REAL EXCHANGE RATES AND REAL INTEREST RATE DIFFERENTIALS: AN EMPIRICAL INVESTIGATION

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ABSTRACT

REAL EXCHANGE RATES AND
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This study investigates the validity of the real exchange rate-real interest rate differential (RERI) relationship for a sample of twenty-three developing and developed countries. The results based on the Johansen cointegration analysis suggest the validity of the long-run RERI relationship only for a small number of countries including Canada, Italy, Switzerland, Belgium, Chile, Israel and Norway. Real interest rate differentials are found to be positively associated with real exchange rates in the long-run for every country except Israel. The results of the weak exogeneity tests suggest that real exchange rates are the adjusting variables for Italy, Switzerland, Belgium and Israel. Consistent with an endogenous response of domestic interest rates to a real exchange rate shock policy rule, real interest rate differentials are found to be endogenous for the parameters of the cointegration vector for Canada, Chile and Norway.

Keywords: Real Exchange Rates, Real Interest Rate Differentials, Cointegration Analysis.

ÖZ

REEL DÖVİZ KURLARI VE REEL FAİZ ORANI DİFERANSİYELLERİ ÜZERİNE AMPİRİK BİR ÇALIŞMA

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Bu çalışmada reel döviz kuru-reel faiz oranı diferansiyeli (RERI) ilişkisinin geçerliliği gelişmiş ve gelişmekte olan yirmiüç ülke için incelenmiştir. Johansen eşbütünleşim analizi ile elde edilen sonuçlar, yalnızca Kanada, İtalya, İsviçre, Belçika, Şili, İsrail ve Norveç için uzun dönem RERI ilişkisinin geçerliliğini ileri sürmektedir. İsrail dışındaki tüm ülkeler için uzun dönemde reel faiz oranı diferansiyelinin reel döviz kuruyla pozitif yönde ilişkisi olduğu bulunmuştur. Zayıf dışsallık test sonuçları İtalya, İsviçre, Belçika ve İsrail için reel döviz kurlarının uygun değişkenler olduğunu göstermektedir. Yurtiçi faiz oranlarının reel döviz kuru şok politikası kuralına verdiği içsel tepki ile tutarlı olarak, reel faiz kuru diferansiyellerinin Kanada, Şili ve Norveç eşbütünleşim vektörü parametreleri için içsel olduğu tespit edilmiştir.

Anahtar Kelimeler: Reel Döviz Kurları, Reel Faiz Oranı Diferansiyeli, Eşbütünleşim Analizi.

To my beloved family ….

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CHAPTER 1

INTRODUCTION

The determinants of real exchange rates and their long-run relationships with real interest rates in financially open economies are central to the international financial economics literature. Both the theoretical and empirical literature offer an extensive list of potential fundamental determinants of real exchange rates. These factors include, differentials in inflation rates (purchasing power parity, PPP), interest rates (uncovered interest parity, UIP), productivity (Balassa-Samuelson affect), money growth rates (monetary model), capital accumulation, current account balances, government spending, wealth, terms of trade and so on (see, *inter alia*, Baxter, 1994; Chin, 1991; MacDonald, 1998; Mussa, 1990, Taylor and Sarno, 2004 and Driver and Westaway, 2005 for surveys).

Following the pioneering study by Meese and Rogoff (1983), one strand of the literature focuses to a simple model that relates the real exchange rate to the real interest rate differential (Edison and Melick, 1999). This is often called as the real exchange rate – real interest rate

(RERI) relationship. The RERI relationship is based on two basic equilibrium relationships of an open economy: the purchasing power parity (PPP) and the uncovered interest parity (UIP) hypotheses.

According to the PPP hypothesis, exchange rates adjust to price differentials in open economies so that the international commodity market stays in equilibrium. In other words, expressed in a common currency, absolute PPP hypothesis equates the two relevant national price levels in such a way that the purchasing power of a unit of one currency is the same in both economies. The lack of absolute price level data constructed for an internationally standardized basket of goods to test the absolute PPP often enforces researchers to consider the relative PPP which defines exchange rate change as a function of relative inflation rates (Sarno and Taylor, 2002). The real exchange rate stationarity or the cointegration of relative inflation rates with a unitary coefficient are often taken as evidence supporting the validity of the absolute and relative PPP hypotheses, respectively.

The PPP hypothesis has crucially important theory and policy implications. Consequently, there is an extensive and growing body of literature to test the empirical validity of the PPP for individual and/or cross-section of countries. As convincingly argued by Sarno and Taylor (2001) and Taylor and Sarno (2004), the bulk of the literature tends to reject the empirical validity of the PPP. The explanations for the failure of the PPP include imperfect competition, pricing to market, the choice of price indices and base country, information costs, transport costs and trade barriers. Non-linear dynamics (Taylor and Sarno, 1998), the low power of the conventional unit root tests over short time spans of data (Lothian and Taylor, 1996; Edison and Melick, 1999), temporal aggregation (Taylor, 2001), and simultaneity bias (Özmen and Gökcan, 2004) are among the empirical modeling issues suggested as the potential reasons for the conflicting results.

The other important international parity condition, the uncovered interest parity (UIP), considers financially open economies and postulates that exchange rates adjust to interest rate differentials. Compared to PPP, UIP has been subject to relatively less scrutiny in the empirical literature. However, the evidence appears to be conflicting also for UIP. The presence of non-stationary time varying risk premium and systematic expectation errors, invalid conditioning due to a simultaneity bias, limited international capital mobility, changes in the term structure of interest rates, non-linear dynamics are among the explanations for the failure of the UIP (Flood and Rose, 2001, Özmen and Gökcan, 2004 and Driver and Westaway, 2005).

The PPP and UIP define the equilibrium conditions for international commodity and asset markets, respectively. As Juselius and MacDonald (2003) and Özmen and Gökcan (2004) argue, a disequilibrium in one market may have repercussions on the other, the two international parity conditions may not be independent of each other in the long run. In this context, Johansen and Juselius (1992) and Juselius (1995) propose an approach combining both international parities referred to as capital enhanced equilibrium exchange rates, or CHEERs by MacDonald (2000). Another approach to consider the interest rate and inflation differentials under a maintained hypothesis that the domestic Fisher parity holds for each of the countries is provided by the RERI relationship (Edison and Melick, 1999; MacDonald and Nagasayu, 2000 and Hoffman and MacDonald, 2003). The RERI hypothesis is often tested for industrial countries and according to Bagchi *et al.* (2003) there exists no substantial empirical evidence in support of it.

In this study, we aim to test the RERI relationship considering the data for both developing and developed countries. Our data set contains 23 countries for which both the real exchange rate and real interest rate variables are readily available from the World Bank Word Development Indicators data base. These 23 countries are Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, South Africa, Spain, Switzerland, the United Kingdom and the United States. The data are annual and span the period of 1981-2002.

The rest of this thesis is organized as follows. In Chapter 2, the real exchange rate-real interest rate relationship is derived by combining the PPP and UIP conditions. This chapter presents also a brief review of the literature. Chapter 3 describes the data and presents empirical results obtained by employing Johansen (1988, 1990) cointegration procedure. Finally, Chapter 4 concludes.

CHAPTER 2

LITERATURE SURVEY

The real exchange rate-real interest rate differential (RERI) relationship is based on two basic equilibrium relationships of a financially open economy: the purchasing power parity (PPP) and the uncovered interest parity (UIP) hypotheses. Since both international parities have reflections on each other, Johansen and Juselius (1992) and Juselius (1995) combine these parities and propose the approach called capital enhanced equilibrium exchange rates or CHEERs by MacDonald (2000). According to Özmen and Gökcan (2004, p. 3),

> The main idea of CHEERs is that non-stationary deviations from PPP and UIP form a stationary relationship consistent with the interdependence of adjustments in asset and good markets towards equilibrium.

Another approach to consider the interest rate and inflation differentials under a maintained hypothesis that the domestic Fisher parity holds for each of the countries is provided by the RERI relationship (Edison and Melick, 1999; MacDonald and Nagasayu, 2000 and Hoffman and MacDonald, 2003). In this chapter we first briefly review the literature on the basic international parity, PPP and UIP, conditions. We then proceed with a brief review of the literature on the RERI relationship.

The PPP and UIP Hypotheses

The PPP hypothesis depends on the law of one price (LOP). According to LOP, measured in a common currency, two relevant national price levels are equated, so that the purchasing power of a unit of either currency is identical. That is,

$$p_t = e_t + p_t^* \tag{2.1}$$

where e is log of the nominal exchange rate (domestic currency per unit of foreign currency), p is the log of the domestic price level while p^* is the log of the foreign price level.

Equation (2.1) can also be written as

$$e_t = p_t - p_t^* . \tag{2.2}$$

to give the absolute (or strong) form of the PPP relationship. The regression equation

$$e_t = \gamma_0 + \gamma_1 p_t - \gamma_2 p_t^* , \tag{2.3}$$

gives the absolute PPP (2.2) under the restrictions, γ_0=0 and γ_1=γ_2=1 (symmetry and proportionality condition). The lack of absolute price level data constructed for an internationally standardized basket of goods to test the absolute PPP often enforces researchers to consider the relative PPP which defines exchange rate change as a function of relative inflation rates (Sarno and Taylor, 2002). The relative (or weak) version of PPP relaxes the restriction that γ_0=0. The real exchange rate (q) can be defined as,

$$q_t = e_t - \left(p_t - p_t^*\right) \tag{2.4}$$

Under the PPP hypothesis, q=1 (Δq=0) and the LOP holds when q=1. However, the PPP hypothesis is seldom supported by empirical evidence. The explanations for the failure of the PPP include imperfect competition, the choice of price indices and base country, pricing to market, the presence of non-tradable goods, Balassa-Samulson affect, information costs, transport costs and trade barriers (Driver and Westaway, 2004 and Taylor and Sarno, 2004). The PPP assumes that all the markets both in home and foreign countries are perfectly competitive, therefore imperfect competition can lead to PPP not to hold. The PPP maintain that the price indices in the countries considered are exactly the same with each other and contain homogeneous products with equal weights. Consumers' preferences in different countries, however, may differ affecting the composition of their consumption basket and thus the price index. In such situations it is no reliable to compare the price indices of different countries. Therefore, the validity of the PPP may crucially depend on the choice of the price indices. The PPP may be expected to hold especially for internationally traded homogeneous commodities (gold, agricultural products, oil, etc.). Also, if countries specialize in producing different goods, this may result in the breakdown of the validity of the PPP hypothesis. Furthermore, PPP does not hold for goods that are not traded such as services due to transport costs and trade barriers. Market structures and different demand conditions may lead to different prices for the same product in different countries. Therefore, pricing to market may cause the PPP not to hold. Productivity differentials between countries may lead to differing price levels for the same products as suggested by the basic Balassa-Samuelson model. Non-linear dynamics (Taylor and Sarno, 1998), the low power of the conventional unit root tests over short time spans of data (Lothian and Taylor, 1996; Edison and Melick, 1999), temporal aggregation (Taylor, 2001), and simultaneity bias (Özmen and Gökcan, 2004) are among the empirical modelling issues suggested as the potential reasons for the conflicting results.

The classical studies by Dornbusch and Krugman (1976) and Rogoff (1996) suggest that the purchasing power parity (PPP) condition can be considered as an anchor for long-run equilibrium real exchange rates. Taylor (2003), on the other hand, argues that, the real exchange rates may not be linear in the long-run. According to Taylor (2003) there are at least three potential sources of nonlinearity in real exchange rates. The first source stems from the presence of transport costs, tariffs and nontariff barriers to the international goods arbitrage. The interaction of heterogeneous agents in the foreign exchange market at the microstructural level can also be a source of the nonlinearity (Sarno and Taylor, 2001a). Finally, the effects of official intervention in the foreign exchange market are considered as the third source (Taylor, 2002; Sarno and Taylor, 2001b). The empirical study by Taylor (2003) employing recently developed non-linear estimation procedures, supports the presence of non-linear affects of real shocks on the underlying equilibrium level of the real exchange rates.

Micheal *et al.* (1997), Sarantis (1999) and Taylor *et al.* (2001) are among the other recent studies employing non-linear estimation procedures. Micheal *et al.* (1997) use monthly interwar data for the French franc-US dollar, French franc-pound sterling and pound sterling-US dollar. According to their test results, they decide to employ exponential smooth transition autoregressive (ESTAR) model rather than the conventional linear models. Taylor *et al.* (2001) deal with real bilateral dollar exchange rates for the recent floating rate period since 1973 and their results support that four major real exchange rates can be modeled by nonlinearly mean-reverting processes. By using Monte Carlo integration, they also estimate the impulse response functions. Sarantis (1999) investigates real effective exchange rates with a data set consisting of ten industrialized countries. Taylor and Peel (2000) also show significant nonlinear relationships in the mean reversion of the real exchange rates for the data covering the post-Bretton Woods period. Their results suggest that small and large shocks to real exchange rate around equilibrium have different effects compared to linear models.

Taylor and Sarno (2004) attempt to solve a conundrum between market efficiency and the long-run PPP hypothesis. This conundrum states that real exchange rate is a unit root process that prevents long-run purchasing power parity to hold between the two countries concerned. It is noted that in the efficient markets PPP formulation, the expected real interest rate differential is assumed to be a constant. While resolving the conundrum, Taylor and Sarno (2004) relax this assumption and investigate the full dynamic equilibrium correction system linking prices and exchange rates. From their findings, they conclude that market efficiency is consistent with a stationary real exchange rate and long-run purchasing power parity.

Cashin and McDermott (2003) argue that the conventional least-squares-based estimates of real exchange rate persistence are biased downward and use a serial correlation-robust median-unbiased estimator to correct for the bias of conventional estimators. Their results based on monthly data for real effective exchange rates for 20 industrial countries over the post-BrettonWoods period (1973:4-2002:4) appear to be consistent with the PPP hypothesis.

The information provided by the data of a single country may not be adequate to test the validity of an international parity relationship such as the PPP. Consequently, the recent studies often employ panel data estimation procedures allowing that the information from the time series dimension to be combined with the information obtained from the cross-sectional data[*].

[*] The reason for the use of panel data is neatly summarized by Banerjee (1999, p. 607): "The emphasis of the literature on unit roots and cointegration in panel data has been the attempt to combine information from the time series dimension with that obtained from the cross-sectional, in the hope that inference about the existence of unit roots and cointegration can be made more straightforward and precise by taking account of the cross-section dimension, especially in environments in which the time series for the data may not be very long but very similar data may be available across a cross-section of units such as countries, regions, firms or industries". Banerjee (1999, p. 607) also considers the asymptotic behavior (rates and modes of convergence)

Azali *et al.* (2001) consider long-run absolute PPP and use heterogeneous panels for the seven Asian developing economies, Indonesia, Malaysia, Philippines, Singapore, Thailand, Taiwan and Korea compared to Japan. Their data set is composed of quarterly time series for the period 1977:4-1998:3. Then, they concentrate on panel unit root and panel cointegration tests, which are developed by Im *et al*. (1997) and Pedroni (1995, 1997), respectively. After applying panel parametric and non-parametric tests, they conclude that there is cointegration between the bilateral exchange rates and relative prices against the selected foreign country, Japan. Hertwartz and Reimers (2002) test the PPP for the post-Bretton Woods era by using panel methods. In their study, the Deutsche mark, the Japanese yen and the US dollar are taken as base currencies. The deflator and final demand are used to approximate national price levels. Their quarterly data is taken for 18 main industrial economies over the period January 1973 to March 1998. By using likelihood ratio tests, they test linear restrictions implied by PPP. Hertwartz and Reimers (2002) also apply error correction models and conclude that PPP is a data-acceptable description of exchange rate dynamics. Camerero and Tamarit (2002) investigate the factors that affect the Spanish peseta real exchange rate during the float and the first years of European Monetary System (EMS). They study the factors from the demand and the supply side of the economy and they conclude that both have important effects in the evolution of the Spanish peseta. Their analysis is performed on ten European Union member countries (Austria, Belgium, Denmark,

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of panel estimators along with the construction of pooled panel and group-mean tests for unit roots and comparison of the ADF regressions with non-parametric procedures.

Germany, France, Italy, Netherlands, Sweden and UK) for the period 1973-1992 with annual time series data. Camerero and Tamarit (2002) apply panel cointegration methods, which are proposed by McCoskey and Kao (2001) and Pedroni (1999).

Recently, Coakley, Flood, Fuertes and Taylor (2005) consider a large data set for the 1970:1–1998:12 period that comprises 19 Organizations for Economic Cooperation and Development (OECD) member countries and 26 developing countries and employ non-stationary panel regression procedures to test the validity of the PPP. Their results support the validity of the relative PPP hypotheses in the sense that inflation differentials are on average reflected one-for-one in long-run nominal exchange rate depreciation.

According to the UIP hypothesis, measured in the same currency, rates of return on domestic and foreign assets are equal in the long run.

$$i_t = i_t^* + \Delta e_t^e , \qquad (2.5)$$

where i_t and i_t^* are domestic and foreign interest rate with maturity $t+m$, respectively and $\Delta e_t^e = E_t \Delta e_{t+m}$ (E_t is the conditional expectations operator on the basis of information available at time t). Under the condition that agents do not make systematic errors with $\Delta e_t + v_t = \Delta e_t^e$, equation (2.5) can be written as:

$$i_t = i_t^* + \Delta e_t + v_t . \qquad (2.6)$$

Equation (2.6) is also the restricted form under δ_1=δ_2=1 of equation (2.7),

$$i_t = \delta_1 i_t^* + \delta_2 \Delta e_t + \varepsilon_t . \tag{2.7}$$

ε is zero mean stationary, ($\varepsilon = v + u$, u being a time-varying risk premium) (Özmen and Gökcan, 2004).

The UIP has been subject to relatively less scrutiny in the empirical literature. The presence of non-stationary time varying risk premium and systematic expectation errors, invalid conditioning due to a simultaneity bias, limited international capital mobility, changes in the term structure of interest rates, non-linear dynamics are among the explanations for the failure of the UIP (Flood and Rose, 2001, Özmen and Gökcan, 2004 and Driver and Westaway, 2005).

Juselius and MacDonald (2003) use a cointegrated VAR model to investigate the long-run relationship between PPP, UIP and Fisher real interest parity conditions for the period 1975:7-1998:1. Their model consists of seasonal and intervention dummies. Their variables are German (home) and US (foreign) price indices, the spot exchange rate (DM/$), the German and US long bond yield and the German and US 3 month Treasury bill rate. Both prices are CPI and the long interest rates are 10 year bond yields. In their study, they both consider long-run stationary relations and common stochastic trends. According to their findings they conclude that US and German inflation rates adjust to PPP and the bond rates. They claim that the nonstationary movements in the

PPP exchange rate cause nonstationary movements in the bond and inflation rate differentials. Although their results about the transmission mechanism over the post Bretton Woods period are different from the theoretical assumptions, they show a strong relation between the spread of long-term bond rates and price adjustment towards sustainable levels of real exchange rate.

Özmen and Gökcan (2004) deal with PPP and UIP and try to understand the long-run relationships by using Johansen cointegration methods. Because of the structure of the economy, they decide to investigate the validity of the PPP and UIP hypotheses for Turkey. Their data set is composed of Turkish and US inflation, interest and exchange rates over the period 1986 to 1999. From their findings, they conclude two stationary relations between the variables, which explain the long-run evolution of Turkish interest rates and inflation rate, respectively. According to the results, which are consistent with the CHEERs theory, there exist UIP and PPP relations. Also, the deviations from PPP and UIP are explained by the interest and inflation rates differentials, respectively.

Driver and Westaway (2004) concentrate on the concept of the equilibrium real exchange rate definitions. They also investigate the inadequancies of the PPP when various real-world problems are faced. They deal with the short, medium and long-run exchange rate equilibria and their behaviours under various theoretical models. Then, they calculate the empirical estimates by explaining the relationships of these equilibrium concepts. In addition to these, they discuss which measures of the equilibrium exchange rates should be used for different models. They also investigate some approaches, including UIP, PPP and the Balassa-Samuelson model, which are helpful in modeling the movements in exchange rates. Finally, Driver and Westaway (2004) try to examine the effect of different shocks on the long-run measures of equilibrium.

The RERI Relationship

Consider the Fisher parity condition for domestic country

$$i_t = r_t + \Delta p_t^e. \tag{2.8}$$

and for foreign country,

$$i_t^* = r_t^* + \Delta p_t^{*e} \tag{2.9}$$

By combining the Fisher parity conditions (2.8)-(2.9), real exchange rate identity (2.4) and the UIP (2.5), the following equation can be obtained,

$$q_t = q_t^e - \left(r_t - r_t^*\right). \tag{2.10}$$

Equation (2.10) supports that current real exchange rate is a function of expected future real exchange rate and the real interest rate differential (Dornbusch, 1976). However, it is not possible to observe the exact value of the expected real exchange rate which is expected to vary across countries. In other words, $q_t^e = \alpha + w_t$ and therefore, the RERI equation (2.10) turns out to be,

$$q_t = \alpha + \beta\left(r_t - r_t^*\right) + w_t, \tag{2.11}$$

where α denotes the constant term specific to each country and w is the disturbance term. Accordingly, if domestic interest rates are higher than foreign interest rates, we should expect the exchange rate to depreciate. An increase in the expected exchange rate or an increase in the risk premium on the domestic assets will all lead to a depreciation of the domestic currency.

In order to test the RERI relation, Hoffman and MacDonald (2003) propose a Vector Autoregression (VAR) based approach. Their data set consists of quarterly data for G7 countries, the United States, Japan, Germany, France, Italy, the United Kingdom and Canada, for the periods 1978-1997. The nominal interest rates are long bond yields and price indices are consumer prices (CPI). CPI-based real exchange rates vis-a-vis the United States using average quarterly dollar exchange rates are calculated. Consisting of the change in the real exchange rate and the real interest differential, they take the projection for the change in the real exchange rate from a bivariate VAR, and then correlate this with the real interest differential. Their results suggest that the real interest differential is associated with the transitory part of the real exchange rate. In most of the cases, their results demonstrate that the expected changes in the exchange rate are more volatile than the real interest differential itself which is consistent with the RERI relationship. They argue that this procedure is much closer to the logic of the RERI relationship than many other alternative tests. Then, they compare their empirical findings with Baxter (1994) and Edison and Pauls (1993). Baxter (1994) also admits that real exchange rate movements can be divided into permanent and transitory components. According to the results of multivariate methods, she concludes that temporary movements in the exchange rates are related with the real interest rate differentials. By using Engle-Granger methodology, Edison and Pauls (1993) state that there is no statistical link between real exchange rates and real interest rate differentials.

Another cointegrated VAR model is established by Jin (2003) for China whose macroeconomic indicators has become increasingly more important for the rest of the world. Jin (2003) focuses on the relationship between real interest rates, real exchange rates and balance of payments over the period 1980:1-2002:7. He investigates whether real exchange rate and foreign exchange reserves are cointegrated. He also examines whether the real interest differential is correlated with the real exchange rate. According to the findings, he concludes significant and usually non-monotonic interactions between these three variables. During his studies, he also considers the institutional changes and policy implications. Jin (2003, p.16) says that

> In addition to the significant general interactions among the three variables, the empirical result suggests specifically that (1) in China where capital flows may be insensitive to short term interest rate changes, an increase in the real interest rate differential may cause depreciation in the real exchange rate, and (2) a real exchange rate appreciation may stimulate supply of nontradable goods, discourage supply of tradable goods and cause downward pressure on inflation. This will in turn increase real interest

> rates, dampen domestic demand, and may go hand-in-hand with a growing surplus in the balance of payments.

Bagchi *et al.* (2003) consider the effects of trade and real interest rate differential on the real exchange rate for the countries, Australia, Austria, Canada, Finland, Italy, New Zealand, Norway, Portugal and Spain. For six out of these nine small open developed economies, the data set covers the period 1973-1995 (quarterly) and for the rest, the sample starts in 1978 and 1983. Their variables are; CPI, ratio of export unit value to import unit value and the difference between the interest rate on long-term government bonds and the expected inflation rate. By considering both the financial and goods markets, they want to estimate the long-run movements and therefore, in order to understand this long-run relationship they apply cointegration analysis. According to their results they conclude that terms of trade and the expected real interest rate differential can be used comfortably as exogeneous variables in representing the long-run real exchange rate of small open developed economies in the post Bretton-Woods era. Bagchi et al. (2003) state that the speed of adjustment of the expected real interest rate differential is larger than the terms of trade. Also, the terms of trade improvement may result in different effects for different countries.

There is also an extensive literature to test the hypothesis that interest rate differentials are unbiased predictors of future exchange rate movements. The results of the bulk of the empirical studies tend to reject this hypothesis. Chin and Meredith (2005), on the other hand, suggest the use of long-horizon data instead of using short-horizon data in the earlier studies. They use interest rates on longer maturity bonds. Their data set covers US, Germany, Japan and Canada. From their empirical findings, they achieve better results compared to the previous ones. In other words, the results by Chin and Meredith (2005) suggest that the coefficients of interest differentials are of the correct sign and are closer to the predicted value of unity. Besides, they obtain robust results irrespective of the different data frequencies, sample periods, yield definitions and base currencies. Finally, regardless of the unbiasedness hypothesis, Chin and Meredith (2005) conclude that it is not reliable to use interest rate differentials for estimating the short-term movements in exchange rates.

Meese and Rogoff (1988), Throop (1994) and Coughlin and Koedijk (1990) also consdider the RERI relationship employing the Engle-Granger cointegration method. Their results suggest the lack of a long run cointegration relationship betteen the variables. On the contrary, Edison and Melick (1999) achieve stronger evidence by using the Johansen (1988) multivariate cointegration procedure. Edison and Melick (1999) consider the real exchange rate real and interest rate relation for the real bilateral exchange rates of the U.S. dollar against the Canadian dollar, deutsche mark, and yen and the trade weighted value of the U.S. dollar against the Group of Ten (G-10) currencies. Their data set covers quarterly observations for the period 1974-1994. To calculate exchange rate and inflation, they use CPIs. While dealing with RERI relationship, they employ and compare three different approaches (standard, standard with additional variables, and *ex post*). The *standard* approach is the most restrictive one and it is based on the assumption that the expected real exchange rate is constant. However, according to the *standard with additional variables*, it is reliable to model the expected real exchange rate by using some additonal variables. Therefore, it has some stochastic properties. Finally, in the *ex post* approach, by substituting the ex post values, Edison and Melick (1999) forecast errors for the expected real exchange rate. From their empirical findings, they conclude that for three of the four exchange rates, there is a single cointegrating vector in systems containing the long maturity interest rates. Another stronger result that shows a clear long-run relationship is achieved by Macdonald (1997).

Fujii and Chinn (2001) consider the real interest parity (RIP) for the G-7 economies, using quarterly data on yields with various maturities. The short-term interest rates cover 3, 6 and 12 month maturity yields while the long-term interest rate data consist of 5 and 10 year yields. They use CPI and wholesale price index (WPI). In their study, assuming rational expectations, they test the RIP hypothesis and then forecast future inflation rates. Their results show that compared to the short horizon, long horizon data give better results which are robust to alternative ways of modeling expected inflation rates. Fujii and Chin (2001) emphasize that this result arises because; both UIP and PPP perform better at long than short-term data.

MacDonald and Nagasayu (2000) investigate the long-run relationship between the real exchange rate and real interest rate differentials by using panel cointegration methods developed by Pedroni (1997). MacDonald and Nagasayu (2000) prefer the Pedroni (1997) panel cointegration tests as these tests do not require a priori restrictions on the parameters of the model and hence are more flexible than the panel unit root tests (Quah, 1994 and Im *et al.,* 1997). MacDonald and Nagasayu

(2000) consider the data for the period 1976-1997 for 14 industrialized countries: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Switzerland and the United Kingdom. The exchange rates are bilateral rates against the U.S. dollar. Also, they exclude the cases which have stationary real interest rate differentials. The emprical results by MacDonald and Nagasayu (2000) suggest the rejection of no cointegration null even when the equilibrium real exchange rate is assumed to be constant and when the long-term interest rates are used, this rejection becomes clearer.

CHAPTER 3

EMPIRICAL ANALYSIS

This chapter presents and discusses empirical results and contains a brief review of the empirical methodology employed. In sections 3.1 and 3.2, we briefly present the Augmented Dickey-Fuller and Johansen cointegration procedures, respectively. Section 3 briefly describes the data used in this study. The empirical results and the estimated long-run relationships between real exchange rates and real interest rate differentials are presented in the final section.

3.1. Unit Root Tests

A stationary time series has a constant long-run mean, a finite variance (time-invariant) and a theoretical correlogram that diminishes as lag length increases. On the other hand, for a nonstationary series, there exists no long-run mean and its variance is time dependent. Therefore, under the condition of nonstationarity, to use classical statistical methods such as ordinary least squares (OLS), usual *t*-tests and *F*-tests, are inappropriate. However, in order to decide the presence of unit roots, only looking at the sample correlogram is unreliable. A formal test to detect the possible presence of unit roots is developed by Dickey and Fuller (1979, 1981).

3.1.1. Dickey-Fuller Test

Assuming that $y_t = a_1 y_{t-1} + \varepsilon_t$, Dickey and Fuller (1979) consider the following three regression equations,

$$\Delta y_t = \gamma y_{t-1} + \varepsilon_t \tag{3.1.1.1}$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + \varepsilon_t \tag{3.1.1.2}$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \varepsilon_t , \tag{3.1.1.3}$$

where $\{\varepsilon_t\}$ is generated from a white-noise process. Equation (3.1.1.1) is a random walk model, equation (3.1.1.2) also contains an intercept term while equation (3.1.1.3) includes both an intercept and a linear time trend. In all these equations, the null hypothesis $\gamma = a_1 - 1 = 0$ is tested, which means that the y_t series is nonstationary and it should be noted that critical values for all these equations are different (Enders, 1995). The appropriate critical values are given in MacKinnon (1991).

3.1.2. Augmented Dickey Fuller Test

y_t series can be different than the first-order autoregressive processes and it can be explained as,

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + ... + a_{p-1} y_{t-p+1} + a_p y_{t-p} + \varepsilon_t . \qquad (3.1.2.1)$$

Under these conditons, to understand the presence of a unit root, augmented Dickey-Fuller procedure (ADF) is applied. Equations (3.1.1.1)-(3.1.1.3) can be extended as,

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (3.1.2.2)$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (3.1.2.3)$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t , \qquad (3.1.2.4)$$

where $\gamma = -\left(1 - \sum_{i=1}^{p} a_i\right)$ and $\beta_i = \sum_{j=i}^{p} a_j$. For all the equations (3.1.2.2)-(3.1.2.4), again the null hypothesis γ=0 is tested against the alternative γ<0 (Enders, 1995). The t-ratio for γ is,

$$t_\gamma = \frac{\hat{\gamma}}{se(\hat{\gamma})},$$

where $\hat{\gamma}$ is the estimate of γ, and $se(\hat{\gamma})$ is the standard error. As it is known, this t_γ statistic is compared with MacKinnon (1991) critical values.

While applying ADF tests, the correct order of the autoregressive process should be decided. If all the autoregressive terms are not included in the model, estimation of γ and its standard error may lead unreliable results. On the other hand, if too many lags are included, the power of the test reduces. Each additional lag included in the model will lead to additional parameter estimation, loss of observation and therefore, loss of degrees of freedom. One approach to select the appropriate lag length is first to choose a relatively long length, p, and to test whether the lag p is significant. If the last lag is not significant, then the regression equation is reestimated using a lag length p-1. This process is repeated until the last lag is significantly different from zero and there is no serial correlation. Also, to decide the optimum lag length, Akaike Information Criteria (AIC) and Schwartz Information Criteria (SIC) can be used.

3.2. Johansen Cointegration Test

The sequences $\{y_t\}$ and $\{z_t\}$ are cointegrated, if they are integrated of the same order, let us say d, or I(d), and their residual sequence is stationary. It is a known fact that OLS estimation procedure can be applied if the variables involved in the model are I(0). The violation of this assumption causes us to obtain spurious correlation (Granger and Newbold, 1974). While dealing this problem, Davidson et al. (1978) state that fitting the regression by using the first differences of the variables would result in a loss of valuable information about the long-run. Therefore, they propose an error correction mechanism (ECM) by combining the first differences of the short-run and undifferenced values of the long-run dynamics. However, Engle and Granger (1987) prove that this method developed by Davidson et al. (1978) is true if the variables in the model are cointegrated.

A theoretically more satisfying approach is developed by Johansen (1988) to consider the cointegration relationship when there are more than two variables. This procedure is explained in Watson and Teelucksingh (2002) as follows; x_t is composed of $(n,1)$ vector of I(1) variables whose vector autoregressive (VAR) representation is given as,

$$x_t = \Pi_1 x_{t-1} + \Pi_2 x_{t-2} + \ldots + \Pi_p x_{t-p} + \varepsilon_t \tag{3.2.1}$$

where Πs are (n,n) matrices. Equation (3.1.3.1) can also be written as,

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \ldots + \Gamma_{p-1} \Delta x_{t-p+1} + \Gamma x_{t-1} + \varepsilon_t \tag{3.2.2}$$

where

$$\Gamma_i = -\left(\Pi_{i+1} + \Pi_{i+2} + \ldots + \Pi p\right)$$

and

$$\Gamma = \left(-I + \Pi_1 + \Pi_2 + \ldots + \Pi_p\right).$$

The purpose of the Johansen procedure can be stated as follows;

(1) to determine the maximum number of cointegrating vectors

(2) to obtain the the maximum likelihood estimators of the cointegrating matrix (β) and adjustment parameters (α) for a given value of r.

The rank of the matrix Γ, r, is equal to the number of independent cointegrating vectors. There can be at most n-1 cointegrating vectors and if r=0, it is a known fact that the variables are not cointegrated and equation (3.2.2) is a VAR model in first differences. If $r=n$, the vector process is stationary. For $0<r<n$, the Γ matrix can be represented as

$$\Gamma = \alpha\beta' \tag{3.2.3}$$

where α and β are full column rank matrices with size (n,r),

$$\alpha = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \dots & \alpha_{1r} \\ \alpha_{21} & \alpha_{22} & \dots & \alpha_{2r} \\ \vdots & \vdots & \vdots & \vdots \\ \alpha_{n1} & \alpha_{n2} & \dots & \alpha_{nr} \end{bmatrix}, \text{ and } \beta = \begin{bmatrix} \beta_{11} & \beta_{12} & \dots & \beta_{1r} \\ \beta_{21} & \beta_{22} & \dots & \beta_{2r} \\ \vdots & \vdots & \vdots & \vdots \\ \beta_{n1} & \beta_{n2} & \dots & \beta_{nr} \end{bmatrix}$$

Equation (3.2.2) is denoted as a vector error correction model (VECM). When there are r cointegrating vectors, r error correction terms appear in each of the n equations. For instance, in the first equation (explaining Δx_{1t}), $\alpha\beta' x_{t-1}$ consists of terms,

$$\alpha_{11}\left(\beta_1' x_{t-1}\right) + \alpha_{12}\left(\beta_2' x_{t-1}\right) + \dots + \alpha_{1r}\left(\beta_r' x_{t-1}\right)$$

It is known that the number of cointegrating vectors is equal to the number of significant characteristic roots of the matrix Γ. Suppose the ordered characteristic roots of the matrix Γ are; $\lambda_1 > \lambda_2 > \dots > \lambda_n$. To obtain the number of characteristic roots that are different from zero, Johansen proposes the following tests, that are based on trace and maximum eigenvalue statistics, respectively.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right) \tag{3.2.4}$$

$$\lambda_{\max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \tag{3.2.5}$$

where $\hat{\lambda}_i$ is the estimated values of the characteristic roots (eigenvalues) of the estimated Γ matrix and T is the number of usable observations.

The trace statistic tests whether the number of cointegrating vectors is less than or equal to r against a general alternative, while the alternative hypothesis for maximum eigenvalue statistic is r+1. The critical values for these statistics are calculated by Johansen and Juselius (1990) with the help of simulation.

3.3. Description of the Data

All the data are obtained from World Development Indicators (WDI) database of the World Bank over the period 1981-2002 (annualy). The data availability constraints us to consider only 23 countries which are Australia, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, South Africa, Spain, Switzerland, the United Kingdom and the USA.

According to the WDI database, real effective exchange rate (2000=100) is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator and real interest rate, is the lending interest rate adjusted for inflation as measured by the GDP deflator. While calculating the real interest rate differential, the US real interest rate is taken as the foreign real interest rate, r^*. All variables are used in the log form and "d" denotes the first difference of variables,

The abbreviations of the variables used in this study are,

q: natural logarithm of the real exchange rate,

r: natural logarithm of [1+ real interest rate/100],

r-r^*: real interest rate differential.

The graphical representation of the levels and first differences of all the variables investigated in this study, are given in the appendix. The time series plots of the levels of the variables purport to be nonstationary processes. However, to obtain the exact integration levels of the variables, only considering the plots is not reliable. Therefore, ADF tests are applied. These test statistics are calculated with a constant (λ_m) and a constant plus a linear time trend (λ_t). The optimum length length is decided with respect to SIC. The results of the ADF test results are given in Table 1.

Table 1. ADF Test Results

		Levels				First Differences	
Series		lag	λ_m	lag	λ_t	lag	λ_m
Australia	q	4	-1.299	2	-3.524	3	-5.123*
	r	0	-2.242	0	-2.258	1	-3.842*
	r-r^*	0	-2.767	0	-2.476	0	-3.731*
Belgium	q	0	-1.753	0	-1.992	0	-4.844*
	r	0	-1.660	0	-2.391	0	-6.870*
	r-r^*	0	-2.397	0	-2.261	0	-5.112*
Canada	q	0	-0.522	1	-2.914	0	-3.209*
	r	0	-2.601	0	-3.573	0	-5.527*
	r-r^*	0	-2.981	0	-0.083	0	-6.472*
Chile	q	2	-2.160	1	-2.764	0	-2.718
	r	2	-2.652	2	-2.600	1	-4.779*
	r-r^*	2	-2.762	2	-2.640	1	-4.949*
China	q	0	-2.400	0	-0.728	0	-2.665
	r	0	-2.046	0	-2.126	0	-4.037*
	r-r^*	0	-2.124	0	-2.437	1	-4.870*
Denmark	q	0	-1.496	0	-1.627	0	-4.120*
	r	1	-1.134	0	-3.061	0	-7.680*
	r-r^*	0	-2.629	0	-2.529	0	-5.043*
Finland	q	2	-0.736	3	-2.171	1	-4.161*
	r	0	-2.457	0	-2.220	0	-4.398*
	r-r^*	0	-2.468	0	-2.306	0	-4.415*
France	q	0	-1.848	0	-1.879	0	-3.798*
	r	0	-2.169	0	-1.728	0	-5.447*
	r-r^*	0	-2.162	0	-1.946	0	-4.192*

Table 1. ADF Test Results (continued)

		Levels				First Differences	
Series		lag	λ_m	lag	λ_t	lag	λ_m
Germany	*q*	0	-1.922	0	-1.748	0	-4.173*
	r	0	-2.773	0	-3.549	0	-5.360*
	$r\text{-}r^*$	0	-1.016	3	-2.266	0	-4.237*
Greece	*q*	1	-2.430	1	-3.221	0	-2.813
	r	0	-1.459	3	1.264	0	-6.423*
	$r\text{-}r^*$	0	-1.675	0	-1.169	0	-6.723*
Iceland	*q*	0	-2.646	0	-2.852	0	-4.657*
	r	3	-3.626	1	-2.378	0	-7.283*
	$r\text{-}r^*$	0	-2.158	0	-3.358	0	-6.994*
Ireland	*q*	0	-2.419	3	-3.562	2	-3.233*
	r	0	-1.858	0	-2.832	0	-5.613*
	$r\text{-}r^*$	0	-2.538	0	-2.881	0	-5.325*
Israel	*q*	0	-2.331	3	-3.213	3	-3.278*
	r	3	-2.638	2	-2.591	3	-4.772*
	$r\text{-}r^*$	3	-2.594	3	-2.088	3	-4.995*
Italy	*q*	0	-1.774	0	-1.938	0	-3.705*
	r	0	-2.941	0	-2.823	0	-3.449*
	$r\text{-}r^*$	2	-2.244	2	2.207	0	-3.375*
Japan	*q*	3	-2.531	4	-1.504	2	-3.436*
	r	0	-2.902	1	-3.457	1	-4.807*
	$r\text{-}r^*$	0	-2.789	0	-2.757	0	-4.762*
Netherlands	*q*	0	-1.634	0	-1.440	0	-4.553*
	r	0	-0.639	0	-1.492	0	-5.664*
	$r\text{-}r^*$	0	-1.322	0	-1.649	0	-4.000*

Table 1. ADF Test Results (continued)

		Levels				First Differences	
Series		lag	λ_m	lag	λ_t	lag	λ_m
NewZealand	q	4	-3.006	4	-2.195	4	-4.077*
	r	1	-2.626	1	-3.346	1	-4.476*
	r-r^*	0	-2.492	1	-3.203	1	-4.648*
Norway	q	0	-1.557	0	-1.485	0	-2.959
	r	0	-2.921	1	-3.117	1	-4.927*
	r-r^*	0	-2.879	1	-2.891	1	-4.292*
South Africa	q	0	-0.374	0	-1.481	0	-3.591*
	r	1	-1.764	1	-2.475	0	-5.917*
	r-r^*	0	-2.074	1	-2.817	0	-6.456*
Spain	q	1	-1.798	1	-1.765	0	-3.400*
	r	1	-1.022	2	-1.397	0	-7.998*
	r-r^*	0	-2.398	0	-2.307	0	-6.886*
Switzerland	q	0	-2.324	0	-2.654	1	-4.967*
	r	0	-2.792	0	-3.296	0	-7.073*
	r-r^*	0	-2.405	0	-3.000	0	-5.657*
UK	q	0	-1.444	3	-2.673	0	-3.241*
	r	0	-2.206	1	-2.769	1	-3.830*
	r-r^*	1	-2.474	0	-3.380	0	-4.902*
USA	q	1	-1.907	0	-0.798	0	-3.178*
	r	0	-2.027	0	-2.383	0	-4.407*

(*) statistics that are significant at the 5% level.

According to the ADF results displayed in Table 1, all the real interest rate differentials and the majority of real exchange rates are integrated of order 1, I(1) at the 0.05 significance level. On the other hand, the real exchange rates of Chile, China, Greece and Norway can be considered as I(1) processes at the 0.10 significance level. Therefore, the results of the ADF unit root tests can be interpreted not to preclude the validity of employing the Johansen cointegration procedure for our sample.

3.4. Empirical Results of RERI Relationship

In this section we employ the Johansen (1988) cointegration procedure to investigate the presence of a long-run relationship between the real exchange rates (q_t) and real interest rate differentials ($r_t - r_t^*$). Considering the results that all the real exchange rates and real interest rate differentials are I(1), we consider all the countries for the analysis. We test the null of no cointegration by using both the Johansen maximum eigenvalue ($\lambda_{\max}$) and trace (λ_{trace}) statistics for a VAR model with a constant and without trend.

In Table 2, eigenvalues(λ_i), the maximum eigenvalue ($\lambda_{\max}$) and trace eigenvalue (λ_{trace}) statistics are reported. Our variable space x_t consists of two variables which are, q_t and $r_t - r_t^*$. The appropriate lag lengths for the VAR model are selected according to the sequential modified likelihood ratio (LR) test, AIC and SIC.

Table 2. Tests of the Cointegration Rank

	Lag	Ho: *r*	λ_i	λ_{max}	λ_{trace}
Australia	1	0	0.431	11.269	16.744
		1	0.239	5.474	5.474
Belgium	1	0	0.450	11.953	18.080
		1	0.264	6.127	6.127
Canada	4	0	0.684	19.590*	23.310*
		1	0.196	3.720	3.720
Chile	2	0	0.486	12.636	19.550
		1	0.305	6.914	6.914
China	1	0	0.335	8.185	13.879
		1	0.248	5.694	5.694
Denmark	1	0	0.312	7.494	11.361
		1	0.177	3.897	3.897
Finland	1	0	0.312	7.488	9.981
		1	0.117	2.493	2.493
France	1	0	0.416	10.746	16.481
		1	0.249	5.735	5.735
Germany	2	0	0.097	1.936	2.252
		1	0.016	0.316	0.316
Greece	2	0	0.386	9.261	13.196
		1	0.187	3.935	3.935
Iceland	1	0	0.366	9.118	14.888
		1	0.251	5.769	5.769
Ireland	1	0	0.328	7.943	11.063
		1	0.144	3.119	3.119

Table 2. Tests of the Cointegration Rank (continued)

	Lag	Ho: r	λ_i	λ_{max}	λ_{trace}
Israel	1	0	0.545	15.751	18.737
		1	0.139	2.987	2.987
Italy	1	0	0.600	18.345*	22.062*
		1	0.170	3.717	3.717
Japan	1	0	0.318	7.647	11.713
		1	0.184	4.067	4.067
Netherlands	1	0	0.296	7.020	9.846
		1	0.116	2.466	2.466
NewZealand	1	0	0.422	10.946	16.873
		1	0.256	5.927	5.927
Norway	1	0	0.461	12.361	18.792
		1	0.275	6.432	6.432
South Africa	1	0	0.226	5.119	8.707
		1	0.164	3.589	3.589
Spain	1	0	0.443	11.697	16.202
		1	0.202	4.505	4.505
Switzerland	1	0	0.588	17.725*	25.371*
		1	0.318	7.646	7.646
UK	1	0	0.287	6.775	10.220
		1	0.158	3.445	3.445

(*) statistics that are significant at the 5% level. 95% critical value for λ_{trace} (r=0)=20.26184, λ_{trace} (r=1)=9.164546 and $\lambda_{\max}$ (r=0)=15.89210, $\lambda_{\max}$ (r=0)=9.164546.

From Table 2, it is seen that there is cointegration between the real exchange rates and real interest rate differentials for the countries Canada, Italy and Switzerland at the 0.05 significance level. Also, for the countries Belgium, Chile, Israel and Norway it can be concluded that there exists long-run relationships at the 0.10 significance level (90% critical value for $\lambda_{trace}(r=0)=17.98038$, $\lambda_{trace}(r=1)=7.556722$ and $\lambda_{\max}(r=0)=13.90590$, $\lambda_{\max}(r=0)=7.556722$). However, for the countries Belgium, Chile and Norway, this unique cointegrating vector is indicated only by λ_{trace} statistic. For all these seven countries for which the null of no cointegration is rejected in favour of one, the cointegrating equations normalized by q are given in Table 3. The values in paranthesis denote the standard errors.

Table 3. Estimated Cointegrating Equations Normalized by the Real Exchange Rate

Country	Normalized Cointegrating Equations
Belgium	$q = 4.624 + 2.214(r - r^*)$ (0.016) (0.809)
Canada	$q = 4.718 + 7.544(r - r^*)$ (0.020) (1.123)
Chile	$q = 2.777 + 44.757(r - r^*)$ (0.848) (11.613)
Israel	$q = 4.535 - 0,465(r - r^*)$ (0.018) (0.116)

Table 3. Estimated Cointegrating Equations Normalized by the Real Exchange Rate (continued)

Country	Normalized Cointegrating Equations
Italy	$q = 4.626 + 9.830(r - r^*)$ (0.047) (1.757)
Norway	$q = 4.657 + 0.874(r - r^*)$ (0.011) (0.243)
Switzerland	$q = 4.698 + 2.800(r - r^*)$ (0.015) (0.427)

The results by Table 3 suggest that the real interest rate differential is significant in the explanation of the long-run evolution of real exchange rates for Belgium, Canada, Chile, Israel, Italy, Norway and Switzerland. We expect a positive real interest rates differential coefficient as higher real interest rates lead to capital inflows for a financially open economy, and thus real exchange rate appreciation. The coefficient of the interest rate differential (positive) is theory-consistent with every country except Israel. The negative interest differential coefficient for Israel may not be surprising if we consider the plausable fact that Israel may be classified as the least financially open economy among these seven countries for which a cointegration evidence is not rejected. Furthermore, Israel experienced a fixed exchange rate regime for the considerable part of our sample period.

Table 4. Estimated Adjustment Coefficients, α

Country	d(q)	standard error	d(r-r*)	standard error
Belgium	-0.3268	0.0988	0.0111	0.0831
Canada	-0.0309	0.1106	0.1441	0.0264
Chile	0.0083	0.0065	0.0243	0.0063
Israel	-0.4721	0.1609	-0.7986	0.5488
Italy	0.0928	0.0498	0.0745	0.0158
Norway	-0.0888	0.1556	0.8133	0.2726
Switzerland	-0.6526	0.1820	0.1649	0.0996

Table 4 provides the estimates of the adjustment coefficients and their standard errors for the real exchange rate and interest differential equations. As discussed Johansen and Juselius (1992) and Juselius (1995) the significance of the adjustment coefficients suggests the rejection of the weak exogeneity null of the variable for the corresponding error/equilibrium correction (ECM) representation. Consequently, according to the results presented in Table 4, real exchange rates appear to be endogenous for the evolution of the long-run relationship between real exchange rates and real interest differentials for the countries except Canada, Chile and Norway. This supports our normalization of the cointegration vector as to represent a long-run real exchange rate equation for these countries. The magnitude of the adjustment coefficients suggest a relatively fast adjustment to a disequilibria (around two periods) for the countries except Italy. However, for the countries Canada, Chile and Norway, the adjustment coefficients are statistically insignificant in the for Δq equations suggesting the weak exogeneity of real exchange rates in the cointegration vector. Consequently, for those countries, presenting the cointegrating vector as representing a long-run real exchange rate may be unreliable due to an invalid conditioning. Therefore, we normalize these cointegrating equations with respect to real interest rate differential and the estimated adjustment coefficients are presented in Table 5. According to these results, all the adjustment coefficients for (r-r^*) are statistically significant supporting our normalization. Table 6 presents the cointegration relations consistent with the endogeneity of the real interest rate differential for the parameters of the long-run relationships.

Table 5. Estimated Adjustment Coefficients Normalized by (r-r^*)

Country	d(r-r^*)	standard error	d(q)	standard error
Canada	-1.0869	0.1993	0.2331	0.8344
Chile	-1.0888	0.2834	-0.3693	0.2946
Norway	-0.7112	0.2384	0.0777	0.1360

Table 6. Estimated Cointegrating Equations Normalized by (r-r^*)

Country	Normalized Cointegrating Equations
Canada	$(r - r^*) = -0.625 + 0.133q$ (0.123) (0.026)
Chile	$(r - r^*) = -0.062 + 0.022q$ (0.397) (0.087)
Norway	$(r - r^*) = -5.325 + 1.144q$ (1.641) (0.351)

Our results are consistent with those presented by Bagchi *et al.* (2003) which investigates the effects of terms of trade and expected real interest rate differential on the real exchange rate. As Bagchi *et al. (2003)* argue, real interest rate differentials and terms of trade capture financial and goods market developments, respectively. Bagchi *et al. (2003)* note that the bulk of the literature on RERI consider mainly the large developed countries, therefore they deal with nine small open developed economies; Australia, Austria, Canada, Finland, Italy, New Zealand, Norway, Portugal and Spain. In our study, not only these countries (except for Austria and Portugal) but also sixteen more countries are examined. Although we have a different sample period, our results appear to be essentially the same with the Johansen cointegration evidence of Bagchi *et al. (2003).* According to Bagchi *et al.* (2003, p. 14)

> Failure to verify empirically that high real domestic interest rates lead to a real currency appreciation is not uncommon, usually attributed to the use of monetary policy to defend pegged exchange rates. Since our sample considers exchange rates that were more or less flexible, we believe that this result may exist because of the presence of different restrictions on capital flows.

The RERI relationship is also investigated by Hoffmann and MacDonald (2003) for the period 1978 to 1997 for the G7 countries. Similar to our study, they use a VAR specification with an unrestricted constant and without trend and then apply Johansen's test for cointegration. However, different from our results, they conclude no-cointegration for all the countries other than the UK. However, Hoffmann and MacDonald (2003) maintain that the real interest rate differential is a stationary variable which indeed may suggest that their Johansen cointegration evidence should be interpreted with a caution. Hoffmann and MacDonald (2003) present also a conventional VAR-based approach as an alternative to cointegration-based tests of the RERI and they claim that this approach harmonizes with the logic of the RERI relationship. They also demonstrate that the expected changes in the exchange rate are more volatile than the real interest differential itself.

Another similar study which examines the long-run relationship between real exchange rates and real interest rate differentials is provided by Macdonald and Nagayasu (2000) for the period 1976-1997 for a panel of fourteen industrialized countries. They apply not only the Johansen procedure but also panel cointegration methods. For the individual country cointegration analysis, they carry out Johansen cointegration test to the countries which have I(1) exchange rate and interest rate differential series. According to their findings, they conclude a long-run relationship between the real exchange rates and real interest rate differentials for the country, Switzerland, which is also consistent with our results.

The question of whether there exists a systematic relationship between the real exchange rate and the real interest rate differential is also examined by Edison and Melick (1999) by using the Johansen (1988) multivariate cointegration procedure. They use four exchange rates and two horizons for the period 1974-1994. While dealing with RERI relationship, they employ and compare three different approaches (standard, standard with additional variables, and *ex post*). From their empirical findings, they conclude that for three of the four exchange rates, there is a single cointegrating vector in systems containing the long maturity interest rates.

CHAPTER 4

CONCLUSION

The long-run relationships between real exchange rates and real interest rate differentials (often referred to as RERI) in financially open economies are central to the international financial economics literature. Both the theoretical and empirical literature offer an extensive list of potential fundamental determinants of real exchange rates. These factors include, differentials in inflation rates (purchasing power parity, PPP), interest rates (uncovered interest parity, UIP), productivity (Balassa-Samuelson affect), money growth rates (monetary model), capital accumulation, current account balances, government spending, wealth, terms of trade and so on. The literature on the validity of RERI is extensive and growing. The empirical support for the RERI hypothesis based on recently developed time-series and panel data procedures, however, appear to be weak and often conflicting. As the bulk of the empirical literature consider advanced industrial countries data, it may be interesting to test the RERI hypothesis for a data set containing both developing and developed countries. To this end, in this thesis, we consider annual data spanning from 1981 to 2002 of a broad number of countries, including Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, South Africa, Spain, Switzerland, the United Kingdom and the United States.

The results of the ADF test statistics suggest that all the real exchange rate and real interest rate differential variables are individually integrated of order 1 (I(1). The nonstationarity of the real exchange rates indeed rejects the validity of the absolute (or strong) purchasing power parity (PPP) hypothesis for these countries. This may not be surprising, as real interest rate differentials may be expected to have a role in the long-run evolution of real exchange rates for a financially open economy. Consequently, international capital flows responding to differentials in real returns (real interest rate differences) can be interpreted as a plausible reason for the deviations of the real exchange rates from the absolute PPP condition in the long-run. In the same vein, the nonstationarity of the real interest rate differentials suggests that real domestic and foreign interest rates are not cointegrated with a unitary coefficient. Consistent with an argument that a disequilibrium in one market can have repercussions on the others, real exchange rates and real interest rate differentials representing basically the international commodity and financial market equilibirium conditions, respectively, may not be independent from each other in the long run. The RERI hypothesis, in fact, postulates such a long-run relationship.

The results of the Johansen cointegration analysis suggest the rejection of the null of no cointegration in favour of one for Canada, Italy, Switzerland Belgium, Chile, Israel and Norway. The RERI relationship expects a positive real interest rates differential coefficient in the long-run real exchange rate equations as higher real interest rates lead to capital inflows for a financially open economy, and thus real exchange rate appreciation. The cointegration results with positive interest rate differential coefficients appears to be theory-consistent with every country except Israel. The negative interest differential coefficient for Israel may not be surprising if we consider the plausable fact that Israel may be classified as the least financially open economy among these seven countries for which a cointegration evidence is not rejected. Furthermore, Israel experienced a fixed exchange rate regime for the considerable part of our sample period. This suggests the importance of the exchange rate regime and the degree of openness to international capital flows in the determination of the real exchange rates.

The empirical literature on RERI often maintains that real exchange rates are the endogenous variables for the parameters of the long-run relationships between real exchange rates and real interest rate differentials. The results of the weak exogeneity tests support this hypothesis for Italy, Switzerland, Belgium and Israel. However, for Canada, Chile and Norway, real interest rate differential variables are found to be endogenous for the cointegration relationship. Considering the fact that, foreign interest rates do not adjust to the domestic variables of a small open economy, this result can be interpreted as supporting the endogeneity of the domestic real interest rates. The endogenous response of domestic interest rates to a real exchage rate shock is indeed consistent with a monetary policy rule defending the value of the domestic currency with interest rates. The magnitudes of the adjustment coefficients for both the long run real interest rate differential and real exchange rate equations suggest a relatively fast adjustment to a disequilibria (around two periods) for most of the the countries.

The results of this study are consistent with the results of earlier studies (such as Bagchi *et al.* (2003), Hoffmann and MacDonald (2003), Macdonald and Nagayasu (2000) and Edison and Melick (1999), in the sense that the RERI hypothesis, may be valid only for a small number of countries. However, there appears to a need for an explicit consideration of the prevailing exchange rate regimes and the degree of the financial openness of the country in testing the validity of the RERI relationships. Our results further suggest the importance of the weak exogeneity tests for the identification of the long-run relationships such as RERI as the cointegration vector may indeed be representing a domestic real interest rate equation rather than a real exchange rate equation for some countries.

REFERENCES

Azali, M., Habibullah, M. S. and A. Z. Baharumshah (2001), "Does PPP Hold between Asian and Japanese Economies? Evidence Using Panel Unit Root and Panel Cointegration" *Japan and the World Economy*, 13, 35-50.

Bagchi, D., Chortareas, G. E. and M. M. Stephen (2003), "The Real Exchange Rate in Small Open Developed Economies: Evidence from Cointegration Analysis" *University of Connecticut, Department of Economics Working Paper Series, Working Paper 2003-27.*

Banerjee, A. (1999), "Panel Data Unit Roots and Cointegration: An Overview" *Oxford Bulletin of Economics and Statistics, Special Issue,* 607-629.

Baxter, M. (1994), "Real Exchange Rates and Real Interest Rate Differentials: Have we Missed the Business Cycle Relationship?" *Journal of Monetary Economics.* 33 1, 5-37.

Camerero, M. and C. Tamarit (2002), "A panel Cointegration Approach to the Estimation of the Peseta Real Exchange Rate," *Journal of Macroeconomics*, 24, 371-393.

Cashin, P. and C. J. McDermott (2003), "An Unbiased Appraisal of Purchasing Power Parity," IMF Staff Papers, 50, No.3.

Chinn, M. (1991), "Some Linear and Nonlinear Thoughts on Exchange Rates," *Journal of International Money and Finance,* 10, 214-230.

Chinn, M. D. and G. Meredith (2005), "Testing Uncovered Interest Parity at Short and Long Horizons During the Post-Bretton Woods Era," NBER Working Paper Series 11077.

Coakley, J., Flood, R. P., Fuertes, A. M. and M. P. Taylor (2005), "Purchasing Power Parity and the Theory of General Relativity: The First Tests" *Journal of International Money and Finance,* 24(2), 293-316.

Coughlin, C. C. and K. Koedijk (1990), "What do we Know About the Long-Run Real Exchange Rate?" St. Louis Federal Reserve Bank Review, 72, 36-48.

Davidson, J. H., Hendry, D. H., Srba F. and S. Yeo (1978), "Econometric Modelling of the Aggregate Time-Series Relationship Between Consumer's Expenditure and Income in the United Kingdom" *Economic Journal* 88, 661-692.

Dickey, D. and W. A. Fuller (1979), "Distribution of the Estimates for Autoregressive Time Series with a Unit Root" *Journal of American Statistical Association,* 74, 427-31.

Dickey, D. and W. A. Fuller (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root" *Econometrica,* 49, 1057-72.

Dornbusch, R. (1976), "Expectations and Exchange Rate Dynamics", J*ournal of Political Economy,* 84, 1161-1176.

Dornbusch, R. and P. Krugman (1976), "Flexible Exchange rates in the Short Run" *Brooking Papers on Economic Activity*, 76, 537-75.

Driver, R. L. and P. F. Westaway (2004), "Concepts of Equilibrium Exchange Rates," Bank of England Working Paper No. 248.

Edison, H. J. and W. R. Melick (1999), "Alternative Approaches to Real Exchange Rates and Real Interest Rates: Three Up and Three Down," *International Journal of Finance and Economics*, 31(April), 93-112.

Edison, H. J. and B. D. Pauls (1993), "A Re-Assessment of the Relationship between Real Exchange Rates and Real Interest Rates: 1974-1990" *Journal of Monetary Economics,* 31 (April), 165-187.

Enders, W. (1995), *Applied Econometric Time Series*. John Wiley and Sons.

Engle, R. F. and C. W. J. Granger (1987), "Co-Integration and Error Correction: Representation, Estimation, and Testing" *Econometrica* 55, 251-276.

Flood, R. P. and A. K. Rose (2001), "Uncovered Interest Parity in Crisis: The Interest Rate Defence in the 1990s" CEPR Discussion Paper No. 2943.

Fujii, E. and M. Chinn (2001), "Fin de Siécle Real Interest Parity" *Journal of International Financial Markets, Institutions and Money,* 11, 289-308.

Granger, C. W. J. and P. Newbold (1974), "Spurious Regressions in Econometrics", *Journal of Econometrics* 2, 111-120.

Herwartz, H. and H.-E. Reimers (2002), "Testing the Purchasing Power Parity in Pooled Systems of Error Correction Models" *Japan and World Economy,* 14, 45-62.

Hoffmann, M. and R. MacDonald (2003), "A Re-Examination of the Link Between Real Exchange Rates and Real Interest Rate Differentials," Cesifo Working Paper No. 894.

Im, K. S., Pesaran M. H. and S. Yongcheol (1997), "Testing for Unit Roots in Heterogenous Panels," Discussion Paper University of Cambridge, December.

Jin, Z. (2003), "The Dynamics of Real Interest Rates, Real Exchange Rates and the Balance of Payments in China: 1980-2002" IMF Working Paper, April 2003.

Johansen, S. (1988), "Statistical Analysis of Co-integration Vectors" *Journal of Economic Dynamics and Control,* Vol. 12 (June-September), 231-54.

Johansen, S. and K. Juselius (1990), "Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money" *Oxford Bulletin of Economics and Statistics* 52, 169-209.

Johansen, S. and K. Juselius (1992), "Testing Structural Hypotheses in a Multivariate Cointegration Analysis of PPP and the UIP for for UK" *Journal of Econometrics*, 53, 211-44.

Juselius, K. (1995), "Do Purchasing Power Parity and Uncovered Interest Parity Hold in the Long Run? An Example of Likelihood Inference in a Multivariate Time-Series Model" *Journal of Econometrics,* 69, 211-40.

Juselius, K. and R. MacDonald (2003), "International Parity Relationships and a Nonstationary Real Exchange Rate: Germany versus the US in the post Bretton Woods Period" Strathclyde Discussion Papers in Economics, No. 03-12.

Kao, C. (1999), "Spurious Regression and Residual-Based Tests for Cointegration in Panel Data" *Journal of Econometrics*, 90, 1-44.

Lothian , J. R. and M. P. Taylor (1996), "Real Exchange Rate Behavior: The Recent Float from the Perspective of the Past Two Centuries" *Journal of Political Economy*, 104, 488-509.

MacDonald, R. (1997), "What Determines Real Exchange Rates: The Long and Short of It" IMF Working Paper 97/21 (Washington: International Monetary Fund).

MacDonald, R. (1998), "What Determines Real Exchange Rates? The Long and the Short of It," *Journal of International Financial Markets, Institutions and Money*, 8, 117-153.

MacDonald, R. (2000), "Concepts to Calculate Equilibrium Exchange Rates: An Overview", Economic Research Group of the Deutsche Bundesbank Discussion Paper, No.3/00.

MacDonald, R. and J. Nagasayu (2000), "The Long-Run Relationship Between Real Exchange Rates and Real Interest Rate Differentials: A Panel Study", IMF *Staff Papers*, 47, 1, 116-128.

MacKinnon, J. G. (1991), "Critical Values for Cointegration Tests" Chapter 13 in R. F. Engle and C. W. J. Granger (Eds.), Long-run Economics Relationships: Readings in Cointegration, *Oxford University Press.*

McCoskey, S. and C. Kao (2001), "A Monte Carlo Comparison of Tests for Cointegration in Panel Data," *Journal of Propagations in Probability and Statistics*, 1, 165-198.

Meese, R. and K. Rogoff (1983), "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *Journal of International Economics*, 14, 3-24.

Meese, R. and K. Rogoff (1988), "What is Real? The Exchange Rate-Interest Differential Relation Over the Modern Floating-Rate Period," *Journal Of Finance,* Vol. XLIII, No. 4 (September), 933-48.

Micheal, P., Avolio R. N. and D. A. Peel (1997), "Transactions Costs and Nonlinear Adjustment in Real Exchange Rates: An Empirical Investigation," *Journal of Political Economy* 105, 862-79.

Mussa, M. M. (1990), "Exchange Rates in Theory and Reality", *Essays in International Finance,* no. 179, Princeton University Department of Economics International Finance Section, Princeton, New Jersey, (1990 Frank D. Graham Memorial Lecture).

Özmen, E. and A. Gökcan (2004), "Deviations from PPP and UIP in a Financially Open Economy: The Turkish Evidence" *Applied Financial Economics*, 2004, 1-6.

Pedroni, P. (1995), "Panel Cointegration, Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with an Application to the PPP Hypothesis." India University, Working Paper in Economics, No. 95-031, June.

Pedroni, P. (1997), "Panel Cointegration, Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with an Application to the PPP Hypothesis: New Results" India University, Working Paper in Economics, November.

Pedroni, P. (1999), “Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors,” *Oxford Bulletin of Economics and Statistics*, 61, 653-678.

Quah, D. (1994), “Exploiting Cross-Section Variance for Unit Root Inference in Dynamic Data,” *Economics Letters*, 44 (Nos. 1-2), 9-19.

Rogoff, K. (1996), “The Purchasing Power Parity Puzzle” *Journal of Economic Literature*, 34, 647-68.

Sarantis, N. (1999), “Modeling Nonlinearities in Real Effective Exchange Rates” *Journal of International Money and Finance* 18, 27-45.

Sarno, L. and M. P. Taylor (2001), “Purchasing Power Parity and the Real Exchange Rate” CEPR Discussion Paper No. 2913.

Sarno, L. and M. P. Taylor (2002), *The Economics of Exchange Rates*, Cambridge University Press, London.

Sarno, L. and M. P. Taylor (2001a), *The Microstructure of the Foreign Exchange Market: a Selective Survey of Literature,* Princeton: Princeton University.

Sarno, L. and M. P. Taylor (2001b), “Official Intervention in the Foreign Exchange Market: Is It Effective and, if so, How does It Work?” *Journal of Economic Literature,* 39, 839-68.

Taylor, A. M. (2001), “Potential Pitfalls for the Purchasing Power Parity Puzzle: Sampling and Specification Biases in Mean-Reversion Tests of the Law of One Price” *Econometrica,* 69, 473-498.

Taylor, M. P. and D. A. Peel (2000), "Nonlinear Adjustment, Long-Run Equilibrium and Exchange Rate Fundamentals" *Journal of International Money and Finance*, 19, 33-53.

Taylor, M. P., Peel D. A. and L. Sarno (2001), "Nonlinear Mean-Reversion in Real Exchange Rates: Towards a Solution to the Purchasing Power Parity Puzzles" *International Economic Review*, 42, 1015-42.

Taylor, M. P. and L. Sarno (1998), "The Behavior of Real Exchange Rates During the Post-Bretton Woods Perod" *Journal of International Economics*, 46, 281-312.

Taylor, M. P. and L. Sarno (2004), "International Real Interest Rate Differentials, Purchasing Power Parity and the Behaviour of Real Exchange Rates: the Resolution of a Conundrum" *International Journal of Financial Economics*, 9, 15-23.

Taylor, A. M. (2002), "A Century of Purchasing Power Parity" *Review of Economics ans Statistics 74*, 139-50.

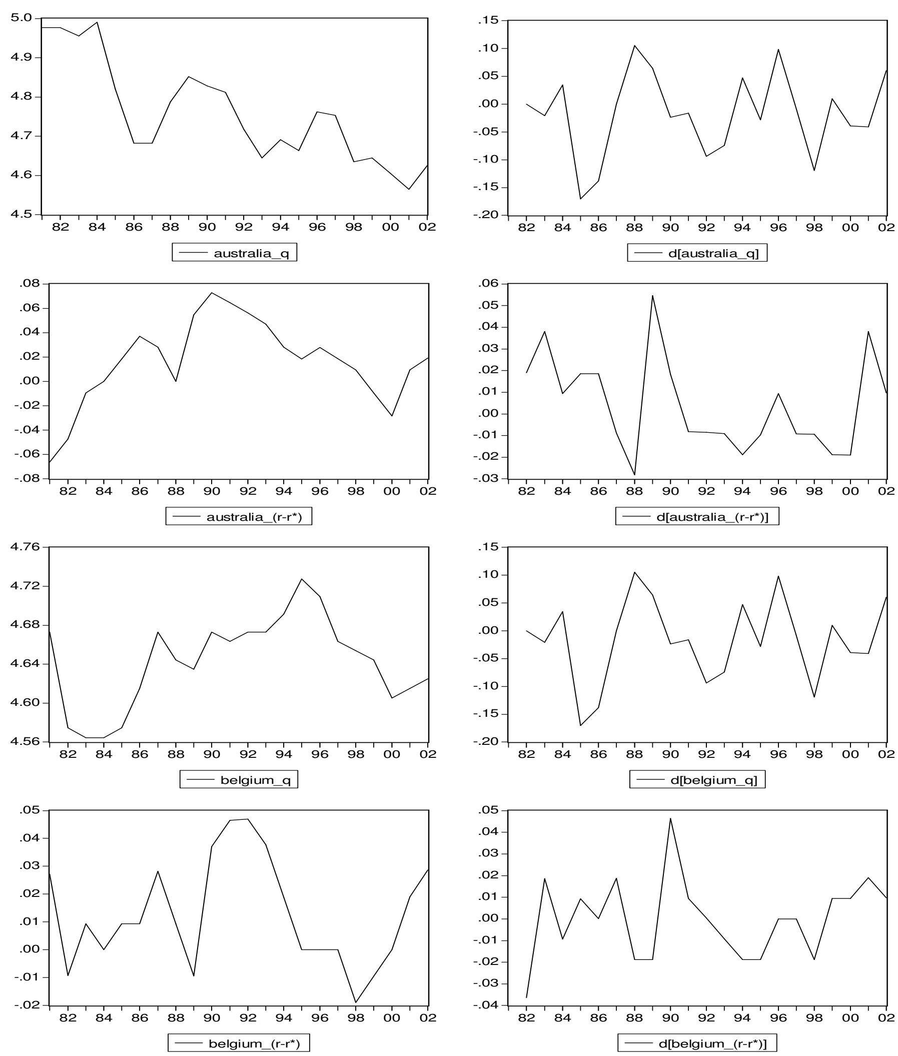
Taylor, M. P. (2003), "Purchasing Power Parity" *Review of International Economics*, 11(3), 436-452.

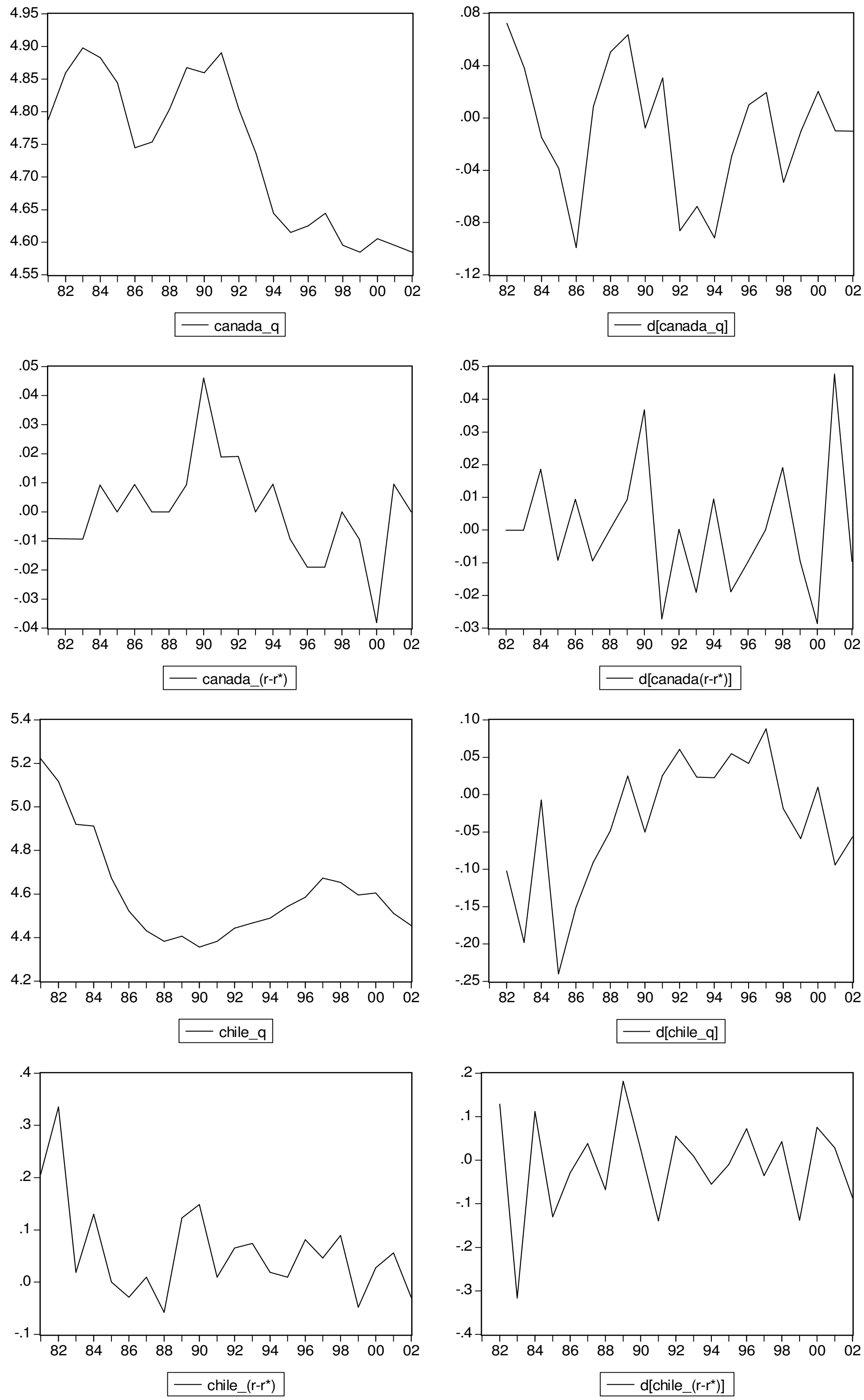
Throop A., (1994), "A Generalised Uncovered Interest Parity Model of Exchange Rates" Federal Reserve Bank of San Fransisco, *mimeo.*

Watson, P. K. and S. S. Teelucksingh (2002), *A Practical Introduction Econometric Methods: Classical and Modern,* University of the West Indies Press.

APPENDIX

Time Series Plots of the Variables Used in Analysis

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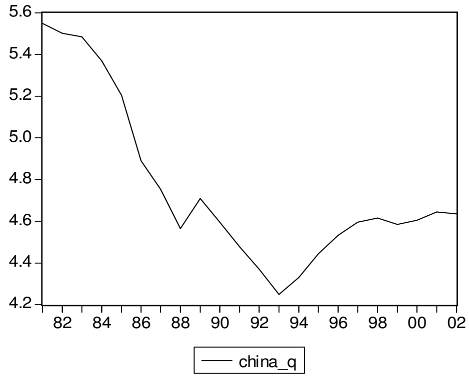
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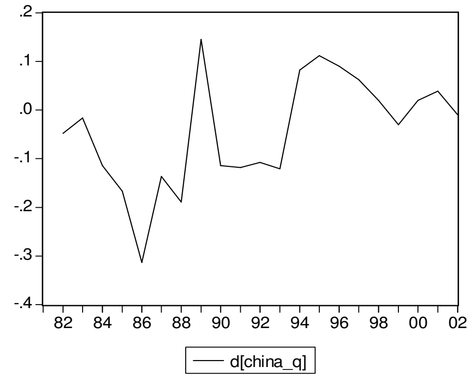
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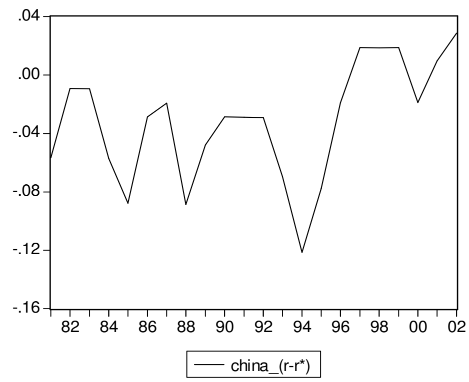
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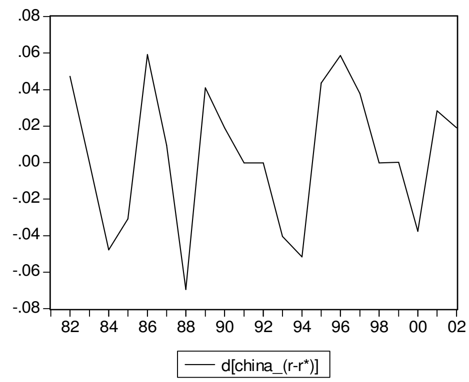
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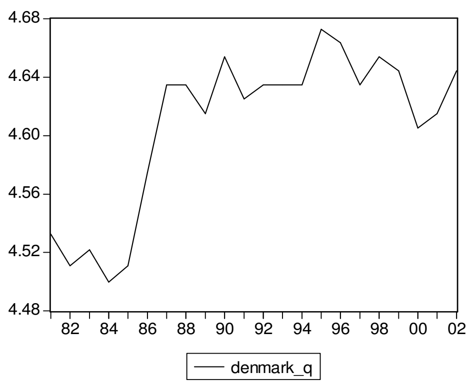
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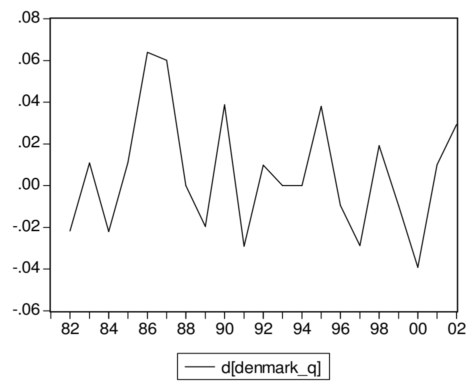
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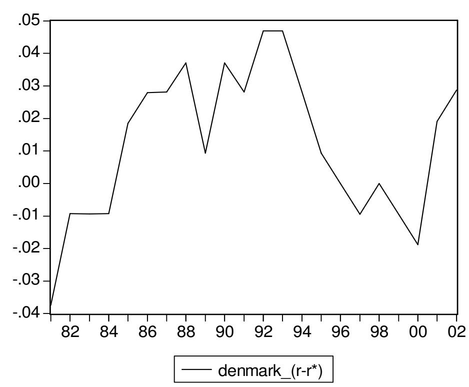
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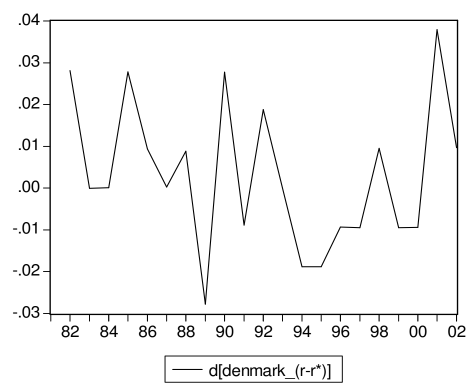
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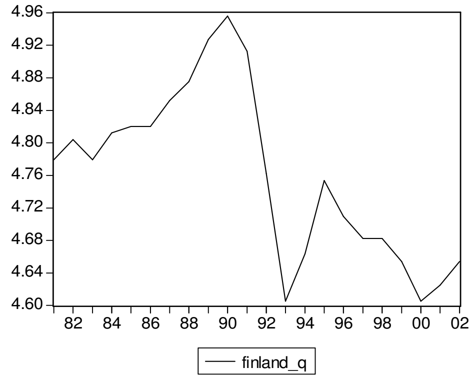
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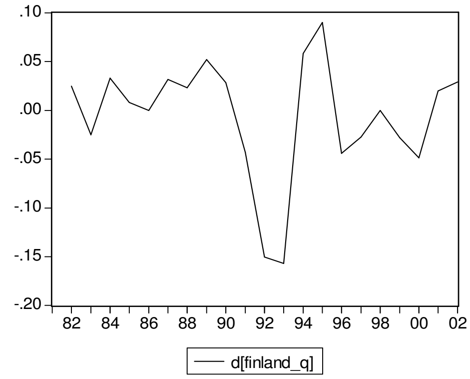
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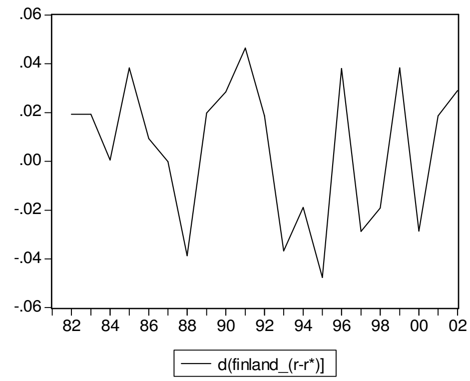
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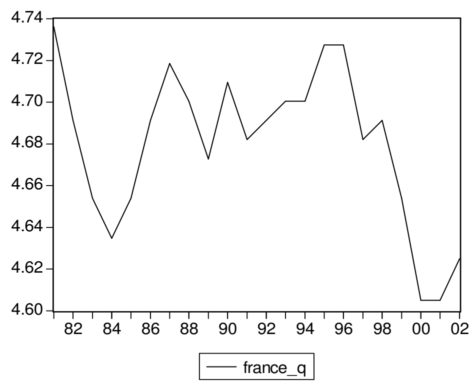
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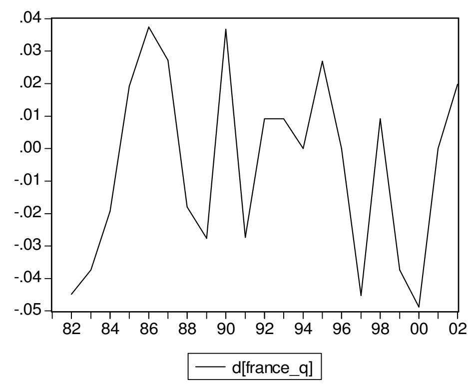
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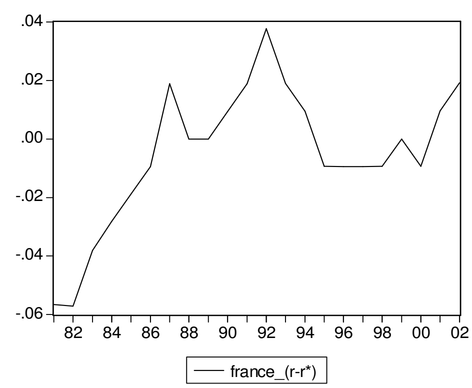
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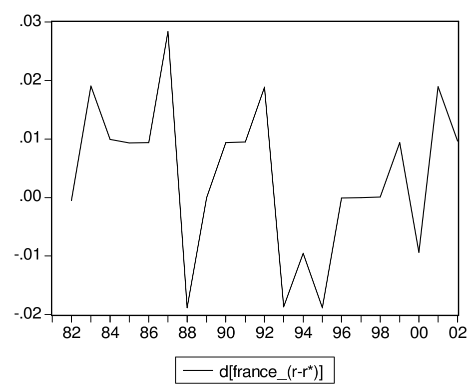
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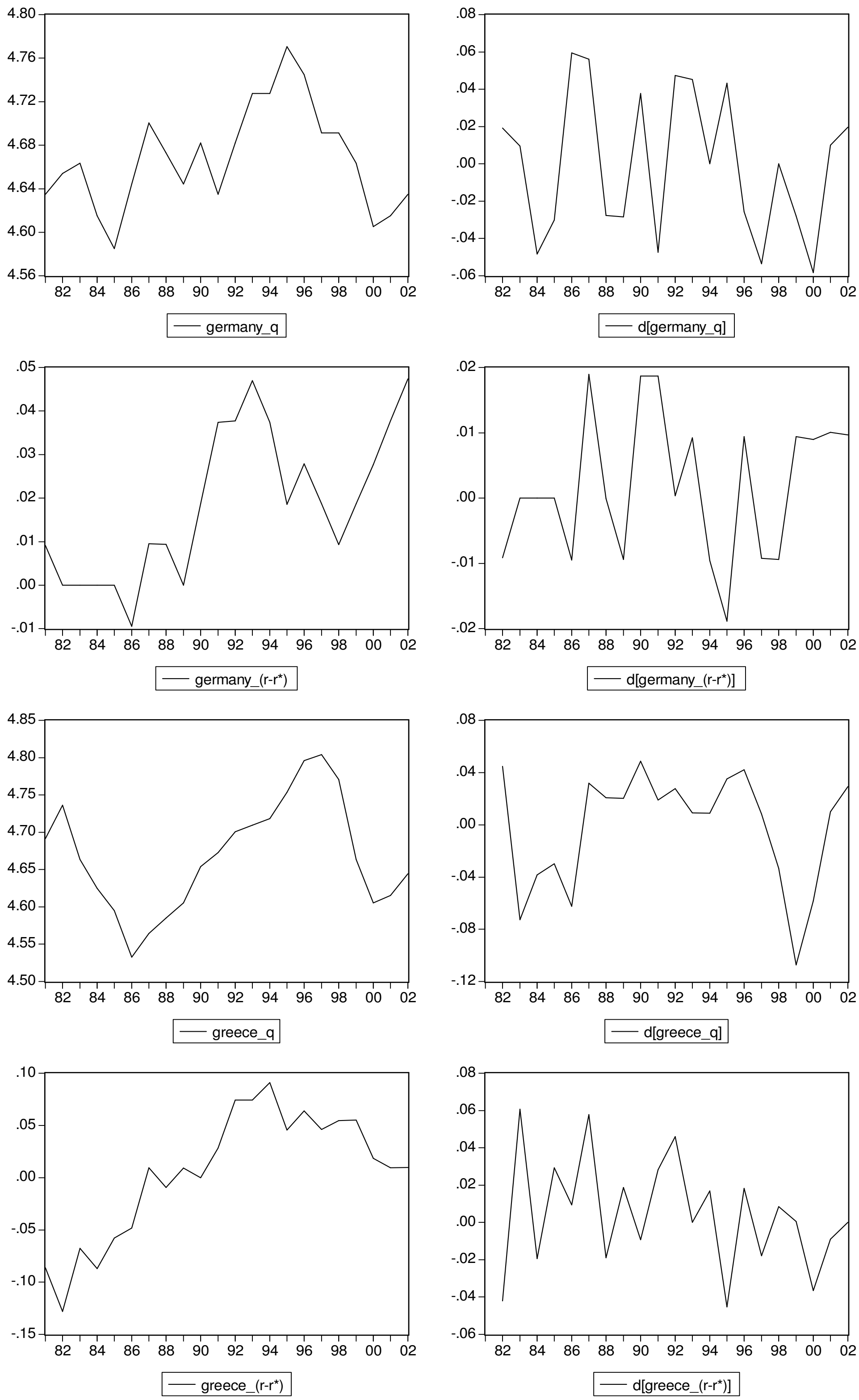
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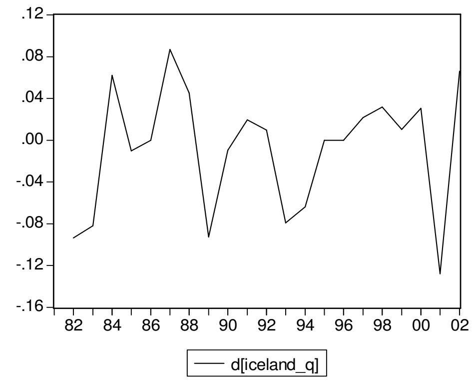
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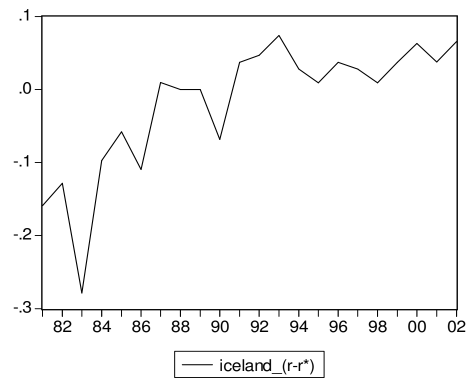
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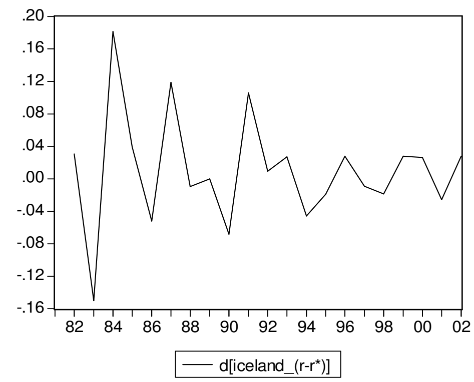
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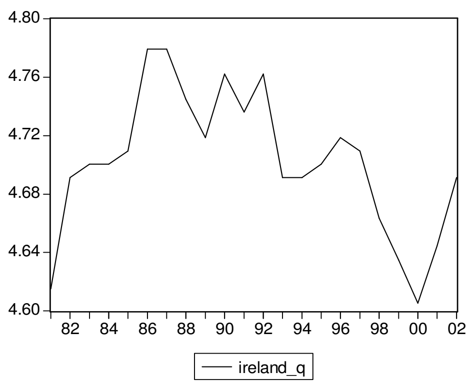
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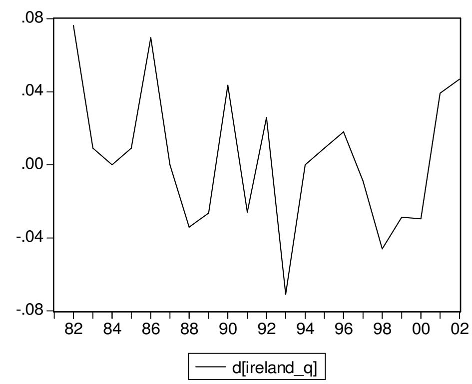
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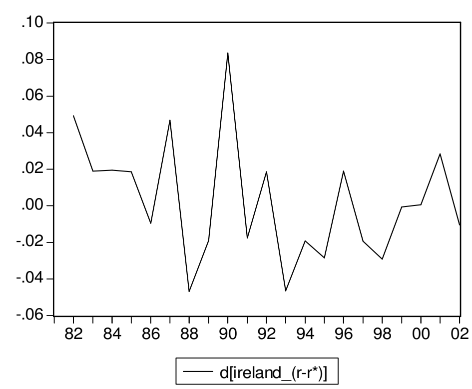
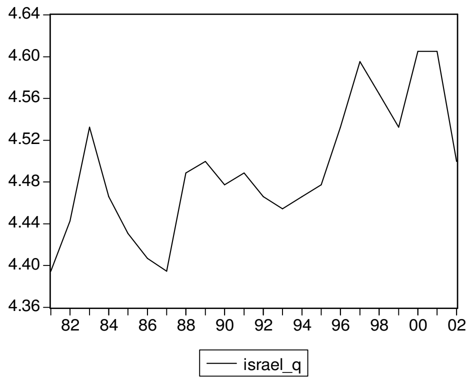
ireland_(r-r*)


d[ireland_(r-r*)]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4.36
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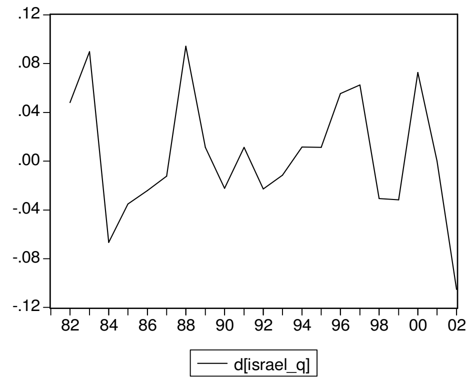
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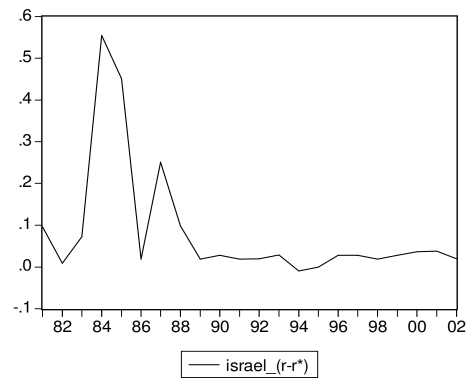
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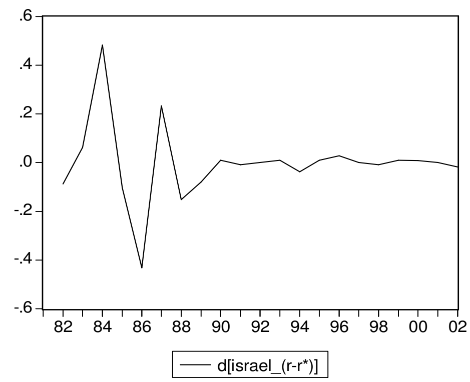
israel_(r-r*)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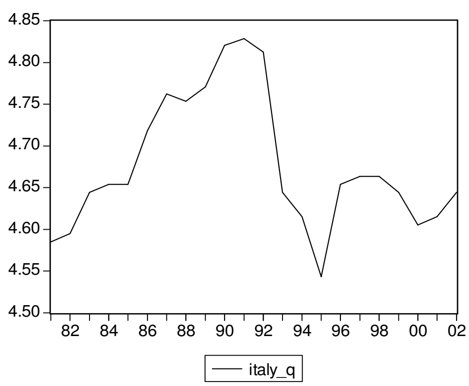
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4.55
4.50
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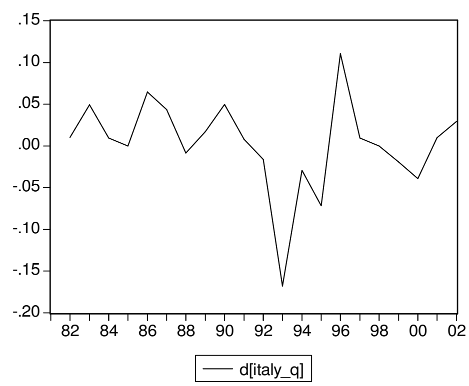
italy_q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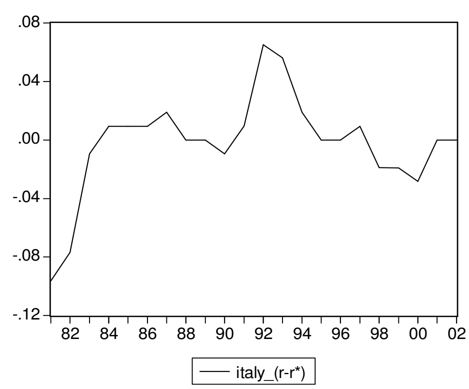
d[italy_q]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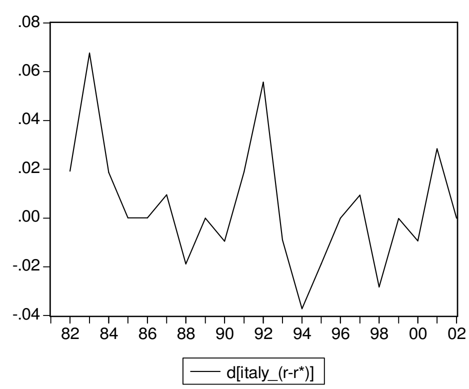
italy_(r-r*)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-.04
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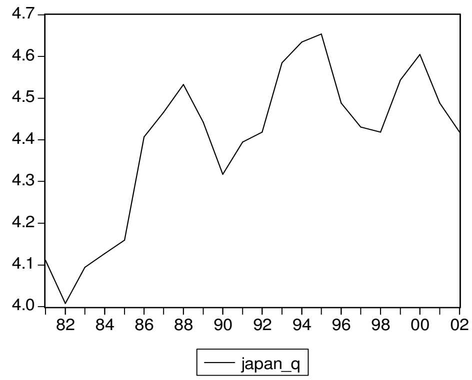
d[italy_(r-r*)]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4.5
4.4
4.3
4.2
4.1
4.0
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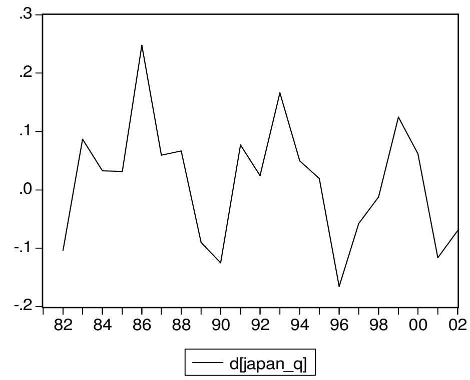
japan_q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.2
.1
.0
-.1
-.2
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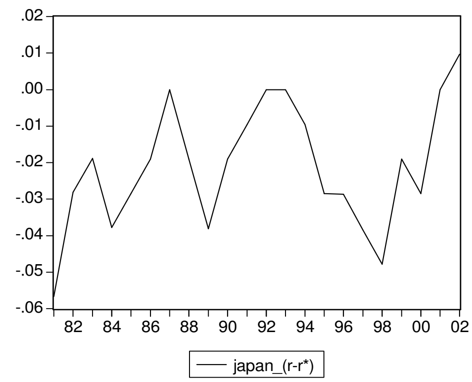
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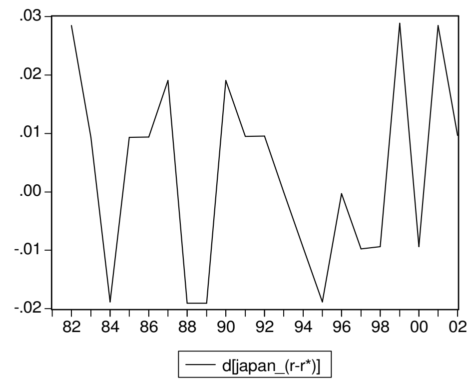
japan_(r-r*)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.02
.01
.00
-.01
-.02
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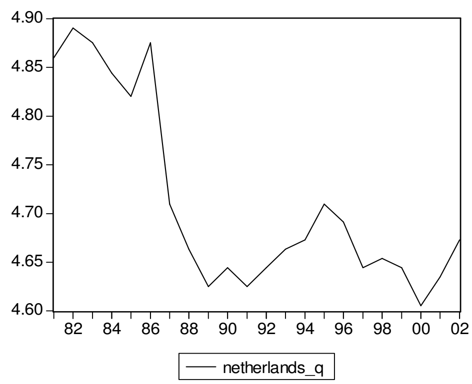
d[japan_(r-r*)]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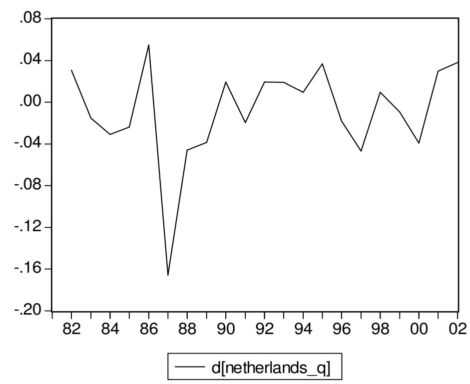
4.85
4.80
4.75
4.70
4.65
4.60
82 84 86 88 90 92 94 96 98 00 02
netherlands_q


.08
.04
.00
-.04
-.08
-.12
-.16
-.20
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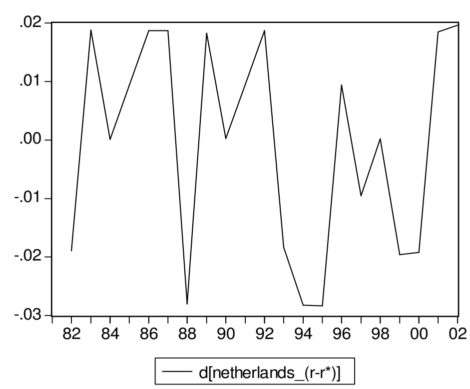
d[netherlands_q]


.06
.04
.02
.00
-.02
-.04
-.06
82 84 86 88 90 92 94 96 98 00 02
netherlands_(r-r*)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.01
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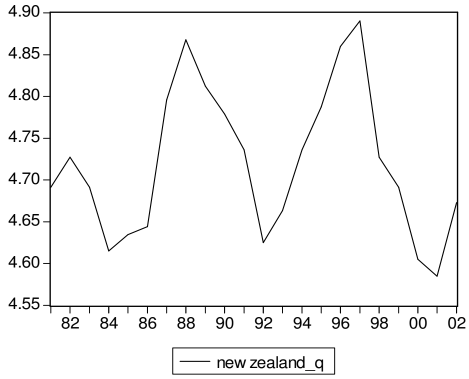
d[netherlands_(r-r*)]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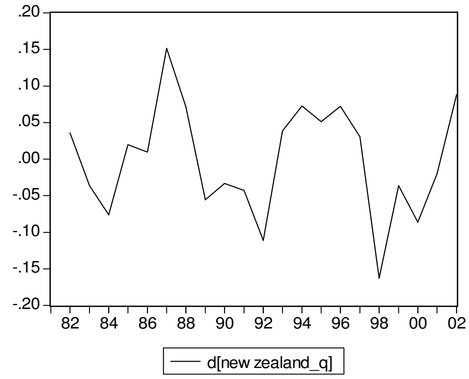
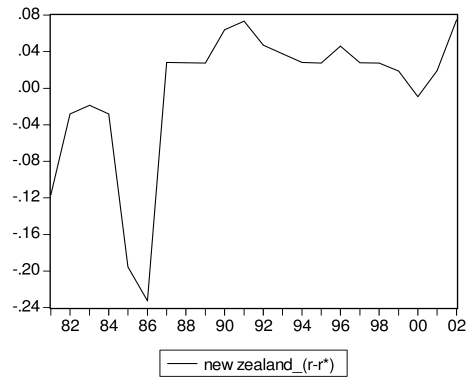
new zealand_q


.20 .15 .10 .05 .00 -.05 -.10 -.15 -.20
82 84 86 88 90 92 94 96 98 00 02
d[new zealand_q]


.08 .04 .00 -.04 -.08 -.12 -.16 -.20 -.24
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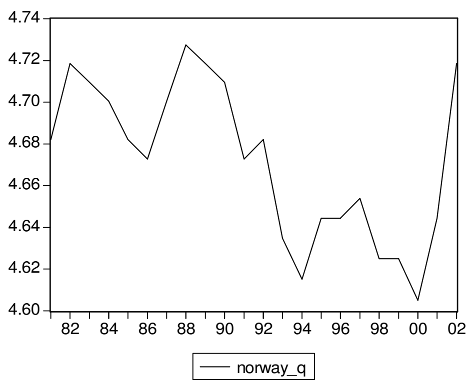
new zealand_(r-r*)


.3 .2 .1 .0 -.1 -.2
82 84 86 88 90 92 94 96 98 00 02
d[new zealand_(r-r*)]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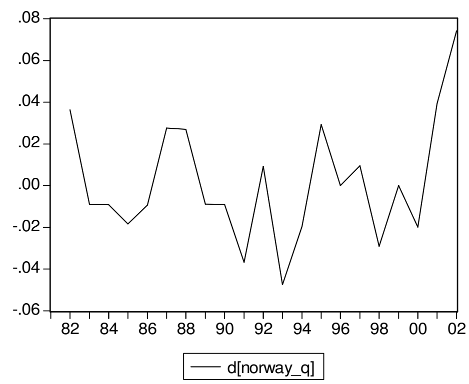
norway_q


.08 .06 .04 .02 .00 -.02 -.04 -.06
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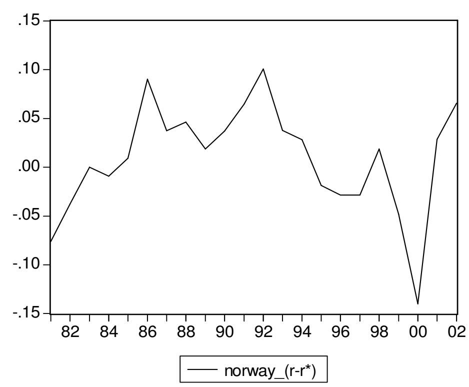
d[norway_q]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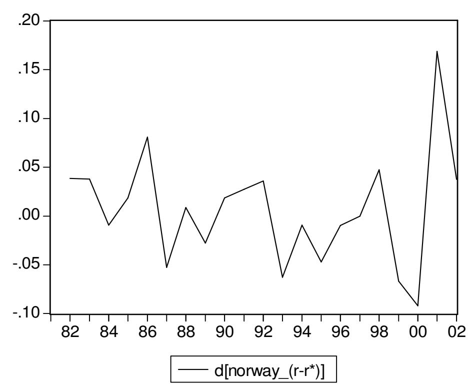
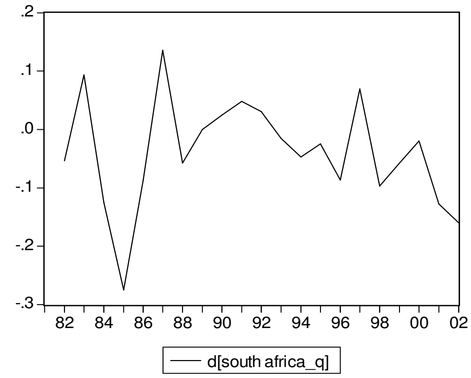
norway_(r-r*)


.20 .15 .10 .05 .00 -.05 -.10
82 84 86 88 90 92 94 96 98 00 02
d[norway_(r-r*)]


5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
82 84 86 88 90 92 94 96 98 00 02
south africa_q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.1
.0
-.1
-.2
-.3
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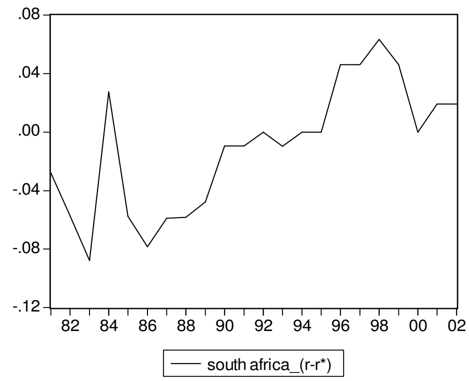
d[south africa_q]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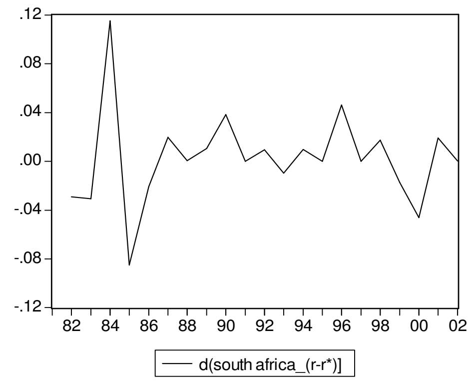
south africa_(r-r*)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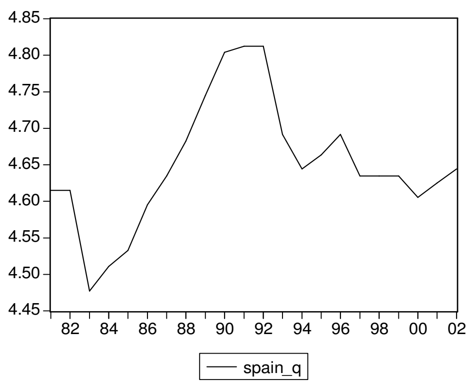
d(south africa_(r-r*)]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4.55
4.50
4.45
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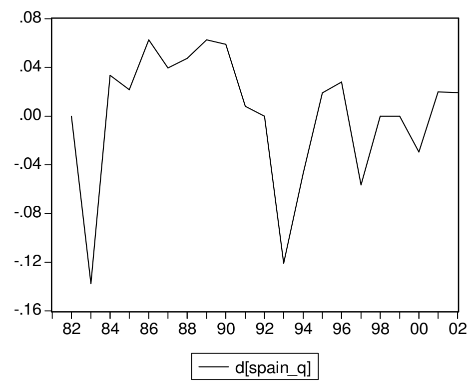
spain_q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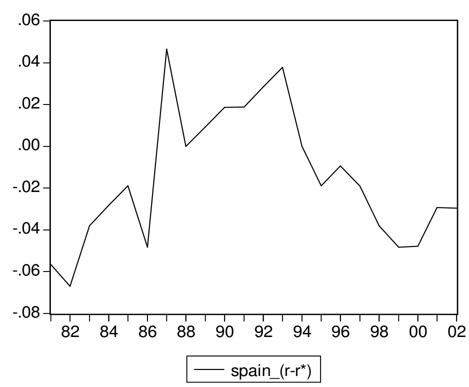
d[spain_q]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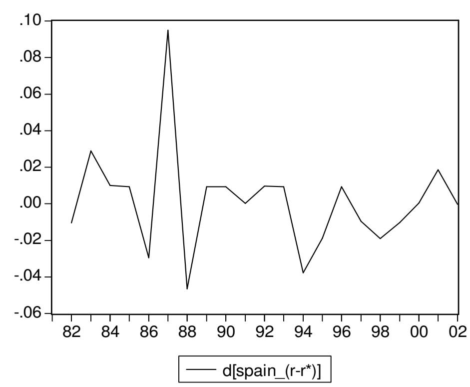
spain_(r-r*)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.08
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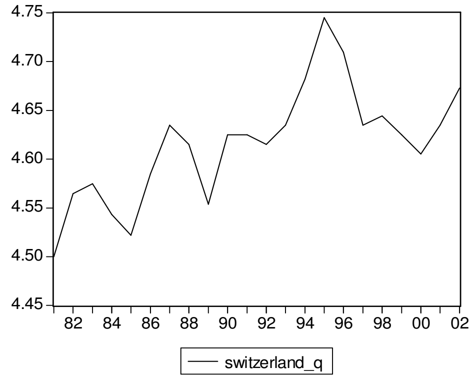
d[spain_(r-r*)]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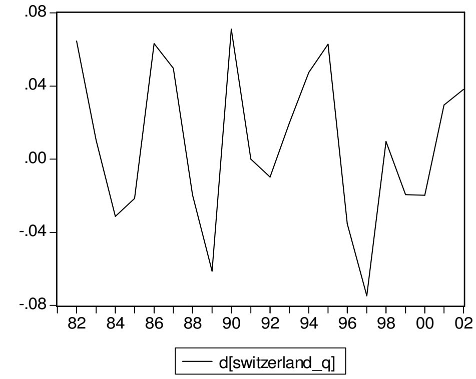
switzerland_q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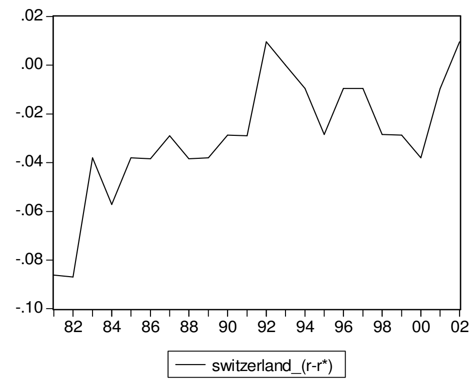
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switzerland_(r-r*)


.05
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.03
.02
.01
.00
-.01
-.02
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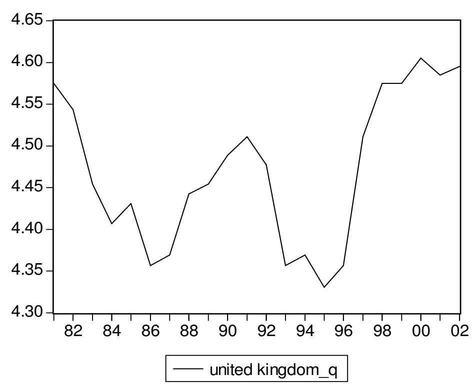
d[switzerland_(r-r*)]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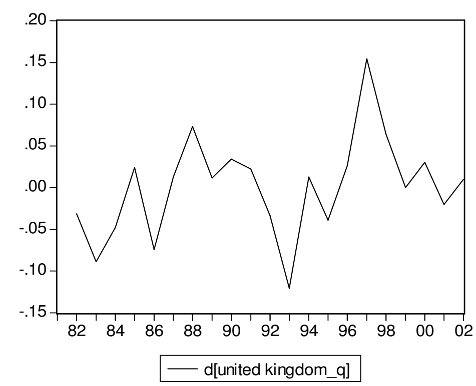
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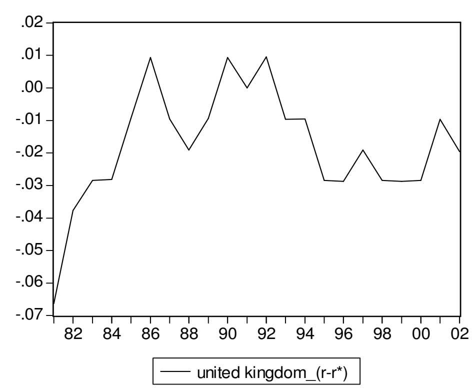
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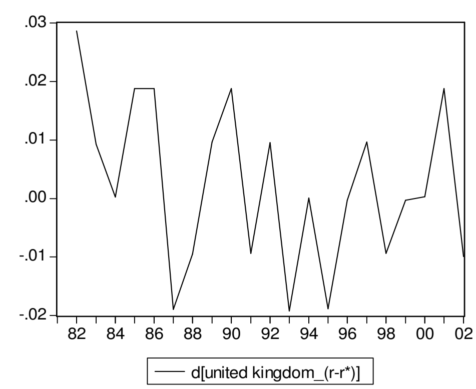
united kingdom_(r-r*)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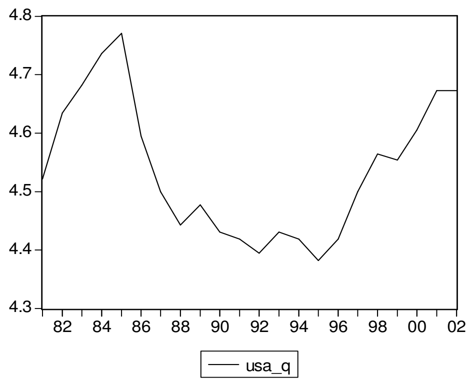
d[united kingdom_(r-r*)]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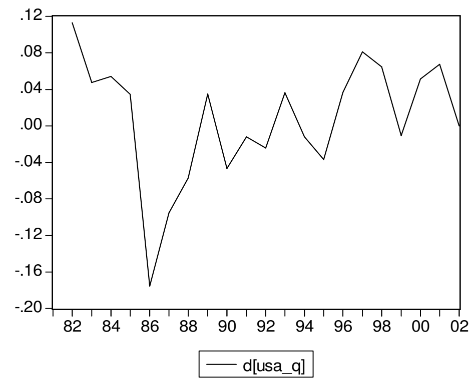
00
02
usa_q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98
00
02
d[usa_q]