A Study of the Outward Transmission of U.S. Interest Rate Shocks

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Abstract

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The primary object of this research is to analyze effects of a shock in U.S. interest rates on the interest rates for countries with whom the U.S. has close economic ties. Simulations are conducted to track the distinct effect of changes in U.S. rates. The data for this study are composed of daily observations for three-month maturity yields on five Eurocurrencies, which include the U.S. dollar, German mark, British pound, Japanese yen and Canadian dollar. The data source is the Bank of International Settlements (BIS). The sample period extends from January 3, 1980 to October 31, 1994.

Cointegration analysis is used to assess the stability of long-run interest rate relationship, while Granger causality analysis is used to assess the short-run relationship. Bivariate reaction functions are estimated, and based on these functions, simulations of the responses of foreign rates to a shock emanating from the United States are conducted. The study suggests methods by which the results may be introduced into the teaching of economic principles and money and banking courses.

The cointegration tests reveal no systematic interest rate relationships in the long run between most pairs of Eurocurrency rates. This finding may be attributed to the structural breaks, the nonstationarity of either expected exchange rate movement or the risk premium, or shifts in expected inflation between the various countries in this study.

The Granger causality tests reveal contemporaneous effects of a U.S. rate shock on the other rates, and the presence of reverse causality from foreign Eurocurrency rates back to the U.S. Eurocurrency rates.

Stability tests show that, except for the Canadian Eurocurrency rates, there are comparatively brief periods within the 14 year sample period in which each relationship can be considered stable. Various explanations are offered for this phenomenon.

Reaction functions linking the foreign and domestic Eurocurrency rates were estimated for the full sample period and for the stable sample period. The simulation results were based on the functions estimated over the stable period.

The study concludes with a review of several issues regarding the teaching of financial integration in economic principles and money and banking courses. The simulations are the key element of that process.

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Chapter I

Introduction

Section 1: Purpose and Importance of the Study

During the last two decades, several developments suggest the emergence of greater financial interdependence among major industrialized countries. First, the Bretton Woods agreement was abandoned in the early 1970s, and a system of floating exchange rates emerged. Second, during the 1970s there was a progressive dismantling of capital controls. Third, the U.S. became an ever-increasing participant in the global economy, with exports and especially imports rising as a share of aggregate output and spending. At the same time, the industrialized countries became increasingly subject to direct influences from abroad in the form of substantial cross-border flows of goods, services, and capital. These changes reflected a worldwide increase in the freedom of goods and capital to move across borders. Finally, global trading of currencies and many financial instruments intensified in the last decade.

Recognizing the growing importance of the global economy, the business schools and colleges have intensified efforts to incorporate the global economy into classroom instruction. This curriculum trend has been reinforced by the American Assembly of Collegiate School of Busines (Keating and Byles, 1991). This study is an effort to provide an understanding of one of many aspects of the global economy in a manner that can be integrated into the classroom instruction of basic economic courses. In particular.

this study examines the linkage between U.S. interest rates and the rates among its industrialized partners.

This study is restricted to assessing the bilateral behavior of nominal, short-run interest rates between the United States on one hand, and Germany, the United Kingdom, Japan and Canada on the other hand. The choices were made to focus on countries with whom the U.S. has the major commercial and financial relationships. Canada and the U.S. have close trading ties. Germany is symbolic of the EMS (European Monetary System). The U.K. was outside the EMS, except for a very brief period, and Japan is the dominant financial power in the Pacific basin.

In particular, this study seeks to answer the following questions:

* What are the time-series characteristics of money market interest rate time series? Are they stationary in levels or in first differences?
* Is there any long term relationship between the pairs of interest rate series under investigation? Can the hypothesis of non-cointegration be rejected?
* What does the adjustment process for these Eurocurrency rates look like?
* Does the assertion hold that there is a unidirectional causal relationship from the United States to the other countries, or does there also exist reverse causality?
* Are there any structural changes taking place during this period?
* What is the pattern of responses of foreign rates to a U.S. shock in interest rates?

Knowledge of the interest rate relationship is very important in the understanding of international financial market integration. In spite of the fact that international integration of financial markets has increased dramatically since the early 1980s, national financial markets appear less than fully integrated; not only do nominal interest rates on similar assets denominated in the currencies of the major industrial countries differ significantly, the real interest rates can also be kept apart for extended periods of time by time-varying expectations of changes in exchange rates and varying premia for bearing exchange rate risk (Pigott, 1993-1994). As a result, arbitrage is extensive in the international financial market, much as in the domestic markets. Investors continually buy and sell assets denominated in foreign currencies until profitable arbitrage opportunities disappear. Therefore, the relationship between interest rates prevailing in the domestic (or external) dollar and external foreign currency markets is an important aspect of capital market integration. The stronger the relationship between external dollar and external foreign currency markets, the more difficult it becomes for governments to pursue independent fiscal and monetary policies designed to intervene the economy, because domestic (foreign) interest rate changes can be transmitted through foreign (domestic) interest rates or through exchange rates. Ceteris paribus, changes in exchange rates should affect trade flows, and changes in interest rates affect capital flow. Moreover, for corporations whose cost of capital is interest sensitive, and for financial institutions whose profits depend upon successful spread and gap management, knowledge of the relationship between pairs of offshore currency yields and the impact of

the change in yields is necessary to anticipate correctly and interpret the meaning of movements in domestic and external interest rates.

Most studies of interest rate linkage concentrate on the relationship between U.S. and European countries. This research is distinguished from its predecessors in the following ways. First, the sample size is larger than most previous inquires (the entire sample period is composed of 3794 daily observations). Second, daily observation is used to capture relationship between international markets that are less visible in data measured over longer interval, which is an important break from other studies that employ weekly, monthly, or quarterly data. Third, not only a long-run trend relationship is assessed by examining the interest rates for evidence of cointegration, a short-run interest rate relationship is also assessed by employing bivariate autoregressive models in first differences. Fourth, structural changes are assessed by using BPCHOW tests to determine the stable sample period for modeling dynamic interest rate relationship models; simulations are conducted to determine the impact of U.S. rate shock (or innovations) on foreign interest rates.

Since this study concentrates on the analysis of bilateral interest rate relationships, the model simulation is limited to the first order effect of U.S. rate change on each of the foreign rate. By treating U.S. rate as an exogenous variable in the basic model, the simulated responses of the foreign rates to a permanent one-percentage point shock in the U.S. with feedback rate are traced.

Section 2: Organization of the Study

This study is organized into six chapters, including the introduction. Chapter 2 reviews studies about financial market integration. The first section of this chapter discusses, in conceptual terms, the implications of financial integration for interest rate relations in an international context. Although interest rates in different countries have tended to move in a more synchronous fashion in the short end of the yield curve as a result of increased capital mobility and asset substitutability, interest rate differentials have not been completely eliminated and continue to display significant variation over time. Interest differentials are likely to vary in magnitude if their underlying determinants shift between or among nations. The most important effect of financial integration is the greatly increased sensitivity of exchange rates to national interest rate fluctuations. Integration means that any change in a nation's interest rates relative to rates abroad will lead to offsetting currency movements.

The second section of Chapter 2 discusses the issue of the international transmission of an interest rate. It follows from the analysis in this section that in a world in which exchange rates are free to move, where assets are not perfect substitutes and exchange-market expectations play an important role, there exists no necessary, tight international linkage among national interest rates. What needs to be emphasized is that this loose-linkage regime exists under the assumption of no policy response. In such a case, foreign countries respond passively to a U.S. interest-rate shock. That is, they are assumed not to change their monetary policy in response. If policy reactions of national authorities respond to foreign interest rate change in an effort to limit or prevent an exchange-rate movement, a very tight linkage can exit even though there is no or only a

very weak structural linkage between interest rates. At the limit, policy reactions may even lead to a complete and immediate transmission of interest rate impulses. This will happen if the policy maker has effective control over domestic interest rates and is unwilling to tolerate any change in their relation to foreign rates.

The final section of this chapter reviews studies about different approaches to the analysis of financial market integration as evidenced by interest rates. There are several different ways of measuring market integration using this technique. The Law of One Price approach involves determining whether interest rates in the major industrial countries move as if their financial markets are integrated. Its typical practice is to look inside the two financial centers at the cost of interbank funds denominated in the same currency. The interest rate parity approach, in contrast to the Law of One Price approach, involves measurement of the deviations from covered interest arbitrage. It examines the degree to which interest rate differentials on assets of comparable risk are related to the forward premium or discount on one of the two currencies involved. Two issues are involved in this approach; one is the measurement of transaction costs as a barrier or deterrent to arbitrage, and the second is the measurement of other barriers to arbitrage which might explain systematic deviations from interest parity. The convergency of interest rates approach is to examine the extent to which real interest rates tend to be equalized or tend to move together internationally. The covariability of interest rates approach analyzes changes in rates.

Chapter 3 outlines the scope and methodology of the research. First, a long-run trend relationship is assessed by examining the interest rates for evidence of

cointegration. Second, a short-run interest rates' relationship is assessed by constructing a reaction function between each foreign Eurocurrency rate and the U.S. Eurocurrency rate, Third, structural changes are assessed for modeling dynamic interest rate relationship models. Forth, simulations are conducted to determine how foreign interest rates react over time to a shock in U.S. interest rates.

Chapter 4 presents and discusses the empirical results. The first section describes the data used in this study. The second section shows the results of a standard unit root test applied to all the interest rate series under the study. The third section reports the results for cointegration between ten pairs of Eurocurrencies' interest rates. The forth section presents the final prediction error tests for the bivariate autoregressive models. Results of the Breakpoint Chow Tests for the models are reported. Once the models with optimal lags have been estimated for the period 1980-1994, the sample is broken down into two different sub-periods, and tests are conducted to determine whether or not any structural changes have taken place over the test period. To apply the Breakpoint Chow test, the model is first estimated for the entire sample period, and then it is re-estimated for each of two sub-periods. Simulation results from the estimated systems are also presented.

Chapter 5 introduces the results of this empirical study into courses such as principles of economics and money and banking. The purpose is to provide students with (1) a demonstration of the international linkages and (2) the importance of computer usage in a business environment. The first section discusses the importance of integrating an international perspective and computer usage into the principles of

economics courses. The second section discusses the effective way of learning economics for the undergraduates. The third section introduces the empirical study results into classroom application to let the students appreciate the importance of empirical study. The last section of this chapter makes some suggestions on introducing empirical contents into an introductory course, such as money and banking.

Chapter 6 offers summaries and conclusions of this research.

Chapter II

Review of Related Literature about Theory and Findings

International financial markets, like their domestic counterparts, serve several important functions. At the very least, they provide channels through which resources can be shifted from savers to dissavers. As a result, they loosen the constraints imposed by self-financing and enable higher investment levels and smoother consumption patterns. Additionally, they provide liquidity and allocate and diversify risk. They may even help to impose disciplines to some errant borrowers by the possibilities of a rising default risk premium, the threat of credit rationing or even the adjustments to the exchange rates. If trade take place in financial assets without regard to either national boundaries or to the nationalities of market participants, there is a strong assumption that the above-mentioned attributes of financial markets (efficiency, liquidity, risk-pooling and disciplinary attributes) will be greatly enhanced (Eiteman, Stonehill and Moffette, 1992).

The benefits of open financial markets are being increasingly recognized, and the international integration of financial markets has increased dramatically over the last two decades. Owing to the technological advances and the progressive dismantling of capital and exchange controls, an enormous increase in cross-border financial transactions and activities and in the Eurocurrency and other international financial markets was occurring. As a result, linkages among national financial markets have been greatly

strengthened, and financial conditions in individual countries have become increasingly sensitive to developments in the markets of their partners.

This chapter reviews studies about financial market integration. There are several aspects concerning financial market integration studies. First, the positive question about the integration of national markets centers on the measurement of its extent: the mirror of this question involves the significance of transaction costs, differences in currency of denomination, political jurisdiction, exchange control, and the organization of the foreign exchange market on the segmentation-integration axes. Second, the normative questions include the implications of a large number of changes in policies and institutional arrangements on the extent of market segmentation (Aliber, 1978). This chapter concentrates on the positive question — the state of knowledge regarding the measurement of the extent of integration of national financial markets, as explained by the interest rates linkage. The first section of this chapter discusses, in conceptual terms. the implications of financial integration for interest rate relations in an international context. The second section discusses the issue of the international transmission of an interest rate. The last section reviews two types of studies of integration; one examines the relationships among changes in interest rates in different countries, while the second examines the elasticity of capital flows with respect to the differences in interest rates on similar assets denominated in different currencies or to changes in these differences.

Section 1: The Meaning of International Financial Integration

Complete integration of an economy's financial markets implies that all participants have equal access to all markets. Equal access to the markets means that interest rates and other terms faced by participants depend only on objective indicators of creditworthiness like financial position and credit history — not on the other conditions such as resident status or nationality (Mishra, B., M. Rahman and S. Caples, 1992). Integration enables portfolio diversification across markets and instruments. Therefore, when the markets become integrated, the tendency of investors to hold assets issued in their own locale is likely to be greatly reduced, even if not totally eliminated.

Now let us analyze how financial integration within a single country, where all assets are denominated in the same currency, affects the behavior of interest rates. Just as explained by Pigott (1993-1994), financial integration has several important effects on interest rates. First, returns on instruments with identical characteristics are equalized regardless of where they are issued or traded because integration allows arbitrage across markets. What needs to be emphasized is that equalization of yields is on a risk-adjusted basis. For example, within most industrialized countries, regional interest differentials among comparable assets are quite small or negligible in most cases. Second, and more generally, integration is likely to lead to much greater synchronization of interest rate movements across markets to reduce interest differentials among similar assets. The reason is that the free capital flow among markets eliminates any local differences in credit conditions. Therefore, regional fluctuations in real income, savings, or other determinants of credit demands and supplies do not themselves lead to great interest rate

divergence. This could only happen if markets are segmented. It follows from the above analysis that interest differentials within a single country largely reflect differences in attributes of an instrument, such as maturity, liquidity, and risk that are priced in the common national market. And interest rates tend to vary with national credit conditions which are determined by real growth, inflation, government fiscal positions, and other domestic macroeconomic conditions.

Although the implications of financial integration for the international economy are quite similar to its implications for a single country, the specific effects on interest rates are not so direct and obvious. There are mainly two reasons to explain it. First, transaction costs are much greater for trades across countries than for those within them. Because there are hosts of barriers to cross-border capital flows, including differences in language and information, tax laws, official restrictions and policies that favor domestic asset trade relative to foreign trade. A catalog of these restrictions can provide useful information about barriers to international capital flows. These barriers are much higher than the barriers that exist among states, provinces, or regions of a single country. As a result, the key characteristics of an instrument such as available maturities, minimum denominations, and liquidity generally vary much more across countries than within any single country (Pigott, 1993-1994).

Second, and most fundamental, is the fact that the international economy is distinguished from the national economy by the existence of multiple currencies whose values are subject to change. For investors deciding how to allocate funds among assets internationally, the relative returns are determined not only by the national interest rates

themselves but also by the change in the relevant exchange rates over the investment horizon. For example, the dollar return on a three-month Japanese yen-dominated asset depends upon the rate at which yen can be exchanged for dollars at maturity.

If exchange rates were fixed, integration would have the same effect internationally as within a single economy, which means that national interest rates would largely converge and their movements would be closely synchronized. The remaining differentials would be explained only by disparities in markets and (noncurrency) instrument characteristics rather than by macroeconomic disparities among countries (Mussa and Goldstein, 1992).

However, in the actual world economy, exchange rates are not fixed. The fact that national markets are linked through foreign exchange markets has practical consequences. The most obvious result is that the disparities in underlying determinants of national interest rates can generally be much greater than within a single country. The disparities in macroeconomic conditions cannot be easily decreased or limited by financial market integration. For example, inflation rates can diverge indefinitely if exchange rates adjust indefinitely to reflect the shift in relative inflation. As a result, any differences in macroeconomic conditions will lead to cross-country differences in national interest rates. Although interest rates in different countries have tended to move in a more synchronous fashion in the short end of the yield curve (see Figures 1 to 10 in the Appendix) as a result of increased capital mobility and asset substitutability, interest rate differentials have not been completely eliminated and continue to display significant variation over time. Financial integration, even if complete, does not bring about interest

convergence or synchronization of national rate movements across countries. Interest differentials are likely to vary in magnitude if their underlying determinants shift between or among nations. The most important effect of financial integration is the greatly increased sensitivity of exchange rates to national interest rate fluctuations. Integration means that any change in a nation's interest rates relative to rates abroad will lead to offsetting currency movements (Pigott, 1993-1994).

Section 2: International Transmission of Interest Rate

Although financial integration does not necessarily lead to convergency of national interest rates, one might ask does it lead to some linkage of interest rate movement, especially between the United States and the other financially advanced countries? In daily life, one often hears news about conditions in its country's money, bond, or equity markets which has repercussions not only in foreign exchange markets and but also in the money, bond, and equity markets of that country's partners. At times, these reactions are so rapid that one would naturally come to the conclusion that domestic and foreign interest rates are directly and very closely linked. This is the main issue that stimulated interest in this topic. In order to better understand this issue, this section reviews some studies about the interest rate transmission mechanism.

2.1. Theory on International Transmission of Interest Rate

The mechanism that effectuates whatever international linkage exists is described by Wallich and Haas (1982). They point out that the interest rate transmission

mechanism operates differently under fixed and floating exchange rate systems. Monetary effects, including interest-rate movements in one country, (unless that country is small), can be quickly transmitted abroad. That is because in the fixed-rate case, the money supply process is endogenous for all countries except for a reserve country. Only the reserve-currency country, or a country whose money supply is large relative to the global money supply, can follow an independent monetary policy (Wallich and Haas, 1982). Although countries can retard this process by accumulation or deaccumulation of foreign-exchange reserves, such possibilities are limited in both magnitude and effectiveness. Therefore, under the Bretton Woods system, commitments to maintain fixed nominal exchange rates closely linked interest rate movements among industrial countries.

For a period of freely floating exchange rates, the international transmissions of interest rates operate differently. Wallich and Haas (1982) refer to a simple monetarist model developed by Mundell (1963). This model operates under two special and essential features. One is that foreign-currency and home-currency bonds are assumed to be perfect substitutes for one another. The other is under the assumption that any change in the exchange rate today is expected to determine the rate in the future. Thus, the exchange-rate expectations are static. Wallich and Haas (1982) also assume that this model is applied in an environment that there is no policy response. Under these circumstances, they show that an increase in foreign interest rates will feed through directly and completely to domestic interest rates. This is because (1) capital flows are indefinitely elastic in this Mundellian model, and (2), money-market equilibrium requires

equivalence between domestic and foreign interest rates. In other words, there is no scope for differences in assets to provide a degree of insulation from interest rate shock from abroad. The inflation-rate expectation also plays no role in altering the effective rate of return on foreign assets since exchange-rate expectation is static.

However, if domestic and foreign bonds are not perfect substitutes for wealth holders, portfolio balance considerations then play an important role. Wealth holders demand higher rates of return to hold increasingly larger quantity of assets. Although domestic rates will be subjected to upward pressure when foreign rates rise, they will not move at the same magnitude as foreign rates. The presence of a variety of differentiated assets gives some elasticity in capital flows. Therefore, home interest rates might be insulated (at least partly) from interest rate shocks from abroad in this regime.

Another source of insulation is given when exchange rate expectations are not static but rather depend on some fundamental factors. In this case, the speed of the adjustment of expectations to their "normal level' plays a crucial role for the tightness of international interest rate linkage. For example, suppose there is an increase in foreign interest rates and the associated depreciation of domestic currency. For a given long-run expected exchange rate, a depreciation of the domestic currency will give rise to an expected appreciation of domestic currency. In that case, the time dimension plays an important role. The faster wealth holders expect the rate to return to its long-run level, the less the domestic interest rate needs to rise to balance asset markets. As a result, exchange market expectations can serve as a wedge between foreign and domestic interest rates.

It follows from the above analysis that in a world in which exchange rates are free to move, where assets are not perfect substitutes and exchange-market expectations play an important role, there exists no necessary, tight international linkage among national interest rates. What needs to be emphasized is that this loose-linkage regime exists under the assumption of no policy response. In such a case, foreign countries respond passively to a domestic interest-rate shock. That is, they are assumed not to change their monetary policy in response. If policy reactions of national authorities respond to foreign interest rate change in an effort to limit or prevent an exchange-rate movement, a very tight linkage can exit even though there is no or only a very weak structural linkage between interest rates. At the limit, policy reactions may even lead to complete and immediate transmission of interest rate impulses. This will happen if the policy maker has effective control over domestic interest rates and is unwilling to tolerate any change in their relation to foreign rates.

2.2. Empirical Findings of International Interest Rate Linkages

Some observers (BIS, 1989) have argued that integration has increased the synchronization of interest rate movements over the last decade. Several studies have reported that correlations between U.S. and foreign interest rates were somehow greater during 1980s as a whole than in the 1970s. Six questions related to international interest rate linkages are addressed in that book. The first question is whether there has, in fact, been a large degree of similar interest rate movements across countries during the period of floating exchange rate system. The study carried out by Johnson and Jones (BIS,

1989) finds that interest rate patterns have exhibited remarkable similarity across countries in recent years and correlations of monthly changes in US and non-US short-term interest rates have been reasonably stable during the period of floating exchange rates. They also find that there has been a marked increase in the correlations among changes in long-run interest rates during the 1980s. They think that this increased correlation is not simply the result of greater correlation among short-term rates. As long-term interest rate movements across countries have displayed greater similarities, term structure equations relating US long rates to their own lagged values and to current and lagged short rates appear to have exhibited parameter instability over the floating rate period. Together with the observed rise in the correlations between U.S. and foreign long-term rates, this finding raises the question of whether, as a result of increased globalization of financial markets, international factors have become more important determinants of US long-term interest rates, and whether domestic influences — including monetary policy — may have become less potent.

Simulation experiments (BIS, 1989) undertaken with Federal Reserve Board's multi-country model (MCM) considers, for example, a regime where short-term assets denominated in different currencies are perfect substitutes, and the monetary authorities' policies are aimed primarily toward achieving monetary objectives or stabilizing domestic short-term rates. In this case, the simulation shows that, as expected, the transmission of financial disturbances or policy measures across countries is quite weak. On the other hand, the MCM results show that, in the context of financial shocks originating from abroad, greater concern by US policy authorities for the path of an

exchange rate will bring about a closer association of long-term rate movements across countries. The same general conclusions would apply to foreign authorities and responses within their countries to financial shocks arising in the United States.

A companion paper written by Lawrence Radecki and Vincent Reinhart (BIS, 1989) investigates the impact of globalization on the determination of U.S. short-term interest rates. Their study provides some empirical evidence supporting the view that an increased impact of foreign developments on the U.S. money markets may have loosened the linkage between changes in the supply of bank reserves and U.S. money market interest rates. If that is an accurate assessment, that finding would complicate the use of monetary policy to influence rates. Their results also show that foreign economic factors have been making a greater contribution to the determination of US short-term interest rates in recent years than in earlier years. A greater role played by foreign factors in the domestic credit markets makes the probable effect of a policy instrument change less certain. However, their paper concludes that closer international financial linkages probably have not greatly impaired the Federal Reserve's ability to influence the three-month Treasury bill rate.

The second question is how did increased interest rate linkages come about? Several papers have discussed this question. The paper prepared by Bank of France economists (BIS, 1989) considers several factors including the improvements in domestic capital and money market integration, the development of new financial markets and instruments (the MATIF in France), the greater institutionalization of money and capital participants, and the improvements in the marketability of government securities, which

mainly refers to the reform of secondary markets in government securities in both France and Italy. Therefore, the authors think that changes in the structure of financial markets, instruments and institutions, and changes in macro-economic policies have contributed in some degree to linkages in long-term interest rates in the major capital markets.

The third question is to what extent that are a country's long-term interest rates influenced by foreign long-term rates and are these influences long or short? How to determine accurately the short and long-run responses of interest rates to exogenous factors is one of the most difficult econometric problems in financial market analysis. Common trends in variables, for example, may bring about problems of spurious correlation. In the paper written by German economists, Willy Friedmann and Heinz Herrmann, these problems are well noted and explained. They observe that although in the period of 1973-1978 interest rates in the Federal Republic of Germany appeared to react with a lag to movements in non-German interest rates, instantaneous feedback between domestic and foreign rates has been more prevalent since late 1970s. In the latter period, they think it necessary to distinguish between the two contribution factors to explain the increased co-movement among long-term interest rates. The first is attributable to the increase in global financial market integration. The second is from the convergence of macroeconomic policy objectives among the major industrial economies because the greater convergency of the economic policies of the major countries and the resultant increased parallelism of current interest rate and inflation expectations could also have caused this phenomenon. This distinction suggests that more emphasis should be put on the study of the likelihood of continued macro-policy convergence and

international exchange rate policies in the major countries. Because this will help us in determining whether coincident movements in long-run interest rates will in the future be long or short-lived.

The fourth question is what economic paradigm is considered appropriate for a qualitative and quantitative analysis of interest rate determination, particularly in an international context? Many approaches are employed in this volume (BIS, 1989). Some papers, like that written by Canadian economists John Murray and Ritha Khemani, emphasize interest rate parity and term structure of interest rate relationships. One paper measures the international asset substitutability and risk premium on domestic securities. All these approaches might be considered as examinations of equilibrium financial arbitrage conditions. In the papers prepared by German and Australian economists, a new variant of expectations model of term structure of interest rate approach is applied. The paper on Australia, for example, finds that U.S. interest rates are significant in explaining excess holding period returns on Australian bonds in the period 1979-1983 but not subsequently. The paper prepared by Federal Reserve Board staff economists, on the other hand, considered international interest rate interrelationships by utilizing the Federal Reserve's multi-country model, in which long-term interest rate determination is based on a variant of expectations model of term structure.

The two remaining questions discussed in this volume are the interrelated questions of whether international interest rate linkages have altered the "transmission mechanism" (the system from which national interest rates can be transmitted) and what the consequences of these linkages might be for monetary policy. It seems that both the

timing and the incidence of the impact of monetary policy on the real economy have changed in several countries due to the increased capital mobility inherent in the floating exchange rate system. To the extent that a country's exchange rate might be influenced by foreign interest rate behavior, it is increasingly the export and import-competing sectors which are "interest rate sensitivity." The paper by Bank of Japan economists observed that during the early 1980s, Japanese institutional investors were attracted by high U.S. interest rates, which resulted in substantial ex ante capital outflows from Japan, placing upward pressure on domestic interest rates. If domestic demand is sensitive to long-term interest rates, international linkage in long-term rates may have altered the transmission mechanism somewhat. It is still a difficult empirical question to determine any change in the transmission mechanism in individual country. The evidence provided in these papers is generally more qualitative than quantitative. However, it is recognized that the channels through which monetary policy affects real aggregate demand in the short run may be changed by movements in foreign long-term interest rates.

Section 3: Measuring the Integration of Financial Markets

There are two main approaches to the analysis of financial market integration. The first focuses upon the sensitivity of international capital flows among the several financial centers in response to changes in interest rate differentials. This approach recognizes that under perfect international capital mobility, there would be no official barriers to international capital flows, and presumably, transaction costs for asset trades would not be much greater for trades across the countries than for those within them. In

the real world, of course, there are hosts of barriers to cross-border capital flows, extending from differences in language and information, to official restrictions and policies that favor domestic asset trade relative to foreign trade.

The second approach focuses on the degree of integration between financial markets as evidenced by the interest rates. There are several different ways of measuring market integration using this technique. The Law of One Price approach involves determining whether interest rates in the major industrial countries move as if their financial markets are integrated. Its typical practice is to look inside the two financial centers at the cost of interbank funds denominated in the same currency. The interest rate parity approach, in contrast to the Law of One Price approach, involves measurement of the deviations from covered interest arbitrage. It examines the degree to which interest rates differentials on assets of comparable risk are related to the forward premium or discount on one of the two currencies involved. Two issues are involved in this approach, — one is the measurement of transaction costs as a barrier or deterrent to arbitrage, and the second is the measurement of other barriers to arbitrage which might explain systematic deviations from interest parity. The convergency of interest rates approach is to examine the extent to which real interest rates tend to be equalized or tend to move together internationally. The covariability of interest rates approach analyzes changes in rates. Along a different tack, several studies have explored whether portfolios of assets held by residents of different countries are internationally diversified to the extent that they would be consistent with perfectly integrated capital markets. In the

remaining section, I attempt to have a brief summary of the related literature about these approaches.

3.1. Law of One Price Approach

A basic characteristic of a perfectly integrated financial market is that the assets' price is the same everywhere in the market, that is, asset price must obey the Law of One Price. This Law holds very strongly in the domestic financial markets. It is assumed that arbitragers link the prices of the identical shares traded in several stock exchanges in each country — on the New York, Midwest, and Pacific exchanges in the United States, on the Tokyo exchanges in Japan, and on the Dussedorf and Frankfurt exchanges in Germany. Tests of the effectiveness of arbitrage in an international environment encounter the problem that the securities available in various countries are denominated in different currencies. In order to avoid this currency risk problem, the typical practice is to look inside the two financial centers at the cost of interbank funds denominated in the same currency. For example, the nominal interest rate on a large, yen-denominated certificate in Tokyo can be compared with that on a London, Euroyen deposit of the same maturity. Because there is no currency risk involved here, any divergence in the yield can be caused by the differences in transaction and information costs, the existence or threat of capital control, differences in tax treatment, and even the possibility of the perceived default risk.

This approach has spawned much literature. Generally speaking, there are two main conclusions from such offshore/onshore comparisons. The first one is that these

differentials have declined greatly since 1980s. This means a move toward closer integration of financial markets, especially for those countries like Japan and France, which have relaxed their capital controls during this period (Obstfeld, 1992). The second conclusion is that during periods of turbulence, these differences can become larger again because uncertainty increases and liquidity decreases (Frenkel and Levich, 1977). When fixed exchange rates are under pressure, the widening of offshore/onshore differentials can be interpreted as a signal that market participants are concerned that the onshore authorities may impose or tighten capital controls to defend the rate. Grauwe (1989), for example, has shown that in the early years of EMS, capital controls employed by weak currency countries like France and Italy became more binding during speculative attacks. At a result, the differential between the domestic and offshore interest rates tends to increase so as to shield the domestic interest rate from speculative movements.

3.2. Interest Rate Parity Approach

There are two versions on interest rate parity. One is the covered interest rate parity (CIP). The other is the uncovered interest rate parity. The concept of interest parity regards that portfolio investors at any time t have the choice of holding assets denominated in domestic currency, offering the own rate of interest $r_{d,T}$ between times t and t+1, or assets denominated in foreign currency, offering the own rate of interest $r_{f,t}$. Therefore, an investor starting with one unit of domestic currency should compare the option of accumulating $1+r_{d,t}$ units with the option of converting at the spot exchange

rate into S_t units of foreign currency, investing in foreign assets to accumulate $S_t (1+r_{f,t})$ units of foreign currency at time t+1, and then reconverting into domestic currency.

3.2.1. Covered Interest Rate Parity

If the domestic and foreign assets differ only in their currencies of denomination, and if investors have the opportunity to cover against exchange rate uncertainty by arranging at time t to reconvert from foreign to domestic currency one period later at the forward exchange rate F_t (in units of foreign currency per unit of domestic currency), then market equilibrium requires the condition of covered interest rate parity (CIP), which is usually expressed algebraically as:

$$1+ r_{d,t} = S_t (1+r_{f,t})/ F_t \qquad (1)$$

where $r_{d,t}$ and $r_{f,t}$ are, respectively, the domestic and foreign interest rates on similar assets between times t and t+1, S_t is the spot exchange rate (foreign price of domestic currency) and F_t is the forward rate of the same maturity as the interest rates.

An approximation to (1) is also sometimes used:

$$f_t - s_t = r_{f,t} - r_{d,t} \qquad (2)$$

where ft and st denote the natural logarithms of the forward and spot exchange rate respectively.

CIP is a basic arbitrage relationship that says the difference in interest rates on instruments issued by comparable borrowers but denominated in different currencies should be just equal to cost of cover in the forward exchange market. In any computation of CIP, it is obviously important to consider domestic and foreign assets which are

comparable in terms of maturity and also in terms of other characteristics such as default and political risk (Aliber 1973; Dooley and Isard 1980; Frankel and MacArthur 1988). For this reason, CIP is usually tested by examining interest rates on Eurocurrency deposits. For example, in the Eurocurrency markets, (where the instruments are identical except for their currency), the dollar return on a three-month Japanese yen deposit whose proceeds at maturity are covered through forward market sale (for dollars) is the same as that on a three-month dollar deposit. As with the offshore/onshore differentials, the assumption is that since the exchange risk has been eliminated, any departure from CIP must be attributed to transaction costs or to "country" or "political" risk factors (capital control and the like.)

Essentially there are two types of empirical tests of CIP conducted. The first depends on computing the actual deviation from interest parity to see if they differ 'significantly' from zero. The significance is usually defined with respect to a neutral band, which is determined by transaction costs. For example, Frenkel and Levich (1975, 1977), for a section of currencies, demonstrate that around 80 percent of apparent profit opportunities lie within the neutral band when treasury bills are used and almost 100 percent when Euro-rate are considered. Frenkel and Levich (1977) also show that during the periods of turbulence a much smaller percentage of deviation from CIP may be explained by transaction costs. This result can be explained by the higher financial uncertainty in these periods. Clinton (1988) shows that deviation from covered interest rate parity should be no greater than the transaction costs in any of the three markets under investigation: the two underlying deposit markets (such as Euro-marks and

Eurodollars) and the foreign exchange swap market, which is the market in which a currency can be simultaneously bought and sold forward against another currency. Based on the analysis of the data for five major currencies against US dollars taken from mid morning quotas on the Reuter Money Service from November 1985 to May 1986, Clinton finds that the neutral band should be within ±0.06 percent per annum from parity. He also finds that although the hypothesis of zero profitable deviation from parity can be rejected, 'empirically, profitable trading opportunities are neither large enough nor long-lived enough to yield a flow of excess returns over time to any factor'.

A second method for testing the validity of CIP has been the use of econometric regression analysis. It is to estimate the following equation:

$$f_t - s_t = a + b(r_{f,t} - r_{d,t}) + u_t \qquad (3)$$

If CIP holds, and in the absence of transaction costs, the estimation of a and b should differ insignificantly from zero and unity respectively, and the error term (u_t) should be non-autocorrelated. Equation (3) has been tested by a number of researchers for a variety of currencies and time periods. See for example, Branson (1969), Marson (1976), Dooley and Isard (1980, Cosander and Laing (1981), and Fratianni and Wakeman (1982).

The main conclusion to be drawn from this line of research is that CIP is generally supported, although there are significant deviations of a from zero, which reflects mostly the non-zero transaction costs, the estimates of b differ insignificantly from unity in majority of cases. Thus, the empirical tests have found that CIP holds to a close approximation in most short-term markets in industrial countries, especially if

Euro-deposit interest rates are considered. The empirical tests also show that the departures from CIP are on average smaller than they used to be, which suggests a trend toward closer integration of international money markets.

3.2.2. Uncovered Interest Rate Parity

Now suppose that market participants choose not to cover currency risk. If investors leave their foreign currency positions uncovered at time t and to wait until time t + 1 to make arrangements to reconvert into domestic currency at the spot exchange rate s_{t+1}. Unlike f_t, the value of s_{t+1} is unknown at time t, so the attractiveness of holding an uncovered position must be assessed in terms of probabilities of different outcomes for s_{t+1}. The assumption of UIP postulates that markets will equilibrate the return on the domestic currency asset with the expected value at time t (E_t) of the yield on an uncovered position in foreign currency:

$$1 + r_{d,t} = E_t[s_t(1 + r_{f,t})/s_{t+1}] = s_t(1 + r_{f,t})E_t(1/s_{t+1}). \quad (4)$$

This is essentially equivalent to combining the CIP condition with the assumption that exchange rates are driven, at the margin, by the risk-neutral market participants who are ready to take uncovered spot or forward positions whenever the forward rate deviates from the expected future spot rate. The assumption of UIP can be approximated as

$$r_{d,t} - r_{f,t} = E_t s_{t+1} - s_t + v_t \quad (5)$$

where E_t refers to the expectations at time t, s is the natural logarithm of the exchange rate (domestic currency per foreign currency unit), and v represents the risk premium. Here the idea is that domestic and foreign interest rates ($r_{d,t}$ and $r_{f,t}$) on similar one-

period loans will differ systematically only to the extent of expected depreciation in the relative value of the home currency, $E_t s_{t+1} - s_t$, where $E_t s_{t+1}$ is the value of s_{t+1} expected of period t. Unsystematic —, i.e., random — sources of discrepancy between $r_{d,t} - r_{f,t}$ are represented by the exogenous disturbance term v_t, which might represent time-varying aggregation or other effects, as well as risk premium.

The assumption of uncovered interest rate parity (UIP) is an important building block for macroeconomic analysis of open economics. It provides a simple relationship between an interest rate on an asset denominated in anyone country's currency unit, the interest rate on a similar asset denominated in another country's currency, and the expected rate of change in the spot exchange rate between two currencies.

Tests of UIP have often dealt with the assessment of whether the forward is a biased predictor of the expected future spot rate. To estimate the expected future spot rate, researchers have relied either on survey data of the expectations of exchange market participants or on the assumption that exchange rate expectations are formed rationally, which permits substitution of the actual exchange rate for the expected rate. There are two main conclusions that can be drawn from these tests. First, the proposition that the forward rates are unbiased predictors of future spot rates has been rejected by most econometric studies. (See, for example, Cumby and Obstfeld 1984). Even if the UIP assumptions were valid, the empirical evidence reveals that the forward exchange rates have been able to explain very little of the variation in future spot rates (Isard 1978, Frenkel 1981). Second, the resulting "risk premium" varies over time but has proven to

be difficult to relate to certain variables such as relative supplies of domestic and foreign assets that theories suggest should influence it (Hansen and Hodrick, 1980).

Using UIP theory, some researchers have studies interest rate linkages within the European Monetary System. Karfakis and Moschos (1990)'s paper has concentrated on the bivariate analysis of interest rate linkages within the EMS. Based on equation (5), $r_{d,t} - r_{f,t} = E_t s_{t+1} - s_t + v_t$, they argue that if the expected exchange rate change and the risk premium are both stationary, then the interest rate differential is also stationary. In this case, they think there exists a long-run equilibrium relationship between $r_{d,t} - r_{f,t}$. They further argue that differential tax rates and/or measurement error may imply bilateral cointegration with a factor of cointegration different from one. That is, they test cointegration with the following regression equation:

$$r_{f,t} = a + br_{d,t} + e$$

where b is not restricted to one. Karfakis and Moschos (1990) regress a number of EMS countries' interest rates on the German interest rate. Cointegration tests do not reveal the existence of systematic interest rate relationships in the long run between Germany and any of the other EMS countries. They think this finding may be attributed to the nonstationarity of either the expected exchange rate movements or the risk premium. They then proceed to bilateral Granger causality tests to investigate the information content of German interest rates about the future course of other countries' rates. They find the evidence of unidirectional interest rate linkages from Germany to the other member countries, which highlights the dominant role of Germany in the EMS.

Katsimbris and Miller (1993) modify the analysis of Karfakis and Moschos

(1990) in two directions. First, they include the U.S. interest rates as a potential important third variable in the analysis of EMS interest linkages. Second, they carefully explore the possibility of cointegration between the German interest rate and the other EMS rates as well as between U.S. rates, including the German rate. Their test results show little evidence of cointegration between the German interest rate and other EMS rates, but stronger evidence of cointegration between U.S. interest rate and EMS rates. The strongest case can be made for stationary interest rate differentials with U.S. interest rates as the base relative to EMS rates, indirect evidence of cointegration. Then they do causality tests for both cointegrated and noncointegrated specifications, using error-correction and vector autoregressive models respectively. Having found that the German and U.S. interest rates exhibit two-way Granger causality, they explore the result of trivariate error-correction models of the German, U.S. and the other five EMS interest rates. The evidence derived from the trivariate Granger-causality tests, in contrast to Karfakis and Moschos (1990), fails to support the hypothesis that the German interest rates play a dominant and independent role within the EMS. Furthermore, their results suggest that the U.S. interest rate also has important causal influence on the EMS members' rates in addition to the German rate.

3.3. Evidence on the Degree of Financial Market Integration

There are two additional approaches to measure financial market integration. One is the convergence of interest rates approach. The other is the covariability of interest rates approach.

3.3.1. Convergence of interest Rates Approach

Thus far, I have discussed the tests of the law of one price and the interest rate parity. They are exclusively in nominal returns. Integration of financial markets is considerably looser once real returns are used in the convergence of interest rates approach.

The convergence of interest rates approach is mainly used to examine the extent to which real interest rates tend to equalize or to move together internationally. The interest rate differential reflects the degree of integration of international markets. Perfectly integrated markets with unlimited arbitrage possibilities lead to a small or zero exchange-rate-adjusted interest rate differential, controlling for political and default risks. A zero differential is called uncovered interest rate parity (UIP).

The integration of real returns for assets denominated in different currencies is a more stringent condition than the integration of nominal returns, because the former also implies close integration of goods markets. That is, equality of real return requires not only UIP holds but also ex ante relative purchasing power parity (PPP) holds as well. The latter condition means that the expected change in the nominal exchange rate needs to be equal to the expected difference in inflation rates between the two countries involved (that is, the real exchange rate remains constant).

Studies by Mishkin (1984), Cumby and Mishkin (1986), and others suggest that real interest rates in the industrial countries do show a tendency to move together but still not enough to establish anything like equality of real returns.

This persistence of real interest rate differentials can be explained in this way. As normally measured, the real interest rate on a given country's asset is actually its return in terms of some aggregate of commodities produced or consumed in that country. The composition of these commodity aggregates usually varies across countries because of the inclusion of nontraded goods and services and differences in production and consumption patterns. The belief that real interest rates should converge internationally is based on the assumption that returns on capital will finally be equalized and that purchasing power parity determines nominal exchange rates. These conditions are likely to hold, if at all, only in the very long-run. Actually, it turns out that nominal exchange rate changes during 1970s and 1980s departed widely from the predictions of relative PPP (Frankel, 1991). So even if integration has clear effects on covered interest rate differentials, it has not led to any obvious convergence of national interest rates. This is mainly the result of the combination of variable exchange rates and continued great disparities among nations' macroeconomic conditions that has characterized the world economy for more than twenty years.

Therefore, in spite of the fact that financial markets become more interdependent as a result of integration, national interest rates, whether nominal or real, do not seem to have converged in any very meaningful sense since the floating exchange rate system and the continued disparities among nations' macroeconomic conditions have made the convergence of national interest rates more difficult to occur. Any differentials in national rates can be explained by fluctuations in real income, inflation, money and fiscal policies, and the changing alignment of these conditions across countries. For example,

the largest divergences in nominal interest rates have tended to occur during periods of rising and relatively high inflation such as the early 1980s. At that period of time, the cross-country disparities in inflation, the stance of monetary policy, and the business cycle positions have generally been greatest. Furthermore, major shifts in the alignment of interest rates across countries have been associated with substantial movements in exchange rates. One obvious illustration is the prolonged appreciation of the dollar accompanying the rise in U.S. interest rates relative to rates abroad during the first half of the 1980s.

Michael and Singh (1993) investigate the extent of Japan's integration with the world economy. Two important issues are addressed in this study. One is how long it takes for real interest rates to reach their equilibrium level. The other is to what extent do rates in Japan adjust compared to rates in U.S. following an initial disturbance. They estimate a simple dynamic model (an "error correction model") of U.S. and Japanese real interest rates. This model takes into account short-run adjustment dynamics as well as the tendency for real interest rate parity to hold in equilibrium in the long run. Their results indicate a very high degree of real interest rate linkage between U.S. and Japan since the early 1980s. They consider it is perhaps in response to the financial measures taken in Japan. They also find that gaps in real interest rates between the two countries appear to close quickly, and Japan seems to play an important role in the determination of rates in the U.S.

Chinn and Frenkel (1994) investigate the extent to which Pacific financial markets are becoming more tightly linked, by analyzing the co-movements of interest

rates in a number of countries around pacific. They examine the interest rate linkages of financial assets and the relative influence of the U.S. and Japanese markets in this area over the period 1982-1992. They decompose the differentials for interest rates of common maturities following:

$$i - i^{us} = (i - i^{us} - fd) + (fd - ds^{e}) + ds^{e}$$

where fd is the forward discount for a consistent maturity and ds^{e} is the expected depreciation over a consistent horizon. This identity merely breaks the nominal interest differential $(i - i^{us})$ into its constituent part. One is the country factors $(i - i^{us} - fd)$, which includes capital controls, differential tax treatments, default risk, localized information, and risk of future capital controls. This gives rise to the covered interest differential, $i - i^{us} - fd$. The others are currency factors, $(fd - ds^{e}) + ds^{e}$, which includes exchange risk premiums, $fd - ds^{e}$, and expected depreciation, ds^{e}. This gives rise to the forward discount, fd.

The key findings of their study show that the Pacific interest rates appear to be increasingly influenced by foreign interest rates (either U.S. or Japanese, as measured by co-movements. Some of these interest rates also appeared to be increasingly influenced by covered interest rates, indicating increasing financial integration for some countries. They find that the region is still far from achieving complete financial integration, particularly among the lesser developed countries. For countries with well-developed forward exchange markets, they attribute most of the barriers to integration to currency factors, just as explained above like expectations of exchange rate changes or exchange rate premium, rather than to country factors, such as capital controls or differential tax

treatment. Although U.S. rates remain the dominant foreign influence for most countries, there is some evidence of greater Japanese role in the countries of Southeast Asia.

3.3.2. Covariability of Interest Rates Approach

The covariability of interest rates approach analyzes the changes in rates. If covariability exits, it implies that the prices of financial assets in countries move in conjunction, but do not necessarily have the same level. Different interest-rate levels may be prevail because of different levels of risk (like currency risk) and different macroeconomic conditions. If capital markets are integrated, capital flows should cause interest rates in the several countries to follow changes in the interest rates in the larger country (Aliber, 1978). A number of studies have been done in this area.

Several studies report on the relationship between interest rates prevailing in the external (Eurodollar) and domestic (U.S.) markets. Among these, early works concentrate on the effect of changes in U.S. domestic rates on Eurodollar rates, a unidirectional approach (only U.S. rates have the effect on Eurodollar rates and not the vise verse. Hendershott (1967) provides an initial theoretical basis for analyzing the transmission mechanism. He presented a stock-flow adjustment model describing the determination of the Eurodeposit rate and the results of some tests of the model. He uses the three-month U.S. Treasury bill to test the model. He finds that short-term Eurodollar interest rates gradually adjust to changes in Treasury-bill interest rates. While the adjustment is eventually complete, it takes almost a full year to occur. His conclusion is that the U.S. bill rate seems to be the primary determinant of the equilibrium Eurodollar

rate, though the short-term interest rates in foreign markets are also the determinants of the Eurodollar rate in his theoretical model.

Kwack (1971) and Levin (1974) extend Hendershott's work by encompassing both foreign rates and the U.S. bill rate, but their work ignores the impacts on U.S. yields resulting from changes in external market yields. They support the position that Eurodollar rate changes lag changes in the U.S. Treasury bill rate and a total adjustment in the Eurodollar rate to U.S. Treasury bill rate may not have taken place. All the above studies find that the U.S. interest rate markets are relatively isolated. As a result, their work generally ignores the impacts on U.S. yield resulting from changes in external market yields. These studies reflect the belief of the day that the U.S. capital market is relatively isolated from foreign events and that United states can effectively pursue independent economic policies.

Giddy, Dufey and Min (1979) are among the first to use deposit (CD) rates rather than TB yields as measures of U.S. rates. Because CD and Eurodollar deposits are issues of banking sectors, risk and maturity characteristics are considered to be similar for yields on CDs and Eurodollar deposits rather than on TBs and Eurodollar deposits. They are also among the first to recognize and study reverse causality in the transmission process. They choose to examine the behavior of interest differential between bank lending and deposit rate instead of stock adjustment models used by earlier studies. They argue that Eurodollar rates are more sensitive to "market" conditions than domestic U.S. rates, hence, U.S. rates adjust more slowly to changing conditions than do Eurodollar rates.

Kaen and Hachey (1983), Hartman (1984) and Edgar Swanson (1984) examined the linkage of Eurodollar and US interest rate by primarily relying on the Granger-Sims causality test. Kaen and Hachey's paper examined whether Eurodollars (Eurostering) and U.S. (U.K.) money market rates lead or lag one another, jointly determine one another in a "feed back" fashion, or exhibit contemporaneous behavior. Data used for the tests is Eurodollar deposit, Eurostering deposit, U.S. treasury bill, U.S. certificates of deposit, U.K. interbank, and U.S. commercial paper rates. All instruments have three-month maturities and enter into the regression as first difference. Hartman (1984) selects US commercial paper rate for comparison to the short-term Eurodollar rate. He uses weekly data to improve the chances of disentangling the timing of interest rate response. Edgar and Swanson (1984) select CD yields as the appropriate proxy for U.S. rate of return and their data set is comprised of daily observations for 3-month maturity yields on Eurodollar deposits and negotiable CDs during the period July 1, 1973 through December 30, 1983. They use Hendershott's regression approach partial correlation coefficient analysis.

All these studies provide further evidence that feedback (not only unidirectional from domestic markets to external markets but also vice versa) effects exist and are of significant magnitude to require inclusion in the analysis of the transmission mechanism. Although all these studies find strong evidence of reverse causality, their results are not entirely consistent on which of the markets responds more rapidly to changes in other markets. Giddy, Dufey, and Min conclude that external dollar markets respond more rapidly to changes in a domestic market yield than domestic markets respond to external

market changes; Kaen and Hatchey find the opposite. The inconsistency may be attributed to the differences in the time periods examined, the data used, and the specific empirical techniques employed.

Swanson (1988) extends the study of capital market integration by investigating the relationships between yields on various currency denominated deposits. He applies Granger causality tests to investigate relationships between yields in (1) domestic and external markets for U.S. dollars and selected foreign currencies, (2) external dollar and external foreign currency markets, (3) domestic foreign and domestic dollar markets. He finds that changes in domestic and offshore yields for the same currency are closely related. Because of the tightness of yield changes in domestic and offshore markets for the same currency, external market relationship behavior is strongly affected by domestic policies. He also finds that the U.S. dollar and all the included foreign currencies reveal highly significant contemporaneous determination between the two geographic markets. These findings suggest that U.S. market is affected by offshore dollar yields, which respond to changes in other offshore currency yields. For example, a direct impact on U.S. markets from changes in the yield in Japanese domestic markets is strongly indicated. However, no direct causality from U.S. to foreign yields is indicated. He points out that the most important dollar/foreign currency relationship occurs for those currencies heavily regulated by their central banks — the Swiss franc, the German mark, and the Japanese yen. These currencies (together with the dollar) represent the world's strongest and most commonly used currencies.

Fung and Isberg (1992) employ a cointegration analysis and an error correction model to test the relationship between U.S. and Eurodollar certificates of deposit (CD) rate for the period 1981 - 1988. Daily observations for three month maturity yields on Eurodollar deposits and negotiable (U.S.) CDs are used to reflect the increasing speed of adjustments in the international financial markets. Results indicate that the structural relationship between U.S. and Eurodollar interest rates has changed during the study period. Consistent with earlier studies, there appears to have been unidirectional causality leading from the domestic to the external market in the earlier period (1981-1983). In the more recent sub-period (1984-1988), however, significant reverse causality is observed. This change was considered to be the increased size of the Eurodollar market and an increase in the volume of Eurodollar futures trading.

Fung, Isberg and Leung (1992) use the same error correction model to investigate the transmission mechanism between the Asian dollar and Eurodollar market for the period 1981-1989. The results show that the two interest rates are cointegrated. The Asian dollar market shows no evidence of cross-market causality during the same period, even when broken down into different periods. Changes taking place in the Asian dollar model indicate that as time has progressed, the market has developed in such a way that more information conveyed by prior interest rate changes are rapidly incorporated into current rates. In the case of the Eurodollar market, recent developments of its characteristics appear to be different. In the early 1980s, the Eurodollar market demonstrates evidence of reverse causality, where changes in the Asian dollar rate has a significant lagged impact on Eurodollar rates. However, in the later sub-period, the

Asian dollar's impact on the Eurodollar has become insignificant. The authors think that this implies that the two markets have become completely integrated. The authors also regard that the main reason for the existence of reverse causality in the Eurodollar but not in the Asian dollar market may be the comparative degree of regulation. The Asian dollar market has historically been characterized by less restrictive regulation. The regulation in the Eurodollar market has been severe, but its reduction is considered to be related to the disappearance of reverse causality in the later period.

There are other studies analyzing the relationships between national money markets. Kirchgasser and Wolters (1987) investigate an international linkage of interest rates between the United States, West Germany, and Switzerland during the period of flexible exchange rates, 1974 -1984. Spectral analysis and Granger causality tests are applied and trivariate autoregressive models are estimated. Two different international capital markets, the short-term Euro-market and the long-term bond market in two different periods are examined. Very different results are found with regard to the two time periods. During the first period from 1974 to 1978, the international linkage of interest rates is only weakly pronounced (Euromarket) or seems to be nonexistent (bond-market). During the second period, a highly significant linkage exists in both markets. They also find very pronounced instantaneous relations in all cases. The authors think that this international linkage might be the result of high substitutability of international capital and money markets in three currencies, U.S. dollar, Germans mark, and Swiss frank. It may also due to the reactions of the Swiss and German National Banks, since

the European National Banks has more incentives to intervene during the second period, which results in a stronger interest rate linkage than the first period.

Bhoocha-oom and Stansell (1990) examine the degree of market integration between the U.S., Hong Kong and Singapore. They employ the Granger-Sim's causality tests (the covariability of interest rate approach) to investigate three separate interest series in each market. They examine both nominal and real interest rates. Nominal interest rates are analyzed on both an uncovered (unadjusted for exchange rates) basis and on a covered (adjusted for exchange rates) basis. The data set used in this study is composed of monthly observations for the period 1976 -1984. The result of the study shows that there is a high degree of covariability between nominal interest rates in the four financial makers examined (the U.S. Singapore, Hong Kong and the Asian dollar markets), which indicate a substantial degree of interest rate harmonization and financial market integration. The authors find that in many cases nominal interest rates, both for Hong Kong and Singapore, react instantaneously to changes in rates in both US and Asian dollar markets. They point out that this instantaneous adjustment of domestic interest rates to foreign interest rates found in this study contradicts (in terms of speed of adjustments) the findings of earlier studies such as Hendershott (1967) and Kwack (1971). They think that the differences in results may be due to the different time periods under investigation. The results of their study also indicate that the direction of causality runs from the US and Asian dollar market to the Hong Kong and Singapore financial market.

Ahmad and Sarver (1994) employ a vector-autoregression model to investigate the interdependence of money markets in Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom, and the United States. Daily data on three-month money market rates from December 13, 1979 to February 28, 1990 is used . The results show that the money markets studied respond very rapidly to a shock in any one country, which is consistent with the notion of informational efficiency. The authors believe that the U.S. money market plays a leading role because the aftereffects of a shock in that market are stronger and last much longer than those of a shock elsewhere. The Japanese market is considered to be the least influential.

Section 4: General Conclusions and Findings

The studies reviewed provide evidence that financial markets across the world have become highly interdependent. They conclude that financial integration has had important and tangible effects on international interest rate relations. Most obviously, integration has nearly eliminated covered interest differentials among major markets of the industrial countries. U.S. rates tend to move closely with major "covered" foreign interest rates, that is, covered against exchange rate uncertainty in the forward market.

Other studies also illustrate that financial integration need not have great impact on the convergence among national interest rates. Even when there are no institutional or government barriers, two elements tend to work against the equalization of interest rates at home and abroad under flexible exchange rates. One is the expected change in

exchange rates. The other is the premium in the interest rates to compensate for the risk of unexpected changes in currency values.

Some studies find that changes in the structure of financial markets, instruments and institutions, and changes in macro-economic policies have contributed in some degree to linkages in interest rates (especially in long-term interest rates) in the major capital markets. General results of existing studies about the relationships between U.S. and Eurodollar, U.S. dollar and foreign currencies for major industrialized countries have been that feedback (reverse causality) effects exist — that the U.S. market is not isolated from foreign market events. Conflicting findings have been reported, however, on which of the markets respond more rapidly to changes in the other markets. The inconsistency may be attributed to the differences in the time periods examined, the data used, and the specific empirical techniques employed.

Chapter III

Scope and Research Methodology

This chapter outlines the scope and methodology of the research. It is organized into five sections. In the first section, a case for financial integration is introduced. In the second section, a long-run trend relationship is assessed by examining the interest rates for evidence of cointegration. In the third section, a short-run relationship is assessed by employing bivariate autoregressive models in first differences. In the forth section, structural changes are assessed for modeling dynamic relationship models. In the last section, the simulations are conducted to determine how foreign interest rates respond over time to a shock in the U.S. interest rates.

Section 1: A Case for Financial Integration

Banks in the Euro-currency markets carry on extensive arbitrage operations between the dollar and non-dollar markets to take advantage of profit from differences in exchange-adjusted rates. Arbitrage between the dollar and non-dollar markets is said to be so extensive that as a general rule the interest arbitrage insures that the interest rates on two highly substitutable one-period assets in different currencies conform to the following relation:

$$i_{1t} - i_{2t} = f_t - s_t \qquad (1)$$

where i_{1t} and i_{2t} are the one-period interest rates in dollar and non-dollar Euro-rate, and f_t and s_t are the natural logarithms of the forward and spot exchange rates. By definition,

$$f_t - s_t = \Delta s_{t+1} + (E_t s_{t+1} - s_{t+1}) + v_t \qquad (2)$$

where Δ and E are the first-difference and expectation operator, and v_t is the risk premium. The expectations error, which is in parenthesis, must be white noise, and therefore, stationary. Since the work of Meese and Rogoff (1983a, 1983b), exchange rates have been recognized to be well modeled as random walks, which indicates that Δs_{t+1} is stationary. The risk premium, v_t, is likely to be stationary according to the conventional wisdom. If the right-hand side items are all stationary, then the interest rate differential is also stationary, in which case there exists a long-run equilibrium relationship between i_{1t} and i_{2t}.

This model strongly suggests that national interest rates should be pairwise cointegrated. What needs to be emphasized is that cointegration of pairs of interest rates across countries is consistent with covered interest rate parity if forward and spot rates are cointegrated. However, pairs of interest rates need not to be cointegrated even if (1) holds. It may be that forward rates and spot rates are not cointegrated (Dwyer and Wallace, 1992).

Karfakis and Moschos (1990) and Katsimbris and Miller (1993) have a similar discussion of the issues. They used the uncovered interest rate parity to argue that differential tax rate's and/or measurement error may imply bilateral cointegration with a factor of cointegration different from one. Specifically, they test cointegration with the following regression equation:

$$i_{2t} = a + bi_{1t} + e \qquad (3)$$

where b is not restricted to one.

In a more general context, the existence of a long-run interest rate relationship can be explained from the viewpoint of cointegration (Engle and Granger, 1987) by investigating for stationarity the process

$$z_t = Y_t - AX_t \qquad (4)$$

where z_t is the equilibrium error term, Y_t and X_t are two time series of interest rates, and A is the parameter that links the two time series together. If the two sequences have the same stochastic trends, that is, if they are cointegrated such that their linear combination $(Y_t - AX_t)$ is stationary, the equilibrium error term z_t is an $I(0)$ process, which is stationary. This specific model is also employed in this study. This model is developed fully in the papers by Granger (1986) and Engle and Granger (1991). The methodology of this model will be discussed in detail in the following section.

Section 2: Assessing the Stability of Long-Run Relationships

The stability of long-run relationships is of interest in this study, because the presence or lack of presence of a stable long-run relationships influences the choice of the short-run model used to capture the shock-transmission mechanism. Thus, the first task is to assess the stability of the long-run relationships among the selected Eurocurrency rates.

The existence of a long-run interest rate relationship can be examined from the viewpoint of cointegration. First, a standard unit root test is applied to all the interest rate series under the study. Second, a cointegration test is employed to two time series which one assumes to be stationary in first differences.

2.1. Stationarity and Nonstationarity

Consider a single series X_t, measured at equal intervals of time. Time series theory starts by considering the generating mechanism for the series. This mechanism should generate all of the statistical properties of the series. The basic ones are the conditional mean, variance and temporal autocorrelations, that are the 'linear properties' of the series, conditional on past data. Some series appear to be 'stationary', which mainly implies that the correlation between a series and its lagged values is assumed to depend only on the length of the lag and not on when the series starts. It is also referred to as a series that is integrated of order zero or as $I(0)$. The process that generates a stationary series is time-invariant. Under stationarity, $\mathrm{Var}(u_t)$ and $\mathrm{Var}(u_{t-s})$ are the same for $s>0$. It is readily noted that the residuals of a regression model with an AR(1) structure satisfy the stationarity property. In a stationary AR(1) series, X_t is generated by

$$X_t = \alpha X_{t-1} + e_t \qquad (5)$$

where $|\alpha|<1$ and e_t is white noise with zero means.

Some series need to be differenced to achieve the stationarity properties and these are called integrated of order one, denoted $X_t \sim I(1)$. More generally, if a series needs differencing d times to become $I(0)$, it is called integrated of order d, denoted $X_t \sim I(d)$. The simplest example of an $I(1)$ series is a random walk, where X_t is generated by

$$X_t = X_{t-1} + e_t \qquad (6)$$

Here X can be seen to be $I(1)$ because $\Delta X_t = e_t$, which is $I(0)$, i.e., stationary. This would theoretically occur for a speculative price generated in an informationally efficient

market. Now let this relationship be expressed in a slightly more formal form as $X_t = AX_{t-1} + e_t$. If $|A| < 1$, then X is $I(1)$, i.e., nonstationary. Most economic time series appear to be $I(1)$, which means that they are not stationary in their level. However, it is possible to convert them to a stationary series through first differencing ($dX_t = X_t - X_{t-1}$).

Now consider two time series, Y_t and X_t that are non-stationary. In order to achieve stationarity, the two series need to be differenced. It is generally true that any linear combination of the two time series is also non-stationary. However, if Y_t and X_t are cointegrated, then there exists a constant A, such that

$$z_t = Y_t - AX_t \qquad (7)$$

is stationary. The parameter A is the cointegration parameter that links the two time series together. If it exists, A will be unique in the situation now being considered. As z_t has such different temporal properties from those of either of its components, it follows that Y_t and X_t must have a very special relationship. Both Y_t and X_t have dominating low-frequency or 'long wave' components, and yet z_t does not. Therefore, Y_t and AX_t must have low-frequency components which virtually cancel out to produce z_t. Further, the relationship

$$Y_t = AX_t \qquad (8)$$

is considered a long-run or 'equilibrium' relationship, suggested by economic theory. The term 'equilibrium' is used in many ways by economists. Here the term is used mainly to describe the tendency of an economic system to move toward a particular region of the possible outcome space. Two cointegrated series will not drift too far apart in the long

run. If X_t and Y_t are $I(1)$ but 'move together in the long run', it is necessary that the equilibrium error term, z_t, be $I(0)$ as otherwise the two series will drift apart without bound (Granger, 1986).

2.2. Testing for a Unit Root

Before testing two time series for cointegration, however, it is important to ensure that they each demonstrate the same order of non-stationarity. Thus, a standard unit root test is applied to both interest rate series as follows:

$$dY_t = \alpha + \beta_1 Y_{t-1} + \sum \theta_i dY_{t-i} + \epsilon_t \qquad (9)$$

where $dY_t = Y_t - Y_{t-1}$; the α is an intercept, which is used to reflect the possibility that under the alternative of stationarity, the intercept is not zero; the β_1 and θ_i are the estimated parameters. In order to ensure that ϵ_t is white noise, there is a popular correction called the parametric solution (Engle and Granger, 1991). This parametric solution, suggested by Dickey and Fuller (1979), is to add sufficient terms in dY_{t-i} to whiten the residuals. If the autoregressive representation of Y_t contains a unit root (i.e., is integrated of order one), the t-ratio for β_1 should be consistent with the hypothesis β_1 = zero. Conventional t-tables are inappropriate for this hypothesis test, therefore, the results of Dickey and Fuller (1979) and the tabulated distribution in Fuller (1976, p. 373) are applied to interpret the t-ratio. The augmented Dickey-Fuller (ADF) has the same asymptotic Dickey-Fuller distribution and will not depend upon θ_i. To determine the number of lags to be used, the model is first estimated with 10 lags. That number is decreased until an optimum is attained based on the Akaike Information Criterion (AIC)

procedure, which is minimized to select regressors in a model, such as choosing the length of a distributed lag.

2.3. Testing for Non-cointegration

To test whether two series are cointegrated, one must first establish that they are individually integrated. Assuming that each series has the same number of unit roots or they are $I(1)$, the cointegration test can commence using an OLS regression in the following form:

$$Y_t = c + \alpha X_t + u_t \qquad (10)$$

where α is the estimator for the equilibrium parameter, like A in equation (7); c is the intercept and u_t is the disturbance term.

This cointegration test is formed to test if the residual u_t appears to be $I(0)$ or not. If Y_t and X_t are cointegrated, OLS should give an estimate of the true cointegration coefficient A when large samples are used. Note that u_t will have a finite (or small) variance only if $\alpha = A$, otherwise, u_t will be $I(1)$ and thus have theoretically a very large variance in a large sample (Engle and Granger, 1991).

A test of null hypothesis Ho: Y_t and X_t are not cointegrated

can be formed from eq. (10), the cointegration regression. The test is based on the augmented Dickey-Fuller (ADF) test. The disturbance terms provided by the cointegration regression (u_t) provide the means for developing the test of cointegration employed here. Using the residuals from eq. (10), the ADF requires estimation of the

following model:

$$u_t - u_{t-1} = \phi_1 u_{t-1} + \sum_{i=1}^{n} b_i (u_t - u_{t-i-1}) + e_t \qquad (11)$$

where ϕ and b_i are the estimated parameters and e_t is the error term. The procedure is simply to test whether there is a unit root in the residual of cointegration regression. If the series are not cointegrated then there must be a unit root in these residuals. If the series are cointegrated, then the residuals will be stationary. The test for cointegration involves the significance of the estimated ϕ coefficient. If the t-statistic on the ϕ coefficient exceeds the critical value, the u_t residuals from the cointegration regression are stationary, and the variables X_t and Y_t are cointegrated. Once again, the number of lags (n) chosen in eq. (11) should be sufficient to ensure that the error term, e_t is white noise. Given this requirement, the test is conducted with a variety of lags, and the optimal result based on the AIC (provided automatically by TSP) is reported.

Unit root and cointegration tests have important practical implications for interest rate series. For example, testing for a unit root is important in constructing interest rate determination models. If interest rates contain a unit root (are nonstationary), econometric models that rely on the levels rather than the first differences of interest rates will produce estimators that do not display the desirable asymptotically normal distribution that arises when the regressors are stationary. Because a difference-stationary unit root series, such as a random walk, does not revert to its mean (no mean reversion), the whole idea of a mean has no meaning for this process (see also Meese and Singleton, 1982).

Cointegration is equally important when jointly modeling the behavior of interest. For example, the divergence of risk-adjusted returns on the same type of security across the maturity spectrum should be minimized. If the differences in rates get out of line, arbitrage opportunities exist, in spite of the fact that such opportunities are rapidly eliminated by market analysts and well-informed investors in efficient markets. Cointegration implies that the underlying variables are driven by some common fundamental so that series may be viewed as being generated by an error correction model. It is well documented that the developed economies examined in this paper have close economic and financial ties. Within the current globalization of the economic and financial environment, and as more developed nations respond to the need to coordinate their macroeconomic policies, these ties are expected to become stronger. In this framework, it seems reasonable to expect interest rates across nations to be determined simultaneously. To account for these interdependencies, as well as to take into consideration the relatively efficient financial markets of the countries examined in this paper, I try to conduct tests for cointegration across currencies. I try to find out whether there exists long-run co-movements between ten pairs of industrialized countries' interest rates.

Section 3: Assessing Short-Run Interest Rates Relationship

The investigation of the linkage between ten pairs of Eurocurrency interest rates can be carried out by the several different approaches. It can use an error-correction

model (ECM), a vector autoregressive (VAR) model or a bivariate autoregressive model. The selection of the specific model depends on the results of the cointegration test.

3.1. Models Estimation

If the null of non-cointegration is rejected, it is common to assert that the evidence of cointegration is found. Then the model will include both differences and the error correction terms. The model is referred to as an error correction model (ECM) and unbiased estimates of the standard errors may be obtained since all the variables are specified in first differences form and the error correction term is stationary.

If the value of the test statistics is insufficient to reject the null hypothesis of non-cointegration, then the researcher typically employs models other than ECMs to assess short-run relationship among the variables. Some researchers utilize a model which imposes non-cointegration by forcing the error correction terms to have zero coefficients. These models are vectors autoregressive (VAR) models in first differences (Enders, 1995).

This study adopts a different approach and utilizes reaction functions expressed as a bivariate autoregressive model in first differences between U.S. and each Eurocurrency rate. This approach was used for two reasons. First, this approach can be used to investigate unidirectional causality, feedback effects, and contemporaneous impacts for two money market rate series. It has been used by a lot of researchers [Karfakis and Moschos (1990) and Katsimbris and Miller (1993), Swason (1988), Hartman (1984), etc.]. Second, when the empirical results are introduced into the principles of economics

courses, such as money and banking, it has more direct and distinct classroom effect. It provides students a better demonstration of international effect.

Admittedly, the bivariate approach has a shortcoming. Namely, it ignores the interaction among the various Eurocurrency rates which may influence the magnitude of the direct and reverse causality effects between the Eurodollar rate and each Eurocurrency rate. This shortcoming was acceptable for two reasons. First, the bivariate approach will provide for a more straightforward classroom application of the shock-transmission mechanism than a multi-variate model. Specifically, it allows the instructor to illustrate the (partial equilibrium) effect of a U.S. interest rate shock on any <u>one</u> of its trading partners. Second, the information in a multi-variate model that is ignored in the bivariate model is likely to be minimal. Here, the U.S. dollar remains the dominant vehicle of international transmissions. Other currencies are increasing in importance, but the growth is dispersed among several countries. More importantly, the other Eurocurrency rates represent countries whose cross financial integration is probably less than the financial integration between the U.S. and each of the selected countries.

In the bivariate autoregressive model, the time path of the sequence $\{dY_t\}$ is affected by current and past realizations of the $\{dX_t\}$ sequence and the time path of the $\{dX_t\}$ sequence is affected by current and past realizations of the $\{dY_t\}$ sequence. The bivariate autoregressive model in first differences can render the time series stationary. The high-order bivariate autoregressive model can be expressed as

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + \sum_{j=1}^{m} \tau_j (dX_{t-j}) + \delta dX_t + e_{yt} \qquad (12)$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + \sum_{j=1}^{m} \tau_j (dY_{t-j}) + \delta dY_t + e_{xt} \qquad (13)$$

where it is assumed (1) that dY_t and dX_t are stationary; (2) e_{yt} and e_{xt} are white-noise disturbances with standard deviation σ_y and σ_x, respectively; and (3) $\{e_{yt}\}$ and $\{e_x\}$ are uncorrelated white-noise disturbances.

The structure of the system incorporates feedback since dY_t and dX_t are allowed to affect each other. Here the contemporaneous variable dY_t and dX_t are included in the right-hand side of the equation for economic justification in this study. It allows an instantaneous feedback from one country to the other. This same day feedback is quite strong, much stronger than any lagged relationship (Enders, 1995).

3.2. Selecting the lag Structure on the Bivariate Autoregressive Variables

An issue concerning the estimation of equations (12) and (13) is the selection of an appropriate lag length for the lag variables of (dY_{t-i}) and (dX_{t-j}). A variety of operational solutions to the problem of choosing the optimal length are available in the literature. Most of these solutions emerge from the objective of choosing lag length to minimize the mean square error of prediction. In this study, optimal lag length is selected using Akaike's final prediction error (FPE) methods (Callen, Chan and Kwan, 1989).

The FPE is defined to be the (asymptotic) mean squared prediction error

$$E(di_{2t} - \hat{di}_{2t})^2 \qquad (14)$$

where $di_{2t} = Y_t - Y_{t-1}$ and $\hat{di}_{2t}$ is the predictor of di_{2t} given by the least square estimates

$$\hat{di}_{2t} = \hat{b} + \hat{\psi}^n_{11}(L)di_{2t} + \hat{\psi}^m_{12}(L)di_{1t}. \qquad (15)$$

where $di_{1t} = X_t - X_{t-1}$, the superscript n and m denote the order lags of $\psi_{11}(L)$ and $\psi_{12}(L)$ respectively, where n and m are bounded above by the maximum lag order investigated. $\hat{\psi}^n_{11}(L)$, $\hat{\psi}^m_{12}(L)$ and $\hat{b}$ are the least squares estimators $\psi^n_{11}(L)$, $\psi^m_{12}(L)$, and the constant term b, respectively. Akaike estimates the Final Prediction Error by

$$FPE(n,m) = [(T + n + m + 1)/(T - n - m - 1)](SSE/T) \qquad (16)$$

where T is the number of observations and n and m are the number of lags in the autoregression. By choosing the lag structure with minimum FPE, Akaike's criterion tries to balance the bias from choosing too small a lag order against the increased variance from a higher lag order specification. More specifically, Akaike has shown that. if the dependence between ψ_{ij} and recent values of the variables (in this case the interest rates of the two countries) decreases as the length of past history increases, then the FPE is comprised of two components. The first component is due to the FPE of the best linear prediction for given *n* and *m* while the second component is due to the statistical deviation of $\hat{\psi}^n_{11}(L)$ and $\hat{\psi}^m_{12}(L)$ from $\psi^n_{11}(L)$, $\psi^m_{12}(L)$.

Generally, if *n* and *m* are increased, the first component decreases whereas the second component increases for a finite length of observations of interest rates. The FPE criterion has been widely used in the literature [Hsiao (1981); Karfakis and Moschos (1990); Fung and Isberg (1992); and others].

The FPE approach yields a number of distinct advantages in terms of identifying the model. First, the data itself are used to determine the lag structure rather then presupposing some arbitrary lag order specification. Secondly, the FPE criterion does not constrain the lag structure of each variable to be identical, i.e., in general, n ≠ m. Thirdly, the FPE criterion is equivalent to choosing the model specification on the basis of an F test with varying significance levels. Thus, rather than specifying an ad hoc significance level of 5 or 10 percent, the choice of whether to include a variable is determined by an explicit optimality criterion, namely, minimizing the mean square prediction error (Callen, Chan and Kwan, 1989).

To apply the test, the optimal order of β_i in equations (12) and (13) are first determined by constraining all τ to zero. Autoregressions containing from one to 20 lags are estimated and the FPEs compared. Second, using the optimal order of β_i found in the first step, regressions are estimated and FPE is calculated for $m = 1$ to $m = 20$ to determine the optimal lag for the cross market terms, τ_j.

3.3. The Direction of Causality

The Granger technique tests for direct causality, reverse causality, and contemporaneous determination of two money market yield series, and the Wald variant has been shown by Swanson (1988) to be an appropriate test for empirical work. The Granger technique tests are very important in this study for two reasons. First, it is an effective way of studying financial market integration. If there is no causal relationship existing between two series, it implies the independence of the domestic rates from

foreign rates. Such results would refute the contention that financial markets are integrated. Second, it also helps to investigate the hypothesis that U.S. rates are indicators of future movements of the other countries' rates and not vice verse. Third, if feedback effects (reverse causality) in this interest rate transmission mechanism analysis are found, then the U.S. market may also be affected by returns on foreign currency denominated deposits. Since feedback (reverse causality) effects from the external dollar markets to the domestic dollar markets have been proven to exist by many researchers, the relationships between external dollar yields and other offshore market yields can provide, by an indirect route, an additional consideration in assessing the integration of U.S. money markets with international money markets.

Formulating the Granger Causality test on the basis of restricted and unrestricted equations for each pair of interest rates and defining all variables in first differences, one can write the equations specified as bivariate autoregressive models in first differences as

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + e_{yt} \qquad (17)$$

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + \sum_{j=1}^{m} \tau_j (dX_{t-j}) + e_{yt} \qquad (18)$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + e_{xt} \qquad (19)$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + \sum_{j=1}^{m} \tau_j (dY_{t-j}) + e_{xt} \qquad (20)$$

for direct and reverse causality and as

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + \sum_{j=1}^{m} \tau_j (dX_{t-j}) + e_{yt} \quad (21)$$

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + \sum_{j=1}^{m} \tau_j (dX_{t-j}) + \delta dX_t + e_{yt} \quad (22)$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + \sum_{j=1}^{m} \tau_j (dY_{t-j}) + e_{xt} \quad (23)$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + \sum_{j=1}^{m} \tau_j (dY_{t-j}) + \delta dY_t + e_{xt} \quad (24)$$

for contemporaneous adjustment. Equations (17) and (18) measure direct causality; equations (19) and (20) measure reverse causality. Equations (21) and (22) test for direct contemporaneous determination; equations (23) and (24) test for reverse contemporaneous determination.

Because of problems occurring in ordinary least squares techniques when lagged values of dependent variables are included as independent variables, Wald's test statistic is used for determining levels of significance for differences between the restricted and the unrestricted equations.

To implement the Wald test, each model [eqs. (17), (19), (21) and (23)] is estimated in its restricted form (R), that is with the coefficients on lagged cross-market terms constrained to zero. Then the model [eqs. (18), (20), (22) and (24)] is estimated in its unrestricted form (U) by removing the constraint. The Wald test statistic which is applied to test the significance of the unconstrained cross-market term. is computed as:

$$F = [(ESSR - ESSU)/m]/[ESSU(T - n - m)] \quad (25)$$

where T is the number of observations used in the unrestricted models in eqs. (17), (19), (21) and (23) , ESSU is the error sum of squares for eqs. (17), (19), (21) and (23), and ESSR is the error sum of squares for the restricted models in eqs.(16), (18), (20) and (22).

Section 4: Assessing Structural Changes

When using long time series, as many of these studies have done, it is important to take account of structural changes. Once the models with optimal lags have been estimated for the U.S. and the other four countries' interest rates, the entire period of 1980-1994 is broken down into two different sub-periods and tests are conducted to determine whether or not any structural changes have taken place over the test period.

In-sample parameter stability is examined by the "Breakpoint Chow Test" (BPCHOW). The "Breakpoint Chow Test" consists of a sequence of 176 ordinary Chow tests for each of 20 observations from 08/22 /1980 to 02/28/1994 (3520 daily observations). For each of these tests the sample is identical and covers the period 01/03/1980-10/31/1994 (3794 daily observations).

The procedure for the Chow test is explained below.

Suppose we want to test whether there has been a structural change at time $t=T_1$. For the first BPCHOW test, we want to find out if there has been a structural break on May 22, 1980. The procedure is to divide the sample of T observations (3794 observations) into two groups — group 1 consisting of the first T_1 observations (100 observations) and group 2 consisting of the $T_2 = T - T_1$ remaining observations (3694 =

3794 - 100). Estimate the model (with k regression coefficients) separately for each of the two sample groups and compute the sum of squared residuals SSR_1 and SSR_2. The unrestricted sum of squares is therefore given by $SSR_u = SSR_1 + SSR_2$. When divided by σ^2 this will have a chi-square distribution with d.f. $T_1 - k + T_2 - k = T - 2k$, because estimation of this model separately implies that each equation has k regression coefficients. Next assume that the regression coefficients are the same before and after period T_1 (which gives rise to k restrictions). Estimate the model again but with the pooled sample, and obtain SSR_0. The appropriate test statistics is now

$$\text{Chow F} = ((SSR_0 - SSR_1 - SSR_2)/k)/((SSR_1 + SSR_2)/(T - 2k)) \quad (26)$$

The test procedure is to reject the null hypothesis that there is no structural change if Chow F exceeds $F_{k, T-2k}$ the point on the F-distribution with k and T- $2k$ d.f. such that the area to the right is equal to the level of significance.

Section 5: Simulations of the Selected Models

Once the models with stable parameters have been determined by the above BPCHOW tests for the U.S. and the other four countries' interest rates, Granger Causality Tests are employed for the stable parameter period. In order to determine how foreign interest rates respond over time to a shock in U.S. interest rates, simulations are conducted by using the selected models.

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + \sum_{j=1}^{m} \tau_j (dY_{t-j}) + \delta_{12} dY_t + e_{xt} \quad (27)$$

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + \sum_{j=1}^{m} \tau_j (dX_{t-j}) + \delta_{21} dX_t + e_{yt} \quad (28)$$

Equations (27) and (28) constitute a higher-order bivariate autoregressive model. The structure of the system incorporates feedback since dY_t and dX_t are allowed to affect each other. For example, δ_{12} is the contemporaneous effect of a unit change of dY_t on dX_t and $\sum \tau_j (dX_{t-j})$. Note that the terms e_{xt} and e_{yt} are pure innovations (or shocks) in dX_t and dY_t, respectively. If δ_{12} is not equal to zero, e_{yt} has an indirect contemporaneous effect on dX_t, and if δ_{21} is not equal to zero, e_{xt} has an indirect contemporaneous effect on dY_t. Such a system could be used to capture the feedback effects in the above models. The first equation allows the current and past values of U.S. interest rates to affect the time path of the foreign interest rate; the second allows for feedback between current and past values of the foreign interest rate and the U.S. interest rate (Enders, 1995).

In order to simulate the effect of a change in U.S. rates (dY_t) on foreign rates (dX_t), U.S. rate (dY_t) is treated as an exogenous variable in the basic system. Equations (27) and (28) are first estimated by using OLS. After increasing the U.S. rate (dY_t) by one percentage point, a simulation is conducted to determine the impact of dX_t (foreign rate) to this permanent one percentage point shock in U.S. rate (dY_t).

Chapter IV

Empirical Results

This chapter presents and discusses the empirical results. The first section describes the data used in this study. The second section shows the results of a standard unit root test applied to all the interest rate series under the study. The third section reports the results for cointegration between ten pairs of Eurocurrencies' interest rates. The fourth section presents the final prediction error tests for the bivariate autoregressive models. Results of the Breakpoint Chow Tests for the models are reported. Simulation results from the estimated systems are also presented.

Section 1: The Data

The data for this study are composed of daily observations for three-month maturity yields on five Eurocurrency instruments, which include the U.S. dollar, German mark, British pound, Japanese yen and Canadian dollar. The data source is the Bank of International Settlements (BIS). The sample period extends from January 3, 1980 through October 31, 1994. A total of 3794 observations are available. The markets chosen were to some extent dictated by the availability of the data. The choices were made to focus on countries with whom the U.S. has the major commercial and financial relationships. Canada and the U.S. have close trading ties. Germany is symbolic of the EMS (European Monetary System). The U.K. was outside the EMS, except for a very brief period, and Japan is the dominant financial power in the Pacific basin.

Figures 1 to 10 (in the Appendix) show the behavior of the yields of ten pairs of Eurocurrency rates respectively over the study period. As can be seen, each pair of interest rates has exhibited similarities in the recent years of the sample period. Both the general level and the volatility of each of the interest rates decreased over the course of the study period.

The plots included are monthly averages of the daily rates for illustrative purposes only. However, as noted earlier, this study uses daily data. The use of daily interest rates is appropriate due to the speed of adjustment in international financial markets. With movement toward 24-hour trading in markets that are connected by sophisticated telecommunications networks, daily data may capture relationships between international markets that are less visible in data measured over longer intervals (Ahmad and Saver, 1994).

Another important data issue involves the use of Eurocurrency rates. In examining the tie between U.S. and other countries' interest rates, Eurocurrency rates are used rather than home-country rates for three reasons, as emphasized by Mark (1985). First, they are market-clearing rates. Second, large offshore banks issue deposit liabilities in a number of different currencies. Third, they are virtually free from regulation and capital controls.

Section 2: Unit Root Test Results

Table 4.1 reports the test results for equation (9), the stationarity test for interest rates in levels. As can be seen by the magnitude and significance of the β_1 coefficients for each series, both tests (DF and ADF) fail to reject the null hypothesis of nonstationarity in levels for all countries at the 5%-level. The results also show that none of the interest rate series possesses a stable univariate autoregressive representation and each contains a unit root. This seems to indicate that short-term Eurocurrency rates are integrated processes with a nonzero drift.

It is evident, however, from the inspection of the β_1 coefficients in Table 4.2, that each series of first differences in the interest rates displays stationarity. The hypothesis of nonstationarity in first differences is rejected for all countries at the 1% level. These results suggest that the two interest rates are integrated in the first order and validate the use of the cointegration test and the bivariate autoregressive models in first differences.

Table 4.1
Results of Unit Root Tests for Daily 3-month Eurocurrency Rates in Levels
1980-1994

Interest Rate in Levels

$$dI_{jt} = \alpha + \beta_1 I_{jt-1} + \sum_{i=1}^{n} \theta_i dI_{jt-i} + \epsilon_t$$

Country	DF	ADF(1)	ADF(2)	ADF(3)	ADF(4)	ADF(5)	ADF(6)
E$	-1.6166	-1.7937	-1.7566*	-1.8058	-1.8049	-1.9599	-1.8794
ECM	-1.2458	-1.2021*	-1.1995	-1.2731	-1.1020	-1.1561	-0.9515
EBP	-1.9153	-1.8823	-1.6783	-1.5736	-1.6378*	-1.7730	-1.7457
EJY	-1.0724	-1.1829*	-1.2857	-1.3526	-1.3507	-1.3128	-1.2900
EC$	-1.2638	-1.2382	-1.2498	-1.2208	-1.2419*	-1.3199	-1.3774

Note: The null hypothesis is that the interest rates I_t of the jth country is a nonstationary series and it is rejected when it is significantly negative. The critical values for the DF and ADF tests with more than five hundred observations at 10, 5 and 1 percent levels are -2.57, -2.86 and -3.43 respectively.
* means the AIC is minimized.

Table 4.2
Results of Unit Root Tests for Daily 3-month Eurocurrency Rates in First Differences 1980-1994

Interest Rate in First Differences

$$ddI_{jt} = \alpha + \beta_1 dI_{jt-1} + \sum_{i=1}^{n} \theta_i ddI_{jt-i} + \epsilon_t$$

Country	DF	ADF(1)	ADF(2)	ADF(3)	ADF(4)	ADF(5)	ADF(6)
E$	-54.5295	-40.6353*	-35.2353	-29.0464	-23.3040	-22.8181	-20.2861
EGM	-59.7390	-40.1557*	-33.7187	-29.9233	-26.1684	-24.3537	-22.2314
EBP	-65.6843	-46.8724	-36.9833	-31.2804*	-26.4918	-23.5756	-22.2808
EJY	-57.2109	-38.4955	-31.7365	-28.6190	-26.3054	-24.5948*	-21.8200
EC$	-62.7765	-43.6697	-36.6647	-31.0691*	-26.3664	-23.1669	-21.6468

Note: The null hypothesis is that the interest rates I_t of the jth country is a nonstationary series and it is rejected when it is significantly negative. The critical values for the DF and ADF tests with more than five hundred observations at 10, 5 and 1 percent levels are -2.57, -2.86 and -3.43 respectively.
*means the AIC is minimized.

Section 3: Cointegration Test Results

The test for cointegration between ten pairs of Eurocurrency interest rates are reported in Table 4.3. The full sample period (1980-1994) is used in these tests. Five lags are employed in the analysis. The unit root (non-cointegration) hypothesis can only be rejected at the 5% level of significance when ϕ_t is greater than the critical value of -2.86. Only three out of the ten pairs of interest rates are cointegrated. The E$ and EC$ exhibit the strongest cointegration. EBP and EJY are also cointegrated at the 5% level of significance. The last pair of cointegrated interest rates is EC$ and EBP. The remaining pairs of interest rates all fail to reject the null hypothesis of noncointegration at the 5 percent significance level.

Lack of cointegration may be attributed to the nonstationarity either of expected exchange rate movements or of the risk premium. It may also simply indicate that a structural break occurred at some point. It does not imply that the chosen pairs of Eurocurrency rates have no systematic relationship to each other in the long run.

Section 4: Estimation of the Short-Run Reaction Functions

The investigation of the linkage between ten pairs of Eurocurrency interest rates is carried out by bivariate autoregressive models in first difference. In developing those models, the first step was the determination of the optimal lag structures.

Table 4.3
Bilateral Cointegration Tests for Daily 3-month Eurocurrency Rates
1980-1994

$$I_{jt} = c + \alpha I_{Jt} + u_t$$

$$u_t - u_{t-1} = \phi_1 u_{t-1} + \sum_{i=1}^{5} b_i (u_t - u_{t-i-1}) + e_t$$

Dep/Idp	E$ DF [ADF(5)]	EGM DF [ADF(5)]	EBP DF [ADF(5)]	EJY DF [ADF(5)]	EC$ DF [ADF(5)]
E$	—	-1.6242	-1.6715	-2.1244	-3.4654*
		(-1.8063)	(-2.6440)	(-2.3853)	(-3.5600)*
EGM	-1.3162	—	-1.4746	-1.4104	-1.5657
	(-1.4471)		(-1.4208)	(-1.5576)	(-1.5444)
EBP	-2.0285	-2.0502	—	-3.3330**	-2.7333^
	(-2.5899)	(-1.9024)		(-3.2220)*	(-3.2791)^
EJY	1.7602	-1.4186	-2.9862**	—	-1.9747
	(-1.9416)	(-1.4044)	(-2.9860)**		(-2.2499)
EC$	-3.3240**	-1.5044	-2.2361**	-2.0927	—
	(-3.2650)**	(-1.6083)	(-3.0000)**	(-2.2577)	

* means significant at 1-percent level. ** means significant at 5-percent level. ^ means significant at 10-percent level.

Table 4.4
Optimal Lag Structures, Entire Sample Period: 1980-1994

Dep. / Ind.	E$	EGM	EBP	EJY	EC$
E$	—	(19, 20)	(19, 15)	(19, 8)	(19, 1)
EGM	(13, 15)	—	(13, 2)	(13, 2)	(13, 1)
EBP	(20, 13)	(20, 20)	—	(20, 1)	(20, 6)
EJY	(20, 3)	(20, 20)	(20, 19)	—	(20, 6)
EC$	(6, 5)	(6, 12)	(6, 10)	(6, 3)	—

Note: The first and second numbers in the optimal lag indicate number of own-and cross interest rate terms respectively.

4.1. Optimal Lag Structure for Bivariate Autoregressive Model

Based on the results of the final prediction error test, the optimal lag structures for the ten pairs of Eurocurrency rates are reported in Table 4.4. These results are based on the full sample period. As can be seen, they vary among currencies. The optimal lag structure for the E$ (E$ as dependent variable) with the other four interest rates contains 19 lagged own-rate terms and 20 lagged EGM, 15 lagged EBP, 8 lagged EJY and 1 lagged EC$, respectively.

4.2. Granger Causality Test Results Analysis

The results of causality tests for changes in yields between two Eurocurrencies are set forth in Table 4.5. These values are based on the following equations.

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + \sum_{j=1}^{m} \tau_j (dX_{t-j}) + e_{yt} \quad (18)$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + \sum_{j=1}^{m} \tau_j (dY_{t-j}) + e_{xt} \quad (20)$$

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dY_{t-i}) + \sum_{j=1}^{m} \tau_j (dX_{t-j}) + \delta_{12} dX_t + e_{yt} \quad (22)$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i (dX_{t-i}) + \sum_{j=1}^{m} \tau_j (dY_{t-j}) + \delta_{21} dY_t + e_{xt} \quad (24)$$

Interpreting the equations, direct causality tests for the causality from dx to dy, reverse causality tests for the causality from dy to dx. See equations (18) and (20), respectively. Here the current value of explanatory variable dx or dy is not included. The Wald-F test is used to test the null hypothesis $H_0: \sum \tau_j = 0$. To test for instantaneous causality between dy and dx, the current values of the explanatory variables are included. See equations (22) and (24), respectively. To check whether dy or dx adds significant explanatory power, an F-test is performed with the null hypothesis $H_0: \delta_{21} = 0$ or $\delta_{12} = 0$. Wald test statistics are reported in the last two rows of every model (each of the five Eurocurrency rates as dependent variable).

For all the included rates, two way causality exists for each pair except for EGM (EC$) and EBP (EJY), for which there exists only one-way causality, from EGM to EC$ and from EBP to EJY.

In examining the tie between the E$ rate and the other four Eurocurrency rates, not only changes in the E$ yield have direct causal effects on the four Eurocurrency yields, but the latter also influence the former (See table 4.5). This indicates that the addition of lagged cross rate terms makes an obvious contribution to the model that is significant at the 1% level. Since strong reverse causality effects, from the external dollar markets to the domestic dollar markets, have been shown by many researchers, [Hartman (1984), Swanson (1988) Fung and Isberg (1992)], the finding of strong reverse causality from the four offshore market yields provides indirect evidence of the integration of U.S. money markets with international money markets.

For the included instruments, instantaneous causality is significant at the 1 percent level, which means that the impacts of changes are evident within one day. This is not surprising. With movement toward 24-hour trading over sophisticated telecommunications networks, any change in one yield should be transmitted rapidly to others.

Table 4.5
Bivariate Causality Tests, Entire Sample Period: 1980-1994

$$dY_t = \alpha_0 + \sum_{i=1}^{n} \beta_i \, dY_{t-i} + \sum_{j=1}^{m} \tau_j \, (dX_{t-j}) - \delta_{12} \, dX_t + e_{yt}$$

$$dX_t = \alpha_0 + \sum_{i=1}^{n} \beta_i \, (dX_{t-i}) + \sum_{j=1}^{m} \tau_j \, (dY_{t-j}) - \delta_{21} dY_t + e_{xt}$$

	E$	EGM	EBP	EJY	ECS
E$ as dependent variable					
No. obs.	—	3508	3637	3764	3767
SSE	—	77.855	88.427	104.03	84.586
R^2	—	0.15173	0.0969	0.0781	0.2510
F-value	—	15.503	11.269	11.3	59.763
Final Prediction Error	—	0.0227	0.0248	0.0281	0.0227
Direct or Reverse Causality	—	41.504	33.171	13.032	5.9407
Instantaneous Causality	—	377.46	226.15	65.55	982.13

Note: The direct or reverse and instantaneous causalities are for the significance of the interest rates (lags and current explanatory variables) on the dependent variable.

Table 4.5 (continued)
Bivariate Causality Tests, Entire Sample Period: 1980-1994

	E$	EGM	EBP	EJY	EC$
EGM as dependent variable					
No. obs.	3508	—	3570	3578	3579
SSE	25.838	—	28.427	28.697	28.114
R^2	0.1290	—	0.0333	0.0261	0.0515
F-value	18.001	—	7.6447	5.2712	12.901
Final Prediction Error	0.0073	—	0.0080	0.0081	0.0079
Direct or Reverse Causality	5.6221	—	14.850	21.816	2.9055
Instantaneous Causality	371.30	—	68.546	20.727	136.85
EBP as dependent variable					
No. obs.	3604	3442	—	3604	3596
SSE	79.891	78.993	—	85.873	83.023
R^2	0.0961	0.0604	—	0.0293	0.0614
F-value	11.264	5.3267	—	4.9109	8.6484
Final Prediction Error	0.0226	0.0235	—	0.0241	0.0234
Direct or Reverse Causality	4.7907	11.253	—	0.1883	3.6041
Instantaneous Causality	214.28	78.642	—	11.927	112.71

Table 4.5 (continued)
Bivariate Causality Tests, Entire Sample Period: 1980-199

	E$	EGM	EBP	EJY	EC$
EJY as dependent variable					
No. obs.	3751	3442	3609	—	3734
SSE	35.360	30.242	31.917	—	35.731
R^2	0.0522	0.0591	0.0524	—	0.0382
F-value	8.5482	5.2712	4.9272	—	5.4532
Optimal Lag	(20, 3)	(20, 20)	(20, 19)	—	(20, 6)
Final Prediction Error	0.0096	0.02351	0.0090	—	0.0097
Direct or Reverse Causality	6.7153	11.253	24.068	—	5.0247
Instantaneous Causality	64.075	78.642	16.153	—	17.295
EC$ as dependent variable					
No. obs.	3770	3585	3673	3765	—
SSE	76.216	85.386	89.17	99.654	—
R^2	0.0247	0.0541	0.0384	0.0125	—
F-value	102.40	107.29	8.5673	4.7204	—
Final Prediction Error	0.0204	0.0241	0.0245	0.0266	—
Direct or Reverse Causality	15.246	38.623	34.466	5.2084	—
Instantaneous Causality	544.98	50.727	111.23	17.295	—

4.3. Breakpoint Chow Test

In order to check whether the relationships between variables have undergone any structural changes, Breakpoint Chow tests are conducted for the models of E$ yield and the other four Eurocurrency yields. The results of the BPCHOW tests are summarized in Table 4.6. If the Chow test is significant at the five percent level or less, this indicates a "failure" or breakpoint. According to this criterion, all models fail the BPCHOW test at some point in time, but some models are obviously more stable than others, like EJY (E$) and EC$ (E$), which fail only 28.98% and 17.61% of the total daily observations tested. Six of the eight models fail this test for well over 5 percent of the daily observations tested. In other words, the BPCHOW tests find parameter instability before the end of 1989 for all the models except EJY (E$) and EC$ (E$), which show a longer stable period.

The parameter instability before the end of 1989 may also explain the previous failure to reject the non-cointegration hypothesis. It may reflect the many economic and financial market disturbances and institutional changes during these years. These would include such developments as high and divergent inflation and interest rate in the early 1980s, the rapid drop in U.S. inflation after 1982, the dollar rapid appreciation through year-end 1985 and the dramatic depreciation through 1987. The parameter stability after 1989 may be attributable to a convergence of inflation rates between the US and its economic partners, and an emphasis on greater price stability by central banks abroad (DePrince, 1993).

Table 4.6
Stability Test for Selected Models, Entire Sample Period: 1980-1994

Model Dep. (Ind.)	BPCHOW failures %	Stable Sub-Period year month day (observations)
E$ (EGM)	66.48%	89/07/13 - 94/01/26
EGM (E$)	64.2%	89/02/17 - 94/01/26
E$ (EBP)	68.75%	89/11/02 - 94/01/26
EBP (E$)	85.8%	92/09/30 - 94/01/26
E$ (EJY)	91.48%	92/12/23 - 94/10/26
EJY (E$)	28.98%	84/05/15 - 94/10/31
E$ (EC$)	100%	
EC$ (E$)	17.61%	82/03/12 - 94/10/31

Note: See the text for details on the stability tests.

4.4. Estimation of the Selected Models for the Stable Periods

Because of the identified breakpoints, two areas were addressed before the simulations were conducted. First, the sensitivity of the Granger causality tests were evaluated. Second, lag structures for the stable periods were identified and compared with the full sample period lag structure. This would help to determine whether Granger Causality test results are sensitive to the sample period selection.

By comparing the different lag structures used for the same model (Table 4.7), one can find that the optimal lag structures for the three models are reduced. For example, as can be seen in the Table 4.7, the optimal lag structure for the EGM(E$) model is reduced form (13, 15) to (6, 3). The new model consists of 6 own and 3 cross-rate terms.

Table 4.7
Comparison of the Optimal Lag Structures
for Stable Sub-Periods and the Full Period

Dep. / Optimal Lag	Full sample Period	Stable Sample Period
EGM	(13, 15)	(6, 3)
EBP	(20, 13)	(19, 16)
EJY	(20, 3)	(2, 1)
EC$	(6, 5)	(6, 3)

Note: The first and second numbers in the optimal lag indicate number of own-and cross interest rate terms respectively.

Applying the re-estimated optimal lag structure to the stable periods for each model, the results of the Wald-F test for Granger causality are reported in Table 4.8. It is found that Granger Causality test results are sensitive to the sample period selection. For example, although the Wald test statistics for EJY(E$) model in Table 4.5 are significant for the full sample period data, they are not significant for the stable period data. What needs to be mentioned here is that, although by using the different lag structures for the same EC$(ES) model, one not only can find that the Wald test statistics are highly significant at 1% level but can also find that the less lagged cross-rate term changes in U.S. rates can be incorporated more rapidly into EC$ rate. These findings support the very significant direct and contemporaneous causality impact of U.S. rate on EC$ interest rates.

Table 4.8
Results of the Estimation of the Selected Models for the Stable Sub-Periods
(Estimates Derived Using Re-estimated Optimal Lags for the Stable Sub-Period)

(a) $$dEGM_t = \alpha_0 + \sum_{i=1}^{6} \beta_i (dGM_{t-i}) + \sum_{j=1}^{3} \tau_j (dE\$_{t-j}) - \delta_{12}\, dE\$_t + e_{yt}$$

(b) $$dEBP_t = \alpha_0 + \sum_{i=1}^{19} \beta_i (dEBP_{t-i}) + \sum_{j=1}^{16} \tau_j (dE\$_{t-j}) - \delta_{12}\, dE\$_t + e_{yt}$$

(c) $$dEJY_t = \alpha_0 + \sum_{i=1}^{2} \beta_i (dEJY_{t-i}) + \sum_{j=1}^{1} \tau_j (dE\$_{t-j}) - \delta_{12}\, dE\$_t + e_{yt}$$

(d) $$dEC\$_t = \alpha_0 + \sum_{i=1}^{6} \beta_i (dEC_{t-i}) + \sum_{j=1}^{3} \tau_j (dE\$_{t-j}) - \delta_{12}\, dE\$_t + e_{yt}$$

Statistic / Dep.	(a) EGM	(b) EBP	(c) EJY	(d) EC$
Stable Sub-period year month day	89/07/13 - 94/10/31	92/09/31 -94/10/31	92/12/23 -94/10/31	82/03/10 -93/03/19
SSE	5.0775	3.6445	0.0536	42.838
R2	0.0655	0.1204	0.1377	0.1902
F-value	10.072*	3.7111*	18.771*	65.610*
No. obs.	1440	535	475	2804
Optimal Lag	(6, 3)	(19, 16)	(2, 1)	(6, 3)
Final Prediction Error	0.00356	0.00728	0.00252	0.0154
Direct or Reverse Causality	2.3087**	2.1788**	2.5360	22.188*
Instantaneous Causality	80.000*	8.9234*	2.1644	536.89*

Notes: * means significant at 1-percent level. ** means significant at 5-percent level. The first and second numbers in the optimal lag indicate number of own-and cross interest rate terms respectively.

4.5. Results of the Model Simulation

From the above analysis, it appears that the U.S. rate has the strongest effect on the EC$ rate and weakest effect on the EJY rate. Simulations of the response of the foreign rates to innovations in the U.S. rate are conducted to quantify the bivariate effects of a change in U.S. rates. Since the Granger causality tests show the two-way causalities existing between U.S. rate and foreign rates, the simulations show the effect of a 1% positive change in U.S. rates on each foreign Eurocurrency rate with feedback to the U.S. rate. Results of the bivariate simulation result of a one-percentage positive shock to U.S. rate are reported in Tables 4.9. In conducting the simulations, the constant terms were suppressed. This was done for two reasons. First, they were statistically insignificant. Second, the simulations were to focus on the effects of a U.S. rate shock independent of other influences such as trend terms.

The reader is cautioned that results are not directly comparable due to the different stable sample periods. Separately, the following effects for a one percent point positive shock are observed:

- Nearly 50% of the shock is transmitted to the Canadian Eurocurrency rate on the same day, and the shock dissipates quickly,
- Slightly less than 25% of the shock is transmitted to the German Eurocurrency rate on the same day, and the shock dissipates quickly,
- Less than 10% of the shock is transmitted to the Japanese Eurocurrency rate, and there is no apparent aftershock, and
- Less than 10% of the shock is transmitted to the U.K. Eurocurrency rate, effects

washout over the 25 day span but follow an over-correction pattern during the period.

Others have also found persistence in the UK response. For example, Ahmad and Sarver (1994) note that the UK may be intervening in the exchange markets to counter effects of changes in the U.S. interest rate on its domestic economy.

Of the four countries, Canada has the highest degree of commercial integration with the U.S. Its initial response was over half the U.S. shock. Again, Ahmad and Saver (1994) offer an explanation:"the bank of Canada generally has adopted a policy of maintaining the exchange rate with the U.S. dollar by allowing domestic interest rates to vary and intervening in exchange markets." For the same reason, the weak response of Japanese Eurocurrency rates to U.S. shocks reflects the greater interdependence of Japanese market, with the practice of tighter credit, interest and capital controls (Wallich and Haas, 1982 and BIS, 1989).

Table 4.9
Bivariate Simulation Results
One-Percentage Point Positive Shock To U.S. Interest Rates

	Canada		U.K.		Germany		Japan	
Days after Shock	Change US	Change Canada	Change US	Change UK	Change US	Change Germany	Change US	Change Japan
0	1.17	0.57	1	0.07	1.06	0.23	0.96	0.08
1	0	0.14	-0.02	-0.05	0	0.03	0	0.06
2	0.03	-0.04	0.03	-0.07	-0.03	-0.05	0	-0.03
3	-0.01	-0.05	0.06	-0.09	0.02	-0.05	0	0
4	0	0.01	-0.01	0.1	-0.01	0.01	0	0
5	0.01	0.01	0.07	0.03	0	-0.01	0	0
6	0.02	0.04	0	-0.05	0.01	-0.02	0	0
7	0.01	0.01	-0.06	-0.32	0	0	0	0
8	0	0	0.01	0.14	0	0.01	0	0
9	0	0	0.04	-0.04	0	0	0	0
10	0	0	0.08	-0.06	0	0	0	0
11	0	0	0.01	0.04	0	0	0	0
12	0	0	-0.06	0.17	0	0	0	0
13	0	0	0.02	0.06	0	0	0	0
14	0	0	0.1	-0.12	0	0	0	0
15	0	0	0.03	0.08	0	0	0	0
16	0	0	-0.01	0.17	0	0	0	0
17	0	0	-0.02	-0.07	0	0	0	0
18	0	0	0.01	0.02	0	0	0	0
19	0	0	0.04	0.03	0	0	0	0
20	0	0	-0.01	-0.06	0	0	0	0
21	0	0	-0.01	0.01	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0.01	-0.01	0	0	0	0
24	0	0	0.02	-0.02	0	0	0	0
25	0	0	0.01	0.01	0	0	0	0
Cumulative lags								
0	1.17	0.57	1	0.07	1.06	0.23	0.96	0.08
1 to 5	0.04	0.08	0.13	-0.09	-0.03	-0.08	0	0.03
6 to 10	0.03	0.04	0.06	-0.33	0.01	-0.01	0	0
11 to 25	0	0	0.13	0.32	0	0	0	0
0 to 25	1.24	0.68	1.33	-0.02	1.04	0.15	0.96	0.11

Chapter V

Introducing Empirical Exercises into Principles of Economics

This chapter discusses how to introduce the results from the empirical study into the teaching of such courses as the principals of economics and money and banking. The first section discusses the importance of integrating an international perspective and computer use into the principles of economics courses. The second section discusses the effective way of learning economics for the undergraduates. The third section tries to introduce the empirical study results into classroom application to let the students appreciate the importance of empirical study. The last section of this chapter makes some suggestions on introducing empirical content into the principles of economics courses.

Section 1: Internationalizing and Computerizing the Principles of Economics

The United States is the world largest economy though its relative importance has declined as others increased their industrial bases. The most important factors in the country's economic success were abundant natural resources and the mass production system. Changes began to emerge in the late 1960s. New technologies and increased competition from newly industrialized countries cut into the U.S. relative strength.

We now live in a world in which the economics of the nations are closely intertwined, and competition for resources and markets is increasingly global in nature. Besides, computers and information systems have become more and more important in

the modern business world. The very basic economic conditions under which firms operate domestically are being affected by global interdependence. These altered economic conditions not only changed the magnitude of the requirements for economic success — they also changed fundamentally the necessary structures and policies. This is so because in the more competitive global information economy, economic success requires greater emphasis on some factors that were much less important in traditional mass production system. These new factors are quality, productivity, and flexibility. In order to compete effectively, manufacturing and other industries must become more flexible, responding rapidly to an open and increasingly affluent world economy (Peak, 1993).

In order to maintain its status as a high-performance country, the United States should have greater investment in human capital, not only in physical capital. Companies can compete effectively only if the graduates and workers are well trained, become more flexible and resourceful.

The importance of integrating an international perspective and computer use into the business school curriculum has been recognized, and the issue has received considerable attention from both educators and the business world alike. The theme of the 1989 annual meeting of the American Assembly of Collegiate School of Business (AACSB) was "The U.S. Competitive Crisis: Are Business Schools Relevant?" The two key questions discussed were: "Are business schools helping American firms meet the challenge of global economic competition?" and "Are business schools providing

students with the skills and knowledge relevant to the issues and opportunities that will face tomorrow's managers?" (Keating and Byles, 1991).

As global competition, computers and information system become more pervasive in the corporate world, business schools are challenged to produce graduates who can function effectively in this information-based environment. Business schools are attempting to meet the challenge by integrating international perspective and computer use into their curricula (Keating and Byles, 1991; Delone and Biles, 1991).

Section 2: An Effective Way of Learning Principles of Economics

Principals of economics courses at MTSU are typically taught in small classes — twenty-five to fifty students. The fewer the students, the more the emphasis can be put on student/faculty interaction. This form of class is much better than the large lecture halls, where hundreds of students are in attendance. Because the instructor can lecture and spontaneously entertain questions from the students. The increased student /faculty interaction in class can help the students learn the material better. In addition to instructor responses to student inquiries, hour-long exams and term papers provide students with feedback as to how well "they think like economists." Workbooks and problem sets are sometimes used as supplementary teaching tools by giving students an opportunity to use theory to solve contrived or simple economic problems.

Bloom (1971) described the general learning process for students as a sequential process. His taxonomy of educational objectives suggests that students begin learning at a very rudimentary level of understanding, such as basic facts and definitions. In an

effective learning environment, students then progress to understanding simple functional or causal relationship. An example of these two steps in economics is that students need to know the precise definitions of income and gross national product in order to understand the national income account. Then students can build upon their knowledge of facts, definitions, and simple relationships to develop more sophisticated understanding of complex interrelationships and system of equations.

"I hear and I forget; I see and I remember; I do and I understand." As the old adage reminds us, learning abstract economic concepts takes place only when the student is actively involved in the learning process, as opposed to listening passively to a lecture or watching someone else work through a problem (Walbert, 1989).

The physics profession understands this connection between learning and doing. "Students cannot learn to understand the relationship between physics theory and experimental evidence if they have minimal personal experience in designing and performing experiments." (American Association of Physics Teacher 1987).

The same argument can be made for students learning economics: they cannot learn economic theory and empirical analysis without personal experience in designing and performing economic research. Very few students can learn to think like economists from the traditional classroom presentation. What they learnt is the received doctrine — that is, what economists claim to know — but they do not learn how economists go about the test of learning. If students are expected to learn to think like economists and to apply their knowledge to a variety of questions and issues they will confront as citizens.

they should be given the opportunity to have a personal hand-on experience in designing and performing some basic economic research.

Section 3: Classroom Application of the Empirical Results

In order to prepare students taking the principles of economics courses to have a more global perspective and to gain a more personal experience from using computers, attempts are made to introduce the results of this empirical study to the teaching of such courses as economic principles and money and banking.

For example, in R. Glenn Hubbard's "Money, the Financial System and the Economy," (the textbook used for money and banking course at MTSU), international perspectives have been incorporated throughout the text. For example, Chapter 8 and 16 introduce foreign exchange rates and international banking, respectively. International comparisons of financial systems and international constraints on central banking decisions making are discussed concurrently with United States in Chapter 22.

After teaching Chapters 8, 16 and 22, results of this empirical study can be introduced into classroom application. At this stage, graphical presentation is used as a means of instruction. However, with computerized classroom, the exercise can easily be extended to allow students conduct "real-time" simulations and instantaneously see the effects of shifting rates. Even with only graphs, the results of the simulation provide more insight into the transmission of international money market movements than the current instructional material.

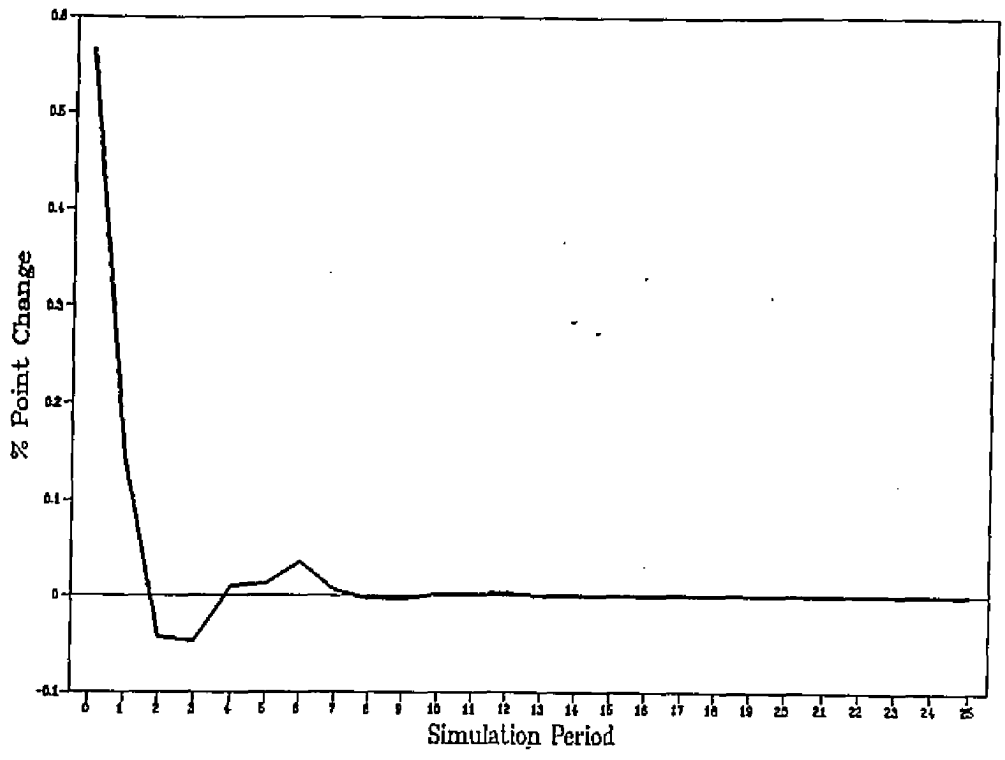


Figure 5.1 Canadian Response: 1% Positive Shock in U.S. Rate

(With Feedback)

The response of the Canadian rate is large. As can be seen from Figure 5.1, by giving a one-percentage point positive shock to U.S. rates, more than 50% of that shock is transmitted to the Canadian rate on the same day. The shock dissipates rapidly. By day 7, the shock it seems to disappear completely.

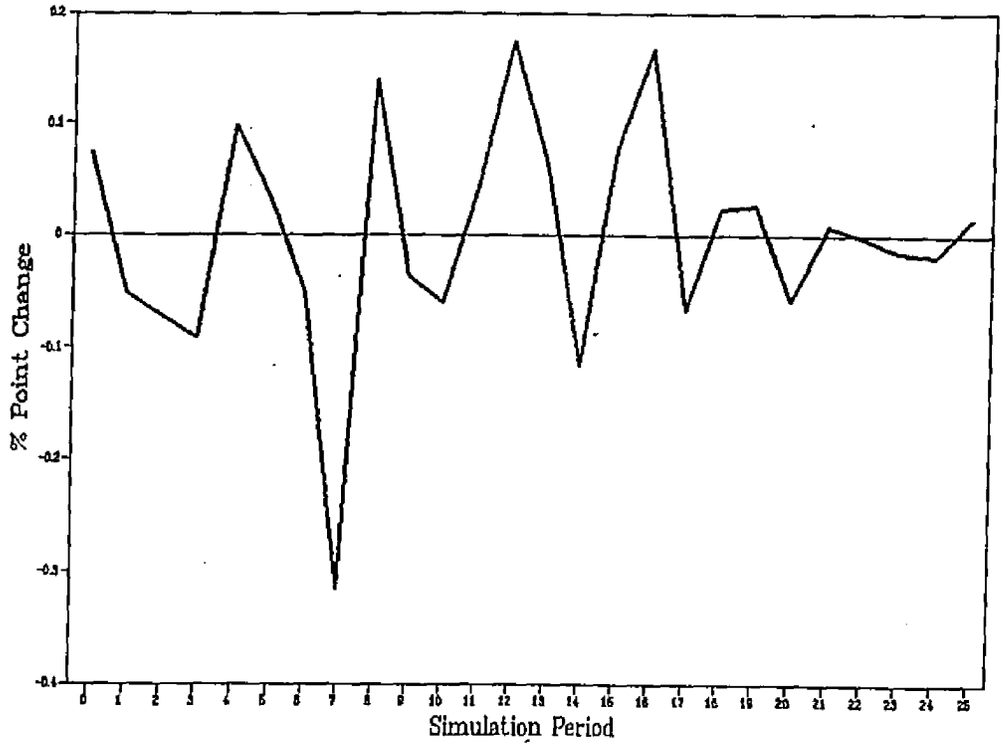


Figure 5.2 UK Response: 1% Positive Shock in U.S. Rate

(With Feedback)

The response of the U.K. rate to U.S. rate shock is minimal, however, it lasts long. Nearly 7% of the U.S. shock is transmitted into the U.K. rate on the same day. However, the response does not disappear completely. A little more than 1% of the shock still exists on day 25.

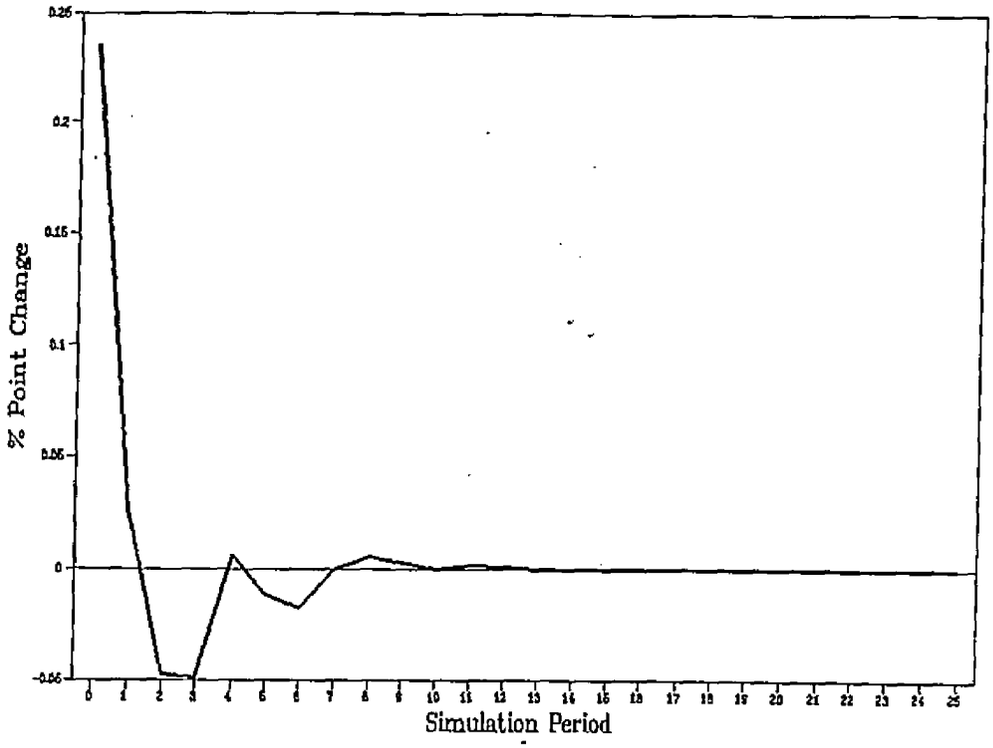


Figure 5.3 German Response: 1% Positive Shock in U.S. Rate

(With Feedback)

As shown in Figure 5.3, slightly less than 25% of U.S. shock is transmitted to German rates on the same day. Effects dissipates quickly, and little effect is seen after the eighth day.

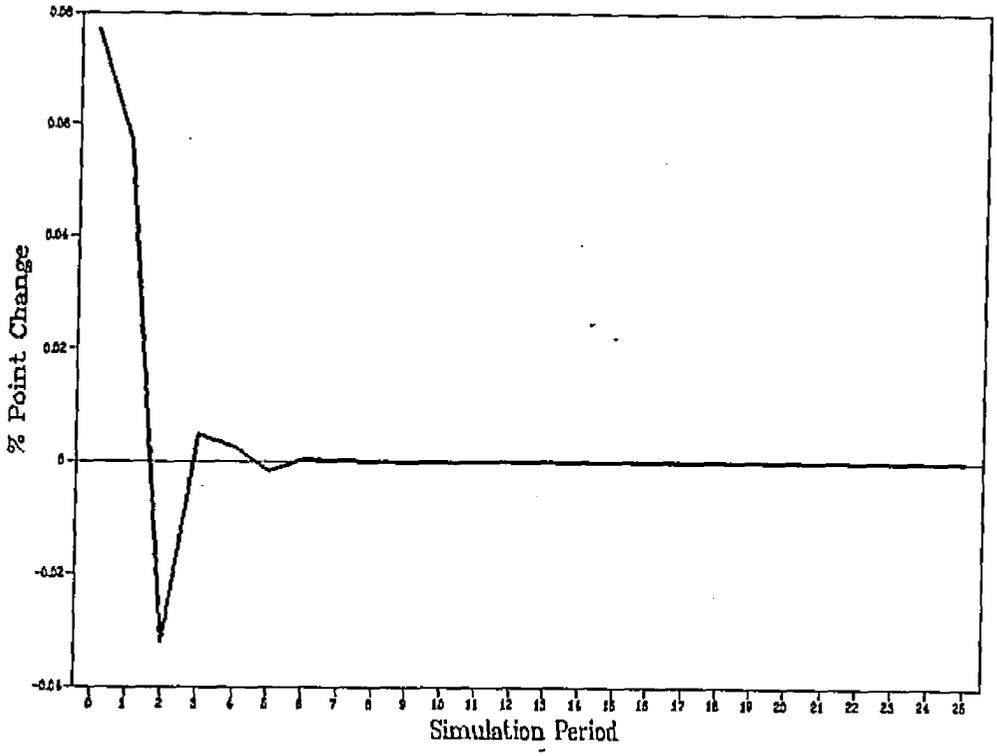


Figure 5.4 Japanese Response: 1% Positive Shock in U.S. Rate (With Feedback)

By shocking U.S. rate one-percentage point, less than 10% of that shock is transmitted into the Japanese Eurocurrency rate on the same day, and the response decreases quickly. On the eighth day after the shock, it almost disappears.

Effects of a U.S. rate shock are not directly comparable among the four selected Eurocurrency rates due to the different stable sample periods. None the less, the difference between the U.K. response and the response of the other Eurocurrency rates is interesting. Except for the U.K., effects of a U.S. rate shock dissipate quickly. For the U.K., effects washout over the 25-day simulation period, but the pattern exhibits wide day-to-day fluctuations.

As noted earlier, some have tied the U.K. pattern to effects to insulate the domestic economy from foreign shocks. This is an important education point, and should be emphasized to students. Namely, as financial and commercial integration intensifies, efforts to isolate oneself from effects will have an effect elsewhere in the domestic economy. At the very least, effects will be felt in exchange rates.

In sum, by introducing the graphs of the simulations of the foreign rates to shocks in U.S. rates into the economic principles and money and banking, the instructor can better explain the interdependence of world economy and the financial market's integration. It also shows the students the importance of empirical research for economists in testing a hypothesis and stimulate their interest in learning how to do the empirical exercises.

If we want our students eventually to think like economists, we need to design a curriculum that gives the students some opportunities for hand-on experience, direction and support over the course of their studies (Barlett and King, 1990).

Section 4: Suggestions on Introducing Empirical Exercises into Principles of Economics

The above section discusses how to introduce the simulation exercises in money and banking course to let the students appreciate the importance of empirical research in testing a hypothesis. Teaching economics as a science means we need to develop computer laboratory components for the principles of economics courses. Laboratory exercises can take a variety of forms, including spending additional class time running computer simulations, doing statistical analysis, and actually performing experiments. The purpose of these exercises is to give students the opportunity to have some experience in using computers to do experiments, as do students in the natural and life sciences.

Although it is important to introduce empirical content into an introductory course, it is still a formidable task. Not many Principles students have had a background course in statistics. Even if the students possessed an adequate statistical background, the logistics of teaching undergraduates the use of a statistical package, setting up computer account still face some difficulties. However, as explained earlier, students who do not have much practice with empirical economics do not truly understand the subject. In order to introduce more empirical exercises into the principles of economics courses, several possibilities are considered.

It seems that students in the physical science have less misunderstanding about science, perhaps because even in introductory courses, students conduct empirical tests during laboratory periods. Introductory science laboratory exercises are designed to

familiarize students with data gathering and gross analysis of the data collected. The useful empirical exercises can also be designed for introductory economics students. Before assigning any empirical exercises, two lectures should be given to the students.

First, students in principles of economics could be required to use scientific methodology, that is, to develop a hypothesis, collect data, and test the hypothesis in a crude manner. The students can be assigned a hypothesis to test. To make it work, a lecture combined with an exercise on the methodology of testing a hypothesis should be direct and simple. For example, accommodating the students' statistical ignorance and to stressing the inexactness of social science, the instructor should tell the students to test only the direction of a relationship. The students should be shown how to plot two variables against each other and how to draw freehand regression though the plot.

Second, the students can also be lectured on how to use an index, how to read a simple data table and how to collect data. For example, lectures about the layout and policies of the library and bibliographical indexes for the social sciences can help the students to know the types of material included in each index and the kinds of data series included in each periodical. This will help them to identify several easy-to-use sources of economic data when they want to test a hypothesis.

Having introduced these two lectures about the methodology and library, the students can be assigned some exercises to use the computers to manipulate and analyze their own collected data. Each empirical assignment should be related to the topic being covered in the class lectures and discussions. Short discussions should also be organized later to help students understand that different hypotheses are possible and there are often

several appropriate data sets for measuring a variable. Through the empirical exercises, the students can discover that the acceptance or rejection of a hypothesis can be dependent on the data set that they choose and the time period covered by the data.

The above are some general ideas and suggestions made to introduce more empirical content into principles of economics courses. The purpose of the empirical exercises is to let the students gain an understanding of the empirical nature of the economics and to practice the methodology used by economics. They can learn how to form a hypothesis, gather data, and test the hypothesis. They will become comfortable in the library, learning how to use social sciences indexes, government periodicals and how to use tabular data. They can learn that economics is more than theory, that economics is not deterministic, and that economists, for many reasons, are not perfect policy makers. They can understand the importance of empirical findings in economics. These lessons are important both for students who are going on in economics and for those who are going into business. By bringing together theoretical knowledge and experimental discovery, students' learning can be greatly enhanced.

Chapter VI

Conclusions

This study sought to quantify the effect that changes in U.S. interest rates may have on countries with whom the U.S. has close trading and financial ties. This study was undertaken in response to the growing importance attached to the global economy within the curriculum of business schools and colleges. The results of the study provide instructors with an opportunity to illustrate the effects of changes in U.S. interest rates on countries with whom the U.S. has close commercial and financial ties.

The instruments chosen for this study were three-month Eurocurrency interest rates. The countries compared with the U.S. were Canada, Germany, the United Kingdom, and Japan.

Using cointegration tests, the study found that there were no long-term relationships between the Eurodollar rate and the Eurocurrency rates for three countries except for Canada. Because of the lack of cointegration, the study chose a bivariate autoregressive model to capture the relationship between the U.S. rate and the other Eurocurrency rates.

Granger causality tests were used to assess the direction of causality, and these tests showed that there was bi-directional causality between the U.S. rate and the other Eurocurrency rates. The test also showed that the contemporaneous terms were important in the short-run relationships.

Tests for structural breaks showed that, except for the relationship between the U.S. and the Canadian rate, there was little stability between the U.S. rate and the other Eurocurrency rates until after 1989. Several reasons are offered in Chapter 4 for the appearing of stable relationships after 1989.

Bivariate autoregressive models were estimated between the U.S. rate and each of the other Eurocurrency rates for the full sample period and for the shorter stable periods. These results were compared, and in general, it was found that the lag structures were shorter over the stable period than over the full sample period.

Simulations of the effect of a one percentage point increase in U.S. interest rate were conducted using the models estimated over the stable period for each foreign Eurocurrency rate. Since the sample period differs for each foreign Eurocurency rate, direct comparison of the reaction of foreign rates to the U.S. rate shock cannot be made. While a limiting factor in this study, this is a problem confronted by most studies involving multiple currencies. In any event, the results do provide the classroom instructor with a means to illustrate to students effects of a U.S. rate change on countries with whom the U.S. has close ties, and this was the original intent of this study.

The study ends with a discussion of the instructional application of the results. First, it discussed the importance of integrating an international perspective and computer usage into economic courses. The trend to incorporate the global economy and computer usage into classroom instruction has been reinforced by the American Assembly of Collegiate School of Business. Second, the study comments on the effective way by which students learn economic principles. Personal experiences in the design and

performance of basic economic research are important, both to understand the course and to apply their knowledge to a variety of questions and issues they will confront as citizens. Third, suggestions were offered on the use of this study's empirical results in the teaching of the principles of economics and money and banking, to provide the students with a demonstration of the international linkages and the importance of computer usage in a business environment. The simulations results of this study provided more insight into the transmission of international money market movements than the current instructional material.

Appendix

Figure 1
Monthly Interest Rate: US Vs Canada

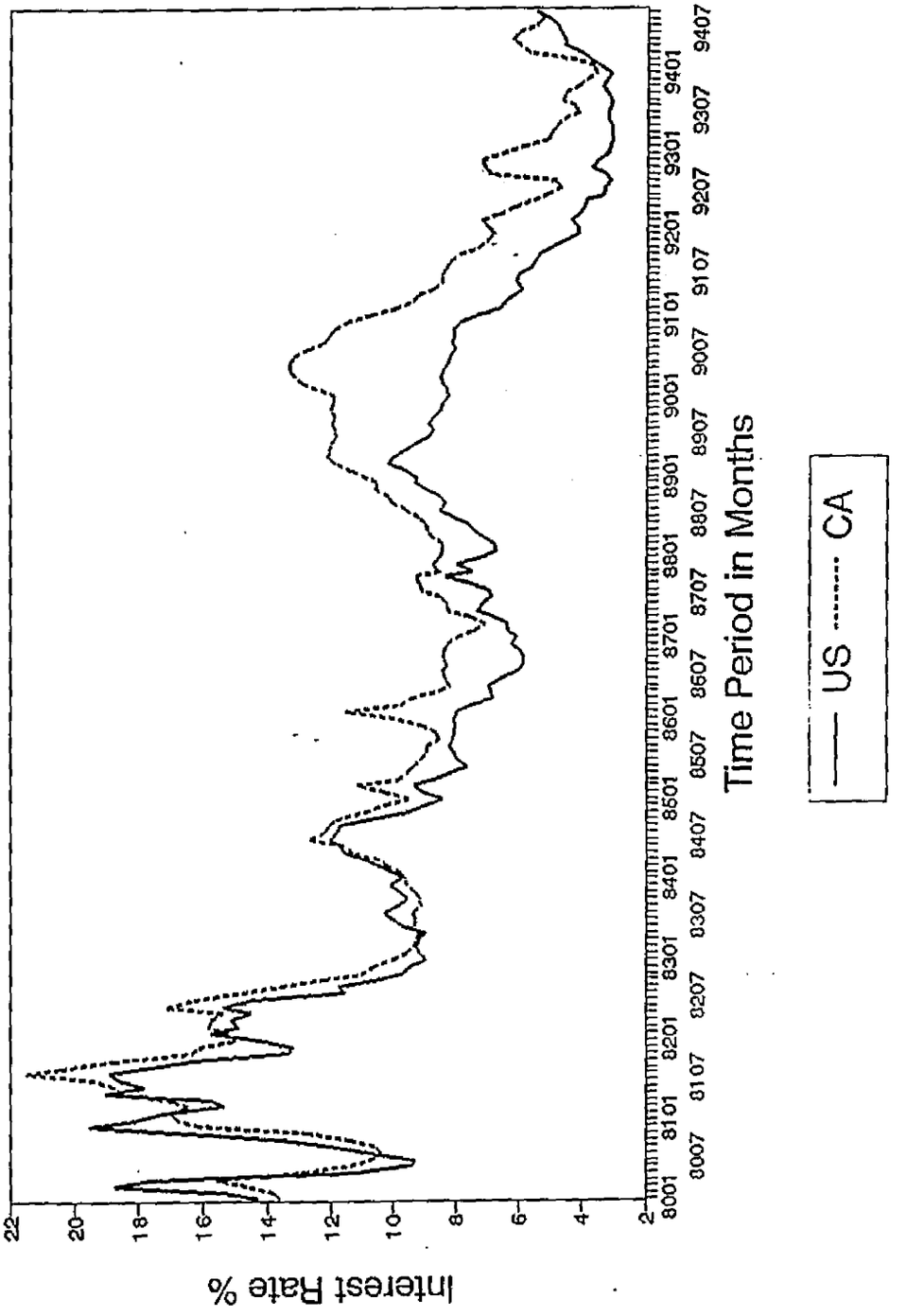


Figure 2
Monthly Interest Rate: US Vs UK

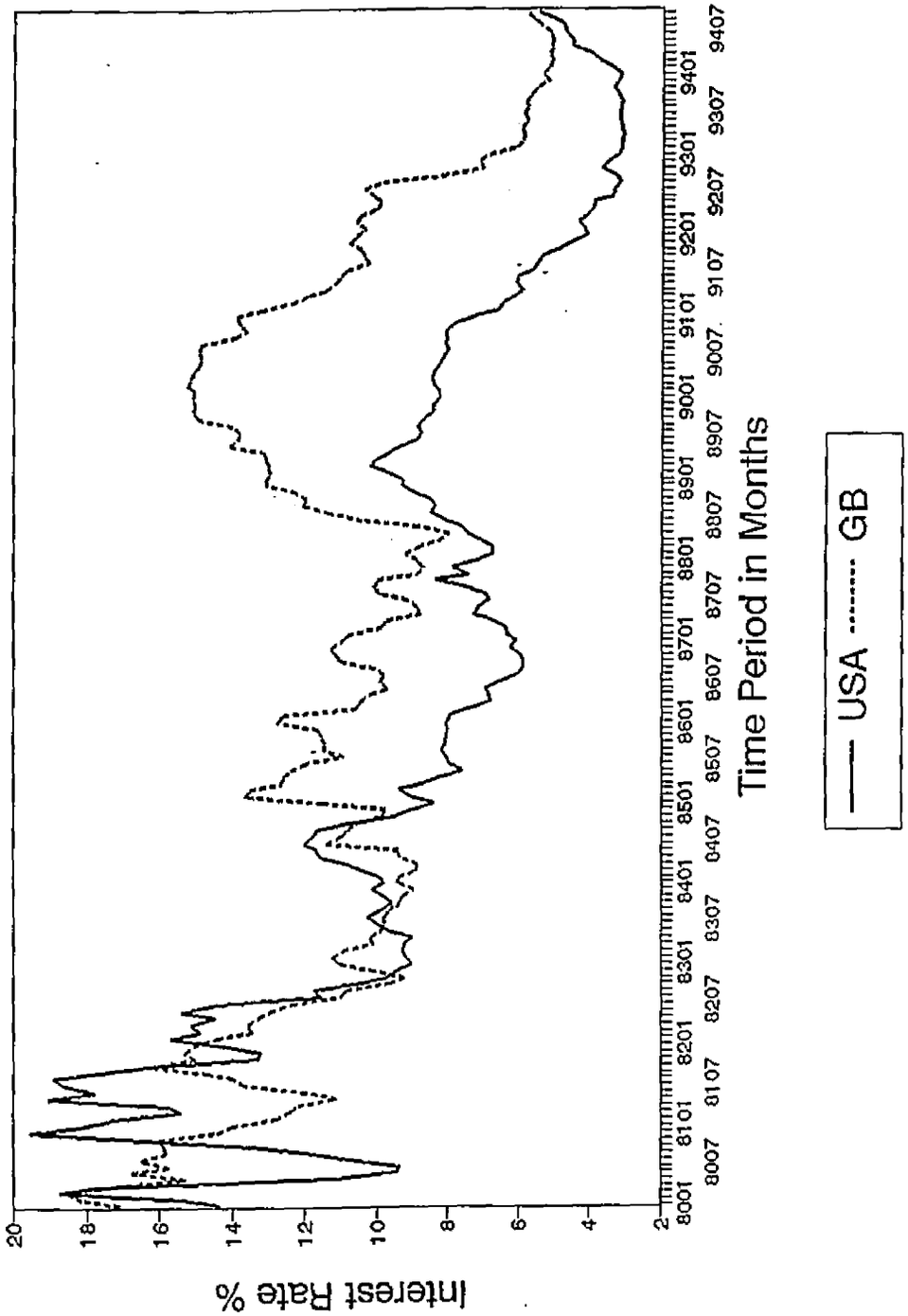


Figure 3
Monthly Interest Rate: US Vs Germany

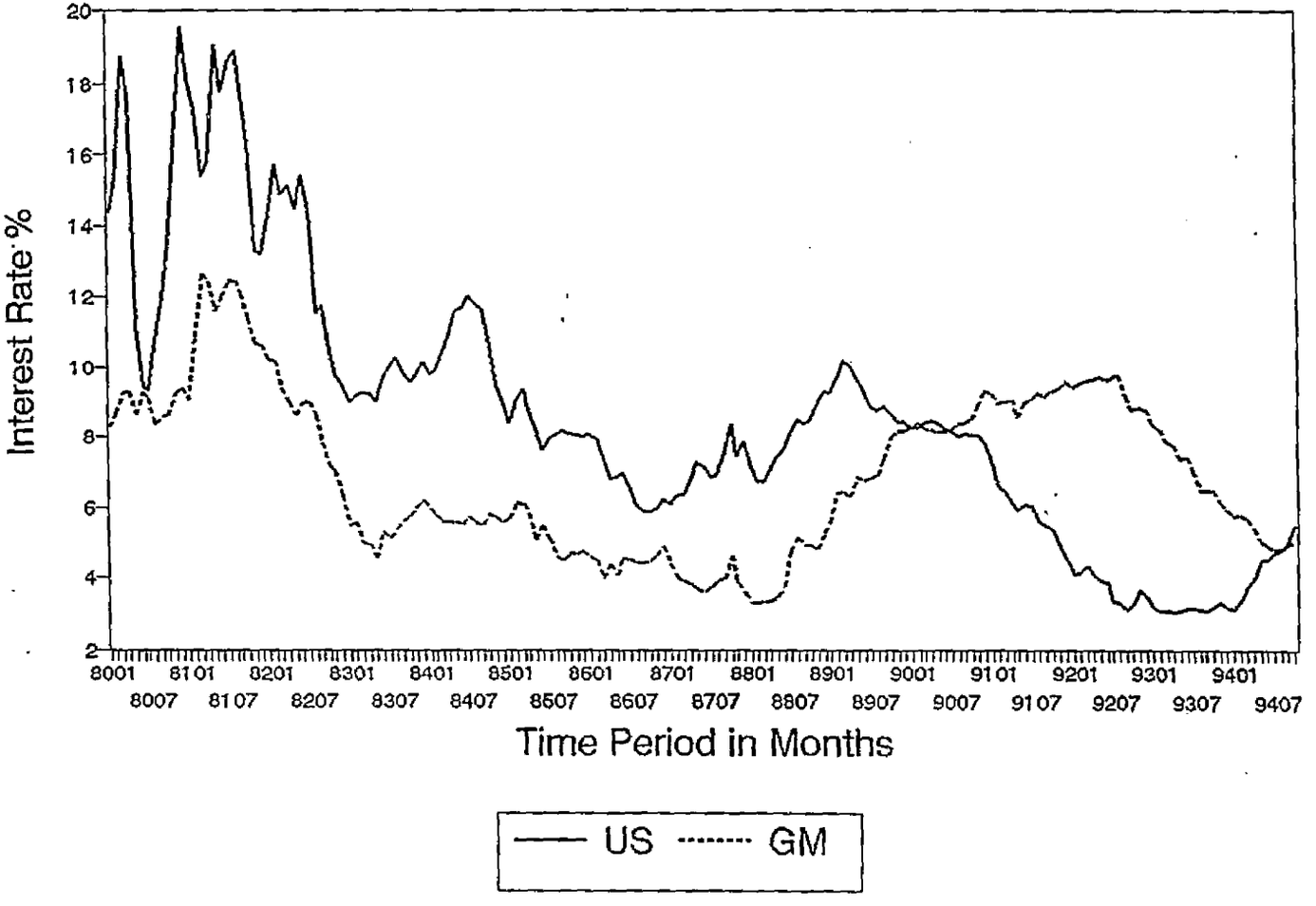


Figure 4
Monthly Interest Rate: US Vs Japan

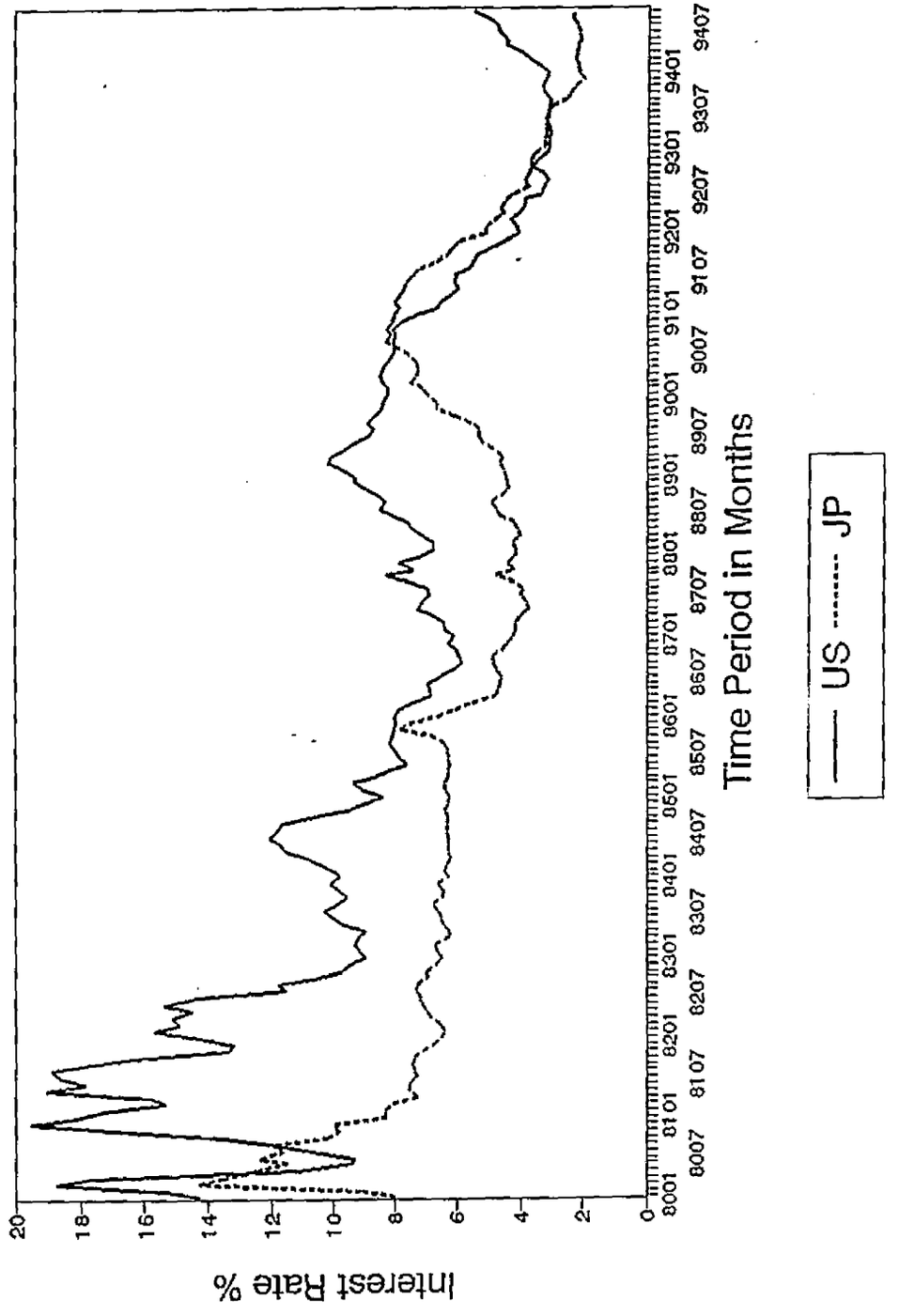


Figure 5
Monthly Interest Rate:Canada Vs Germany

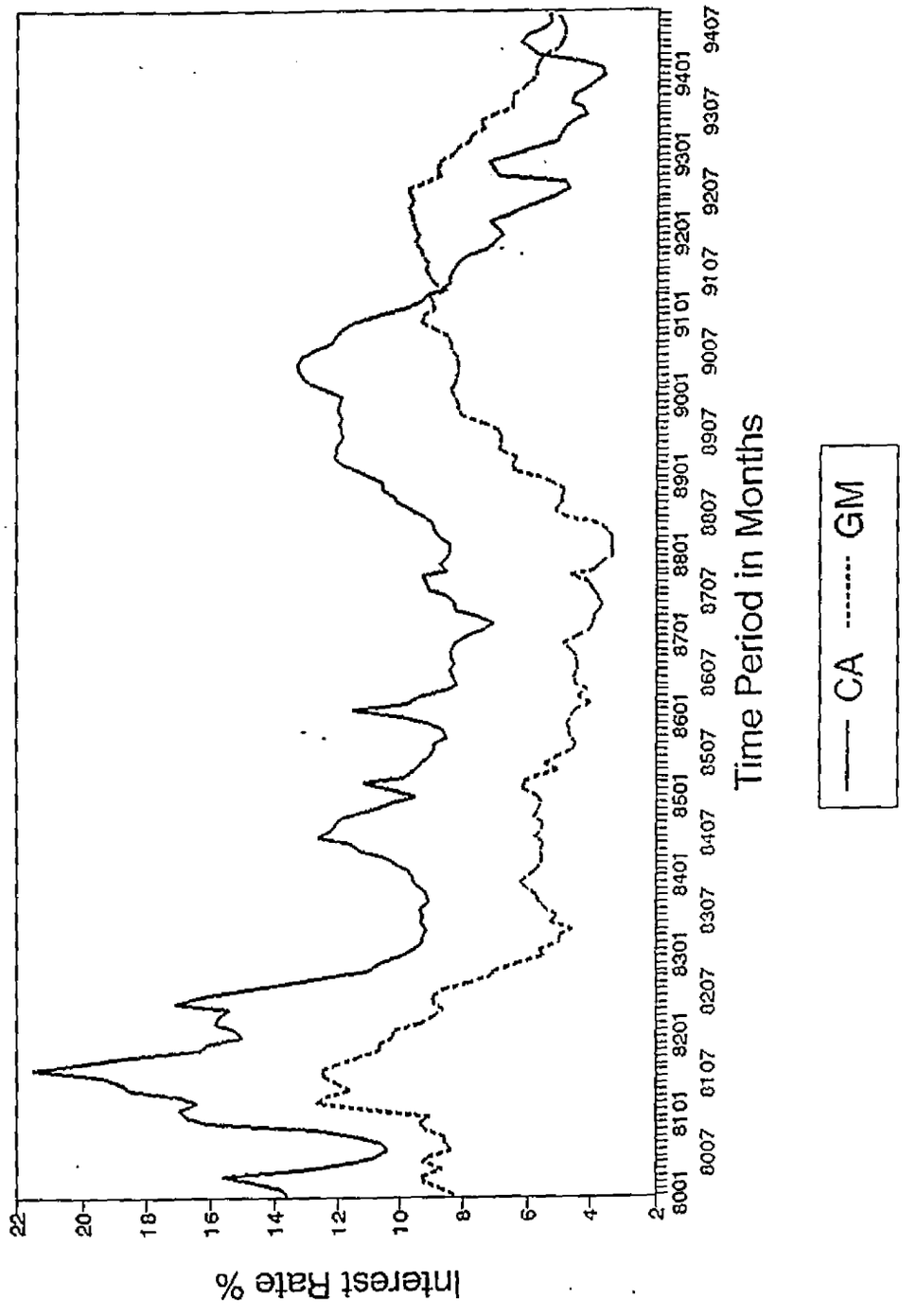
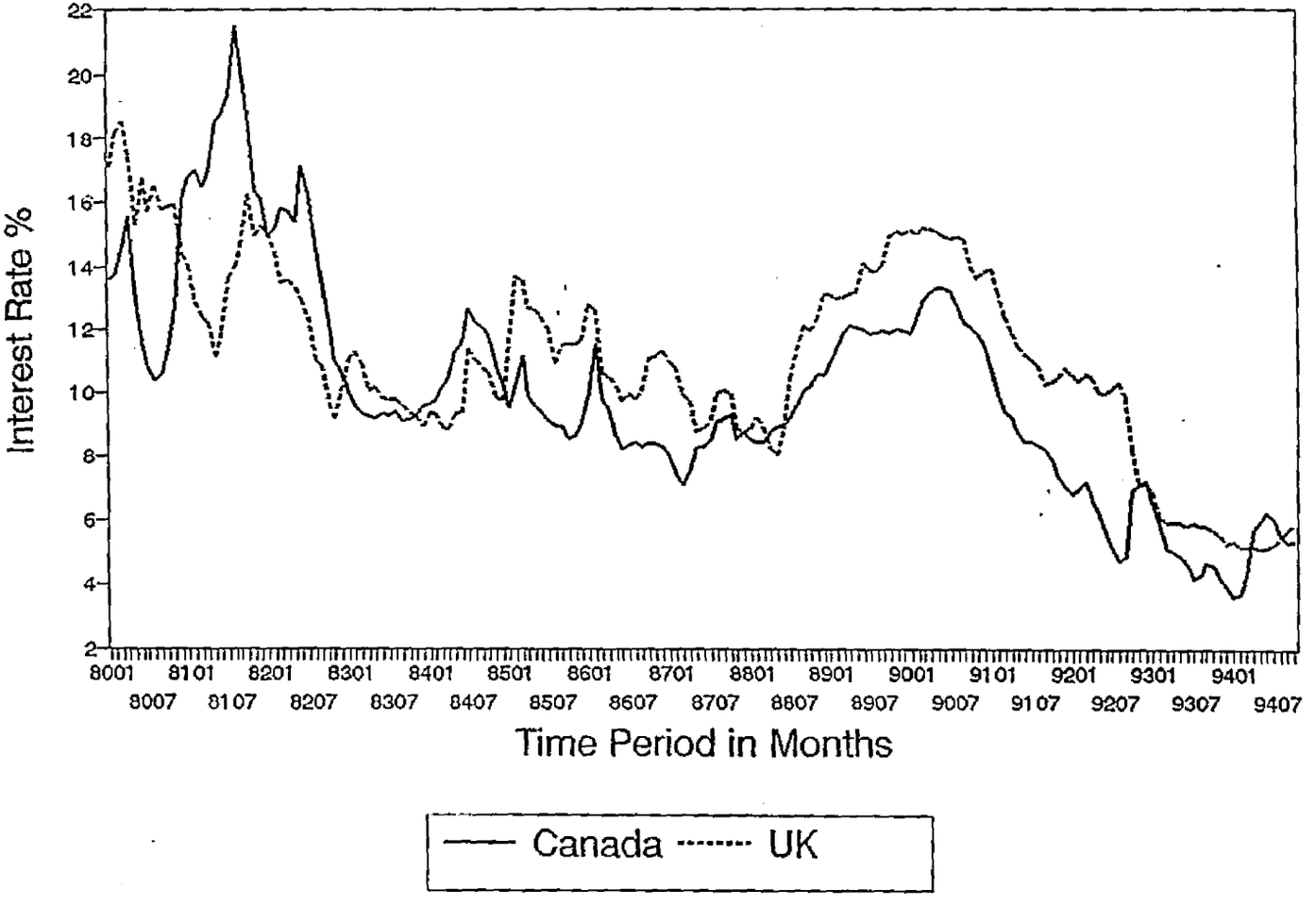


Figure 6
Monthly Interest Rate: Canada Vs UK



Gigure 7
Monthly Interest Rate: Canada Vs Japan

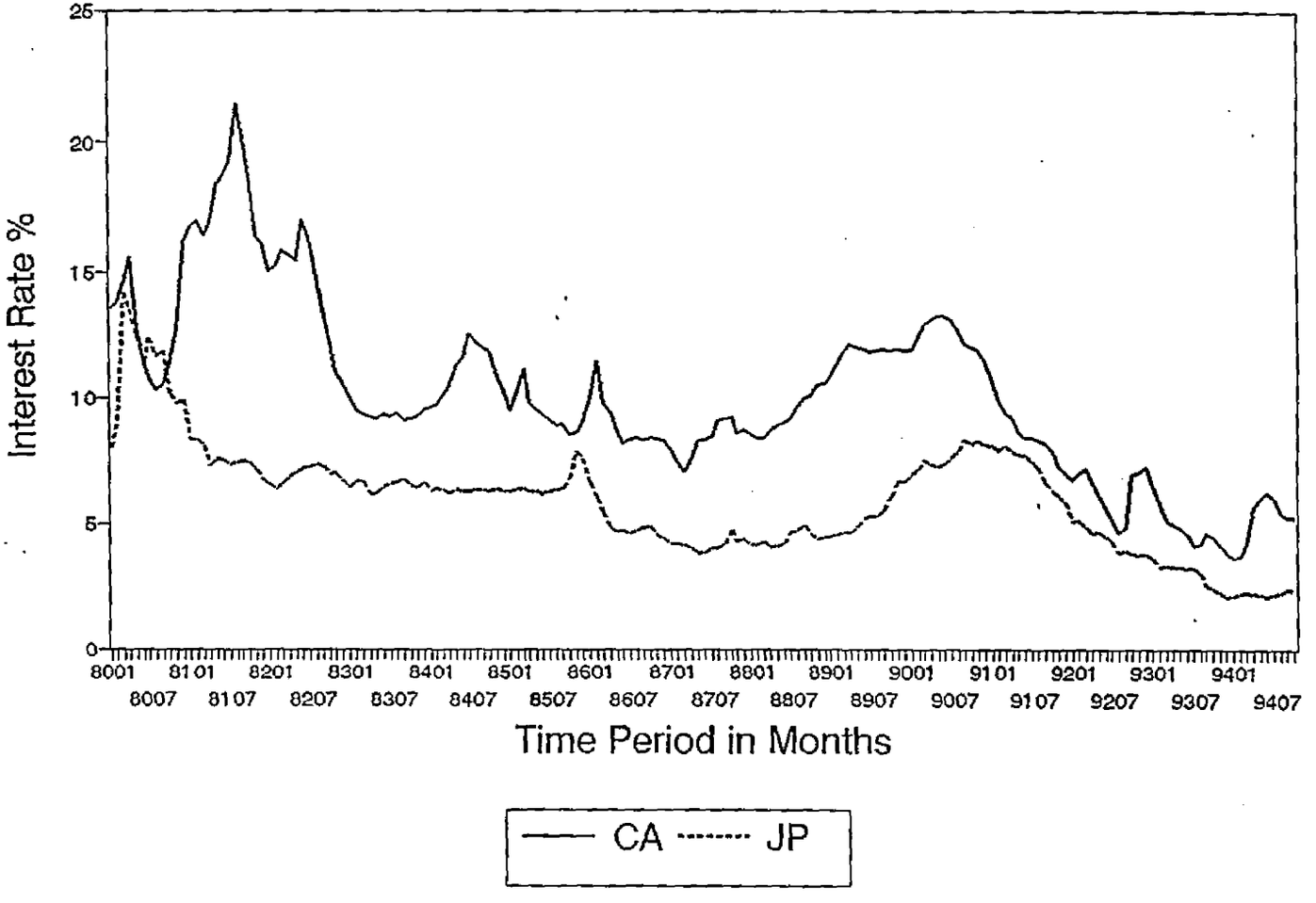


Figure 8
Monthly Interest Rate: Germany Vs Japan

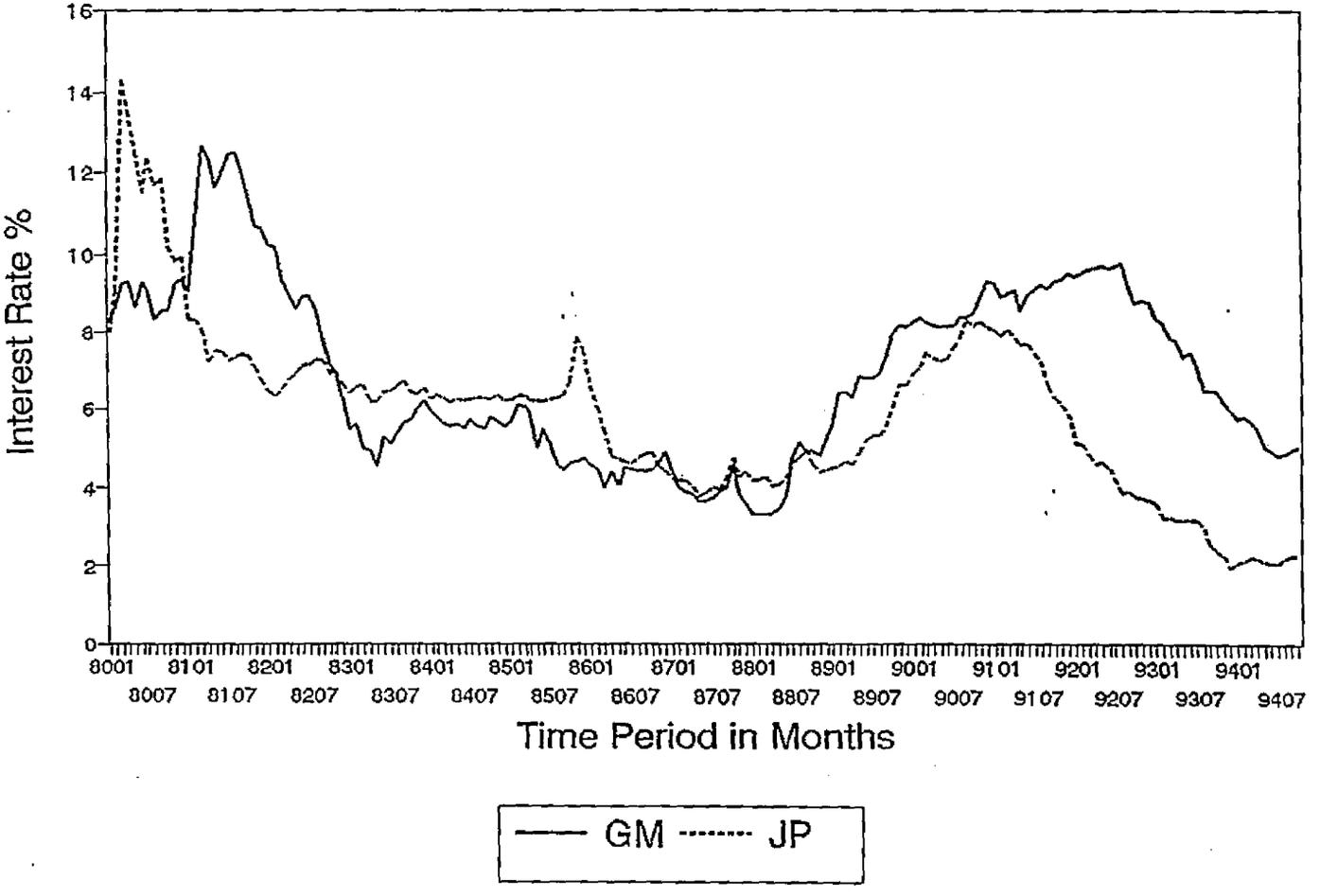


Figure 9
Monthly Interest Rate: UK Vs Japan

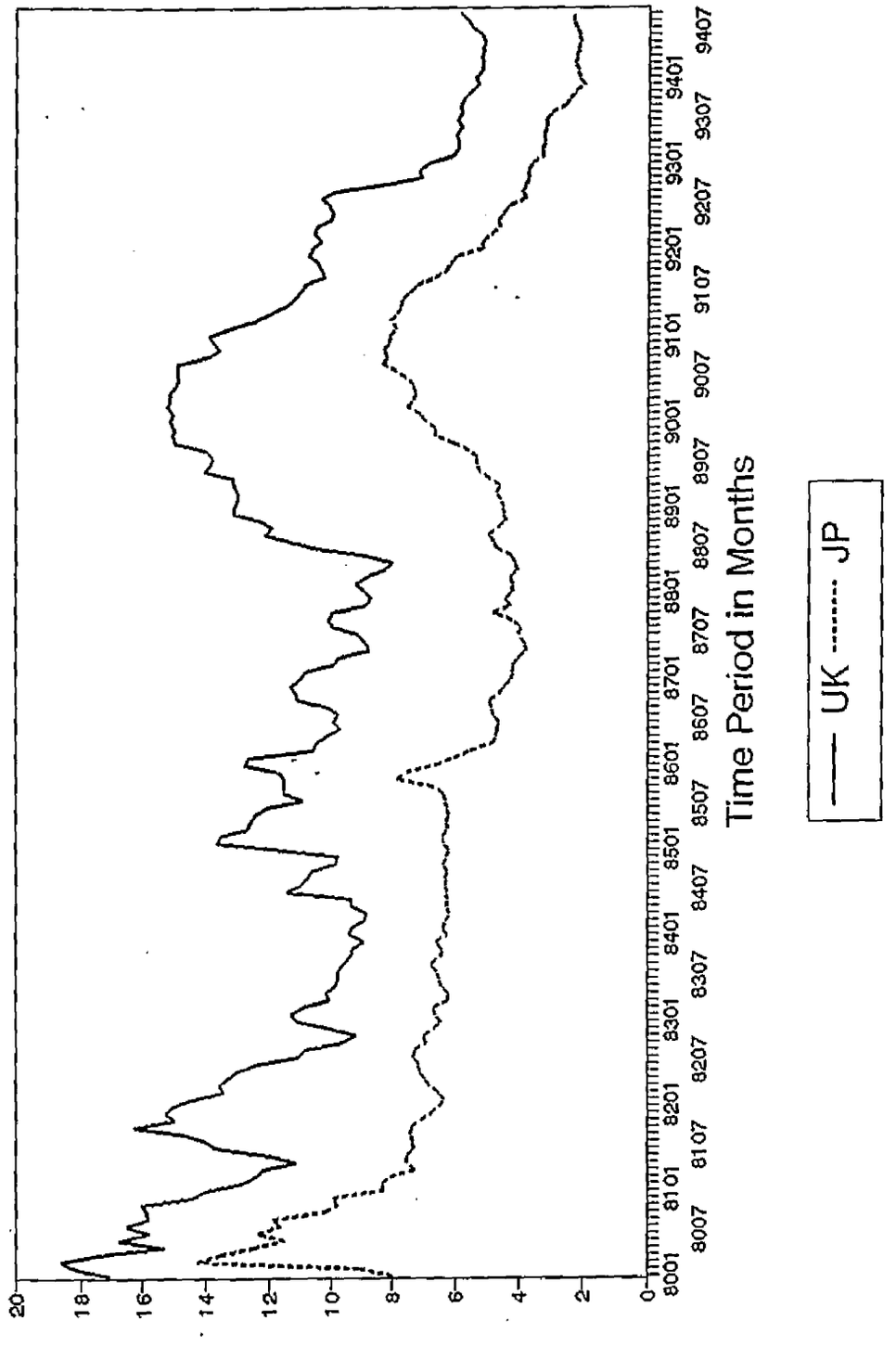
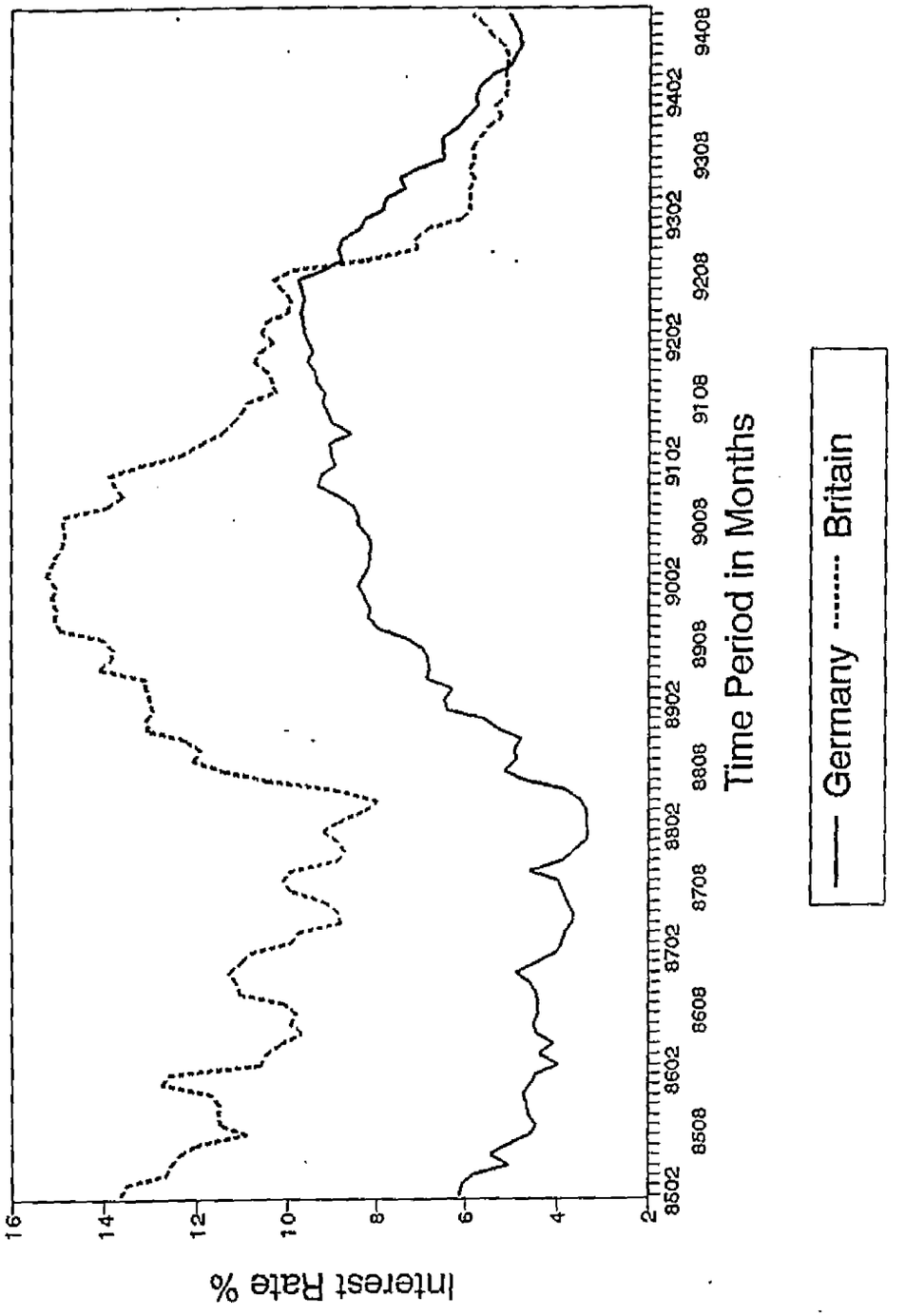


Figure 10
Monthly Interest Rate:Germany vs UK



Bibliography

Bibliography

Ahmad, S. M. and L. Sarver. "The International Transmission of Money Market Fluctuation." The Financial Review. (August 1994): 319-344.

Aliber, R. Z. "The Integration of National Financial Markets: A Review of Theory and Findings." Weltwirtschaftliches Archiv. (1978): 448-480.

American Association of Physics Teachers. AAPT Announcer . (1987).

_____. "International Interest Rate Linkages and Monetary Policy." (BIS) Bank for International Settlements. Spring Economists' Meeting , (March 1989).

Barlett, Robin L. and Paul G. King . "Laboratory Science." Journal of Economic Education. (Spring 1990): 181-193.

Bhoocha-oom, A. and S. Stansell. "A Study of International Financial Market Integration: An Examination of the US, Hong Kong and Singapore Markets." Journal of Business Finance and Accounting. (1990): 193-212.

Bloom, B. S., J. T. Hastings and G. F. Madaus. 1971. Handbook on Formative and Summative Evaluation of Student Learning, New York: McGraw-Hill.

Branson, W. H. "The Minimum Covered Interest Differential Needed for International Arbitrage Activity." Journal of Political Economy. (1977): 1028-35.

Callen, J., M. W. Luke and C. Y. Kwan. "Spot and Forward Exchange Rates: A Causality Analysis." Journal of Business Finance and Accounting. (Spring 1989): 105-118.

_____. 1994. Exchange Rate Policy and Interdependence: Perspectives from the Pacific Basin. Click, Reuven and Michael Hutchison, eds., Cambridge University Press.

Clinton, K. "Transaction Costs and Covered Interest Arbitrage: Theory and Evidence." Journal of Political Economy. (1988): 358-70.

Crow, J.W. 'The Work of Canadian Monetary Policy. "Eric J. Hanson memorial Lecture, University of Alberta, Edmonton, January 18, 1988.

Cumby, R. and F. Mishkin. "The International Linkage of Real Interest Rates: The European -U.S. Connection." Journal of International Money and Finance. (1986): 5-23.

Cumby, R.E. and Obstfeld, M. (1984) "International Interest Rate and Price Level Linkages under Flexible Exchange Rates; A Review of Recent Evidence." In Exchange Rate Theory and Practice, ed. J.F.O. Bilson and R.C. Marston, Chicago: University of Chicago Press.

De Grauwe, Paul. (May 1989) "Is the European Monetary System A DM-Zone?" Working paper, No. 297, Center for Economic Policy Research, London.

Delone, W. H. and Biles G. E. "Integration of Computers and Information Systems Into the Business School Curriculum: A Case Study." Journal of Education for Business. (November/December 1991): 111-115.

Dooley, M. P. and P. Isard. "Capital Controls, Political Risk and Deviations from Interest-Rate Parity." Journal of Political Economy. (1980): 370-84.

Dwyer, G. P. and M. S. Wallace. "Cointegration and Market Efficiency." Journal of International Money and Finance. (August 1992): 318-327.

Edgar, S. M. and P. E. Swanson. "The Relationship between Selected Domestic and External Dollar Denominated Asset Yields." Weltwirtschaftliches Archiv. (1984): 455-459.

Eiteman, D. K., A. I. Stonehill and M. H. Moffett. 1992. Multinational Business Finance. Addison-Wesley Publishing Company, Inc.

Enders, Walter. 1995.Applied Econometric Time Series. New York: John Wiley & Sons, Inc.

Engle, R. F. and C. W. J. Granger. 1991. Long-Run Economic Relationships, Readings in Cointegration. Engle, R. F and C. W. J. Granger., Ed. New York: Oxford University Press,

Engle, R. F. and C. W. J. Granger. "Co-integration and Error Correction: Representation, Estimation, and Testing." Econometrics. (March 1987): 251-276.

Frenkel, Jacob A. "The Collapse of Purchasing Power Parities During the 1970's." European Economic Review. (Feb. 1984).

Frenkel, Jacob A. and R. M. Levich. "Transaction Costs and Interest Arbitrage: Tranquil Versus Turbulent Periods." Journal of Political Economy. (1977): 1207-24.

Fung, H. G. and S. C. Isterg. "The International transmission of Eurodollar and US Interest Rates: A Cointegration Analysis." Journal of Banking and Finance. (1992): 757-769.

Fung, H. G., S. C. Isberg and W. K. Leung. "A Cointegration Analysis of The Asian Dollar and Eurodollar Interest Rate Transmission Mechanism."Asian Pacific Journal of Management. (October 1992): 167-177.

Giddy, I., G. Dufey and S. Min. "Interest Rates in the US and Eurodollar markets." Weltwirtschaftliches Archiv. (1979): 51-67.

Granger, C. W. 1991."Developments in the Study of Cointegrated Economic Variables." Long-Run Economic Relationships, Readings in Cointegration. Engle, R. F and C. W. J. Granger, Ed. New York: Oxford University Press.

Grauwe, P.D. March 1989. "Is the European Monetary System A DM-Zone?" Discussion Paper No.267. Center for Economic Policy Research, London.

Gros, D. "Capital Controls and Foreign Exchange Market Crisis in the EMS." European Economic Review. (December 1992): 1533-1544.

Hall, Bronwyn H., Clint Cummins and Rebecca Schnake. 1992. TSP User's Guide and TSP Reference Manual. TSP International.

Hartman, D. G. "The International Financial Market and US Interest Rates." Journal of International Money and Finance. (April 1984): 91-103.

Hamao, Y., and P. Jorion. 1991. "International Capital Market Integration."New Palgrave Dictionary of Money and Finance. Eatwell, J., M. Milgate, and P. Newman, Ed. London: The Macmillan Press Ltd.

Hendershott, P. H. "The Structure of International Interest Rates. The US Treasury Bill Rate and Eurodollar Deposit Rate." Journal of Finance. (September 1967): 455-465.

Henderson, D. W. and S. Sampson."Intervention in Foreign Exchange Markets: A Summary of Ten Staff Studies." Federal Reserve Bulletin. (November 1983): 830-36.

Hsiao, Cheng. "Autoregressive Modelling of Canadian Money and Income Data." Journal of American Statistical Association. (September 1979): 553-60.

Hamao, Y., and P. Jorison. 1992. "International Capital Market Integration." in P. Newman, M. Milgate and J. Eatwell, eds., New Palgrave Dictionary of Money and Finance. London: Macmillan.

Hubbard, R. G. 1994. Money, the Financial System and the Economy. New York: Addison-Wesley Publishing Company, Inc.

Hutchison, Michael, and Nirvikar Singh. April 1993. "Long-Term International Capital Mobility: New Evidence from Equilibrium Real Interest Rate Linkages." FRB San Francisco, Center for Pacific Basin Monetary and Economic Studies, Working Paper No. 93-06 .

Isard. P. "Exchange-Rate Determination: A Survey of Popular Views and Recent Models." Princeton Studies in International Finance. No. 42, International Finance Section, Department of Economics, Princeton University.

Kaen, F. R. and G. A. Hachey. "Eurocurrency and National Money Market Interest Rates." Journal of Money, Credit, and Banking. (August 1983): 327-338.

Karfakis, J. C. and D. M. Moschos. "Interest Rate Linkages within the European Monetary System: A Time Series Analysis." Journal of Money, Credit, and Banking. (August 1990): 388-94.

Katsimbris, G. M. and S. M. Miller. "Interest Rate Linkages within the European Monetary System: Further analysis." Journal of Money, Credit, and Banking. (November 1993): 771-79.

Keating, R. and Byles, C. M. "Internationalizing the Business School Curriculum: Perspectives on Successful Implementation." Journal of Education for Business. (September/October 1991): 12-16.

Kenedy, Peter. "A Guide to Econometrics." Cambridge, Massachusetts: The MIT press.

Kirchgasser, Gebhard, and Jurgen Wolters. "U.S.-European Interest Rate linkage: A Time Series Analysis for West Germany, Switzerland, and the United States." Review ofEconomics and Statistics, (November 1987): 675-684.

Kwack, S. Y. "The Structure of International Interest Rates: An Extension of Hendershott's Tests." Journal of Finance. (September 1971): 897-900.

MaCallum, B. T. "A Reconsideration of the Uncovered Interest Parity Relationship." Journal of Monetary Economics. (1994): 105-132.

Maddala, G. S. 1992. Introduction to Econometrics. New York: Maxwell Macmillan Publishing Company.

Mark, N. C. "Some Evidence on the International Inequality of Real Interest Rate." Journal of International Money and Finance. (June 1985): 189-208.

Martson, R. C. "Interest Arbitrage in the Eurocurrency Markets." European Economic Review. (1977): 1-13.

Marston, Richard. 1992. "Determinants of Short-Term Real Interest Rate Differential Between Japan and the United States." NBER Working Paper No. 4147.

Meese, R. A. and K. Rogoff. "Empirical Exchange Rate Models of Seventies: Do They Fit Out of Sample?" Journal of International Economics. (February 1983a): 3-24.

_____. "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Errors or Misspecification?" In Exchange Rates and International Macroeconomics. Frenkel, J. A., Ed. Chicago: The University of Chicago Press, (February 1983b) : 67-112.

Menzie Chinn and Jeffrey Frankel. 1994. "Financial Links Around the Pacific Rim: 1982- 1992." Introduction to Exchange Rate Policy and Interdependence: Perspective from the Pacific Basin Reuven Glick and Michael Hutchison, Ed. Cambridge: Cambridge University Press.

Meulendyke, Ann-Maririe. "International Aspects of Monetary Policy and Financial Markets." U.S. Monetary Policy and Financial Markets. (1989): 202-224.

Mishra, B., M. Rahman and S. Caples. "Cotegration, Error correction, and Joint Efficiency in Forward and Futures Markets For Major Foreign currencies." Global Finance Journal. (1992): 171-180.

Mishkin, F. S. "Are Real Interest Rates Equal Across Countries?" Journal of Finance. (1984): 1345-57.

Mussa, M. and M. Goldstein. "The Integration of World Capital Markets." FRB Kansas City Symposium Series, Changing Capital Markets: Implication for Monetary Policy. (1993): 245-313.

Mougoue, M. "The Term Structure of Interest Rates As A Cointegrated System: Empirical Evidence From Eurocurrency Market." The Journal of Financial Research. (Fall 1992): 285-296.

Mundell, Robert A. "Capital Mobility and Stabilization Policy Under fixed and Flexible Exchange Rates." Canadian Journal of Economics and Political Science. (November 1963).

Peak, Martha H. "Managing for Radical Change." Management Review. (February 1993): 22-26.

Pigott, Charles. "International Interest Rate Convergence: A Survey of Issues and Evidence." FRB New York Quarterly Review. (Winter 1993-1994): 24-37.

Pindyck, S. Robert and Daniel L. Rubinfeld. 1991. Econometric Models and Economic Forecasts. NewYork: McGraw-Hill.

Ramanathan, R. 1995. Introductory Economics With Applications. Florida: The Dryden Press, Harcourt Brace College Publisher.

Scheraga, Joel D. "Instruction in Economics Through Simulate Computer Programming." Journal of Economic Education. (Spring 1986): 129-139.

Schnitzel, P. "Testing for the Direction of Causality between the Domestic Monetary Base and The Eurodollar System." Weltwirtschaftliches Archiv. (1983): 616-629.

Shufeldt, L. M., J. E. Parmley, and D. G. Kopp. "Computer Use in Required Business Statistics Courses at AACSB Member Schools." Journal of Education for Business, (March/April 1992): 210-213.

Stewart, Thomas A. "U.S. Productivity: First but Fading." Fortune. (October 19, 1992): 54-57.

Swanson, P. E. "The International Transmission of Interest Rates: A Note on Causal Relationships between Short-Term External and Domestic US Dollar Returns." Journal of Banking and Finance. (1988): 563-573.

Taylor, M. P. "Covered Interest Arbitrage and Market Turbulence." European Journal. (1989): 371-90.

Thornton, John. ""Interest Rates in Domestic and Eurocurrency markets." Applied Economics, (October 1992): 1103-1105.

Tiemann, Thomas K. "Introducing Empirical Exercises into Principles of Economics." Journal of Economic Education. (Spring 1985): 121-130.

_____. 1987. The New Palgrave, A Dictionary of Economics. Eatwell, J., M. Milgate and P. Newman, Ed. London: The Macmillan Press Ltd.

Walbert, Mark S. "Writing Better Software for Economics principles Textbooks." Journal of Economic Education. (Summer 1989) : 281-289.

Walker, J. "Experimental Economics in the Classroom." Journal of Economic Education. (Winter 1987): 51-57.

Wallich, H. C. and R. D. Haas. "International Transmission of Interest-Rate Movements." Aussenwirtschaft. (1982): 247-259.