

NOMINAL EXCHANGE RATE REGIMES AND THE BEHAVIOR OF REAL EXCHANGE RATES: EVIDENCE AND IMPLICATIONS

MICHAEL MUSSA
University of Chicago

I. INTRODUCTION

The real exchange rate between two countries may be defined as the relative price of one country's consumption basket in terms of the consumption basket of the other country.¹ This study investigates the behavior of real exchange rates under two different nominal exchange rate regimes: fixed exchange rate regimes where the nominal exchange rate between two countries is kept rigidly fixed or within narrow bands (except for infrequent changes in the official parity), and floating exchange rate regimes where market forces are allowed significant latitude to move the nominal exchange rate on a virtually continual basis. For pairs of countries with similar and moderate inflation rates, it is shown that there are substantial and systematic differences in the behavior of real exchange rates under these two different nominal exchange rate regimes. Under a floating exchange rate regime, real exchange rates typically show much greater short term variability than under a fixed exchange rate regime. The increased variability of real exchange rates under floating exchange rate regimes is largely accounted for by the increased variability of nominal exchange rates, with little contribution from changes in the variability of ratios of national price levels or in the covariances

¹There are several possible empirical measures and conceptual definitions of "the real exchange rate." National price levels could be measured by wholesale price indices or national product deflators, rather than by consumer price indices. Doing this would make little difference to the analysis and empirical results of this study. For some purposes, the real exchange rate for a country might be defined as the relative price of nontradable goods produced and consumed in that country in terms of tradable goods produced or consumed in that country. This concept of the real exchange rate is not the one that is most relevant to the objectives and analysis of this study. Use of this concept is impaired by the general lack of good measures of the relative prices of nontradables in terms of tradables.

between movements in nominal exchange rates and movements in the ratio of national price levels. Changes in real exchange rates under floating exchange rate regimes typically exhibit a high degree of persistence, similar to the persistence exhibited by changes in nominal exchange rates. In contrast, ratios of national price levels typically exhibit similar, relatively smooth paths of evolution under both types of a nominal exchange rate regime.²

The substantial and systematic differences in the observed behavior of real exchange rates under floating versus fixed exchange rate regimes provide important evidence concerning the empirical relevance and validity of broad classes of theoretical models of the behavior of exchange rates and national price levels. Specifically, the observed empirical regularities provide strong evidence against theoretical models that embody the property of "nominal exchange regime neutrality." Models that embody this property share the empirical implication that the behavior of real exchange rates should not be substantially and systematically affected by the nature of the nominal exchange rate regime. For example, models that assume strong adherence to relative purchasing power parity have this property because they imply little movement of the real exchange rate under either a fixed or a floating exchange rate regime. However, even weak adherence to relative purchasing power parity is not essential for a model to embody the property of nominal exchange regime neutrality. Virtually any model that assumes that prices of individual commodities adjust on an essentially continuous basis to maintain equilibrium in individual

²The facts concerning the behavior of nominal and real exchange rates under floating exchange rate regimes have been documented in a number of previous studies. References to some of these studies are provided in footnote 6.

commodity markets is likely to embody this property.³ In principle, such models allow for very wide deviations from relative purchasing power parity in response to changes in real economic conditions requiring adjustments in the relative prices of different commodities.

One broad class of models that does not embody the property of nominal exchange regime neutrality consists of models that assume sluggishness in the adjustment of nominal price levels, relative to the speed of adjustment of nominal exchange rates under a floating exchange rate regime.⁴ Such models imply that real exchange rates move relatively slowly under fixed nominal exchange rate regimes, except for sharp changes in real exchange rates that are associated with changes in official parities. This is precisely the behavior that will be shown to be typical of real exchange rates under fixed exchange rate regimes. Under floating exchange rate regimes, these models imply that real exchange rates should exhibit many of the characteristics of the behavior of prices of assets traded in highly organized markets which are exhibited by nominal exchange rates under floating exchange rate regimes. Such behavior is very different from the actual behavior of real exchange rates under fixed exchange rate regimes, but it is typical of the actual behavior of real exchange rates under floating exchange rate regimes.

³The list of theoretical models that embody the property of nominal exchange regime neutrality is very long. It encompasses a broad array of models with very different specifications, including virtually all models that do not assume some sluggishness of the adjustment of prices or wages. For instance, many of the simple monetary models of exchange rate behavior, including those that allow for variations in relative prices of nontradable goods, have this property; see Frenkel (1978a), Frenkel and Clements (1981), and Clements and Frenkel (1980). Some dynamic versions of these monetary models that take account of the influence of expected future money supplies and other variables on current exchange rates also have this property; see, in particular, the nonsticky price model described in Mussa (1982 and 1984) or the model presented by Barro (1978). Many models that generate a demand for money by assuming that money enters the utility function possess the property of nominal exchange regime neutrality; see Stockman (1980), Obstfeld (1981) and Obstfeld and Stockman (1985). This is also true of models that generate a demand for money by introducing a cash in advance constraint, such as Lucas (1982), Helpman (1981), and Helpman and Razin (1982). In general, the models of exchange rate dynamics discussed in the excellent survey by Obstfeld and Stockman (1985), except those that assume some stickiness of prices, possess the property of nominal exchange regime neutrality.

⁴The assumption of price or wage stickiness was common in the older literature on open economy macroeconomics; for a survey of this literature, see Kenen (1985) or Mussa (1978). In the more recent literature, Dornbusch's (1976) famous analysis of exchange rate "overshooting" is based on the assumption of sluggishly adjusting prices. See also Buiter and Miller (1981 and 1982) and the relevant sections of Mussa (1982 and 1984), Obstfeld and Stockman (1985), and the surveys of Marston (1985) and Obstfeld and Stockman (1985).

Three points should be emphasized concerning the strategy for testing the broad classes of theoretical models of the behavior of real and nominal exchange rates and ratios of national price levels. First, the outcome of the test depends on finding substantial and systematic differences in the behavior of real exchange rates under different nominal exchange rate regimes, of the type that are consistent with models that assume sluggishness of adjustment of national price levels. The search for such differences could have turned up empty, and should have turned up empty if the hypothesis of nominal exchange regime neutrality were correct or if there were no sluggishness of adjustment of national price levels. Differences in the behavior of real exchange rates might have been modest, or differences in individual cases might have been substantial but not systematic across cases or not of the type predicted by models that assume sluggishness of adjustment of national price levels. The finding of substantial and systematic differences in the behavior of real exchange rates under different nominal exchange rate regimes, across a wide range of individual cases, therefore, is powerful evidence that something in the economic system makes the relative prices of the consumption baskets of different nations behave differently under different nominal exchange rate regimes.

Second, maintenance of a fixed nominal exchange rate generally imposes constraints on economic policies that are not imposed when a nominal exchange rate is allowed to float freely. The approach adopted in this study is to define the "nominal exchange rate regime" to include the set of economic policies typically employed in conjunction with a particular nominal exchange rate policy. This implies that some of the observed differences in the behavior of real exchange rates between fixed and floating exchange rate regimes are probably attributable to differences in economic policies pursued under these two different nominal exchange rate regimes. The task for those who believe that such policy differences are largely responsible for differences in the behavior of real exchange rates is to identify and relate differences in policies to the substantial and systematic differences that are observed in the behavior of real exchange rates.

Third, the results of this study do not imply blanket condemnation of models embodying the property of nominal exchange regime neutrality for all analytical purposes. Even models that assume absolute adherence to relative purchasing power parity can be quite useful in illustrating important principles concerning the operation of real world economic

systems. However, demonstration of fundamental inconsistency between the hypothesis of nominal exchange regime neutrality and empirical reality does suggest that caution should be used in applying models embodying this hypothesis to the analysis of real world economic issues, including analysis of the welfare effects of alternative economic policies and alternative exchange rate regimes.

The empirical analysis in this study is closely related to a large body of empirical research on the behavior of exchange rates and related variables under floating exchange rate regimes.⁵ It is also closely related to the voluminous literature on purchasing power parity.⁶ This study draws inspiration and support from much of this research. Many who have carried out this research would probably be little surprised by the findings of this study. However, the main objective, principal focus, and research methodology of this study are somewhat different from those of most other studies.⁷ Here the objective is not to assess the empirical relevance of purchasing power parity during periods of floating exchange

⁵Among the many excellent studies of the behavior of exchange rates, the early work of Poole (1967) deserves particular notice. More recent studies that are relevant to the issues discussed here include Cornell (1977), Cumby and Obstfeld (1985), Dornbusch (1980), Edwards (1982), Frankel (1979), Frenkel (1978a, 1980 and 1981a), Frenkel and Clements (1981), Genberg (1953), Hooper and Morton (1982), Hsieh (1985), Meese and Rogoff (1983), Mussa (1979a), Shafer and Loopesko (1983), Wasserfallen and Kyburz (1985), and Wolff (1985). An excellent survey of this empirical literature, with an extensive list of references, is provided by Levich (1985).

⁶In addition to providing interesting evidence on the relevance of purchasing power parity during the floating exchange rate period of the 1920s, Frenkel (1978b) provides an informative discussion of the history of the theory and a comprehensive list of references to the relevant literature. Another useful survey is provided by Officer (1976). Among the recent work on purchasing power parity, it is relevant to take particular notice of Adler and Lehman (1983), Aliber (1976), Cumby and Obstfeld (1985), Frenkel (1981b), Genberg (1978), Hakkio (1984), Isard (1977), Kravis and Lipsey (1978), Kravis, et al. (1975), Krugman (1978), and Roll (1979). Dornbusch (1985) provides an interesting discussion of the relevance of the theory of purchasing power parity for judging the equilibrium values of exchange rates.

⁷There has been much criticism of models that assume close adherence to relative purchasing power parity for purposes of analyzing either the behavior of the balance of payments under a fixed exchange rate regime (see, for instance, Kravis and Lipsey (1978)) or the behavior of exchange rates under a floating exchange rate regime (see, for instance, Dornbusch (1980)). It has not generally been recognized, however, that many models that allow for wide variations from relative purchasing power parity nevertheless embody the property of nominal exchange regime neutrality. Nor has it generally been recognized that models embodying this property can be tested by comparing the behavior of real exchange rates under the two types of nominal exchange rate regime. Indeed, relatively little of the empirical work that has documented substantial deviations from relative purchasing power parity has examined how the nature and extent of such deviations is related to the nominal exchange rate regime. Two exceptions in this regard are Aliber (1976) and Genberg (1978).

rates or in the long run, or to estimate the parameters of a specific model of exchange rate determination. Rather, the objective is to provide an empirical test of a broad class of theoretical models that predict no substantial and systematic differences in the behavior of real exchange rates under fixed versus floating exchange rate regimes, against a class of theoretical models that predict specific and important differences in such behavior under these two different nominal exchange rate regimes.

The scope of the empirical research undertaken in this study, the nature of the data used in this research, and the procedures used to analyze these data are described in Section 2. The results of the empirical analysis are presented in Sections 3 through 9. Analysis of the behavior of real exchange rates for thirteen industrial countries versus the United States for the period 1957 through 1984 is undertaken in Section 3. This analysis provides thirteen separate but related case studies of differences in the behavior of real exchange rates under a fixed exchange rate regime (the subperiod for 1957 through 1970) versus a floating exchange rate regime (the subperiod from 1973 through 1984). The case of Canada versus the United States is treated separately in Section 4 because there are two subperiods during which the Canadian dollar was floating against the U.S. dollar (1951 through early 1962 and early 1970 through 1984) separated by a subperiod (early 1962 through early 1970) when this nominal exchange rate was fixed. The data available for Canada and the United States also allow for an interesting and informative analysis of the behavior of real exchange rates between cities in these two countries. The cases of Ireland versus the United Kingdom, the United States, and West Germany are examined in Section 5. These cases are given separate treatment because Ireland kept its currency rigidly pegged to sterling through 1978 and then joined the European Monetary System in early 1979. The cases of Belgium and Luxembourg versus each other and of each of these countries versus West Germany and the United States are investigated in Section 6. These cases are interesting because the nominal exchange rate between Belgium and Luxembourg is rigidly fixed throughout the sample period, while the nominal exchange rate between either Belgium or Luxembourg and West Germany was subject to occasional adjustments which increased in frequency after 1973. The cases of Austria and Switzerland versus each other and versus West Germany are considered in Section 7. The nominal exchange rate between Austria and Switzerland was constant from 1957 through 1970, while the nominal exchange rates for these two countries against West Germany were affected by two official parity changes of the

Deutsche mark in 1961 and again in 1969. Starting in 1973, the Swiss franc was allowed to fluctuate with moderate freedom against the Deutsche mark, while Austria maintained a much tighter control of its nominal exchange rate against West Germany. A large number of additional cases of experiences with fixed and floating exchange rate regimes between industrial countries for the period starting in 1957 is summarized in Section 8. The experience with floating and fixed exchange rates between the United States and Great Britain in the period during and after the American Civil War, and the experiences with floating and fixed exchange rates among France, Great Britain and the United States in the period following the First World War are discussed briefly in Section 9.

Consideration of this large array of different cases is undertaken in order to demonstrate that substantial differences in the behavior of real exchange rates under different nominal exchange rate regimes are systematically observed across a very broad range of experience. These differences cannot be attributed to the peculiar events of a particular time period or a particular pair of countries.

The possibility that the observed differences in the behavior of real exchange rates under different nominal exchange rate regimes might be explained by deficiencies in the data, especially the data concerning national price levels, is discussed in Section 10. Basically, the conclusion is that observed differences in the behavior of real exchange rates are too large and too systematic to be explained away by deficiencies of the data.

In Section 11, the evidence is summarized that leads to conclusive rejection of the hypothesis of nominal exchange regime neutrality. Rejection of models embodying this property is not based on the statistical confidence level or power of a test for differences in the behavior of real exchange rates in individual cases of pairs of countries that have experienced different nominal exchange rate regimes. Indeed, the size of the observed difference in the short-term variability of real exchange rates under floating rather than fixed exchange rate regimes is generally so large that measures of statistical significance are irrelevant. The consistent observation of these large differences, without exception, across a broad array of cases is fatal to the hypothesis of nominal exchange regime neutrality.

The evidence supporting models that assume sluggishness in the adjustment of national price levels is reviewed in Section 12. It is argued that this assumption helps to explain observed regularities

concerning the behavior of ratios of national price levels, nominal exchange rates, and real exchange rates under different nominal exchange rate regimes. Consideration of the behavior of nominal and real exchange rates also provides a useful benchmark against which to judge the speed of adjustment of national price levels, and provides important evidence that appears to contradict the assumption that national price levels behave in the manner suggested by many models that assume instantaneous adjustment of all individual prices.

The study concludes, in Section 13, with a brief discussion of implications for economic policy which emphasizes the difficulty of stating strong conclusions about the welfare effects of alternative nominal exchange rate regimes.

II. SCOPE, DATA, AND METHODOLOGY

The purpose of the empirical analysis in this study is to investigate the behavior of real exchange rates under different nominal exchange rate regimes and to characterize the differences in such behavior that are systematically observed across a range of experiences with fixed and floating exchange rate regimes. The empirical analysis focuses on the experiences of sixteen of the more advanced industrial countries since 1957; Austria, Belgium, Canada, Denmark, France, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, the United States, and West Germany. Analysis of bilateral relationships between pairs of these sixteen countries allows potentially for 120 separate case studies of the effects of alternative nominal exchange rate regimes on the behavior of real exchange rates. Not all of these potential case studies, however, are independent, nor are they equally instructive with respect to the issues examined in this study. Accordingly, specific results will be presented only for a limited number of cases, and the results for other cases will be discussed in summary fashion.

Attention is focused on the experiences of the above-named industrial countries since 1957 because reasonably good data are easily available for nominal exchange rates and national price levels for these countries from the IFS tapes prepared by the International Monetary Fund, and because we can state with reasonable confidence and simplicity what the nominal exchange rate regime linking any pair of these countries was at various

times since 1957. (For the case of Canada versus the United States, the time period is extended back to 1951 and data sources other than the IFS tapes are used.⁸) By and large, these countries shared similar economic structures, enjoyed similar levels of economic development, and experienced similar and modest rates of general price inflation. Capital controls, exchange controls, and commercial policies have been used by these countries only to a relatively modest extent for purposes of influencing exchange rates and international payments positions. These same characteristics may be shared by a few other countries over a similarly extended time period. However, for many other countries, price-level data are less reliable or available for only a short time period. The nominal exchange rate regime is more difficult to identify; inflation rates have been high or highly variable; exchange controls, capital controls, or commercial policies have been used extensively to influence exchange rates and international payments positions; or other problems have existed which complicate considerably the analysis of relationships between the behavior of real exchange rates and the nature of the nominal exchange rate regime. Much probably can be learned from analysis of the experiences of these other countries, but it is beyond the scope of the present study to consider these experiences in any detail.

The behavior of three key variables will be analyzed for each of the pairs of countries examined in this study: the nominal exchange rate, the ratio of national price levels, and the real exchange rate. To maintain symmetry between two countries in measuring these three variables (and for other reasons), it is desirable to work with the natural logarithms of these variables, which always satisfy the relationship.

$$r = e + p \tag{1}$$

where r is the logarithm of the real exchange rate (defined as the

⁸The data used in Section 4 for the analysis of Canada versus the United States comes from the following sources. For the period from 1957 through 1984, the IRS tapes were used for the data for the two countries and for the exchange rate data in the study of Canadian and U.S. cities. Data on the consumer price index for Canada in 1950 and 1957 and for Toronto and Vancouver for the whole sample period were obtained from various issues of Statistics Canada, Consumer Prices and Price Indices. Exchange rate data for the period from 1950 to 1957 were obtained from various issues of the Federal Reserve Bulletin. Consumer price index data for Chicago and Los Angeles for the whole period were obtained from the data tape of the U.S. Consumer Price Index obtained from the Bureau of Labor Statistics

logarithm of the relative price of the home country's basket of commodities in terms of the basket of commodities of the foreign country), e is the logarithm of the nominal exchange rate (defined as the logarithm of the price of a unit of domestic money in terms of units of foreign money), and p is the logarithm of the ratio of the domestic price level to the foreign price level. With these definitions, an appreciation of the real exchange rate (an increase in r) has the common sense meaning of an increase in the real value of domestic goods in terms of foreign goods. Such a real appreciation can be brought about either by an appreciation of the nominal exchange rate (an increase in e), or by an increase in the ratio of the domestic price index to the foreign price index (an increase in p).

Consumer price indices (CPIs) are used to measure national price levels because reliable data for such price indices are generally available on at least a quarterly basis for the desired set of countries over the relevant time period. Wholesale price indices (WPIs) are also generally available on at least a quarterly basis for this same set of countries over the same period. However, I believe indices (WPIs) are generally less appropriate as measures of national price levels for the purposes of the present study. Hence these indices are used only to confirm the results established using consumer price indices as the basic measure of national price levels. National product deflators are generally not available on a reliable basis for a sufficiently long period for so broad a range of countries.

In almost all cases, quarterly average observations on consumer price indices are used because data on quarterly average CPIs are conveniently available from the IFS tapes. Because quarterly average data are used to measure national price levels, quarterly average data are also used to measure nominal exchange rates. This means that the two components of the real exchange rate, and hence the real exchange rate itself, are measured on the same quarterly average basis. As is well-known, use of time averaged data alters the serial correlation properties of a data series, relative to what would be observed with point-in-time (or end-of-period) data. Fortunately, the nature and extent of the alteration of the serial correlation properties of the series for the logarithms of the nominal exchange rate and the real exchange rate can be estimated with reasonable confidence (as discussed below), and this can be taken into account interpreting the results obtained by using quarterly averaged data.

One technique employed in this study for analyzing the behavior of real exchange rates, nominal exchange rates, and ratios of national price

levels under alternative nominal exchange rate regimes is simply to plot the behavior of the logarithms of these three variables for a particular pair of countries over a time period (usually 1957 through 1984) in which the nominal exchange rate is sometimes fixed and sometimes floating. In the figure for each pair of countries, movements in r are always exactly the sum of movements in e and movements in p ⁹. Many important regularities concerning the behavior of real exchange rates and their relationship with the behavior of nominal exchange rates and ratios of national price levels are immediately apparent from examination and comparison of these figures. For example, if relative purchasing power parity held exactly all of the time, regardless of the nominal exchange rate regime, we should observe that the path of r is completely flat and that movements in e exactly offset movements in p . The fact that we do not observe this in any figure indicates that relative purchasing power parity does not hold absolutely all of the time. The extent of divergence from relative purchasing power parity under different exchange rate regimes is indicated by the extent of movements in r . The extent to which divergences from purchasing power parity are accounted for by movements in the nominal exchange rate (including changes in official parities under a fixed exchange rate regime) is indicated by the degree of correspondence of movements in r with movements in e .

In terms of these figures, the property of nominal exchange regime neutrality translates into the proposition that the path of r should not exhibit systematically different behavior during periods of floating rather than fixed nominal exchange rates. As we shall see, this is not the case. Quite systematically, when the nominal exchange rate is floating, there is greater short-term variability of the real exchange rate, there is strong correlation between movements in the nominal exchange rate and movements in the real exchange rate, and there is substantial persistence of short-term movements in the real exchange rate. (There is also some evidence of a long-run tendency for nominal exchange rates and ratios of national price levels to move in the offsetting fashion required for the maintenance of relative purchasing power parities, at least for pairs of countries with substantial differences in long-run inflation rates.)

⁹In many of the figures, constants have been added to the value of p , e , or r in order to obtain visual separation of the plots of these series. Since the issues of concern are the relationships among movements in these series, this practice does not create any difficulty.

Further evidence concerning the behavior of nominal exchange rates, ratios of national price levels, and real exchange rates is provided in tables that report, for each pair of countries, statistics concerning the means, the variances, the covariances, and the first-order serial correlation coefficients of quarterly changes in e , p and r . Using a Δ to denote quarterly changes, these means are denoted by $\text{Mean}(\Delta e)$, $\text{Mean}(\Delta p)$, and $\text{Mean}(\Delta r)$. The variance and covariances are denoted by $\text{Var}(\Delta e)$, $\text{Var}(\Delta p)$, $\text{Var}(\Delta r)$, $\text{Cov}(\Delta e, \Delta p) = \text{Cov}(\Delta p, \Delta e)$, $\text{Cov}(\Delta e, \Delta r) = \text{Cov}(\Delta r, \Delta e)$, and $\text{Cov}(\Delta p, \Delta r) = \text{Cov}(\Delta r, \Delta p)$. The first-order serial correlation coefficients are denoted by $\text{Corr}(\Delta e)$, $\text{Corr}(\Delta p)$, and $\text{Corr}(\Delta r)$. In general, statistics concerning these means, variances, covariances, and serial correlation coefficients are reported for the whole sample period (usually 1957:2 through 1984:3) and for subperiods corresponding to different nominal exchange rate regimes. The subperiod (for quarterly changes) from 1957:2 through 1970:4, during which the currencies of all industrial countries except Canada were always pegged to the U.S. dollar, is usually referred to as the fixed-rate subperiod. The subperiod from 1970:4 through 1973:1 is usually treated separately as a transition period from a fixed exchange rate regime to a floating exchange rate regime. The subperiod from 1973:1 through 1984:3 is usually referred to as the floating rate subperiod because exchange rates against the U.S. dollar were generally floating during this subperiod and because many other (but not all) bilateral exchange rates among industrial countries were also floating during this period.

Since quarterly changes in e , p , and r necessarily satisfy the relationship

$$\Delta r = \Delta e + \Delta p, \quad (2)$$

it must always be true that

$$\text{Mean}(\Delta r) = \text{Mean}(\Delta e) + \text{Mean}(\Delta p). \quad (3)$$

Also, the variance-covariance matrix for Δe , Δp , and Δr must always be singular, possessing only three, rather than the usual six, independent elements. In particular, the variance of quarterly changes in r can always be expressed as

$$\text{Var}(\Delta r) = \text{Var}(\Delta e) + \text{Var}(\Delta p) + 2 \cdot \text{Cov}(\Delta e, \Delta p); \quad (4)$$

and the covariances involving Δr can be written as

$$\text{Cov}(\Delta e, \Delta r) = \text{Var}(\Delta e) + \text{Cov}(\Delta e, \Delta p), \quad (5)$$

$$\text{Cov}(\Delta p, \Delta r) = \text{Var}(\Delta p) + \text{Cov}(\Delta e, \Delta p). \quad (6)$$

Given the relationships (2) through (6), it would be possible to reduce the statistics reported for quarterly changes in e , p , and r to two means, two variances, one covariance, and two serial correlation coefficients. This is not done in order to preserve the symmetry of treatment of the nominal exchange rate, the ratio of national price levels, and the real exchange rate.

Maintenance of such symmetry is desirable because all of these variables are jointly determined endogenous variables whose behavior reflects the influence of more fundamental economic forces. There is no necessary reason to believe, a priori, that changes in nominal exchange rates and changes in ratios of national price levels are determined by essentially independent economic forces, with changes in real exchange rates determined by the sum of these essentially independent factors. Indeed, if the property of nominal exchange regime neutrality held empirically, we should expect that the real exchange rate would be driven by essentially independent real economic forces, with movements in ratios of national price levels and also, under floating exchange rate regimes, movements in nominal exchange rates adjusting to accommodate necessary movements in real exchange rates.

It might be objected that variances of quarterly changes in p , e and r are not necessarily the appropriate measures of the short term variability of these series. In particular, the time series processes characterizing the evolution of any of these variables (under either a fixed or floating exchange rate regime) might be such that a significant portion of the quarterly change in a variable is predictable on the basis of past behavior. If so, then the variance of the quarterly change in the variable would generally overstate the extent of unpredictable short-term volatility of the variable. Also, if time series processes were different under different exchange rate regimes, then increases in the variances of quarterly changes in p , e , or r might not be valid indications of increases in the extent of unpredictable short-term volatility of these variables.

Three points should be noted in dealing with this difficulty. First, the basic issue in this study is whether real exchange rates exhibit

substantially and systematically different behavior under different nominal exchange rate regimes. The figures that describe the time paths of real exchange rates for different pairs of countries generally show such dramatic differences in behavior under fixed and floating exchange rate regimes that exact statistical characterization of these differences is not essential to address this central issue. Second, under floating exchange rate regimes, real and nominal exchange rates (both measured with end-of-period data) are usually well-described by random walks. The variances of quarterly changes in these variables (adjusted for the use of quarterly average data), therefore, provide reasonably accurate measures of the extent of unpredictable short-term volatility in real and nominal exchange rates under floating exchange rate regimes. Third, under fixed rate regimes, real and nominal exchange rates are often not well-described as random walks. This generally implies that variances of quarterly changes in these variables overstate, rather than understate, the extent of unpredictable short-term volatility in these variables. This tends to bias results against the main findings of the present study. Large changes in nominal and real exchange rates associated with infrequent official parity changes under fixed exchange rate regimes probably increase this bias. Fourth, with respect to the behavior of the ratio of national price levels, the important conclusion is that the volatility of short-term movements in p (under both fixed and floating exchange rate regimes) is generally small relative to the volatility of short-term movements in e and r under floating exchange rate regimes. Use of the variance of quarterly changes in p to measure short-term volatility of p does not seriously prejudice the evidence in favor of this conclusion.

A more elaborate procedure would be to estimate and report vector autoregressions for quarterly changes or levels of e , p , and r for subperiods with different nominal exchange rate regimes and for a number of pairs of countries.¹⁰ This is not done primarily because it adds complexity and confusion to what can and should be a simple demonstration of systematic differences between fixed and floating exchange rate regimes. With vector autoregressions, the order of the process (which could be different under different nominal exchange rate regimes or for

¹⁰Meltzer (1985) has employed the technique of vector autoregressions to investigate relationships among movements in prices, income levels, money supplies, and the exchange rate between Japan and the United States and has produced some interesting results.

different pairs of countries) would need to be determined. Coefficients representing lagged relationships among changes in e , p , and r , as well as contemporaneous relationships, would need to be estimated along with their respective standard errors. The variance-covariance matrix of innovations in the joint stochastic process for e , p , and r would need to be estimated and the results might need to be reported in as many as six different ways in order to preserve symmetry treatment of e , p , and r . All of this would need to be done in many cases where only a relatively small number of quarterly observations is available. Fortunately, it is not necessary to report and interpret the mass of statistics derived from vector autoregressions in order to demonstrate substantial and systematic differences between fixed and floating exchange rate regimes.

Facts concerning the behavior of e , p , and r observed for many pairs of countries that are relevant for demonstrating important and systematic differences between fixed and floating exchange rate regimes are stated (in capital letters) as empirical regularities. The first important regularity is that

The short term variability of real exchange rates is substantially larger when the nominal exchange rate between these countries is floating rather than fixed.

Evidence supporting this regularity comes from figures illustrating the behavior of the real exchange rate between a particular pair of countries. Further evidence comes from the fact that $\text{Var}(\Delta r)$ is generally four to eighty times larger during periods when the nominal exchange rate between two countries is floating than it is during subperiods when the nominal exchange rate between these countries is fixed.

The second important regularity apparent from the figures plotting the behavior of e , p , and r is that

During subperiods when the nominal exchange rate is floating, there is strong correlation between short-term movements in the real exchange rate and short-term movements in the nominal exchange rate.

The fact that during floating rate subperiods, $\text{Var}(\Delta r)$ is approximately the same size as $\text{Var}(\Delta e)$, and the ratios $\text{Cov}(\Delta e, \Delta r)/\text{Var}(\Delta e)$ and $\text{Cov}(\Delta e, \Delta r)/\text{Var}(\Delta r)$ are generally close to unity provides statistical confirmation of this regularity. Further evidence comes from using equation (4) to assess the factors that account for the increase in $\text{Var}(\Delta r)$ between a subperiod with a fixed nominal exchange rate and a subperiod with a floating nominal exchange rate. Increases in $\text{Var}(\Delta e)$ always account for

most of the increase in $\text{Var}(\Delta r)$, with only small contributions from increases in $\text{Var}(\Delta p)$ and even smaller (and sometimes negative) contributions from changes in $\text{Cov}(\Delta e, \Delta p)$.

The third important regularity is that

The ratio of national price levels exhibits smoother evolution during fixed and floating exchange rate subperiods than does either the real exchange rate or the nominal exchange rate during subperiods when the nominal exchange rate is floating.

Statistical evidence supporting this regularity comes from the fact that $\text{Var}(\Delta p)$ during both fixed and floating exchange rate subperiods is typically much smaller than $\text{Var}(\Delta r)$ or $\text{Var}(\Delta e)$ during floating rate subperiods.

The fourth important regularity is that

Short-term changes in nominal exchange rates and in real exchange rates show substantial persistence during subperiods when the nominal exchange rate is floating.

This regularity is apparent in the figures which often show relatively large cumulative changes in nominal and real exchange rates over periods extending to a year or more. Statistical evidence supporting this regularity comes from the serial correlation coefficients $\text{Corr}(\Delta e)$ and $\text{Corr}(\Delta r)$. Generally, these serial correlation coefficients are positive and relatively small (less than 0.4) during subperiods when the nominal exchange rate is floating. This indicates that changes in the nominal or real exchange rate in one quarter do not tend to be offset, but rather to a small extent reinforced, by changes in the subsequent quarter.

The small apparent tendency toward reinforcement of quarterly changes in e and r under floating rate regimes is probably a consequence of using quarterly average data to measure national price levels and nominal exchange rates. Several studies have shown that under floating exchange rate regimes, logarithms of nominal exchange rates measured on an end-of-period basis are well-described as random walks.¹¹ This means that there is essentially zero serial correlation of changes in logarithms of nominal exchange rates measured on an end-of-period basis. Logarithms of real

¹¹The approximate random walk behavior of nominal exchange rates under floating exchange rate regimes is documented in many studies; in particular, Poole (1967), Cornell (1977), Kohlthagen (1978), Meese and Rogoff (1983), Mussa (1979), and Wasserfallen and Kyburz (1985).

exchange rates measured using end-of-period data are also reasonably well-described as random walks.¹² Suppose that based on daily data, logarithms of nominal exchange rates and logarithms of real exchange rates followed random walks during periods of floating nominal exchange rates. It may be shown theoretically that if we used quarterly averaged values of daily observations on logarithms of nominal exchange rates and logarithms of real exchange rates, the estimated serial correlation coefficients for changes in these quarterly averages (in large samples) should be very close to 0.20.¹³ In fact, the estimated serial correlation coefficients $\text{Corr}(\Delta e)$ and $\text{Corr}(\Delta r)$ based on quarterly average data, during subperiods with floating nominal exchange rates, are generally positive and close to 0.20. This indicates that the degree of persistence of quarterly changes in e and r under floating exchange rate regimes is close to the degree of persistence that would be observed if nominal and real exchange rates followed random walks. (The point here is not to demonstrate that r follows a random walk, which would imply the odd conclusion that the logarithm of the relative price of the consumption baskets of two countries passes outside of any finite bound with probability one over a sufficiently long-time horizon. Rather the point is to demonstrate that quarterly changes in r , as well as quarterly changes in e , exhibit substantial persistence.)

It should be noted that the tendency toward persistence of short-term changes in real exchange rates is also a characteristic of fixed exchange rate regimes. This is especially so when changes in official parties induce large simultaneous movements in nominal and real exchange rates. The distinguishing feature of floating rate regimes is that large movements in real exchange rates (usually corresponding to movements of similar magnitude in nominal exchange rates) occur with much greater frequency than

¹²The approximate random walk behavior of real exchange rates is less well-documented than that of nominal exchange rates, but is also a fairly well-known phenomenon; see, in particular, Abuaf (1985), Mussa (1979), Roll (1979), and Saidi and Swoboda (1981).

¹³Suppose that end-of-day data were available for ratios of national price levels, as well as for nominal exchange rates. Suppose that based on such data, logarithms of real exchange rates, as well as logarithms of nominal exchange rates, followed random walks on a daily basis. Take quarterly averages of these daily observations. The serial correlation coefficient for changes in these quarterly averages has a theoretical value close to 0.20. A similar theoretical calculation shows that the variance of the change in the quarterly average nominal or real exchange rate should be close to two-thirds of the value of this variance using end-of-quarter data.

under fixed exchange rate regimes, and these large short-term movements in real exchange rates show substantial persistence.

The fifth regularity concerns the relationship between changes in official parities under a fixed exchange rate regime and contemporaneous changes in real exchange rates:

Substantial changes in official parities under a fixed exchange rate regime are generally associated with contemporaneous changes of similar magnitude in corresponding real exchange rates.

This regularity is usually visually apparent from the figures showing the paths of e , p , and r . More precise evidence can generally be obtained by comparing Δe and Δr for those quarters in which Δe is affected by an official parity change.

III. THE UNITED STATES AND THIRTEEN OTHER INDUSTRIAL COUNTRIES

Under the Bretton Woods system, nominal exchange rates between the United States and other industrial countries (except Canada) were fixed with only infrequent changes in official parities from the 1950s until August 1971. After a nineteen-month attempt to sustain the Bretton Woods system, nominal exchange rates between the United States and other industrial countries were generally allowed to float, starting in March 1973 and continuing to the present day. Efforts have sometimes been made to limit movements of nominal exchange rates against the U.S. dollar through sterilized and nonsterilized intervention and by other means. Despite these efforts, nominal exchange rates of other industrial countries against the United States have behaved very differently in the floating rate period since 1973 than they did in the fixed-rate period prior to 1971. In particular, it is well-known that since 1973 nominal exchange rates against the U.S. dollar (often measured logarithmically) are statistically well-described as random walks with standard deviations of monthly or quarterly changes of about 3% per month and 5% per quarter. This contrasts sharply with the very small monthly or quarterly movements of nominal exchange rates against the U.S. dollar (except for official parity changes) prior to 1971.

These substantial changes in the behavior of nominal exchange rates between the United States and other industrial countries are reflected in substantial changes in the behavior of real exchange rate between the

United States and these countries. Key facts concerning changes in the behavior of these real exchange rates and their relationship to changes in the behavior of the corresponding nominal exchange rates are revealed in Figures 1 through 8 and in Table 1. Each of the figures shows the path of the logarithm of the nominal exchange rate measured as the U.S. dollar price of a unit of foreign currency (lighter solid line), the path of the logarithm of the ratio of the foreign CPI to the U.S. CPI (dashed and dotted line), and the path of the logarithm of the real exchange rate measured as the logarithm of the relative price of the foreign consumption basket in terms of the United States consumption basket (heavier solid line). Table 1 reports statistics for the means, variances, covariances, and serial correlation coefficients of quarterly changes in the logarithms of nominal exchange rates, ratios of national price levels, and real exchange rates for different countries against the United States. For each country, statistics are reported for the whole period 1957:2 through 1984:3; for the fixed rate subperiod 1957:2 through 1970:4; for the transition period 1970:4 through 1973:1; and for the floating rate subperiod 1973:1 through 1984:3.¹⁴ In the figures and in Table 1, quarterly average data are used: To conserve space, only statistics and not figures are presented for some of the smaller European countries; specifically, Austria, Belgium, Denmark, Luxembourg, and Norway. The omitted figures look similar to the figures actually presented, resembling most closely the figures for the Netherlands or Sweden. No important additional regularity concerning the behavior of real exchange rates would be revealed and no regularity here stated would be contradicted by these omitted figures.

Five important regularities are immediately apparent from Figures 1 to 8 and the statistics reported in Table 1:

Short-term variability of real exchange rates between the United States and other industrial countries is substantially greater during the floating rate

¹⁴The third quarter of 1984 was the last quarter for which data were available from the IFS tapes used for this study. Statistics for the transition period from the first quarter of 1971 through the first quarter of 1973 are reported separately. This transition period could be regarded as part of the fixed rate period or part of the floating rate period or as a separate period with its own exchange rate regime (or lack thereof). Adding the transition period to either the earlier fixed rate period or the later flexible rate period does not materially affect the conclusions of this study.

FIGURE 1

France v. U.S

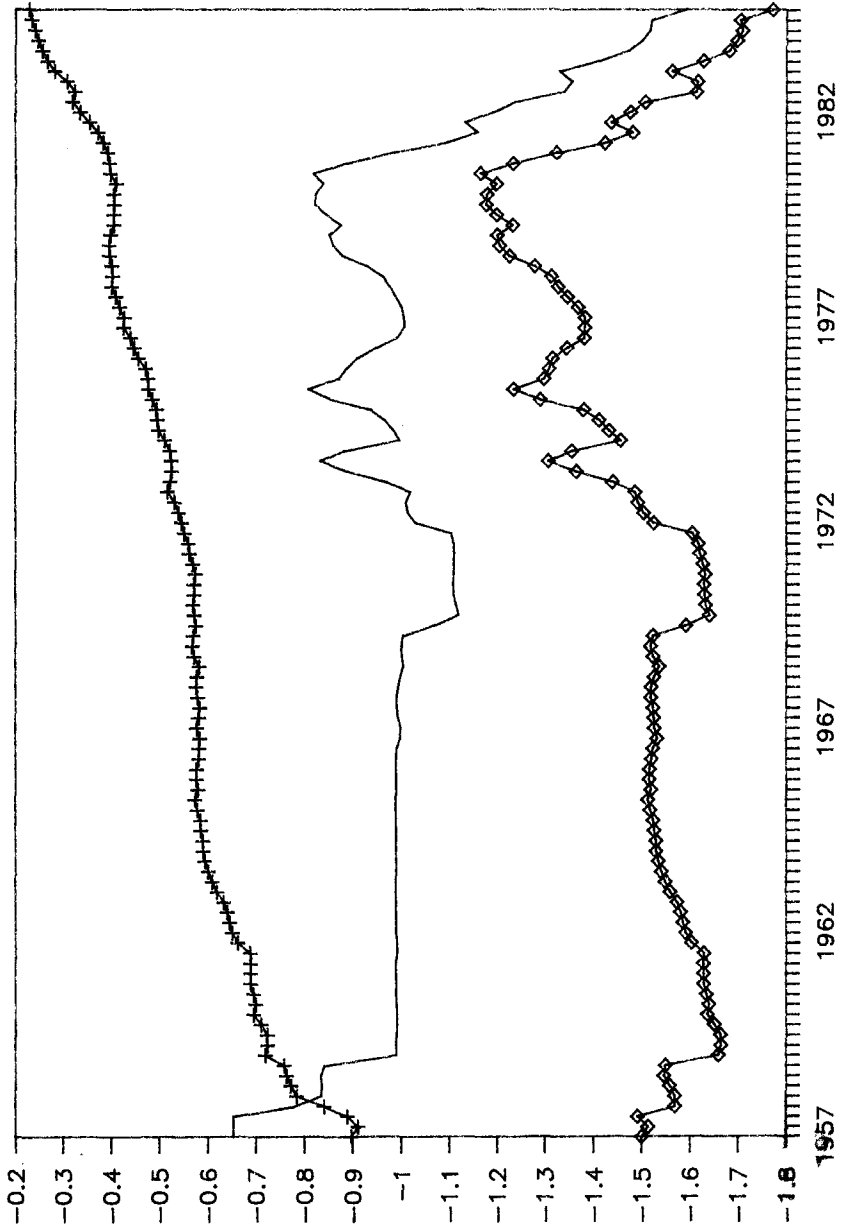


FIGURE 2

Italy v. U.S.

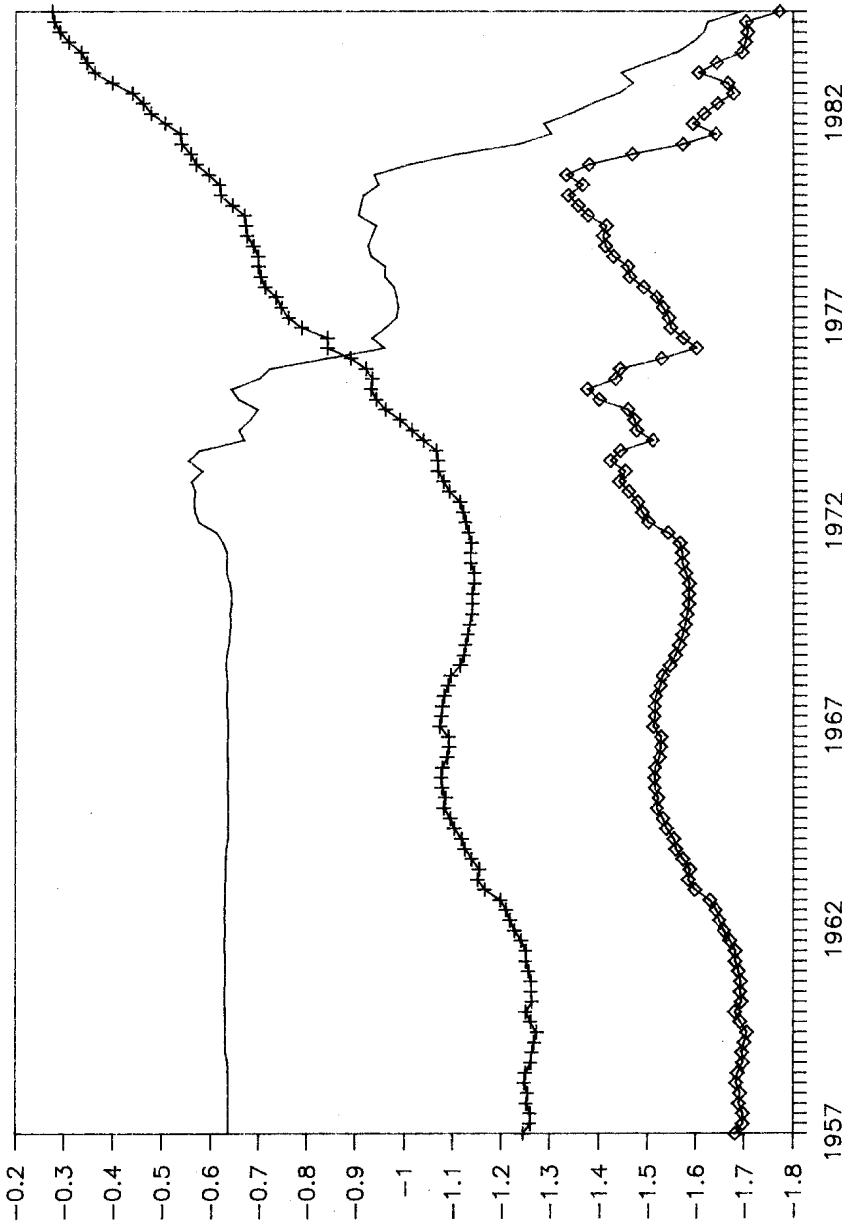


FIGURE 3

Japan v. U.S.

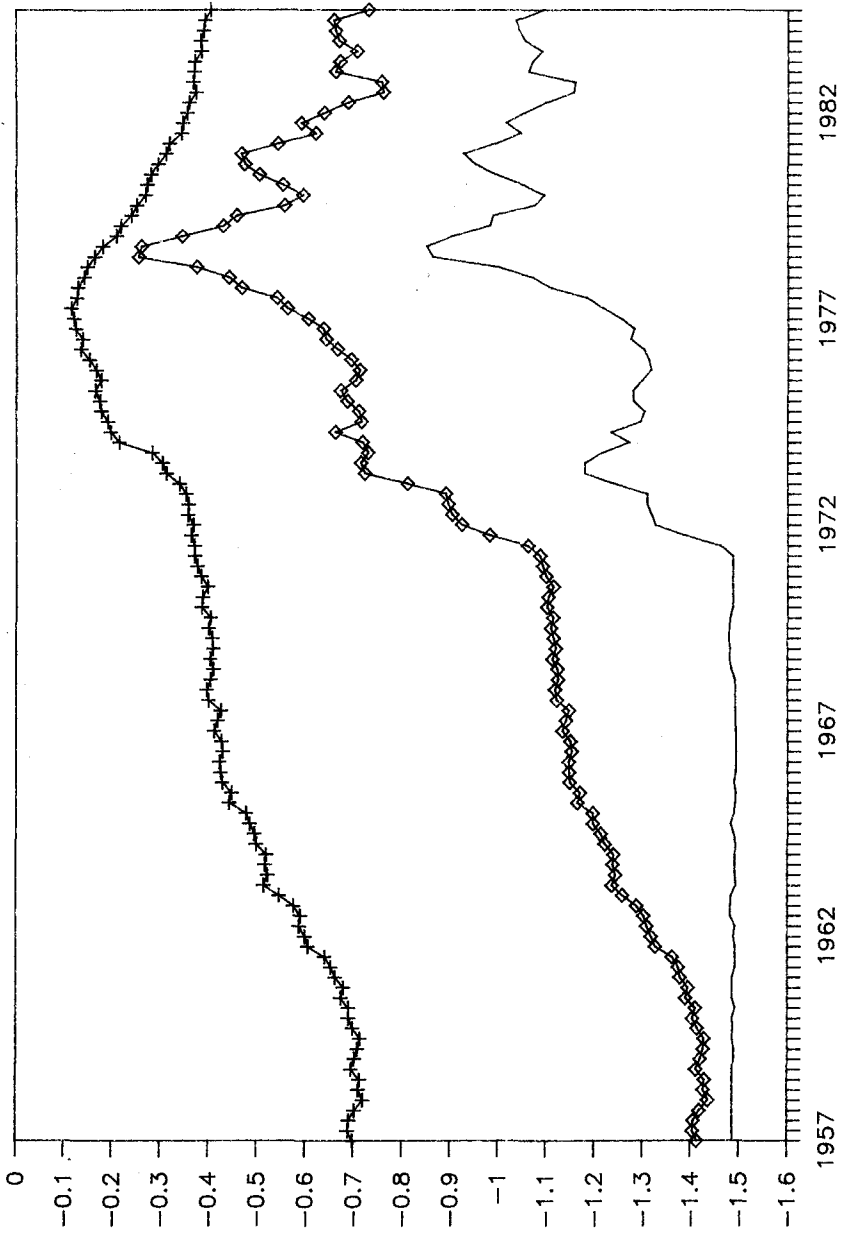


FIGURE 4

Netherlands v. U.S.

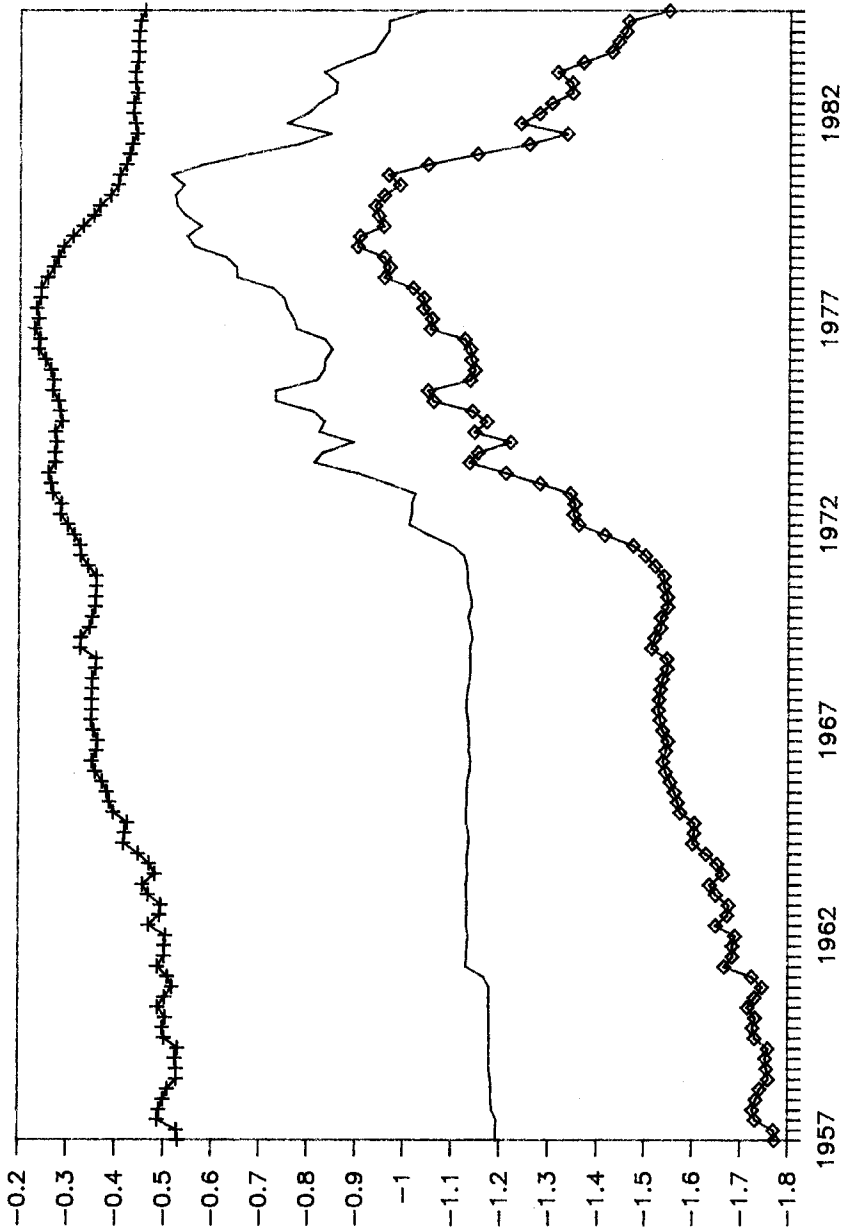


FIGURE 5
Sweden v. U.S.

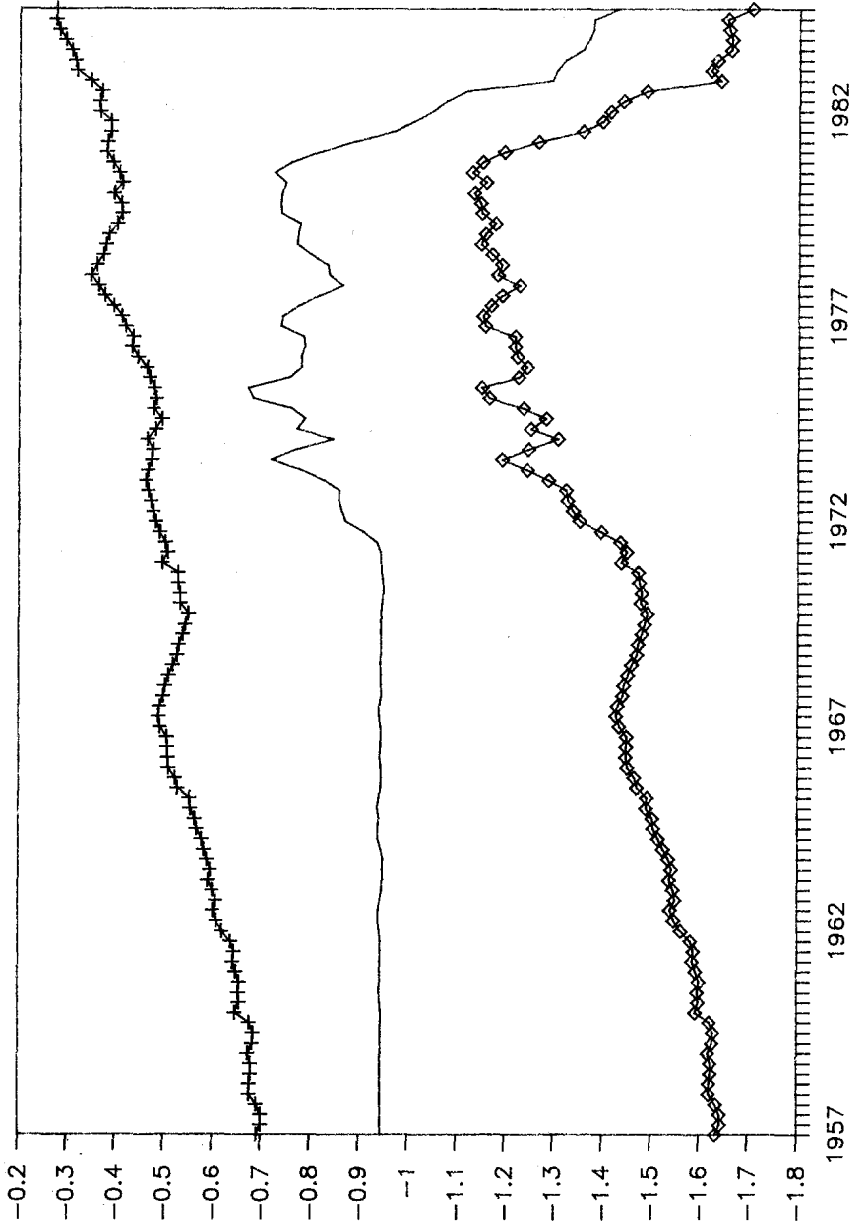


FIGURE 6

Switzerland v. U.S.

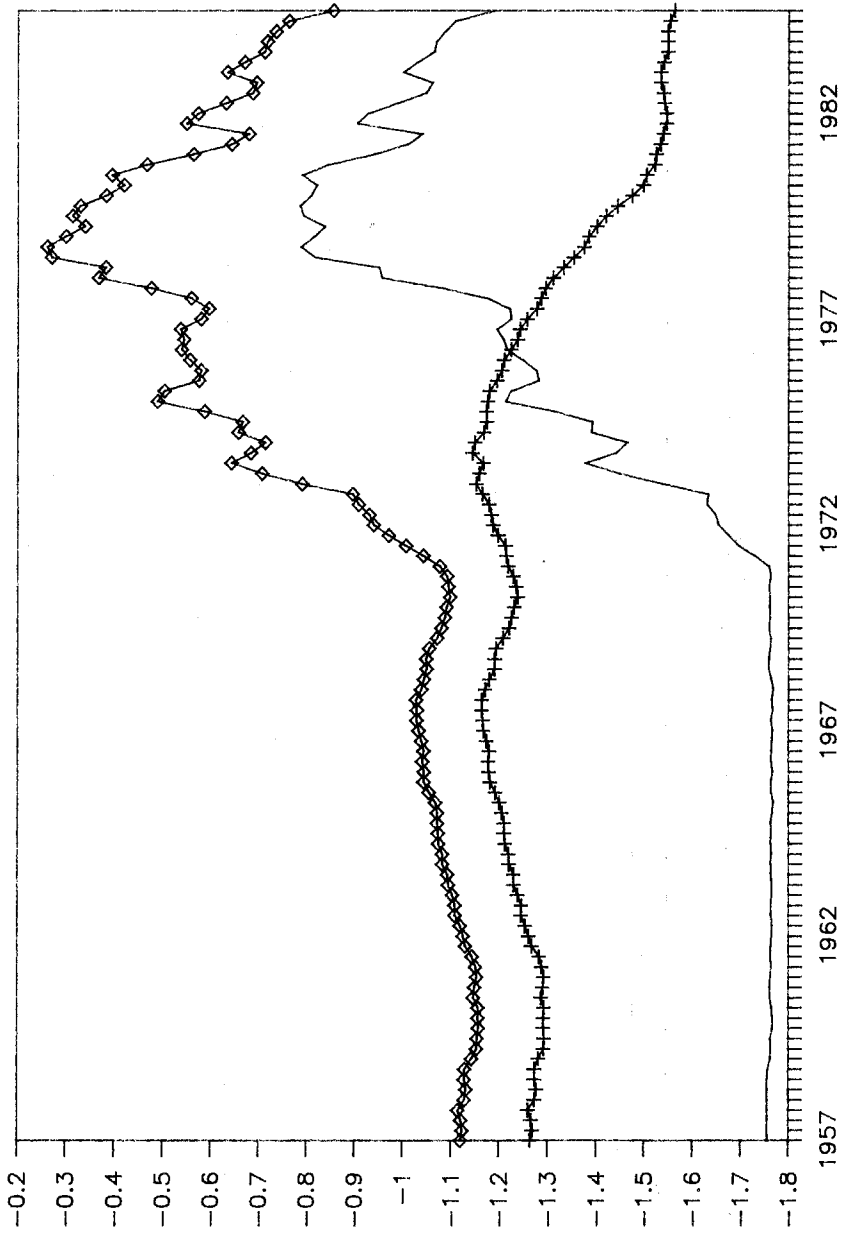


FIGURE 7
United Kingdom v. U.S.

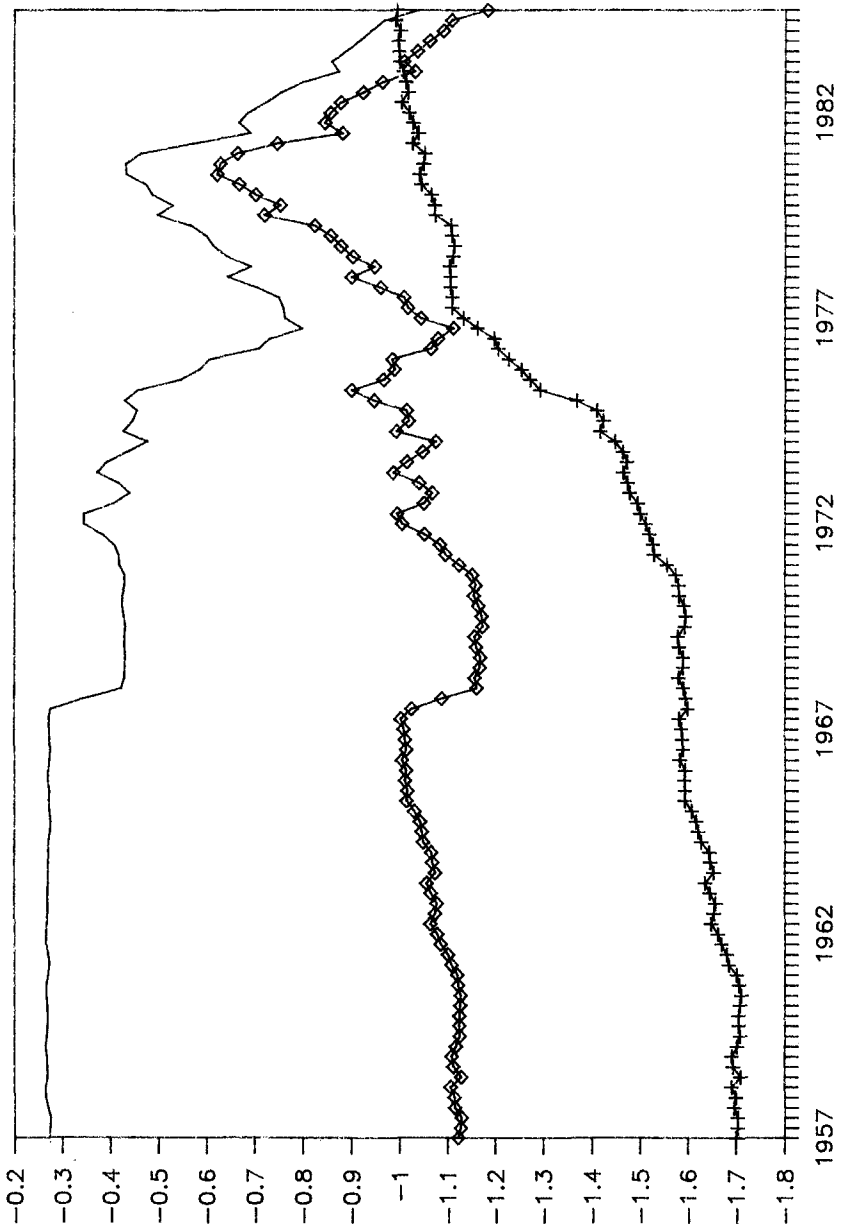


FIGURE 8

Germany v. U.S.

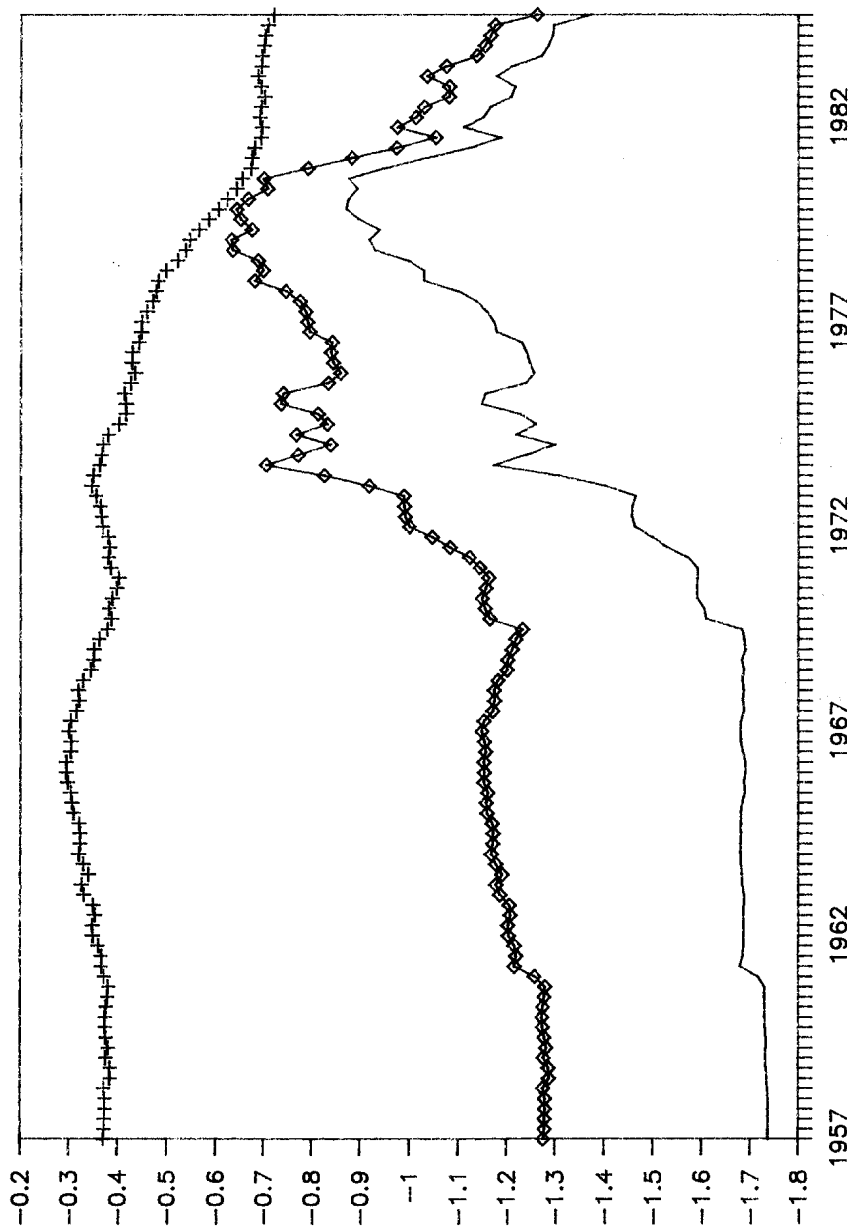


TABLE 1

1.1 Austria versus the United States

	1957,2-1984,3	1957,2-1972,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	-.103	.099	.544	-.469
Mean (e)	.214	.006	1.707	.261
Mean (r)	.111	.105	2.251	0.208
Var (p)	1.600	2.042	.280	1.084
Var (e)	11.445	.019	4.435	26.440
Var (r)	13.032	2.079	4.800	27.395
Cov (e,p)	-0.006	.010	.042	-.065
Cov (p,r)	1.597	2.051	.322	1.018
Cov (e,r)	11.438	.029	4.478	26.375
Corr (p)	.1218	-.0670	.2671	.2736
Corr (e)	.2194	.0154	-.1531	.2148
Corr (r)	.1753	-.0592	-.0694	.1721

1.2 Belgium versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.016	-.023	.415	-.029
Mean (e)	-.146	.022	1.705	-.618
Mean (r)	-.130	-.001	2.120	-.648
Var (p)	.721	.346	.345	1.230
Var (e)	11.820	.057	5.827	26.430
Var (r)	12.525	.403	6.817	27.332
Cov (e,p)	-.008	0.000	.323	-.164
Cov (p,r)	.714	.346	.668	1.064
Cov (e,r)	11.807	.057	6.150	26.267
Corr (p)	.5578	.2314	-.0887	.6488
Corr (e)	.3299	.0667	.1817	.3092
Corr (r)	.2800	.2369	.1798	.2452

1.3 Denmark versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.510	.508	.549	.487
Mean (e)	-.392	-.149	1.394	-.923
Mean (r)	.118	.359	1.943	-.436
Var (p)	1.421	1.575	.426	1.447
Var (e)	10.368	.491	3.247	23.040
Var (r)	12.348	2.187	3.489	25.613
Cov (e,p)	.281	.061	-.093	.563
Cov (p,r)	1.702	1.636	.333	2.010
Cov (e,r)	10.647	.552	3.155	23.603
Corr (p)	.0674	.1532	-.3351	-.0201
Corr (e)	.2902	.4978	.0793	.2568
Corr (r)	.2353	.0679	.2543	.2174

1.4 France versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.607	.587	.499	.614
Mean (e)	-.855	-.829	1.411	-1.220
Mean (r)	-.247	-.242	1.910	-.606
Var (p)	1.002	1.543	.301	.540
Var (e)	15.085	8.197	7.252	24.275
Var (r)	13.352	5.258	6.462	23.590
Cov (e,p)	-1.370	-2.241	-.545	-.611
Cov (p,r)	-.369	-.598	-.244	-.071
Cov (e,r)	13.718	5.956	6.707	23.662
Corr (p)	.3799	.3865	-.2825	.4078
Corr (e)	.3664	.1756	-.06489	.4317
Corr (r)	.3072	.1150	.03260	.3376

1.5 Italy versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.880	.180	.632	1.738
Mean (e)	-.961	.006	.822	-2.399
Mean (r)	-.081	.186	1.454	-.661
Var (p)	1.732	.886	.476	1.636
Var (e)	9.296	.032	1.290	17.944
Var (r)	8.020	.864	1.500	16.859
Cov (e,p)	-1.505	-.027	-.133	-1.362
Cov (p,r)	.227	.859	.343	.275
Cov (e,r)	7.793	.005	1.158	16.583
Corr (p)	.4936	.3957	.2494	.1578
Corr (e)	.4105	.1923	.3111	.2912
Corr (r)	.3154	.3605	.3164	.2778

1.6 Japan versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.237	.515	.613	-.113
Mean (e)	.355	.011	.2395	.452
Mean (r)	.592	.527	3.008	.339
Var (p)	1.920	1.368	.413	2.689
Var (e)	10.783	.078	8.850	23.501
Var (r)	12.768	1.420	9.064	26.720
Cov (e,p)	.033	-.013	-.100	.265
Cov (p,r)	1.953	1.355	.313	2.954
Cov (e,r)	10.816	.065	8.750	23.766
Corr (p)	.4127	.1733	-.1455	.5159
Corr (e)	.3637	.1329	.2234	.3411
Corr (r)	.3727	.1186	.1279	.3682

1.7 Luxembourg versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	-.085	-.110	.333	-.160
Mean (e)	-.146	.022	1.705	-.618
Mean (r)	-.231	-.088	2.038	-.778
Var (p)	.855	.468	.326	1.376
Var (e)	11.820	.057	5.827	26.430
Var (r)	11.992	.513	5.958	25.827
Cov (e,p)	-.340	-.006	-.096	-.991
Cov (p,r)	.515	.462	.230	.385
Cov (e,r)	11.478	.051	5.730	25.439
Corr (p)	.5149	.1976	-.2841	.6537
Corr (e)	.3299	.0667	.1817	.3092
Corr (r)	.2663	.2185	.1494	.2306

1.8 Netherlands versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.067	.310	.932	-.398
Mean (e)	.137	.112	1.673	-.039
Mean (r)	.204	.422	2.605	-.437
Var (p)	1.700	2.220	.652	.843
Var (e)	10.831	.345	5.876	24.275
Var (r)	13.323	2.826	5.929	26.143
Cov (e,p)	.396	.131	-.301	.512
Cov (p,r)	2.097	2.351	.351	1.355
Cov (e,r)	11.227	.475	5.577	24.787
Corr (p)	.2484	-.0567	-.5048	.4314
Corr (e)	.1533	.1314	.0964	.2394
Corr (r)	.2178	-.0829	.1985	.2064

1.9 Norway versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.351	.352	.706	.273
Mean (e)	-.144	-.001	1.337	-.505
Mean (r)	.207	.351	2.043	-.232
Var (p)	1.174	1.112	.312	1.382
Var (e)	7.643	.012	3.897	17.340
Var (r)	8.316	1.108	4.322	17.250
Cov (e,p)	-.251	-.008	.057	-.739
Cov (p,r)	7.393	.004	3.954	16.600
Corr (p)	.2218	.4820	-.0586	.3774
Corr (e)	.2805	.0634	-.0660	.2680
Corr (r)	.1974	.0627	-.0146	.1764

1.10 Sweden versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.378	.295	.668	.407
Mean (e)	-.442	-.002	1.205	-1.216
Mean (r)	-.064	.293	1.872	-.809
Var (p)	1.080	.735	1.300	1.414
Var (e)	9.647	.038	2.028	21.271
Var (r)	9.187	.782	3.752	18.879
Cov (e,p)	-.770	.003	.213	-.190
Cov (p,r)	.309	.741	1.512	-.516
Cov (e,r)	8.878	.041	2.241	19.368
Corr (p)	.1329	.1610	-.5677	.2238
Corr (e)	.3144	.1570	.1691	.2718
Corr (r)	.2401	.1717	-.1345	.1969

1.11 Switzerland versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	-.272	.063	.829	-.847
Mean (e)	.512	-.014	2.206	.935
Mean (r)	.240	.049	3.035	.088
Var (p)	.937	.423	.238	1.008
Var (e)	15.047	.057	7.885	34.610
Var (r)	15.101	.464	8.398	34.141
Cov (e,p)	-.442	-.007	.137	-.737
Cov (p,r)	.495	.415	.375	.271
Cov (e,r)	14.605	.050	8.023	33.869
Corr (p)	.6367	.4943	-.0380	.4465
Corr (e)	.2965	-.1543	-.1685	.2872
Corr (r)	.3081	.4215	-.0903	.2821

1.12 The United Kingdom versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.641	.230	1.061	1.031
Mean (e)	-.698	-.286	.124	-1.276
Mean (r)	-.056	-.056	1.185	-.245
Var (p)	1.701	.748	.566	2.648
Var (e)	11.010	1.970	8.474	21.630
Var (r)	12.500	2.640	8.623	24.630
Cov (e,p)	-.108	-.039	-.208	.174
Cov (p,r)	1.593	.709	.358	2.821
Cov (e,r)	10.900	1.931	8.265	21.804
Corr (p)	.2756	-.1427	-.1229	.3175
Corr (e)	.2871	.5306	.3308	.2367
Corr (r)	.1954	.3688	.3141	.1551

1.13 West Germany versus the United States

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1984,
Mean (p)	-3.19	-.060	.530	-.799
Mean (e)	.331	.263	1.872	.198
Mean (r)	.013	.203	2.402	-.581
Var (p)	.787	.549	.449	.715
Var (e)	12.720	1.291	5.310	27.800
Var (r)	13.706	1.712	5.857	28.778
Cov (e,p)	.010	-.064	.049	.131
Cov (p,r)	.797	.485	.498	.845
Cov (e,r)	13.716	1.228	5.349	27.930
Corr (p)	.4886	.2642	-.3418	.4352
Corr (e)	.2223	.0965	.0738	.2185
Corr (r)	.2187	.0746	.0001	.1910

Notes: Mean(x) refers to the mean of quarterly changes in x.
 Var(x) refers to the variance of quarterly changes in x.
 Cov(x,y) refers to the covariance between quarterly changes in x and quarterly changes in y.
 Corr(x) refers to the first order serial correlation coefficient of quarterly changes in x.
 p is the logarithm of the ratio of CPI in a country to the CPI in the U.S.
 e is the logarithm of the price of a unit of the country's money in terms of U.S. dollars
 r is the logarithm of the relative price of the country's consumption basket in terms of the U.S. consumption basket ($r = p + e$).
 The subperiods in the table refer to quarterly intervals; e.g. 1957,2-1984,3 refers to quarterly changes starting with the second quarter of 1957 (the change from the first quarter of 1957 to the second quarter of 1957) and extending through the third quarter of 1984 (the change from the second quarter of 1984 to the third quarter of 1984).

subperiod 1973-84 than during the fixed rate subperiod 1957-70.

There is strong correlation between short-term movements in nominal exchange rates and short-term movements in real exchange rates between the United States and other industrial countries during the floating rate subperiod 1973-84.

Short-term movements in nominal and real exchange rates between the United States and other industrial countries show substantial persistence during the floating rate subperiod 1973-84.

Changes in official parities against the United States dollar under the fixed exchange rate system are generally associated with changes of similar magnitude in real exchange rates; and aside from these changes in real exchange rates associated with changes in official parities, changes in real exchange rates are typically much smaller during the fixed rate subperiod than during the floating rate subperiod.

For the whole period 1957-84, ratios of national price levels of other industrial countries against the United States typically exhibit smoother evolution than nominal or real exchange rates during the floating rate subperiod 1973-84.

Comparison of the variances of quarterly changes in real exchange rates for the floating rate subperiod 1973-84 with the variances of quarterly changes in real exchange rates for the fixed rate subperiod 1957-70 provides dramatic support for the first of these empirical regularities. For all thirteen countries versus the United States for which statistics are reported in Table 1, $\text{Var}(\Delta r)$ is generally eight to eighty times greater in 1973-84 than it is in 1957-70. The only exception is France versus the United States, where $\text{Var}(\Delta r)$ increases by a factor of four between the fixed and floating exchange rate subperiods. The relatively smaller increase in $\text{Var}(\Delta r)$ for France versus the United States is due to the three substantial depreciations of the French franc (1957, 1958, and 1969) during the fixed rate subperiod. If quarters affected by changes in official parities are purged from the data, then $\text{Var}(\Delta r)$ increases by at least a factor of ten between the fixed and floating rate period for all industrial countries versus the United States.

The strong correlation between short-term movements of nominal exchange rates and short-term movements of real exchange rates during the floating rate subperiod 1973-84 is visually apparent for eight countries versus the United States from Figures 1 through 8. Statistical evidence supporting this regularity is provided by the fact that during the floating rate subperiod, the ratios of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta e)$ and of $\text{Cov}(\Delta e, \Delta r)$ are all close to unity. Alternatively, we may use the decomposition of the variance of quarterly changes in the real exchange rate, $\text{Var}(\Delta r) = \text{Var}(\Delta e) + \text{Var}(\Delta p) + 2 \cdot \text{Cov}(\Delta e, \Delta p)$, to assess the factors responsible for the increase in $\text{Var}(\Delta r)$ between the fixed rate subperiod 1957-70 and the floating rate subperiod 1973-84. In all thirteen cases, nearly all of the increase in $\text{Var}(\Delta r)$ is accounted for by the increase in $\text{Var}(\Delta e)$, with only a small contribution from the increase in $\text{Var}(\Delta p)$ and a small and sometimes negative contribution from the change in $\text{Cov}(\Delta e, \Delta p)$.

The persistence of quarterly changes in nominal and real exchange rates between the United States and other industrial countries during the floating rate subperiod is visually apparent from Figures 1 through 8. Statistical evidence indicating such persistence is provided by the fact that the serial correlation coefficients for quarterly changes in nominal and in real exchange rates, $\text{Corr}(\Delta e)$ and $\text{Corr}(\Delta r)$. For the 1973-84 subperiod these serial correlation coefficients are generally near or a little above the 0.20 value that would be expected from use of quarterly average data if the nominal exchange rate and the real exchange rate (measured with point-in-time data of high frequency) each followed a random walk. There is no evidence of strong negative serial correlation of quarterly changes in nominal or real exchange rates which would be an indication that short-term movements in these variables tend to be quite transitory.

The regularity concerning the effects of official parity changes refers to the following events. In 1967, the British pound and the Danish krone were both devalued against the U.S. dollar. The Dutch guilder was revalued against the U.S. dollar along with the West German mark in 1961. The West German mark was revalued again in 1969. The French franc was devalued against the U.S. dollar in 1957, in 1958, and again in 1969. Official parities for the other countries (Austria, Belgium, Italy, Japan, Luxembourg, Norway, Sweden, and Switzerland) against the United States were not altered during the fixed rate subperiod 1957-70. During the transition subperiod 1971-72, the currencies of all thirteen of these countries were revalued against the U.S. dollar. For the eight countries illustrated in

Figures 1 through 8, these changes in official parities are reflected in roughly equal changes in nominal and real exchange rates. The same is true for the five countries for which no illustration is provided.

The relative smoothness of the paths of the ratios of national price levels throughout the period 1957-84, in comparison with the jaggedness of the paths of real and nominal exchange rates during the floating rate subperiod 1973-84, is convincingly demonstrated by looking at Figures 1 through 8. This visual impression is confirmed by the relatively small size of the variances of quarterly changes in ratios of national price levels, $\text{Var}(\Delta p)$, in both the fixed and floating rate subperiods, in comparison with the variances of quarterly changes in nominal exchange rates, $\text{Var}(\Delta e)$, and the variances of quarterly changes in real exchange rates, $\text{Var}(\Delta r)$, during the floating rate subperiod.

IV. CANADA AND THE UNITED STATES

The Canadian dollar was floating against the United States dollar from the end of 1950 to the second quarter of 1962, was fixed against the United States dollar from the second quarter of 1962 to the first quarter of 1970, and has been floating against the United States dollar since the second quarter of 1970. Movements of nominal exchange rate between the Canadian and United States dollars during both of these floating rate subperiods are generally smaller than movements of nominal exchange rates of the currencies of other industrial countries against the United States dollar since 1973. In particular, standard deviations of monthly or quarterly percentage changes in the nominal exchange rate between Canada and the United States during these two floating rate subperiods are generally less than one-half as large as standard deviations of monthly or quarterly percentage changes of nominal exchange rates for other industrial countries against the United States since 1973. The behavior of the nominal exchange rate between Canada and the United States during the two floating rate subperiods, however, shares the key qualitative feature of other examples of floating exchange rates.

The existence of two subperiods during which the nominal exchange rate between Canada and the United States is floating, separated by a subperiod with a fixed nominal exchange rate, provides critical evidence of the consequence of different nominal exchange rate regimes, as opposed simply to different time periods, for the behavior of real exchange rates. In

this regard, it is helpful that the first floating rate subperiod for Canada against the United States occurs when inflation rates in both countries are quite low, while the second floating rate subperiod occurs when inflation rates for both countries are quite high by historical standards.

In Figure 9, the lighter solid line plots the path of the logarithm of the nominal exchange rate between Canada and the United States, measured as the price of a Canadian dollar in terms of U.S. dollars. The dashed and dotted line plots the path of the logarithm of the ratio of the Canadian CPI to the U.S. CPI. The heavier solid line plots the path of the logarithm of the real exchange rate between Canada and the United States, defined as the relative price of the Canadian consumption basket in terms of the United States consumption basket. In contrast to Figures 1 through 8 and all other figures in this paper, except Figure 10, the data underlying Figure 9 are not quarterly averages for nominal exchange rates and consumer price indices. Instead, the end-of-quarter value has been used for the nominal exchange rate, and the last month of the quarter observation has been used for the CPI for both Canada and the United States. For quarterly observations, this achieves approximately the correct temporal alignment between the nominal exchange rate and consumer price indices. The Canadian CPI for a given month is based on data collected during the last two weeks of that month and the first week of the succeeding month. The U.S. CPI for the same month is based on data collected for the last three weeks of that month.

Table 2 reports statistics for the means, variances, covariances, and serial correlation coefficients of quarterly changes in the logarithms of the nominal exchange rate, the ratio of national price levels, and the real exchange rate between Canada and the United States. These statistics are reported for the whole period 1951:1 through 1984:3 and for the subperiods 1951:1 to 1962:2, 1962:3 to 1970:1, and 1970:2 to 1984:3.

The data underlying the statistics reported in Table 2 are the same as the data underlying Figure 9; namely, the end-of-quarter nominal exchange rate and the last month of the quarter CPIs. The statistics reported in Table 3 are also the means, variances, covariances, and serial correlations coefficients for the same subperiods reported in Table 2, but based on quarterly average data for the nominal exchange rate and the Canadian and U.S. CPIs. There is no important difference between Tables 2 and 3 with respect to the regularities they reveal concerning the behavior of nominal exchange rates, ratios of national price levels, and real exchange rates.

FIGURE 9

Canada v. U.S.

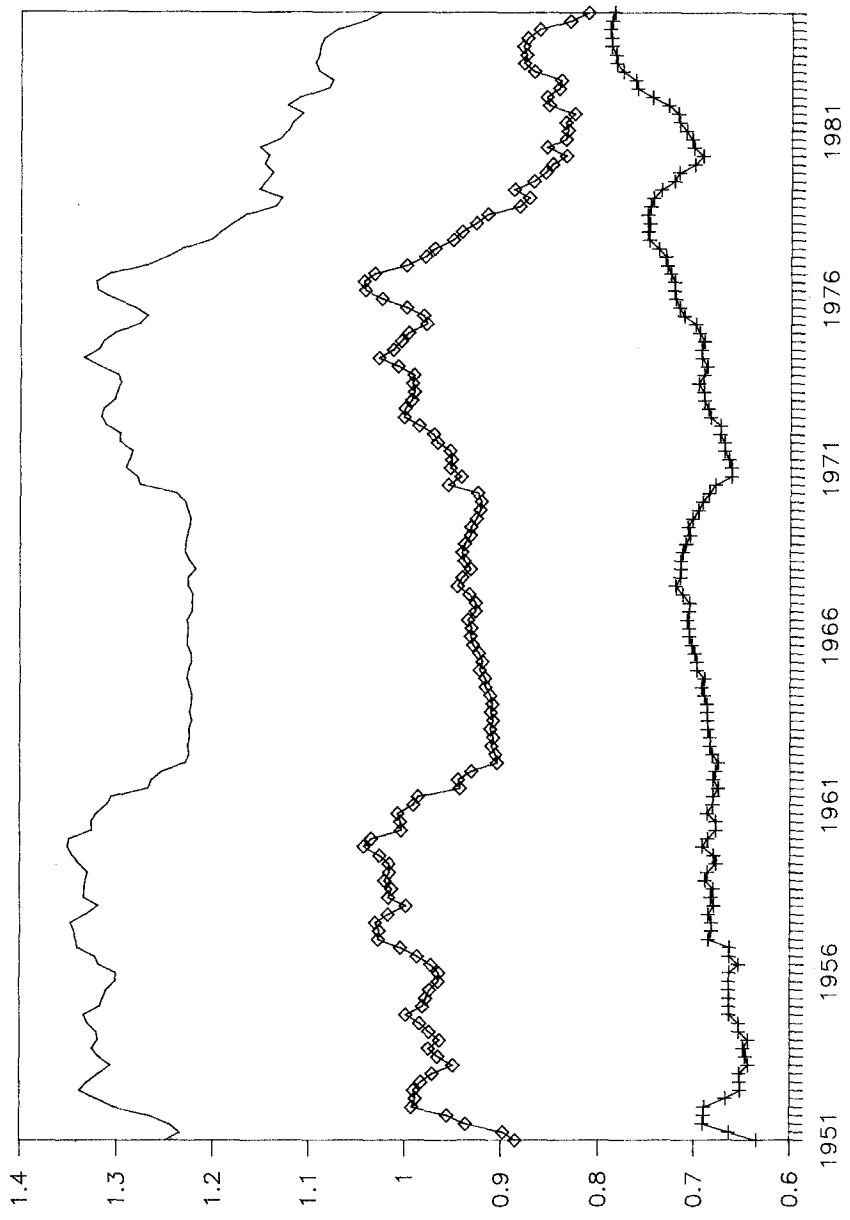


TABLE 2

Canada versus the United States (based on end-of-quarter data)

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,2-1984,3
Mean (p)	.091	.040	.036	.160
Mean (e)	-.161	-.044	.026	-.355
Mean (r)	-.071	-.004	.062	-.195
Var (p)	.563	.580	.195	.756
Var (e)	2.641	2.394	.125	4.183
Var (r)	3.079	2.976	.301	4.701
Cov (e,p)	-.063	.001	-.010	-.119
Cov (p,r)	.500	.581	.185	.637
Cov (e,r)	2.578	2.395	.115	4.064
Corr (p)	.2043	.2723	-.1035	.1763
Corr (e)	.1163	.1187	.0290	.1030
Corr (r)	.0536	.1361	-.0251	.0194

TABLE 3

Canada versus the United States (based on quarterly averages)

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,2-1984,3
Mean (p)	.088	.019	.052	.162
Mean (e)	-.166	-.049	.001	-.349
Mean (r)	-.078	-.029	.053	-.187
Var (p)	.509	.829	.136	.461
Var (e)	1.647	1.823	.107	2.316
Var (r)	1.940	2.591	.228	2.372
Cov (e,p)	-.108	-.031	-.008	-.203
Cov (p,r)	.401	.799	.128	.258
Cov (e,r)	1.539	1.793	.099	2.113
Corr (p)	.2689	.1118	.1700	.4837
Corr (e)	.3906	.3516	-.1381	.4011
Corr (r)	.2422	.1976	.0306	.2881

Similarly, it would make no important difference for present purposes if Figure 9 (and Figure 10 to be discussed shortly) were based on quarterly average data, rather than on end-of-quarter and last-month-of-quarter data.

From Figure 9 and either Table 2 or Table 3, the following regularities are apparent with respect to the behavior of nominal and real exchange rates and ratios of national price levels between Canada and the United States:

The short-term variability of the real exchange rate is substantially greater during either of the two subperiods with a floating nominal exchange rate than it is during the subperiod with a fixed nominal exchange rate.

There is strong correlation between short-term movements in the real exchange rate and short-term movements in the nominal exchange rate during both of the subperiods with a floating nominal exchange rate.

Short-term movements of nominal and real exchange rates show substantial persistence during both of the subperiods with a floating nominal exchange rate.

For the whole period, the ratio of national price levels exhibits much smoother evolution than either the nominal exchange rate or the real exchange rate during either of the two subperiods with a floating nominal exchange rate.

These regularities are essentially the same as the corresponding regularities discussed in the preceding section for the cases of thirteen industrial countries versus the United States. The statistical evidence supporting each of these regularities is also essentially the same as in that earlier discussion. The variance of quarterly changes in the real exchange rate, $\text{Var}(\Delta r)$, is many times greater in each of the floating rate subperiods than it is in the fixed rate subperiod, indicating greater short-term variability of real exchange rates under a floating rate regime. The ratio of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta r)$ is above 0.75 for both floating rate subperiods, indicating strong correlation between short-term movements in nominal and real exchange rates. Alternatively, the increase in $\text{Var}(\Delta r)$ between the fixed rate subperiod and either of the two floating rate subperiods is accounted for primarily by the increase in $\text{Var}(\Delta e)$, rather than by increases in $\text{Var}(\Delta p)$ or $\text{Cov}(\Delta e, \Delta p)$. The serial correlation coefficients $\text{Corr}(\Delta e)$ and $\text{Corr}(\Delta r)$ reported in Table 3 for the two floating

rate subperiods are somewhat higher than the 20% values expected from quarterly averaged data if the nominal and real exchange rates followed random walks based on point-in-time data, but they still indicate persistence of shorter-term changes in nominal and real exchange rates during the floating rate subperiods.¹⁵ (As expected, the serial correlation coefficients $\text{Corr}(\Delta e)$ and $\text{Corr}(\Delta r)$ reported in Table 2 have smaller values than those reported in Table 3, while the variances $\text{Var}(\Delta e)$ and $\text{Var}(\Delta r)$ have larger values. This is due to the effects of using end-of-quarter rather than quarterly average data.) The variance of quarterly changes in the ratio of national price levels, $\text{Var}(\Delta p)$, during each of the subperiods is small relative to $\text{Var}(\Delta e)$ or $\text{Var}(\Delta r)$ during either of the two floating rate subperiods, indicating the relative smoothness of the path of the ratio of national price levels.

Observance of the above-stated regularities for Canada versus the United States (where there are two subperiods with a floating exchange rate separated by a subperiod with a fixed exchange rate) provides important evidence that differences in the behavior of real exchange rates under floating and fixed exchange rate regimes are due to differences between these regimes, rather than being the consequence of larger real disturbances requiring adjustments of relative prices that happen to occur during a particular time period. Further evidence on this point can be obtained from an investigation of the behavior of real exchange rates between Canadian and United States cities using the data on consumer price indices reported for SMSAs (Standard Metropolitan Sampling Areas) in both

¹⁵The relatively high value of the serial correlation coefficient of 0.1187 for quarterly changes in the nominal exchange rate reported for end-of-quarter data in Table 2 for the first floating rate subperiod is consistent with Poole's finding of some positive correlation of exchange rate changes in the cases of the Canadian dollar versus the U.S. dollar. This is reflected in Table 3 in a serial correlation coefficient of 0.3516 for quarterly changes in the nominal exchange rate for this subperiod based on quarterly average data. If there were no serial correlation based on end-of-quarter data, we would have expected that the serial correlation coefficient based on quarterly average data would be close to 0.20. The same points apparently apply to the second floating rate subperiod and for quarterly changes in the real exchange rate as well as the nominal exchange rate.

Canada and the United States.¹⁶ Since the nominal exchange rate between any two United States cities is rigidly fixed at unity, the real exchange rate between two such cities is the ratio of the CPIs for these two cities. The same is true for the real exchange rate between two Canadian cities. The real exchange rate between a Canadian city and a United States city, however, is influenced by the nominal exchange rate linking the Canadian and U.S. dollars--a nominal exchange rate that is floating between 1951:1 and 1962:2, fixed between 1962:3 and 1970:1, and floating from 1970:2 to 1984:3. The question of interest is how the behavior of the real exchange rate between two cities in Canada or the United States is influenced by the nominal exchange rate linking the monies used in these two cities.

Evidence relevant to this question is presented in Figure 10. The lighter solid line at the top of this figure plots the logarithm of the nominal exchange rate measured as the U.S. dollar price of a Canadian dollar. (The flat section in the middle line corresponds to the subperiod when the nominal exchange rate between Canada and the United States is fixed.) The dashed and dotted line just below the middle of the figure plots the logarithm of the ratio of the CPI in Toronto to the CPI in Chicago. The heavier solid line just above the middle of the figure plots the logarithm of the real exchange rate between Toronto and Chicago, defined as the relative price of the Toronto consumption basket in terms of the Chicago consumption basket. The lighter solid line second from the bottom of the figure plots the logarithm of the ratio of the CPI in Chicago to the CPI in Los Angeles, which corresponds to the logarithm of the real exchange rate between Chicago and Los Angeles. The lighter solid line at the bottom of the figure plots the logarithm of the ratio of the CPI in Toronto to the CPI in Vancouver, which corresponds to the logarithm of the real exchange rate between Toronto and Vancouver.

Table 4 reports the statistics for the means, variances, covariances, and serial correlation coefficients of quarterly changes in the logarithms of nominal exchange rates, ratios of consumer price indices, and real exchange rates between pairs of the four cities: Toronto, Vancouver,

¹⁶The idea of analyzing the behavior of real exchange rates between Canadian and U.S. cities and comparing this with the behavior of real exchange rates between two Canadian cities was inspired partly by Genberg's (1975) use of measures of deviations from purchasing power parity among U.S. cities to gauge the extent of such deviations that might be expected between countries.

FIGURE 10

Canadian and U.S. Cities

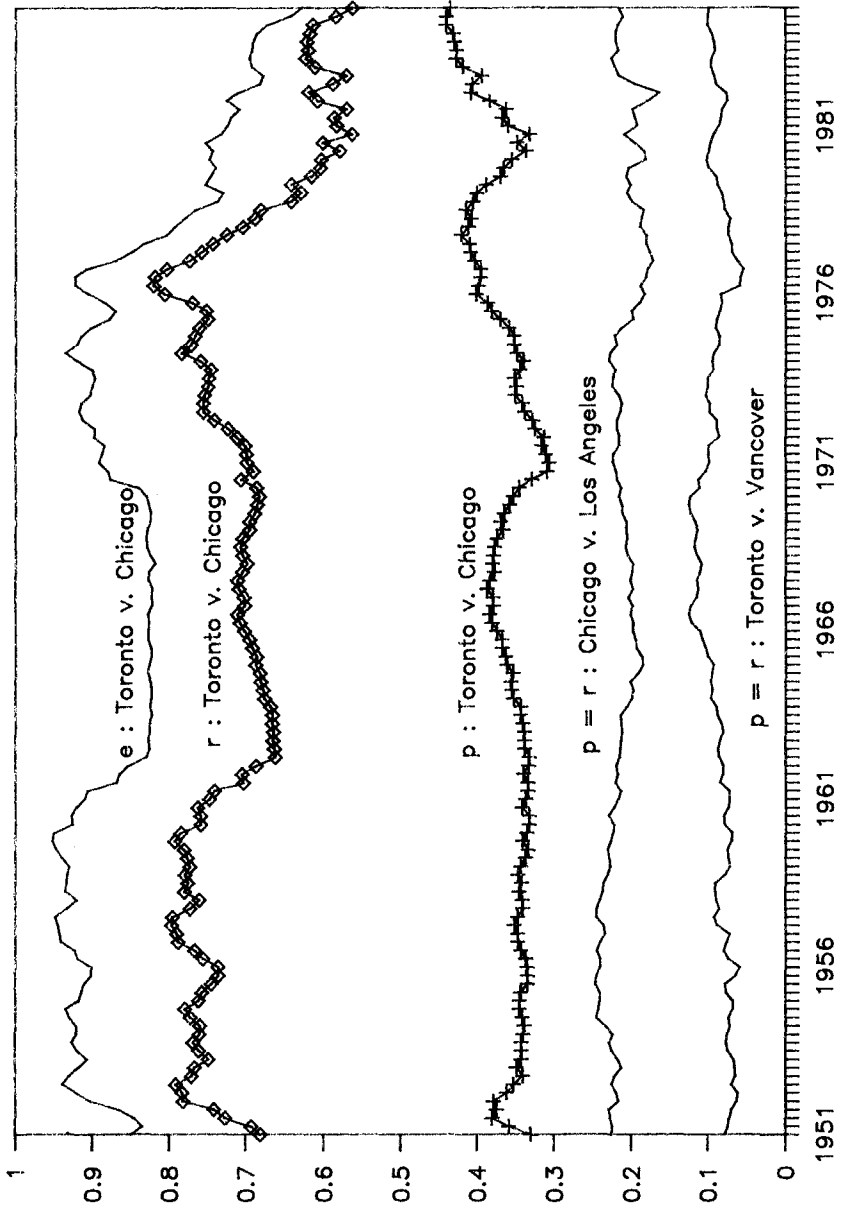


TABLE 4

4.1 Chicago versus Los Angeles

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,2-1984,3
Mean(p)	-.012	-.047	.019	-.002
Var(p)	.726	.382	.312	1.240
Corr(p)	-.1086	-.1931	-.1929	-.7149

4.2 Toronto versus Vancouver

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,1-1984,3
Mean(p)	.022	.040	.112	-.041
Var(p)	.552	.766	.252	.552
Corr(p)	-.1531	-.2357	-.1305	-.0888

4.3 Toronto versus Chicago

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,2-1984,3
Mean(p)	.079	.025	.048	.137
Mean(e)	-.161	-.044	.026	-.355
Mean(r)	-.083	-.019	.075	-.218
Var(p)	.980	.611	.325	1.643
Var(e)	2.641	2.394	.125	4.183
Var(r)	3.519	3.140	.416	5.539
Cov(e,p)	-.051	.068	-.017	-.144
Cov(p,r)	.929	.679	.308	1.500
Cov(e,r)	2.591	2.462	.108	4.040
Corr(p)	-.0117	.0826	-.3128	-.0211
Corr(e)	.1163	.1187	.0290	.1030
Corr(r)	-.0225	.0521	-.2133	-.0476

4.4 Vancouver versus Chicago

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,2-1984,3
Mean(p)	.057	-.015	-.064	.178
Mean(e)	-.161	-.044	.026	-.355
Mean(r)	-.105	-.059	-.037	-.178
Var(p)	1.297	1.138	.451	1.885
Var(e)	2.641	2.394	.125	4.183
Var(r)	4.179	3.390	.550	6.849
Cov(e,p)	.121	-.071	-.013	.391
Cov(p,r)	1.418	1.067	.438	2.274
Cov(e,r)	2.761	2.323	.112	4.571
Corr(p)	.0173	.0929	-.3040	.0092
Corr(e)	.1163	.1187	.0290	.1030
Corr(r)	.0508	.2033	-.2227	.0092

4.5 Toronto versus Los Angeles

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,2-1984,3
Mean (p)	.066	-.022	.067	.135
Mean (e)	-.161	-.044	.026	-.355
Mean (r)	-.095	-.066	.094	-.220
Var (p)	1.028	.714	.367	1.650
Var (e)	2.641	2.394	.125	4.183
Var (r)	3.624	3.388	.497	5.547
Cov (e,p)	-.022	.140	.003	-.143
Cov (p,r)	1.006	.854	.370	1.507
Cov (e,r)	2.617	2.534	.128	4.040
Corr (p)	.1448	.1554	-.1747	.1673
Corr (e)	.1163	.1187	.0290	.1030
Corr (r)	.0212	.0164	-.0497	.0294

4.6 Vancouver versus Los Angeles

	1951,1-1984,3	1951,1-1962,2	1962,3-1970,1	1970,2-1984,3
Mean (p)	.044	-.062	-.045	.176
Mean (e)	-.161	-.044	.026	-.355
Mean (r)	-.117	-.106	-.019	-.179
Var (p)	1.182	.974	.437	1.748
Var (e)	2.641	2.394	.125	4.183
Var (r)	4.120	3.371	.575	6.713
Cov (e,p)	.149	.002	.007	.391
Cov (p,r)	1.331	.976	.444	2.139
Cov (e,r)	2.790	2.396	.132	4.573
Corr (p)	.1032	.1486	-.2794	.1216
Corr (e)	.1163	.1187	.0290	.1030
Corr (r)	.0745	.1661	-.1410	.0557

Chicago, and Los Angeles. Between the two Canadian cities (Toronto and Vancouver) and between the two United States cities (Chicago and Los Angeles), only the means and the variances of quarterly changes in the logarithms of real exchange rates (which are identical to means and variances of changes in the logarithms of ratios of consumer price indices) are reported. For these two city pairs, the means, and variances of quarterly changes in the logarithms of nominal exchange rates and the covariances involving quarterly changes in the logarithms of nominal exchange rates are identically equal to zero. The subperiods for which statistics are reported in Table 4 are the same as those in Tables 2 and 3. The data underlying these statistics and Figure 10 are end-of-month observations for the nominal exchange rate and last-month-of-the-quarter observations for consumer price indices.

The results depicted in Figure 10 and reported in Table 4 are not materially affected by the specific choice of Canadian and United States cities, or by the use of end-of-quarter data for the nominal exchange rate and last-month-of-the-quarter data for consumer price indices. The following regularities would generally be well-supported if other Canadian and United States cities were chosen:

The short-term variability of the real exchange rate between a Canadian city and a United States city is substantially greater during either floating rate subperiod than during the fixed rate subperiod, and is also substantially greater than the short-term variability of the real exchange rate between two Canadian cities or between two United States cities during any subperiod.

There is strong correlation between short-term movements in the real exchange rate between a Canadian city and a United States city and short-term movements in the nominal exchange rate between Canada and the United States during either of the floating rate subperiods.

Short-term movements in nominal and real exchange rates between Canadian and United States cities show substantial persistence during both subperiods with a floating nominal exchange rate.

For the whole period, the ratio of the consumer price index in a Canadian city to that in a United States

city exhibits smooth evolution comparable to that shown by the ratio of consumer price indices for two Canadian cities or two United States cities.

These regularities are clearly apparent from Figure 10. The behavior of the real exchange rate between Toronto and Chicago mimics quite closely the behavior of the nominal exchange rate, showing little movement when the nominal exchange rate is fixed and moving in close sympathy with the nominal exchange rate when it is floating. The behavior of the ratio of the CPI in Toronto to the CPI in Chicago does not appear very different from the behavior of the ratios of the CPIs between Chicago and Los Angeles or between Toronto and Vancouver. The only modest exceptions to this point are the downward movement of the ratio of the CPI in Toronto to the CPI in Chicago in 1970 and the gradual uptrend in this ratio after 1971.

Confirmation of these visual impressions is provided by the statistics reported in Table 4. $\text{Var}(\Delta r)$ between Toronto and Chicago, Vancouver and Chicago, Toronto and Los Angeles, or Vancouver and Los Angeles during either of the floating rate subperiods is six to twelve times larger than $\text{Var}(\Delta r)$ for these same pairs of Canadian and United States cities during the fixed rate subperiod, and is even larger relative to $\text{Var}(\Delta r)$ between Toronto and Vancouver or between Chicago and Los Angeles. For the four pairs of Canadian and United States cities the ratios of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta e)$ are close to unity, and the ratios of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta r)$ are above two-thirds in both of the floating rate subperiods. Alternatively, for these pairs of cities, most of the increase in $\text{Var}(\Delta r)$ in the two floating rate subperiods relative to the fixed rate subperiod is accounted for primarily by the increase in $\text{Var}(\Delta e)$, rather than by increases in $\text{Var}(\Delta p)$ or $\text{Cov}(\Delta e, \Delta p)$. For all four pairs of Canadian and United States cities, the serial correlation coefficients $\text{Corr}(\Delta e)$ and $\text{Corr}(\Delta r)$ for the two floating exchange rate periods indicate substantial persistence of quarterly changes in nominal and real exchange rates. For all four pairs of Canadian and United States cities, $\text{Var}(\Delta p)$ is close to the same size in the first floating rate subperiod as it is in the fixed rate subperiod, is close to the same size as $\text{Var}(\Delta p)$ between the two Canadian cities or between the two United States cities during these two subperiods, and is small relative to $\text{Var}(\Delta r)$ or $\text{Var}(\Delta e)$ for these four pairs of cities during the first floating rate period. The increase in $\text{Var}(\Delta p)$ in the second floating rate subperiod for the four pairs of Canadian and United States cities, relative to the levels of the earlier subperiods, is of about the same size as the increase in $\text{Var}(\Delta p)$ between Chicago and Los Angeles. For

all four pairs of Canadian and United States cities, $\text{Var}(\Delta p)$ during the second floating rate subperiod is less than one half of $\text{Var}(\Delta e)$ and less than one-third of $\text{Var}(\Delta r)$ for this subperiod.

These results suggest that some of the increase in the short-term variability of real exchange rates between Canadian and United States cities during the second subperiod with a floating nominal exchange rate, relative to the fixed rate subperiod, may be due to general economic factors that also increased the short-term variability of real exchange rates between cities within a given country. The higher rate of price inflation in both Canada and the United States during the second subperiod with a floating nominal exchange rate (and the economic factors ultimately responsible for these higher inflation rates), may be among the general economic factors that contributed to greater short-term variability of real exchange rates among North American cities. This is consistent with several studies that have shown that higher general price inflation is associated with great variability of relative prices. However, it must be emphasized that much of higher short-term variability of real exchange rates between Canadian and United States cities during subperiods when the nominal exchange rate between Canada and the United States is floating is clearly associated with fluctuations in the nominal exchange rate. This is important further evidence that the behavior of real exchange rates is significantly affected by the nature of the nominal exchange rate regime.

V. IRELAND, THE UNITED KINGDOM, THE UNITED STATES, AND WEST GERMANY

Ireland provides another instructive example of the consequences of alternative nominal exchange rate regimes for the behavior of real exchange rates. The Irish pound was pegged at par with the British pound until the end of 1978. In January 1979, Ireland joined the joint float of the continental European countries which was formalized in European Monetary System (EMS) in March 1979. The real exchange rates of greatest interest in the case of Ireland are those between Ireland and the United Kingdom, Ireland and the United States, and Ireland and West Germany (used as the representative of the EMS). The three subperiods of special interest are (1) the fixed rate period from 1957 through 1970 when the nominal exchange rates for Ireland were affected only by the devaluation of sterling in November 1967 and the revaluations of the Deutsche mark in 1961; (2) the

first part of the floating rate period from 1973 through 1978 when the Irish pound remained rigidly pegged to sterling but floated freely against both the U.S. dollar and the Deutsche mark; and (3) the second part of the floating rate period from 1979 through 1984 when the Irish pound was linked with limited flexibility to the Deutsche mark and floating against both the U.S. dollar and sterling.

The behavior of the nominal exchange rate, the ratio of national price levels, and the real exchange rate between Ireland and the United Kingdom, Ireland and the United States, and Ireland and West Germany are illustrated in Figures 11, 12, and 13 for the whole period from 1957 through 1984. Natural logarithms of quarterly average data are plotted in all cases. The lighter solid lines show the nominal exchange rate, defined as the foreign currency price of an Irish pound. The dashed and dotted lines show the ratio of the Irish CPI to the foreign CPI. The heavy solid lines show the real exchange rate, defined as the relative price of the Irish consumption basket in terms of the foreign consumption basket. As before, the figures are constructed so that movements in the real exchange rate are the sum of movements in the nominal exchange rate and movements in the ratio of national price levels.

The statistics for the means, variances, covariances, and serial correlation coefficients of quarterly changes of natural logarithms of nominal exchange rates, ratios of national price levels, and real exchange rates between Ireland and the United Kingdom, Ireland and the United States, and Ireland and West Germany are reported in Table 5. These statistics are reported for the whole period 1957 through 1984, for the three subperiods of special interest (1957 through 1970, 1973 through 1978, and 1979 through 1984), and for the transition period 1970,4 to 1973,1.

One familiar regularity that is apparent from these figures and statistics is the following:

Short-term movements of real exchange rates between Ireland and the United Kingdom, the United States or West Germany are substantially larger when the nominal exchange rate between Ireland and a particular country is freely floating rather than rigidly fixed or subject to limited flexibility.

A key point to emphasize about this regularity in the case of Ireland is that the short-term variability of the real exchange rate is related to the nature of the nominal exchange rate regime linking Ireland with a foreign country, and not to the particular time period or to the particular foreign

FIGURE 11

Ireland v. United Kingdom

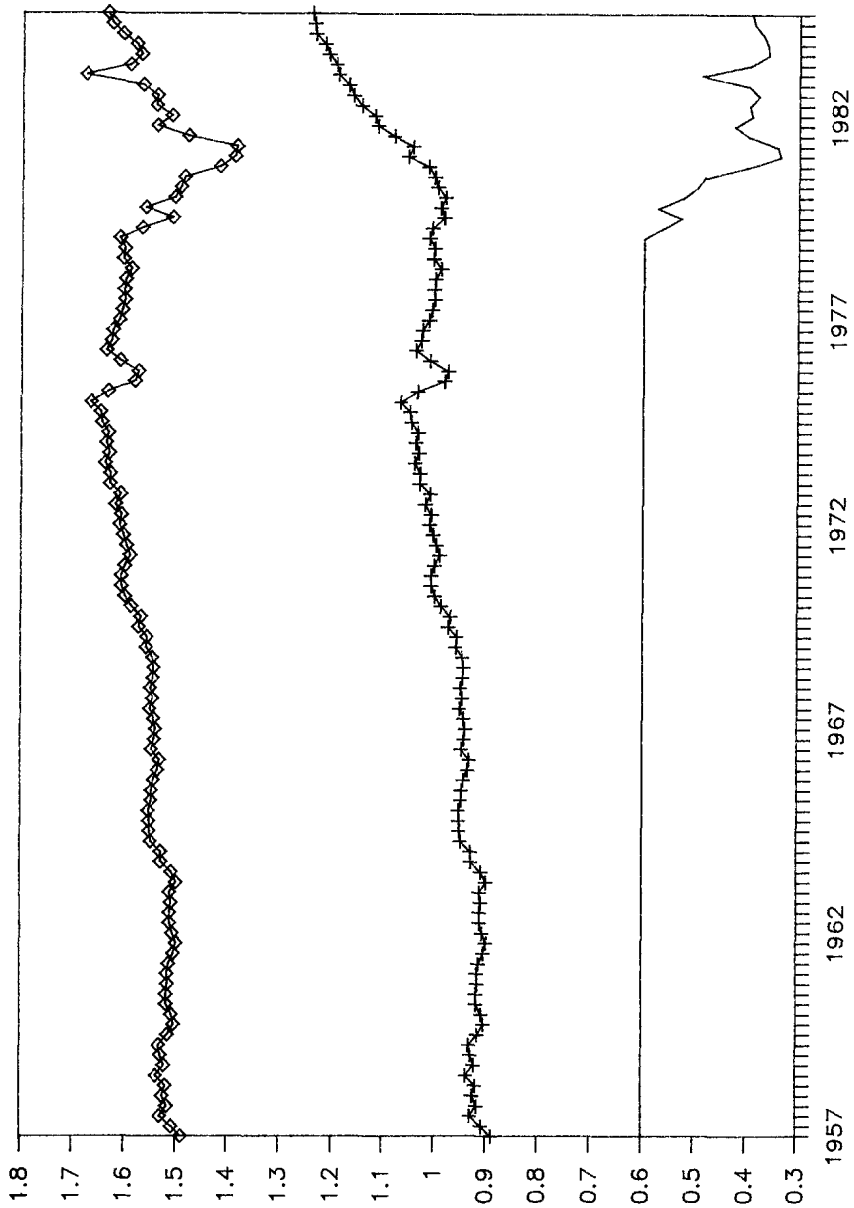


FIGURE 12

Ireland v. U.S.

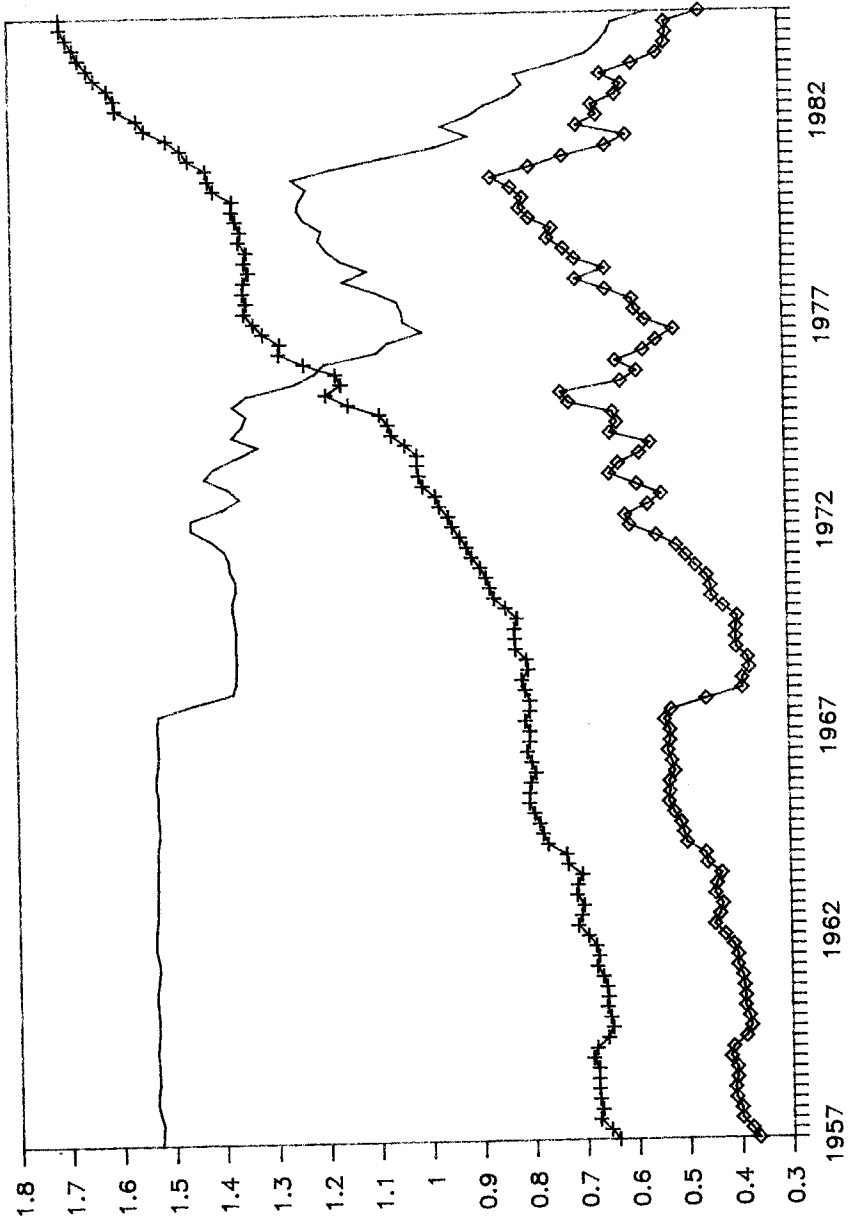


FIGURE 13

Ireland v. Germany

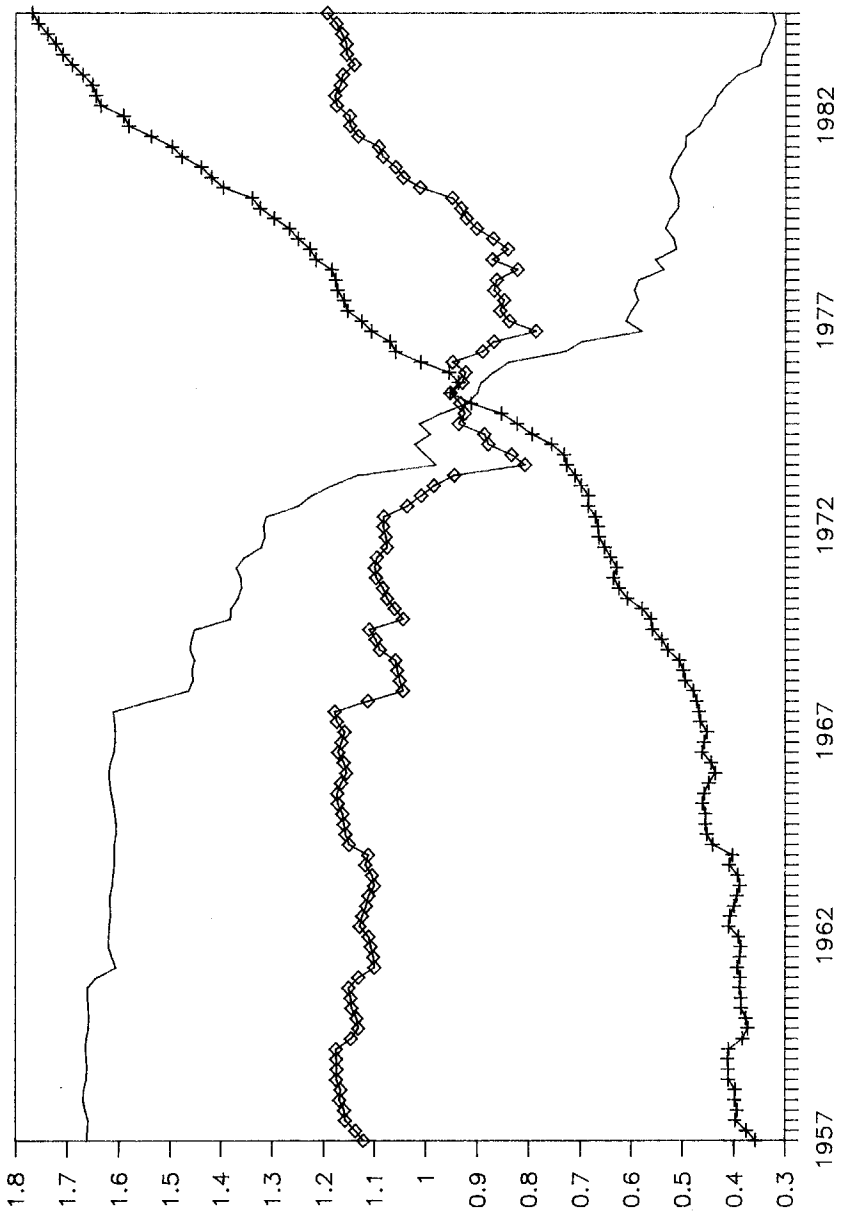


TABLE 5

5.1 Ireland versus the United Kingdom

	1957,2-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1978,4	1979,1-1984,3
Mean (p)	.321	.215	.218	-.026	1.040
Mean (e)	-.187	0.0	0.0	0.0	-.893
Mean (r)	.134	.215	.218	-.026	.147
Var (p)	1.750	.919	.962	3.154	2.152
Var (e)	3.869	0.0	0.0	0.0	18.507
Var (r)	6.022	.919	.962	3.154	24.010
Cov (e,p)	.202	0.0	0.0	0.0	1.672
Cov (p,r)	1.952	.919	.962	3.154	3.825
Cov (e,r)	4.071	0.0	0.0	0.0	20.182
Corr (p)	.1238	-.0912	-.3198	.2130	-.0094
Corr (e)	.0566	0.0	0.0	0.0	.2028
Corr (r)	-.0102	-.0912	-.3198	.2130	-.0295

5.2 Ireland versus the United States

	1957,1-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1978,4	1979,1-1984,3
Mean (p)	.962	.444	1.279	1.495	1.557
Mean (e)	-.884	-.285	.127	-.731	-2.738
Mean (r)	.078	.159	1.406	.763	-1.181
Var (p)	2.256	1.186	.315	4.906	1.713
Var (e)	10.791	1.971	8.473	20.857	18.870
Var (r)	12.306	3.168	9.193	25.200	21.096
Cov (e,p)	-.370	.007	.204	-.283	.253
Cov (p,r)	1.886	1.193	.518	4.625	1.967
Cov (e,r)	10.421	1.977	8.676	20.574	19.126
Corr (p)	.2059	.0958	-.4711	.1616	-.0859
Corr (e)	.3021	.5306	.3308	.1381	.2334
Corr (r)	.1173	.4180	.2634	-.0174	.0319

5.3 Ireland versus West Germany

	1957,1-1984,3	1957,2-1970,4	1970,4-1973,1	1973,1-1978,4	1979,1-1984,3
Mean (p)	1.281	.504	.749	2.261	2.349
Mean (e)	-1.214	-.548	-1.744	-2.963	-.813
Mean (r)	.065	-.044	-.996	-.702	1.537
Var (p)	2.465	1.290	.532	3.208	1.603
Var (e)	7.519	3.091	4.814	20.712	1.703
Var (r)	7.812	4.149	3.471	19.901	3.197
Cov (e,p)	-1.084	-.115	-.939	-2.008	-.056
Cov (p,r)	1.381	1.175	-.407	1.200	1.547
Cov (e,r)	6.432	2.975	3.877	18.702	1.648
Corr (p)	.4201	.2489	-.4863	.1777	-.0746
Corr (e)	.1346	.3162	.2017	-.1075	.2718
Corr (r)	.1303	.1861	.3336	-.0527	.3361

country. For Ireland versus the United Kingdom, there is a sizable increase in the variance of quarterly changes in the real exchange rate, by a factor of about 3.5, between the fixed rate subperiod 1957-70 and the first floating rate subperiod 1973-78. Since the Irish pound remained pegged to sterling until 1979, this increase in real exchange rate variability was clearly the consequence of greater short-term divergences of national inflation rates between Ireland and the United Kingdom after 1973. However, the really large increase in the variance of monthly changes in the real exchange rate between Ireland and the United Kingdom comes in the second floating rate subperiod when the Irish pound was linked to the ECU and floating against sterling. During this last subperiod, the variance of quarterly changes in the real exchange rate between Ireland and the United Kingdom is eight times larger than during the first floating rate subperiod and twenty times greater than during the fixed rate subperiod. For Ireland versus the United States, the variance of quarterly changes in the real exchange rate increases by a factor of 7 or 8 in each of the floating rate subperiods relative to the fixed rate subperiod. For Ireland versus West Germany, the variances of quarterly changes in the real exchange rate increases by a factor of 4 in the 1973-78 subperiod relative to the 1957-70 subperiod, and then falls back to its 1957-70 level during the 1979-84 subperiod when the Irish pound was pegged to the ECU.

A second regularity that is apparent for the case of Ireland concerns the relationship between short-term movements in nominal exchange rates and short-term movements in real exchange rates:

Under both fixed and floating exchange rate regimes, large short-term movements in the nominal exchange rate between Ireland and the United Kingdom, the United States, or West Germany are reflected in roughly equivalent and reasonably persistent movements in corresponding real exchange rates.

It is clear from the figures that when the British pound and the Irish pound are devalued against the U.S. dollar and the Deutsche mark in the last quarter of 1967, there is a sharp and reasonably persistent downward movement of the real exchange rate between Ireland and the United States and between Ireland and West Germany of about the same magnitude as the nominal devaluation. There is no sharp movement of the real exchange rate between Ireland and the United Kingdom at this time. This suggests that the nominal exchange rate devaluation was the proximate cause of the sharp real exchange rate movements against the United States and West Germany.

The revaluations of the Deutsche mark relative to the U.S. dollar and to the British and Irish pounds in the first quarter of 1961 and the fourth quarter of 1969 are reflected in movements of similar magnitude in the real exchange rate between Ireland and West Germany, without any indication of similar movements in real exchange rates between Ireland and the United States or Ireland and the United Kingdom. In periods when the Irish pound was floating against other currencies, it is also apparent from the figures that sharp movements in nominal exchange rates are reflected in sharp and reasonably persistent movements of real exchange rates. This is true for Ireland versus the United Kingdom after 1979, for Ireland versus the United States after 1973, and for Ireland versus West Germany from 1973 through 1978.

Further evidence on this point comes from the statistics reported in Table 5. For the subperiods during which the nominal exchange rate between Ireland and a particular country is floating, the ratios of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta e)$ and of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta r)$ are close to unity. Alternatively, the statistics reported in Table 5 show that high values of $\text{Var}(\Delta e)$ are primarily responsible for high values of $\text{Var}(\Delta r)$ during subperiods when the nominal exchange rate between Ireland and another country is floating. For Ireland versus the United Kingdom, the increase in $\text{Var}(\Delta e)$ from zero to 18.5 in the 1979-84 subperiod accounts for 89% of the increase in $\text{Var}(\Delta r)$ from 1973-78 subperiod and for 80% of the increase in $\text{Var}(\Delta r)$ from the 1957-70 subperiod. For Ireland versus the United States, the increase in $\text{Var}(\Delta e)$ accounts for 86% of the increase in $\text{Var}(\Delta r)$ from 1957-70 to 1973-78 and for 94% of the increase in $\text{Var}(\Delta e)$ from 1957-70 to 1979-84. For Ireland versus West Germany, the higher level of $\text{Var}(\Delta e)$ in the floating rate subperiod 1973-78 accounts for 110% of the increase in $\text{Var}(\Delta r)$ relative to the subperiod 1957-70 and accounts for 114% of the increase in $\text{Var}(\Delta r)$ relative to the subperiod 1979-84. The increase in $\text{Var}(\Delta e)$ accounts for slightly more than 100% of the increase in $\text{Var}(\Delta r)$ because the $\text{Cov}(\Delta e, \Delta p)$ is more negative in the subperiod 1973-78 than in the other two subperiods. This means that during the subperiod 1973-78, movements of the nominal exchange rate between Ireland and West Germany were offsetting movements in the ratio of national price levels to a somewhat greater extent than in the other periods. This effect, however, was sufficiently weak that it does not impair the overall generalization that quarterly movements in nominal exchange rates for Ireland under a floating nominal exchange rate regime are translated primarily into quarterly movements in real exchange rates.

The persistence of these quarterly movements in real exchange rates is indicated statistically by the values of the serial correlation coefficients $\rho(\Delta r)$ for subperiods when the nominal exchange rate between Ireland and a particular country was floating. Generally, $\rho(\Delta r)$ has a smaller (algebraic) value than would be expected, given the use of quarterly average data, if the real exchange rate (measured with point-in-time data) followed a random walk. There is some evidence, therefore, that a change in the real exchange rate in one direction in one quarter tends to be partially offset by a change in the opposite direction in the subsequent quarter. This offsetting effect, however, is small, so large quarterly changes of the real exchange rate do show considerable persistence. Over the longer term, especially in the case of Ireland versus West Germany, there is an apparent tendency for ρ and e to move in the offsetting manner that tends to limit deviations from relative purchasing power parity and hence to limit longer run movements in the real exchange rate.

A third familiar regularity that is relevant for the case of Ireland concerns the behavior of ratios of national price levels:

For Ireland versus the United Kingdom, the United States or West Germany, the ratio of national price levels evolves relatively smoothly throughout the 1957-84 period, in comparison with the more jagged evolution of nominal or real exchange rates under a floating exchange rate regime.

This regularity is apparent from examination of Figures 11, 12, and 13. With the exception of a sharp V-shaped movement in the ratio of price levels between Ireland and the United Kingdom in 1976 and similar less distinct movements of the ratios of price levels between Ireland and the United States and Ireland and West Germany at the same time, the paths describing the evolution of the ratio of national price levels in Figures 11, 12, and 13 all exhibit relatively smooth behavior throughout the whole period from 1957 to 1984. Paths of nominal exchange rates exhibit smooth evolution during periods of fixed exchange rates, except at times of changes in official parities. Paths of nominal exchange rates are more jagged during periods when nominal exchange rates are floating; specifically, after 1978 for Ireland versus the United Kingdom, after 1973 for Ireland versus the United States, and from 1973 through 1978 for Ireland versus West Germany.

These visual impressions are confirmed by comparing the variances of quarterly changes in the ratios of national price levels and the variances

of changes in nominal exchange rates for fixed and floating rate subperiods. For Ireland versus the United Kingdom, $\text{Var}(\Delta p)$ increases by a factor of 2 or 3 in the 1973-78 and 1979-84 subperiods relative to its level in the 1957-70 subperiod, but $\text{Var}(\Delta e)$ during the 1979-84 subperiod when the nominal exchange rate between Ireland and the United Kingdom is floating is at least six times greater than $\text{Var}(\Delta p)$ during any subperiod. Similarly for Ireland versus the United States or Ireland versus West Germany, $\text{Var}(\Delta e)$ during subperiods when the nominal exchange rate is freely floating is at least four times greater than $\text{Var}(\Delta p)$ during any subperiod.

VI. BELGIUM, LUXEMBOURG, WEST GERMANY, AND THE UNITED STATES

The nominal exchange rate between Luxembourg and Belgium is fixed rigidly at one to one. The real exchange rate between Luxembourg and Belgium, therefore, corresponds to the ratio of national price levels. In contrast, nominal exchange rates linking either Luxembourg or Belgium with other countries have not been rigidly fixed for the whole period from 1957 through 1984, and movements of real exchange rates reflect movements of nominal exchange rates as well as movements of ratios of national price levels. The key issue to be illuminated by analysis of the behavior of the real exchange rate between Luxembourg and Belgium and comparison of its behavior with the behavior of real exchange rates between either Luxembourg or Belgium and other countries is whether or not a rigidly fixed nominal exchange rate is associated with significantly different behavior of a real exchange rate than are other nominal exchange rate regimes.

Several other countries might be used for comparative purposes in addressing this issue. West Germany and the United States are selected because each is representative of a class of countries with substantially different behavior of nominal exchange rates vis-a-vis Luxembourg and Belgium since the collapse of the Bretton Woods system. Movements of the nominal exchange rate between Belgium/Luxembourg and West Germany have been controlled (with occasional realignments) under the European "Snake" and more recently under the European Monetary System. The same is true, to a greater or lesser extent, of movements of the nominal exchange rate between Belgium/Luxembourg and the Netherlands, Denmark, France, Austria, Sweden, Switzerland, and Italy. In contrast, nominal exchange rates have been essentially freely floating between Belgium/Luxembourg and the United States, Canada, the United Kingdom, and Japan.

The path of the logarithm of the real exchange rate of Belgium versus Luxembourg is illustrated as the lower dashed and dotted line in Figure 14. The upper dashed and dotted line shows the path of the logarithm of the ratio of the CPI in Belgium to the CPI in West Germany. The lighter solid line shows the path of the logarithm of the nominal exchange rate between Belgium and West Germany, defined as the price of a Belgian franc in terms of Deutsche marks. The heavier solid line shows the path of the logarithm of the real exchange rate between Belgium and Germany, defined as the relative price of the Belgian consumption basket in terms of the West German consumption basket. In all cases, quarterly average data have been used. The statistics for the means, variances, covariances, and serial correlation coefficients of quarterly changes in these series (and the similar series for Luxembourg versus West Germany) are reported in Table 6. The corresponding statistics for Belgium and Luxembourg versus the United States were reported in Tables 1.2 and 1.7 in Section 3.

From Figure 14 and the statistics reported in Table 6 and Tables 1.2 and 1.7 we observe the following regularities:

The real exchange rate between Belgium and Luxembourg (which have maintained a rigidly fixed nominal exchange rate) shows consistently small short-term movements in comparison with movements of real exchange rates between Belgium or Luxembourg and other countries for which rigidly fixed nominal exchange rates have not been maintained.

The extent of quarterly changes in the real exchange rate between Belgium and Luxembourg, as measured by $\text{Var}(\Delta p) = \text{Var}(\Delta r)$, is quite small in all three of the subperiods considered in Table 6, and is nearly the same size in the 1973-84 subperiod when exchange rates were generally floating against the U.S. dollar as it was in the 1957-70 period when exchange rates were generally fixed (with occasional official parity changes) against the U.S. dollar. This indicates that whatever is responsible for the substantial increase in short-term variability of real exchange rates between countries with freely floating exchange rates since 1973 is not reflected in an increase in the short-term variability of the real exchange rate between Belgium and Luxembourg which maintained a rigidly pegged nominal exchange rate.

Further, comparing the path of the real exchange rate between Belgium and Luxembourg illustrated at the bottom of Figure 14 with the paths of the real exchange rates between Chicago and Los Angeles or between Toronto and

FIGURE 14

Belgium v. Germany v. Luxembourg

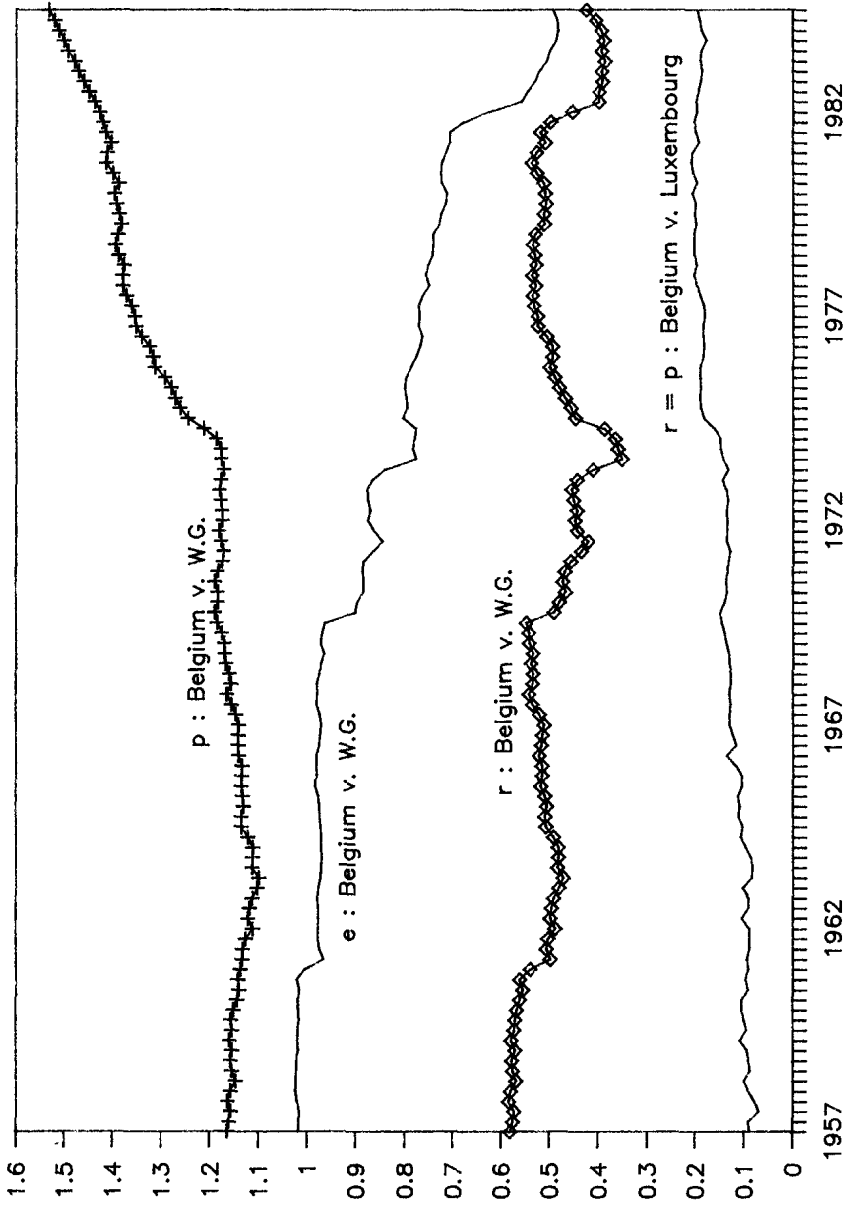


TABLE 6

Belgium, Luxembourg and West Germany

6.1 Luxembourg versus Belgium

	1957,1-1984,3	1957,1-1970,4	1970,4-1973,1	1973,1-1984,3
Mean(p)	-.101	-.087	-.082	-.131
Var(p)	.449	.507	.210	.454
Corr(p)	-.1036	-.2120	.0143	.0322

6.2 Belgium versus West Germany

	1957,1-1984,3	1957,1-1970,4	1970,4-1973,1	1973,1-1984,3
Mean(p)	.335	.036	-.115	.749
Mean(e)	-.477	-.241	-.166	-.816
Mean(r)	-.143	-.204	-.282	-.067
Var(p)	.642	.403	.297	.686
Var(e)	1.980	1.130	1.550	2.870
Var(r)	2.525	1.503	1.623	3.909
Cov(e,p)	-.048	-.015	-.114	.176
Cov(p,r)	.593	.389	.185	.862
Cov(e,r)	1.933	1.115	1.438	3.046
Corr(p)	.4145	.0404	.1899	.4241
Corr(e)	.2966	.0764	.1161	.3635
Corr(r)	.3145	.0704	.1827	.4329

6.3 Luxembourg versus West Germany

	1951,1-1984,3	1957,1-1970,4	1970,4-1973,1	1973,1-1984,3
Mean(p)	.233	-.050	-.197	.619
Mean(e)	-.477	-.241	-.166	-.816
Mean(r)	-.244	-.291	-.364	-.197
Var(p)	.697	.724	.351	.488
Var(e)	1.980	1.130	1.550	2.870
Var(r)	2.471	1.904	2.102	3.272
Cov(e,p)	-.103	.024	.102	-.043
Cov(p,r)	.594	.749	.452	.446
Cov(e,r)	1.877	1.155	1.650	2.827
Corr(p)	.3111	.0079	-.1022	.4634
Corr(e)	.2966	.0764	.1161	.3635
Corr(r)	.2169	.0275	.0457	.3623

Vancouver illustrated at the bottom of Figure 4, or comparing the related statistics reported in Tables 6 and 4, we may observe that

The behavior of the real exchange rate between Belgium and Luxembourg is similar to the behavior of the real exchange rate between two cities within the United States or two cities within Canada where the nominal exchange rate is rigidly fixed.

This regularity provides further evidence that the nature of the exchange rate regime, rather than the particular time period or the countries (or regions) of comparison, has an important influence on the qualitative behavior of real exchange rates.

VII. AUSTRIA, SWITZERLAND, AND WEST GERMANY

Among the many bilateral real exchange rates between continental European countries, three of the most interesting for the purposes of the present discussion are the real exchange rates between Switzerland and West Germany, Austria and West Germany, and Switzerland and Austria. Throughout the fixed exchange rate period (until 1971), Switzerland and Austria had exactly the same nominal exchange rate policies -- their nominal exchange rates were rigidly pegged vis-a-vis the U.S. dollar. Since 1973, Switzerland and Austria have followed significantly different nominal exchange rate policies. Both the Swiss franc and the Austrian shilling have floated freely against the U.S. dollar, but the Austrian shilling has been quite tightly linked to the Deutsche mark, while the Swiss franc has floated with greater freedom against the Deutsche mark. This means, of course, that the nominal exchange rate regime between Switzerland and Austria changed from a rigidly fixed nominal exchange rate through 1971 to a more freely floating nominal exchange rate after 1973.

The paths of the logarithms of nominal exchange rates, ratios of national price levels, and real exchange rates for Switzerland versus West Germany, Austria versus West Germany, and Switzerland versus Austria are illustrated in the standard format in Figures 15, 16 and 17, respectively. As in previous figures (except Figures 9 and 10), the series plotted are for quarterly average data. The statistical results for the means, variances, covariances and serial correlation coefficients of quarterly changes in the logarithms of nominal exchange rates, ratios of national price levels, and real exchange rates for these three pairs of

FIGURE 15

Switzerland v. Germany

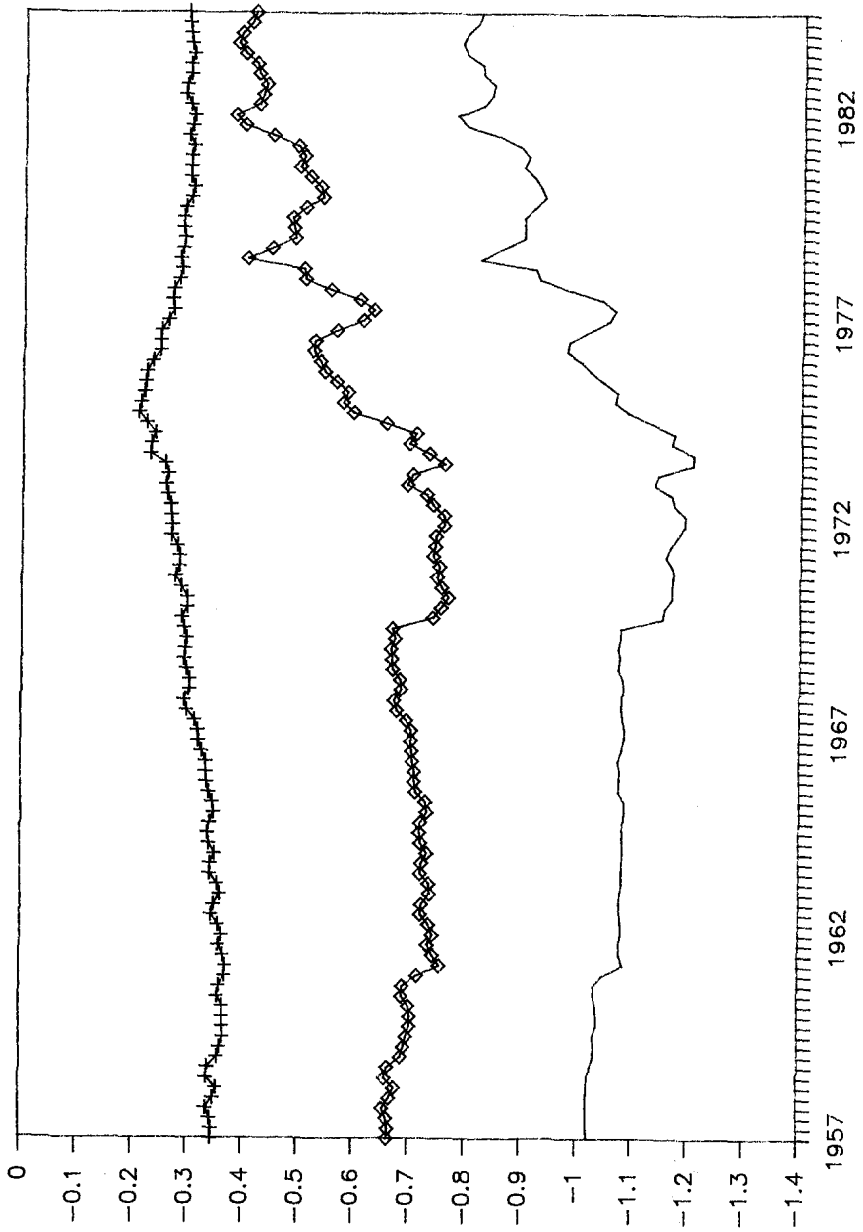


FIGURE 16

Austria v. Switzerland

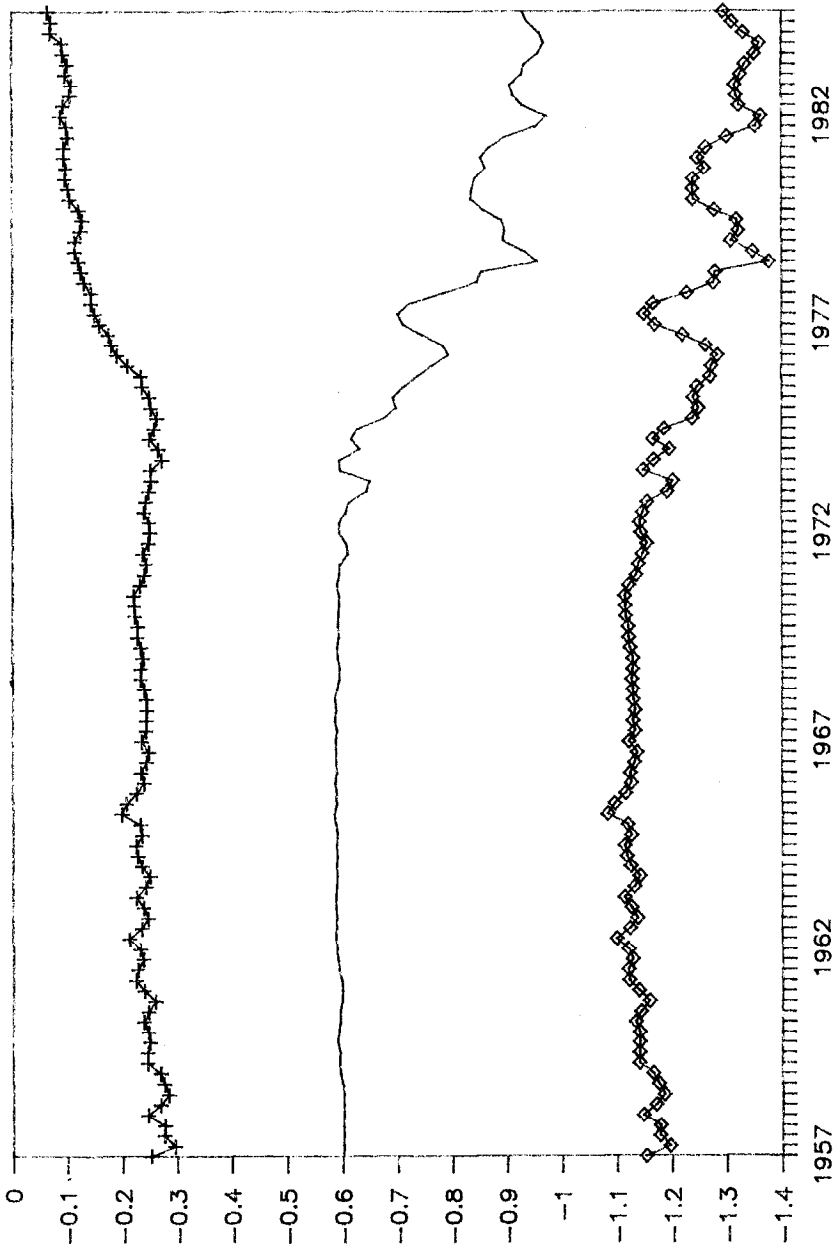
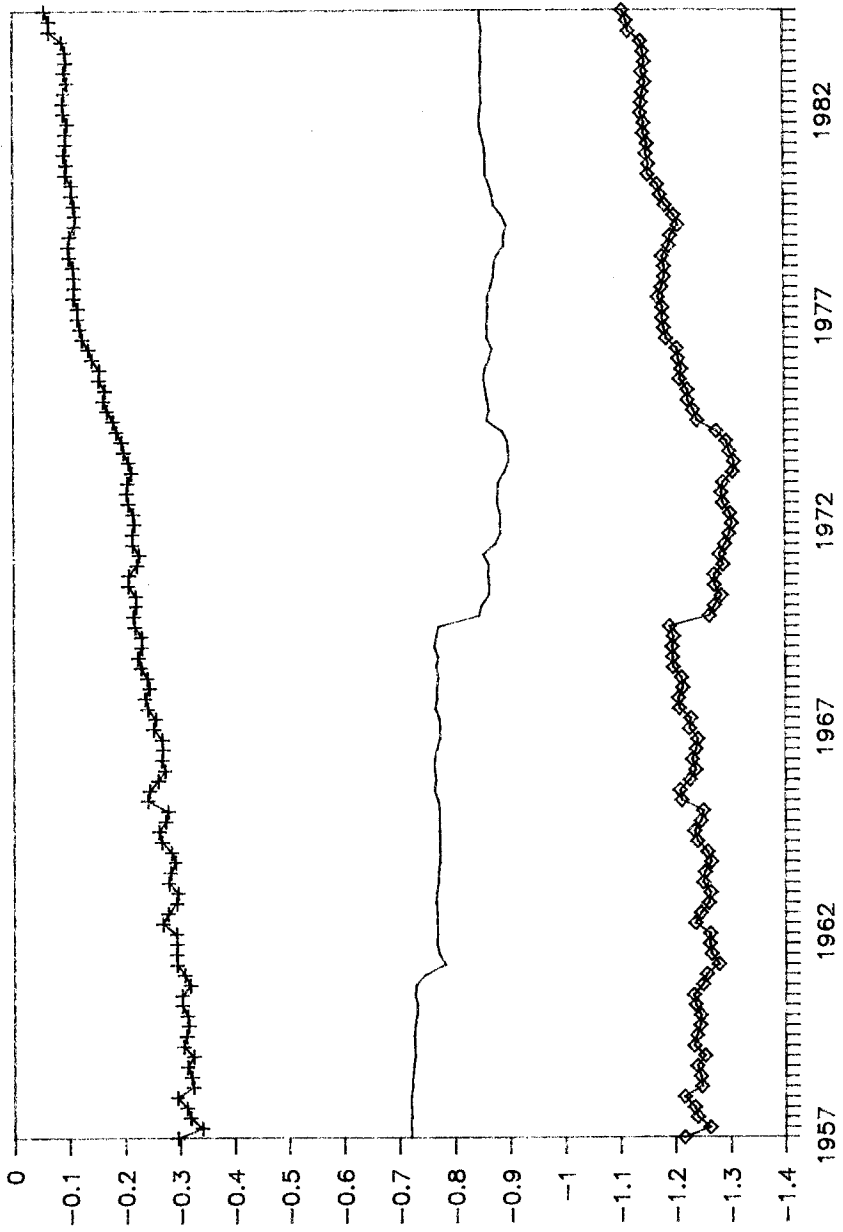


FIGURE 17

Austria v. Germany



countries are reported in Table 7, both for the whole period 1957-84 and for relevant subperiods.

From these figures and statistical results, the following regularities are apparent:

During the fixed rate subperiod 1957-70, real exchange rates between Switzerland and West Germany, Austria and West Germany, and Switzerland and Austria show relatively little short-term variability, with sharp changes occurring only at the time of the revaluation of the Deutsche mark in 1969 and to a lesser extent at the time of the revaluation of the Deutsche mark in 1961.

During the floating rate subperiod since 1973, the real exchange rate between Austria and West Germany continues to show relatively little short-term variability, but there is a marked increase in the short-term variability of the real exchange rates between Switzerland and West Germany and between Switzerland and Austria.

During the floating rate subperiod since 1973, there has been a strong correlation between short-term movements in nominal exchange rates and short-term movements in real exchange rates for Switzerland versus West Germany and Switzerland versus Austria.

Short-term movements of nominal and real exchange rates between Switzerland and West Germany and between Switzerland and Austria during the floating rate subperiod 1973-84 show substantial persistence.

Ratios of national price levels between Switzerland and West Germany, Switzerland and Austria, or Austria and West Germany show relatively smooth evolution through the 1957-84 period, despite changes in official parities during the fixed rate subperiod or fluctuations in nominal exchange rates during the floating rate subperiod.

The increase in the short-term variability of real exchange rates between Switzerland and West Germany and between Switzerland and Austria during the floating rate subperiod 1973-84 is indicated by the high levels of $\text{Var}(\Delta r)$ during this subperiod for Switzerland versus West Germany and Switzerland

TABLE 7

7.1 Switzerland versus West Germany

	1957,1-1984,3	1957,1-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.046	.123	.300	-.068
Mean (e)	-.181	-.276	.334	.737
Mean (r)	.223	-.153	.633	.669
Var (p)	.554	.547	.328	.598
Var (e)	4.986	1.421	1.968	9.376
Var (r)	5.570	2.170	1.940	10.093
Cov (e,p)	.015	.101	-.177	.057
Cov (p,r)	.569	.648	.150	.655
Cov (e,r)	5.001	1.522	1.791	9.436
Corr (p)	.1249	.0839	-.2598	.1644
Corr (e)	.2531	.0373	.2210	.2448
Corr (r)	.2160	.1364	.1927	.2045

7.2 Austria versus West Germany

	1957,1-1984,3	1957,1-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.216	.158	.013	.310
Mean (e)	-.117	-.256	-.165	.063
Mean (r)	.098	-.098	-.151	.373
Var (p)	1.104	1.809	.539	.368
Var (e)	.941	1.367	.756	.421
Var (r)	1.985	3.010	.763	.888
Cov (e,p)	-.029	-.084	-.266	.049
Cov (p,r)	1.074	1.726	.272	.418
Cov (e,r)	.911	1.283	.490	.470
Corr (p)	-.1578	-.2104	.1273	.0210
Corr (e)	.1261	.0747	-.1201	.2853
Corr (r)	-.0228	-.1126	-.0857	.2103

7.3 Austria versus Switzerland

	1957,1-1984,3	1957,1-1970,4	1970,4-1973,1	1973,1-1984,3
Mean (p)	.169	.035	-.285	.379
Mean (e)	-.299	.020	-.499	-.674
Mean (r)	-.129	.055	-.784	-.295
Var (p)	1.374	1.929	.442	.844
Var (e)	4.162	.056	1.558	9.406
Var (r)	5.318	2.079	1.520	9.992
Cov (e,p)	-.108	.047	-.240	-.130
Cov (p,r)	1.266	1.976	.203	.714
Cov (e,r)	4.053	.103	1.318	9.277
Corr (p)	-.0342	-.1335	.0328	.1275
Corr (e)	.2748	-.1268	.0827	.2596
Corr (r)	.1570	-.1266	.1580	.2116

versus Austria, in comparison with the levels of $\text{Var}(\Delta r)$ for these country pairs in the floating rate subperiod 1957-70 and for Austria versus West Germany in both the 1957-70 subperiod and the 1973-84 subperiod. The strong correlation of short-term movements in nominal and real exchange rates between Switzerland and West Germany or Switzerland and Austria in the 1973-84 subperiod is indicated by the fact that the ratios of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta e)$ and of $\text{Cov}(\Delta e, \Delta r)$ to $\text{Var}(\Delta r)$ are close to unity. Alternatively, increases in $\text{Var}(\Delta e)$, rather than in $\text{Var}(\Delta p)$ or in $\text{Cov}(\Delta e, \Delta p)$, account for most of the increases in $\text{Var}(\Delta r)$ for Switzerland, versus Austria or West Germany between the fixed and floating rate subperiods. Persistence of changes in nominal and real exchange rates between Switzerland and West Germany or Switzerland and Austria during the floating rate subperiod is indicated by the fact that the serial correlation coefficients $\rho(\Delta e)$ and $\rho(\Delta r)$ are close to the 20% values they would have (based on quarterly average data) if the nominal and real exchange rates (measured by point-in-time data) followed random walks. Smooth evolution of ratios of national price levels for all three pairs of countries throughout the period from 1957 through 1984 is indicated by the relatively low levels of $\text{Var}(\Delta p)$ in all subperiods for all country pairs.

VIII. OTHER COMBINATIONS OF INDUSTRIAL COUNTRIES IN THE POSTWAR PERIOD

Analysis of the behavior of real exchange rates between industrial countries could be extended to many pairs of countries not already considered. It is useful to make some general observations about these cases without presenting detailed analyses.

For Canada versus other industrial countries, the short-term volatility of real exchange rates during 1957-62 when the Canadian dollar was floating is generally greater than during 1962-70 when the Canadian dollar is fixed to the U.S. dollar and to other currencies. This result is usually weaker than for Canada versus the United States because the ratio of national price levels is usually more variable between Canada and other industrial countries than between Canada and the United States. Also nominal exchange rates between Canada and some other industrial countries were affected by official parity changes during the 1962-70 subperiod. Short-term volatility of real exchange rates between Canada and other industrial countries is generally much greater since 1973 than during 1962-

70. Increases in the variance of quarterly changes in the nominal exchange rate between Canada and other industrial countries account for most of the increases in the variance of quarterly changes in real exchange rates. Between Canada and other industrial countries since 1973, there is a strong correlation between short-term movements in nominal exchange rates and short-term movements in real exchange rates. Also, large short-term movements in real exchange rates typically exhibit substantial persistence. Thus, the regularities for Canada versus other industrial countries may be summarized as follows:

During the initial period when the Canadian dollar was floating against the U.S. dollar and hence against the currencies of other industrial countries, real exchange rates between Canada and other industrial countries exhibited the properties typically associated with floating exchange rate regimes, though in a somewhat less dramatic fashion than since 1973 when the Canadian dollar was also floating against the currencies of other industrial countries. In contrast, during the subperiod 1962-70, when the Canadian dollar was fixed against the U.S. dollar and hence against the currencies of other countries, real exchange rates between Canada and other industrial countries exhibited the behavior typically associated with fixed exchange rate regimes.

For Japan versus other industrial countries, the empirical regularities that characterize the behavior of real exchange rates are much the same as those for the United States versus other industrial countries. The Japanese yen was rigidly pegged to the U.S. dollar throughout the 1957-70 subperiod. Since 1973, the Japanese yen has floated relatively freely against the U.S. dollar and against the currencies of other industrial countries. During the fixed rate subperiod 1957-70, changes in official parities of the currencies of other industrial countries against the U.S. dollar and the Japanese yen are generally associated with changes of a similar magnitude in the real exchange rate between Japan and these countries. The short-term volatility of real exchange rates between Japan and other industrial countries is generally much greater after 1973 than during the fixed rate subperiod. To a large extent, increases in the variances of quarterly changes in nominal exchange rates during the floating rate subperiod account for increases in the

variances of quarterly changes in real exchange rates between Japan and other industrial countries. After 1973, there is a strong correlation between short-term movements in nominal exchange rates and short-term movements in real exchange rates for Japan versus other industrial countries. Aside from the exact paths followed by real exchange rates, the key difference between real exchange rates against Japan and real exchange rates against the United States is the long-run trend of real appreciation for Japan against all other industrial countries. With this qualification in mind, it may be stated that

The empirical regularities that characterize the behavior of real exchange rates for Japan versus other industrial countries and their relationships with alternative nominal exchange rate regimes are essentially the same as the empirical regularities that are applicable for the United States versus other industrial countries.

The story for real exchange rates of the United Kingdom versus other industrial countries (except Ireland) is similar to the stories for the United States or Japan. During the fixed rate subperiod 1957-70, the devaluation of sterling in November 1967 was associated with a sharp change in real exchange rates between the United Kingdom and countries that maintained their exchange rates fixed to the U.S. dollar. The short-term volatility of real exchange rates between the United Kingdom and other countries is generally much lower during the fixed rate subperiod 1957-70 than during the floating rate subperiod 1973-84. Increases in the variances of quarterly changes in real exchange rates between the United Kingdom and other countries since 1973 are largely accounted for by increases in the variances of quarterly changes in nominal exchange rates; and the correlations between short-term movements in nominal exchange rates and short-term movements in real exchange rates are quite high. In summary, it may be said that

The empirical regularities that characterize the behavior of real exchange rates for the United Kingdom versus other industrial countries and their relationships with alternative nominal exchange rate regimes are essentially the same as the empirical regularities that are applicable for the United States versus other industrial countries.

Continental European countries generally pegged their nominal exchange

rates to the United States through 1970. Since 1973, most of these countries have had limited nominal exchange rate movements against each other, but the nature and extent of these limitations has varied widely. France sometimes participated in the Snake and sometimes did not. Italy joined in official arrangements for limiting fluctuations of nominal exchange rates at a relatively late date and with much wider bands than for other countries. The Netherlands, which participated in official arrangements for limiting movements of nominal exchange rates among continental European countries, permitted very little movement of the nominal exchange rate against West Germany. Belgium, Luxembourg, and Denmark, which participated in the same official arrangements, had larger and more frequent depreciations against West Germany. Austria, which was not an official participant in the Snake or the EMS, followed the example of the Netherlands; while Sweden, which shared the same official status as Austria, followed more the examples of Belgium, Luxembourg, and Denmark. Switzerland sometimes allowed its nominal exchange rate against West Germany to float with relative freedom, and at other times appeared to limit movements of this nominal exchange rate.

Three general statements can fairly be made concerning the behavior of real exchange rates among continental European countries (Austria, Belgium/Luxembourg, Denmark, France, Italy, the Netherlands, Norway, Sweden, Switzerland, and West Germany):

Short-term variability of real exchange rates among continental European countries is generally greater after 1973 than during the fixed rate subperiod for those pairs of countries for which there is greater variability of nominal exchange rates.

Sharp changes in nominal exchange rates between continental European countries are generally reflected in sharp and relatively persistent changes in corresponding real exchange rates.

Nominal exchange rates for the higher inflation continental European countries (Denmark, France, Italy, Norway, and Sweden) have generally depreciated against the lower inflation countries (Austria, Belgium/Luxembourg, the Netherlands, Switzerland, and West Germany).

With the possible exception of nominal exchange rates against Switzerland, there are no consistent examples of freely floating exchange rates among

these continental European countries after 1973. Hence, the increased volatility of nominal exchange rates arises primarily from a greater magnitude and higher frequency of changes in officially controlled nominal exchange rates than was characteristic of the fixed rate subperiod 1957-70. Changes in officially controlled nominal exchange rates are generally associated with contemporaneous changes of similar magnitude in corresponding real exchange rates, leading to strong correlation of short-term movements in nominal and in real exchange rates. The tendency for depreciation of the currencies of higher inflation countries relative to lower inflation countries refers to movements over a decade or longer and not necessarily to movements over shorter periods.

IX. OTHER EXPERIENCES WITH ALTERNATIVE NOMINAL EXCHANGE RATE REGIMES

Limitations on data and space preclude extensive consideration of other experiences with the behavior of real exchange rates under alternative nominal exchange rate regimes. There are, however, two such experiences that merit some attention. First, there is the case of the United States during and after the greenback period, 1862-78, when the U.S. dollar was on an inconvertible paper standard. Second, there are the cases of European countries versus the United States and versus each other during the 1920s and 1930s when nominal exchange rates were sometimes fixed and sometimes floating.

The behavior of prices and the exchange rate (price of gold) for the United States under the greenback standard has been examined in a number of studies, most extensively in the work of Wesley C. Mitchell. During the period 1862 to 1878 when price of the U.S. dollar in terms of gold was not officially fixed, there was relatively little movement of price indices for Britain (Sauerback's index) or Germany (Soetbeer's index), in comparison with movements in prices in the United States or in the exchange rate for the U.S. dollar as represented by the dollar price of gold. Hence, most of the action in terms of movements of real exchange rates between the United States and Britain or the United States and Germany is associated with movements in commodity prices in the United States relative to the price of gold in the United States. Concerning such movements, Mitchell (1966, pp. 40-41) writes as follows:

...During the [Civil] war gold moved up or down in

price more quickly than the mass of commodities-- probably because the market for gold was more highly organized and more sensitive than markets for other goods to the many influences touching the credit of government notes which formed the money in which all prices were quoted. When gold was rising in price, the majority of commodities followed, but more slowly....

When gold was falling in price the majority of commodities stood still or followed more slowly....

This more sluggish movement of commodity prices appears still more clearly after the war. Rapid as was the fall of prices in the spring of 1865, it was not so rapid as the fall in gold.... ..Prices declined with tolerable consistency from 1866 to 1869, while gold, despite continual ups and downs, maintained substantially the same general level. Again, the last three months of 1869 and the first two months of 1870 marked a turning-point in the price of gold, but not in the prices of commodities. After February, 1870 gold fluctuated about a much lower level than that of 1866 to 1869, but without any substantial further decline until 1876. Commodity prices, however, after a slight and irregular rise in the early 70s, resumed their downward trend, and stood considerably lower by the close of 1875 than they had stood in 1870. Finally, the almost unbroken fall of gold from March, 1876, to December, 1878 was accompanied by a fall of prices, but one considerably greater in degree, and this fall appears to be but a continuation of the decline which had begun definitely in 1875.

With the exception of an inflationary surge in the United States in the early 1880s, wholesale prices in the United States and Great Britain followed very similar paths from the resumption of official convertibility of the U.S. dollar into gold on January 1, 1879 through at least the end of the century. The same statement basically applies to wholesale prices in the United States versus those in Germany, though the general trend of price deflation between the early 1880s and 1895-96 is somewhat weaker in Germany than in either the United States or Great Britain.

With respect to the behavior of the real exchange rate between the

United States and either Great Britain or Germany during the last forty years of the past century, the facts indicate the following. When the nominal exchange rate between the United States and either Great Britain or Germany fluctuated quite violently in 1862 to 1865 and again in late 1869 and early 1870, there were also sharp changes in the same direction in the corresponding real exchange rates. Except over very brief periods, however, there was greater tendency for negative correlation of movements in nominal exchange rates and in ratios of national price levels (as implied by the theory of purchasing power parity) than has been characteristic of experience with floating exchange rates in the 1970s and 1980s. When the nominal exchange rate between the United States and either Great Britain or Germany showed relatively little movement, during most of the period after 1865 and certainly after 1878, movements in corresponding real exchange rates were generally less violent than during periods when these nominal exchange rates were fluctuating more violently.

These observations are broadly consistent with the regularities concerning the behavior of real exchange rates under alternative nominal exchange rate regimes discussed in preceding sections. The major difference is that national price levels for the United States, Great Britain, and Germany typically exhibit more violent up and down movements in this earlier period than during the period since the end of the Second World War. This difference in the behavior of price levels is part illusion and part reality. The illusion is due to the fact that price indices for the latter part of the last century are based on a limited number of commodities whose individual prices exhibit much greater variability than is characteristic of the prices of most commodities that enter into modern, broadly-based indices of consumer or producer prices. If the analysis of previous sections were redone using price indices for the modern period based on a similar set of commodities, the results would show substantially greater movement in ratios of national price levels (under both fixed and floating exchange rate regimes) than is revealed using modern, more broadly-based price indices. Conversely, if modern, broadly-based consumer price indices were available for the period 1860 to 1900, analysis of the behavior of ratios of national price levels, nominal exchange rates, and real exchange rates would probably yield results more similar to the results described in earlier sections. Nevertheless, the reality would probably still remain that price levels were more variable in

the latter part of the last century than they are today.¹⁷ Correspondingly, we should expect to observe somewhat greater movement of real exchange rates under fixed exchange rate regimes in this earlier period than has been characteristic of the period since the Second World War.

In the early 1920s the British pound, the French franc, and the German mark (and the currencies of several other countries) were on floating exchange rates vis-a-vis the U.S. dollar which remained fixed to gold. By 1927, fixed exchange rates had generally been re-established, only to collapse again at various times in the early 1930s. Germany falls into a different class than other countries because it experienced a hyperinflation in the early 1920s and made fairly extensive use of exchange controls in the later 1930s. The experiences of Britain and France, versus each other and versus the United States, however, fall into the same broad category as the experiences of most industrial countries since the Second World War.

The experience with floating exchange rates during the 1920s has been extensively examined, especially in the work of Jacob Frenkel and his collaborators. Basically, Frenkel finds that under floating exchange rate regimes in the 1920s, relative purchasing power parities held much better than during the 1970s. Specifically, regression coefficients for logarithms of ratios of national price levels in explaining logarithms of spot exchange rates are generally close to unity, and the fraction of the variance of the logarithm of the nominal exchange rate explained by such regressions is generally above 0.9. Results from regressions involving monthly changes in logarithms of nominal exchange rates and ratios of national price levels are generally less impressive. However, if one looks at periods of three to six months, there appears to be closer correspondence of movements in nominal exchange rates and movements in ratios of national price levels (in the offsetting manner called for by maintenance of relative purchasing power parities) than is typically the case under floating exchange rate regimes in the 1970s and 1980s. It is typically true in the 1920s, as in the 1970s and 1980s, that large short-term movements in nominal exchange rates are associated with movements in

¹⁷ Interesting evidence on the change in the behavior of prices and wages in the period after the Second World War from that prevailing earlier is provided by Gordon (1983) and Romer (1985).

the same direction of corresponding real exchange rates. But, this tendency is less pronounced than in the recent period of floating exchange rates, and is somewhat obscured by a countervailing tendency in the 1920s for offsetting movements in nominal exchange rates and in ratios of national price levels.

Overall, the experience of the 1920s does not directly contradict the previously stated regularities concerning the behavior of real exchange rates, nominal exchange rates, and ratios of national price level, except that national price levels exhibited more rapid adjustment in the 1920s than has been true recently. The evidence supporting these regularities from the 1920, however, is certainly weaker and less persuasive than the evidence from the recent period. In part, this weakness is due to the nature of the price indices used to analyze the experience of the 1920s. The price indices used by Frenkel are wholesale price indices involving a limited number of commodities whose prices, even in today's markets, show substantially greater variability that is characteristic of the prices of most commodities that enter into modern broadly-based indices of consumer or producer prices. If consumer price indices similar in scope and construction to modern broadly-based consumer price indices were available for the 1920s, they would exhibit smoother evolution of national price levels, and we would probably find somewhat more support for other previously stated regularities than is indicated by the actually available price indices.

Evidence supporting this contention is available from studies of the behavior of prices in the period before and after the First World War. Based on their extensive study of the behavior of prices up to the early 1930s, Warren and Pearson (1933) comment:

Over a long period of time, wholesale prices and the cost of living follow a somewhat similar course. Inflation and deflation disturb this relationship. If inflation occurs, wages and the cost of living rise less rapidly than wholesale prices. If deflation occurs, wages and the cost of living fall less rapidly.

Warren and Pearson present extensive evidence that this is what happened in the period surrounding the First World War. In the United States and Great Britain, wholesale prices (of those commodities that entered into wholesale price indices) rose more rapidly and reached a higher peak relative to their prewar levels during the wartime and immediate postwar inflation than did wages or consumer prices. In the deflationary period from 1921 through

1923, wholesale prices fell more rapidly and to a greater extent than did wages or retail prices. The same is also true for Great Britain in the period surrounding the Napoleonic Wars and for the United States in the period surrounding the Civil War. Modern evidence of this phenomenon comes from comparing the recent behavior of the raw materials component of the U.S. producer price index (which is similar in structure and composition to older wholesale price indices) with that of either the U.S. CPI or the finished goods component of the U.S. producer price index. Raw materials prices show much stronger up and down movements than do either consumer prices or finished goods prices.

X. DEFICIENCIES OF THE DATA

One explanation of observed differences in the behavior of real exchange rates under fixed versus floating exchange rate regimes that merits some consideration is the possibility that these differences might be primarily attributable to deficiencies in the series used to measure nominal exchange rates or national price levels. With respect to nominal exchange rates, minor problems arise from the use of exchange controls or multiple exchange rates by some industrial countries at various times since 1957. On the whole, however, for the industrial countries, the quoted nominal exchange rates used in this study are generally representative of the rate at which transactions were made. Moreover, divergences from unrestricted transactions at uniform exchange rates could not account for any substantial part of the observed differences in the behavior of real exchange rates under fixed versus flexible exchange rate regimes. In none of the industrial countries examined in this study were exchange controls manipulated in the manner and to the extent required to replicate, during the fixed rate subperiod, the type of random walk behavior of nominal exchange rates observed during the floating rate subperiod. Nor were controls manipulated during the floating rate subperiod to maintain the constancy of shadow values of nominal exchange rates that was typically observed during the fixed rate subperiod.

With respect to nominal exchange rates, some distortion results from the use of quarterly average data. Use of quarterly average data for nominal exchange rates, as previously noted, induces positive serial correlation of measured quarterly changes in logarithms of nominal exchange rates. It also reduces the reported variance of quarterly changes in the

logarithms of nominal exchange rates by about one third.¹⁸ Since most of the variance of quarterly changes in the logarithms of real exchange rates under floating exchange rate regimes is accounted for by the variance of quarterly changes in the logarithms of nominal exchange rates, it follows that use of quarterly average data for nominal exchange rates diminishes the apparent increase in the short-run variability of real exchange rates under a floating exchange rate regime. Despite this bias in favor of the hypothesis of nominal exchange regime neutrality, however, we find consistent and convincing evidence against this hypothesis and in favor of the alternative hypothesis of systematic and important effects of nominal exchange rate regimes on the behavior of real exchange rates.

With respect to the measure of national price levels, there is legitimate concern that the nature of the data on consumer price indices may bias the results in favor of showing excessive smoothness in the evolution of logarithms of ratios of national price levels under both fixed and floating exchange rate regimes. Given the observed volatility of nominal exchange rates under floating exchange rate regimes, this may contribute artificially to the impression of greater volatility of real exchange rates under floating exchange rate regimes. Part of this bias arises from use of quarterly average data for consumer price indices. However, theoretical calculations of the effects of using quarterly average data for CPIs, as well as the evidence for the case of Canada versus the United States, indicate that this bias cannot account for any substantial part of the observed differences between fixed and floating exchange rate regimes.

A potentially more serious problem arises from the possibility that consumer price indices are measured in ways that inherently tend to overstate the smoothness of the evolution of national price levels. One source of this problem is the failure to update measures of some components of the CPI on a monthly basis. For the United States in the postwar period, this has particularly been a problem with the "shelter" component of the CPI which generally was updated every six months. In other industrial countries, some important components of CPIs are measured only

¹⁸If the logarithm of the nominal exchange rate follows a random walk over very brief intervals of time (as evidence concerning daily behavior of nominal exchange rates suggests), then it can be shown that the variance of the change in the quarterly average value of the logarithm of the exchange rate should be two-thirds of the variance of the quarterly change in the logarithm of the exchange rate measured on an end-of-quarter basis.

every two months, every three months, every six months, or even once every year.

Use of quarterly data, rather than monthly data, diminishes the effect of this problem because most components of CPI for most industrial countries are measured on at least a quarterly basis. The residual problem resulting from infrequent measurement of some components of CPIs is not of sufficient importance to overturn any of the stated regularities concerning differences between fixed and floating exchange rate regimes. In particular, exclusion of the shelter component from the U.S. CPI (and hence the stochastic properties of the logarithm of the ratio of the U.S. CPI to the CPI of other countries). Replication of the analysis in Section 4 for Canada versus the United States, using consumer price indices for both countries that exclude the shelter component, has little visible effect on Figure 9 and only very small effects on the statistics reported in Tables 2 or 3. Use of the food components of the CPIs for Canada and the United States, in place of the overall CPIs, has more substantial effects since food prices typically show greater month-to-month and quarter-to-quarter variability than overall CPIs. However, even using these more highly variable components of the Canadian and U.S. CPIs there is a substantial (two-to-one) increase in the variance of the logarithm of the real exchange rate between Canada and the United States in either of the two floating exchange rate subperiods relative to the fixed exchange rate subperiod, and this increase in short-term real exchange rate variability is primarily accounted for by the increase in the short-term variability of the nominal exchange rate. The same statements apply to analyses of real exchange rates between Canadian and United States cities. For other pairs of countries, analysis based on components of CPIs is hampered by lack or inconvenience of availability of data. However, since the short-term variability of the nominal exchange rate between the United States and other industrial countries typically increased much more under a floating exchange rate regime than the short-term variability of the nominal exchange rate between the United States and Canada, it is exceedingly unlikely that such analysis would overturn previously stated regularities concerning differences between fixed and floating exchange rate regimes.

Even if all prices used in constructing consumer price indices were measured at the same time with the same frequency as the reported index, a bias in the direction of smoothness might be introduced because many different prices of the "same" product are averaged in constructing the index or because some prices are "contract prices" not equally available to

new and old purchasers of a particular product from a particular source. An individual consumer who purchases goods from particular sources might experience greater short-term price variability than is indicated by an average of prices across different sources of supply and also might experience sharper occasional changes in contract prices (such as rents) than is indicated by an index that averages across contract prices adjusted at different points in time. For the purpose of analyzing the behavior of real exchange rates between countries, however, it is not clear the perspective of an individual consumer, rather than an average consumer, is necessarily appropriate. Moreover, there is no evidence to indicate that the difference in behavior between a price index for an individual consumer and the price index for an average consumer (represented by the CPI) is systematically affected by the nature of the nominal exchange rate regime linking particular pairs of countries. It would require an extraordinarily implausible (and probably logically impossible) set of coincidences for shifts in the behavior of price indices for individual consumers, relative to price indices for average consumers, to explain away the observed differences in the behavior of real exchange rates under fixed versus floating exchange rate regimes.

In this connection, it is important to keep in mind the nature and extent of the deficiencies of consumer price indices necessary to explain away observed differences in the behavior of real exchange rates under fixed and floating exchange rate regimes. Based on end-of-quarter data, the standard deviation of quarterly percentage changes in nominal exchange rates between the United States and other industrial countries (except Canada) has been about 5% per quarter since 1973, with little or no serial correlation of such quarterly changes in nominal exchange rates. Correspondingly, cumulative percentage changes in nominal exchange rates against the United States over four successive quarters have had a standard deviation of about 10%, and movements as large as 15% over a four-quarter period are far from unknown. Given the relative smoothness of the paths of evolution of ratios of consumer price indices, this volatile behavior of nominal exchange rates has translated into similar volatility of behavior of real exchange rates--something quite different from the relative smoothness of evolution of real exchange rates (except for official parity changes) during the period of fixed nominal exchange rates. Purely random errors of measurement in consumer price indices could swamp the apparent differences in the behavior of real exchange rates before and after 1973 only if such measurement errors were on the order of five to ten percent in

a given quarter and ten to fifteen percent in a given year. Measurement errors of half this size might suffice to wipe out observed differences in the behavior of real exchange rates if these measurement errors behaved in just the right way to offset movements in nominal exchange rates in the floating exchange rate period. Such fortuitous behavior of measurement errors, however, is extraordinarily implausible. Moreover, measurement errors of even this smaller size would imply that changes in consumer price indices (or in other price indices exhibiting similar behavior) are essentially worthless as measures of national inflation rates over periods of a month, a quarter, a year, or even two or three years, thus casting grave doubt on the results of all studies employing these price indices. Indeed, because the behavior of nominal exchange rates changes so dramatically under a floating exchange rate regime, the results of this study are far less sensitive to the problems of measurement error in consumer price indices than are the results of other studies that employ these indices (or other price indices exhibiting similar behavior) as measures of national price levels.

For some purposes, producer price indices or wholesale price indices might be more appropriate measures of national price levels than consumer price indices. Replication of most of the analysis of Sections 3 through 8 using quarterly average data for wholesale prices (from the IRS tape) does not alter in any significant way the stated regularities concerning the behavior of real exchange rates under alternative nominal exchange rate regimes. Wholesale price indices are probably subject to deficiencies at least as severe as those of consumer price indices. However, observation of the same regularities with respect to the behavior of real exchange rates for both types of price indices increases confidence that these regularities describe important aspects of economic reality and are not the consequence of peculiarities in the measurement of particular price indices. Confidence on this point is further enhanced by a number of studies using a variety of measures of national price levels that have shown relatively high short-term volatility of real exchange rates and strong correlation of movements of nominal and real exchange rates under

XI. NOMINAL EXCHANGE RATE REGIME NEUTRALITY

In many theoretical models that embody the principle of nominal exchange rate regime neutrality, movements in real exchange rates can be induced by a variety of real economic disturbances. Real economic disturbances might, for example, raise the relative price of nontradable goods in terms of tradable goods in one country while lowering the relative price of nontradable goods in terms of tradable goods in another country. This would cause an appreciation of the real exchange rate of the first country relative to the second country. Alternatively, real economic disturbances might increase the price of tradable goods that have heavy weight in the price index of one country relative to tradable goods that have heavy weight in the price index of another country. This would also cause an appreciation of the real exchange rate of the first country relative to the second country. If real disturbances requiring adjustments of real exchange rates happened to be different during a period when the nominal exchange rate between two countries was floating rather than fixed, differences between the behavior of the real exchange rate between the fixed and floating exchange rate period might be wrongly attributed to an effect of the nominal exchange rate regime.

This possibility would need to be taken very seriously if the only evidence showing important differences in the behavior of real exchange rates under different nominal exchange rate regimes came from comparisons of the behavior of real exchange rates of other industrial countries versus the United States before and after the collapse of the Bretton Woods system. Because a number of European countries maintained some form of joint float against the United States after the collapse of Bretton Woods, the evidence from individual bilateral comparisons is not all

¹⁹Williamson (1983), in particular, presents evidence of both the short-term volatility of various measures of real exchange rates and the very large cumulative movements of real exchange rates (which Williamson interprets as evidence of exchange rate "misalignments") that have occurred during the recent period of floating nominal exchange rates. Evidence of the volatility of real exchange rates and the correlation between their movements and movements in real exchange rates is also provided in a number of other studies, including the careful and systematic study by Wasserfallen and Kyburz (1985).

independent. Moreover, it is logically possible that real economic disturbances requiring adjustments of real exchange rates were substantially larger and occurred with greater frequency after 1973. There is some specific evidence of the occurrence of such shocks from large movements in the relative price of oil and other commodities, from the increase in the amplitude of business-cycle fluctuations, and from the increased amplitude of fluctuations in interest rates and other variables that might be indicative of underlying real economic disturbances. Efforts to relate specific movements in real exchange rates among industrial countries since 1973 to specific real economic disturbances have not proved notably successful. However, this failure has probably been no more dramatic than the failure to relate movements in nominal exchange rates to nominal disturbances, and hence should not be counted as strong evidence against the hypothesis of nominal exchange rate regime neutrality.

More convincing evidence against this hypothesis has been provided in this study and deserves brief recapitulation. For Canada versus the United States, the behavior of the real exchange rate is substantially and systematically different during both subperiods with a floating exchange rate regime. The first subperiod when the nominal exchange rate between Canada and the United States was floating was during a time when nominal exchange rates for other industrial countries against the U.S. dollar were fixed, and real exchange rates for these countries were exhibiting the properties typical for a fixed nominal exchange rate regime. Further, the behavior of the real exchange rate between a Canadian city and a United States city was substantially and systematically different during the two floating exchange rate subperiods from what it was during the fixed rate subperiod. However, real disturbances apparently did not produce corresponding differences in the behavior of the real exchange rate between two Canadian cities or between two United States cities in these different subperiods.

For Ireland versus the United Kingdom, the shift in the behavior of the real exchange rate to that characteristic of a floating exchange rate regime starts in 1979. For Ireland versus the United States, this shift occurs in 1973. For Ireland versus West Germany, the real exchange rate exhibits behavior typical of a floating exchange rate regime between 1973 and 1979, but returns to behavior more characteristic of a fixed exchange rate regime from 1979 through 1984. For Ireland versus each of these three countries, therefore, the nature of the behavior of the real exchange rate is strongly associated with the nominal exchange rate regime rather than

with a particular time period.

For Belgium versus Luxembourg, where the nominal exchange rate has always been rigidly fixed, the real exchange rate has always exhibited the behavior typical of a fixed exchange rate regime; whereas the behavior of real exchange rates between Belgium or Luxembourg and other countries in a particular time period has been typical of the behavior of real exchange rates under the nominal exchange regime prevailing between Belgium or Luxembourg and the other country during that period.

When the nominal exchange rate between Austria and Switzerland was rigidly fixed prior to 1973, the real exchange rate between these countries exhibited the behavior typically observed under a fixed exchange rate regime; but the behavior of this real exchange rate shifted to that typical of a floating exchange rate regime when the nominal exchange rate between Austria and Switzerland began to float starting in 1973. It is difficult to believe that real economic disturbances with strong differential effects on Austria and Switzerland were responsible for movements of the real exchange rate between these countries starting in 1973, when there is no evidence of such disturbances prior to 1973 and when the real exchange rate between Austria and West Germany (for which the nominal exchange rate was allowed very little flexibility after 1973) continued to exhibit the behavior typical for a fixed nominal exchange rate regime after 1973. This evidence is consistent with and strongly supported by the evidence from Section 3 concerning bilateral comparisons of other industrial countries against the United States. It is also consistent with and strongly supported by the evidence summarized in Section 9 concerning many bilateral comparisons among countries other than the United States, and by the evidence from earlier periods summarized in Section 10. These individual cases are not all completely independent, but taken together they constitute a massive body of evidence demonstrating substantial and systematic differences in the behavior of real exchange rates under different nominal exchange rate regimes.

XII. GRADUAL ADJUSTMENT OF NATIONAL PRICE LEVELS

Demonstration of substantial differences in the behavior of real exchange rates under alternative nominal exchange rate regimes does not automatically provide an explanation of the fundamental causes of these differences. The systematic qualitative features of the behavior of

nominal exchange rates, ratios of national price levels, and real exchange rates under alternative exchange rate regimes, however, are suggestive of proximate causes of these differences in the behavior of real exchange rates. In particular, the evidence discussed in Sections 3 through 9 is consistent with theories that contrast the "asset price" behavior of nominal exchange rates under a floating exchange rate regime with the relatively sluggish adjustment of ratios of national price levels (between moderate inflation countries) under both floating and fixed exchange rate regimes.

The "asset price" behavior of nominal exchange rates under floating exchange rate regimes has been discussed and analyzed in a number of theoretical and empirical studies.²⁰ It has been widely observed that nominal exchange rates under floating exchange rate regimes exhibit many of the same behavioral characteristics of the prices of other assets traded on organized exchanges, such as the prices of common stocks, long-term bonds, or commodities like wheat, pork bellies, or gold (after the freeing of the gold price). Specifically, nominal exchange rates or their logarithms are well-described as following random walks. Daily, weekly, monthly, or quarterly changes in nominal exchange rates or in their logarithms (measured with end-of-period data) are largely unpredictable on the basis of information in past exchange rates, price levels, interest rates, or other data. The variances of these largely unpredictable changes in nominal exchange rates are typically quite large relative to the variances of changes over comparable periods in ratios of national price levels.

Sluggishness of adjustment of national price levels, especially in the industrial countries in the period since the end of the Second World War,

²⁰The theoretical aspects of the behavior of exchange rates as "asset prices," in the sense in which that term is presently being used, are emphasized in Frenkel (1981), Frenkel and Mussa (1980 and 1985), Mussa (1979a, 1982 and 1984). Empirical evidence on the "asset price" behavior of exchange rates is provided by a host of studies referred to in footnote 6.

has been a much-discussed phenomenon.²¹ The regularities described in Sections 3 through 9 are consistent with sluggishness of adjustment of national price levels and provide additional evidence of the existence and nature of such sluggishness. If the hypothesis of nominal exchange regime neutrality (which is consistent with most market-clearing models of the determination of national price levels) were correct, ratios of national price levels would exhibit roughly the same degree of volatility under rigidly fixed nominal exchange rates regimes. This clearly is not what we observe. Given the volatility of real exchange rates under floating exchange rate regimes, ratios of national price levels exhibit too-little volatility under fixed exchange rate regimes. Given the stability of real exchange rates under fixed exchange rate regimes, ratios of national price levels exhibit too-little volatility under floating exchange rate regimes. Specifically, ratios of national price levels under floating exchange rate regimes do not move enough to offset the volatility of nominal exchange rates under floating exchange rate regimes and thereby preserve the stability of real exchange rates observed under fixed exchange rate regimes. Thus, no matter what view one takes about the appropriate degree of volatility of real exchange rates (that observed under fixed exchange rate regimes, that observed under floating exchange rate regimes, or some average of the two), the conclusion must be that ratios of national price levels show too little volatility, under one exchange rate regime or the other, relative to that implied by the hypothesis of nominal exchange regime neutrality.

Of course, the hypothesis of nominal exchange regime neutrality is not identical to the hypothesis that prices adjust on a continuous basis to clear all markets. No doubt, theories can be constructed that explain the apparent sluggishness of adjustment of ratios of national price levels in a manner that is consistent with individual maximizing behavior, taking account of relevant costs, and subject to relevant constraints. My own

²¹Sluggishness of adjustment of price levels or wage levels is, of course, an important element in many macroeconomic models, including the recent models that have focused on wage contracts, in particular, Fischer (1977), Phelps and Taylor (1977) and Taylor (1980). Stickiness of prices or wages was also a common element in many open-economy macroeconomic models developed in the 1940s through the 1960s, and has been incorporated in some recent models of exchange rate behavior, including most notably Dornbusch (1976) and also Buiter and Miller (1981 and 1982), Flood (1981), Flood and Hodrick (1983), Wilson (1979), and Mussa (1982 and 1984). Empirical evidence on sluggishness of adjustment of prices is presented in Gordon (1983) and recently in Carlton (1985), among many others.

approach on how this should be accomplished differs to a greater or lesser degree from the approaches adopted by others.²² The point here, however is not to assess the relative merits of alternative models of sluggish price adjustment, but rather to emphasize the need to account for such sluggishness in a model of exchange rate and price level behavior that seeks to comprehend the observed empirical regularities.

XIII. IMPLICATIONS FOR WELFARE AND POLICY

So far, nothing has been said about the implications of the foregoing analysis for economic welfare and economic policy. There are three important reasons why it is dangerous to leap to conclusions concerning these issues from the observed regularities in the behavior of nominal exchange rates, ratios of national price levels, and real exchange rates under alternative nominal exchange rate regimes.

First, while real exchange rates show greater short-term variability under floating exchange rate regimes than under fixed exchange rate regimes, it does not automatically follow that this greater variability of real exchange rate is undesirable. Presumably, the relative prices of the outputs of different nations should adjust in response to some actual or anticipated changes in economic conditions. It may be that fixed exchange rate regimes artificially impede these necessary and desirable adjustments, and that floating exchange rate regimes generally allow for more appropriate behavior of real exchange rates.²³

Second, movements in nominal exchange rates and associated movements in real exchange rates under floating exchange rate regimes presumably occur for some reason. There is some change in actual economic conditions or some change in expectations of future economic conditions that causes

²²My views on the modelling of price stickiness are described in Mussa (1981a and 1981b). Similar but somewhat different approaches are presented by Barro (1972), Flood (1981), Flood and Hodrick (1983), McCallum (1980), Rogoff (1979), and Rotemberg (1982). Obstfeld and Rogoff (1983) have demonstrated an essential equivalence among some of these approaches, at least for certain purposes. Carlton (1979 and 1985) has developed theories that emphasize variations in delivery times as an important means of nonprice rationing in the presence of price rigidities.

²³The effects of volatility of nominal and real exchange rates, especially the effects on the volume of trade, have been a much-studied and somewhat controversial matter; see Williamson (1983), IMF (1984), Kenen and Rodrik (1984), and Gotur (1985).

exchange rates to move. Unless it is shown that the disturbances responsible for movements in nominal and real exchange rates under floating exchange rate regimes are themselves created by the nature of the exchange rate regime, it is illegitimate to conclude that the effects of these disturbances would disappear from the economic system under a fixed exchange rate regime. It is by no means clear that the alternative manifestations of these disturbances would be less damaging to economic welfare than whatever may be the deleterious consequences of fluctuations in nominal and real exchange rates.

Third, maintenance of a fixed exchange rate between two countries requires more than a wish that the exchange rate would not fluctuate. In the short-run, monetary authorities must intervene in the foreign exchange market to prevent the nominal exchange rate from deviating from its official parity. In the longer-run, monetary policies (and perhaps other policies) must be conducted in a manner consistent with the maintenance of the official parity. Hence, the welfare effects of different nominal exchange rate regimes necessarily involve the welfare effects of the economic policies that must be carried out in conjunction with these different regimes.

Having stated these important caveats, it should be emphasized that this study does indicate that the choice of a nominal exchange rate regime has important economic consequences. Real exchange rates do exhibit substantially and systematically different behavior under different nominal exchange rate regimes. These differences may have had an important influence on choices of exchange rate regimes by particular countries. There is a great deal of trade among the countries of Western Europe. Efforts to limit fluctuations in nominal exchange rates among Western European countries after the collapse of the Bretton Woods system may have reflected a desire to reduce real exchange rate fluctuations among these countries. The choice of some groups of countries to maintain regional systems of limited exchange rate flexibility, however, does not necessarily imply the desirability of a global system of fixed exchange rates.

Finally, it is worthwhile speculating about the more fundamental causes of greater volatility of nominal and real exchange rates under floating exchange rate regimes. Greater violence of economic shocks requiring adjustments in real exchange rates is probably part of the explanation for why countries adopt floating exchange rate regimes and, hence, partly explains differences in behavior of real exchange rates under floating rather than fixed exchange rate regimes. As has already been

emphasized, however, the differences in behavior of real exchange rate under different nominal exchange rate regimes appear to be too substantial and too systematic to be accounted for solely by exogenous real shocks.

Some have suggested that part of the volatility of exchange rates must be due to speculative bubbles and other departures from rational economic behavior.²⁴ In my judgment, the evidence is too weak to call upon "devils and demons" to explain the behavior of nominal and real exchange rates under floating exchange rate regimes.²⁵ Instead, I would emphasize differences in the actual or perceived conduct of economic policies as important determinants of differences between fixed and floating exchange rate regimes. My view is that commitment to policies consistent with the maintenance of fixed nominal exchange rates plays a critical role in stabilizing the behavior of nominal and real exchange rates under fixed exchange rate regimes. This commitment does not necessarily entail specific rules for monetary and fiscal policy (and perhaps other policies), but rather a general commitment to do whatever is necessary (within limits) to sustain official parities. So long as private agents believe that this commitment will be fulfilled, they need not worry about the implications of short-run variations in policy variables or other economic disturbances for the appropriate level of the nominal exchange rate. They know what the nominal exchange rate is likely to be (and therefore have a very good idea of what the real exchange rate is likely to be) because they know that the government is committed to keeping the nominal exchange rate at its official parity. In contrast, under a floating exchange rate regime, private agents must continually revise their expectations of the future behavior of money supplies and other relevant variables in forming their views about the appropriate level of the nominal exchange rate. This continual revision of expectations in the light of new information imparts to the nominal exchange rate its characteristic properties as an "asset

²⁴Dornbusch (1982) suggests both speculative bubbles and excessive response to irrelevant information as possible causes of excessive exchange rate volatility. Krugman (1985) concludes that some form of irrational speculative bubble is necessary to explain the recent strength of the U.S. dollar.

²⁵Okina (1984) presents some empirical results concerning the possible influence of "bubbles" on exchange rates. At least some of Okina's results cast doubt on the empirical relevance of bubbles. I have discussed Okina's analysis of the recent strength of the U.S. dollar (Mussa (1985)) and have concluded that the evidence does not strongly support the assertion of market irrationality.

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