)(p_N^*-p_T^*).$$

---

[3] In actual practice, CPIs take weighted arithmetic averages rather than geometric averages.

Again, if nominal prices are sticky, all of the variation in the real exchange rate comes from the first term to the right of the equal sign, and none from the second two terms. On the other hand, if the law of one price holds, so that the first term is zero, a model might emphasize the role of the movements of the price of non-traded to traded goods within each country, as in the second two terms.

The point of these two textbook examples is to illustrate how models of the real exchange rate might make different predictions about the behavior of relative prices of different goods within countries and relative prices of the same good across countries. However, the assumptions of these textbook models are extreme and known not to hold. That is, the law of one price does not literally hold for most traded goods (Isard (1977)), and the nominal prices of goods are not literally perfectly predictable from one month to the next. This paper seeks to assess the comparative importance of prices such as p_i-s-p_i^* and p_i-p_j in determining real exchange rate movements.

Section 2 of the paper presents evidence of the relative variability of these two types of prices using disaggregated consumer price data for six countries -- the U.S., Japan, Germany, Italy, France and Canada. It demonstrates that the volatility of prices of similar goods across countries is generally smaller than the volatility of different prices within a country. (Throughout the paper, this relation will be expressed in the notation: $V(p_{ij}) < V(p_{ii^*})$.)

Section 3 confirms that this relation holds for goods which constitute most of consumer expenditure, using highly disaggregated consumer price data for the U.S. and Canada. However, for a group of goods that contribute a small fraction to overall consumer expenditures -- simple, homogeneous goods -- the reverse relation holds: $V(p_{ij}) > V(p_{ii^*})$. These goods constitute such a small part of consumer spending that they cannot explain the overall movements of the real CPI exchange rates, but the existence of this reverse relation might offer some clues to the forces influencing real exchange

rates.

The conclusions section offers some potential explanations for the empirical regularities uncovered in the paper.

2. Six-Country Relative Prices

This section investigates the behavior of consumer prices for the G7 industrial countries (with the exception of the U.K.). The series consist of the aggregate consumer price indexes and four disaggregated indexes -- energy, food, services and shelter. The price data are monthly, beginning in April 1973 and running to September 1990. This period corresponds to the time in which nominal exchange rates were floating between most bilateral pairs of these countries. However, during parts of this period there were exchange rate arrangements between France, Germany and Italy that to some extent limited the flexibility of the rates. (See the Data Appendix for a more complete description of the price series.)

These four sub-categories of consumer prices do not collectively comprise the entire consumer price index. They were chosen because the data source collected only these four series across all six countries. Furthermore, these sub-indexes are not mutually exclusive. The services and energy indexes contain prices that are also in the food and shelter indexes.

For example, the U.S. consumer price index is a weighted average of seven main indexes -- food and beverages; housing; apparel and upkeep; transportation; medical care; entertainment; and other goods and services. Other countries sub-divide their consumer price index along somewhat different lines, so it is impossible to compare all categories of prices. In addition to these sub-indexes which collectively constitute the U.S.

consumer price index, the Bureau of Labor Statistics calculates various other indexes of interest -- such as a commodities index, a services index, an energy index and several more. These indexes, including the services and energy indexes which are used in this study, use prices from across the seven major sub-indexes of the consumer price index.

We will see in the next section that the goods for which $V(p_{ij})$ tends to be largest are in the food and energy categories. Thus, by using food and energy as two of only four sub-categories that we examine, there is a bias toward finding $V(p_{ij}) > V(p_{ii^*})$ (but we nonetheless find the opposite result).

The price indexes for these countries are constructed by gathering prices on several days during the month and taking averages. For stationary series, averaging would lead to a reduction in measures of the variance of the series. Thus, there would be a tendency to find the volatility of p_i-p_j smaller than the volatility of p_i-s-p_i^* unless some equivalent adjustment were made to the measure of the nominal exchange rate. Therefore, the exchange rates were taken as monthly averages.

This paper is concerned with the short to medium term volatility of the real exchange rate. This type of volatility is not captured by the variance of a series. For example, suppose the data generating process for a series x_t was first-order autoregressive with a coefficient near one on the lag of x_t. Even if the innovations had a very small variance, the series x_t would have a large variance. If the series x_t followed a random walk, its variance would be infinite.

Rather than focus on the variance of the series itself, we instead measure the variance of the news about the series.[4] We do not provide a model of the relative price processes based on economic theory in order to construct forecasts and forecast errors. Instead, we note the well-known fact that under general conditions, we can represent the

[4] Alternatively, we refer to the news as the innovation or the forecast error.

stationary series x_t as an infinite-order autoregression.[5] We approximate this model by estimating twelfth-order autoregressions for each relative price. Our volatility measure is then the variance of the conditional forecast of the price. Using this procedure, our measure of volatility is not dependent on the nature of the stochastic process that determines the long-run behavior of the prices. For example, the procedure allows us to measure the volatility of the series whether it is near to being white noise, or near to being a random walk.

However, the series must be stationary in order to approximate it by an AR(12). Dickey-Fuller tests and Phillips-Perron tests were conducted on all of the relative price series (the p_i-p_j and the p_i-s-p_i^*), but these tests were inconclusive and are not reported. For some of the prices, the tests failed to reject a unit root. However, these tests have notoriously low power against stationary alternatives that are nearly non-stationary. In some cases, it would be economically implausible there is actually a unit root.

Without firm knowledge of whether the series were stationary or not, an AR(12) was fit for each series in levels and in first-differences. The variances of the forecasts reported in Table 1 are from autoregressions on the (log) levels of the relative prices. Although the variance of the forecast of prices from the differenced AR(12) series were numerically different from those from the AR(12) estimated on levels, there was essentially no qualitative difference in the two sets of estimates.[6] In fact, the variances were almost always very close numerically. This is because the series tended

---

5 That is, Wold's Theorem shows that any stationary series can be represented as an infinite order moving average process, $C(L)\epsilon_t$, and a deterministic component. If the C(L) is invertible, the series has an AR representation.

6 Of the 2400 comparisons of $V(p_{ij})$ to $V(p_{ii^*})$, only five were different using the two different methods of estimating the AR(12). With the differenced estimates, $V(p_{ij}) > V(p_{ii^*})$ a net total of one more time than with the level series.

to be close to being simple random walks. If the series exactly followed random walks, the variance of the forecast error would simply be the variance of the difference in the series. In practice, the variance of the forecast errors were numerically very close to the variance of the differences.

We wish to document for each good i, the relation between the forecast variance of p_i-p_j (denoted $V(p_{ij})$) and the forecast variance of p_i-s-p_i^* (denoted $V(p_{ii^*})$). We make the comparison at four different horizons (one-month, three-month, six-month and twelve-month) because models do not generally designate the calendar time needed to set prices. There are five price indexes in each country, so for each good i, four relative prices, p_i-p_j, can be calculated. These can be compared to the forecast variance of p_i-s-p_i^* in five other countries. Thus for each good within each country, twenty comparisons can be made at each forecast horizon, or a total of eighty comparisons of variances using all four horizons. Because there are five indexes within each country, this means that four hundred comparisons can be made per country, for a total of 2400 comparisons of $V(p_{ij})$ to $V(p_{ii^*})$.

Table 1 shows that of the 2400 comparisons of variances, 2250 have the variance of the relative price within the country for different goods smaller than the variance across countries for the same type of good. Most of the cases in which an intra-country relative price was more variable than an inter-country relative price involve energy. There are 1440 comparisons that do not involve any energy prices, and for 1420 of these, $V(p_{ij}) < V(p_{ii^*})$. Even for comparisons that involve energy prices, 86.5% (830 out of 960) confirm $V(p_{ij}) < V(p_{ii^*})$.

In some models, such as ones involving sticky nominal prices, $V(p_{ij}) < V(p_{ii^*})$ because nominal prices do not vary much over the short run and have a low forecast variance, while the nominal exchange rate may have a large forecast variance. If, however, the nominal exchange rate is fixed, or kept within narrow bands, this prediction

would no longer necessarily hold. For large parts of the sample examined here, there have been arrangements that limit the fluctuations of nominal exchange rates between France, Germany and Italy. So, for some models, it would be interesting just to compare $V(p_{ij})$ to $V(p_{ii^*})$ for countries that are not in the European Community (EC). Table 1 reports comparisons that involve prices in no more than one of those countries. In 1882 of the 1920 comparisons involving the non-EC countries, $V(p_{ij}) < V(p_{ii^*})$. This holds for 95.7% of the comparisons involving energy prices and almost all (99.6%) of the comparisons for non-energy prices.

Table 2 displays all of the forecast variances for one country -- the United States. This table is representative of the comparisons in other countries -- particularly for the comparisons that do not involve two European countries. The non-energy relative prices within a country generally have forecast variances that are one, and sometimes two, orders of magnitude smaller than the variances of prices of in the same category across countries. Consider, for example, relative prices that involve services. At the one-month horizon, the smallest conditional variance of U.S. service prices relative to service prices in other countries is 1.06×10^{-4}. For relative prices across other prices across other countries, the one-month forecast variances range from 5.73×10^{-4} to 7.03×10^{-4}. By comparison, the variance of the price of U.S. services to U.S. food is 2.30×10^{-5}, while the variances of U.S. services to the U.S. C.P.I. are only 5.85×10^{-6} and 2.26×10^{-6} respectively. The variance of the relative price of energy to services, at 1.72×10^{-4}, is larger than the variance of U.S. service prices relative to Canadian service prices, but smaller than all of the other variances of relative service prices across borders.

Figure 1 displays a histogram of the ratios of the forecast variances at the one-month horizon, $V(p_{ii^*})/V(p_{ij})$. (The histograms for the other horizons are very similar.) It shows that many of the ratios are greater than 10 -- the median being 6.7. We do not

attempt a formal statistical test of the null hypothesis that the ratio of the variances is less than or equal to one, but Figure 1 makes it abundantly clear that such a null should be rejected. If we were willing to assume that each of the forecast error series were independent and normal, then a test that each of the ratios of variances is greater than or equal to one is distributed F with 197 numerator and 197 denominator degrees of freedom. For a one-sided test, the 95% critical value for each of the ratios is 1.265, and for a two-sided test it is 1.323. Clearly the null would be rejected in the vast majority of these case by case tests.

The results of this section show that models in which relative consumer price movements within a country play a large role in determining real CPI exchange rate movements do not accord well with the data.

3. U.S./Canadian Data

This section looks at the behavior of relative prices based on 34 sub-indexes of consumer prices from the U.S. and Canada. Most of the sub-indexes involve prices at a very disaggregated level -- for example, ground beef, televisions and gasoline. The thirty-four categories are listed in Table 3. With these price indexes we are able to answer more specific questions about the nature of real exchange rate changes.

These thirty-four indexes were chosen primarily because the indexes in the two countries are based on categories of goods that are very similar. There are a disproportionate number of prices of fresh foods compared here. That is because it was easy to match indexes across countries for these items. Fourteen of the thirty-four prices are food prices. This does not represent the approximate share of food purchases in the consumer budget. Food prices receive a weight of about 18% in the overall

consumer price index in both countries.

The sample period was again chosen to be April 1973 to September 1990. Even though the U.S. dollar/ Canadian dollar exchange rate was floating since 1970, these dates were retained for comparability with section 2. The exchange rate is the same as the one used in that section.

As in section 2, unit roots tests were performed for all prices, as a pretest to determine whether the AR(12) used to produce price forecasts should be estimated in levels or differences. For some prices, unit roots could not be rejected, but, again, the inability to reject a unit root in these series is probably evidence of the low power of these tests for relative price series with seventeen years of data. The results of these tests are not reported.

Forecast variances for relative prices were calculated as in section 2. They are based on twelfth order autoregressions on the log levels of prices. Variances of in-sample forecast errors were calculated for 1, 3, 6 and 12 month horizons. As in the previous section, there is virtually no qualitative difference if the forecast variances are calculated from a system that is estimated on the first-differences.

It is difficult to summarize the results of the comparisons of forecast variances. Fortunately, within each country, the pattern of forecast variances are very similar within two groups of goods prices, which I will label volatile goods prices and stable goods prices. Tables 3a-3d provide representative findings for a volatile goods price in each country (bananas in Canada and the U.S., in Tables 3a and 3c respectively) and for a stable goods price (televisions in Canada and the U.S., in Tables 3b and 3d, respectively).

In Canada, the volatile prices are ground beef, poultry, apples, bananas, lettuce, coffee, gasoline, airline fares, potatoes and fuel oil. In the U.S. the volatile prices are the same, except for airline fares.

For a typical stable goods price $V(p_{ij}) < V(p_{ii^*})$ unless the jth price is a volatile price, as can be seen from Table 3. For a typical volatile goods price, it is more often the case that $V(p_{ij}) > V(p_{ii^*})$. For bananas, as reported in Table 3, the ordering of variances is this direction for almost all relative prices.

The goods which make up the volatile price group constitute a small fraction of overall expenditures. Most of them are foods, yet we saw in section 2 that taken as an aggregate, food prices across borders are more volatile than prices of food relative to other goods within a country. Furthermore, the foods that are in this group are all fresh foods (that is, not highly processed) and comprise a tiny portion of total food consumption. We cannot attribute real exchange rate variability to the variability of prices of ground beef, poultry, apples, bananas, lettuce, coffee, gasoline, airline fares, potatoes and fuel oil. Taken as a whole, the evidence still strongly supports $V(p_{ij}) < V(p_{ii^*})$, and, so real exchange rate variability is stemming more from $V(p_{ii^*})$ than $V(p_{ij})$.

Nonetheless, it is interesting to investigate the nature of those prices which fall into the volatile category, since their behavior might yield insight into the forces behind real exchange rate movements. Most of the goods in this category are traded goods. Yet, this is probably not an important defining characteristic, because most of the prices in the stable category are also for traded goods.

All of the prices in the volatile category are at a disaggregated level. However, again, it does not seem to be a general rule that disaggregated prices are volatile and only aggregated prices are not. Most of the prices in the stable category are also highly disaggregated.

The prices in the volatile category tend to be simple, homogeneous goods that are either agricultural or have a strong resource content. Several of them are perishables. There are few goods in the stable category that fit this description. So, this

homogeneity is probably the defining characteristic of the goods in the "volatile" category.

4. Conclusions

This paper examines the components of the real exchange rate measured by consumer prices. The empirical work on the real exchange rate is split between using producer prices and consumer prices. There are at least two strong empirical regularities that emerge from the consumer price data. First is the well-known fact that the real CPI exchange rates of the industrialized countries are highly volatile. The second is the strong tendency for $V(p_{ij}) < V(p_{ii^*})$. A successful open-economy macro model should be able to explain these facts -- irrespective of whether it can explain analogous facts for producer price real exchange rates.

This section will sketch a few models that might be consistent with these facts. Of course, these examples do not exhaust all the possibilities. It may also be the case that elements of each of these explanations should be incorporated in a model that can match the important moments in the data.

A model which incorporates prices which are sticky in terms of the currency where the good is consumed is consistent with $V(p_{ij}) < V(p_{ii^*})$. Such a model can generate volatility in the real CPI exchange rate if it allows for nominal exchange rate volatility. Two points should be noted. The price stickiness of the Dornbusch (1976) model, which assumes that the prices of domestically produced goods are sticky in terms of domestic currency is less consistent with our findings than the type of stickiness in Giovannini (1988), for example, which assumes the prices of goods consumed domestically are sticky in terms of the domestic currency. The second point is that whatever

mechanism leads to price stickiness should also explain why goods in the "volatile" category of section 3 apparently do not have sticky prices.

Another possible mechanism, which does not rely on price stickiness, is proposed by Marston (1990). Suppose that goods markets are segmented enough that the law of one price fails for almost all goods. If most of the shocks that hit producers in one country are supply shocks at the national, but not international level -- such as labor market disturbances -- the real exchange rate might change, but relative prices within the country might not be disturbed (except for the real wage.) Perhaps the goods in the "volatile" category are sold in markets that are not as segmented, because trading costs are lower for these type of goods.

Along similar lines, suppose that most goods sold to consumers are joint products -- the actual good, and the marketing service that brings the good to the consumers. If the marketing service is non-traded and a large component of the price, then relative prices within the country may be fairly stable. (Note that this explanation is very different from the textbook explanation in the introduction that relies on changes in p_N-p_T.) The goods in the "volatile" category, on the other hand, might have a smaller marketing component. Such a story can easily accommodate a highly variable real exchange rate in terms of traded commodities. It might have a more difficult time explaining real CPI exchange rate variability, but perhaps could appeal to some of the elements of the model outlined in the previous paragraph.

A fourth alternative is that there is nothing that requires economic explanation -- that it is all measurement error. The statistical agencies may find it more difficult to measure actual transactions prices (and not simply list prices) for goods which are not in the homogeneous category. Furthermore, there is a shopping cost which is not included in the consumer price data. Such a cost is likely to be lower for the goods in the "volatile" category. However, if this argument were true, it would cause trouble not

only for this paper, but for virtually all empirical studies which have used consumer price data. It seems unlikely that measurement error could explain Figure 1, where the median ratio of $V(p_{ii^*})/V(p_{ij})$ is 6.7.

It would appear that the relation $V(p_{ij}) < V(p_{ii^*})$ is a true fact, and a useful gauge for assessing open-economy macro models.

Data Appendix

The exchange rate data are monthly averages of daily exchange rates. The exchange rate is taken as the mid-point of the bid and ask rate on the London market at noon Swiss time. The series is collected by the Bank of International Settlement, and is on the Federal Reserve Board's FAME (Forecasting Analysis and Modeling Environment) database.

The price indexes used in section 2 are from the same source. The B.I.S. collects the data from various sources in each country.

The U.S. price data in section 3 are also from the FAME database, which collects the series from the Bureau of Labor Statistics' C.P.I. Release.

The Canadian price data in section 3 were obtained from Statistics Canada. All price data is not seasonally adjusted.

References

Caves, Richard E., Jeffrey A. Frankel, and Ronald W. Jones, 1990, World Trade and Payments: An Introduction, fifth edition (New York: Harper Collins).

Dornbusch, Rudiger, 1976, "Expectations and Exchange Rate Dynamics," Journal of Political Economy 84 (December) 1161-1176.

Giovannini, Alberto, 1988, "Exchange Rates and Traded Goods Prices," Journal of International Economics 24 (February) 45-68.

Isard, Peter, 1977, "How Far Can We Push 'The Law of One Price'?" American Economic Review 67 (December) 942-948.

Krugman, Paul R., and Maurice Obstfeld, 1991, International Economics: Theory and Policy, second edition (New York: Harper Collins).

Marston, Richard C., 1990, "Systematic Movements in Real Exchange Rates in the G-5: Evidence on Integration of Internal and External Markets," Journal of Banking and Finance 14 (November) 1023-1044.

Table 1

Variance of Forecast Errors
Six-Country Data
Monthly, April 1973 - September 1990

This table summarizes comparisons of $V(p_{ij})$ with $V(p_{ii^*})$. The forecasts come from AR12s estimated on the levels of the relative prices. The forecasts were at 1, 3, 6 and 12 month horizons. Under the heading # is the number of comparisons in that category. Under the heading $V(p_{ij}) < V(p_{ii^*})$ are the number of those comparisons for which $V(p_{ij}) < V(p_{ii^*})$. Under the heading % is the percentage of comparisons for which $V(p_{ij}) < V(p_{ii^*})$.

Prices	#	$V(p_{ij}) < V(p_{ii^*})$	%
All Price Comparisons	2400	2250	93.8
All Non-Energy Prices	1440	1420	98.6
All Prices involving Energy	960	830	86.5
All Non-EC Prices	1920	1882	98.0
All Non-Energy, Non-EC Prices	1152	1147	99.6
All Energy, Non-EC Prices	768	735	95.7

Table 2

Variance of Forecast Errors for U.S.

C.P.I.s	1 month	3 month	6 month	12 month
CAN/US	1.0646e-04	3.4442e-04	6.9983e-04	1.5791e-03
FRA/US	6.4183e-04	2.6387e-03	6.2956e-03	1.3699e-02
GER/US	6.6984e-04	2.8782e-03	6.3136e-03	1.3463e-02
ITA/US	5.3008e-04	2.4516e-03	5.6748e-03	1.2605e-02
JAP/US	7.6146e-04	3.2640e-03	7.6772e-03	1.7011e-02
ENER/ALL	1.5217e-04	1.0284e-03	2.4935e-03	5.1710e-03
FOOD/ALL	1.2852e-05	7.8164e-05	1.6960e-04	3.1191e-04
SERV/ALL	5.8501e-06	2.8712e-05	5.9320e-05	1.2664e-04
SHEL/ALL	5.1001e-06	2.0841e-05	3.5882e-05	6.2045e-05

ENERGY	1 month	3 month	6 month	12 month
CAN/US	5.7773e-04	1.6462e-03	3.1068e-03	6.9493e-03
FRA/US	8.7273e-04	3.4631e-03	7.4683e-03	1.2540e-02
GER/US	8.8817e-04	3.9632e-03	8.2097e-03	1.4256e-02
ITA/US	1.1126e-03	4.8537e-03	1.1144e-02	2.0422e-02
JAP/US	1.1905e-03	5.7075e-03	1.3207e-02	2.6207e-02
ENER/ALL	1.5217e-04	1.0284e-03	2.4935e-03	5.1710e-03
ENER/FOO	1.8764e-04	1.2610e-03	3.2743e-03	6.7443e-03
ENER/SER	1.7223e-04	1.1867e-03	2.8666e-03	6.3120e-03
ENER/SHE	1.6618e-04	1.1023e-03	2.5701e-03	5.2732e-03

FOOD	1 month	3 month	6 month	12 month
CAN/US	1.4690e-04	3.6730e-04	5.8092e-04	9.9474e-04
FRA/US	6.4391e-04	2.6770e-03	5.9707e-03	1.2226e-02
GER/US	7.2972e-04	3.2893e-03	6.7218e-03	1.3445e-02
ITA/US	5.2267e-04	2.3326e-03	5.1904e-03	1.1320e-02
JAP/US	8.8308e-04	3.4332e-03	7.4302e-03	1.5736e-02
FOOD/ALL	1.2852e-05	7.8164e-05	1.6960e-04	3.1191e-04
ENER/FOO	1.8764e-04	1.2610e-03	3.2743e-03	6.7443e-03
FOOD/SER	2.3577e-05	1.3412e-04	3.0351e-04	5.6116e-04
FOOD/SHE	2.3006e-05	1.2237e-04	2.6987e-04	4.8085e-04

SERVICES	1 month	3 month	6 month	12 month
CAN/US	1.0601e-04	4.0186e-04	9.1091e-04	2.3238e-03
FRA/US	6.6860e-04	2.7831e-03	6.7962e-03	1.5290e-02
GER/US	6.7534e-04	2.8881e-03	6.6484e-03	1.4729e-02
ITA/US	5.7328e-04	2.7081e-03	6.2714e-03	1.3730e-02
JAP/US	7.0337e-04	3.1634e-03	7.4570e-03	1.6922e-02
SERV/ALL	5.8501e-06	2.8712e-05	5.9320e-05	1.2664e-04
ENER/SER	1.7223e-04	1.1867e-03	2.8666e-03	6.3120e-03
FOOD/SER	2.3577e-05	1.3412e-04	3.0351e-04	5.6116e-04
SERV/SHE	2.2618e-06	1.0196e-05	2.7157e-05	8.0445e-05

SHELTER	1 month	3 month	6 month	12 month
CAN/US	1.1987e-04	5.0389e-04	1.1912e-03	2.9479e-03
FRA/US	7.2826e-04	2.8057e-03	6.7891e-03	1.5201e-02
GER/US	6.8811e-04	3.0018e-03	6.7307e-03	1.4511e-02
ITA/US	9.7888e-04	3.5634e-03	8.3023e-03	1.7508e-02
JAP/US	7.0448e-04	3.3207e-03	8.1974e-03	1.9116e-02
SHEL/ALL	5.1001e-06	2.0841e-05	3.5882e-05	6.2045e-05
ENER/SHE	1.6618e-04	1.1023e-03	2.5701e-03	5.2732e-03
FOOD/SHE	2.3006e-05	1.2237e-04	2.6987e-04	4.8085e-04
SERV/SHE	2.2618e-06	1.0196e-05	2.7157e-05	8.0445e-05

Table 3a

Variance of Forecast Errors for Canadian Bananas
Monthly, April 1973 - September 1990

good	1 month	3 month	6 month	12 month
U.S. Bananas	5.4122e-04	7.5631e-04	9.9836e-04	1.1616e-03
Cereal & Bakery	1.3306e-03*	1.8225e-03*	1.9560e-03*	1.9348e-03*
Ground Beef	1.6857e-03*	3.5222e-03*	4.8614e-03*	6.1701e-03*
Poultry	1.5422e-03*	2.3336e-03*	2.7435e-03*	2.7307e-03*
Eggs	1.6021e-03*	2.6288e-03*	3.0905e-03*	3.2371e-03*
Butter	1.3512e-03*	1.9761e-03*	2.1770e-03*	2.2042e-03*
Apples	2.9035e-03*	5.9524e-03*	6.3874e-03*	6.8077e-03*
Lettuce	7.8365e-03*	1.2004e-02*	1.2212e-02*	1.2422e-02*
Coffee	1.8129e-03*	3.9182e-03*	6.8377e-03*	1.0722e-02*
Food Away from Home	1.4096e-03*	2.0909e-03*	2.3525e-03*	2.3768e-03*
Alcholoic Beverages	1.4493e-03*	2.2745e-03*	2.6681e-03*	2.8304e-03*
Home Maintenance	1.4181e-03*	2.1081e-03*	2.3707e-03*	2.4098e-03*
Rent	1.4287e-03*	2.1909e-03*	2.5409e-03*	2.6372e-03*
Electricity	1.4512e-03*	2.2217e-03*	2.5063e-03*	2.5412e-03*
Gas (Piped)	1.5923e-03*	2.9411e-03*	3.8358e-03*	4.3573e-03*
Telephone	1.5007e-03*	2.4269e-03*	2.9383e-03*	3.2179e-03*
Textiles	1.3921e-03*	2.0316e-03*	2.3038e-03*	2.3189e-03*
Furniture	1.4569e-03*	2.2141e-03*	2.5216e-03*	2.6010e-03*
Television	1.4215e-03*	2.1831e-03*	2.5000e-03*	2.6149e-03*
Men's Clothing	1.3913e-03*	2.0427e-03*	2.3379e-03*	2.4074e-03*
Wonen's Clothing	1.3726e-03*	1.9905e-03*	2.2403e-03*	2.2910e-03*
Automobiles	1.4289e-03*	1.9563e-03*	2.1155e-03*	2.0819e-03*
Gasoline	1.7127e-03*	3.2048e-03*	4.3369e-03*	4.7686e-03*
Tires	1.4832e-03*	2.2178e-03*	2.5992e-03*	2.6488e-03*
Airline Fares	2.0317e-03*	3.3424e-03*	4.2008e-03*	4.9326e-03*
Medical Care	1.4175e-03*	2.1496e-03*	2.4942e-03*	2.5861e-03*
Entertainment	1.4057e-03*	2.0690e-03*	2.3673e-03*	2.4469e-03*
Tobacco	1.6118e-03*	2.8788e-03*	3.6602e-03*	4.4826e-03*
Services	1.4308e-03*	2.2144e-03*	2.5865e-03*	2.6739e-03*
Dairy Products	1.3835e-03*	2.0326e-03*	2.2647e-03*	2.2764e-03*
Potatoes	4.6180e-03*	1.1352e-02*	1.2882e-02*	1.3806e-02*
Wine	1.4439e-03*	2.1884e-03*	2.5361e-03*	2.5984e-03*
Fuel Oil	1.6686e-03*	3.2865e-03*	4.7724e-03*	5.8298e-03*
Personal Care	1.4034e-03*	2.0618e-03*	2.3173e-03*	2.3624e-03*

* Indicates variance of price of bananas relative to this price is greater than variance of price of bananas relative to U.S. bananas

Table 3b

Variance of Forecast Errors for Canadian Televisions
Monthly, April 1973 - September 1990

good	1 month	3 month	6 month	12 month
U.S. Televisions	1.1643e-04	3.6226e-04	7.7454e-04	1.7106e-03
Cereal & Bakery	1.8424e-05	5.4304e-05	1.2778e-04	3.0506e-04
Ground Beef	3.3591e-04*	1.1390e-03*	2.1723e-03*	4.9426e-03*
Poultry	1.4130e-04*	3.3562e-04	5.8731e-04	8.1317e-04
Eggs	5.7645e-05	1.7350e-04	3.2529e-04	4.5359e-04
Butter	4.4115e-05	1.1401e-04	1.7632e-04	2.4139e-04
Apples	9.4925e-04*	3.7049e-03*	5.4947e-03*	5.7602e-03*
Bananas	1.4215e-03*	2.1831e-03*	2.5000e-03*	2.6149e-03*
Lettuce	7.5747e-03*	1.1925e-02*	1.2662e-02*	1.3235e-02*
Coffee	1.0108e-04	6.8084e-04*	2.1361e-03*	5.2218e-03*
Food Away from Home	8.4224e-06	2.2876e-05	4.3020e-05	7.1963e-05
Alcoholic Beverages	1.6339e-05	4.6612e-05	9.0403e-05	1.5557e-04
Home Maintenance	1.9967e-05	4.6238e-05	6.2655e-05	6.9967e-05
Rent	7.8820e-06	2.3254e-05	4.8056e-05	9.9344e-05
Electricity	3.7173e-05	9.3775e-05	1.5239e-04	1.9703e-04
Gas (Piped)	5.3069e-05	1.8827e-04	3.8126e-04	8.1628e-04
Telephone	2.7153e-05	7.6989e-05	1.4791e-04	2.9100e-04
Textiles	2.6404e-05	4.1445e-05	6.4337e-05	9.1544e-05
Furniture	1.8089e-05	3.8751e-05	6.3378e-05	1.0599e-04
Men's Clothing	1.2799e-05	2.4593e-05	4.1041e-05	7.0140e-05
Women's Clothing	1.4106e-05	3.0320e-05	4.6686e-05	8.5956e-05
Automobiles	3.0431e-05	7.5391e-05	1.1768e-04	1.6047e-04
Gasoline	1.5606e-04*	4.3363e-04*	9.3692e-04*	1.7248e-03*
Tires	5.5988e-05	1.1540e-04	2.3352e-04	4.2045e-04
Airline Fares	5.4088e-04*	1.1165e-03*	1.6409e-03*	2.1669e-03*
Medical Care	1.6558e-05	3.8498e-05	5.7840e-05	8.2626e-05
Entertainment	9.8577e-06	2.7395e-05	4.8220e-05	7.4652e-05
Tobacco	6.4061e-05	2.0083e-04	3.3080e-04	5.4724e-04
Services	7.2395e-06	2.0046e-05	4.0761e-05	9.6631e-05
Dairy Products	1.6737e-05	5.7322e-05	1.2786e-04	2.8112e-04
Potatoes	3.1115e-03*	1.1619e-02*	1.6539e-02*	1.8061e-02*
Wine	5.8449e-05	1.7387e-04	2.4942e-04	3.1686e-04
Fuel Oil	1.4204e-04*	4.9479e-04*	1.0606e-03*	2.4857e-03*
Personal Care	7.6166e-06	1.6767e-05	2.9291e-05	4.8249e-05

* Indicates variance of price of televisions relative to this variable is greater than variance of price of televisions relative to U.S. televisions

Table 3c

Variance of Forecast Errors for U.S. Bananas
Monthly, April 1973 - September 1990

good	1 month	3 month	6 month	12 month
Canadian Bananas	5.4122e-04	7.5631e-04	9.9836e-04	1.1616e-03
Cereal & Bakery	6.9239e-04*	1.1328e-03*	1.1646e-03*	1.0957e-03
Ground Beef	8.0419e-04*	1.8036e-03*	2.1944e-03*	2.5590e-03*
Poultry	8.4706e-04*	1.8308e-03*	1.9744e-03*	1.9586e-03*
Eggs	1.4272e-03*	3.3610e-03*	4.2129e-03*	4.2392e-03*
Butter	8.5628e-04*	1.8479e-03*	2.3717e-03*	2.4620e-03*
Apples	1.5023e-03*	3.6762e-03*	4.1146e-03*	4.2896e-03*
Lettuce	4.0706e-03*	7.8979e-03*	8.2697e-03*	8.6427e-03*
Coffee	9.7957e-04*	2.7359e-03*	4.7380e-03*	7.7657e-03*
Food Away from Home	7.0275e-04*	1.2130e-03*	1.2825e-03*	1.2898e-03*
Alcoholic Beverages	6.8837e-04*	1.1460e-03*	1.1894e-03*	1.1821e-03*
Home Maintenance	7.0918e-04*	1.2810e-03*	1.3655e-03*	1.3784e-03*
Rent	7.3002e-04*	1.3518e-03*	1.4919e-03*	1.5632e-03*
Electricity	7.5506e-04*	1.4937e-03*	1.6288e-03*	1.7939e-03*
Gas (Piped)	8.2470e-04*	1.6188e-03*	1.9966e-03*	2.5070e-03*
Telephone	7.8268e-04*	1.5475e-03*	1.8718e-03*	2.1412e-03*
Textiles	7.1913e-04*	1.2708e-03*	1.4197e-03*	1.4567e-03*
Furntiure	6.9010e-04*	1.2287e-03*	1.3224e-03*	1.3735e-03*
Television	7.1831e-04*	1.2928e-03*	1.4045e-03*	1.4626e-03*
Men's Clothing	6.9550e-04*	1.2421e-03*	1.3776e-03*	1.4282e-03*
Women's Clothing	7.4919e-04*	1.3514e-03*	1.4937e-03*	1.5357e-03*
Automobiles	7.1456e-04*	1.2734e-03*	1.3574e-03*	1.3835e-03*
Gasoline	9.6362e-04*	2.4187e-03*	3.3522e-03*	4.0646e-03*
Tires	7.1264e-04*	1.2819e-03*	1.3645e-03*	1.4163e-03*
Airline Fares	8.2355e-04*	1.8458e-03*	2.3540e-03*	2.9377e-03*
Medical Care	7.3883e-04*	1.3969e-03*	1.5616e-03*	1.7207e-03*
Entertainment	6.9372e-04*	1.1875e-03*	1.2489e-03*	1.2528e-03*
Tobacco	7.8187e-04*	1.5720e-03*	1.8184e-03*	2.2305e-03*
Services	7.4065e-04*	1.3964e-03*	1.5449e-03*	1.6387e-03*
Dairy Products	7.1097e-04*	1.2376e-03*	1.3321e-03*	1.2937e-03*
Potatoes	1.4821e-03*	4.5813e-03*	5.4043e-03*	5.8439e-03*
Wine	7.0863e-04*	1.2172e-03*	1.2942e-03*	1.3094e-03*
Fuel Oil	1.1294e-03*	2.7730e-03*	4.1266e-03*	5.0160e-03*
Personal Care	7.0110e-04*	1.2258e-03*	1.2974e-03*	1.3156e-03*

* Indicates variance of price of bananas relative to this price is greater than variance of price of bananas relative to Canadian bananas

Table 3d

Variance of Forecast Errors for U.S. Television
Monthly, April 1973 - September 1990

good	1 month	3 month	6 month	12 month
Canadian Television	1.1643e-04	3.6226e-04	7.7454e-04	1.7106e-03
Cereal & Bakery	7.3088e-06	2.9600e-05	8.6470e-05	2.2171e-04
Ground Beef	6.3240e-05	3.1283e-04	7.6514e-04	1.5921e-03
Poultry	8.0774e-05	4.1210e-04*	7.6061e-04	1.2292e-03
Eggs	6.4781e-04*	1.8460e-03*	2.9630e-03*	3.5558e-03*
Butter	3.8020e-05	1.6663e-04	3.2462e-04	4.4471e-04
Apples	4.6672e-04*	2.1333e-03*	3.2922e-03*	3.5594e-03*
Bananas	7.1831e-04*	1.2928e-03*	1.4045e-03*	1.4626e-03
Lettuce	3.5188e-03*	7.4000e-03*	8.0361e-03*	8.1247e-03*
Coffee	9.1570e-05	7.7162e-04*	2.3922e-03*	6.0481e-03*
Food Away from Home	4.5188e-06	1.2892e-05	2.8415e-05	5.7251e-05
Alcoholic Beverages	6.4910e-06	1.8380e-05	4.2889e-05	8.7668e-05
Home Maintenance	8.9561e-06	2.5877e-05	4.9348e-05	8.5753e-05
Rent	5.1537e-06	1.4536e-05	3.4684e-05	7.8481e-05
Electricity	4.1658e-05	1.2839e-04	2.1141e-04	2.5780e-04
Gas (Piped)	3.4807e-05	1.0508e-04	2.4530e-04	4.6884e-04
Telephone	1.2484e-05	4.2235e-05	1.0926e-04	2.5548e-04
Textiles	2.5166e-05	4.9533e-05	7.9699e-05	1.3050e-04
Furniture	1.4407e-05	3.2641e-05	5.3401e-05	1.0274e-04
Men's Clothing	1.1703e-05	3.8812e-05	6.9279e-05	1.2209e-04
Women's Clothing	2.3961e-05	9.0950e-05	1.3977e-04	2.1708e-04
Automobiles	1.3231e-05	3.9020e-05	6.7510e-05	1.2247e-04
Gasoline	9.6429e-05	6.7659e-04*	1.6327e-03*	3.3246e-03*
Tires	1.7065e-05	4.5071e-05	9.6353e-05	2.2949e-04
Airline Fares	2.6262e-05	1.1072e-04	3.1013e-04	8.9525e-04
Medical Care	5.3755e-06	1.4896e-05	3.1917e-05	7.0836e-05
Entertainment	5.3283e-06	1.4945e-05	3.1524e-05	6.3749e-05
Tobacco	1.5568e-05	5.6915e-05	1.1780e-04	2.9513e-04
Services	6.5205e-06	2.2031e-05	5.1150e-05	1.0553e-04
Dairy Products	8.1349e-06	3.1103e-05	7.3810e-05	1.3584e-04
Potatoes	8.5101e-04*	4.5869e-03*	7.6373e-03*	9.3649e-03*
Wine	1.0808e-05	2.7323e-05	5.7311e-05	1.2230e-04
Fuel Oil	2.1887e-04*	8.8764e-04*	2.0190e-03*	3.7387e-03*
Personal Care	5.0251e-06	1.3296e-05	2.9979e-05	6.3381e-05

* Indicates variance of price of televisions relative to this variable is greater than variance of price of televisions relative to Canadian televisions

Figure 1