Ferreira, Alex Luiz (2005) ***The real interest rate parity hypothesis : an investigation for developed and emerging markets.*** **Doctor of Philosophy (PhD) thesis, University of Kent.**

To the poor and unemployed of Brazil

Abstract

This study investigates the existence and causes of real interest rate differential(s) [*rid(s)* hereafter] across a heterogeneous sample of countries. This is relevant for various reasons. First, the research sheds some light on the extent to which economic authorities are able to pursue independent monetary policy in an open-economy, at least in the short-run. Second, it unveiled interesting characteristics of the dynamics of interest rate differentials. This is important because an indebted economy experiencing persistent *rids* is prone to face default. Finally, *rids* indicated the extent of market integration between economies.

The adjustment of *rids* to equilibrium is found to be fast in both emerging and developed economies, a finding that is compatible with the Real Interest Rate Parity Hypothesis. The equilibrium in emerging economies, however, is statistically different from zero pointing out to frictions in either goods or assets markets.

We found that the general causes of the differentials are UIP deviations and nominal interest rate differentials. The more specific causes are: 1) persistent reaction of monetary policy to changes in prices and slow adjustment in interest rates; 2) systematic excess returns, possibly induced by anticipated changes in macroeconomic fundamentals and sticky bond prices; 3) large unexpected changes in exchange rates driven by unexpected changes in macroeconomic fundamentals; 4) risk premium. Monetary policy resistance to price and exchange rate changes introduces an element of persistence in equilibrium nominal interest rate differentials which can explain excess returns, in other words, the fact that high interest rates are associated with appreciating exchange rates. Fundamentals can explain excess returns on the basis of systematic excess returns due to interest rate smoothing (sticky bond prices), or large forecast errors associated with unexpected changes in exchange rates. The evidence presented also points out to risk premium as another determinant of bond spreads and, hence, the cause of *rids*.

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Declaration

An earlier version of Chapter 2 was presented at the University of Kent (PhD upgrading seminar) in July 2003. It was also presented at the International Conference on Policy Modelling, EconMod2003, Istanbul, Turkey, July, 2003, the 2003 European Workshop in European economics, from August 24 to August 31, University Campus in Rethymno, Crete, Greece and, finally, at the Universidade Católica de Brasília, Brazil, in April, 2004. A paper version of Chapter 2 was also published in 2003 in the series Studies in Economics , number *03-01*, University of Kent.

Chapter 3 was presented at the "International Conference on Policy Modelling, EconMod2004, University of Paris I - Sorbonne, Paris, France, June 30 – July 2, 2004, the Brazilian Central Bank and also at the State University of São Paulo, Brazil in April 2004. Chapters 3, 4 and 5 were presented in internal seminars at the Department of Economics at the University of Kent. A paper version of Chapters 3 and 4 was published in 2004 in the series Studies in Economics of the Department of Economics, University of Kent, numbers 04-07 and 04-13, respectively.

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Introduction

"How internationally mobile is the world's supply of capital? Does capital flow among industrial countries to equalise the yield to investors? Alternatively, does the saving that originates in a country remain to be invested there? Or does the truth lie somewhere between these two extremes? The answers to these questions are not only important for understanding the international capital market but are critical for analysing a wide range of issues..." [Feldstein and Horioka (1980), p. 314]

Research Questions and Motivation

The questions stated on the quote above, posed by Feldstein and Horioka (1980), still raise intense debate and resilient disagreement. It is peculiar that the liberalisation of capital and goods markets carried out in the last decades and the increasing speed of capital movement have not sealed the enigma put forward by Feldstein and Horioka (1980) more than twenty years ago. On the contrary, according to Obstfeld and Rogoff (2000, p. 341) this is still "one of the most robust and intractable puzzles in international finance".

There are two central questions in this thesis. The first one is at the heart of Feldstein and Horioka (1980) concern: "**Is there evidence on the existence of real interest rate differentials in a selected group of emerging and developed economies?**" We provide an answer to this question in chapter 2. The second question: "**What are the causes that underlie real interest rate differentials**?" is the research objective of the next chapters. In brief, we investigate the existence and causes of *ex post* real interest rate differentials [*rid*(*s*) hereafter] in a group of economies. The countries chosen for our tests can be split into two groups. The first one comprises some small open-economies of emerging markets: Argentina, Brazil, Chile, Mexico and Turkey. The second group is composed of the open-economies of developed countries: France, Italy, Spain, the UK and Germany. Finally, we use the US as the reference large economy. The period of the tests broadly corresponds to the interval that spans from the mid 1990s to the beginning of the 2000s, with differences highlighted accordingly in each chapter. Both the period and the choice of the countries will be explained in following chapters, however, we can emphasise that this heterogeneous sample of countries allows inter-group comparisons and the detection of similar patterns between them.

Our study is relevant for various reasons. First, the research can shed some light on the extent to which economic authorities might be able to pursue independent monetary policy in an open-economy, at least in the short-run. If there are no *rids*, real rates in a particular small economy are determined in the larger country [Cumby and Mishkin (1984), Cavaglia (1992), Al-Awad and Grennes (2002), Lavoie (2000), Bernhardsen (2000) and Phylaktis (1997)]. Thus, policy makers would be interested to know the extent to which they can influence real interest rates.

Second, an indebted economy experiencing permanent, persistent or explosive (and positive) *rids* is prone to face default [see, for example, Obstfeld and Rogoff (1996), chapter 2]. Higher real interest rates in relation to other foreign economies, *ceteris paribus*, imply relatively smaller growth of investment, consumption and, consequently, income. On the other hand, an increase in interest rates increases the services of the domestic debt. It follows that a country will be running into insolvency if interest payments increase faster than income. As a matter of fact, several developing countries have already experienced painful situations of debt default. The latest critical case was Argentina in 2002, but Turkey was also on the edge of collapse during 2001. As it occurred with economies like Brazil, Turkey and Mexico during the eighties, insolvency also reached Argentina in that decade. Tables 1.1, 1.2 and 1.3 illustrate the uncomfortable situation faced by those emerging markets during the nineties.

Table 1.1 shows the increasing burden of interest payments as a percentage of the Gross National Income (GNI) in emerging economies. Payments in Mexico reached a peak in the mid nineties. Chile had a relatively stable proportion during the 1990s but payments started to increase fast by the end of that decade. The figures are also not good for Argentina, Brazil and Turkey. As can be seen in Tables 1.1 and 1.2, the debt burden as a percentage of GNI and exports reached alarming levels by the end of the 1990s. Argentina's story culminated with default and a debt crisis at the beginning of the 2000s. Interestingly, Table 1.2 is part of the "Millennium Indicators Database Goals, Targets and Indicators" which is composed of a total of 8 goals, 18 targets and 48 indicators measuring progress towards the "Millennium Development". A target of the goal number 8 is to "deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term". Hence, ensuring that debt payments are low and stable is an objective of the United Nations for the new millennium.

Thirdly, escalating interest payments represent a serious threat for public accounts. High interest payments are problematic especially for developing economies since scarce resources are allocated to the holders of the public debt instead of being channelled to vital areas of economic and social development. Economists, such as Stiglitz (2002), emphatically claim that allocation of financial resources is worsened when interest rates are high, perhaps because of moral hazard issues [which can be destabilising as in Minsky (1982)]. Nonetheless, this problem can also be relevant for developed countries. Tables 1.3 and 1.4 illustrate the fact that some emerging and economies spent a large proportion of their GDP on interest payments.

Finally, as shown in detail in the following chapter, *rids* indicate the extent of market integration between economies. The stronger the integration, the faster is the speed of convergence between *rids*. Hence, the research can also reveal distinctive aspects of financial and trade integration. Unveiling the causes of *rids* and understanding their dynamic behaviour is essential to the design of the appropriate macroeconomic policies. The subject is not only motivating for its relevance but also because it offers a fertile ground for theoretical and empirical exploration. As explained below, real interest equality is based on the three pillars of International Finance.

Theory and Evidence

As far as agents make forecasts using rational expectations, arbitrage in goods and assets' markets ensure that the real interest rate parity hypothesis hold (RIPH hereafter). Arbitrage is formalised by the uncovered interest rate parity (UIP) and the relative purchasing power parity (PPP) conditions under the assumption of perfect markets. When the assumption of risk neutrality does not hold, then speculation is the driving force behind commodity and asset prices. It seems that

Roll (1979) was the first author who noticed that PPP, UIP and rational expectations altogether implied RIPH. The hypothesis is based on the assumptions that homogeneous goods are costless traded across countries and that arbitrageurs face a risk-free bond economy with perfect asset substitutability and perfect capital mobility. The simple monetary model of exchange rate determination is a theory fully compatible with RIPH. The speed of adjustment to equilibrium in this model is so high that equality of real rates hold at all times[1]. However, *rids* may exist if assumptions of perfect markets, as in the monetary model, fail to hold. Hence, in order to understand the causes of *rids* we need to verify whether and why UIP, PPP and the rational expectations hypothesis fail to hold. A common approach used to examine both the existence and causes of *rids* is to test the individual arbitrage conditions and RIPH separately. This approach was originally employed by Mishkin (1984) who did not find empirical support for RIPH and concluded that models based on the assumption of costless international arbitrage cannot explain the behaviour of real interest rates better than that those allowing for frictions. It must be also stressed that Cumby and Obstfeld's (1984) study is contemporaneous to Mishkin's (1984) test of RIPH.

Price sluggishness is a typical friction that causes PPP to be violated in the short-run. In the Dornbusch (1976) model of sticky prices, for example, a *rid* arises whenever the exchange rate overshoots[2]. On the other hand, transaction costs violate the assumption of perfect capital mobility. For an extensive number of authors, a simple constant term added to previous equations is able to capture

[1] Using data from the hyperinflationary period in Germany during the 1920s, Frenkel (1976) has given the seminal evidence for this theory.
[2] See Frankel (1979) for the first version of Dornbusch's (1976) "*rid* model" and Isaac and Mel (2001) for recent tests.

transaction costs. Others, such as Phylaktis (1999) and Goodwin and Grennes (1994), credited them to the autoregressive parameters of the *rid*. Finally, there are models based on international arbitrage in which transaction costs generate non-linearities and *rids* [Obstfeld and Rogoff (2000), Nakagawa (2002)]. The finding of non-linearities in the exchange rate adjustment has been further substantiated by recent developments [see Sarno (2003)].

The perfect asset substitutability assumption of UIP fails to hold when countries are perceived to have different probabilities of default or currency risks. As a matter of fact, risk has been the most alluded explanation for differentials [see Frankel (1992), for example]. The literature on the subject is extensive and can be very sophisticated [for a survey, see Engel (1996) and Lewis (1994)]. For instance, Marston (1994), Anker (1999), Baillie and Bollerslev (2000), Leduc (2002) and Ewing (2003) all dealt with risk using different approaches. There are different approaches to measure risk but many authors attribute them to the volatility of expected returns, in the case of *rids* mostly due to the volatility of exchange rate changes. Granger (2002a) and Granger (2002b) have made a very strong point in this respect. He insisted that volatility is not a measure of risk only: "Investors will agree that there is uncertainty in the upper part of the distribution but risk only occurs in the lower part. Portfolios are selected to reduce risk in the lower tail, but not uncertainty in the upper tail. The investor does not diversify to reduce the chance of an unexpected large positive return, only that of a large negative one." [Granger (2002a), p. 450]. Hence, the idea in Granger (2002a) and Granger (2002b) seems to suggest that both risk and uncertainty are embedded in the variance of expected returns. Keynesian analysis also supposes that risk and uncertainty can explain deviations from RIPH. Smithin (2002) regarded both instances as being fundamentally different and subject to measurement by some kind of statistical probabilistic process.

Authors have been raising issues regarding the behaviour of monetary authorities, especially in the floating era, which might have had an impact on nominal interest rate differentials (*nids* hereafter) and, thus, on UIP deviations. McCallum (1994a) developed a model that considers the effect of policy making on the determination of *nids*. The idea is that UIP's failure can be explained by the simultaneous relationship between two factors: a policy reaction function and UIP itself. The distinguishing features of the policy function are that monetary authorities slowly change interest rates and resist exchange rate changes. Calvo and Reinhart (2002) documented that countries have been suffering from the "fear of floating" which means that authorities manage interest rates in order to smooth exchange rate volatility. This idea is further developed by the study of Iwata and Tanner (2003), but its origins can be traced back to McCallum (1994a) and McCallum (1994b). Finally, Kaminsky and Leiderman (1998) explained interest rate differentials on the grounds of government lack of credibility.

Some authors find it difficult to accept, for example Engel (1996), but agents may not be rational after all. Marston (1994), for example, tested the three parity conditions in order to distinguish if RIPH failure is due to risk premiums or to systematic forecast errors. Froot and Frankel (1989) showed that agents would do better in financial markets if they systematically expected less exchange rate depreciation. The failure of rational expectations has not received as much attention from the economic literature as the modelling of risk, but still authors either discussed or documented its existence [see Lewis (1994) for a discussion and Sachsida et al. (2001) for recent evidence].

In summary, the violation of the two parity conditions, relative PPP and UIP and the rational expectations hypothesis are associated with the existence of *rids*. Factors such as default and risk premium, transaction costs, price sluggishness, systematic forecast errors, government spending [Elmendorf and Mankiw (1998), Allen (1990), Doménech et al. (2000)] changes in the level or growth of money supply [as in the sticky price models of Buiter and Miller (1981) and Lyons (1990)], (un)expected productivity or output increases [Obstfeld and Rogoff (1996)] and several other macroeconomic fundamentals can explain the causes of *rids*.

As mentioned before, we will address the question regarding the dynamics of *rids* in chapter 2. The underlying causes are investigated from chapter 3 onwards. We initially verify which parity condition causes more deviations from RIPH and then examine what are the determinants of those deviations. In the following section, we present the structure of the thesis in addition to the main findings of each chapter.

Structure of the Thesis

The thesis comprises five chapters, four of which are original material and one is a literature review. The first provides an explanation of the theory underlying the RIPH and also surveys the related empirical works. As stated before, theory asserts that RIPH holds in the presence of rational arbitrageurs in perfect goods and assets markets. In other words, if PPP, UIP and the efficient market hypothesis simultaneously hold, *rids* do not exist. However, for each possible failure of PPP, UIP and the rational expectations hypothesis, a theoretical possibility for the existence of *rids* arises. We analysed in more detail the typical cases of deviation from PPP and UIP driven by sticky prices, transaction costs, risk premium and forecast errors. We also surveyed an important strand of the literature which emphasises the role of monetary policy on the determination of *rids*. An explanation of the relationship between *rids* and the marginal productivity of capital was also provided. On empirical grounds, our survey has not identified any conclusive answer about the existence of *rids* across countries while evidence regarding their underlying causes is disputable. We observed that if *rids* exist their causes are most likely to be time and country specific.

Chapter 2 asks whether RIPH holds in the set of emerging and developed countries that is our object of study. Our findings show that *rids* exist in emerging economies. The evidence is found by carrying out a set of unit-root tests on the *rids* with respect to the US. Results support the hypothesis of a rapid reversion towards a zero differential for developed countries and towards a positive one for emerging markets. Mean reversion is faster for emerging markets. Another important result is that this adjustment tends to be highly asymmetric and markedly different for developed and emerging economies. Our evidence also reveals a high degree of market integration for developed countries and highlights the importance of frictions for emerging markets.

After we provided an answer to the question on the existence of *rids*, which is affirmative for emerging economies, we move towards the investigation of their causes. The following three Chapters of the thesis focus on emerging countries but results are compared with developed economies. Chapter 3 analyses the volatility of *rids* separating out the deviations from the individual parity conditions and also breaking down the variability between *nids* and inflation differentials. The variance of *rids* is decomposed between deviations from relative purchasing power parity and uncovered interest rate parity. The findings point out to *nids* and deviations from UIP as the main source of volatility in *rids*. A VAR with *rids* and *nids* was estimated and forecast error variance decompositions calculated. Using both short and long-run restrictions in order to recover the structural parameters, we found that real shocks are the most likely cause of *rids*. Impulse response functions also reveal that real shocks have a large impact on *rids*. Chapter 3 directs us to the study developed in Chapters 4 and 5, which is concerned with the determinants of *nids* and the causes of excess returns, which sheds light on the nature of UIP *ex ante* deviations.

As previously explained, the economic literature has been emphasising the importance of monetary authorities in the determination of *nids*, especially in emerging countries [Calvo and Reinhart (2002)]. Chapter 4 investigates the nature of the association between *nids* and the actions of monetary authorities. Using the model proposed by McCallum (1994a), we present evidence that the simultaneous relationship between UIP and a monetary policy function can explain the empirical failure of the former. The results lend strong support to the view that monetary policy affects the equilibrium *nid* between emerging economies and the US. Slow adjustment of interest rates and reaction against price changes seem to be the prominent features of the policy reaction function. Shocks have an asymmetric impact on the volatility of the differentials which is also significant to explain monetary policy. Finally, the dynamic properties of excess returns influence the equilibrium *nids*.

In Chapter five we investigated whether other factors, rather than monetary policy, could explain excess returns. Using an insight from Engel (1996), the final chapter asks whether excess returns are risk by verifying if they respond to macroeconomic fundamentals. A general unrestricted model of excess returns and fundamentals, based on the literature that tested the relationship between macroeconomic variables and dollar-denominated bond spreads [Edwards (1985)], was initially formulated. Employing the automated model selection criteria of PcGets, the general model was simplified to a parsimonious and, in many cases, a congruent specification. The findings reveal that fundamentals explain excess returns. However, the sign of the coefficient is not as expected in several of the estimated equations showing that the relationship between the two variables is likely to be complex. Most of the volatility of excess returns is related to the dynamics of exchange rates. If an anticipated deterioration in fundamentals tend to depreciate the exchange rate but interest rates do not rise accordingly, perhaps because of slow adjustment of interest rates, then a negative *ex post* deviation from UIP, or a negative excess return, arises. We also found that outliers are associated with large unanticipated changes in exchange rates, the latter possibly due to unexpected changes in fundamentals. For example, when fundamentals worsen unexpectedly and exchange rate depreciates a negative excess return arises.

The final part concludes and presents some policy suggestions. The answer for the question on the existence of *rids* is affirmative for emerging economies. As the adjustment to equilibrium is fast, RIPH is partially corroborated. Hence, the parity condition is not only a matter of advanced economies long integrated in international capital markets, but it is also an arbitrage condition that emerging markets obey. With respect to the question on the determinants of *rids* we found that the general causes are UIP deviations and *nids*. The more specific determinants are: 1) persistent reaction of monetary policy to changes in prices and slow adjustment in interest rates; 2) systematic excess returns, possibly induced by anticipated changes in macroeconomic fundamentals and sticky bond prices; 3) large unexpected changes in exchange rates driven by unexpected changes in macroeconomic fundamentals; 4) risk premium. The main policy conclusion is that real interest rates are not entirely decided in the larger economy but can be determined through the conduct of monetary policy or the management of macroeconomic fundamentals.

Tables

Table 1.1. Total Debt Service (% of GNI)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Argentina	2.2	2.5	2.3	3.5	4.9	6.4	7.4	9.3	9.9	9.2	6.1
Brazil	2.3	2.5	3.0	3.1	3.3	5.2	6.7	13.7	11.1	11.1	11.7
Chile	6.7	6.6	5.9	7.9	9.1	5.5	5.3	6.9	8.4	10.4	11.9
Mexico	5.9	6.1	4.9	9.5	12.7	10.7	7.1	7.5	10.4	7.9	6.8
Turkey	5.7	4.8	7.9	6.7	5.9	6.2	7.3	10.0	10.3	15.6	15.2

Source: World Development Indicators, ESDS (Economic and Social Data Service) Internet on line.
Note: Total debt service is the sum of principal repayments and interest actually paid in foreign currency, goods, or services on long-term debt, interest paid on short-term debt, and repayments (repurchases and charges) to the IMF.

Table 1.2. Debt Service (% of Exports)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Argentina	27.5	30.9	25.2	30.2	39.5	50	57.6	75.6	70.8	66.1	18.3
Brazil	20.2	23.6	30.1	36.6	42.2	62.7	79.5	117.8	93.5	75.4	68.9
Chile	20.8	23.1	18.9	24.5	28.1	17.4	17.4	22.2	24.8	27.9	32.8
Mexico	33.8	35.7	25.7	27	35.1	31.9	20.9	22.3	30.5	25.9	23.2
Turkey	32.1	28.6	31.4	27.7	21.6	20.5	24	35.4	35.4	40	46.8

Source: Millennium Indicators – United Nations Statistic Division http://unstats.un.org/unsd/
Note: exports of goods and services and net income from abroad.

Table 1.3. Public and publicly guaranteed debt service (% of GNI)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Argentina	1.4	1.9	1.4	2.1	2.6	4.0	4.0	4.4	6.0	6.1	4.3
Brazil	1.4	1.1	1.6	1.9	1.7	2.0	2.2	4.8	4.1	4.1	4.9
Chile	3.6	3.6	2.5	4.7	5.3	1.8	1.0	1.1	1.6	1.9	2.3
Mexico	4.3	2.7	2.9	5.6	8.4	7.2	4.3	3.4	4.3	4.1	3.0
Turkey	4.7	3.9	5.9	5.3	4.6	4.5	5.2	4.6	4.9	8.0	5.6

Source: World Development Indicators, ESDS (Economic and Social Data Service) available in the Internet on line.
Note: Public and publicly guaranteed debt service (PPG) is the sum of principal repayments and interest actually paid in foreign currency, goods, or services on long-term obligations of public debtors and long-term private obligations guaranteed by a public entity.

Table 1.4. General Govt. Net Debt Interest Payment (% of Nominal GDP)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
France	3.3	3.3	3.2	3.1	2.9	2.8	2.8	2.7	2.6	2.5	2.5	2.5
Italy	10.9	10.9	8.8	7.8	6.2	6.0	5.9	5.3	4.8	4.7	4.7	4.9
Spain	4.9	5.0	4.4	4.0	3.3	3.1	2.8	2.5	2.2	2.2	2.1	2.0
UK	2.9	2.9	3.1	3.0	2.4	2.2	1.8	1.5	1.6	1.5	1.5	1.5
Germany	3.2	3.2	3.2	3.3	3.1	2.9	2.8	2.7	2.8	2.7	2.8	2.8
US	3.6	3.4	3.2	3.1	2.7	2.5	2.3	2.1	1.8	1.8	2.0	2.2

Source: OECD Economic Outlook No. 76 Annex Tables.
Note: values for 2005 and 2006 are OECD projections.

Chapter 1. The Real Interest Rate Parity Hypothesis: Theory and Evidence

1.1. Introduction

Theory states that in a perfect world, arbitrage in goods and assets market, under the assumption of rational expectations, ensures the equality of real interest rates across countries. In other words, if relative PPP, UIP and the efficient market hypothesis hold, interest rate differentials follow a zero mean-reverting process. The simple monetary model is a theory fully compatible with the above. Frenkel (1976) provided the pioneer evidence for this theory. On the other hand, if assumptions of perfect markets - as in the monetary model - fail to hold, *rids* may exist. In the Dornbusch (1976) model, for instance, imperfections (sluggishness) in the price adjustment mechanism generate a short-run *rid*. The empirical support for this theory is provided by Frankel (1979). We explain the most common causes of PPP and UIP violations in order to show how interest rate differentials can arise with such failures. The existence of transaction costs, risk premium and the irrationality of expectations (due to Peso problems or adaptive expectations, for instance) are the typical examples of PPP and UIP failures, respectively. We highlight the effects of expected productivity and output shocks on *rids* as well. Finally, we present and discuss the results of our empirical survey on tests of RIPH.

The objective of this chapter is to identify and discuss the theoretical approaches and related empirical findings on the literature that explains *rids* in an open economy. Following, we introduce and analyse the theory of the RIPH as put forward by Roll (1979) [according to Mishkin (1984)].

1.2. The Theory of the RIPH

One of the main forces influencing the behaviour of economic variables is arbitrage. Arbitrage is defined as the purchase and sale of a good or an asset in different markets in order to profit from price differences. Theories that explain the behaviour of economic variables in an open economy stress that arbitrage in goods and assets markets would be the crucial force determining interest rates. The UIP condition, as defined below, formalises the impossibility of no exploitable excess profits in the assets market. In a risk-free small open-economy with perfect asset substitutability and perfect capital mobility, arbitrage guarantees that the following condition holds

$$i_{t,k} = i^{*}_{t,k} + (s^{e}_{t+k} - s_{t}) \qquad (1.1)$$

where the subscript t represents time, the superscript e denotes expected values, s_t is the natural logarithm of the spot exchange rate, defined as the domestic price of the foreign currency, i_t is the interest rate paid on a bond with k periods to maturity and the asterisk stands for the foreign economy. For simplicity, we assume that $k = 1$, hence the bond matures at time $t+1$. For the one-period maturity bond, the rate at which the exchange rate is expected to depreciate is defined as the following logarithmic difference

$$\Delta s_{t+1}^{e} = s_{t+1}^{e} - s_{t} \tag{1.2}$$

where Δ is the first difference operator. Lower case variables, except interest rates, here and elsewhere represent natural logarithms. We rewrite equation (1.2) as

$$i_t - i_t^* = \Delta s_{t+1}^{e} \tag{1.3}$$

For simplicity, the nominal interest rate differential(s) between the domestic and the foreign economy is labelled *nid(s)* and equation (1.3) can be written as

$$nid_t = \Delta s_{t+1}^{e} \tag{1.4}$$

where $nid_t = i_t - i_t^*$. Equation (1.4) states that the *nid* at time t is equal to the expected depreciation from time t to time $t+1$. The equilibrium *nid* thus depends on the extent to which agents expect a depreciation of the domestic currency.

Note, however, that UIP alone does not help in explaining *rids*. UIP requires the theory of purchasing power parity (PPP) in order to explain *rids*. PPP states that once converted to a common currency, national price levels should be equal.

Arbitrage, once again, enforces parity in prices across a sufficient range of individual goods. The PPP is derived from the arbitrage condition for a single homogenous commodity that is traded across countries without transport costs, i.e., from the "The Law of One Price". The absolute PPP is defined as

$$P_{t+1} = S_{t+1} P^*_{t+1} \tag{1.5}$$

where P_{t+1} and P^*_{t+1} are the price indexes in the domestic and foreign economy, respectively. A less stringent version of the absolute PPP is obtained by taking the (natural) logarithm of (1.5)

$$p_{t+1} = s_{t+1} + p^*_{t+1} \tag{1.6}$$

Subtracting the one-period lagged terms from both sides, one can write changes in the exchange rate as:

$$\Delta s_{t+1} = \pi_{t+1} - \pi^*_{t+1} \tag{1.7}$$

where the rates of domestic and foreign inflation are $\Delta p_{t+1} = p_{t+1} - p_t = \pi_{t+1}$ and $\Delta p^*_{t+1} = p^*_{t+1} - p^*_t = \pi^*_{t+1}$, respectively. Equation (1.7) is known as the relative PPP. The last foundation of RIPH is the hypothesis of rational expectations, as below

$$\Delta s^e_{t+1} = \Delta s_{t+1} + \varepsilon_{t+1} \quad (1.8)$$

where ε_{t+1} is a random disturbance term, equal to the forecast error of s_{t+1}, and exhibits the classical properties, in other words, ε_{t+1} is iid $N(0,\sigma^2_\varepsilon)$ and σ^2_ε represents its variance. Combining equations (1.8) and (1.7) and substituting into (1.4) results

$$nid_t - (\pi_{t+1} - \pi^*_{t+1}) = \varepsilon_{t+1} \quad (1.9)$$

This can alternatively be written as

$$rid_t = \varepsilon_{t+1} \quad (1.10)$$

It follows from equation (1.10) that if UIP, PPP and rational expectations hold, the rid_t is equal to the unforeseeable disturbance term related to the forecast of exchange rate depreciation[3]. From equation (1.10) we observe that a *rid* does not exist in the long-run because its unconditional mean, or expected value, is equal to zero. The conclusion is that the dynamics of *rids* depends on the three pillars of International Finance. In other to investigate the causes of *rids*, it is necessary to verify whether the assumptions underlying this theory are compatible with the real

[3] The *ex post rid* can also be derived from the Fisher (1930) equation. In this case the *ex post rid* equals the *ex ante rid* plus a disturbance term related to the inflation forecast, given that rational expectations is assumed [see Mishkin (1984)]. *Rids* will depend not on the actions of arbitrageurs but on the borrowing and lending of transnational firms around the world. For an arbitrageur, foreign inflation only matters to the extent that it impacts on expected depreciation.

world. Departures from RIPH can be explained by *ex post* deviations from relative PPP and UIP, since violations of the rational expectations hypothesis would already be embedded in the deviations from UIP. It is then possible to conclude that for each possible breakdown of relative PPP, UIP and rational expectations, a possibility for the existence of a *rid,* different from the one predicted in (1.10), also emerges.

Perfect Markets (The Monetary Model)

It is important to analyse the simple monetary approach to the determination of the exchange rate because, as we will be showing, this model implies equality of real interest rates across countries at all times.

The monetary approach to exchange rates has its roots in the classical general equilibrium model. The supply curve is vertical which means that prices are perfectly flexible in all markets and that output can vary only with changes in productivity and factors of production. The aggregate demand curve determines the price level. The dichotomy between monetary and real variables holds. Changes in the money stock, for instance, will be fully matched by changes in prices. PPP is the basic assumption considering the external sector (goods market) and UIP enters the framework in order to conceive a role for expectations. Actually, UIP is the means by which agents measure their future yields. The monetary approach also assumes a demand for money of the general form

$$m_t = \lambda y_t + p_t - \psi r_t \qquad (1.11)$$

Equation (1.11) represents the demand for real balances that positively depends on income (y_t) and negatively on interest rates. The nominal money stock is represented by m_t and p_t is the price level. All variables are in natural logarithms. The parameters λ and ψ are the income and interest elasticities.

It is useful to understand how the *rid* is originated and how it dissipates in the monetary model using the graphical IS x LM framework as depicted in Figure 1. The PPP line is represented on the left graph of Figure 1. The graph on the right represents the aggregate supply and demand curves and at the right bottom are the IS and LM curves. The IS curve is vertical due to the unique possibility of a single equilibrium in the goods market as implied by the also vertical AS curve. The slope of the AS is determined by the assumption that prices are flexible. We will examine how equilibrium is temporarily disturbed in this model when agents expect a depreciation of the exchange rate arising from an expected change in the money supply. Consider that the economy is initially resting at equilibrium represented by points A, a and a_0. Given the initially unchanged money stock, an expected exchange rate depreciation causes a rise in the domestic nominal interest rate (from i_0 to i_1). The increase in interest rates generates an excess of money balances. Because the assumption of the quantity theory of money is that agents reduce their money balances by buying goods and services (as bonds are not a substitute for money) the demand for goods increases. The IS curve temporarily moves rightward to $\mathrm{IS}_1^{'}$. Aggregate demand also shifts to the right and the economy will momentarily be at point b, where output demanded is y_1. At that point, however, the maximum output produced is y_0 so prices rise with the increased demand. The price level increases until supply and demand reach equilibrium. However, the economy is undercompetitive with the initial level of the exchange rate (point B in the PPP line). Imports increase and exports diminish with the rise in the domestic price level and, as a consequence, the demand for domestic currency decreases and the exchange rate depreciates. Arbitrage in goods market provokes an instantaneous increase in the exchange rate. Final equilibrium is reached with the rise in nominal exchange rates to S_1. The whole process develops in a high speed. The initial rise in interest rates causes an expectation of depreciation that is automatically fulfilled. Because domestic and foreign prices are tied up via PPP, domestic prices rise in order to keep up with the balance-of-payments equilibrium. Finally, the IS curve returns to its initial position at a_0 as the excess supply of money is cleared up with the increase in domestic prices.

The process explained above can also be explained in a different way. With the prospect of an increase in the money supply agents expect a depreciation of the domestic currency. Given the initially unchanged domestic interest rate such an expectation generates an incipient capital outflow movement and an excess demand for money (in order to buy foreign exchange) that immediately depreciates the domestic currency and increases interest rate. The depreciated domestic currency implies that the demand for domestic output will be well above supply. Hence, prices increase clearing the goods and money market. In summary, expected depreciations in the monetary model are automatically fulfilled and prices change accordingly, thus RIPH holds at any point of time.

Frictions

Deviations from PPP

The number of tests on PPP is vast and the objective of this subsection is not to review this literature. A summary of the conclusions reached by Rogoff (1996), who surveyed the work on PPP, is illustrative of the emerging consensus regarding the main empirical findings. Rogoff (1996) identifies the short-term volatility of real exchange rate and the slow rate at which shocks damp out as the main stylised facts regarding PPP. The puzzle, according to him, is how to reconcile PPP with these two stylised facts as long as they cannot be accounted for real shocks neither to monetary ones - the former are not so frequent and the later are supposed to fade away very fast. According to Rogoff (1996), short-run price rigidity, which is discussed in the next section, could play this key role. The Balassa-Samuelson hypothesis is another attempt of bringing PPP and empirical evidence together. Another reconciliation attempt is the view that government spending, which tends to fall heavily on non-traded goods, puts pressure on domestic prices. However, in Rogoff's (1996) opinion, frictions in goods market could better explain the persistent deviations from PPP. Tariffs, transportation costs, non-tariff barriers, pricing to market (monopolistic firms limiting arbitrage), non-traded components in traded goods (such as rent, labour, insurance, etc) and quality differences could drive a wedge between prices across countries. As a consequence, nominal exchange rate movements would not cause an immediate and proportional response in relative domestic prices.

The consensus, says Rogoff (1996), is that PPP deviations tend to damp out but at a slow rate. The view that long-run PPP holds is shared by recent works, such as Sarno and Taylor (2002). However, the latter authors also emphasise the role of non-linearities in the movement of real exchange rate towards equilibrium. They claim that the non-linear behaviour of this variable could reconcile the puzzle of high persistence and high volatility. The closer the exchange rates are to equilibrium, the slower the effect of small shocks will disappear. On the other hand, the real exchange rate reverts fast to equilibrium when there are large shocks.

The finding of a very slow degree of adjustment has been subject to controversy. Taylor (2001) criticises the use of small frequency data and the linear econometric specifications for the empirical tests. Sarno et al. (2004), for example, tested non-linearities in the law of one price and also presented a recent survey on the subject. Sarno et al. (2004) claim that their work contributes to the formation of a consensus view of regime switching in deviations from the law of one price. The non-linear dynamics is essentially motivated on the basis of transactions costs. Sarno et al. (2004, p. 22) conclude that "adjustment towards the law of one price is observed to be fairly fast although the estimated delay parameter, which measures the timing of the reaction of market participants to deviations from the law of one price, is estimated to be longer than one might perhaps expect."

The "invisible hand" of the market, allocating goods in different countries and ensuring that prices measured in a common currency are brought into equality, is underlying PPP. In other words, the theory is founded on the same assumptions of perfect competition. Therefore, if any of the assumptions fail to hold one would also expect PPP not to hold. If there are market imperfections, then the real exchange rate may deviate from its PPP value.

Following, we explain how the failure of some of the assumptions mentioned above can theoretically influence the *rid*. We start with the general model of sticky prices put forward by Dornbusch (1976) and then discuss some sources of non-linearities.

Sticky Prices

Although the model of Dornbusch (1976) is built along the lines of the monetary model, the assumption that PPP does not hold in the short-run characterises a different behaviour for interest rate differentials across countries. The crucial aspect of this model is the difference in the speed of adjustment in the goods and assets market: while UIP holds at all times, PPP only works in the long-run. In other words, the initially horizontal aggregate supply curve becomes vertical along time.

UIP with rational expectations minus expected inflation differentials [i.e. expected inflation differentials are subtracted from both sides of equation (1.4)] gives

$$rid_t^e = \Delta q_{t+1}^e \qquad (1.12)$$

where rid_t^e is the ***ex ante*** **real interest rate differential** and Δq_{t+1}^e is the expected change of the real exchange rate, $\Delta q_{t+1}^e = \Delta s_{t+1}^e - (\pi_{t+1}^e - \pi_{t+1}^{*e})$. Because the *rid* is defined as the ***ex post*** **real interest rate differential,** for which relative PPP is assumed to hold, and supposing rational expectations, equation (1.12) can also be written as

$$rid_t^e = rid_t + \varepsilon_{t+1}^{\pi} = \Delta q_{t+1} + \varepsilon_{t+1} + \varepsilon_{t+1}^{\pi} \qquad (1.13)$$

where ε_{t+1}^{π} follows the classical properties and is defined as the forecast error of the inflation differential. Recall that ε_{t+1} is the forecast error of the exchange rate change, as explained in (1.8). Equation (1.13) can be simplified to the ***ex post*** **real interest rate differential**

$$rid_t = \Delta q_{t+1} + \varepsilon_{t+1} \qquad (1.14)$$

Equation (1.14) shows how price stickiness can change the predictions of RIPH. If $\Delta q_{t+1} \neq 0$, then changes in the real exchange rate can play a role in the determination of the *rid*.

Now, consider the equation below taken from Dornbusch (1976):

$$s_t = \bar{s} - \frac{1}{\lambda\theta}(\bar{p} - p_t) \qquad (1.15)$$

where the coefficients θ is as a parameter that measures the speed to which the spot exchange rate is perceived (by agents) to move towards its long-run equilibrium level (denoted by the bars over the letters). The long-run exchange rate represented by $\bar{s}$ in equation (1.15) is assumed to be known.

It follows from (1.15) that, for given long-run values of exchange rates and prices, the current spot exchange rate will be a function of the current price level. An expected depreciation in the equilibrium exchange rate will lower demand for domestic money causing an immediate depreciation of the spot exchange rate. The lower demand for real balances also diminish the nominal interest rate. The reduced interest rate forces agents to depreciate the exchange rate further away its long-run equilibrium level. A *rid* exists as far as the exchange rate overshooting is not matched by a correspondent increase in domestic prices. Only when prices adjust to their long-run equilibrium level (the one consistent with PPP) and the overshooting disappears, real interest rates will be equal. It follows from the Dornbusch (1976) model that a positive *rid* is associated with an appreciated exchange rate.

The relation between the short-run failure of PPP and *rids* is explored in Frankel (1979) who developed and tested a model that encompasses both the simple monetary and Dornbusch (1976) hypotheses. According to Frankel (1979, p. 610) his "real interest differential model" combines "...the Keynesian assumption of sticky prices with the Chicago assumption that there are secular rates of inflation." The relationship between the exchange rate and the *nid* is hypothesised negative in the sticky price model, because increases in the nominal interest rate will be associated with a capital inflow and an appreciating exchange rate. On the other hand, the relationship between the exchange rate and the *nid* is hypothesised positive in the monetary model, because increases in the nominal interest rate will be associated with a concurrent depreciation of the domestic currency. Assuming, as in Frankel (1979), that expectations are formed as follows

$$\Delta s_{t+1}^{e} = -\vartheta(\bar{s} - s_t) + \bar{\pi}^{e} - \bar{\pi}^{*e} \tag{1.16}$$

where $\bar{\pi}^{e}$ and $\bar{\pi}^{*e}$ are defined as the domestic and foreign rates of expected long-run inflation, respectively. This equation shows that agents form expectations taking into account not only the long-run equilibrium level of the spot exchange rate [as in Dornbusch (1976)] but also the inflation differential. A problematical aspect of (1.16) is that the existence of a long-run nominal equilibrium exchange rate cannot be consistent with a steady state inflation differential. The reason is that the changing expected inflation differential implies a changing equilibrium exchange rate since long-run PPP requires a unique equilibrium real exchange rate. As the objective is to present the model we follow Dornbusch (1976) and plug UIP into equation (1.16) and rearranging

$$s_t = \bar{s} + \frac{1}{\vartheta}[(i_t - i_t^{*}) - (\bar{\pi}^{e} - \bar{\pi}^{*e})] \tag{1.17}$$

Because $s_t = \bar{s}$ in the long-run, equation (1.17) can be written as

$$\bar{i} - \bar{i}^* = \bar{\pi} - \bar{\pi}^* \quad (1.18)$$

In other words, the long-run *nid* is equal to the long-run inflation differential and the long-run *rid* is equal to zero as predicted by RIPH. The implication is that while a short-run *rid* can exist in the short-run with sticky prices, the long-run *rid* still converges to zero.

Transaction Costs

Aiming to provide a convincing answer to the puzzle set by Feldstein and Horioka (1980) pointed out in a previous section, Obstfeld and Rogoff (2000) formulated a model in which transaction costs can explain the existence of *rids* across countries. Basing their work on an insight from Samuelson (1954) where home bias in consumption could be derived from transport costs, Obstfeld and Rogoff (2000) showed that even small cost differences could generate high *rids*:

"We show that trade costs can create a wedge between the effective real interest rates faced by borrowers and lenders. In our model, the effect is highly non-linear, manifesting itself strongly only when current-account imbalances become very large. We argue that it is precisely such incipient real-interest-rate effects that keep observed current-account imbalances within a modest range. Though we rely primarily on the theoretical force of the argument, we do demonstrate empirically that current-account-deficit countries tend to have higher real interest rates, as our model predicts." (p. 341)

Obstfeld and Rogoff (2000) claim that deviations from Feldstein and Horioka's empirical regularity imply high current account deficits which in turn leads to high inflation. We reproduce Obstfeld and Rogoff (2000) two-period, two-good small country endowment model with "Samuelsonian iceberg" transport costs (represented by τ). The existence of transport costs[4] in international trade means that for every unit of home (foreign) good shipped out of the country, only a fraction $(1-\tau)$ arrives at the foreign (home) economy. The home good H can only be produced at home while the foreign good F is exclusively produced abroad. All prices are measured in a common currency and there is no foreign inflation. Arbitrage in competitive goods market implies:

$$P_F = \frac{P_F^*}{(1-\tau)} \text{ and } P_H = (1-\tau)P_H^* \tag{1.19}$$

where P_F is the home price of the foreign good and P_H is the home price of the home good. P_H^* and P_F^* are the corresponding foreign prices of the home and foreign good. The overall price level in home is:

$$P = (P_H^{1-\theta} + P_F^{1-\theta})^{\frac{1}{(1-\theta)}} \tag{1.20}$$

where θ is the elasticity of substitution. Equations (1.21) and (1.22) represent the intertemporal budget constraints faced by a representative home resident in period 1 and 2 respectively:

[4] According to Obstfeld and Rogoff (2000), p. 340, trade costs may include transport costs but also tariffs, non-tariff barriers, and other factors that constraint trade.

$$P_{H,1}Y_{H,1} + D = P_{H,1}C_{H,1} + P_{F,1}C_{F,1} = P_1C_1 \quad (1.21)$$

$$P_{H,2}Y_{H,2} - (1+r^*)D = P_{H,2}C_{H,2} + P_{F,2}C_{F,2} = P_2C_2 \quad (1.22)$$

where C_H is home consumption of the home-produced good, C_F is home consumption of the foreign-produced good and the letter r represents the real interest rate. The subscript 1 and 2 refers to periods 1 and 2, respectively. Home agents are endowed with Y_H per capita of the home good and foreign agents are endowed with Y_F. Foreign agents are assumed to have identical utility functions in C_H and C_F. Total real consumption depends on consumption of the home and foreign goods. Now consider that total consumption in period 1 is smaller than in period 2, which is the same to say that a country runs a current account surplus in period 1. Equations (1.21) and (1.22) tell us that the monetary surplus flows from home towards the foreign country.

Now, the percentage change of domestic purchasing power in period 2 derived from a unit of domestic currency invested abroad during period 1 is shown in equation (1.23) as [see Obstfeld and Rogoff (2000), p. 353]

$$1 + r = (1+r^*)\frac{P_1}{P_2} \quad (1.23)$$

Substituting price levels in equation (1.20) into (1.23) yields

$$1+r=\frac{(1+r^*)(P_{H,1}^{1-\theta}+P_F^{1-\theta})^{\frac{1}{1-\theta}}}{(P_{H,2}^{1-\theta}+P_F^{1-\theta})^{\frac{1}{1-\theta}}} \tag{1.24}$$

Recall that the home good was exported in period 1, i.e. there had been a current account surplus. However, the home good must be imported in the following period, if the constraints are to be respected. Because there are costs to transport the good from abroad, the overall price level in period 2 must increase. There will be expected inflation and *ex ante* real interest rates of the domestic lender country will be smaller than the foreign real interest rate as shown below

$$(1+r)=\frac{(1+r^*)\left[(1-\tau)P_H^{1-\theta}+P_F^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\frac{P_H^{1-\theta}}{(1-\lambda)}+P_F^{1-\theta}\right]^{\frac{1}{1-\theta}}}<(1+r^*) \tag{1.25}$$

It follows that a country experiencing a current account deficit at period 1 (and a corresponding current account surplus in period 2) will face a higher real interest rate than abroad. In order to support the conclusions of their model, Obstfeld and Rogoff (2000) presented evidence showing that countries running current account surpluses had lower real interest rates than deficit countries. Using annual data from 1975 to 1998 and panel estimations, they performed a regression of the domestic real interest rate on the ratio of the current account surplus to GDP for all OCDE countries except Iceland, Korea, Mexico and Turkey. The finding was that a 1%

increase in the current account surplus was associated with a 20% to 30% decline in real interest rates.

In the model of Obstfeld and Rogoff (2000) current account imbalances will arise depending on agent's inter-temporal spending decisions. A country experiencing a significant current account imbalance in period 1 will face changing prices in period 2. Transport costs conceal arbitrage in goods and assets market with the existence of *rids* across countries.

Empirical works such as those performed by Meese and Rogoff (1988) and Edison and Pauls (1993) did not find sound results to support the relationship between real interest rate and exchange rates because they did not recognise a non-linear relationship between those two variables, according to Nakagawa (2002). This author has proposed an interesting model that combines the sticky price hypothesis of Dornbusch (1976) with transaction costs[5] following the non-linear idea of Obstfeld and Rogoff (2000). Nakagawa (2002, p. 631) observes that deviations from PPP can be persistent because: "...transaction costs and uncertainty can produce nonlinearity in real exchange rates by creating a 'band of inaction', or a no arbitrage region." He established non-linearity in the following way:

$$y_t^d = \begin{cases} \bar{y} + \varphi(q_t - c) & \text{if } q_t > c \\ \bar{y} & \text{if } |q_t| \leq c \\ \bar{y} + \varphi(q_t + c) & \text{if } q_t < -c \end{cases} \tag{1.26}$$

[5] According to Nakagawa (2002) transaction costs include transport costs, trade barriers, fixed costs of adjustment, and uncertainty over exchange rates and policy intervention.

In (1.26) the real exchange rate q_t is defined as the deviation of the real exchange rate from its equilibrium level, for convenience set at $\overline{q}_t = 0$. The equilibrium level of the exchange rate is associated with the full employment equilibrium of the economy $\overline{y}$. The variable y_d is the demand for the domestic output and c represents transport costs.

Condition (1.26) means that international trade happens only if deviations from the equilibrium real exchange rate are large enough to compensate for transport costs. When the actual real exchange rate does not offer this incentive, the demand for domestic output is insensitive to the real exchange rate. Nakagawa (2002) also claims that the spot exchange rate does not depend on the interest rate differential inside the band. According to him: "...there is no tendency for the real exchange rate to move towards the long-run equilibrium level: the real exchange rate follows a random walk and is not expected to bear any relationship with the real interest differentials."(p. 636).

Our interpretation of Nakagawa's (2002) model is that the difference between the **expected** and the spot rate follows a random walk. When the equilibrium exchange rate lies inside the band, then any real exchange rate can be the equilibrium one. Also, the real exchange rate can still bear some relationship with the *rid* inside the band. Suppose that the equilibrium spot exchange rate lies inside the band and there is an increase in the interest rate differential, for example. Since PPP does not hold inside the band – because there is no international trade - agents will not expect any change in the nominal exchange rate motivated by future changes in prices. However, an incipient capital inflow movement arising from the increased *nid* will generate an appreciation of the exchange rate until an adjustment in price eliminates the increased interest differential. In summary, *rids* exist inside the band because there is no convergence (hence, a random walk) and outside the band, in the region where international trade takes place, there is mean reversion. The interesting aspect of Nakagawa's (2002) model is that *rids* arises from transaction costs and are compatible with the assumption of arbitrage in goods and assets markets, the same conclusion reached by Obstfeld and Rogoff (2000)[6].

Deviations from UIP

Risk Premium

The puzzle of Feldstein and Horioka (1980) about the high correlation between domestic savings and investment, inaugurated an avenue of research which aims to verify why the degree of capital mobility across countries was so low[7]. Feldstein and Horioka (1980) conceived that UIP could work well in the short-run but they doubted on the extent of long-term arbitrage. They claimed that for most agents, uncertainty and risk aversion "become increasingly important for longer-term and less liquid investments, implying that short-term liquid asset arbitrage is consistent with much less mobile long-term capital." (p. 316).

As a matter of fact, risk is generally used as an explanation for deviations from UIP[8]. The reason might be related to the assumption of perfect asset substitutability

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[6] Another paper is Goodwin and Grennes (1994). They showed that transaction costs help to establish the real interest rate equality hypothesis.

[7] In spite of the results being challenged by the development of new tests [see Ho (2002a)], the study is important mainly because of the literature that it has spawned.

[8] Textbooks maintain that risk is a strong possibility for *ex ante* UIP not to hold [see Mark (2001) or Obstfeld and Rogoff (1995), for example]. Sarno and Taylor (2001), for instance, wrote that in testing the portfolio balance model "Typically, risk premium is measured by deviations from

or, alternatively, to the assumption of riskless bonds that underlies UIP. This assumption seems to be too strong because, as country fundamentals differ, probabilities of default are also likely to vary.

On the other hand, portfolio models relax the assumption of perfect asset substitutability. The result is that an interest rate differential can exist indefinitely because the supply of assets is not perfectly elastic and there is no automatic mechanism that forces i_t to equalise with $i_t^* + \Delta s_{t+1}^e$. Risk premium is supposed to explain deviations from UIP in the major part of the economic literature but, since Fama's (1984) famous results, there is a great amount of controversy on the question of whether actual deviations can be explained by models of risk aversion.

Huisman et al. (1998) argued that much of the failure in finding support for the UIP when tested for a group of countries can be circumvented by the use of panel estimation techniques. The panel approach is more robust than bilateral tests because currencies may differ in their response to shocks and to the reference currency. There also might be time and country specific effects [Huisman et al. (1998)]. They have chosen the dollar and the mark as the reference currencies for tests involving 15 countries during the period 1979M1 to 1996M3. They found that the slope coefficient of the forward premium equals 0.5 and it is not significantly different from zero. When they tested UIP in a sample of outliers – arbitrarily defined as the 5% largest observations in relation to the average value of the forward premium – they found a coefficient that is not statistically different from

uncovered interest parity, either assuming rational expectations or employing survey data." (p. 852 and p. 853). Some authors claim that both the risk premium and forecast errors are broader classes of explanations but they normally focus on the first conditioned on the second [see Bams et al (2004), and Ho (2002b), for recent examples]. An indication of the relative importance of the risk premium over forecast errors in the International Finance literature might be the fact that Engel (1996) omits the review on the irrationality of agents in his influential survey of the forward premium anomaly.

one: “We find evidence that UIP almost perfectly holds in periods where the average cross-sectional forward premium is large.” (p. 213). Using panel estimation techniques for long-term maturity bonds Meredith and Chinn (2004) found slope coefficients on the order of 0.60, very similar to the one encountered by Huisman et al. (1998). Their tests were applied to the G-7 countries for the period from 1980 to 2000. For most countries, the hypothesis that the slope coefficient equals zero can be strongly rejected (and most of the estimated slopes are very close to unity). According to Meredith and Chinn (2004), the results support the evidence that short-term UIP’s failure reflects the endogeneity of interest rate movements in the face of disturbances in foreign exchange markets. Their explanation is that macroeconomic fundamentals play little role in driving short-term interest rates because of the existence of a risk premium. However, as the importance of the risk premium fade away along time, the empirical support for UIP grows. They notice that over short horizons most empirical studies found that exchange rate depreciates while interest differentials increase. In their opinion, a temporary increase in the risk premium causes the spot exchange rate to depreciate relative to the expected future rate leading to higher inflation and higher interest rates thus explaining this short-term failure.

Berk and Knot (2001) tested UIP for the long-run using PPP as a measure for exchange rate expectations. According to them, this methodology is a novelty since most of the literature use rational expectations “...where actual exchange rate movements proxy for expected ones.” (p. 378). They have regressed the long-term interest rate against the American rate for five major industrialised countries from 1975M1 to 1997M12 on an intercept, expected depreciation (estimated according to PPP) and a time-varying risk premium. The risk premium was estimated using the standard deviation of the interest rate differential. Intercepts were also used to take into account some country specific characteristics (such as the liquidity of foreign bonds and differences in taxation). The slope coefficients had the correct sign but they were not close to unity. The sign of the risk premium was different across countries.

There are empirical papers testing UIP with fundamentals [Bernhardsen (2000) and Knot and de Haan (1995)]. The finding is that fundamentals are significant to explain differentials. Finally, a number of authors have either modelled or assumed that risk is autoregressive. [Bams et al. (2004), Nijman et al. (1993) and Wolff (1987)]

Monetary Policy

Authors have been raising issues regarding the behaviour of monetary authorities, especially in the floating era, which might have had an impact on *nids* and thus *rids*. McCallum (1994a), for example, developed a model in which the UIP's failure can be explained by the simultaneous relationship between a policy reaction function and UIP itself. The reaction function is characterised by the slow change in interest rates and resistance against exchange rate changes. McCallum (1994b) implies that the hypothesis that monetary authorities manage interest rates so as to smooth out their movements, while also resisting to changes in not only exchange rates but also prices, is theoretically plausible and maybe empirically stronger.

Calvo and Reinhart (2002) documented that countries have been suffering from the "fear of floating". In their analysis the fear may arise because one of the following reasons: the domestic debt is fairly denominated in foreign currency, there are output costs associated with exchange rate fluctuations, the supply of external funds may be inelastic (generating the possibility of overshooting), the government suffers from lack of credibility (manifested in large and frequent risk-premium shocks) and there had been high pass through from exchange rates to prices. As a consequence of the reasons above, monetary authorities tend to put too much weight on exchange rate stabilisation when setting interest rates. Calvo and Reinhart (2002) have analysed the behaviour of exchange rates, foreign exchange reserves and interest rates for 39 countries from 1970M1 to 1999M11 in different exchange rate arrangements. They have demonstrated that the probability of a change in monthly interest rates is higher in developing countries. The variance of nominal and real interest rates is also higher in those countries even when inflation is low. Indeed, the variance of interest rates in low inflation emerging markets was estimated in about four times that of developed economies. They claim that evidence on greater variability of interest rates and (the stock of) foreign reserves suggest an attempt to smooth out exchange rates rather than being a by-product of monetary targeting: "Yet, there is an apparent change in the conduct of monetary-exchange rate policy in many emerging markets – interest rate policy is (at least partially) replacing foreign exchange intervention as the preferred means of smoothing exchange rate fluctuations" (pp. 404 and 405). Canzoneri and Harris (1998) showed that Central Bank operating procedures affect the risk premium. Nominal interest rate targeting produces the highest real interest rates while money targeting produces the lowest rates. According to them, the perception that real interest rates may have risen in past years can be explained by the fact that the role of monetary aggregates has diminished in most central banks' operating procedures.

Anker (1999) argued that the failure of UIP can be a consequence of systematic monetary-policy reactions in order to control exchange rate changes.

Failure of the Rational Expectations Hypothesis

Although a great part of the literature explains the forward discount bias and deviations from UIP on the grounds of risk aversion, forecast errors are another important explanation. An influential contribution on this area is given by the work of Froot and Frankel (1989). Using survey-based exchange rate expectations, they showed that anticipated exchange rate depreciation is systematically high (in comparison to actual values) and that there is no evidence of risk premia. Investigating the forward premium bias, they assume a single expectation that is homogenously held and measured by the median of survey response. The forecast error thus corresponds to the expected rate minus the actual exchange rate. Their finding is that this expectation error is correlated with the forward premium. Froot and Frankel (1989) conclude "We cannot reject the hypothesis that all of the bias is attributable to these systematic expectational errors, and none to a time-varying risk premium" (p.159).

Models of intertemporal maximisation under uncertainty [see Obstfeld and Rogoff (1995), chapter 5, for example] provide the microeconomic fundamentals for the allocation of resources under risk aversion. Microeconomic models explain that risk is associated with the curvature of the utility function which, in turn, depends on the elasticity of substitution for consumption between goods in the present and the future [see Dey (1979)]. The difference between the utility of expected income and the expected utility of a "lottery", which is similar to the

Jensen inequality term of a quadratic utility function, can be a measure of the degree of risk aversion. In other words, agents pay to convert a risky choice (the lottery) into a riskless one (the utility of expected income). Furthermore, the probabilities associated with the expected outcomes play an important role in determining individual choices. If the probability of a future gain is perceived to be higher than what it actually is, then the difference between the utility of expected income and the expected utility of a lottery will be smaller. In the data, this appears as a small degree of risk aversion. Peirson (2005), for example, has demonstrated how these probabilities can explain the usual finding of excessive risk loving in some games. On the other hand, Froot and Frankel (1989) argued that investors are not extremely risk averse as it is normally implied by estimations of CAPM models, but rather that agents would do better if they systematically expected less depreciation. In other words, agents put too much weight on the expectation of lower returns[9].

Marston (1994) attempted to disentangle the effect of risk premia and forecast errors on the three parity conditions (UIP, PPP and RIPH) for a set of Eurocurrency interest rates and Japan. Using the idea that forecast errors would impact both UIP and PPP but the risk premia could only affect UIP. The evidence is that deviations from the three parity conditions are systematically related to a set of information variables. The latter contains the interest rate differential, inflation differentials and the share yield in equity markets of each pair of countries. More interestingly, Marston (1994) found that deviations from the three parity conditions are perfectly correlated in many cases. His final conclusion is that "interest differentials cannot

[9] Froot and Frankel's (1989) results have been challenged with the development of new tests [see Cavaglia et al (1994)]

be attributed to either risk premia or systematic forecast errors alone" (p.26) and that "a common factor maybe driving all three deviations" (p. 27).

Forecast errors could reflect the irrationality of expectations due, for example, to infrequent shocks and learning [Lewis (1994)]. If it takes time for agents to learn about a change, then expectations are adaptive. According to Bams et al. (2004, p. 272), forecast errors also comprise measurement issues and other problems: "Measurement difficulties arise when the distribution of shocks that effect the economy undergo infrequent shifts. Natural disasters and monetary policy regime changes are examples of such shifts." Forecast errors could also be due to Peso problems, i.e. a small probability of a large event, and evidence shows that they might be important [Sachsida et al. (2001)].

Real Interest Rates and the Marginal Productivity of Capital

In this section we explain the nature of the relationship between real interest rates and the marginal productivity of capital in both an autarky and an open-economy. It will be shown that if international capital is perfectly mobile, the marginal productivity of capital in a small open-economy will be equal to the world interest rate, which is a prediction that accords to RIPH. Thus we will show that RIPH is consistent with macroeconomic models derived from microfoundations. We use a simple intertemporal utility maximisation model derived from Obstfeld and Rogoff (1996), chapter 1, which allows us to show that an economy's marginal product of capital can be different from the autarky's real interest rate if there is international borrowing and lending.

Open economies have the ability to lend or borrow from abroad in order to change their consumption path. Consider a two-period endowment economy that is able to exchange resource across time. The consumer's intertemporal trade problem in this economy is to maximise utility in (1.27) subject to the budget constraint in (1.28)

$$U_1^j = u(c_1^j) + \beta u(c_2^j) \tag{1.27}$$

$$c_1^j + \frac{c_2^j}{1+r^*} = y_1^j + \frac{y_2^j}{1+r^*} \tag{1.28}$$

where β is a fixed preference parameter or time-preference factor and $(0 < \beta < 1)$, U is the lifetime utility, c is the consumption between periods, j represents the individual and y represent output which is perishable and cannot be accumulated. The variable r^* stands for the real interest rate that would prevail when the economy can borrow or lend internationally. The utility maximum is achieved when

$$u'(c_1^j) = (1+r^*)\beta u'(c_2^j) \tag{1.29}$$

or alternatively written as

$$\frac{\beta u'(c_2^j)}{u'(c_1^j)} = \frac{1}{(1+r^*)} \tag{1.30}$$

The left-hand side of equation (1.30), also known as the intertemporal Euler equation, is the consumer's marginal rate of substitution of present for future consumption while the right hand side is the domestic price of future consumption in terms of present consumption. It follows from (1.30), for example, that if the world real interest rate is higher than the subjective discount time-preference factor, agents will decrease consumption in period 1 raising it in period 2. In other words, consumers will maximise their utility by spending less in period 1 and increasing their consumption in period 2.

Next, we show how *rids* arise when there is no capital mobility, i.e. when the economy is barred from international borrowing and lending. By assuming that all individuals are identical and population size is equal to one we can aggregate quantities and drop the superscript j from equation (1.30). Replacing consumption with output in (1.30) and considering that the previous economy was an autarky, we have

$$\frac{u'(y_2)}{u'(y_1)} = \frac{1+r^*}{1+r^a} \tag{1.31}$$

where r^a is the interest rate that would prevail if the economy was impeded to borrow or lend from abroad and that $\beta = \frac{1}{1+r^*}$. It follows from (1.31) that a single reason for the autarky's real interest rate to be different from the world's real interest rate is a changing output.

Expected productivity increases can also affect the model. Adding investment (I) to the aggregate version of equation (1.28) gives the following budget constraint

$$C_1 + I_1 + \frac{C_2 + I_2}{1+r^*} = Y_1 + \frac{Y_2}{1+r^*} \qquad (1.32)$$

In this economy, a representative individual will maximise equation (1.27) subject to (1.32) instead of (1.28)

$$\max u(C_1) + \beta u\{(1+r^*)[F(K_1) - C_1 - I_1] + F(I_1 + K_1) + I_1 + K_1\} \qquad (1.33)$$

where we assumed a production function with the form $Y = F(K)$ and partial derivatives: $F'(K) > 0$ and $F''(K) < 0$. The stock of capital K_1 is given, $K_2 = K_1 + I_1$ and $I_2 = -K_2$. The first order conditions for maximisation, $\frac{\delta U}{\delta C_1} = 0$ and $\frac{\delta U}{\delta I_1} = 0$, are equation (1.29) and

$$F'(K_2) = r^* \qquad (1.34)$$

One can conclude from (1.34) that a small open economy with a high marginal product of capital can borrow from abroad in order to explore profitable opportunities. When financial markets are open, the marginal product of capital of the domestic economy will be equal to the world real interest rate, in other words, there are no *rids*. In autarky, however, the marginal product of capital is $F'(K_1) = F'(K_2) = r^a$ [10] which can be different from the world's real interest rate, put in another way, there could be *rids*.

1.3. Evidence

We now present and discuss evidence of tests on RIPH in this part of the chapter. We also discuss in detail some of the methodology employed in seminal tests. We highlight some empirical evidence that supports the existence of frictions in both goods and assets markets. Evidence on the effect of macroeconomic policy on *rids* is also presented. The empirical literature on *rids* is incipient, hence we could not find evidence on deviations from RIPH such as those generated by imperfect competition, pricing to market, Peso effects, rational speculative bubbles, transaction costs in assets markets, capital controls and differences in tax rules.

[10] Investigating how productivity changes affect the *rid* between a small open economy and the rest of the world, Chowdhry and Titman (2001), reached a different conclusion than the model earlier presented. They studied the case of Hong Kong where nominal interest rates had been the same as in the USA but inflation rates had been different. In their analysis, changes in the price of non-tradables explained the inflation differentials. Using insights of the Balassa-Samuelson effect, Chowdhry and Titman (2001) developed a model where anticipated increases in the productivity of the traded sector, shift resources in the production of non-traded durable goods (such as houses and factories). Two effects follow the shift in resources: 1) the increased capital implies a higher marginal productivity of labour in that sector, hence wages and prices of non-traded goods rises; 2) the extra supply of non-traded durable goods depresses their rental rates in the current period increasing their price to rental ratios, in other words, decreasing the *ex ante* real rate of interest.

Pioneer Works

As seen in the previous section, the simple monetary model (when UIP, PPP and the efficient market hypothesis are assumed) implies equality of real interest rates across countries at all times. The seminal reference on the empirical validity of this model is found in Frenkel (1976). His tests with the monetary model are for the period of hyperinflation in Germany during the 1920s. The results are supportive for the model's predictions. The author first tested the CIP (covered interest rate parity) condition, viewed as "...the measure of expectations that is appropriate for empirical implementation" (p. 210), to verify the extent to which the forward exchange rate was an efficient predictor of the spot rate. He found that f_{t-1}, the price of the foreign currency at time $t-1$ for delivery at t, summarised all relevant information about the exchange rate at time *t*. The results of the estimated equation are reproduced below

$$\underset{}{s_t} = \underset{(0.26)}{-0.45} + \underset{(0.08)}{1.10} f_{t-1} - \underset{(0.08)}{0.006} f_{t-2} \qquad (1.35)$$

where standard errors are in parenthesis.

In equation (1.35) the log of the spot rate s_t is equal to the log of the forward exchange rate f_{t-1} and its lagged value plus a constant term. The author concludes that the efficient market hypothesis is supported as the constant term is not statistically significant [Frenkel (1976), p. 212)]. The last term of equation (1.35) reveals that past values of the forward exchange rate (which contains information available at time t-1) do not help to predict the spot rate any better. Frenkel (1976) then used variations in the forward exchange premium to proxy for changes in the expected inflation rate (π^e). Finally the estimated determinants of the exchange rate are given below:

$$\begin{aligned} s_t &= -5.135 + 0.975 m_t + 0.591 \pi^e \\ &\quad (0.731) \quad (0.050) \quad (0.073) \end{aligned} \tag{1.36}$$

The evidence in (1.36) provides support for the monetary model. As can be seen, the money stock (m_t) and inflationary expectations explain the exchange rate, which affects the price level via arbitrage in goods market. At the same time, arbitrage in assets market guarantees that the forward exchange rate correctly reflects exchange rate depreciation, or alternatively, inflationary expectations.

Frankel (1979) tested his "*rid* model", a hybrid of the alternative hypotheses of both the Dornbusch (1976) and the monetary model, for the mark/dollar rate using a sample of observations spanning from 1974M7 to 1978M2. The model used to perform the econometric tests is given by the equation below

$$s_t = \phi_0 (m_t - m_t^*) - \phi_1 (y_t - y_t^*) + \phi_2 (\pi_t - \pi_t^*) - \phi_3 nid_t \tag{1.37}$$

where the asterisk stands for foreign variables, y_t is output and the ϕ_j are coefficients, where $j = 0,1,...,4$. The idea of the *rid* model is that the exchange rate is negatively related to the *nid* but positively related to the expected long-run inflation differential, encompassing both the Dornbusch (1976) and the hypothesis of the monetary model. If the Dornbusch (1976) model is more accurate than the monetary approach the parameter ϕ_3 is negative and since inflationary expectations will be reflected in the *nid*, ϕ_2 equals zero. However, if the monetary approach is valid ϕ_3 is expected to be zero and ϕ_2 positive. Estimated regressions were found to have coefficients that are significant and with the sign predicted by both Dornbusch (1976) and the monetary model.

Driskill and Sheffrin (1981) raised the main criticism about the econometric procedure employed by Frankel (1979). They argued that the interest rate differential was endogenous and thus could not be an explanatory variable. Because money supply is exogenous in the models of Frankel (1979) and Dornbusch (1976), then interest rates would be endogenous. For instance, an unexpected increase in the money supply would impact the interest rate (by increasing the supply of money in relation to bonds) and also generates an expectation of depreciation that quickly materialises (because the higher money balance increases prices). The unexpected change in money supply causes an incipient capital outflow movement leading to a depreciation of the spot exchange rate away from its equilibrium level and a further decrease in interest rates. In summary, an unexpected change in the money supply changes both the spot exchange rate and interest rates, hence the later cannot be used in the right hand-side of equation (1.38). Frankel (1981) answered Driskill and Sheffrin (1981) affirming that tests should be performed substituting the interest rate for an instrumental variable without making any modification in the original model.

Isaac and Mel (2001) tested Frankel's (1979) model using recent data and affirmed: "We are forced to conclude that Frankel's validation of the RID model was pure historical accident." (p. 491). The failure of Isaac and Mel (2001) attempt to update the results may not come as a surprise after all, as Frankel (1981) and Frankel (1982) had acknowledged the difficulty to explain the relationship between the mark and the dollar after 1978. In particular, Frankel (1981) and Frankel (1982) noted that the growth rate of nominal money supply in the US after 1978 was lower than both American and the German inflation rates. He recognised that the "mystery of missing dollars" and the "mystery of multiplying marks" could not be elucidated without a modification in the *rid* model[11]. The modification includes wealth, measured as an accumulation of past current account surplus, in the money demand function. Frankel (1981) and Frankel (1982) argued that wealth implies a raising demand for foreign money and a depreciating exchange rate. Testing for the mark/dollar exchange rate from 1974 to 1980, Frankel (1982) found favourable results for the *rid* model extended with the current account. In particular, he found that all variables had the sign predicted by the theory and most of them were significant, except real income.

Mishkin (1984) was a pioneer in the investigation of the RIPH as put forward by Roll (1979) and presented in section 1.2. His results, however, are different from the ones predicted by the monetary model. We present the methodology employed by Mishkin (1984) by recalling Fisher (1930) equation, where the domestic country real interest rate for a one-period bond is defined as

[11] Attempts to conciliate the "two mysteries" spawned a literature on portfolio balance models.

$$r_t^e = i_t - \pi_{t+1}^e \tag{1.38}$$

where r_t^e is the *ex ante* domestic real interest rate, i_t is the domestic nominal interest rate as previously defined as well as π_{t+1}^e which is the inflation rate from *t* to *t+1*, and expected at time *t*. The real interest rate described in equation (1.38) cannot be directly observed while the *ex post* real interest rate defined below, is observable

$$r_t = i_t - \pi_{t+1} = r_t^e - (\pi_{t+1} - \pi_{t+1}^e) = r_t^e - \varepsilon_{t+1}^{\pi} \tag{1.39}$$

With the assumption that expectations are formed rationally, the forecast error of inflation (ε_{t+1}^{π}) is unpredictable. Thus, equation (1.39) can be written as

$$r_t^e = E(r_t \mid \phi_t) \tag{1.40}$$

where ϕ_t is the set with all information available until *t*. Using equation (1.41) below Mishkin (1984) illustrates that equality of real rates across countries imply a non-predictable *rid* given any information available at *t*, i.e. the error term is stationary with a zero mean, as below

$$r_t^e - r_t^{e*} = E(r_t - r_t^* \mid \phi_t) = 0 \tag{1.41}$$

where r_t^{e*} is the foreign *ex ante* real interest rate.

Mishkin (1984) tested the null hypothesis of real rate equality across countries by verifying if the parameter α in the equation (1.41) was not statistically different from zero

$$r_t - r_t^* = I_t\alpha + \varepsilon_t \qquad (1.42)$$

If there is any information (I_t) available in the set ϕ_t that can be used to predict the interest rate differential (at t with maturity t+1), then real interest rate across countries are not equal. It is implicit to his argument that a rejection of the null is supportive for models allowing for frictions in the goods and/or assets market[12]. Following, Mishkin (1984) analysed the validity of the basic parity conditions individually. Consider the equations below

$$i_t - i_t^* = f_t - s_t \qquad (1.43)$$

$$E(\pi_{t+1} - \pi_{t+1}^* - (s_{t+1} - s_t) \mid \phi_t) = 0 \qquad (1.44)$$

$$f_t = E(s_{t+1} \mid \phi_t) \qquad (1.45)$$

[12] On the other hand, the failure of not rejecting the null could simply mean lack of relevant information in the set ϕ_{t-1}.

where f_t is the price of the foreign currency at time t for delivery at $t+1$, and s_{t-1} is the natural logarithm of the spot exchange rate. Equation (1.43) is the covered interest rate parity condition, equation (1.44) represents an *ex ante* version of the relative PPP and (1.45) represents the unbiasedness of forward rate forecasts. UIP condition is obtained by substituting (1.45) in (1.43) which gives

$$E(i_t - i_t^* - (s_{t+1} - s_t) \mid \phi_t) = 0 \tag{1.46}$$

RIPH is derived subtracting the *ex ante* relative PPP in (1.44) from the UIP condition (1.46) which yields

$$E(r_t - r_t^* \mid \phi_t) = r_t^e - r_t^{e*} = 0 \tag{1.47}$$

In summary the tests performed by Mishkin (1984) comprise the estimation of equation (1.42), (1.48) and (1.49) as stated below

$$i_t - i_t^* - (s_{t+1} - s_t) = I_t \delta + \eta_t \tag{1.48}$$

$$\pi_{t+1} - \pi_{t+1} - (s_{t+1} - s_t) = I_t \gamma + \omega_t \tag{1.49}$$

where η_t and ω_t are random error terms that follow the classical assumptions.

The equations above were estimated (using OLS) during the period that spans from 1967 to 1979 for a sample of seven developed countries. The information set (I_t) contained four lags of the dependent variable and a constant term. Mishkin (1984) used the Euro deposit rate, which he supposed to be a risk free asset. The tests were performed using both a wholesale and a consumer price indexes. The results showed that when UIP and PPP are tested together, either implicitly as in equation (1.42) or explicitly, when testing the joint hypotheses that δ and γ are equal to zero in (1.48) and (1.50), equality of real rates across countries is rejected. Mishkin (1984) concluded that models based on the assumption of costless international arbitrage in goods and assets markets cannot explain the behaviour of real interest rates better that those allowing for frictions.

Other Tests of RIPH

Other tests of RIPH include Cumby and Mishkin (1984) who tested the comovement of short-term real interest rates in eight countries. They used three month interest rates in the euro deposit and domestic money markets from 1973M6 and 1983M12 for Canada, Italy, the Netherlands, France, West Germany, the UK and the US. CPI was used as the price index. They regressed the *ex post* real interest rate on a constant term, a time trend, the nominal interest rate and three values of lagged inflation in order to estimate the *ex ante* real interest rate (the fitted values of the regression). Their general conclusion regarding these estimates is that the timing and the extent of real rate movements differ between countries. Furthermore, they also regressed *ex post* real rates of each country against the US interest rate. The hypothesis of no linkage was rejected for all countries except Switzerland while the hypothesis of one-to-one relationship was rejected for 5 countries. The finding is that there is a statistical association between real rates in nearly all pairs of countries.

Frankel and Okongwu (1995) proposed to investigate why real interest rates of nine Latin American and East Asian countries during the period from 1987 to 1994 have not converged to US levels in spite of the large amount of capital inflows directed to those countries in that period. Frankel and Okongwu (1995) argued that if the cause of capital inflows was external - as most of the empirical papers before the Mexican crisis have suggested – the interest rate differential should have declined. However, they recognised that a positive relationship between domestic monetary tightening and capital inflows could exist either because inflows are attracted by high interest rates or because it reflects the sterilisation of the inflows. They claimed that a methodological innovation of their work is the use of a direct measure of exchange rate expectations. Frankel and Okongwu (1995) have used exchange rate expectation from survey data[13] on the forecasts of 45 economic agents including multinational firms and forecasting companies. They decomposed the total interest rate differential in three parts: the expected depreciation, the country-risk and the exchange rate premium. For country-risk they have employed either secondary-market debt prices or the spread between the domestic dollar interest rate and the US treasury bills, depending on data availability. For many countries, expected depreciation appeared to be accounting for most of the changes in the interest rate differential. They concluded that the *nids* are explained by the expectation of depreciation (which is derived from the sterilisation side effects

[13] The data is from Currency Forecasters' Digest as explained by Frankel and Okongwu (1995), p. 8.

rather than a risk premium). In relation to the degree of capital mobility they found that inflows are, in general, negatively related to the US interest rates and domestic monetary expansion. On the other hand, evidence on the significance of domestic interest rates, specific country effects (measured by dummy variables), country risk and even expected depreciation to explain inflows were dubious. In summary, Frankel and Okongwu (1995) did not find support for perfect capital mobility.

Recent works that support RIPH include Gagnon and Unferth (1995) who tested this hypothesis for nine major industrialised countries using panel data techniques over the past 16 years. They showed that each country's real interest rate is highly correlated with the estimated world real interest rate. The exception is the behaviour of the American real interest rate, which exhibits persistent deviations from the estimated world real interest rate, but it is still correlated. Ong et al. (1999) extended Gagnon and Unferth's (1995) approach by weighting countries in terms of relative GDP and trade. They have demonstrated that the choice of the deflator can change the result found by Gagnon and Unferth (1995) but they still find support for real rate equality across countries. Jorion (1996) investigated the validity of RIPH for long-term bonds across the US, UK and Germany for period from 1973M8 to 1991M12. Using a set up for the tests similar to the one employed by Mishkin (1984), results do not support the view that expected real interest rates tend to be equalised over longer maturities, however there is evidence that UIP holds. Al-Awad and Goodwin (1998) examined weekly real interest rates for G-10 countries using a variety of time-series tests. Their results provide strong support for well integrated markets but not to real interest rate equality particularly in the long-run. Chinn (1995) found that in the Pacific Region, RIPH holds for US-Singapore, US-Taiwan and Japan-Taiwan. Phylaktis (1997) and Phylaktis (1999) also concluded that financial markets in the Pacific-Basin Region have become more integrated with both U.S. and Japan during the 1980s. Using monthly data over the period 1982M1 to 1993M12, Alexakis et al. (1997) demonstrated that RIPH is accepted for nine European countries both on a non-EMS and an EMS basis. This relationship proves to be stronger on the EMS. Cavaglia (1992) applied Kalman filtering techniques to estimate the persistence of *ex ante* real interest differentials for the period from 1973 to 1987. He found that *ex ante* real interest differentials are relatively short-lived and mean-reverting to zero, thus providing empirical support for real rate equality in the long-run steady state.

Kugler and Neusser (1993) tested for RIP searching for linear combinations between time-series, using monthly data for Japan, the UK, Germany (Federal Republic), Switzerland and the US from 1980 to 1991. They first found that real interest rates are stationary. Second, their evidence indicates that there is a strong relationship between real interest rates and also that deviations disappear very quickly. Generally, the hypothesis that the long-run mean is equal to zero cannot be rejected. Sekioua (2004b) performed a cointegration analysis of RIPH for France, Germany, Japan, Switzerland and the UK with respect to the US. The period of the tests is from 1974M1 to 1998M12. He used long-term government bond yields, with maturities of 10 years. Price indexes are the CPI and a price index of traded goods. The Johansen cointegration test is performed within a VAR framework. The finding is that there at least one cointegrating vector between interest rate and inflation differentials. Deviations from the estimated cointegrating relationship adjust fully within three years.

Unit Root Tests on *Rids*

Meese and Rogoff (1988) performed unit root tests in the series of *rids* of the US, UK, Japan and Germany over the period 1974M2 to 1986M3. They could not reject the hypothesis that there is a unit root in the series of long term *rids*, but not in short-term differentials. In fact, they found that both nominal and real short-term interest rate differentials appear to be stationary in levels. Along the same line of Meese and Rogoff (1988), Edison and Pauls (1993) performed ADF-tests on *rids* using quarterly observations from 1974 to 1990 for the G-10 countries. They could not reject the unit root hypothesis.

Obstfeld and Taylor (2002) questioned why Meese and Rogoff (1988), Edison and Pauls (1993) and MacDonald and Nagayasu (2000) could not reject the unit root hypothesis given the increasing globalisation of capital markets "...if capital is perfectly mobile, this dooms to failure any attempts to manipulate local asset prices to make them deviate from global prices, including the most critical macroeconomic asset price, the interest rate" (p.17). In their view, the failure to reject the null stems from the fact that these authors focused attention on the recent float, had shorter samples, and used tests of low power such as the ADF test. The sample used by Obstfeld and Taylor (2002) includes *rids* of three countries (the UK, France and Germany) relative to the US, from 1870 to 2000. Their results, using standard ADF and Elliott (1999) tests, show that the hypothesis of a unit root can be rejected at the 1% level in all periods except for the recent float: "The most striking impression conveyed by the figure is that differentials have varied widely over time, but have stayed relatively close to a zero mean. That is, the series appears to have been stationary over the very long-run, and even in shorter sub periods." (p.26). By splitting the sample of the recent float in two sub periods (1974-1986 and 1986-2000) they found that the evidence against a unit root is stronger over the second sub period.

Goldberg et al. (2003) find similar results for a set of six major industrialised economies. They use quarterly short-term treasury bill for Canada, the UK and the US and call money rates for France, Germany, and Japan (the choice for the latter countries is due to availability). The consumer price index was used to calculate the real interest rates within a period that span from 1975Q1 to 2000Q2. The countries are chosen because of their central role in the world economy and because of larger data availability. They find that most of the country pairs of *rids* are stationary after a structural break in 1980, and in most of the cases *rids* revert to an equilibrium that is not statistically different from zero: "Fluctuations in differentials occur periodically over the sample period, but somewhile persistent, in the end prove transitory." (p.1) In general, mean reversion of *rids* is found to be fast, especially for the recent floating period.

Sekioua (2004a) tested for unit roots on *rids* but the focus of his paper is on the persistence of *rids*. Sekioua (2004a) uses monthly interest rates and prices spanning from the beginning of the first quarter of the 20th century for the UK, Japan, and France relative to the US. Interest rates are long-term government bond yields of maturities of seven years or more. The inflation rate is calculated as the average value of the previous 12 months. The unit root is rejected for the three countries at the 1% significance level. Results are weaker when the sample is divided in sub-periods. The unit root, for example, cannot be rejected for the period of the recent float using the 5% and 1% significance level. He also calculates confidence intervals for the dominant root (point estimates of the root), which is estimated to be in the vicinity of 1. Using point estimates of the half-lives, Sekioua (2004a) found that it takes approximately 17 months for mean reversion in the UK which he concludes that is compatible with RIPH. However, it may take more than 75 months for shocks to die out in France, pointing towards a very high degree of persistence. Point estimates for Japan indicate a half-life of about 24.3 months during the whole period. Sekioua (2004a) also found that the behaviour of *rids* across different exchange rate regimes seems to be uniform. The tests reject the unit root but confidence intervals for the dominant root seem to be high.

1.4. Concluding Remarks

RIPH is founded on the three pillars of International Finance: PPP, UIP and rational expectations or the efficient market hypothesis. This hypothesis is also in accordance with microeconomic models derived from utility maximisation conditions. RIPH states that real interest rates across countries would equalise if transactions costs are absent and if there is perfect asset substitutability. Hence, *rids* would converge to a zero mean in the long-run.

Unit roots tests on *rids* and cointegration tests between real interest rates of pairs of countries are the two approaches most commonly used in the empirical literature. Using different techniques, several studies have tested RIPH, however, there is no conclusive answer regarding the existence of *rids*. Authors tend to conclude that *rids* are relatively short-lived and mean-reverting but different from zero in the long-run. Hence, the existence of *rids*, if does exist, is time and country specific.

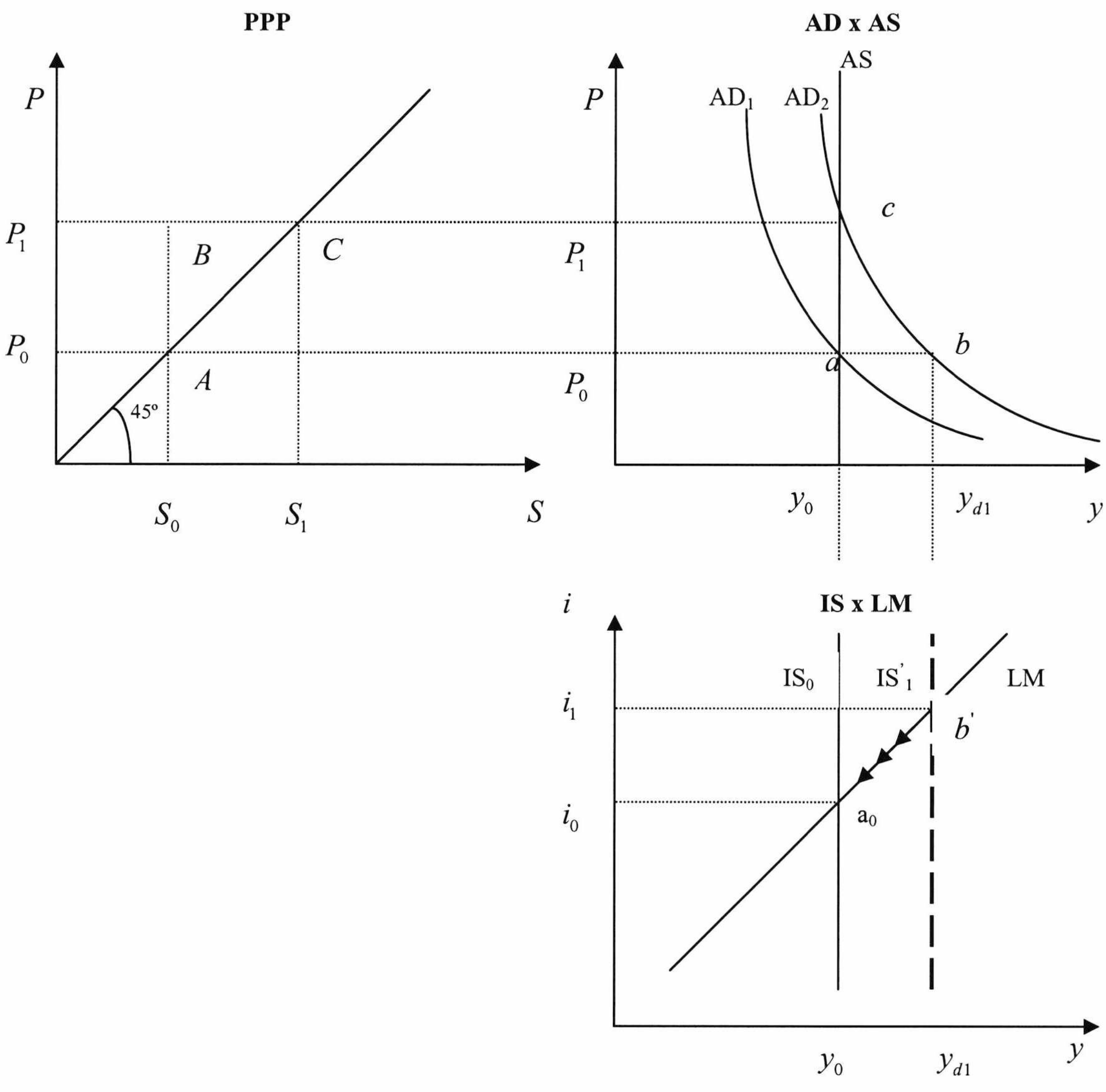
RIPH is based on the assumption of frictionless markets and, for this reason, *rids* can also reveal the degree of trade and financial integration between markets. Existent tests of RIPH are predominantly for developed economies. However, as emerging markets carried out processes of economic liberalisation during the 1990s, the question of interest is whether the higher integration has led to real interest rate equalisation in these economies. Thus, we first perform RIPH tests on a selected group of emerging markets comparing the results with developed economies.

Investigation on the determinants of *rids* have not been subject to much empirical research in the economic literature. This enquiry is most important because macroeconomic policies, especially monetary, are being redesigned in emerging economies. There is scope for policy suggestions arising from a better understanding of the dynamic properties of *rids*.

We have shown that the failure of the individual parity conditions imply deviations from RIPH. The underlying determinants must then be related to the causes of failure of these arbitrage conditions and the rational expectations hypothesis. Thus, we will focus on the causes of *rids* by initially separating out the contributions of the deviations from relative PPP and UIP to the deviations from RIPH. Afterwards, we verify the underlying causes by analysing the arbitrage condition that is more important for the determination of the *rid*. This is done in the last 3 chapters of the thesis.

Figures

Figure 1. *Rids* in the Monetary Model



Chapter 2. Does the Real Interest Rate Parity Hold?

2.1. Introduction

We have shown that if agents make their forecasts using rational expectations, and arbitrage forces are free to act in the goods and assets markets, then real interest rates between countries will equalise, in other words the RIPH holds.

The importance of this hypothesis stems from the fact that empirical evidence can be interpreted as a measure of international integration in goods and assets markets. This is particularly emphasised in Chinn and Frankel (1995), Phylaktis (1999), Alexakis et al. (1997), Al-Awad and Goodwin (1998), Obstfeld and Taylor (2002), Mancuso et al. (2002) and Goldberg et al. (2003). This is because the RIPH is based on the existence of frictionless markets. It follows that a test of the real interest rate parity is a test of the degree of market integration. That is, in integrated goods and capital markets factor price equalisation would occur, leading to equal returns to capital across the world.

This chapter presents further evidence on the RIPH for a sample of open-economies in relation to the US. We do so by carrying out a set of unit root tests in order to characterise the dynamic behaviour of *rids*. Contrary to cointegration, unit root tests do not require previous knowledge of the order of integration of the *rids*. However, while there is a substantial number of papers testing unit roots in nominal interest rates, inflation and even real interest rates, few studies are concerned with *rids*. As seen in the previous section, the main examples of unit roots tests on *rids* are Meese and Rogoff (1988), Edison and Pauls (1993), Obstfeld and Taylor (2002) and Goldberg et al. (2003). Our study complements these authors in three main directions. First, we make use of more powerful unit root tests and take structural changes into account. Second, in line with recent theoretical and empirical models of capital flows, we simultaneously test for the existence of asymmetries and unit roots in the behaviour of *rids*.[14] Third, we focus both on developed and emerging market economies. This will allow us to compare the dynamic behaviour of *rids* in both groups and extract conclusions about the driving forces behind them as we would expect differences to be more marked between these two groups. Our findings show that *rids* are in general quickly mean reverting, with a positive mean for emerging markets and zero or close to zero for developed ones. We also show that *rids* show strong features of asymmetry, but the behaviour for emerging and developed markets is substantially different.

The chapter is organised as follows. In Section 2.2 we give some theoretical background and describe the methodology involved in the tests; in Section 2.3 we describe the data; Section 2.4 presents the results of unit root tests; Section 2.5 presents the results of the asymmetry tests and Section 2.6 concludes. In an appendix to this chapter we discuss some implications for our tests of the use of monthly data and bonds for which the maturity does not match.

[14] See, for instance, Kraay (2003), Pakko (2000) and the review of Stiglitz (1999). Asymmetries could also arise in the adjustment of prices due to goods market frictions arising from transaction costs as in Obstfeld and Rogoff (2000).

2.2. Methodology

Summarising the theory explained in chapter 1, arbitrage forces are formalised by the uncovered interest rate parity and the relative purchasing power parity conditions which are restated in equations (2.1) and (2.2), respectively:

$$i_t - i_t^* = \Delta s_{t+1}^e \tag{2.1}$$

$$\Delta s_{t+1} = \pi_{t+1} - \pi_{t+1}^* \tag{2.2}$$

$$\Delta s_{t+1}^e = \Delta s_{t+1} + \varepsilon_{t+1} \tag{2.3}$$

where variables are as defined in the previous chapter. Equation (2.3) represents the rational expectations hypothesis.

If relative PPP holds, we can substitute equation (2.2) into (2.3) and the result into (2.1), which yields:

$$i_t - i_t^* = \pi_{t+1} - \pi_{t+1}^* + \varepsilon_{t+1} . \tag{2.4}$$

The version of PPP assumed in this model is a relative one in which *inflation* differences are expected to be such that real exchange rates remain constant over time. Equation (2.4) can also be rewritten as

$$(i_t - \pi_{t+1}) - (i_t^* - \pi_{t+1}^*) = rid_t = \varepsilon_{t+1} \tag{2.5}$$

since ε_{t+1} are iid $N(0, \sigma_\varepsilon^2)$, the expected value of the *rid* is zero.

Consider that rid_t from equation (2.5) follows the autoregressive process:

$$rid_t = a_0 + a_1 rid_{t-1} + \upsilon_t \tag{2.6}$$

where $|a_1| < 1$ and υ_t is a white-noise error term. Assuming that rid_0 is a deterministic initial condition, the solution to the difference equation above is:

$$rid_t = \frac{a_0(1 - a_1^t)}{(1 - a_1)} + a_1^t rid_0 + \sum_{i=0}^{t-1} a_1^i \upsilon_{t-i} . \tag{2.7}$$

Taking expectations of equation (2.7) and considering RIPH, we have

$$E(rid_t) = \frac{a_0}{1 - a_1} = 0 \quad \text{thus } a_0 = 0 \tag{2.8}$$

For $t \to \infty$, the *rid* converges in distribution to normality with mean $\frac{a_0}{1-a_1}$, i.e.:

$$rid_t \xrightarrow{d} N\left(\frac{a_0}{1-a_1}, \frac{\sigma_\upsilon^2}{1-a_1^2}\right) \qquad (2.9)$$

The theory explained in chapter 1 shows that, if UIP, PPP and rational expectations hold, the *rid* is equal to the unforeseeable disturbance term related to the forecast of exchange rate depreciation. From equation (2.9) we observe that a *rid* does not exist in the long run because its unconditional mean, or expected value, is equal to zero. The problem is to verify whether shocks to the series of *rids* dissipate and the series returns to its long-run zero mean level. This objective can be accomplished by performing unit root tests on the series of *rids*.

The error correction representation of (2.6) can be augmented with lagged differences of *rids* to account for possible residual autocorrelation in the errors. We can augment the model of equation (2.6) as a *p*th-order autoregressive process,

$$\Delta rid_t = a_0 + \psi rid_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta rid_{t-i} + \upsilon_t , \qquad (2.10)$$

where,

$$\psi = \sum_{i=1}^{p} a_i - 1. \qquad (2.11)$$

The following possibilities arise from the estimation of the ADF-type equation (2.10):

$$\hat{\psi} > 0 \qquad (2.12)$$

$$\hat{\psi} = 0 \qquad (2.13)$$

$$\hat{\psi} < 0 \text{ and } a_0 = 0 \qquad (2.14)$$

$$\hat{\psi} < 0 \text{ and } a_0 \neq 0 \qquad (2.15)$$

Inequality (2.12) represents the case in which the parameter $\hat{\psi}$ is statistically greater than zero. The path of *rids* in this case would be explosive and the series would not converge to any mean in the long-run. In (2.13) the series contains a unit root and *rids* follow an integrated AR(p-1) with shocks affecting the variable on a permanent basis. In cases (2.14) and (2.15) the estimated parameter ($\hat{\psi}$) is such that $\sum_{i=1}^{p} \hat{a}_i < 1$. Deviations from the mean are temporary and the estimated root provides information on whether the *rid* is short-lived or persistent. In (2.14) the *rid* follows a stationary process and converges to a zero mean. The RIPH holds and the speed of adjustment of the *rid* to its equilibrium level is a measure of the degree of persistence. In (2.15) *rids* converge to a mean that is different from zero. In summary, short-lived *rids* are consistent with the RIPH because the series rapidly reverts to zero. Persistent *rids* that converge to a constant mean that is equal to zero are also consistent with the RIPH, since shocks eventually dissipate. The existence of a mean different from zero may arise theoretically from frictions in goods and assets markets. However, random walks, permanent or explosive *rids* are inconsistent with the RIPH[15].

Three usual problems with standard unit root tests, such as the ADF, arise. First, it is well known that the power of these tests tends to be very low, leading to over-acceptance of the null of a unit root. The low power problem is magnified for small samples because a stationary series could be drifting away from its long-run equilibrium level in the short-run. Another serious problem of unit root tests is not considering the existence of structural breaks in the series. When there are structural changes, the standard tests are biased towards the non-rejection of a unit root [Perron (1989)]. Finally, since the work of Neftci (1984), it has been increasingly recognised that macroeconomic time series show strong asymmetry over the business cycle. If asymmetry is present in *rids*, linear unit-root tests will suffer from a loss of power.[16]

Several tests have been put forward to alleviate these problems. Kwiatkowski et al. (1992) use the LM statistic to test the null hypothesis of stationarity (KPSS test). The time-series in their model is written as the sum of a deterministic trend, a

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[15] Interestingly, Sarno and Taylor (2004) showed that the assumption that *rids* are stationary is sufficient to conceal the finding that long-run PPP holds with the random walk behaviour of the real exchange rate as implied by UIP and the efficient market hypothesis.

[16] See Enders and Granger (1998). They also show evidence of asymmetry in the adjustment of the term structure of interest rates.

random walk and a stationary error. The null corresponds to the hypothesis that the variance of the random walk equals zero, in other words, the variance of the error is constant. When the series has an unknown mean or linear trend, the tests suggested by Elliot et al. (1996) (ERS test hereafter) and Elliot (1999) are recommended. These tests use information contained in the variance of the series to construct a test statistic (DF-GLS and ADF-GLS) that has more asymptotic power than the standard ones. The initial condition is assumed to be zero in the ERS test while it is drawn from its unconditional distribution in Elliot (1999). Regarding the existence of structural breaks, Perron (1997) developed a procedure to test for unit-roots that endogenously searches for structural breaks in the series using two methods. In the first method, the break date is chosen to be the one in which the t-statistic for testing the null hypothesis of a unit root is smallest among all possible break points. In the second method, the break point corresponds to a maximum of the absolute value of the t-statistic on the parameter associated with the change in the intercept. We will make use of both when testing the RIPH assuming symmetric behaviour of the *rid* to positive and negative shocks. Later on we relax this assumption and apply the tests proposed by Caner and Hansen (2001) that allows for testing unit roots and asymmetry using threshold autoregressive methods. This is because some theoretical and empirical models of credit markets with imperfect information point out to possible asymmetric behaviour of *rids* as changes in interest rates may influence subjective risk perceptions by creditors. If the series are asymmetric, the power of unit-root tests will improve. The pattern of asymmetry showed by *rids* is also a relevant issue in itself, especially when we compare different country experiences.

We can also calculate the half-life of the *rid* using the parameter ψ. The half-life (h) is defined as the number of periods required by a unit shock to dissipate by one half. The half-life measures the speed of adjustment to the equilibrium and is calculated according to the following formulae

$$h = -\left(\frac{\ln(2)}{\ln(1-\psi)}\right) \qquad (2.16)$$

In summary, short-lived *rids* are consistent with RIPH because the series rapidly reverts to zero. Persistent *rids* that converge to a constant mean that is equal to zero are also consistent to the RIPH, since shocks eventually dissipate. However, random walks, permanent or explosive *rids* are inconsistent with RIPH.

2.3. Data

As explained in the introduction, the countries chosen for our tests can be split into two groups. The first one comprises some small open-economies of emerging markets: Argentina, Brazil, Chile, Mexico and Turkey. The second group is composed of some open-economies of developed countries: France, Italy, Spain, the UK and Germany. Finally, we used the US as the reference large economy for the calculation of *rids*[17]. We have chosen a heterogeneous sample of countries in order to perform inter-group comparisons and to investigate the existence of similar patterns between them. For instance, most countries in the first group have

[17] As a matter of fact, we also tested using Germany as the reference economy. Because results were very similar to the ones using the US and for the sake of conciseness and clarity, we decided not to report them.

experienced external problems during the mid 1990s. Recurrent current account deficits were reflected in high liquidity constraints that may have impacted *nids* and or *rids*.

The period of the tests for this chapter corresponds to the interval that spans from 1995M3 to 2002M5, with the exceptions of Argentina, for which we have calculated *rids* until 2002M3, and Chile and the UK, with *rids* calculated until 2002M4. The sample period of the following chapters is slightly longer - spans until 2004 – and this is due to the extended availability of the data at the time we performed the tests.

Our sample period starts in the mid 90s because harmonised data for the construction of the *rids* for some of our countries did not exist before this period.[18] Table 2.1 shows some summary statistics. The data is monthly and the start of the sample was selected according to data availability for Brazil. Data was available for this country since 1980M2. However, as it is well known, Brazil experienced episodes of hyperinflation in the 1980s and in the early 1990s. Both inflation and interest rates during these periods show a very erratic behaviour of *rids* that for some observations take values beyond one billion. Observations for which *rids* take a value higher than 1,000 make up 12% of the sample for Brazil. On the other hand, and according to the way IMF calculates short term interest rates for these countries, hyperinflation may have had a huge impact on the bond weights used to build the interest rates series, leading to serious problems of measurement error[19]. Because of this, and the intractability of the data, we have chosen to leave the high

[18] We decided to test RIPH for the same period for all countries to allow for comparison of the results.

[19] It must be stressed that the problem of measurement error also applies for Argentina, during the beginning of the 1990s.

inflation years out of the sample. The monetary change of the Brazilian "Real Plan" happened in the 2nd half of 1994, hence we decided to use the sample from 1995. This means that we have a sample of approximately 9 years and, because it consists of monthly observations, our sample comprises 83 observations.

An advantage of using this period is that after the mid-90s most of the countries had liberalised capital markets and had advanced substantially in their trade liberalisation process, which presumably reduced the effect of capital controls and transaction costs on UIP. As shown previously, the RIPH is based on the assumptions of frictionless goods ands assets' markets. If there are restrictions to trade in these markets, arbitrage would be constrained and different outcomes from those predicted by the RIPH may arise. The process of trade and financial liberalisation happened during different periods for the countries in our sample. Trade liberalisation in developing economies was carried out in the late 1980s and early 1990s[20]. Financial liberalisation happened almost simultaneously[21]. Hence, we focus on the second half of the 1990s using data available until the beginning of the 2000s.

Data on interest rates was obtained from the International Financial Statistics (IFS), of the International Monetary Fund (IMF). Among the several categories of interest rates available in the IFS database, we considered the Treasury Bill Rate as being the most appropriate for the tests. In practice, there is no unique variable that international arbitrageurs use to compare their prospective returns at home and abroad. However, the Treasury Bill Rate is available in domestic markets to

[20] See UNCTAD (1999).

[21] Edwards (2001), among others, acknowledged the difficulty in measuring the "true" degree of capital mobility and thus the starting period of the financial liberalisation. In spite of this difficulty, however, it is recognised that there has been a marked increase in the flows of capital across countries especially during the nineties.

international arbitrageurs and has a fixed maturity. For these reasons, we have chosen to use the Treasury Bill Rates for Brazil, Mexico, Italy, Spain, UK, US and Germany. We use deposit rates for Argentina, Chile and Turkey because the availability of data on Treasury Bill Rate was limited for these countries. This is the only other short-term interest rate available with a specified maturity. As regards the choice of maturity, as stated by the liquidity premium theory, investors tend to prefer bonds with short-term maturities rather than bonds with longer-term maturities, since the former bear less default risk. With regard to the currency risk, forecast errors of exchange rate changes are likely to enlarge as the maturity of the bond increases. Because we are interested in verifying the degree to which real interest rates are different across countries, we have decided to use short term rates instead of long-term ones in order to avoid a greater influence of risk premium and forecast errors in the composition of *rids*.

Hence, in order to calculate *rids* we transformed the annualised monthly interest rate into a compounded quarterly rate; the real interest rate was then calculated by subtracting the quarter-on-quarter inflation rate from the compounded nominal interest rate of three months[22]. The inflation rate is the rate of growth of the Consumer Price Index (CPI).[23] Our choice of interest rate and inflation is in accordance with the data used by the majority of the authors testing UIP. For instance, Mishkin (1984), Knot and de Haan (1998), Nakagawa (2002), Phylaktis (1999), Alexakis *et al.* (1997) used interest rates that included either the 3-month Treasury Bill or the 3-month deposit rate. The great majority of authors also used the CPI as the appropriate deflator.

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[22] *Ex post* real interest rates (or *ex post* real returns) are calculated as in Cumby and Mishkin (1984).
[23] The results using the Producer Price Index (PPI) were remarkably similar and are not reported here to save space.

Figure 2.1 plots the different *rids* with respect to the US. With the exception of Chile, *rids* were high in all developing countries at the beginning of the sample period and behaved differently afterwards. The *rids* of Argentina, for example, were stable until mid-1998 when they experienced a substantial increase that accelerated with the 2001 crisis. The *rids* of Brazil initially diminished but started to increase again until 1999 when they fell and stayed relatively constant. A possible explanation for this apparent structural break in Brazil is that the change in the exchange rate arrangement in 1999M1 released monetary policy from the objective of attracting capital flows to sustain the hard peg[24]. The *rids* of Turkey were volatile around a positive mean during the whole sample period. The *rids* of Mexico showed a "negative trend" until 1999 and a positive mean afterwards. It is difficult to see any pattern in the *rid* of Chile, so we prefer to describe it as being volatile with a positive mean. The shortage of international liquidity triggered by the Mexican crisis of 1994-1995 may explain the high common level of *rids* in the initial period of the sample.

The graphs of the *rids* of developed countries tell different stories. The pattern of the *rid* is very similar for Spain and Italy. These countries experienced positive *rids* in a first period that finished by mid-1997 and negative *rids* during the second period. For France and the UK it is difficult to see a clear pattern. They are relatively volatile and seem to fluctuate around a zero mean. Much of the evolution of *rids* for these countries can be explained in terms of the closing gaps in nominal rates due to the convergence criteria imposed for the launch of a common currency. The speed of convergence increased considerably after the establishment of the

[24] See Frankel et al (2002) for an analysis of the empirical regularities concerning the sensitivity of domestic interest rates to international ones under different currency regimes. They also verify in the paper whether floating exchange rate regimes allow independent monetary policy.

irrevocable parities in 1999M1 (with the exception of the UK). In fact, convergence to a lower level of nominal interest rates, given a higher inflation rate, may explain the negative mean of the *rids* of Spain and Italy in the period that started after mid-1997.

2.4. Unit Root Tests

The results of ADF tests are reported in Table 2.2. We found the optimal augmentation lags by using a sequential general to specific criteria. The results show that we can reject the hypothesis of a unit root only for Brazil, Mexico and Turkey. It must be stressed, however, that our test statistics were very sensitive to the number of lags, which means that inaccuracy in the lag selection may have led to biased conclusions. Increasing the number of lags of Brazil from 3 to 5, or in the case of Mexico from 1 to 5, for example, imply the non-rejection of the null hypothesis of a unit root. Nonetheless, as briefly discussed in the previous section, failure to reject the unit root is likely to be explained by the low power of ADF tests. Hence, we performed the already mentioned more powerful tests. As we can see in Table 2.2, the results using ERS (1996) were slightly different. Using the same number of lags chosen for the ADF tests, we could reject the unit root hypothesis not only for Brazil, Mexico and Turkey but also for the *rid* of Chile. The findings of the tests using the method proposed by Elliot (1999) were very similar to that of ERS (1996). The KPSS test allowed us to accept the hypothesis of stationarity for most countries of the sample. Apart from the countries mentioned before, we could not reject the hypothesis of level stationary for the *rids* of Argentina and France but not for Brazil. We could also not reject the null of stationary for the *rid* of the UK and Germany.

Although these methods provide more powerful alternatives to the ADF test, they do not take into account structural breaks. The plots of *rids* in Figure 2.1 reveal that many of these series may contain a break in their mean. This is especially so for Argentina, Mexico, Brazil, Italy and Spain.[25] For this reason we applied Perron's (1997) tests assuming that the series contain an innovational outlier with a change in the intercept.[26] This model can be represented as

$$rid_t = a_0 + \theta DU_t + \lambda D(T_b)_t + a_1 rid_{t-1} + \sum_{i=1}^{p} \beta_i \Delta rid_{t-i} + \upsilon_t, \tag{2.17}$$

where T_b denotes the break date; $DU_t = 1(t > T_b)$ and $D(T_b)_t = 1(t = T_b + 1)$. The test is performed using the t-statistic for the null hypothesis that a_1=1. The results of this test are reported in Table 2.3.

We were able to reject the unit root for Brazil, Chile, Mexico and Turkey using the date break suggested by the first method. The unit root hypothesis was also rejected for Mexico, Turkey and Italy using the date break of the second method. Nevertheless, we could not find evidence of non-stationarity for the *rids* of Spain in any of the tests.

The date breaks retrieved by the tests suggest that the Asian crisis (starting in mid 1997) impacted on the *rids* of Chile and, less likely, the *rids* of France, Italy and Spain. Another explanation for the break dates of the latter countries is that *rids*

[25] This is further confirmed by plots of the recursive Chow tests of the AR parameter as shown in Figure 2.2.

[26] We assume only one structural break on the basis that visual inspection of the data points out to only one break, which is consistent with the fact that each country suffered only one major crisis or event during the period under consideration.

were affected by the Stability and Growth Pact signed by the European Council in 1997M6 and the prospect of the establishment of the European Central Bank (ECB), that officially took place in 1998M6. The Mexican crisis (1994M12) appears to have impacted on the *rids* of Brazil, as can be seen in the date break found by the first method. The Russian crisis (mid 1998) may have had an effect on the *rids* of Mexico and Chile. The Brazilian crisis (1999M1) is captured by the date break of the *rids* of that country retrieved by the second method. The Brazilian crisis probably impacted the *rids* of Argentina as can be seen in the date break suggested by the second method. The free float of the Peso in Argentina 2002M1 is reflected in the date break of the first method. The results also indicate that the Turkish crisis, which culminated in 2001M2 with the free floating of the Lira, may have its origins at the beginning of 1999.

According to our results, the irrevocable parities announced in 1999M1 for the Euro area and the introduction of the Euro as a medium of exchange in 2002M1, have not been reflected in the form of a structural break during the sample period. Our results also suggest that the Asian financial crisis and/or the establishment of the European System of Central Banks may have affected the *rids* of developed countries in a structural manner.

The tests carried out also allowed us to calculate half-lives of deviations from equilibrium and the equilibrium itself as given by equation (8)[27]. It must be stressed that *rids* converge to an equilibrium level only if there is not a unit root in the series. As previously stated, the low power of the traditional tests implies that a unit root may not exist even if we are not able to reject the null. Hence, we decided to

[27] The discussion carried out in the appendix should be taken into consideration when reading the results of the estimated half-lives.

calculate the half-life and equilibrium level of *rids* for all countries including Spain. The results are reported in Tables 2.4 and 2.5.

According to the estimated roots obtained with standard ADF tests, some countries of our sample have highly persistent *rids*. The half-life of the *rid* of Argentina, for example, is 13.1 months. In the case of Spain and Italy, the half-life is 5 months and 7.3 months, respectively. The most persistent *rids*, according to our results, are those of Argentina and Italy. On the other hand, the tests using the Perron (1997) methods suggest a smaller degree of persistence for the *rids* of all countries. Half-lives vary between 0.8 and 3.2 months, with the exception of Argentina. Thus, when possible structural changes are taken into account, *rids* of almost the whole sample are short-lived.

Estimated equilibrium levels for the *rids* from the ADF and Perron (1997) equations are reported in Table 2.5.[28] Equilibrium levels of *rids* are significantly different from zero if both the intercept and estimated root are significant. Inspection of Table 2.5 shows that the *rids* of Brazil, Chile, Mexico, Turkey and Germany converge to a mean value that is statistically different from zero. These equilibrium levels were higher for Turkey, Brazil, Argentina, Mexico and Chile in descending order. These results point out to the existence of frictions as a likely explanation of the permanent higher levels of real interest rates. When we allowed for structural changes using the date breaks retrieved by the first method of Perron (1997), we found that the *rids* of Argentina, Brazil, Chile, Mexico, Turkey, Italy and Spain converge to equilibrium values that are statistically significant. By comparing the averages of the speed of adjustment and equilibrium levels in both

[28] We just report equilibrium levels obtained using Perron (1997) for break search method 1, as method 2 gave similar results.

groups of countries in Tables 2.4 and 2.5, one can see that while the speed of convergence is fast, the equilibrium levels are substantially higher in emerging economies.

2.5. Asymmetry and unit roots

The previous unit-root tests assume that *rids* follow a linear representation or linear path around a breaking trend. However, recent developments in the theory of imperfect capital markets/imperfect information suggest that the behaviour of *rids* may be asymmetric because risk perceptions may vary with changes in interest rates themselves. The idea of an endogenous risk premia is summarised in Stiglitz (1999) and another argument is put forward in Pakko (2000).[29] Given the existence of asymmetric information in international credit markets, lenders will look at increases in interest rates as a signal that determines their subjective probability of bankruptcy (or default). As Stiglitz (1999, p. 64) explains "[...] the probability of bankruptcy may depend on the interest rate charged, so that beyond a point, increases in the interest rate charged actually lead to lower expected returns" which relates to the idea that "The dominant effect of large, unanticipated increases in interest rates is thus induced bankruptcies and an increase in non-performing loans" (p. 65). The consequence of these arguments for the RIPH is that the country risk premium may depend on changes of the interest rate and, hence, *rids* would converge to different equilibrium differentials if previous changes in *rids* surpass a certain threshold. On the other hand, Pakko (2000) builds a model in which changes

[29] Some of these features are commonly introduced in models of speculative attacks with asymmetric information. The idea in the context of the 1997 South East Asian crisis is discussed in Radelet and Sachs (1998).

in interest rates affect the probability of debt default which increases with changes in expected fiscal deficits. Hence, an increase in interest rates could raise debt servicing to a level at which the country-default risk premia is affected. It follows that the *rid* would converge to a higher equilibrium after being set on motion. The change in interest rates performed by the Central Bank would translate into a fiscal impact that causes both the risk premium and equilibrium *rids* to rise. This multiple equilibria idea would induce asymmetries in the time series behaviour of *rids*.

As explained in the previous chapter, recent papers by Nakagawa (2002) and Obstfeld and Rogoff (2000), amongst others, present evidence suggesting that convergence towards PPP may be non-linear. This is usually associated with theoretical models in which market segmentation arising from various transaction costs introduce non-linearities in the adjustment of real exchange rates (RER) as in Obstfeld and Rogoff (2000). These kinds of non-linearities may also induce asymmetry in the speed of adjustment of *rids* to positive and negative shocks, as the RER and *rids* are functionally related by the RIPH. Evidence on this *rid* nonlinearity is presented, for instance, in Mancuso et al. (2002).

In summary, non-linearities in differentials could arise from the endogeneity of risk premium. The channels through which risk is endogenous to changes in interest rates are two. First, there might be asymmetries of information in financial markets, which causes agents to interpret changes in interest rates performed by the Central Bank as a signal that the probability of default has increased. The other is through the fiscal impact of interest rate changes. The increase in debt servicing affects expected fiscal deficits and the country default risk by consequence. If asymmetries are present in the adjustment of *rids*, unit-root tests may lose power and suffer size distortions unless they are incorporated in the tests [Enders and Granger (1998)]. Our approach allows us to simultaneously test for asymmetry and unit roots in the *rids* series, revealing interesting features about the RIPH. If *rids* behave asymmetrically, we can use the following TAR (Threshold Autoregression) representation [Caner and Hansen (2001)]:

$$\Delta y_t = I_t \left[\theta_1' y_{t-1} + \sum_{j=1}^{p} \gamma_{1j} \Delta rid_{t-j} \right] + (1 - I_t) \left[\theta_2' y_{t-1} + \sum_{j=1}^{p} \gamma_{2j} \Delta rid_{t-j} \right] + \zeta_t, \quad (2.18)$$

where $y_{t-1} = (1 \quad rid_{t-1})$ and I_t is the indicator function that takes the form

$$I_t = \begin{cases} 1 & if \quad z_{t-1} < \lambda \\ 0 & if \quad z_{t-1} \geq \lambda \end{cases}$$

where λ is a threshold and the variable z_t is any stationary variable that would determine the change of regime. For our purposes, we set $z_t = rid_t - rid_{t-m}$. That is, we assume that *rids* behave differently depending on whether past *changes* in *rids* have been higher or lower than a certain threshold λ. This is a momentum-TAR model or M-TAR model with two regimes as in Enders and Granger (1998). The lag length m for the changes in *rids* will be data determined as will be the search for the optimal threshold λ. Finally, the parameter vectors θ_1 and θ_2 can be partitioned as

$$\theta_1 = \begin{pmatrix} \mu_1 \\ \rho_1 \end{pmatrix}, \quad \theta_2 = \begin{pmatrix} \mu_2 \\ \rho_2 \end{pmatrix},$$

where μ_i is an intercept and ρ_i is the autoregressive parameter with $i = 1, 2$. The choice of the threshold λ could be simply made on an a priori basis, such as setting $\lambda = 0$ or equal to the sample mean of Δrid_t. However, this would be a biased estimate of the threshold if asymmetric adjustment exists and a subjective measure. In order to search for the optimal threshold, we follow Chan (1993) and find λ as the value of Δrid_t that minimises the residual sum of squares of the OLS estimation of (2.18).[30]

In order to test for the existence of asymmetry in the adjustment under both regimes we test the null hypothesis $H_o : \theta_1 = \theta_2$ on the OLS estimation of (2.18), making use of the Wald statistic (W) proposed in Caner and Hansen (2001). The RIPH would imply rejecting H_o: $\rho_1 = \rho_2 = 0$, and we also make use of two Wald statistics (R1 and R2). Finally, we also chose m to minimise the residual sum of squares. Given that the Wald test of asymmetry is a monotonic function of the residual variance, we choose m as the value which maximizes the Wald test of asymmetry.

The procedure we follow to test simultaneously for asymmetry and unit roots implies first estimating a baseline model for the linear ADF regression to determine the lag augmentation of the DF regression using general-to-specific techniques as in previous sections. We then select the threshold by minimising the residual sum of squares of (2.6) as mentioned earlier and fit the M-TAR model by OLS for every

[30] In practice we eliminated the highest and lowest 10% values of Δrid_t.

value of m. We choose the m that minimises the residual sum of squares for all values of m.[31]

Given that the asymptotic null distribution of the asymmetry test (W) is non-standard, Caner and Hansen (2001) recommend the use of bootstrap methods to obtain p-values. In a Monte Carlo experiment they show that the power and size of the test does not crucially depend on whether we impose a unit-root. Hence, we obtained p-values by carrying out 1,000 iterations of the unconstrained asymmetry test, i.e. not imposing the existence of a unit root. Finally, the unit root hypothesis involves testing for H_o: $\rho_1 = \rho_2 = 0$. There are two possible alternatives: H_1: $\rho_1 < 0$ *and* $\rho_2 < 0$ and

$$H_2 : \begin{cases} \rho_1 < 0 \quad and \quad \rho_2 = 0 \\ or \\ \rho_1 = 0 \quad and \quad \rho_2 < 0 \end{cases}$$

The first alternative corresponds to the stationary case, whilst the second implies stationarity in only one of the regimes, which implies overall non-stationarity but a different behaviour from the classic unit-root. Caner and Hansen (2001) develop asymptotic theory for the distribution of this unit-root test. However, for finite samples they recommend the use of bootstrapping. As the distribution of the test statistic will depend on whether or not a threshold effect exists, p-values obtained through the bootstrap are not unique. We hence obtained the bootstrapped p-values from 1,000 iterations under the hypothesis that the threshold is not identified (R1)

[31] Usually, for monthly data we take $m = 1,\ldots, 12$.

and under the hypothesis that it is identified (R2). These two tests have substantially more power than the ADF test as threshold effects become more important. In order to discriminate between the two alternatives in H_2, Caner and Hansen (2001) recommend looking at the t-ratios of ρ_1 and ρ_2.

An intuitive economic interpretation of (2.18) is that the threshold could be determined, for example, by a certain level of increase in interest payments that causes a change in agent's risk perception either by changing expected public deficits or for being a clear signal that the Central Bank foresees inflationary pressures. The dynamics of *rids* would then be triggered by an exogenous shock, such as an unexpected increase in interest rates performed by the Central Bank. After the increase there is a change in the autoregressive regime and both the level and the speed of convergence of the *rid* towards equilibrium would therefore vary. If the risk premium increases with the higher interest rates, then *rids* would converge to a higher equilibrium at a different speed. The nature of the dynamics underlying (2.18) implies that there are two stable autoregressive regimes that depend on the size of the changes in *rids* after they are being set on motion by exogenous shocks.

The results are provided in Table 2.6 where we report the estimated threshold (λ), the lag of the change in *rids* for the determination of the threshold (m), and the estimates of the parameters μ_i and ρ_i of (2.18) in both regimes. Asymmetry appears to be a prevalent feature in some countries. We can reject the null of no asymmetry for at least 5 pair of *rids*. Observing the values and t-ratios of the intercepts and autoregressive terms we can see that this asymmetry is associated with both differences in intercepts in both regimes and asymmetric adjustment speeds, although the former appears more frequently. As for unit roots, the results confirm that taking asymmetry into account is important, as we can reject the null of non-stationarity for 7 countries by at least one of the R tests except for Argentina, Italy and Spain.[32] In several cases, such as Germany and UK, *rids* appear to be stationary when decreasing and non-stationary when increasing above the threshold. The other way around occurs for Brazil, Chile and Turkey.

Other important features appear when observing the different behaviour of emerging and developed markets in our sample. For France, UK and US(Ger) the intercept is either statistically insignificantly different from zero or close to it in both regimes. The speed of adjustment for these countries, as already mentioned, is higher when decreasing and lower when increasing. This pattern in the speed of adjustment is reversed for Brazil, Chile, Mexico and Turkey. Furthermore, for these countries the intercept tends to be close to zero when the *rids* are growing below the threshold and significantly higher than zero when they are growing above the threshold. This positive intercept would imply large equilibrium *rids* especially for Turkey and Brazil. In relation to the theoretical models of imperfect information in credit markets, these results may seem to indicate that large increases in interest differentials may be negatively interpreted by the market, which in turn imposes a higher risk premium. The fact that this pattern does not seem to arise for developed markets also supports this idea as, during this period, none of these countries has suffered large swings of their interest rates that may have induced this change in risk perception effect.

[32] For Italy and Spain structural breaks may be driving most of the results as seen previously.

2.6. Additional Tests

In a working paper version of this chapter [Ferreira and León-Ledesma (2005)], we replicated the unit root tests above using the longest period available for each country. The exceptions are Brazil and Argentina because of measurement problems regarding interest rates, as explained earlier. As can be seen in Table 2.7 we used 474 monthly observations for the UK and 393 for France, for example. With respect to emerging economies, there were 306 and 308 observations for Mexico and Chile, respectively. *Rids* were calculated using a different measure for inflation, as the real interest rate at time t was obtained by subtracting the quarterly average of the twelve-month inflation ahead of period t. The findings were somewhat robust to the tests and results discussed in the previous sections.

Overall we found short half-lives for *rids* especially if we compare them with PPP studies where half-lives range between 2 and 4 years.[33] According to the estimated roots obtained with standard ADF tests, on average the half-lives of *rids* for emerging markets are substantially lower (5.54 months) than those of developed countries (16.68 months). Nevertheless, there are some variations especially within the emerging markets group from a small 0.78 months in Argentina to a higher value of 11.81 months in Mexico. Developed economies show more persistence as the half-life varies from 13.97 months to 18.59 months. The most persistent *rids*, according to our results, are those of Italy and the UK.

On the other hand, the tests using the Perron (1997) methods retrieve a smaller degree of persistence for nearly all countries. Half-lives of emerging economies

[33] Note, however, that the PPP condition in *rids* is based on the relative version in which we use *inflation* differentials rather than price *levels*. We would hence expect a quicker adjustment to PPP because of this first differentiation of price levels.

vary between 0.96 and 7.02 months while developed countries still show a slower speed of convergence. Half-lives for the latter economies are between 8.14 and 15.77 months. Thus, when possible structural changes are taken into account, *rids* of most of the sample are relatively short-lived.

The equilibrium *rids* of emerging markets are substantially higher than those of developed countries. Only for Mexico and Turkey we found equilibria that are statistically insignificantly different from zero. Brazil shows the highest equilibrium *rid* (4.12%). For Mexico we found a negative but insignificant *rid* although, this is mostly driven by the period before liberalisation when Mexico was not fully integrated in world capital markets. For developed countries, the equilibrium values were either statistically insignificant or significant but close to zero.

When we allowed for structural changes using the date breaks retrieved by the first method of Perron (1997), we found that the *rids* of Argentina, Chile, Mexico, Germany and Italy converge to equilibrium values that are statistically significant in both periods. The mean of the equilibrium level is higher in emerging economies and in the second period (during the 1990s). This is mostly driven by the increases in Argentina and Brazil after their financial crises and the increase in Mexico that, before being fully open to capital inflows could maintain lower real returns. For Chile, the most stable economy of the sample, equilibrium differentials fall in the second period as Chile was able to avoid contagion from the various financial crises shocking emerging markets in the 1990s. For the majority of developed countries equilibrium *rids* are not statistically different from zero in both periods, although they tend to be higher in the second (except for Germany). This may simply be evidence of these countries not being able to match the deflationary US-Volker policies of the early 1980s. The exception is Germany because of the anti-inflationary bias of the Bundesbank.

We can strongly reject the null of no asymmetry for all countries except for Spain. The values and t-ratios of the intercepts and autoregressive terms show that this asymmetry is also associated with both differences in intercepts in both regimes and asymmetric adjustment speeds. As for unit roots, the results confirm that we can reject the null of non-stationarity for all the countries by at least one of the R tests with the exception of Spain. In only one case, the UK, *rids* appear to be stationary when increasing below and non-stationary when increasing above the threshold. The other way around occurs for Brazil, Mexico, Turkey and Italy.

Other important features appear when observing the different behaviour of emerging and developed markets in our sample. For Germany, Italy, Spain and the UK the intercept is statistically insignificantly different from zero in both regimes. The speed of adjustment for these countries does not seem to follow a clear pattern. On the other hand, the speed of adjustment shows a clear pattern for all emerging markets. For these countries the speed of adjustment is faster when *rids* grow above the threshold. Furthermore, for these countries the intercept tends to be close to zero when *rids* are growing below the threshold and significantly higher than zero when they are growing above the threshold. This positive intercept would imply large equilibrium *rids* especially for Argentina, Brazil and Chile. The only exception to this pattern seems to be Turkey, whereas for Mexico it is likely that the clear structural break in 1987 is driving most of the results.

In summary, results were robust to the tests performed in the sample analysed in this chapter. Hence, the additional tests of Ferreira and León-Ledesma (2005) lend support to the conclusion that the results are not driven by sample-specific characteristics. Furthermore, the conclusions in Ferreira and León-Ledesma (2005) are qualitatively the same as the ones elaborated below.

2.7. Concluding Remarks

We have presented evidence on the RIPH for a set of developed and emerging markets for the period that spans from the mid-90s until the middle of 2002. Our results show that, despite the short time span, we were able to find mean reversion in *rids*. The speed of mean reversion is high, indicating that real differentials tend to be short lived. This is especially so if we allow for the likely possibility of structural breaks in the series. We were able to reject the unit root hypothesis or to accept the null of stationarity for all countries, excluding Spain. This evidence supports the hypothesis of a high degree of market integration, which is consistent with financial liberalisation and the emergence of global capital markets. The pattern of adjustment is asymmetric, that is, whenever *rids* grow above or below a certain threshold they tend to behave differently. For emerging markets adjustment is quicker when *rids* grow fast, while for countries such as France and the UK adjustment is quicker when *rids* grow below the threshold.

Nonetheless, we found evidence supporting the existence of a positive long-run mean in the *rids* of, especially, emerging markets. The long-run mean of emerging market economies tends to be higher than for developed ones, for which it is zero or close to zero. Our results also suggest that foreign financial crisis may have generated structural changes in *rids*. Finally, we found evidence that equilibrium *rids* for emerging markets are high in periods of rapid growth of the *rid*. All these features point out to the existence of large frictions in emerging markets, but not for developed markets.

In general, our results support recent evidence on the RIPH for developed countries despite the short sample of our study. It also complements this literature with evidence from emerging markets. For these countries, a less stringent version of RIPH seems to be a more realistic specification. We also find that asymmetries induced by either risk perception changes or transaction costs (transport costs) seem to be an important feature when explaining real interest rates differentials.

As discussed in chapter 1, the causes of *rids* could be related to the violation of the parity conditions and/or the rational expectations hypothesis. The next chapter investigates which individual parity is more important to explain deviations from RIPH. Once the nature of the RIPH's violation is identified, we will be able to direct our efforts towards the verification of the fundamental or underlying causes of *rids*.

Figures

Figure 2.1. Real Interest Rate Differentials

Figure 2.1.1. Argentina

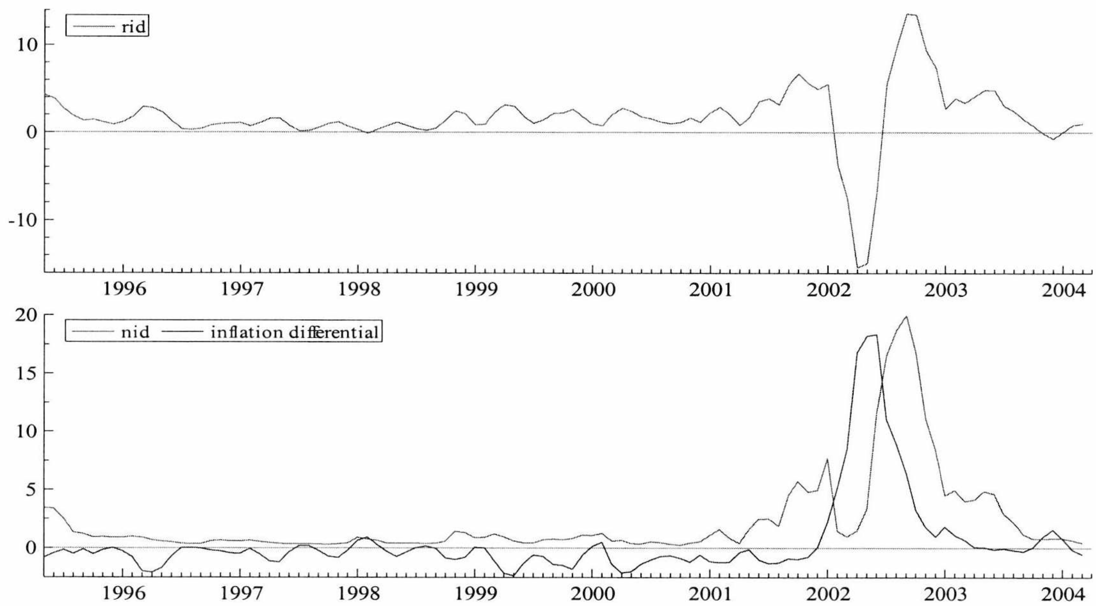


Figure 2.1.2. Brazil

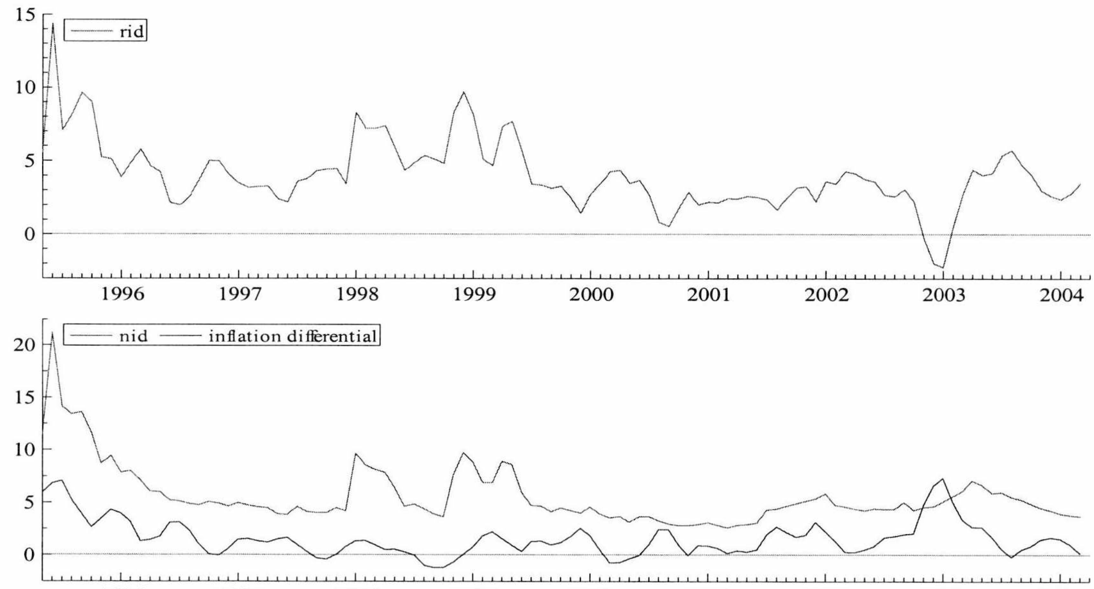


Figure 2.1.3. Chile

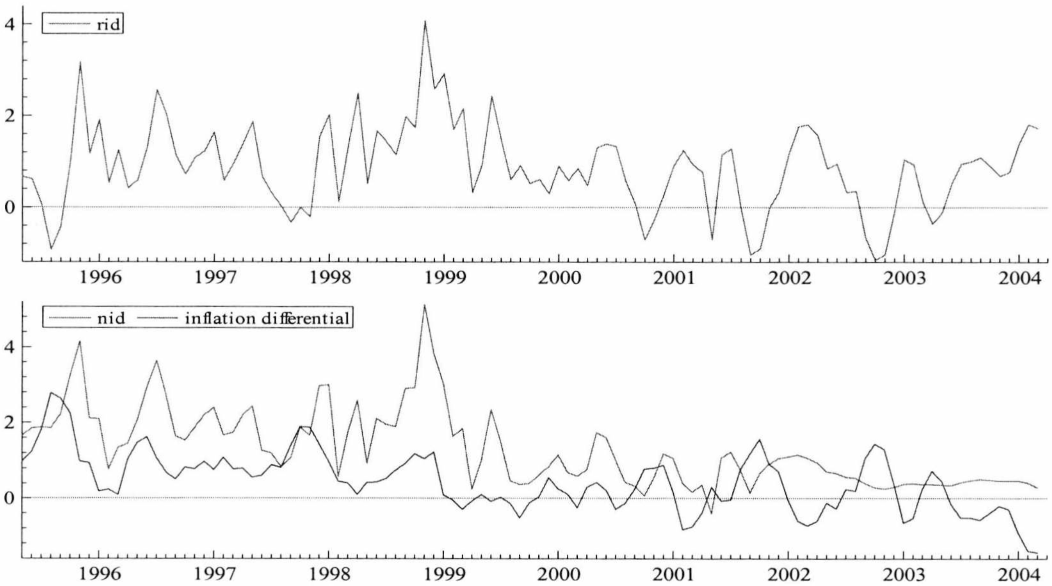


Figure 2.1.4. Turkey

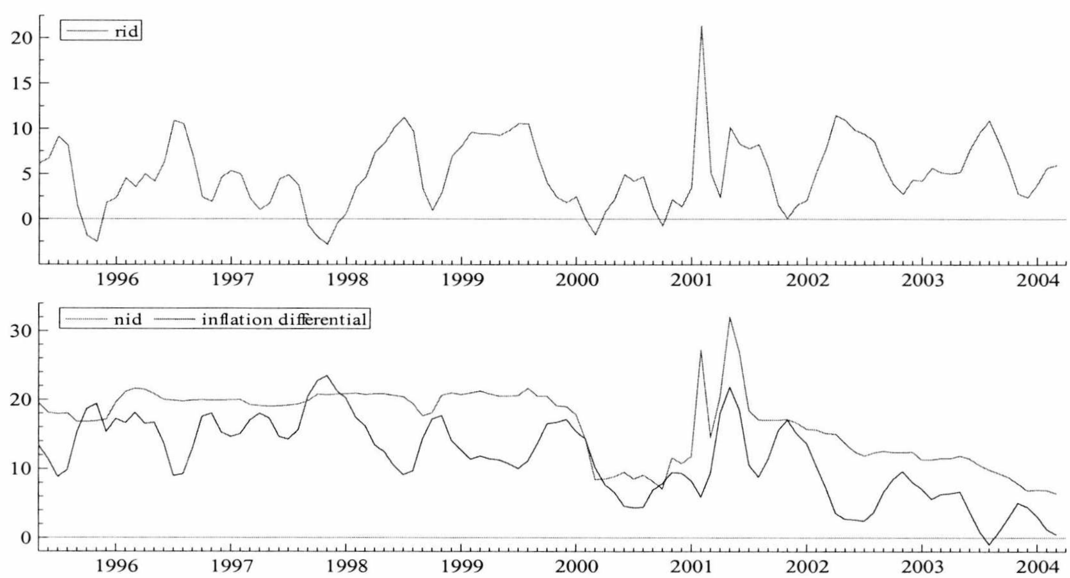


Figure 2.1.5. France

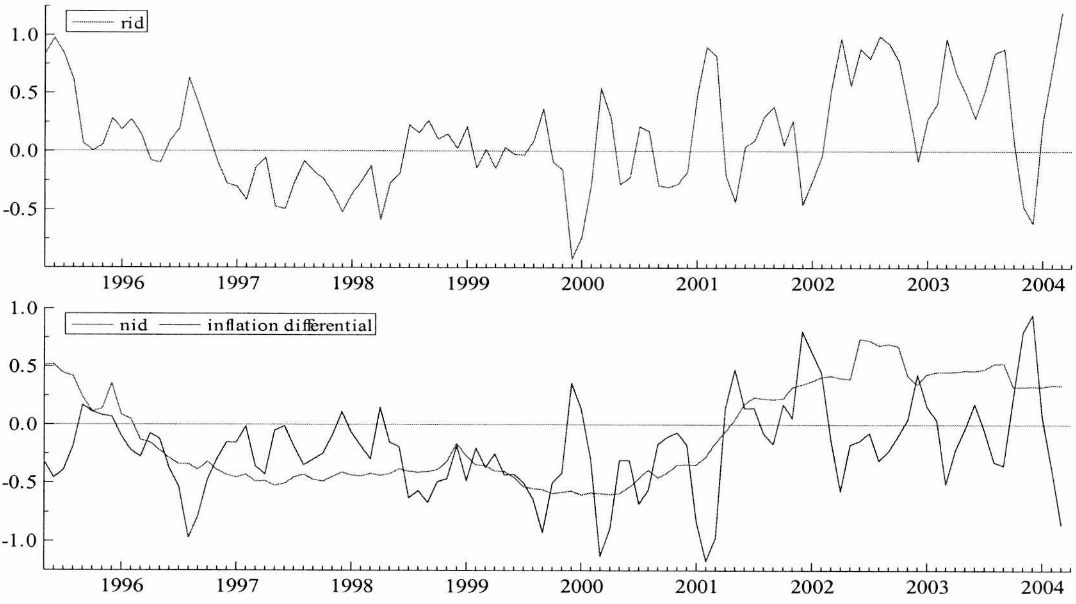


Figure 2.1.6. Italy

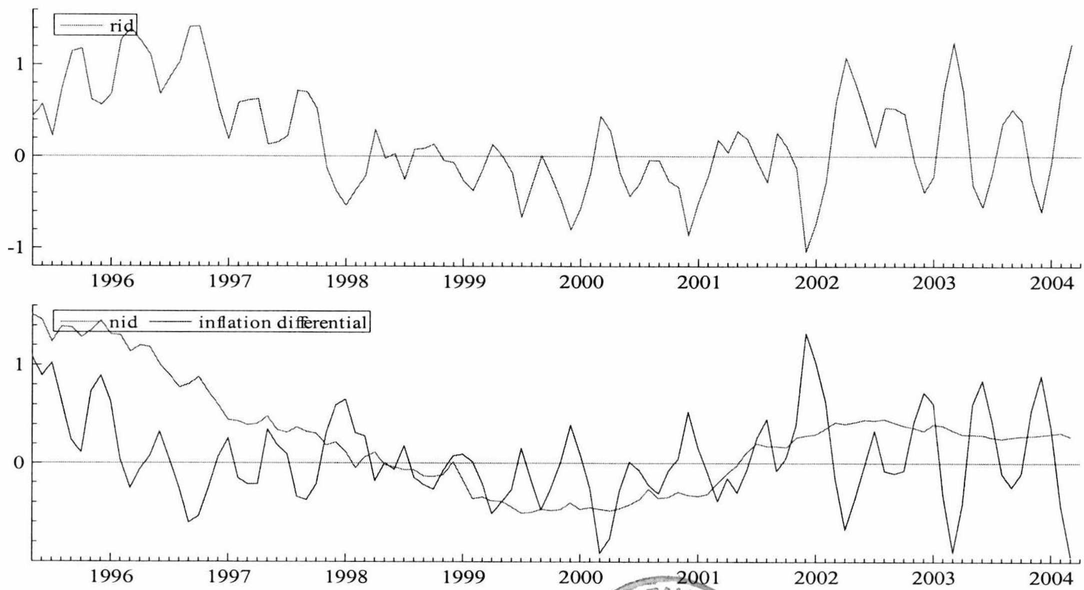


Figure 2.1.7. Spain

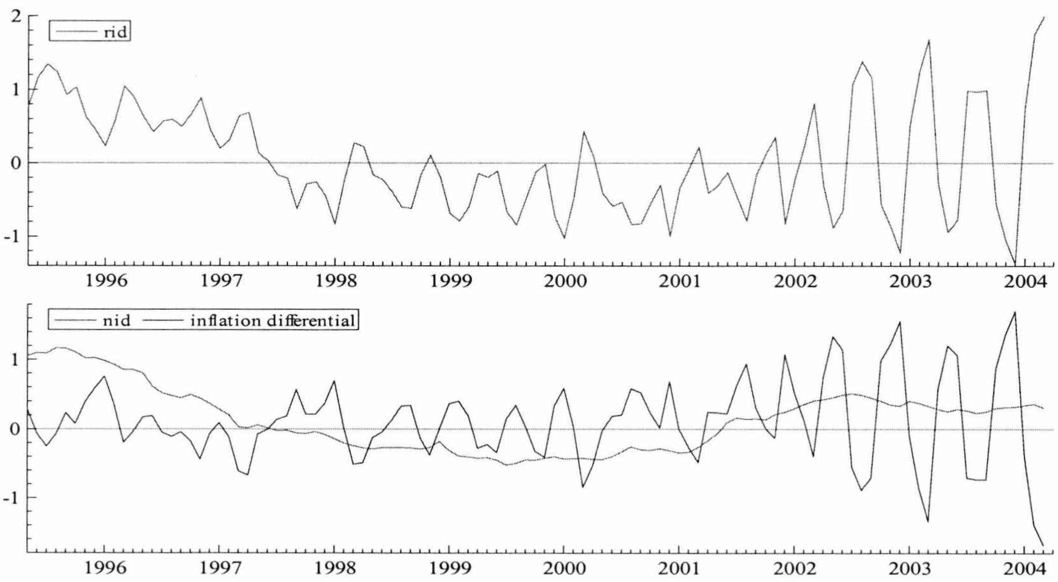


Figure 2.1.8. UK

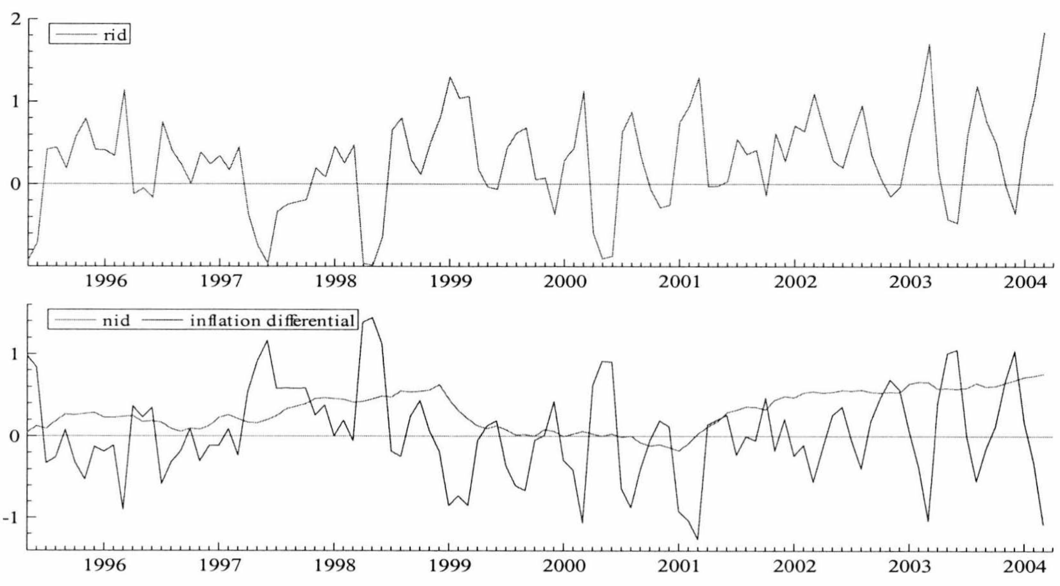


Figure 2.1.9. Germany

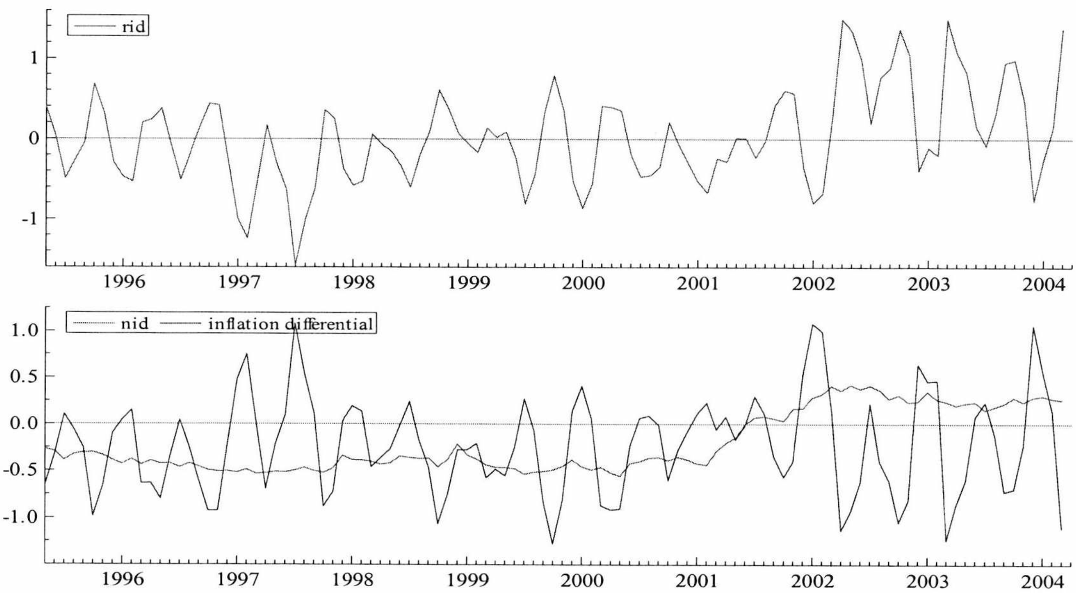
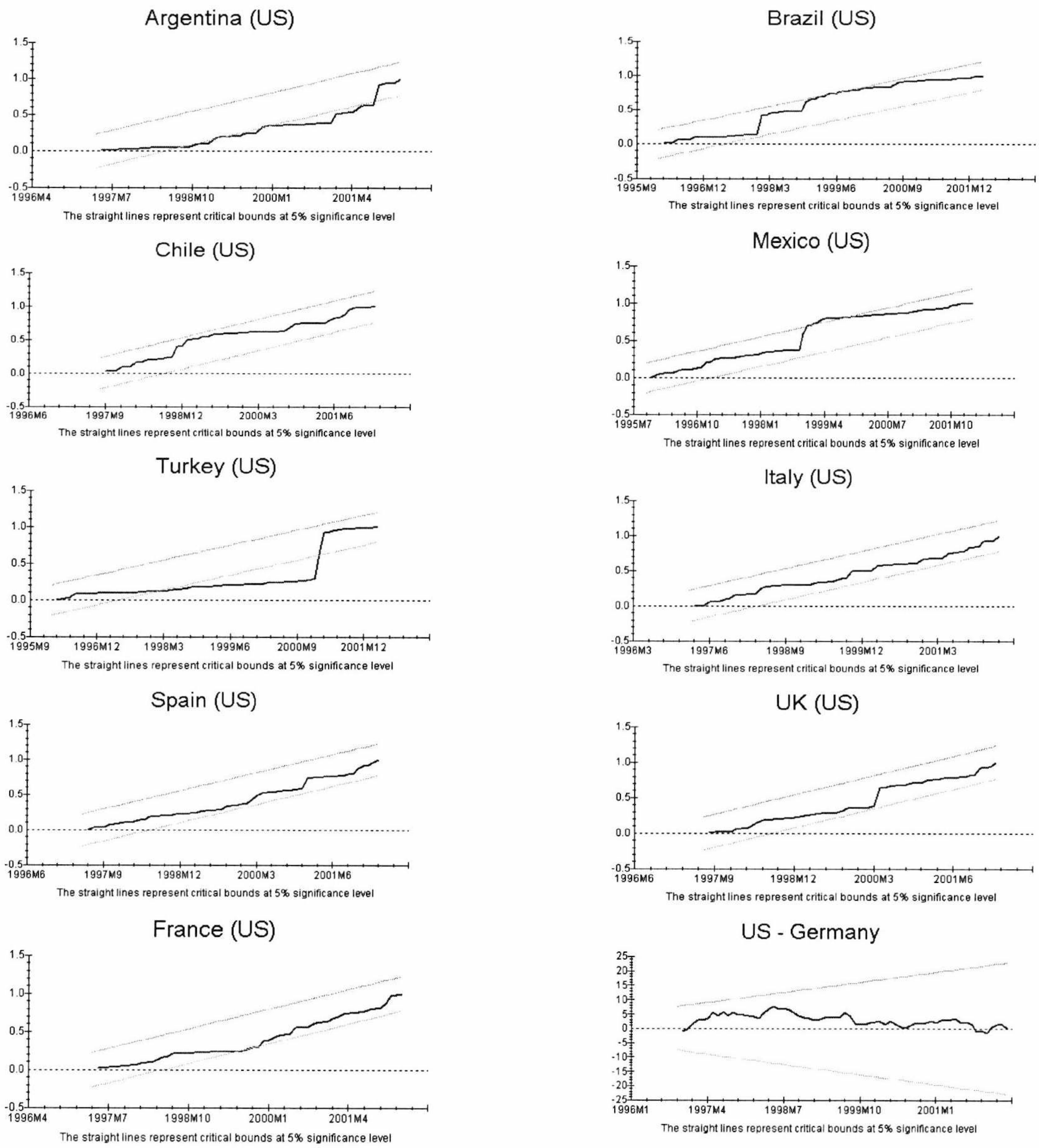


Figure 2.2. Structural Stability



Tables

Table 2.1. Descriptive Statistics of *rids*

Series	Obs	Mean	Std Error	Minimum	Maximum
Argentina	81	1.77	1.38	-0.15	6.72
Brazil	83	4.36	2.32	0.54	14.39
Chile	82	0.95	0.95	-1.04	4.08
Mexico	83	1.44	1.44	-1.72	4.83
Turkey	83	4.68	4.09	-2.81	21.33
France	82	0.01	0.37	-0.93	0.98
Germany	83	-0.15	0.46	-1.58	0.79
Italy	83	0.16	0.57	-1.04	1.42
Spain	83	-0.01	0.59	-1.02	1.34
UK	82	0.20	0.55	-0.99	1.30

Table 2.2. Unit Root Tests on *rids*

Country	Nº of lags	ADF	KPSS	ERS (DF-GLS)	Elliot (1999) (DF-GLS$_{\mu}$)
Argentina	10	-0.421	0.389*	-0.855	-0.878
Brazil	3	-3.015*	0.702	-2.489*	-2.937*
Chile	12	-2.054	0.179*	-1.971*	-2.086
Mexico	1	-4.593*	0.239*	-2.901*	-4.580*
Turkey	3	-4.230*	0.078*	-3.948*	-4.201*
France	10	-2.259	0.186*	-0.424	-1.783
Italy	9	-1.485	0.688	-0.945	-1.312
Spain	9	-1.759	0.643	-0.349	-1.144
UK	10	-1.723	0.153*	-0.434	-1.624
US – Ger	7	-2.752	0.082*	-0.795	-1.803

Notes: * indicates rejection of the null of a unit root at the 5% confidence level for the ERS (1996) and Elliott (1999) tests and acceptance of the null for the KPSS test.

Table 2.3. Perron (1997) unit root tests on *rids*

	Break Search Method I			Break Search Method II		
Country	**Lags**	**Break Date**	**T-ratio**	**Lags**	**Break Date**	**T-ratio**
Argentina	9	2001:07	-1.529	9	1999:04	-0.055
Brazil	0	1995:09	-5.184*	5	1999:04	-3.683
Chile	0	1998:10	-5.726*	12	1997:10	-2.046
Mexico	1	1998:09	-4.613*	1	1998:09	-4.613*
Turkey	3	1999:07	-4.299*	3	1999:08	-4.068*
France	10	1996:10	-2.637	10	1996:11	-2.493
Italy	3	1997:08	-3.315	11	1996:11	-4.128*
Spain	9	1997:05	-3.375	9	1997:04	-3.439
UK	9	1998:03	-2.871	9	1998:04	-2.444
US – Ger	7	1996:10	-3.114	7	1996:11	-2.897

Notes:
* Indicates rejection of the null of a unit root at the 5% confidence level.

Table 2.4. Half-Lives

	ADF		Structural Break			
			Method 1		*Method 2*	
Country	**Estimated Root**	**Half Life (months)**	**Estimated Root**	**Half Life (months)**	**Estimated Root**	**Half Life (months)**
Argentina	0.95	13.1	0.81	3.2	0.99	72.8
Brazil	0.79	3.0	0.55	1.2	0.64	1.6
Chile	0.54	1.1	0.48	0.9	0.54	1.1
Mexico	0.66	1.6	0.65	1.6	0.65	1.6
Turkey	0.48	1.0	0.46	0.9	0.48	1.0
Mean	***0.68***	***3.96***	***0.59***	***1.56***	***0.66***	***15.62***
France	0.58	1.3	0.43	0.8	0.46	0.9
Italy	0.91	7.3	0.60	1.4	0.63	1.5
Spain	0.87	5.0	0.40	0.8	0.46	0.9
UK	0.68	1.8	0.52	1.1	0.55	1.1
US – Ger	0.58	1.3	0.50	1.0	0.53	1.1
Mean	***0.72***	***3.34***	***0.49***	***1.02***	***0.53***	***1.10***

Notes: Half-lives were calculated according to the formula $-\left(\frac{\ln(2)}{\ln(1-\psi)}\right)$, where ψ is the estimated autoregressive coefficient in the ADF equation.

Table 2.5. Equilibrium Level

	ADF equation			Perron (1997) Method 1			
				Period I		*Period II*	
Country	**Intercept**	**Estimated Root**	**Long-run Equilibrium Value**	**Intercept**	**Long-run Equilibrium Value**	**Intercept**	**Long-run Equilibrium Value**
Argentina	0.12	0.95	2.33	0.29*	1.48*	2.01	10.42
Brazil	0.80*	0.79*	3.82*	4.94*	11.10*	1.75*	3.92*
Chile	0.45**	0.54*	0.98**	0.55*	1.05*	0.39	0.74
Mexico	0.47*	0.66*	1.37*	0.39*	1.12*	0.57	1.64
Turkey	2.30*	0.48*	4.44*	2.54*	4.70*	2.28	4.22
Mean	***0.83***	***0.68***	***2.59***	***1.74***	***3.89***	***1.40***	***4.19***
France	-0.02	0.58*	-0.05	0.11	0.20	-0.04	-0.08
Italy	-0.01	0.91	-0.11	0.32*	0.79*	-0.07*	-0.17*
Spain	-0.04	0.87**	-0.31	0.32*	0.53*	-0.20*	-0.34*
UK	0.07	0.68	0.22	0.03	0.07	0.16	0.34
US – Ger	0.06**	0.58*	0.15**	0.00	0.00	0.09	0.19
Mean	***0.01***	***0.72***	***-0.02***	***0.16***	***0.32***	***-0.01***	***-0.01***

Notes:
1) We used the intercept model to calculate long-run equilibrium levels.
2) The null hypothesis is that the long-run equilibrium level is equal to zero.
* denotes significance at 5%
** denotes significance at 10%

Table 2.6. M-TAR model for *rids*

Country	Argentina	Brazil	Chile	Mexico	Turkey
λ	-0.381	-0.459	-0.237	-0.886	-0.926
M	2	2	1	1	1
M_1	-0.013	1.679	1.428	0.687	3.027
	(-0.055)	(1.829)	(2.610)	(2.421)	(2.997)
μ_2	-0.584	0.696	0.207	0.194	-2.427
	(-1.867)	(0.770)	(0.325)	(0.293)	(-1.337)
ρ_1	-0.031	-0.472	-0.720	-0.341	-0.506
	(-0.213)	(-3.558)	(-2.727)	(-4.127)	(-4.127)
ρ_2	-0.355	-0.123	-0.304	-0.217	-0.402
	(2.260)	(-0.786)	(-1.001)	(-1.658)	(-1.180)
W	**17.64**	0.865	5.367	1.56	**21.470**
p-value	***0.040***	*0.903*	*0.440*	*0.707*	***0.000***
R1	2.954	**9.112**	**8.695**	**22.603**	**21.16**
p-value	*0.227*	***0.010***	***0.050***	***0.000***	***0.000***
R2	4.017	**9.139**	8.437	**19.783**	**20.575**
p-value	*0.360*	***0.047***	*0.133*	***0.000***	***0.003***
Lag	10	3	12	1	3

Notes: T-ratios in parentheses. Bold indicates rejection of the null of symmetry or unit roots at the 10% level. P-values for the asymmetry and unit-root tests were obtained by the bootstrap method of Caner and Hansen (2001). W is the Wald test for asymmetry and R1 and R2 are Wald tests for the null of a unit root assuming an unidentified and an identified threshold respectively.

Table 2.6. M-TAR model for *rids* (cont.)

Country	France	Italy	Spain	UK	US- Ger
λ	0.264	-0.087	0.030	-1.110	0.506
M	6	4	2	3	1
M_1	0.627	0.026	0.100	-0.025	0.510
	(2.381)	(0.153)	(0.615)	(-0.191)	(2.433)
μ_2	-0.221	-0.048	-0.448	-0.441	0.019
	(-1.659)	(-0.279)	(-3.029)	(-0.964)	(0.262)
ρ_1	-0.278	-0.124	-0.126	-0.388	-0.379
	(-1.198)	(-0.945)	(-0.834)	(-1.482)	(-1.798)
ρ_2	-0.382	-0.041	0.074	-0.795	-0.549
	(-1.757)	(-0.273)	(0.515)	(-2.202)	(-3.671)
W	5.941	**15.679**	**13.504**	0.727	**20.420**
p-value	*0.357*	***0.016***	***0.057***	*0.947*	***0.006***
R1	**7.710**	0.823	0.135	**5.432**	**10.105**
p-value	***0.060***	*0.523*	*0.783*	***0.090***	***0.010***
R2	7.105	0.968	0.804	6.027	**16.098**
p-value	*0.177*	*0.790*	*0.773*	*0.217*	***0.010***
Lag	10	9	9	11	7

Notes: T-ratios in parentheses. Bold indicates rejection of the null of symmetry or unit roots at the 10% level. P-values for the asymmetry and unit-root tests were obtained by the bootstrap method of Caner and Hansen (2001). W is the Wald test for asymmetry and R1 and R2 are Wald tests for the null of a unit root assuming an unidentified and an identified threshold respectively.

Table 2.7. Descriptive Statistics as in Ferreira and León-Ledesma (2005)

Series	Start	Obs	Mean	Std Error	Minimum	Maximum
Argentina	1992M1	140	1.3	3.4	-10.1	19.8
Brazil	1995M1	104	4.3	2.9	0.4	11.9
Chile	1978M1	308	2.4	3.9	-5.5	21.5
Mexico	1978M3	306	-0.8	6.5	-22.0	36.8
Turkey	1979M2	295	-1.0	7.4	-30.7	17.6
France	1970M3	393	0.3	0.7	-2.3	2.4
Germany	1975M9	336	0.2	0.6	-1.6	1.3
Italy	1977M5	316	0.4	0.9	-2.5	3.4
Spain	1979M3	294	0.3	0.9	-2.2	2.2
UK	1964M3	474	0.0	0.9	-4.0	2.0

Appendix 1

In this appendix, we show that when RIPH is established in Fisherian fashion, then it becomes apparent that the frequency of the data used in the tests combined with the maturity of assets can render persistence in *rids* influencing the estimation of the autoregressive root. The intuitive idea is that a bond purchased at time *t*, with 2 periods to maturity, for example, will be subject to shocks at $t+1$ and $t+2$. Because of the monthly frequency of the data, a bond purchased in $t+1$ will also be affected by the shocks at time $t+2$. On the other hand, if the maturity was one-period such problem would not exist as demonstrated below.

Let us rewrite the *ex ante* version of relative PPP from equation (2.2)

$$\Delta s_{t+1}^{e} = \pi_{t+1}^{e} - \pi_{t+1}^{*e} \tag{2.19}$$

where variables are as defined in the previous chapter. Assuming UIP as in (2.1) and that RIPH holds, we have an *ex ante rid* that is equal to zero

$$rid_{t,1}^{e} = i_{t,1} - i_{t,1}^{*} - (\pi_{t+1 \cdot t}^{e} - \pi_{t+1 \cdot t}^{*e}) = 0 \tag{2.20}$$

where the second subscript related to interest rates and the *rid* stands for the maturity of the asset. The second subscript of inflation refers to the time at which the prediction is carried out. Given rational expectations, one can rewrite (2.20) as

$$rid_{t,1} = rid^e_{t,1} + \mu_{t+1 \cdot t} \tag{2.21}$$

with the prediction error of the inflation differential being white-noise and equal to $\mu_{t+1} = \pi_{t+1 \cdot t} - \pi^*_{t+1 \cdot t} - (\pi^e_{t+1 \cdot t} + \pi^{*e}_{t+1 \cdot t})$. It follows that

$$E\left[\mu_{t+1} \middle| \Omega_t\right] = 0$$

$$E\left[rid_{t,1} \middle| \Omega_t\right] = 0 \tag{2.22}$$

$$E\left[rid_{t,1} \middle| rid_{t-1,1}\right] = 0 \Leftrightarrow Cov\left[rid_{t,1}, rid_{t-1,1}\right] = 0$$

where Ω_t is the information set. Hence, for bonds whose maturity matches the frequency of the data we find that the autoregressive root of the *ex post rids* matches that of the *ex ante rids*.

For a two term contract bond:

$$rid^e_{t,2} = i_{t,2} - i^*_{t,2} - (\pi^e_{t+2 \cdot t} - \pi^{*e}_{t+2 \cdot t}) = 0 \tag{2.23}$$

which, given rational expectations, can also be written as

$$rid_{t,2} = rid_{t,2}^{e} + \mu_{t+2\cdot t} \tag{2.24}$$

Assuming that the inflation differential follows a stationary process

$$\pi_t - \pi_t^{*} = \overline{\kappa} + \sum_{j=s}^{\infty} \gamma_j \mu_{t-j} \tag{2.25}$$

where γ_j are the parameters, $\overline{\kappa}$ is a constant term and it is assumed that $\gamma_0 = 1$.

Therefore the s-step predictor is given by

$$\pi_{t\cdot t-s}^{e} - \pi_{t\cdot t-s}^{*e} = E\left[\pi_t - \pi_t^{*} \middle| \Omega_{t-s}\right] = \overline{\kappa} + \sum_{j=s}^{\infty} \gamma_j \mu_{t-j} \tag{2.26}$$

and the prediction error is found to be $\mu_{t\cdot t-s} = \sum_{j=0}^{s-1} \gamma_j \mu_{t-j}$. Thus we can write:

$$\begin{aligned} rid_{t,2} &= rid_{t,2}^{e} + \mu_{t+1\cdot t} + \mu_{t+2\cdot t} \\ &= rid_{t,2}^{e} + \mu_{t+1} + \mu_{t+2} + \gamma_1 \mu_{t+1} \end{aligned} \tag{2.27}$$

The covariance of the *ex post rid* can be calculated as:

$$Cov\left(rid_{t+1,2}, rid_{t,2}\right) = E\left[rid_{t+1,2} - E\left(rid_{t+1,2}\right)\right]\left[rid_{t,2} - E\left(rid_{t,2}\right)\right] \tag{2.28}$$

Given that the expected *rid* is equal to zero, (2.28) becomes

$$Cov\left(rid_{t+1,2}, rid_{t,2}\right) = E\left[rid_{t+1,2} rid_{t,2}\right] \tag{2.29}$$

Substituting rid_{t+1} by the forecast errors [as done for the rid_t in (2.27)], we then have

$$E\left[rid_{t+1,2} rid_{t,2}\right] = E\left\{\left[(1+\gamma_1)\mu_{t+1} + \mu_{t+2}\right]\left[(1+\gamma_1)\mu_{t+2} + \mu_{t+3}\right]\right\} \tag{2.30}$$

From the white-noise properties of the innovations and after some algebra, (2.30) can be simplified to

$$E\left[rid_{t+1,2} rid_{t,2}\right] = (1+\gamma_1)E\left[\mu_{t+2}^2\right] = (1+\gamma_1)\sigma_\mu^2 \tag{2.31}$$

where σ_μ^2 stands for the variance of inflation innovations. Hence, the covariance can be calculated as:

$$Cov\left(rid_{t+1,2}, rid_{t,2}\right) = (1+\gamma_1)\sigma_\mu^2 \tag{2.32}$$

The main implication of the mismatch between the maturity and the frequency of the data is for the estimation of the autoregressive root of the *rid*. This is represented by α

$$\alpha = \frac{Cov\left(rid_{t+1,2}, rid_{t,2}\right)}{Var\left(rid_{t+1,2}\right)} = \frac{(1+\gamma_1)\sigma_\mu^2}{Var\left(rid_{t+1,2}\right)} \qquad (2.33)$$

Hence, the maturity will affect the estimated root through the parameter γ_1 and the variance of the error term. The conclusion is that the higher is the maturity the larger will be the effect described above. Hence, this problem can result in the overestimation of α and also of the persistence of *ex ante rids*. It follows that the estimated half-lives in our chapter should be read with caution.

Chapter 3. Real Interest Parity Decomposition

3.1. Introduction

We have seen that UIP under the assumption of rational expectations and relative PPP entail the RIPH [Roll (1979)]. The conclusion regarding the existence of *rids* across countries since the seminal papers of Mishkin (1984) and Cumby and Obstfeld (1984) is not decisive [see, for example, Obstfeld and Taylor (2002)]. The usual finding is that *rids* are autoregressive and relatively short-lived. The aim of the current chapter is to investigate the general causes of *rids* as the earlier evidence indicates that they mean-revert to a positive equilibrium and have asymmetric behaviour.

Unit root tests have shown that all *rids*, except Spain, are stationary. Most differentials were found to be short-lived, especially if structural breaks were taken into consideration. Additionally, short-lived *rids* tend to converge to a significant long-run equilibrium that is different from zero in emerging economies and close to zero in developed countries. In summary, the last chapter presented evidence supporting the existence of *rids*, especially for emerging economies. The evidence for developed countries is less stringent. Despite being small and short-lived, *rids* in these economies seem to exist. The aim of the current and following chapters is to investigate the general causes of *rids* in emerging economies.

As discussed in the Introduction, interest payments represent a significant part of total public expenditure of emerging and some developed countries. Interest expenses also explain a great part of the current account deficit of developing economies. Since high *rids* can impose heavy costs to an economy, unveiling the causes and understanding their dynamics is essential to design the appropriate macroeconomic policies to change differentials.

On the one hand, as demonstrated by a broad range of models based on sluggish price adjustment, the real interest rate is an important instrument of macroeconomic policy. One the other hand, an implication of RIPH, as it stands on its simplest form, is that no *rids* can mean no independent monetary policy. Hence, is the existence of *rids* found in chapter 2 reflecting an independent monetary policy? A detailed investigation of the causes of *rids* can provide an answer to this question.

Departures from RIPH can be explained by *ex post* deviations from relative PPP and UIP, as violations of the rational expectations hypothesis are already embedded in deviations from UIP. Hence, a question that arises is whether *rids* are caused by frictions in goods or assets markets? Another related question is if real shocks (changes in risk perception or unexpected changes in non-monetary fundamentals: such as preferences or productivity increases, for example) are more important than nominal shocks (such as unexpected changes in money supply, for instance) to explain deviations from interest parity. These questions are relevant because RIPH is based on the existence of frictionless markets and *rids* reflect the degree of market integration. The answers might be of practical importance for researchers as well as for policy makers. For example, stabilising the variance of *rids* can be a target of monetary policy in itself[34]. If *rids* are very volatile, returns are unstable and investors dislike variance. The higher the variance, the smaller is the incentive to invest in a bond and the greater must be its return. Hence, policy makers would

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[34] See Iwata and Tanner (2003) for evidence on the trade-off between exchange rate and interest rate volatility in developing countries.

like to offset shocks that cause great variability. Also, high *rids* can impose heavy costs to an economy - because of interest payments on the public, domestic and foreign debt - so unveiling the causes and understanding their dynamics is essential to design the appropriate macroeconomic policies to change differentials.

In this chapter we focus on the importance of the arbitrage conditions in the determination of *rids*. The general question is whether *rids* can be explained by relative PPP and UIP *ex post* deviations and to which extent. The main objective is to separate out the driving sources of volatility in the variance of *rids*. Ultimately, this task is relevant because *rids* represent a measure of market integration.

The second objective of this chapter is to characterise the dynamic response of *rids* to real and nominal disturbances and to breakdown its variability according to these two types of shocks. Once the general nature and dynamics of shocks are identified, we will direct our efforts towards the verification of the specific causes of *rids* as discussed in chapter 1. For example, if we verify that real disturbances play a more important role than monetary shocks, then it might be the case that factors driving non-monetary fundamentals or risk premium rather than changes in money supply would be driving *rids*' behaviour. Similarly, the finding of an opposite result would direct our attention to a different line of research.

There are also theoretical issues motivating the work. Variance decompositions can shed light on the nature of the relationship between *rids* and real exchange rates. There has been a debate on whether this relationship holds since Frankel (1979). Evidence can be non-supportive as Meese and Rogoff (1988), Edison and Pauls (1993), MacDonald (1997), Breedon et al. (1999) and Isaac and Mel (2001) or favourable as Astley and Garrat (2000), Chortareas and Driver (2000), Macdonald and Nagayasu (2000), Camarero and Tamarit (2002) and Jin (2003). Because of Balassa-Samuelson effects, the sign of an impact of a real shock on exchange rates (and *rids*, as we will explain on a later stage) is theoretically undetermined and depends on the type of the disturbance and the sector of the economy that is hit. The proposed tests can help to clarify this issue because, as MacDonald and Ricci (2003) observed: "**real interest rate differentials may also reflect productivity differentials: to the extent that the measure employed to proxy for the Balassa-Samuelson effect is not perfect, the real interest differential may help capture this empirically.**" (pp. 4 and 5, emphasis added).

This chapter presents further evidence on a higher degree of friction in assets rather than goods' markets and the predominance of real shocks in the path of *rids* for a set of emerging economies. To our knowledge, no work has performed innovation accounting on *rids*, hence the tests are innovative in this sense. The work also complements papers on the relationship of real exchange rates and *rids* by reinforcing the finding of weak correlation between variables. The rest of the chapter is organised as follows. Section 3.2 describes the methodology involved in the tests and discusses the identifying restrictions; Section 3.3 explains the data and presents the results. Section 3.4 concludes.

3.2. Methodology and Theory

The first method draws insights from Levine (1991) and Frankel and MacArthur (1988) but it is based on Cheung et al. (2003). The latter work separated the variance of *rids* between deviations from relative PPP and UIP using the relationships given by RIPH as in the following equation

$$rid_t = (i_t - i_t^* - \Delta s_{t+1}^e) - (\pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}^e) \qquad (3.1)$$

where i_t is the domestic nominal interest rate and i_t^* is the foreign interest rate that matures at time t+1. The expected rate of foreign exchange depreciation is the logarithmic change in the spot rate $\Delta s_{t+1}^e = s_{t+1}^e - s_t$, with the superscript e denoting expected values and the subscript t standing for time. Domestic and foreign rates of inflation are π_{t+1} and π_{t+1}^*, respectively. Observe that $i_t - i_t^* - \Delta s_{t+1}^e$ are *ex ante* deviations from UIP and $\pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}^e$ correspond to *ex post* deviations from PPP in addition to a forecast error.

Given the definition of variance and covariance and noting that forecast errors cancel out in (3.1), we can write

$$\begin{aligned} &Var(rid_t) = \\ &[(i_t - i_t^* - \Delta s_{t+1}) - \mu_{i_t - i_t^* - \Delta s_{t+1}}]^2 + [(\pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}) - \mu_{\pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}}]^2 \\ &-2[(i_t - i_t^* - \Delta s_{t+1}) - \mu_{i_t - i_t^* - \Delta s_{t+1}}][(\pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}) - \mu_{\pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}}] \end{aligned} \qquad (3.2)$$

where the $\mu(s)$ represent the (sample) mean and their subscripts stand for the corresponding *ex post* deviations. Equation (3.2) is equivalent to

$$\begin{aligned} &Var(rid_t) = \\ &Var(i_t - i_t^* - \Delta s_{t+1}) + Var(\pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}) \\ &-2Cov(i_t - i_t^* - \Delta s_{t+1}; \pi_{t+1} - \pi_{t+1}^* - \Delta s_{t+1}) \end{aligned} \qquad (3.3)$$

Another way to decompose the variance of *rids* is by noting that changes in the exchange rate also cancel out in (3.1). As *rids* are equal to interest rate differentials subtracted from inflation differentials by construction, we can also write

$$\begin{aligned} &Var(rid_t) = \\ &[(i_t - i_t^*) - \mu_{i_t - i_t^*}]^2 + [(\pi_{t+1} - \pi_{t+1}^*) - \mu_{\pi_{t+1} - \pi_{t+1}^*}]^2 \\ &-2[(i_t - i_t^*) - \mu_{i_t - i_t^*}][(\pi_{t+1} - \pi_{t+1}^*) - \mu_{\pi_{t+1} - \pi_{t+1}^*}] \end{aligned} \tag{3.4}$$

which is similar to

$$\begin{aligned} &Var(rid_t) = \\ &Var(i_t - i_t^*) + Var(\pi_{t+1} - \pi_{t+1}^*) - 2Cov(i_t - i_t^*; \pi_{t+1} - \pi_{t+1}^*) \end{aligned} \tag{3.5}$$

As explained by Engel (1996, p. 138), this type of RIPH decomposition "makes sense – real interest parity could fail either because *ex ante* PPP fails (goods markets are not integrated) or because uncovered interest parity fails (capital markets are not integrated)". Engel (1996) has further criticised the works of Canova (1991), Bekaert (1994), Gokey (1994) and Huang (1990) who decomposed deviations from UIP into deviations from PPP and RIPH because "Efficiency of the forward market does not require *ex ante* PPP or *ex ante* real interest equality. Both could fail, and fail wildly, yet uncovered interest parity could still hold." (p. 137). Apart from Cheung et al. (2003), the only work performing variance decomposition along the lines set on (3.3) and (3.5) is Tanner (1998). However, Tanner's (1998) paper suffers from the same shortcomings raised by Engel (1996) to the aforementioned previous works. The reason is that Tanner (1998) decomposes both the level and the variance of UIP deviations between deviations from PPP and RIPH[35].

The second method consists in recovering the relevant parameters for innovation accounting using short and long-run restrictions on a bivariate VAR system of equations. From equation (1.14) (in chapter 1, section 1.2.1), we know that UIP under rational expectations minus expected inflation differentials is equivalent to

$$rid_t = \Delta q_{t+1} + \varepsilon_{t+1} \tag{3.6}$$

where Δq_{t+1} represents changes in the real exchange rate. UIP imply a relationship between exchange rates and interest rates which allows one to classify real and nominal factors as being the main sources of disturbances affecting *rids* and *nids*. This classification is based on the literature that applied variance decomposition to exchange rates [Rogers (1999), Enders and Lee (1997) and Astley and Garratt (2000), for example]. Ignoring intercept terms for simplicity

$$rid_t = \varepsilon r_{t+1} + \varepsilon n_{t+1} \tag{3.7}$$

35 His conclusion for the study for 34 emerging and developed economies is that the variance of *rids* explain most part of the variance of UIP deviations.

$$nids_t = \varepsilon r_{t+1} + \varepsilon n_{t+1} \tag{3.8}$$

where real and nominal shocks are represented by εr_{t+1} and εn_{t+1}, respectively; disturbances are assumed to be iid $N(0, \sigma_\varepsilon^2)$ in which σ_ε^2 represents variance. Sequences (3.7) and (3.8) can be represented as moving average processes

$$rid_t = \sum_{k=0}^{\infty} c_{11}(k)\varepsilon r_{t+1-k} + \sum_{k=0}^{\infty} c_{12}(k)\varepsilon n_{t+1-k} \tag{3.9}$$

$$nid_t = \sum_{k=0}^{\infty} c_{21}(k)\varepsilon r_{t+1-k} + \sum_{k=0}^{\infty} c_{22}(k)\varepsilon n_{t+1-k} \tag{3.10}$$

The letter *c* stands for the coefficients associated with the responses of *rids* and *nids* to shocks at each period *k*. The VAR representation is

$$\begin{pmatrix} rid_t \\ nid_t \end{pmatrix} = \begin{pmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{pmatrix} \begin{pmatrix} rid_{t-1} \\ nid_{t-1} \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \tag{3.11}$$

where *e* stands for the error terms, which are composite of the pure innovations $\varepsilon r_t, \varepsilon n_t$.

The Choleski decomposition imposes a contemporaneous restriction in (3.7) or (3.8) in order to recover the parameters of (3.9) and (3.10) from the estimates of the system in (3.11). The assumption is that a real shock does not have a contemporaneous impact on *nids*, a conjecture that is valid provided that real shocks affect prices instantaneously while interest rates are impacted after one lag[36]. Another interpretation is that policy makers react to a real shock after having more knowledge of its nature. The time elapsed for the reaction to take place is one month[37].

An alternative is the method proposed by Blanchard and Quah (1989). For this decomposition we considered that the sum of nominal shocks has a zero impact on the series of *rids*

$$\sum_{k=0}^{\infty} c_{12}(k)\varepsilon n_{t+1-k} = 0 \qquad (3.12)$$

Following the idea of Faust (1998), as explained below, the restriction in (3.12) is used to test for robustness of the Choleski decomposition.

As a matter of fact, either identifying restriction (long-run or contemporaneous) depends on a set of assumptions that might not be entirely accepted. It is often attributed to the VAR literature, the use of incredible restrictions (assumptions) for

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[36] We discarded the possibility that a nominal shock does not contemporaneously affect *rids* because it is logically inconsistent. The reason is that a nominal shock would have to impact interest rates and prices both at the same time and by the same magnitude, leaving *rids* at time *t* absolutely unchanged. The inconsistency arises because even if there is no initial impact on *rids*, there would be lagged effects.

[37] Monetary Policy Committee meetings in Brazil, for example, are realised on a monthly basis and, in most of the cases, interest rates cannot change until the day of the meeting.

identification. Nonetheless, as pointed out by Sims (1980), Faust (1998) and Faust et al. (2003), even incredible restrictions can result in useful analysis provided that reasonable economic interpretations can be given to the findings. Faust (1998), for example, has elaborated a way of checking for robustness of contentious restrictions by taking a particular assumption and checking "...all possible identifications of the VAR for the one that is the worst case for the claim, subject to the restriction that the implied economic structure produce *reasonable* responses to policy shocks." (p. 209, emphasis from the author). Then, he adds, "If in the worst case the variance share is small, then the claim is supported. If the share is large, then either the identifying information – the characterization of a *reasonable* policy shock – must be sharpened or we must view the issue as unsettled." (p. 210). We performed and compared variance decompositions of *rids* using both short and long-run restrictions as a way to verify the "robustness" of the assumptions.

3.3. Results

For a detailed explanation of the source and description of the data used in these tests, refer to chapter 2, section 2.3. The only difference relates to the period of the tests which corresponds to the interval that spans from 1995M5 to 2004M3, due to availability of the data at the time the tests were performed. Recall that we transformed the annualised monthly interest rate and the inflation rate into compounded quarterly rates and then subtracted the latter from the former to calculate *rids* using *nids* and inflation differentials. As the data are on a monthly basis, there are 107 observations for each country. Quarterly changes in exchange rates were calculated using data on end-of period exchange rates.

Plots of *rids* and *nids* for this sample period can also be viewed in Figure 2 of the last chapter. Descriptive statistics of the differentials are reported in Tables 3.1 and 3.2. Note that *rids* are smaller than *nids* in all countries with the exception of Argentina. The reason is that Argentina experienced deflation in many months. The highest differentials are in Turkey followed by Brazil, Mexico, Argentina and Chile.

We started by performing a sequence of unit root tests on the series of *nids* in order to investigate their univariate properties. Because of the low power of ADF test, we also checked for unit roots using the KPSS, ERS, Elliott (1999) and Perron (1997) tests. We calculated the number of lags using a general to specific (joint F-test for the significance of the parameters at the 5% confidence level) approach starting from 12 lags. As can be seen in Tables 3.3 and 3.4, we found overall support for stationarity. Turkey and the UK were the only countries in which we could not reject the unit root or to accept stationarity. The low power of unit root tests, as mentioned before, and the relatively short period of our sample - for which a cointegrating relationship may not hold - can be driving these non-stationary results. The findings that will be presented for these countries should then be read with caution. Regarding Perron (1997) tests, the break date is endogenously chosen to be the one in which the t-statistic for testing the null hypothesis of a unit root is smallest among all possible break points. The breaks of emerging economies, presented in Table 3.4, seem to be related to the effect of domestic and financial crises. The introduction of the Euro as a medium of exchange in 2002M1 is apparently reflected in the form of a date break of developed countries, with the exception of the UK.

Regarding variance decomposition, results presented in Table 3.5 demonstrate that the share of *ex post* deviations from UIP in the variance of *rids* is higher than the share of *ex post* deviations from relative PPP for Argentina, Brazil, Chile and Mexico. The high volatility of exchange rates is responsible for most part of the variance of individual parity conditions. A clear picture on the causes of deviations from RIPH emerges when *rids* are decomposed between *nids* and inflation differentials, as in Table 3.6. *Nids* are the predominant source of variability for most *rids* of the sample while inflation differentials account for a higher share of *rids*' variance only in Turkey. The covariance between *nids* and inflation differentials and the value of the correlations (the latter is not reported) indicate that the two variables have some degree of dependence. Interestingly, there is a lack of correlation between both *nids* and inflation differentials with respect to exchange rate changes (the exceptions are Argentina and Turkey, the latter in a smaller degree).

In conclusion, the volatility of *nids* explains the majority of *rids*' variance in most economies. *Nids* seem to be fairly independent from exchange rate variations which point out to other factors explaining its behaviour and, by consequence, the dynamics of *rids*. Large unanticipated changes in fundamentals (which thus impact the exchange rate), risk premium or the influences of monetary policy on deviations from UIP, as pointed out by McCallum (1994a), are possible explanations. Inflation differentials play a smaller role in explaining the variance of *rids* in emerging economies, with the exception of Turkey.

We turn to the findings of innovation accounting by first analysing forecast error variance decompositions[38]. Figure 3.1 shows the percentage of variance explained by real shocks for some selected time-horizons: 1, 6 and 36 months for Blanchard and Quah (1989) and 6 and 36 for Choleski decomposition. Real shocks are the main source of variation in *rids* for all countries at all horizons according to the Choleski decomposition. Blanchard and Quah (1989) reveals that, with the exception of Chile, the highest share of total variation in *rids* derives from a real shock.

Figure 3.2 presents impulse responses obtained through the use of Blanchard and Quah (1989) technique as short-run responses would be somewhat influenced by the contemporaneous restriction. Long-run restrictions leave the short-run dynamics of the VAR unconstrained or data-determined and structural theoretical explanations for variance decompositions and impulse responses can be made, as Clarida and Gali (1994) and Astley and Garratt (2000) emphasised.

It is important to note that a positive shock to the *rid* means that the expected exchange rate depreciation is higher than the one actually observed. The exchange rate depreciates by more than expected when there are no Balassa-Samuelson effects and the economy is subjected to an unexpected productivity increase (a positive real shock), hence *rids* diminish. On the other hand, *rids* increase if there are Balassa-Samuelson effects. The reason is that an unexpected rise in productivity generates an unexpected appreciation. The channel by which risk affects *rids* is direct. Hence, an unanticipated increase in risk raise *rids*. Finally, a real demand

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[38] We do not present and discuss the results of the VAR estimates as the primarily objective of the chapter is to analyse forecast error variance decomposition and impulse responses. The optimal lag length was selected by a general to specific method using a likelihood ratio test for the exclusion of the last lag in each VAR equation, starting with 12. The lags chosen were Argentina (12), Brazil (10), Chile (10), Turkey (5) and (9) for the *nids* of Turkey in first difference.

shock leads to a real appreciation and also enlarge *rids*. Unexpected changes in non-monetary fundamentals that depreciate the exchange rate will decrease *rids*.

Responses were normalised so each structural shock correspond to one standard deviation. As can be seen in Figure 3.2, a real shock causes a positive impact in both *rids* and *nids* of Argentina. The response of *rids* to nominal disturbances go to zero very quickly in Brazil but real shocks trigger a more persistent effect. The initial (and accumulated) effect of a real shock to both *rids* and *nids* is positive. After 3 years, a real shock adds 6.52 units to the sum of *rids* of Brazil. Impulse responses of Chile show that the first impact of a real shock is positive for *nids* but not for *rids*. The accumulated effect of a real shock after 36 periods is a rise of 1.94 units in the *rids* of Chile. A real shock originally increases *rids* and *nids* of Mexico. On the other hand, the initial effect of a nominal shock is ambivalent. After 36 months the accumulated impact of a nominal shock to *rid* dies out while a real shock effect sums up to 1.85 units. A positive shock (real or nominal) increases *nids* and *rids* of Turkey in the short-run. After 3 years, a real shock increases *rids* by 5.71 units. Because stationarity was not found for *nids* of Turkey, impulse responses using the series in first difference were also estimated. Results, however, are similar.

The final impact of a real shock is considerably larger in Argentina (4.8 units)[39], Brazil and Turkey and just slightly higher in Chile and Mexico. The reason for a higher accumulated impact than the initial increase might be related to frictions in financial markets or to the breakdown of rational expectations. Finally, while the sign of the accumulated impact of real shocks on *nids* is ambivalent, they are

[39] It must be stressed, however, that the presence of outliers casts some doubt on the results for Argentina.

positive for *rids* of all countries with the exception of Chile. As the 1990s was a period characterised for productivity increases, this result, *prima facie*, can lend support for Balassa-Samuelson effects[40]. However, the 1990s was also plagued by financial crisis which possibly imply risk premium shocks. Finally, nominal shocks can have different sorts of impacts on *rids* and *nids* in the short-run.

3.4. Concluding Remarks

Deviations from international parity conditions are large as exchange rate changes are very volatile. The variance of *rids* is small in comparison to the variance of deviations because, exchange rates cancel out in the composition of *rids*. We found that the variance of *nids* explains most part of the volatility of *rids* for all countries, except Turkey. Recall that *rids* are calculated *ex post* so the aforementioned variance decomposition does not require any statistical test based on probabilities because *rids* are equal to *nids* subtracted from inflation differentials by definition. *Nids* seem to be fairly independent from actual exchange rate variations which signal to other factors explaining its behaviour and, by consequence, the dynamics of *rids*. These results may not come as a surprise since many empirical works did not find a significant relationship between interest rate differentials and exchange rates. Frictions in financial markets, such as the impact of unexpected changes in non-monetary fundamentals and their corresponding impact on exchange rates, risk premium and the effect of monetary policy on the determination of *nids* are potential candidates.

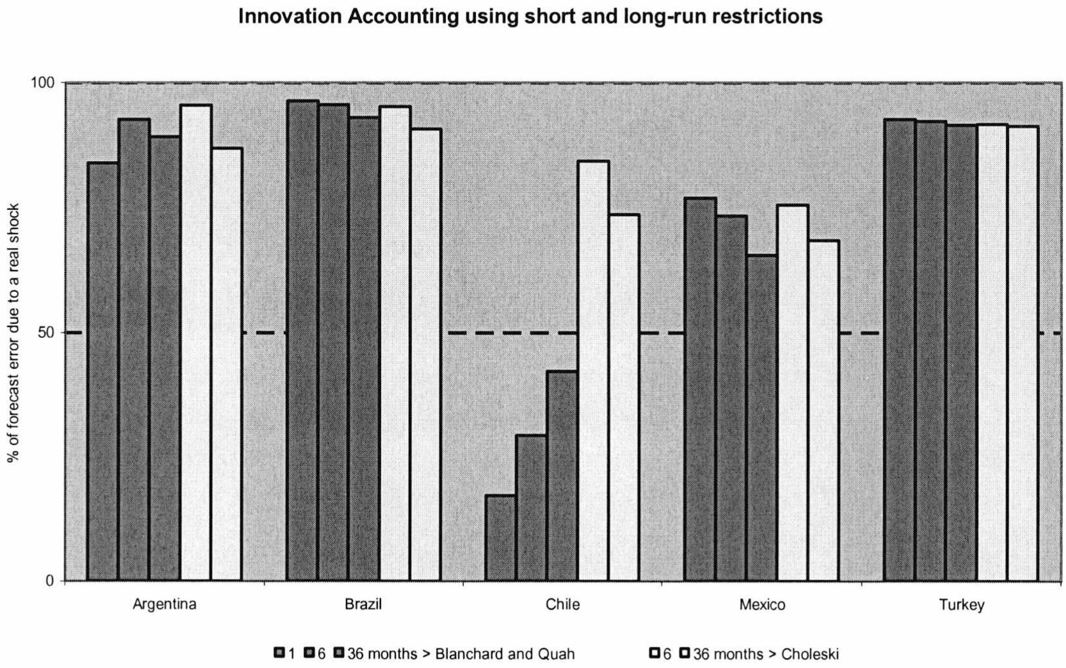
[40] See Lee and Tang (2003) for latest survey and evidence on the relationship between productivity and real exchange rates. See Faria and Leon-Ledesma (2003) for a test of Balassa-Samuelson effects on developed countries.

We found evidence of stationarity for all *nids* in the sample, with the exception of Turkey. Forecast error variance decomposition shows that real shocks explain most part of the variation in *rids* and the results are robust to either form of identifying restriction. The effect of a real shock tends to be amplified in the long-run, reflecting the fact that, whenever differentials of developing economies start to grow, the tendency is for them to accumulate by more than the initial increase. This reinforces the findings of frictions in assets markets. The sign of the impact of real shocks on *nids* is ambivalent, but they are positive for *rids* of all countries with the exception of Chile. At the extent to which real shocks reflect productivity changes, this result provides support for Balassa-Samuelson effects. However, it must be stressed that the 1990s was also a period of various financial crises and the results of endogenous date breaks seem to reflect this fact. Finally, nominal shocks can have different sorts of effects on *rids* and *nids* in the short-run.

Arbitrage is supposed to be largely enforced by increased market integration. As our sample period follows the trade and financial liberalisation, one would expect that departures from parity conditions played a minor role in the composition of *rids*. This possibility is weakened if imperfect asset substitutability or irrationality of expectations are more plausible conjectures for the financial markets. The findings of the present chapter reveal the predominance of *nids* and real shocks in the path of *rids* for most countries which points out to deviations from UIP as their driving source.

Figures

Figure 3.1 Forecast Error Variance Decomposition of *rids*



Note: The forecast error variance decomposition is the percentage of the mean squared error due to a real shock.

Figure 3.2. Impulse Responses

1) Lines in blue represent standard errors which were calculated using one thousand bootstrap draws.
2) The first column shows the impact of a nominal shock while the second column presents the impact of a real shock. The third and fourth columns show the accumulated impact of a nominal and real shock, respectively. *Rids* are on the first line and *nids* on the second.

Argentina

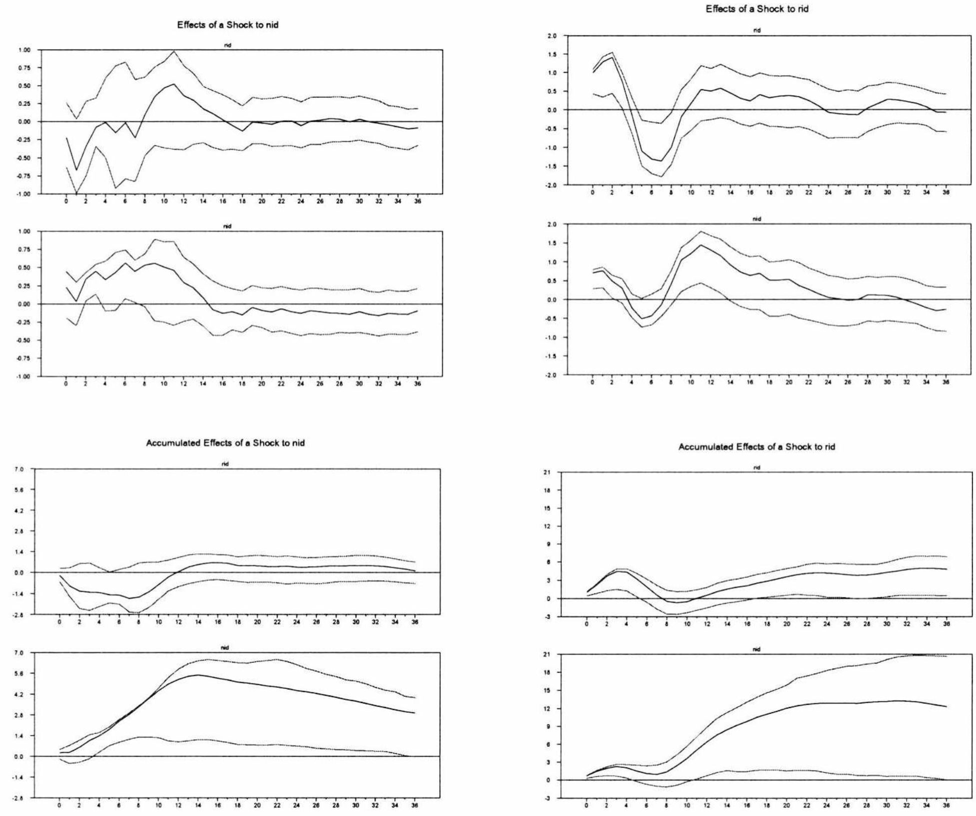
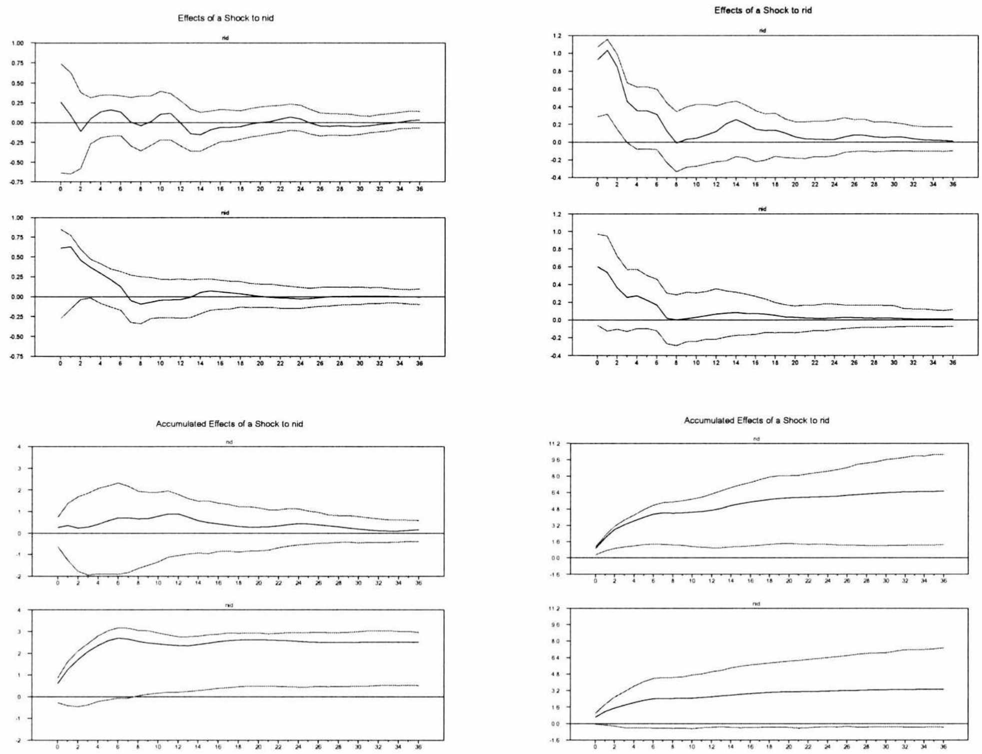


Figure 3.2. (continuation)

Brazil



Chile

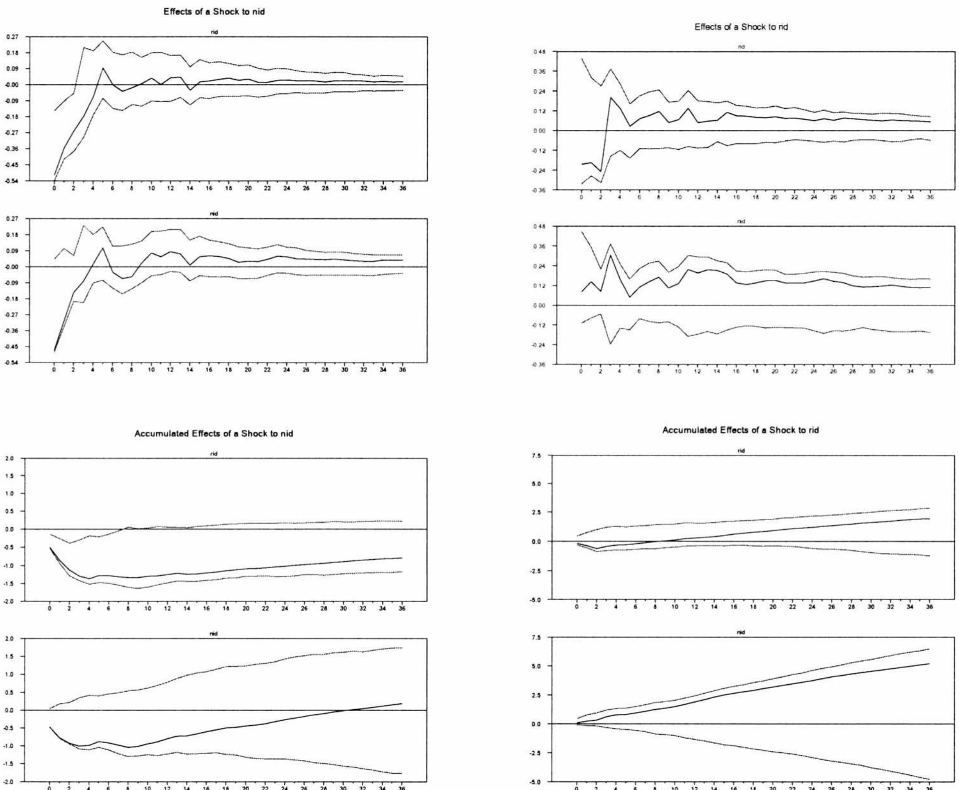
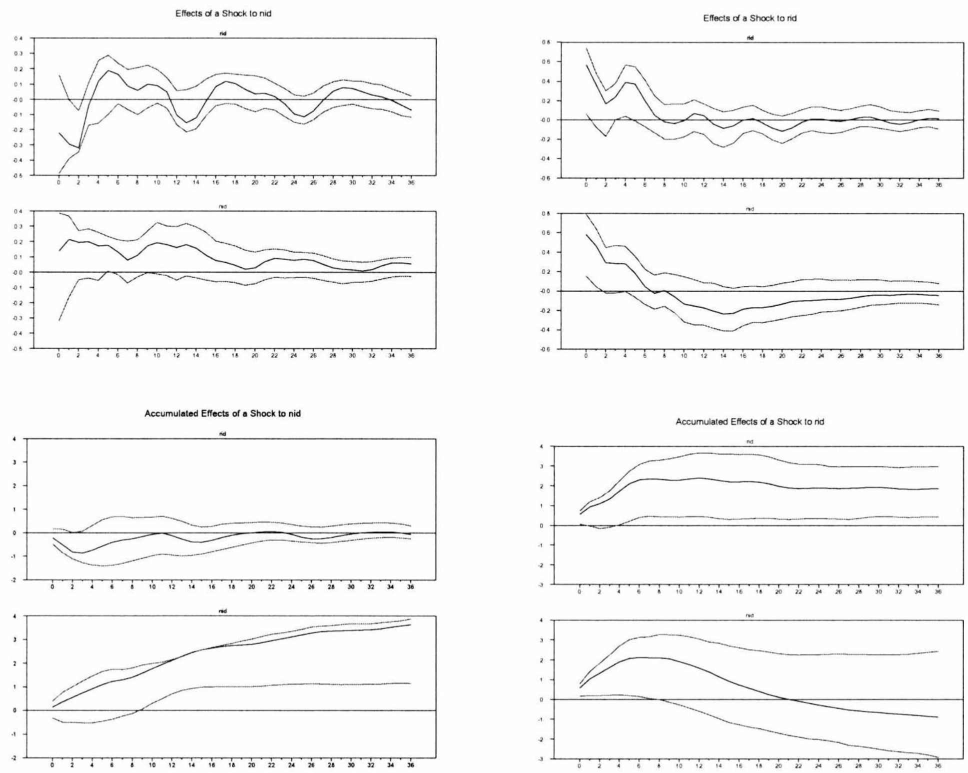


Figure 3.2. (continuation)

Mexico



Turkey

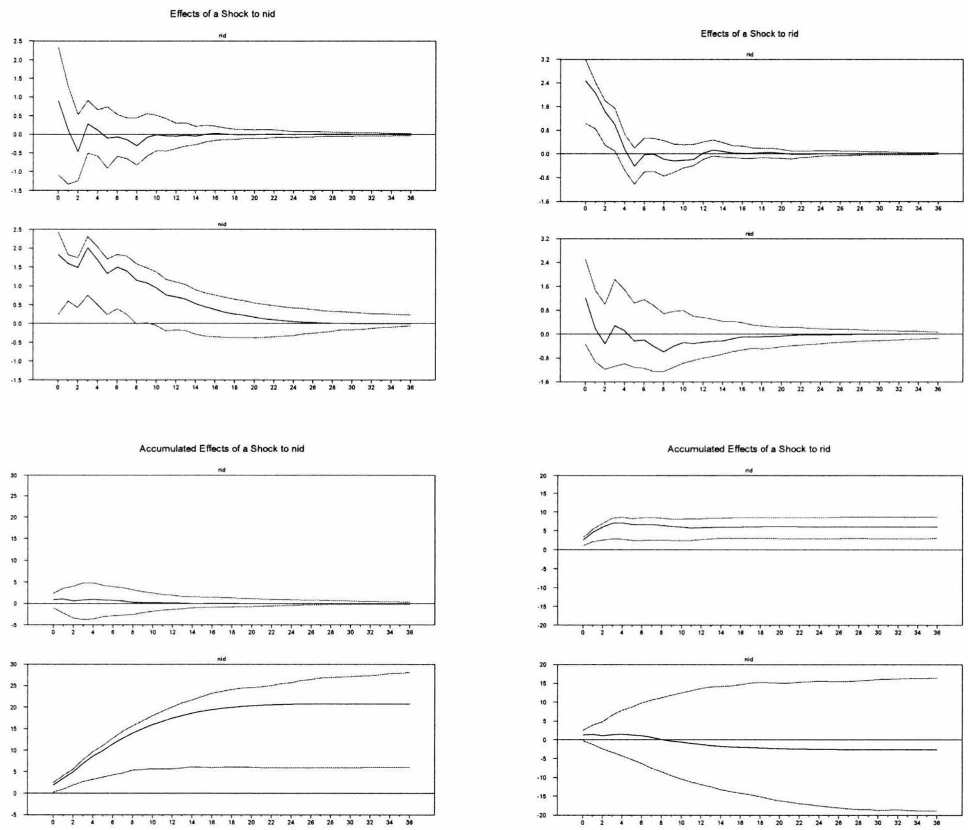
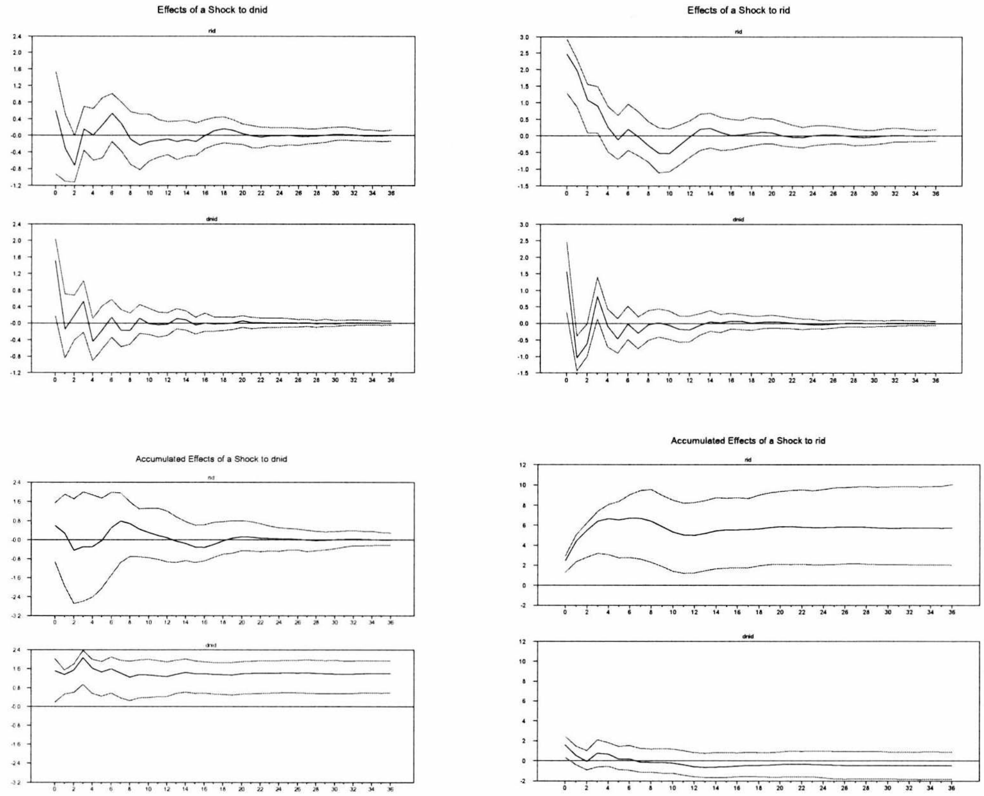


Figure 3.2. (continuation)

Turkey (*nids* in first difference)



Tables

Table 3.1. Descriptive Statistics of *rids* for Chapters 3 and 4.

Series	Obs	Mean	Std Error	Minimum	Maximum
Argentina	107	2.23	3.76	0.24	20.00
Brazil	107	5.58	2.79	2.60	21.21
Chile	107	0.87	0.93	-1.16	4.08
Mexico	107	1.27	1.37	-1.72	4.83
Turkey	107	5.09	3.90	-2.81	21.33
France	91	0.08	0.42	-0.93	0.99
Germany	107	0.02	0.60	-1.58	1.50
Italy	106	0.19	0.55	-1.04	1.42
Spain	107	0.03	0.73	-1.38	1.99
Uk	107	0.28	0.58	-0.99	1.84

Table 3.2. Descriptive Statistics of *nids*

Series	Obs	Mean	Std Error	Minimum	Maximum
Argentina	107	2.23	3.76	0.24	20.00
Brazil	107	5.58	2.79	2.60	21.21
Chile	107	1.31	1.01	-0.41	5.13
Mexico	107	4.12	3.37	0.88	18.41
Turkey	107	16.59	5.06	6.47	32.04
France	91	-0.17	0.40	-0.60	0.74
Germany	107	-0.21	0.32	-0.56	0.42
Italy	106	0.25	0.54	-0.51	1.51
Spain	107	0.13	0.46	-0.52	1.17
Uk	107	0.31	0.24	-0.18	0.76

Table 3.3. Unit Root Tests on *nids*

		ADF	KPSS	ERS	Elliot (1999)
	nº of lags	t-ratio	η_μ	DF-GLS	DF-GLS_u
Argentina	8	-2.32	0.43*	-2.27*	-2.33
Brazil	7	-3.55*	0.53*	-0.47	-2.78*
Chile	5	-1.83	1.31	-1.65**	-1.89
Mexico	6	-2.26	1.23	1.087	-1.17
Turkey	3	-1.80	1.33	-1.61	-1.88
France	12	-1.58	0.25*	-1.12	-1.51
Italy	12	-2.88**	0.36*	-1.03	-2.48**
Spain	8	-2.61**	0.25*	-0.99	-2.26
UK	1	-1.04	2.97	-0.47	-1.12
Germany	12	-1.74	0.66**	-1.80**	-1.88

Notes: * indicates rejection of the null of a unit root at the 5% confidence level for the ERS (1996) and Elliott (1999) tests and non-rejection of the null for the KPSS test at 95% confidence level. ** indicates rejection of the null of a unit root at the 10% confidence level for the ERS (1996) and Elliott (1999) tests and non-rejection of the null for the KPSS test at 99% confidence level.

Table 3.4. Perron (1997) Unit Root Tests on *nids*

	Lags	Break Date	T-ratio
Argentina	12	2002:01	-5.98*
Brazil	7	1999:06	-3.93
Chile	3	1999:05	-6.10*
Mexico	1	1996:04	-5.37*
Turkey	10	2001:02	-3.72
France	0	2000:12	-4.22**
Italy	12	2001:01	-3.94**
Spain	8	2001:01	-4.38*
UK	3	1998:11	-1.48
Germany	12	2001:01	-6.43*

Notes: * indicates rejection of the null of a unit root at the 5% confidence level and ** indicates rejection of the null of a unit root at the 10% confidence level.

Table 3.5. Variance Decomposition of *rids* between UIP and PPP deviations

	Argentina	Brazil	Chile	Mexico	Turkey
Variance of:					
Rids	13.2	5.4	0.9	1.9	15.0
Deviations from UIP	648.9	178.4	22.3	35.2	98.7
Deviations from relative PPP	541.5	175.8	21.4	29.8	105.7
% of *Rids*' variance:					
Deviations from UIP	4930.9	3289.8	2603.8	1895.0	656.07
Deviations from relative PPP	4115.0	3241.3	2492.5	1601.0	702.7
-2cov(UIP, relative PPP)	-8945.9	-6431.1	-4996.3	-3396.0	-1258.8

Table 3.6. Variance Decomposition of *rids* between *nids* and inflation differentials

	Argentina	Brazil	Chile	Mexico	Turkey
Variance of:					
Rids	13.2	5.4	0.9	1.9	15.0
Nids	14.0	7.7	1.0	11.3	25.4
Inflation differential	12.8	3.0	0.6	9.1	31.7
% of *Rids*' variance					
Nids	**106.6**	**142.4**	**117.3**	**606.1**	**168.7**
Inflation differential	**97.5**	**54.7**	**71.4**	**488.7**	**210.7**
-2cov(*Nids*, Inf. Differential)	-104.1	-97.1	-88.7	-994.9	-279.4

Chapter 4. Leaning Against the Parity

4.1. Introduction

The third chapter presented evidence that *nids* are more important than inflation differentials to explain *rids*, pointing out to departures from UIP as the main source of deviations from RIPH. There was also indication that frictions in assets markets were driving *rids* behaviour. In summary, deviations from UIP and *nids* were found to be the main determinant of the volatility of *rids*. The results encountered so far led to the idea that the causes of *nids* are also the underlying reasons of *rids*. This conclusion directs our efforts towards the task of finding out the causes of *nids*. Hence, "what determines *nids*?" is the question that we need to answer in order to accomplish the final objective of the present research. Because interest rates in an open economy are supposed to follow UIP, our goal is to explain *ex post* deviations from this condition as unveiled in the previous chapter. This is the major motivation of the present work.

Flood and Rose (2001, p.3) wrote that it is always easy to motivate another look at the UIP. The reason is that UIP is used as the cornerstone of many macroeconomic models but evidence is, at best, mixed. The contrast between its widespread theoretical use and the precarious empirical support is puzzling and provides another motivation for the present chapter.

The UIP, under the assumption of frictionless markets, predicts that *nids* between two economies will be equal to expected changes in the exchange rate. However, the vast majority of the empirical literature has found a robust negative relationship between the two variables. Estimates suggest that an expected appreciation of the domestic currency leads to an increase in domestic interest rates, or otherwise, that an expected depreciation decreases the *nid*.

Several approaches aim at explaining the UIP's empirical failure. Most of the supportive results are conditioned on particular circumstances and specific data sets[41]. Among the competing views, risk premium with time-varying components seems to be dominant. However, this explanation also presents problems which arise from the fact that risk is not directly observed [Engel (1996)].

There is a growing literature emphasising the role of monetary policy to explain UIP deviations. Authors have been raising issues regarding the behaviour of monetary authorities, especially in the floating era, which might have had an impact on *nids* and, thus, on UIP deviations. As mentioned before, a related work on the subject is Calvo and Reinhart (2002). They argued that some economies suffer from the "fear of floating". According to them, monetary authorities of emerging countries put a heavy weight on exchange rate stabilisation when setting interest rates because their Central Banks are scared of exchange rate volatility. The "Pick your Poison" tale, put forward by Iwata and Tanner (2003), can be considered as a side effect of the remedies that are used to heal an economy from the fear of floating. Their account is that monetary authorities of emerging economies have to choose between the venoms of wild exchange rate changes or increased interest rate volatility.

[41] For example, Flood and Rose (1996), Jorion (1996), Huisman *et al.* (1998), Meredith and Chinn (2004), Bernhardsen (2000), Berk and Knot (2001), Flood and Rose (2001), Muinhos *et al.* (2001), Sachsida *et al.* (2001), Francis *et al.* (2002) and Lothian and Wu (2003) used diverse approaches to explain UIP failure.

In a previous work, McCallum (1994a) developed a model that considers the effect of policy making on the determination of *nids*. The idea is that the UIP's failure can be explained by the simultaneous relationship between two factors: a policy reaction function and UIP itself. The distinguishing features of the policy function is that monetary authorities slowly change interest rates, in other words, they practice "interest rate smoothing[42]", and also resist exchange rate changes, or put in another way, they "lean against the wind". The simultaneous interaction between the two factors implies an equilibrium *nid* that, under certain parameter values, can explain the empirical failure of the UIP.

Christensen (2000) tested McCallum's (1994a) idea for developed countries (the US, Germany and Japan) and, in short, he did not find supporting evidence. Our contribution to the literature is twofold. First, we apply McCallum's (1994) model for a sample of not only developed, but also emerging markets. As stressed before, the evidence shows that emerging economies were prone to have suffered from the fear of floating (or monetary resistance against exchange rate changes). We not only verify whether McCallum's (1994) approach is consistent with our data but also compare our results with Christensen's (2000) findings regarding developed economies. Second, we check whether and how the findings change if the policy reaction function is modified to include other variables besides exchange rate changes. The monetary authorities in both McCallum's (1994a) model and Christensen's (2000) tests practice interest rate smoothing and react to exchange rate changes only, however, the general understanding is that monetary authorities also pay attention to variables such as inflation, output gap or output changes.

[42] Sack and Wieland (2000), p. 205, define interest rate smoothing as being the tendency of Central Banks to change interest rates "in sequences of small steps in the same direction and reverse the direction of interest rate movements only infrequently".

Furthermore, it is also known that many emerging economies have recently embarked into inflation target regimes. Finally, we also perform estimations considering possible structural breaks. The reason is that changes in exchange rate systems, as experienced by the countries of our sample, may have implied changes in the monetary policy.

The rest of the chapter is organised as follows: the next section first explains the model and then introduces an alternative specification for the policy reaction function; secondly, it briefly surveys the literature that focuses on the role of monetary policy to explain *nids*; section 4.3 analyses the empirical results and the final section concludes.

4.2. The Model

A testable version of UIP under the assumption of rational expectations is represented by the equation below

$$s_{t+1} - s_t = \alpha + \beta nid_t + \varepsilon_{t+1} \tag{4.1}$$

where the subscript t represents time, s_t is the spot exchange rate, defined as the domestic price of the foreign currency, $nid(s)$ represents the nominal interest differential(s) between the domestic and the foreign economy, i.e. $nid_t = i_t - i_t^*$ in which i_t is the interest rate paid on a one-period bond that matures at time $t+1$ and the asterisk stands for the foreign economy; ε_{t+1} is the random error term, associated with the forecast of s_{t+1}, and has zero mean and unit variance. All variables, except interest rates (and, therefore, *nids*) are in logarithms. If the hypothesis regarding UIP under rational expectations holds, then, estimated parameters α and β would not be statistically different from 0 and 1, respectively, and the error term would be white noise. However, as discussed before, the almost unanimous finding of the empirical literature is a robust negative estimate of β [43,44]. This phenomenon is at odds with the theory that explains the functioning of international financial markets on the basis of arbitrage and the assumption of no frictions.

McCallum's (1994) model[45] attempts to explain this empirical failure without abandoning either the UIP hypothesis or the assumption of rational expectations. As it will be shown, however, the model allows for frictions in financial markets. The policy reaction function is given below[46]

$$nid_t = \lambda^s (s_t - s_{t-1}) + \sigma nid_{t-1} + \zeta_t \qquad (4.2)$$

where λ^s stands for the degree to which a Central Bank leans against the wind, σ is the parameter representing the interest rate smoothing and the white-noise

[43] Baillie and Bollerslev (2000) and Bekaert and Hodrik (2001), for example, are few exceptions of supportive results for UIP. See Engel (1996) and Wang and Jones (2002) for recent surveys on the subject.

[44] A great part of the estimations of β are done through tests of forward exchange rate unbiasedness [see Engel (1996)]. However, note that covered interest parity, $nid_t = f_t - s_t$, in which f_t is defined as the price of the foreign currency at time *t* for delivery at $t+1$, imply that a test of equation (1) also corresponds to a test of foreign market efficiency. The reason is that covered interest parity substituted in (1) gives $s_{t+1} - s_t = \alpha + \beta(f_t - s_t) + \varepsilon_t$.

[45] Engel (1996) explained that his model is a particular case of the more general model of Boyer and Adams (1988).

[46] We present a solution for a version of this model in Appendix 2.

term ζ represents "random policy influences". The UIP condition is rewritten as follows

$$s_t = s_{t+1}^e - nid_t + \vartheta_t \qquad (4.3)$$

where the superscript *e* represents expectation, ϑ_t stands for *ex ante* deviations from UIP, which can be due to frictions in financial markets (such as risk premium) and is autoregressive, i.e. $\vartheta_t = \rho\vartheta_{t-1} + \upsilon_t$, where υ_t is white-noise [47]. Rearrange equation (4.3) with the nid_t in the left-hand side and then substitute the result into (4.2) to obtain

$$\Delta s_{t+1}^e = \lambda^s \Delta s_t + \sigma nid_{t-1} + \zeta_t - \vartheta_t \qquad (4.4)$$

where Δ represents the first difference operator and $\Delta s_{t+1}^e = s_{t+1}^e - s_t$. Postulating a bubble-free linear solution of (4.4) using the method of undetermined coefficients and also considering rational expectations, the model can be solved for exchange rates:

$$\Delta s_t = \left(\frac{\rho - \sigma}{\lambda^s}\right) nid_{t-1} - \frac{1}{\lambda^s}\zeta_t + \left(\frac{1}{\lambda^s + \sigma - \rho}\right)\upsilon_t \qquad (4.5)$$

[47] The presence of the foreign interest rate in equation (2) accounts for the fact that monetary authorities abroad may also resist exchange rate changes. Alternatively, it may indicate that domestic monetary policy cares about the level of the foreign interest rate. In any case, we will be referring to equation (2) as the policy reaction function.

with the assumption that $|\rho|<1$ and the presumption that $\rho>0$. McCallum (1994a) thought that if $\sigma \cong 0.8$ and $\lambda^s \cong 0.2$ in particular, then $\left(\frac{\rho-\sigma}{\lambda^s}\right)$ would have a similar value and the same sign of the anomalous regression's coefficient, which is normally estimated at around -3 [48].

The final result of a bond bid is a possible way to interpret equation (4.5). In this bid, agents use rational expectations to form forecasts about future exchange rate changes while authorities implement monetary policy reacting to variables that are considered to be relevant to their objectives. The simultaneous nature of this process leads to a result that does not corroborate the prediction of UIP. The coefficients in equation (4.5) show that the impact of a unit change of the predetermined variable on the exchange rate change may not be equal to one in equilibrium.

Other Policy Reaction Functions

In general, Central Banks either follow a Taylor-type rule or minimise a loss function with positive weights for both inflation and output [e.g., see Blanchard and Fischer (1989) and Sack and Wieland (2000)]. Meredith and Chinn (2004, p. 420), considered that the reaction function of McCallum (1994a) "does not incorporate variables that are usually believed to be of concern to policymakers, such as inflation and output." McCallum (1994b) also argued that monetary authorities pay more attention to inflation and output rather than to exchange rate movements and, hence, a monetary function as in equation (4.2) represents a simplification. He has

[48] Therefore, the implicit presumption is that $\rho \cong 0.2$.

also suggested to estimate different policy reaction functions and to test for diverse countries. For these reasons, we conduct several empirical tests in order to assess whether lagged *nids*, exchange rates, prices, output changes, output gap or any combination of these variables affected the *nids* of a heterogeneous sample of countries. We also check whether the parameters of the estimated policy reaction function are consistent with the "parable" proposed in McCallum (1994a). In spite of the fact that one should not expect those coefficients to have the same sign and the exact magnitude that McCallum (1994a) had hypothesised, as it is emphasised in the conclusion of McCallum (1994b), we will still compare our results with his guesses. For example, the following monetary policy reaction function is the one that generates the closest results with regard to McCallum's (1994) predictions when OLS estimations are used:

$$nid_t = \lambda^p (p_t - p_{t-1}) + \sigma nid_{t-1} + \zeta_t \tag{4.6}$$

where p represents price and λ^p is the degree to which monetary authorities react to price changes. By virtue of relative purchasing power parity, one can substitute price changes in equation (4.6) for exchange rate changes and substitute it into UIP in order to obtain the same coefficients of equation (4.5). This modification keeps the attractive simplicity of the original theoretical formulation[49]. However, as it will be shown, a more general policy reaction function gives closer results when conditional volatility is taken into account.

[49] Taylor (1999), for instance, lists an extensive number of policy reaction functions. The aim of this chapter is not to assess all possibilities but to test a selected number of those that seem reasonable from the point of view of the theory underlying the model.

The methodology adopted in this chapter is based on Christensen (2000). It consists in estimating the parameters $\lambda^s, \lambda^p, \sigma$ and ρ from the structural models in order to see whether the intuition behind McCallum (1994a) corresponds to the stylised facts of the actual data. As emphasised before, we extend the work in two main directions. Firstly, we apply the model to a sample of emerging markets as well as developed economies. The second contribution is that we allow the policy reaction function to depend on other variables besides exchange rate changes and also verify whether modifications in the way that policy makers react to these variables has changed, as the countries of our sample experienced periods of fixed, managed and floating exchange rates.

Finally, it is possible to define what we understand as "leaning against the parity". The economic literature labels leaning against the wind as the attempt of monetary authorities to resist exchange rate changes. As McCallum (1994a) shows, this resistance alters the predictions of UIP. But if monetary policy is also likely to take inflation into account, then relative purchasing power parity implies that UIP results can be similarly affected. Any attempt to avoid either exchange rate or price changes could alter the predictions of UIP and, consequently, the RIPH. Thus, leaning against exchange rates or prices imply leaning against the parity.

Simultaneity between Arbitrageurs and Policy Makers

Kugler (2000) analysed the expectation hypothesis of the term structure of interest rates using a policy reaction function. One of his conclusions is that interest rate smoothing and leaning against the wind lead to a negative relationship of the spot exchange rate change and the lagged forward premium and, thus, a rejection of the UIP. Bonser-Neal *et al.* (2000) presented an UIP model in which the Federal Reserve can choose to offset shocks to exchange rates via interest rates. Meredith and Chinn (2004) developed a macroeconomic model based on McCallum (1994a) and ran regressions on data generated by stochastic simulations. Their simulations replicated the sign and magnitude of the parameters usually found in the literature using bonds of short-run maturity. They concluded that UIP fails in the short-run because of risk premium shocks and endogenous monetary policy. Anker (1999) argued that the failure of UIP can be a consequence of systematic monetary-policy reaction to exchange rate changes.

A number of authors have stressed the influence of monetary policy on *nids* through several different channels. Huisman *et al.* (1998) showed that monetary uncertainty is important to explain shifts in the real interest rate. Kaminsky and Leiderman (1998) explained interest rate differentials on the grounds of a government's lack of credibility. Flood and Rose (2001) argued that deviations from UIP are a necessary condition for defending the exchange rate. Cushman and Zha (1997, p. 434) stated that Central Banks of small open economies "are likely to respond quickly to foreign variables, invalidating the assumption that the interest innovations are independent." Faust and Rogers (2003) found that monetary policy shocks led to UIP deviations. Using overnight Eurocurrency deposit rates, Baillie and Osterberg (1998) reached the conclusion that Central Bank interventions impact on the risk premium and thus affect UIP. Cecchetti *et al.* (2002, p. 2), quote Ball (1999) who found "that adding the exchange rate to the Taylor rule improves macroeconomic performance in a model where the exchange rate has a significant role in the transmission mechanism of structural shocks and monetary policy". To summarise, the empirical and theoretical literature reports that policy makers tend to place a significant weight on inflation or exchange rates when setting interest rates, in other words, the influence of monetary policy on the dynamics of *nids* has been largely documented.

4.3. Results

4.3.1. Data

Data for *rids*, *nids* and exchange rate changes that are used throughout this chapter are the same as explained in the previous chapters. Output, obtained from the IFS of the IMF, is measured as the natural logarithm of industrial production. The output gap was obtained by first de-trending the series using the Hodrick-Prescott filter. The value used for the smoothing coefficient is 126.400, which is recommended for monthly observations. We then subtracted the trend from the natural logarithm and multiplied by one hundred in order to obtain a numerical value comparable to the percentages of the other variables. Output changes were calculated as the monthly percentage changes in the index of industrial production. With regard to output, the data finish in 2000M5 for Argentina, 2004M1 for Brazil and Italy, 2004M2 for Chile, Mexico, Turkey, Spain and the UK and finally, 2003M10 for Germany.

4.3.2. Estimations of Equations (4.2) and (4.6)

Table 4.1 presents parameter estimates of equation (4.2) in which the authorities lean against exchange rates. The findings are similar to Christensen (2000) who performs his tests for the US, Germany and Japan. The coefficient λ^S is close to zero in both studies (in most cases) and generally insignificant. On the other hand, σ is significant and lies between 0.96 and 0.98 in Christensen (2000) and among 0.75 and 1.00 in our tests. Results, *prima facie*, indicate that Central Banks of both developed and emerging economies practice interest rate smoothing but do not react to exchange rate changes. The above finding also points out to a very high degree of persistence in interest rates and for Germany the process seems to follow a unit root (which, as shown before, had been rejected).

In short, the results do not corroborate the intuition of McCallum (1994a), as he predicted $\lambda^s \cong 0.20$ and $\sigma \cong 0.80$. Regarding diagnostic tests, serial correlation was often eliminated through the introduction of additional lags without any considerable change in the parameters[50]. F-tests of autoregressive conditional heteroscedasticity (ARCH) with 4 lags show that variance is time dependent in most countries. Because of normality and conditional heteroscedasticity problems, we tested equation (4.2) using ARCH and generalised autoregressive conditional heteroscedasticity (GARCH) models. However, the findings above are roughly repeated.

Table 4.2 presents the results from the estimations of equation (4.6). The parameter λ^p, associated with price changes, is not significant in any developed country. For emerging markets, however, λ^p is significant and close to 0.2. Also, the degree of interest rate smoothing diminishes when the policy reaction function is modified. Regarding residuals, serial correlation was eliminated by adding more lags to the regression without any important change in parameter values. We also ran a battery of OLS regressions using a combination of exchange rates, output

[50] For the sake of space and conciseness we do not report these results.

changes and output gap on the right-hand side of equation (4.2). The inclusion of more variables in the modified policy reaction function does not influence the coefficient λ^p to a great extent. None of these variables appeared to be systematically significant, thus, results are not shown.

As can be seen in (4.5), Δs_t depends on ζ_t, therefore in (4.2) Δs_t and ζ_t are correlated. Hence the OLS estimator of λ^s is inconsistent. However, there is no identification problem because the rank condition for equation (4.2) in the system formed by (4.2), (4.3) and the autoregressive *ex ante* deviations from UIP, is satisfied (the analysis is not shown for the sake of space). It follows that the parameter can be estimated. Because of the correlation between explanatory variables and the error term in our system of simultaneous equations, we then estimated equations (4.2) and (4.6) using lags as instruments for the dependent variables. As can be seen in Tables 4.3 and 4.4, the results are similar to the OLS ones, in which they show a pattern of strong reaction against price changes in emerging economies (and few cases of leaning against the wind that are not reported). Results for developed economies are analogous to the previous and, for this reason, not reported. We have also tested many versions of the monetary policy reaction functions using up to four lags of Δp_t and Δq_t. Sargan tests do not reject the hypothesis of correct specification and validity of the instruments.

Problems of normality and conditional heteroscedasticity were common. When the number of lags in the squared residuals is reduced to 1 or increased to 12, then conditional volatility seems to be a feature of nearly all estimated equations. We dealt with conditional heteroscedasticity and normality altogether by making use of ARCH and GARCH models and a generalised error distribution for the error term, which is appropriate when the time series is leptokurtic or exhibits tallness[51] [see Nelson (1991)]. We have chosen the type of the model [between ARCH, GARCH, EGARCH (exponential GARCH), LGARCH (leveraged GARCH) etc] according to the significance of the parameters on the conditional variance equation. The lags of the conditional variance were selected according to tests of ARCH effects. We started with a (p,q) model (1,1) in which p represents the order to the autoregressive term and q the number of lags of the moving average term. More lags were included if F-tests indicated serial correlation in the squared normalised residuals. The number of autoregressive terms in the mean equation was selected by analysing serial correlation in the normalised residuals. In the estimations that follow, the model for Argentina, Mexico and Turkey corresponds to an ARMA(1,1) while an AR(1) is used for Brazil and Chile. Finally, we added dummies for the largest outliers, which are likely to be associated with foreign or domestic financial crises, in order to ameliorate remaining normality problems.

In Table 4.5, we report the coefficients of the mean equation using the model represented by (4.6) which was estimated taking conditional volatility into consideration. Results for developed countries are similar to the ones using OLS and are not reported. Comparing the λ^{p} coefficients of emerging economies in Table 4.2 with the ones in Table 4.5, it is possible to see that the degree of leaning against price changes diminishes when volatility clustering is taken into account. However, the estimates for Argentina, Brazil and Mexico are still relatively close to the presumption of 0.2.

[51] This distribution is represented by a function that captures the leptokurtic properties of a series, in other words, the density function has a higher probability for extreme events.

The variance of the series significantly influences not only the squared error but also the mean equation in three countries. The ARCH-in-mean term ranges from a small positive value of 0.18 in Mexico to a higher one of 0.97 in Argentina. A possible interpretation is that monetary authorities consider uncertainty and/or risk[52], arising from the volatility of *nids*, when formulating their policy. A one unit increase in the variance of the *nids* of Argentina, for example, increases the difference between the quarterly nominal return of that country and the US by nearly 1%. Diagnostic tests show that there are no ARCH effects - at least in the four lags of squared normalised residuals – and the Ljung-Box Q-Test statistic reveals that there is no serial correlation in the normalised residuals. Jarque-Bera tests show that the distribution of the error term is normal[53].

Asymmetry in the squared residuals is a common characteristic of most estimated equations. The fact that EGARCH or LGARCH models were the most relevant for all countries except Turkey shows that conditional variance depends asymmetrically on negative and positive shocks. The EGARCH model put forward by Nelson (1991) allows not only the magnitude of unanticipated returns to determine the variance but also the signs of the residuals. The leverage term of the LGARCH model is a dummy that captures asymmetry in the conditional variance. The dummy takes the value one when the residual is negative and zero otherwise.

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[52] Granger (2002) suggests that variance cannot be a measure of risk premium only, but also uncertainty: agents diversify their portfolio in order to avoid unexpected large losses but not large gains.

[53] With respect to the dummies, we used two in Argentina for the months 2001M9 and 2001M11, which may be reflecting the start of the financial crises that led to the free floating of the Peso; we also needed dummies for the months 1998M1, 1998M11 and 1998M12 in Brazil as they are likely mirroring the disproportionate responses of monetary policy to the threat that the Asian and Russian crises posed to the peg of the Brazilian Real; for Chile and Mexico we had to use a single dummy for 1998M11 which probably indicates a radical monetary response to the Russian crisis; finally, we had dummies for 1996M11, 2000M11 and 2001M12 in Turkey, the last two years possibly associated with the financial crisis that culminated with the free floating of the Lira.

We also performed several tests alternating and combining exchange rates, output changes and output gap in the policy reaction function, but results did not show any major difference in relation to the parameters reported in Table 4.2, 4.3 and 4.5.

Changes in Monetary Policy

Because exchange rate regimes changed during the sample period, the "Lucas Critique" may apply in one sense: alterations in the way economic policy is conducted would influence the predictions of the models above. Hence, we decided to test whether changes in exchange rate systems have influenced the results previously found. We performed these tests using the following specification:

$$\begin{aligned} & nid_t = \alpha + \sigma_1 nid_{t-1} + D\sigma_2 nid_{t-1} + \lambda_1^p \Delta p_t + \\ & D\lambda_2^p \Delta p_t + \lambda_1^s \Delta s_t + D\lambda_2^s \Delta s_t + \theta_1 y_t^g + D\theta_2 y_t^g + \mu_t \end{aligned} \tag{4.7}$$

where y_t^g is the output gap and μ_t is an error term with zero mean and variance following a heteroscedastic process; the dummy variable *D* takes the value zero in the first period and one in the second; the coefficients $\sigma_1, \sigma_2, \lambda_1^p, \lambda_2^p, \lambda_1^s, \lambda_2^s, \theta_1$ and θ_2 stand for the response of the monetary authorities to the variables that they are associated, for the corresponding periods 1 and 2 as shown in the subscripts. The first period corresponds to the Currency Board in Argentina (which finished in 2002M1) and managed exchange rates in Brazil (terminating in 1999M1) and also in Turkey (ending in 2001M2), while the second is the floating system. For Chile, the first period corresponds to the floating system with bands, which was abandoned in 1999M9 for a flexible regime. Mexico had a floating system during the whole sample period and, for this reason, we did not select any date break for it.

Results are presented in Table 4.6. An EGARCH was the most relevant model for Brazil and Turkey, a LGARCH for Chile and Mexico and a GARCH model was the most adequate to Argentina. We used a generalised error distribution for all the emerging economies, except Brazil for which Jarque-Bera tests showed that residuals are normal[54]. Finally, F-tests rejected that ARCH effects or serial correlation remained in the normalised residuals up to lag four.

Tests including the output gap for Argentina are inappropriate because they entail a loss of more than half of the observations due to data availability. As can be seen in Table 4.6, interest rate smoothing decreases significantly in this country and reaction against inflation seems to be stronger during the floating period. For Brazil, all coefficients but the dummies of the interest rate smoothing variable and the output gap are significant. During the pegged system, an exchange rate change of 1% corresponded to an increase of 0.37% in the mean of *nids* (keeping other variables constant) which indicates a significant degree of leaning against the wind. Prices explain *nids* in the two periods but the sign of the parameter in the first is negative, which is puzzling. In the floating period, exchange rate changes do not have an impact on *nids* but inflation provokes a response of 0.12% in *nids*. *Nids* seem to react to the output gap during the managed float (they decrease as the gap

[54] We had a dummy for Argentina in 2001M9 while for Chile and Mexico the dummy was for 1998M11; in Turkey we used one in 2001M2 in addition to another one for 1998M11. As can be seen in Table 4.2, the Jarque-Bera tests show that there could still be some concern for normality problems in Argentina, Mexico and Turkey. We opted for showing the present results because as more dummies are included and normality problems are eliminated, the estimated parameters do not change by much but there is a loss in terms of degrees of freedom.

increases) but are not significant during the floating period. Chile presents the smallest degree of interest rate smoothing which is around 0.50. Reaction to price changes, exchange rate changes and output gap is apparent only in the first period. After the change in the exchange rate regime, there is interest rate smoothing but results suggest that there is no reaction to any other variable. Results for Mexico are robust with regard to the choice of the technique. Reaction against price changes is significant and in the order of 0.22. There is weak evidence of reaction to exchange rates or output for this country. According to the results, Turkey experienced a high degree of interest rate smoothing during the managed float with small reaction of *nids* to any of the variables (prices, exchange rates and output). The degree of interest rate smoothing diminishes during the floating period and there is a significant increase in the reaction against price changes. Finally, the variance of the series of *nids* positively influences the mean equation in Argentina and Chile but is not significant to explain the mean of Brazil, Turkey and Mexico. The ARCH-in-mean term is 0.18 and 0.32 in Argentina and Chile, respectively. In general, results suggest that shocks affect variance (which can be understood as a measure of uncertainty and/or risk) in a non-linear way and also that this variable is taken into account during the formulation of monetary policy.

The findings seem to provide support for the idea that there is leaning against the parity for at least one period in all countries. The results are stronger for Argentina, Brazil, Mexico and Chile, the last country only in the first period. Brazil seems to lean against the wind during the managed float and react to inflation subsequently. There is evidence of strong reaction against price changes during the floating period in Argentina. According to the results, Chile leant against the parity by reacting to price changes until 1999M9. Evidence of monetary response in this country during the pure floating period is loose. Apparently, Mexico responded to inflation only. With the exception of Brazil most countries appear not to react to exchange rate changes, using both OLS and maximum likelihood conditional volatility estimations. A similar result (of nearly no policy reaction) is verified for the coefficients associated with the output gap and to output changes (the latter is not reported).

The importance of the output gap on the estimated policy reaction functions is negligible or the parameter is insignificant. One reason might be associated with the fact that price stability is generally the Central Bank's main concern[55]. Another possible justification is that output gap is not directly observed and, hence, imperfect measurements are not able to capture the statistical relationship between the two variables. Similarly to output, exchange rate changes are generally not significant in the estimated policy reaction functions. The importance of the exchange rate channel to the formulation of monetary policy is directly related to the degree of pass-through. Devereux and Engel (2002, p. 914), for example, explained that "low pass-through of exchange rates might imply high exchange rate volatility in equilibrium." If the exchange rate has little effect on domestic expenditure, then it might take large changes in this variable to achieve equilibrium after some shock to fundamentals. Obstfeld (2004) presents a model showing that a free exchange rate system might be desirable, even if this variable has no expenditure-switching role, because it releases domestic authorities from using interest rates as a stabilisation tool. These ideas could explain why the statistical

[55] Theoretically, even if the Central Bank follows the strict rule of targeting price changes, it would still react to output to the extent at which this variable contains information about inflation [see Eichengreen (2002)].

link between *nids* and exchange rates is so weak, especially during the floating period.

As a matter of fact, the fear of floating literature is incipient and more research needs to be carried out. We speculate whether Central Banks may only fear large swings in the exchange rate. In special, monetary authorities of emerging economies would drastically increase interest rates when there is a high probability of depreciation and reduce it slowly when the threat fades away. When pursuing its inflation target, the Central Banks of those countries would only be afraid of large upward swings on the exchange rate and welcome appreciations as it helps in pushing inflation down. Alternatively, there would not be any significant reaction to exchange rate appreciations if prices are rigid downwards. These ideas could explain the finding of little or no statistical relationship between *nids* and actual exchange rate changes.

4.3.3. Excess returns

The final step is to estimate the parameter ρ from $\vartheta_t = \rho\vartheta_{t-1} + \upsilon_t$. The variable ϑ represents *ex ante* deviations from UIP, which can stem from frictions in financial markets, and is supposed to be autoregressive. Since *ex ante* deviations cannot be observed we apply unit root tests on *ex post* UIP deviations and investigate the dynamic properties of this variable. *Ex post* deviations from UIP, hereafter also referred as excess returns, are characterized as

$$\xi_t = nid_t - \Delta s_{t+1} \tag{4.8}$$

ADF statistics are presented in Table 4.7. We calculated the number of lags using a general to specific as in sections 2.4 and 3.2. ADF statistics shows that the unit root is rejected at the 5% significance level in all cases, except Mexico. We also tested for unit roots in the excess returns of Mexico using the Kwiatkowski *et al.* (1992) and Elliott *et al.* (1996) but there was no support for stationarity. Tests using the approach of Elliott (1999) provide the only test statistic that is able to reject the null, however, at the 10% confidence level.

The estimated root, which is assumed to be , is significant and ranges from 0.50 to 0.70, which implies that the dynamic properties of UIP *ex post* deviations, often interpreted as risk premium [see Kugler (2000) and Berk and Knot (2001), for instance], influence the equilibrium *nid* by a substantial extent. A robust aspect of the results is that estimated parameters of the autoregressive term are significant and the speed of convergence is similar in magnitude. No assumptions were made for this coefficient in McCallum (1994a) and no estimation was performed in Christensen (2000), so it is not possible to compare the results.

4.4. Concluding Remarks

The findings using the original model of McCallum (1994a) do not support his intuition as there is no evidence of leaning against the wind for most countries in most periods. The version of the policy reaction function with reaction against prices lends support to the idea of leaning against the parity using OLS estimation but only for emerging economies. The size and the sign of the parameters surprisingly resemble the values presumed by McCallum (1994a). This model gives similar results when heteroscedasticity and normality problems are taken into consideration – Turkey and Chile are the exceptions. Then, we tested a policy reaction function including exchange rate changes, output gap and also checked whether parameter values changed by considering structural breaks (which were identified by changes in exchange rate regimes). We found evidence of leaning against the parity in all emerging countries in at least one period. Finally, evidence of interest rate smoothing was found to be robust for all countries and the dynamic properties of excess returns influenced the equilibrium *nid* of emerging economies to a reasonable extent. The impact of positive and negative shocks on the conditional variance is asymmetric. Furthermore, there is evidence that monetary authorities allow for uncertainty and/or risk in the policy reaction function.

This chapter presented results that lend support to the view that policy actions simultaneously interact with the decisions of arbitrageurs and change the results predicted by international parity conditions, such as UIP and also, by consequence, the RIPH. McCallum (1994a) showed that smoothing interest rates and leaning against the wind under certain assumptions about parameter values imply that high nominal returns are associated with exchange rate appreciations, instead of (*ex post*) depreciations. Christensen (2000) did not find support for his model in a sample of developed countries. We have shown that monetary authorities play a role in the determination of *nids* in emerging countries if reaction against prices and exchange rate regime changes are taken into account into the estimation of the monetary policy reaction function.

The conclusion is that monetary policy, through persistent reaction against price or exchange rate changes, has had an impact on equilibrium, or long-run *nids*. Equilibrium *nids* are negative related to exchange rate changes, in other words, a high *nid* is associated with an appreciating exchange rate. An appreciating exchange rate is compatible with falling prices according to relative PPP. Thus, the results of this Chapter sheds some light on the determinants of the positive equilibrium *rids* found in the second Chapter. It follows from the model and from our supportive results that monetary authorities can permanently lean against the parities.

The model presented shows that both the equilibrium and the dynamics depend on excess returns, for given parameters of policy reaction. As *nids* and UIP deviations account for most of the variation in *rids*, we need to investigate the determinants of their dynamics in more depth, an objective pursued in the following Chapter.

Tables

Table 4.1. Results obtained from the OLS estimation of Equation (4.2)

Developed Countries

	France	Italy	Spain	UK	Germany
Intercept	-0.004	-0.002	-0.002	0.013	0.005
	(0.009)	(0.008)	(0.005)	(0.008	(0.007)
σ	0.96*	0.96*	0.97*	0.97*	1.00*
	(0.023)	(0.014)	(0.011)	(0.023)	(0.019)
λ^s	-0.003	0.000	-0.002	-0.002	0.001
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
R^2	0.96	0.98	0.98	0.95	0.97
Serial Correlation[a]	18.80	17.10	28.58	18.83	14.77
	[0.93]	[0.14]	[0.00]	[0.09]	[0.25]
Functional Form[b]	0.92	0.13	0.28	0.00	0.18
	[0.34]	[0.71]	[0.59]	[0.93]	[0.66]
Normality[c]	50.56	0.95	6.88	2.50	5.90
	[0.00]	[0.62]	[0.03]	[0.28]	[0.05]
Heteroscedasticity[d]	1.91	8.34	0.03	1.05	2.52
	[0.17]	[0.00]	[0.85]	[0.31]	[0.11]
F-ARCH (4 lags)	0.30	5.34	2.95	4.93	0.97
	[0.87]	[0.00]	[0.02]	[0.00]	[0.42]

Emerging Markets

	Argentina	Brazil	Chile	Mexico	Turkey
Intercept	0.15	0.91*	0.31*	0.29*	2.96*
	(0.171)	(0.323)	(0.108)	(0.149)	(0.92)
σ	0.92*	0.83*	0.75*	0.89*	0.76*
	(0.038)	(0.051)	(0.066)	(0.027)	(0.059)
λ^s	-0.006	-0.008	0.002	0.002	0.079*
	(0.006)	(0.011)	(0.014)	(0.018)	(0.024)
R^2	0.85	0.71	0.56	0.91	0.74
Serial Correlation[a]	47.33	21.23	16.32	13.52	23.20
	[0.00]	[0.05]	[0.18]	[0.33]	[0.03]
Functional Form[b]	0.05	7.24	2.19	3.29	19.58
	[0.82]	[0.00]	[0.14]	[0.07]	[0.00]
Normality[c]	773.85	3910.6	22.52	695.41	943.98
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Heteroscedasticity[d]	9.27	8.54	12.11	14.14	6.65
	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]
F-ARCH (4 lags)	12.21	0.10	1.63	0.17	5.37
	[0.00]	[0.98]	[0.17]	[0.96]	[0.00]

Notes: * denotes significance at 5% level, standard errors are in parenthesis and significance levels in brackets. With regard to diagnostic tests: a) Lagrange multiplier test of residual serial correlation for 12 lags; b) Ramsey's RESET test using the square of the fitted values; c) Based on a test of skewness and kurtosis of residuals; d) Based on the regression of squared residuals on squared fitted values.

Table 4.2. Results obtained from the OLS estimation of Equation (4.6)

Developed Countries

	France	Italy	Spain	UK	Germany
Intercept	-0.007	-0.026	-0.009	0.005	-0.002
	(0.012)	(0.018)	(0.008)	(0.009)	(0.007)
σ	0.97*	0.95*	0.97*	0.99*	0.99*
	(0.022)	(0.014)	(0.011)	(0.002)	(0.017)
λ^p	0.005	0.042	0.009	0.009	0.018
	(0.022)	(0.028)	(0.009)	(0.008)	(0.011)
R^2	0.95	0.98	0.98	0.95	0.97
Serial Correlation[a]	17.21	15.26	28.99	19.63	14.06
	[0.14]	[0.23]	[0.00]	[0.07]	[0.29]
Functional Form[b]	1.19	2.08	0.01	0.08	0.48
	[0.27]	[0.15]	[0.92]	[0.77]	[0.49]
Normality[c]	96.91	1.64	5.86	2.28	6.98
	[0.00]	[0.44]	[0.05]	[0.32]	[0.03]
Heteroscedasticity[d]	1.67	10.73	0.13	0.47	2.11
	[0.19]	[0.00]	[0.72]	[0.49]	[0.15]
F-ARCH (4 lags)	0.16	4.00	1.63	4.58	0.87
	[0.95]	[0.00]	[0.17]	[0.00]	[0.48]

Emerging Markets

	Argentina	Brazil	Chile	Mexico	Turkey
Intercept	0.076	0.77*	0.11	0.09	2.45*
	(0.015)	(0.319)	(0.119)	(0.118)	(0.863)
σ	0.85*	0.76*	0.70*	0.57*	0.66*
	(0.035)	(0.099)	(0.064)	(0.045)	(0.067)
λ^p	0.20*	0.22*	0.25*	0.46*	0.25*
	(0.037)	(0.058)	(0.079)	(0.058)	(0.059)
R^2	0.88	0.73	0.60	0.94	0.76
Serial Correlation[a]	47.40	8.01	18.25	14.96	21.29
	[0.00]	[0.78]	[0.11]	[0.24]	[0.05]
Functional Form[b]	2.43	6.08	0.00	0.07	3.72
	[0.12]	[0.01]	[0.94]	[0.79]	[0.05]
Normality[c]	270.25	2967.6	27.87	760.12	1331.3
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Heteroscedasticity[d]	15.69	11.99	9.45	2.30	0.01
	[0.00]	[0.00]	[0.00]	[0.13]	[0.93]
F-ARCH (4 lags)	13.59	0.21	1.18	0.42	4.45
	[0.00]	[0.93]	[0.32]	[0.99]	[0.00]

Notes: * denotes significance at 5% level, standard errors are in parenthesis and significance levels in brackets. With regard to diagnostic tests: a) Lagrange multiplier test of residual serial correlation for 12 lags; b) Ramsey's RESET test using the square of the fitted values; c) Based on a test of skewness and kurtosis of residuals; d) Based on the regression of squared residuals on squared fitted values.

Table 4.3. IV (Instrumental Variables) estimation of Equation (4.2)

Emerging Markets

	Argentina	Brazil	Chile	Mexico	Turkey
Intercept	0.15	0.72*	0.30*	0.31	3.76*
	(0.181)	(0.276)	(0.109)	(0.313)	(1.053)
σ	0.92*	0.82*	0.75*	0.93*	0.65*
	(0.039)	(0.047)	(0.066)	(0.038)	(0.082)
λ^s	0.00	0.03	0.00	-0.08	0.17*
	(0.006)	(0.020)	(0.018)	(0.169)	(0.049)
R^2	0.84	0.74	0.56	0.92	0.72
Instruments (lags)	1 and 2	2 and 3	1 and 2	4 and 5	2 and 3
Sargan test	30.35	2.62	1.38	0.75	0.61
	[0.00]	[0.10]	[0.24]	[0.38]	[0.43]
Serial Correlation[a]	14.33	1.93	0.95	0.64	5.93
	[0.00]	[0.11]	[0.43]	[0.63]	[0.00]
Normality[c]	107.88	33.39	14.99	73.43	112.89
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Heteroscedasticity[d]	18.00	2.55	4.34	2.92	13.10
	[0.00]	[0.04]	[0.00]	[0.02]	[0.00]
F-ARCH (4 lags)	12.34	0.98	1.73	0.56	4.47
	[0.00]	[0.42]	[0.15]	[0.69]	[0.00]

Notes: * denotes significance at 5% level, standard errors are in parenthesis and significance levels in brackets. With regard to diagnostic tests: a) Lagrange multiplier test of residual serial correlation for 12 lags; b) Ramsey's RESET test using the square of the fitted values; c) Based on a test of skewness and kurtosis of residuals; d) Based on the regression of squared residuals on squared fitted values. The null hypothesis of the Sargan test is that the instrumental variables are uncorrelated to the residuals.

Table 4.4. IV (Instrumental Variables) estimation of Equation (4.6)

Emerging Markets

	Argentina	Brazil	Chile	Mexico	Turkey
Intercept	-0.02	1.21*	-0.05	0.19	2.37*
	(0.193)	(0.229)	(0.131)	(0.137)	(0.846)
σ	0.76*	0.73*	0.66*	0.73*	0.66*
	(0.050)	(0.041)	(0.067)	(0.084)	(0.073)
λ^p	0.48*	0.05	0.48*	0.23*	0.26*
	(0.078)	(0.058)	(0.099)	(0.118)	(0.068)
R^2	0.81	0.81	0.57	0.92	0.77
Instruments (lags)	3 and 4	1 and 2	1 and 2	2 and 3	1 and 2
Sargan test	2.50	0.11	1.74	2.04	0.28
	[0.11]	[0.74]	[0.18]	[0.15]	[0.59]
Serial Correlation[a]	13.95	1.05	0.44	2.46	4.23
	[0.00]	[0.38]	[0.77]	[0.05]	[0.00]
Normality[c]	145.85	47.47	9.06	176.16	61.02
	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]
Heteroscedasticity[d]	24.69	2.26	2.43	3.40	0.16
	[0.00]	[0.06]	[0.05]	[0.01]	[0.95]
F-ARCH (4 lags)	16.29	0.14	0.84	0.02	4.59
	[0.00]	[0.97]	[0.50]	[0.99]	[0.00]

Notes: * denotes significance at 5% level, standard errors are in parenthesis and significance levels in brackets. With regard to diagnostic tests: a) Lagrange multiplier test of residual serial correlation for 12 lags; b) Ramsey's RESET test using the square of the fitted values; c) Based on a test of skewness and kurtosis of residuals; d) Based on the regression of squared residuals on squared fitted values. The null hypothesis of the Sargan test is that the instrumental variables are uncorrelated to the residuals.

Table 4.5. Conditional Heteroscedasticity Estimation of Equation (4.6)

	Argentina	Brazil	Chile	Mexico	Turkey
Model	LGARCH(1,1)	LGARCH(1,1)	EGARCH(1,1)	EGARCH(2,2)	ARCH(1)
Intercept	0.03	0.82*	0.12*	0.11	-0.41*
	(0.046)	(0.197)	(0.029)	(0.126)	(0.074)
σ	0.59*	0.78*	0.64*	0.76*	0.99*
	(0.059)	(0.023)	(0.071)	(0.038)	(0.004)
λ^{p}	0.15*	0.10*	-0.02*	0.17*	0.03*
	(0.028)	(0.039)	(0.008)	(0.040)	(0.001)
Arch-in-Mean	0.97*	-0.23	0.62*	0.18*	--
	(0.275)	(0.488)	(0.184)	(0.475)	
Jarque-Bera	3.996	0.410	1.717	2.675	2.918
	[0.135]	[0.814]	[0.423]	[0.262]	[0.232]
F-ARCH (4 lags)	0.640	0.547	1.613	0.306	0.706
	[0.635]	[0.701]	[0.177]	[0.835]	[0.589]
Ljung-Box Q-Test (4 lags)	1.823	1.248	5.152	3.9153	2.358
	[0.609]	[0.741]	[0.161]	[0.271]	[0.501]

Note: * denotes significance at 5% level, standard errors are in parenthesis and significance levels are in brackets.

Table 4.6. Conditional Heteroscedasticity Estimation of Equation (4.7)

	Argentina	Brazil	Chile	Mexico	Turkey
Model	GARCH(1,1)	EGARCH(1,1)	LGARCH(1,1)	LGARCH(1,1)	EGARCH(1,1)
α	0.00 (0.012)	0.89* (0.151)	0.12* (0.047)	0.29* (0.104)	2.07* (0.401)
σ_1	0.85* (0.039)	0.75* (0.055)	0.52* (0.063)	0.71* (0.038)	0.87* (0.020)
σ_2	-0.19* (0.039)	-0.01 (0.07)	0.13 (0.11)	--	-0.11* (0.022)
λ_1^P	0.08* (0.028)	-0.14* (0.085)	0.37* (0.069)	0.22* (0.044)	0.00 (0.018)
λ_2^P	0.19* (0.071)	0.26* (0.092)	-0.39* (0.071)	--	0.09* (0.029)
λ_1^s	--	0.37* (0.174)	0.05* (0.025)	-0.02* (0.008)	0.04* (0.014)
λ_2^s	0.00 (0.009)	-0.36* (0.175)	-0.05* (0.026)	--	-0.03* (0.016)
θ_1	--	-0.10* (0.037)	0.04* (0.015)	0.001 (0.006)	-0.02* (0.009)
θ_2	--	3.73 (4.54)	-0.04* (0.016)	--	-0.04* (0.015)
ARCH-in-Mean	0.18* (0.073)	-0.10 (0.227)	0.32* (0.177)	0.00 (0.151)	-0.10 (0.119)
Jarque-Bera	7.901 [0.019]	0.712 [0.700]	4.52 [0.104]	4.74 [0.093]	4.890 [0.087]
F-ARCH (4 lags)	0.79 [0.53]	0.41 [0.801]	0.39 [0.811]	1.77 [0.142]	0.43 [0.785]
Ljung-Box Q-Test (4 lags)	5.45 [0.141]	2.09 [0.554]	4.41 [0.220]	2.32 [0.507]	2.74 [0.433]

Note: * denotes significance at 5% level, standard errors are in parenthesis and significance levels in brackets.

Table 4.7. Unit Root (ADF) tests on ξ_t

	Argentina	Brazil	Chile	Mexico	Turkey
N° of lags	4	4	4	7	1
ADF statistic	-4.437*	-4.477*	-4.704*	-2.610	-5.871*
ρ (estimated root)	0.67*	0.50*	0.60*	0.70*	0.58*

Note: * represents rejection of the null at 5% level for the ADF statistic, and significance at 5% for the estimated root.

Appendix 2

The simple modification presented in this appendix does not incorporate output in the policy reaction. The reason is given by our empirical results (targeting prices yields the best fit in OLS estimations and keeps analytical simplicity). Rewriting the system of equations

$$nid_t = \lambda \Delta p_t + \sigma nid_{t-1} + \zeta_t \tag{A2.1}$$

$$s_t = s^e_{t+1} - nid_t + \xi_t \tag{A2.2}$$

$$\vartheta_t = \rho \vartheta_{t-1} + v_t \tag{A2.3}$$

where the policy reaction function is represented in (A2.1), UIP in (A2.2) and the "aggregation of time varying components" in (A2.3). Variables were previously defined. Rational expectations imply $s^e_{t+1} = E_t s_{t+1}$. Subtracting s_t from both sides gives $E_t s_{t+1} - s_t = E_t \Delta s_{t+1}$. Rearranging (A2.2) as $E_t \Delta s_t = nid_t - \vartheta_t$ UIP can alternatively be written

$$E_t \Delta s_{t+1} = nid_t - \vartheta_t \tag{A2.4}$$

Replace (A2.1) in (A2.4)

$$E_t \Delta s_{t+1} = \lambda \Delta p_t + \sigma nid_{t-1} + \zeta_t - \vartheta_t \quad \text{(A2.5)}$$

Relative PPP allow us to interchangeably write $\Delta s_t = \Delta p_t$, given the assumption that the logarithm of foreign prices is relatively constant, $\Delta p_t^* \equiv 0$. It follows

$$E_t \Delta s_{t+1} = \lambda \Delta s_t + \sigma nid_{t-1} + \zeta_t - \vartheta_t \quad \text{(A2.6)}$$

Using the relevant state variables, we can postulate a linear solution by the method of undetermined coefficients

$$\Delta s_t = \phi_1 nid_{t-1} + \phi_2 \zeta_t + \phi_3 \vartheta_t \quad \text{(A2.7)}$$

where ϕ_i ($i = 1,2,3$) are the undetermined coefficients. Taking the one-period expectation of (A2.7) considering (A2.3) gives

$$E_t \Delta s_{t+1} = \phi_1 nid_t + \phi_3 \rho \vartheta_t \quad \text{(A2.8)}$$

Substituting relative PPP in equation (A2.1) and the result of this substitution into (A2.8) to have

$$E_t \Delta s_{t+1} = \phi_1 (\lambda \Delta s_t + \sigma nid_{t-1} + \zeta_t) + \phi_3 \rho \vartheta_t \quad \text{(A2.9)}$$

Now plugging (A2.6) into (A2.9)

$$\lambda \Delta s_t + \sigma nid_{t-1} + \zeta_t - \vartheta_t = \phi_1 (\lambda \Delta s_t + \sigma nid_{t-1} + \zeta_t) + \phi_3 \rho \vartheta_t \quad \text{(A2.10)}$$

Replace Δs_t in (A2.10) with its postulated solution (A2.7)

$$\begin{aligned} &\lambda(\phi_1 nid_{t-1} + \phi_2 \zeta_t + \phi_3 \vartheta_t) + \sigma nid_{t-1} + \zeta_t - \vartheta_t = \\ &\phi_1 [\lambda(\phi_1 nid_{t-1} + \phi_2 \zeta_t + \phi_3 \vartheta_t) + \sigma nid_{t-1} + \zeta_t] + \phi_3 \rho \vartheta_t \end{aligned} \quad \text{(A2.11)}$$

Multiplying terms in parenthesis and brackets and rearranging (11)

$$\begin{aligned} &nid_{t-1}\left[-\phi_1^2 \lambda_1 - \phi_1(\sigma - \lambda) + \sigma\right] + \zeta_t\left[\phi_2 \lambda (1 - \phi_1) + 1 - \phi_1\right] \\ &+ \vartheta_t \left[\phi_3 (\lambda - \phi_1 \lambda - \rho_t) - 1\right] = 0 \end{aligned} \quad \text{(A2.12)}$$

Solving for the coefficients attached to the variables we have, for the *nid*

$$\phi_1^2 \lambda + \phi_1 (\sigma - \lambda) - \sigma = 0 \quad \text{(A2.13)}$$

this yields the following roots

$$\Delta = (\sigma - \lambda)^2 + 4\sigma\lambda = \sigma^2 - 2\sigma\lambda + \lambda^2 + 4\sigma\lambda = \sigma^2 + \lambda^2 + 2\sigma\lambda = (\sigma + \lambda)^2$$

$$\phi_1^{'} = \frac{-(\sigma - \lambda) + \sqrt{(\sigma + \lambda)^2}}{2\lambda} = \frac{-\sigma + \lambda + \sigma + \lambda}{2\lambda} = 1 \qquad \text{(A2.14)}$$

$$\phi_1^{''} = \frac{-(\sigma - \lambda) - \sqrt{(\sigma + \lambda)^2}}{2\lambda} = \frac{-\sigma + \lambda - \sigma - \lambda}{2\lambda} = -\frac{\sigma}{\lambda}$$

As in McCallum (1994), the bubble free solution requires the abandonment of the first root. Hence, the coefficient attached to *nids* is $\phi_1 = -\frac{\sigma}{\lambda}$. Now, solving for ζ_t

$$\zeta_t \left[\phi_2 \lambda (1 - \phi_1) + 1 - \phi_1 \right] = 0 \qquad \text{(A2.15)}$$

$$\phi_1 \phi_2 \lambda - \phi_2 \lambda + \phi_1 - 1 = 0$$

Substituting ϕ_1 for $-\frac{\sigma}{\lambda}$ yields:

$$\phi_2 = \frac{-\lambda - \sigma}{\lambda(\lambda + \sigma)} = \frac{-1(\lambda + \sigma)}{\lambda(\lambda + \sigma)} = \frac{-1}{\lambda} \qquad \text{(A2.16)}$$

Finally, we solve for ϑ_t

$$\phi_3(\lambda - \phi_1\lambda - \rho_t) - 1 = 0 \qquad \text{(A2.17)}$$

Substituting ϕ_1 in (A2.17) yields

$$\phi_3(\lambda + \sigma - \rho_t) - 1 = 0 \qquad \text{(A2.18)}$$

$$\phi_3 = \frac{1}{\lambda + \sigma - \rho_t}$$

These parameters imply the following equation for (A2.7)

$$\Delta s_t = \frac{-\sigma}{\lambda} nid_{t-1} - \frac{1}{\lambda}\zeta_t + \left(\frac{1}{\lambda + \sigma - \rho}\right)\vartheta_t \qquad \text{(A2.19)}$$

We substitute (A2.19) into (A2.1) in order to find the solution for *nids*

$$nid_t = \lambda\left[\frac{-\sigma}{\lambda} nid_{t-1} - \frac{1}{\lambda}\zeta_t + \left(\frac{1}{\lambda + \sigma - \rho}\right)\vartheta_t\right] + \sigma nid_{t-1} + \zeta_t \qquad \text{(A2.20)}$$

this yields

$$nid_t = \frac{\lambda}{\lambda + \sigma - \rho} \vartheta_t \tag{A2.21}$$

or rearranging

$$\vartheta_t = \frac{\lambda + \sigma - \rho}{\lambda} nid_t \tag{A2.22}$$

Because ϑ_t is correlated with *nids*, we first plug (A2.3) into (A2.19) to obtain

$$\Delta s_t = \frac{-\sigma}{\lambda} nid_{t-1} - \frac{1}{\lambda} \zeta_t + \left(\frac{1}{\lambda + \sigma - \rho} \right) (\rho \vartheta_{t-1} + \upsilon_t) \tag{A2.23}$$

Now we lag expression (A2.22) in one period $\left(\vartheta_{t-1} = \frac{\lambda + \sigma - \rho}{\lambda} nid_{t-1} \right)$, and substitute it into (A2.23) gives

$$\Delta s_t = \frac{-\sigma}{\lambda} nid_{t-1} - \frac{1}{\lambda} \zeta_t + \left(\frac{1}{\lambda + \sigma - \rho} \right) \left[\rho \left(\frac{\lambda + \sigma - \rho}{\lambda} \right) nid_{t-1} + \upsilon_t \right] \tag{A2.24}$$

This can be simplified to

$$\Delta s_t = nid_{t-1}\left(\frac{\rho-\sigma}{\lambda}\right)-\frac{1}{\lambda}\zeta_t+\left(\frac{1}{\lambda+\sigma-\rho}\right)\upsilon_t \qquad \text{(A2.25)}$$

Equation (A2.25) expresses the solution for the system. The terms ζ_t, υ_t, representing the composite disturbance, are uncorrelated with *nids* and are white noise.

Chapter 5. Is it Risk? The Role of Fundamentals on Excess Returns

5.1. Introduction

So far, the thesis has shown that *ex post* deviations from RIPH or, in other words, *rids*, revert to a positive equilibrium in emerging economies. Because *rids* follow an autoregressive process, its equilibrium depends not only on the constant term but also on the parameter of the first lag or, alternatively, the equilibrium is the general solution to the difference equation. Hence, the understanding of the dynamics of *rids* can help to unveil their fundamental causes. The dynamics of *rids*, in turn, depend on deviations from individual parity conditions. Chapter 3 pointed out to *nids*, deviations from UIP and real shocks as the most likely causes of deviations from RIPH in opposition to deviations from relative PPP, inflation differentials and nominal shocks. Chapter 4 showed that monetary authorities play a role in the determination of the equilibrium *nid*. *Nids* were explained without abandoning either *ex ante* UIP or rational expectations. Afterwards, the model was amended and *ex ante* deviations were considered to be an autoregressive process, an assumption later supported by unit root tests on excess returns.

As shown, the majority of the empirical literature has found a robust negative relationship between *nids* and exchange rate changes. Estimates suggest that deviations from UIP are the rule rather than the exception. Apart from monetary policy are there any other factors that can explain excess returns (or *ex post* deviations from UIP)? As the final objective of the thesis is to understand the reasons of *rids*, we need to investigate their primary determinants in more detail. This final chapter will also allow us to draw policy suggestions.

A remark made by Engel (1996) strongly influenced our work. He asked whether the usual interpretation and (often) assumption that the forward premium is risk can be regarded as true. If the forward premium is risk, he argues, then it should vary according to the factors that are supposed to influence this variable, such as economic fundamentals. In other words, the forward premium would correspond to a risk premium if the variable is "found to be determined by the economic variables to which theory says it should be related." [Engel (1996), p. 130]. This chapter aims at verifying empirically whether excess returns can be interpreted as a compensation for agents to bear risk premium plus a forecast error of exchange rate depreciation by examining if excess returns can be explained by economic fundamentals.

While the nature of the relationship between exchange rate and fundamentals is subject to debate and research, it is widely recognised that the two variables are correlated[56]. Expected changes in fundamentals should be reflected on the expected depreciation of the exchange rate which would, in turn, be embedded in differentials. If rational expectations are assumed, unexpected changes in fundamentals would correspond to a random forecast error of exchange rate depreciation. Excess returns that are different from the forecast error would, thus, arise from other factors. The most common explanation is a compensation for agents to bear the probability of an unexpected change in the value of the currency or in the country default risk.

[56] See Abhyankar et al (2005) for a fresh look at the relationship between exchange rates and monetary fundamentals.

Our investigation is important because most authors frequently interpret *ex ante* deviations from UIP as a risk premium but there is no conclusive evidence that excess returns correspond to risk (in addition to a random forecast error) [see Marston (1998), for instance]. Also, other works claim that expectations might be irrational or advocate the presence of bubbles, Peso problems, transaction costs etc. We provide evidence that can help to elucidate the controversy. There are important implications from our work. If excess returns are indeed explained by the fundamentals, then can our results be concealed with models of risk-fundamentals? In other words, can the size and the sign of the parameters be reasonably explained by macroeconomic theory? The results could also allow us to propose policies that are able to change the *nid* and, possibly, the *rid*.

To our surprise and to the extent of our knowledge, there is no economic research aimed at the question: can excess returns be explained by economic fundamentals? There is an extensive literature that verifies whether the forward exchange rate premium corresponds to risk from the perspective of consumption-based models of risk [Hodrick (1987), Lewis (1994), and Engel (1996), for example, present surveys on the subject]. However, there is a class of models suggesting that risk depends on other fundamentals, for example, studies that examine the determinants of debt crises in the 1980s and currency crises in the 1990s: Krugman (1979), Sachs (1985), Obstfeld (1995), Milesi-Ferretti and Razin (1998), Corsetti et al. (1999), Kaminsky and Reinhart (2000) and IMF (2001). We draw insights from the literature above and from papers like Bernhardsen (2000) and Knot and de Haan (1995) which tested the relationship between *nids* and fundamentals. Nevertheless, there is not a theoretical or empirical literature concerned with the question that we propose. In the following section, we survey the literature that attempts to answer a similar question, the determinants of dollar-denominated bond spreads, which do not contain the currency risk and can also be understood as excess returns. It is especially focused on emerging economies and provides a further guidance to our tests [Edwards (1985), Edwards (1998), Cantor and Packer (1996), Eichengreen and Mody (1998), Kamin and Kleist (1999), Min (1998), Akora and Cerisola (2001), Beck (2001), Nogués and Grandes (2001), Fiess (2003), Ferruci (2003), Uribe and Yue (2003), Jahjah and Yue (2004), Tillmann (2004) and Ferrucci (2003)]. Our work complements this literature is two ways. First, we investigate whether excess returns (given by returns on uncovered bond spreads, instead of dollar-denominated bond spreads) can be explained by economic fundamentals. Second, we apply the most recent methodology of automated model selection for a sample of not only emerging, but also developed economies.

We run regressions of excess returns against a set of economic fundamentals using an automated model selection criteria as embodied in the algorithm of the econometric software PCGets. We explain the methodology in the next section [see Krolzig and Hendry (2001) for a detailed description of the procedure], but this tool seems to be the most relevant for our purposes because theory and empirical evidence provide some idea of the form of the general unrestricted model (GUM) of the risk premia, but the true data generating process of the excess returns is unknown. The lack of empirical papers on our specific subject provides a reason for the use of an algorithm that mechanises and standardises a series of search processes. Monte Carlo experiments show that PcGets recovers the data generation process (DGP) with an accuracy close to what one would expect if the specification was know a priori [Krolzig and Hendry (2001), Hendry and Krolzig (2003)]. This will be true provided that the GUM contains all the variables that matter in the

DGP. The methodology employed outperforms a simple general-to-specific approach as it pays special attention not only to the significance of the parameters but also to diagnostic tests, in order to ensure that the model selected has a high explanatory power and the residuals are white-noise.

The rest of the chapter is organised as follows. We survey the literature analysing the determinants of dollar denominated bond spreads. Then, we present the methodology for the tests, including an explanation about the automated process that is adopted. Following, we discuss the data and the results. The final section concludes.

5.2. The Related Literature

As stated, risk[57] is generally used as an explanation for excess returns. The reason could be related to the strong assumption of perfect asset substitutability that underlies UIP. The assumption seems to be too strong because, as country fundamentals differ, probabilities of default are also expected to vary. On the other hand, it is difficult to abandon the hypothesis of rational expectations[58]. Transaction costs are likely to change only infrequently and, thus, would be unable to explain time-varying excess return.

[57] Default, currency and liquidity are the general types of risk often mentioned in the literature. Ferruci (2003), for example, defined default (credit) risk as the possibility that the debtor will not fulfil its obligation on time in full. This type of risk depends on the fundamental characteristics of the issuer and on the ability of the lender to enforce contract. Currency risk arises when there is a likelihood that exchange rates may depreciate by more than expected. Liquidity risk is the risk that investors will not be able to liquidate their portfolios without depressing secondary market prices.

[58] Engel (1996), for example, is sceptical about the possibility that expectations are not rational. Wang and Jones (2002) wrote that the possibility of irrational expectations is unacceptable for most academics. Fama's (1984) well-known results are conditional on the assumption of rational expectations, for instance.

Portfolio models relax the assumption of perfect asset substitutability. The result is that an interest rate differential can exist indefinitely because the supply of assets is not perfectly elastic. Hence, there is no automatic mechanism that forces i_t to equalise with $i_t^* + \Delta s_{t+1}^e$. In portfolio models, the size of the risk premium normally depends on the variance of the exchange rate, the attitude to risk bearing and the size of the net forward spending. This result is derived from the mean-variance approach to risk and has been used to model risk in several different versions of portfolio balance models[59].

Models of intertemporal maximisation under uncertainty [see Obstfeld and Rogoff (1995), chapter 5, for example] provide the microeconomic fundaments for the allocation of resources under risk aversion. Investors choose their portfolios in a way that the expected real returns in every asset, discounted by the intertemporal marginal rate of substitution, are equal in equilibrium. The concavity of the utility function can be a measure of risk aversion. It depends on the elasticity of substitution between goods, which can take the CARA (constant absolute risk aversion) or the CRRA (constant relative risk aversion) form. The literature that models risk from this perspective usually estimates these elasticities or verifies whether the data is compatible with such models [see, for example, Cumby (1987), Froot and Frankel (1989), or Hodrick (1987) for a survey]. Engel (1996) concluded that the estimated elasticity is too high, i.e. investors are incredibly risk averse, and estimations are plagued with problems. Fama (1984) concluded that while the risk premium may be small relative to forecast errors, its variance is as large as the

[59] Markowitz (1952) is considered to be the seminal of modern portfolio theory and linear relationship between risk and return, the basis of the capital asset pricing model [see chapter 2, Berndt (1996)].

variance of expected exchange rate changes. His results remain robust to the present time.

We do not presume that excess returns are risk. Our macroeconomic approach and the nature of the problem that we investigate are substantially different from the one used in literature above. Our question is closely associated with the literature that relates dollar-denominated bond spreads and fundamentals. The main difference is that sovereign bonds are supposed to predominantly carry default risk, while excess returns also contain the currency risk and forecast errors of exchange rate depreciation. Theoretical and empirical models that relate the probability of default (risk) with fundamentals were largely developed after the debt crisis of the 1980s and the financial crises during the 1990s. The literature is extensive and, for this reason, we focus especially on the studies that relate sovereign bond spreads and macroeconomic factors.

5.2.1. Fundamentals and Bond Spreads

We start the review with a summary of Bernhardsen's (2000) study. He studied the relationship between long-term maturity bonds, interest rate differentials and macroeconomic fundamentals for nine European countries relative to Germany over the period from 1979 to 1995. Bernhardsen (2000, p. 290) noted that in the case of UIP with perfect capital mobility: "the interest rate differential can be influenced only through the expected rate of depreciation" and deduced that "to reduce the domestic interest rate the government must change macroeconomic policy to reduce depreciation expectations". So, fundamentals are supposed to influence the interest rate differential via the expectation of depreciation. The dependent variable in his regressions is the average nominal interest rate differential at 12 months maturity relative to Germany. The explanatory variables, in addition to a constant term and lags of the dependent variable, are the rate of unemployment, real income growth differential, relative labour costs, inflation differential, current account and public deficit. All variables are on a yearly basis. Using panel data techniques, Bernhardsen (2000) found that fundamentals were significant at the 5% confidence level, except unemployment and public deficit.

Empirical papers testing UIP with macroeconomic variables also include Knot and de Haan (1995) who noticed that in the case of Austria, the Netherlands and Belgium: "Despite almost fixed exchange rates, small but persistent interest rate differentials vis-à-vis Germany have existed in these countries during the last decade" (p.364). They remarked that: "For the Netherlands this positive interest differential has emerged notwithstanding the fact that the average Dutch inflation has been less than German inflation during the period under consideration." (p.364). Knot and de Haan (1995) also suspected that a continuous expected depreciation and risk premium arising from differences in economic fundamentals explained the differential. Knot and de Haan (1995) have initially estimated an expected rate of appreciation within the band (tests span from 1980M1 to 1991M12) using the insight that it has a mean reverting behaviour inside the band. They found that for Austria and The Netherlands, expectations concerning exchange rate movement inside the band explained interest rate differentials. The results for Belgium were not clear since the country followed a dual exchange rate system. They also tested if fundamentals "Granger-caused" interest rate differentials using quarterly data on inflation, government deficit and current account, all measured as ratios of GDP.

Fundamentals tend to be significant in explaining differentials for exchange rate movements within the band but the evidence is not regarded to be too strong.

Investigating the difference between the international bond and loans markets, Edwards (1985) tested the proposition that the default risk premium, given by the spread between the domestic and the US bond, is a positive function of the level of the debt and a negative function of the level of investment. The specification of his tests draws from Edwards (1984). The latter paper presents a model in which the spread is log-linearly related to its fundamental determinants. Edwards (1985) models sovereign bond spreads assuming the spread over the risk-free interest rare as a function of the probability of default and of the loss given default. The linear specification allows to test whether the probability of default also depends on a set of fundamentals. The expected sign of the parameters in his specification would reflect the theoretical upward-sloped shape of the supply curve for funds (supply of funds on the horizontal axis and the costs on the vertical one). He estimated pooled regressions on spreads for 26 countries during 1976-1980 using both OLS and instrumental variables. The dependent variable was the dollar-denominated spread and the independent variables were the ratio of international reserves to GNP, investment to GNP ratio, ratio of the current account to GNP, the debt output ratio, an index of trade weighed real effective exchange rate and the maturity of the debt. Edwards (1985) found that the debt output ratio, the investment GNP ratio and maturity were significant. The sign of these parameters were as expected. The linear specification employed by Edwards (1985) and Edwards (1984) is used to motivate many of the work on bond spreads and fundamentals.

Another research that is also often cited in this literature is Cantor and Packer (1996). They provide "a systematic analysis of the determinants and impact of the sovereign credit ratings assigned by the two leading risk evaluation agencies, Moody's Investors Service and Standard and Poor's" (p. 37). The ratings are assessments of the probability that a borrower will default on its obligations [Cantor and Packer (1996), p. 38]. According to them, the two agencies state their rating criteria based on numerous economic, social and political factors. However, the relationship between the criteria and the rating itself is not clear, as some of the criteria are not quantifiable and they do not provide clear indication on the weight given to each factor. Cantor and Packer (1996) run a regression of the rating levels, for which they assigned quantifiable measures, on eight explanatory variables "that are repeatedly cited in rating agency reports as determinants of sovereign rates." (p. 39): per capita income, GDP growth, inflation, fiscal balance (public deficit), external balance (current account deficit), economic development (threshold effect related to a certain level of income or development and default history). They found that *per capita* income, GDP growth, inflation, external debt, and some indicator variables for economic development and default history are statistically significant, have the anticipated signs and the explanatory power of the model is very high. On the other hand, the coefficient on the fiscal and external balance are insignificant and of the unexpected sign. They attribute the lack of significance to a possible endogeneity between fiscal policy and capital flows "countries trying to improve their credit standings may opt for conservative fiscal policies, and the supply of international capital may be restricted for some low-rated countries." [Cantor and Packer (1996), p. 41]. Their results suggest that Moody's Investors Service and Standard and Poor's share the same criteria with different weights. They show that sovereign yields (spreads on dollar denominated bonds) tend to rise as ratings decline. However, a regression of the spreads against the same set of variables explains less of the sample variability than the regression of the ratings on the fundamentals. They conclude that "ratings effectively summarise the information contained in macroeconomic indicators" [Cantor and Packer (1996), p. 8]. Finally, they also found that the impact of ratings announcements on dollar bond spreads is highly significant and that it also depends on the agency that makes the announcement.

Another influential research was carried out by Eichengreen and Mody (1998). They have studied the pricing and issuing of emerging market bonds. Their data comprises around 1000 initial launches between 1991M1 and 1996M12, and a great part is formed by Brady bonds. According to Eichengreen and Mody (1998) launch spreads and secondary market spreads move differently along time. They have used macroeconomic variables in order to analyse the issue decision and the spread: ratio of total external debt to GNP, the ratio of debt service to exports, a dummy variable for debt restructuring agreement, the ratio of international reserves to GNP, the growth rate of real GDP, and the budget deficit to GDP ratio. They have also controlled for the maturity of the bond, principal amount, whether it was private or public, the region of the borrower, the type of borrower (sovereign, public or private) and the rating. The risk-free rate is the ten-year US Treasury bonds. Eichengreen and Mody (1998) perform a regression of the change in spreads against the change in fundamentals and found that the latter is important to explain spreads. They have interpreted different coefficients for different periods as a change in the market sentiment.

The study of Kamin and Kleist (1999) goes along the lines of Eichengreen and Mody (1998). Their starting point is that "emerging market spreads in the years preceding the Asian financial crisis declined by more than can be explained by improvements in risk factors alone." [Kamin and Kleist (1999), p. 3]. The results for tests during the 1990s show that spreads have a strong relationship with credit rating, maturity and currency denomination. Bond spreads were systematically higher than spreads on loans. They have found indication of "flight to quality" i.e., the tendency of agents to choose safer bonds during periods of financial distress. The supporting evidence, for example, would be the continuous fall of spreads after the Tequila crisis. However, they have not identified a strong positive link between interest rates of US, Japan and Germany and emerging market spreads and also do not examine the role of other fundamentals.

Min (1998) investigates the determinants of bond spreads in Latin American and Asian countries. The tests are motivated by Edwards (1985), Sachs (1985) and Haque et al. (1996). Sachs (1985) investigates the role of policies and economic fundamentals during the debt crisis and provides the empirical rationale for using certain fundamentals in the determination of risk-premium. Haque et al. (1996) examined the economic determinants of developing country creditworthiness and found that fundamentals - foreign exchange rates to reserves, current account to GDP ratio, growth and inflation - can explain variation in credit ratings. Min (1998) distinguished four categories for the explanatory variables: liquidity and solvency, macroeconomic fundamentals, external shocks and dummy variables. Liquidity and solvency were represented by the debt to output ratio (with an expected positive sign), imports over reserves (negative sign) and the current account balance to GDP (with a positive coefficient). Macroeconomic fundamentals are supposed to impact long-run solvency. The fundamentals chosen are the inflation rate, viewed as a proxy for the quality of economic management, changes in the terms of trade, which would reflect the effects of shocks on trade flows, and the real exchange rate which is included as a measure of the competitiveness of a country. External shocks are thought to be reflected on changes in interest rates and, finally, oil prices and dummies were used to capture financial contagion. Min (1998) finds that coefficients have the expected sign and variables are generally significant for the determination of the spread: debt to GDP ratio, international reserves to GDP ratio, debt service ratio, export and import growth rates, domestic inflation, net foreign asset position (cumulative current account deficits) and terms of trade.

Akora and Cerisola (2001) empirically investigate the relationship between spreads of (secondary) sovereign bonds and the US monetary policy by including the federal funds rate as an explanatory variable. The Treasury bill rate, normally used as proxy for the monetary instance, and the federal funds rate tend to fluctuate together. However, there are some episodes, such as the "flight to quality" during the Asian crisis, in which the Treasury bill shows independent volatility. They estimated a model for a group of emerging economies for the period from 1994 to 1999. Akora and Cerisola (2001) use fiscal balance, net foreign asset position of the banking system, central government external debt, total external debt (all expressed as a percentage of GDP), together with the debt service ratio and the ratio of gross international reserves to imports as macroeconomic explanatory variables. An ARCH model was estimated in order to capture market volatility. The results show that higher net foreign assets, lower fiscal deficits and lower ratios of debt service to exports and debt to GDP are associated with decreases in spreads. In summary, they found that the level of US interest rates has a positive impact on bond spreads, as well as country specific fundamentals.

Nogués and Grandes (2001) examine the determinants of sovereign dollar-denominated bonds spreads between Argentina and the US. Using the linear specification of Edwards (1985), they verify if fundamentals (given by indicators of solvency/liquidity, political uncertainty and contagion) impacted the spreads. As a measure of contagion, they have used J.P. Morgan's price index of Mexican bonds and other non-Latin American countries, in addition to a dummy for the Tequila crises. Dummies were also introduced to capture exogenous political events. Nogués and Grandes (2001) found that risk responded to the ratio of external debt service to exports, the fiscal deficit of the federal Government, GDP growth, the 30-year US treasury bond, contagion effects and political noise.

According to Beck (2001, p. 8), real GDP growth "increases the country's tax revenues and thus raises its ability to pay back sovereign debt". Inflation can proxy for the quality of economic management and is thus supposed to increase risk. Interestingly, Beck (2001) argues that the impact of a current account deficit on risk depends on the type of external financing: "If an expected current account deficit can reasonably be expected to be financed mostly by FDI, a large deficit does not have to be a concern for a bond investor" (p. 9). He uses a panel of nine emerging market Eurobond spreads from 1998M12 to 2000M8 and monthly market forecasts of some macroeconomic variables: real GDP growth, inflation and the current account deficit in addition to control variables (such as international interest rates and market variables). The general finding, using both fixed and random effects, is that macroeconomic factors and international interest rates can explain spreads. The coefficient of the current account deficit's forecast is found to be negative, i.e. a deficit decreases spreads. Beck (2001) finds that the variance of spreads does not increase spread and that there is a correlation between the country and the market spread.

Fiess (2003) separates the common from the country specific components of emerging countries' bond spreads (including Argentina, Brazil and Mexico) in the 1990s. He argues that the probability of default of a sovereign bond is related to short-term liquidity and long-term solvency risks: "The determinants of default or country risk are usually approximated by economic variables related to solvency and liquidity, macroeconomic fundamentals and external shocks." (p. 3). Fiess (2003) argues that the evidence of correlation in bond spreads reflects spillovers from developments in one country to another. Fiess (2003) builds the idiosyncratic portion of the spread as being the residual of a regression of the spread on the first principal component "while the first principal component itself (systemic component of the spread) is driven by global factors and/or contagion" (p. 4). Fiess (2003) simultaneously tests for cointegration between gross capital inflows, country risk, global risk, the US long-term interest rate, the ratio of total public debt to GDP and the primary balance to GDP ratio using monthly EMBI spreads from January 1991 to February 2002. Fiess (2003) further concludes that variables related to fiscal sustainability, primary balance to GDP ratio and the ratio of public debt to GDP are determinants of the country risk.

Ferruci (2003) also studied the determinants of bond spreads using data from EMBI and EMBI Global. His objective was to explain the long-run determinants and to model short-run dynamics controlling for external factors, liquidity and market risk. The importance of the study, for example, is that the Bank of England uses the spreads of emerging market bonds as a measure of market's risk perception (p. 9). His model relates credit risk to a set of common country-specific and external shocks. Ferruci (2003) emphasises important data limitations in his study. He employed panel data techniques and used monthly observations which, in turn, were created via linear interpolation from quarterly and yearly data in order to overcome the problem of the small sample size. Ferruci (2003) recognises the costs of imposing a linear model, but he is also concerned with possible bias stemming from omitted variables, with the fact that some stock variables presumably do not change suddenly over time, and that there is a loss of degrees of freedom using a low frequency data. The variables are external debt, budget, trade balance, current account and reserves (expressed as ratios of the GDP) openness as measured by the ratio between the sum of exports and imports divided by the GDP, inflation, interest payments divided by external debt, amortisation divided by reserves, arrears divided by external debt and, finally, changes in the real exchange rate. In order to control for changes in liquidity and market premia he used yield spreads between low and high-rating US corporate bonds. He found that fundamentals are significant to explain risk in most of his estimated specifications, which also includes Argentina, Brazil and Mexico.

Uribe and Yue (2003) analysed the relationship between sovereign spreads, the world interest rate and business cycles in emerging countries. They estimate a VAR which includes some measures of the world interest rate, the country interest rate and a number of domestic macroeconomic variables. The assumption for identification is that real variables are affected by innovations after one quarter. They use a panel of seven emerging countries from 1994 to 2001 at a quarterly frequency. The main finding is that the US and domestic interest shocks explain about a third of the business cycle movements; US interest shocks affect domestic variables via their effects on country spreads which, in turn, respond to business conditions and vice-versa. US interest rates impact business cycles because sovereign spreads respond systematically to changes in this variable. They do not use the real exchange rate as a fundamental but include additional variables (output, investment and trade balance) in order to verify the robustness of the estimates. Uribe and Yue (2003) concluded that business cycles in emerging markets are correlated with the cost of borrowing (the correlation between the EMBI+ and the output gap is found to be negative). Finally, they claim that more research is needed on the theoretical side, in order to provide microfoundations for the models, possibly using the literature on sovereign debt as the starting point.

Jahjah and Yue (2004) examined the link between bond spreads and exchange rate policy using data on 51 counties. They claim that their "study is the first empirical work that explicitly investigates exchange rate policy in the study of bond spreads" as they "incorporate exchange rate regime classifications and measures of exchange rate misalignment in the determinants of bond spreads" (p. 4). Spreads on the primary market (reflecting the costs of borrowing) were calculated as the difference between the yield on the domestic and the US-Treasury bond with "comparable" maturity, over the period 1990-2001. Misalignment is the difference between the log of the actual exchange rate and its trend. The trend is computed using a Hodrick-Prescott filter on the real exchange rate. The real interest rate on ten-year US treasury bonds is used as a proxy for the global economic condition. Jahjah and Yue (2004) also employed domestic economic indicators, such as the ratio of debt to GDP, ratio of debt services to exports, GDP growth rate, inflation and the short-term debt to total debt ratio. They assume, as in Edwards (1984), a log-linear relationship between sovereign bond spreads and fundamentals. Jahjah and Yue (2004) used a probit model in order to verify the determinants of bond issue. One finding is that an overvaluation tends to raise spreads. The sign of other coefficients are as expected. Misalignment seems to depend on the exchange rate regime, but it generally increases the cost of borrowing. They also conclude that a country tends to borrow more when it experiences an overvaluation

Tillmann (2004) investigates the relationship between sovereign bond spreads and global variables using a non-linear approach. The model assumes a crisis and a tranquil regime, linear within the regime and non-linear across regimes. Tillmann (2004) estimates are carried out using a Markov switching VAR. The three endogenous variables are the 3-month Treasury bill, the EMBI+ and the spread between a Brady bond and the yield on the 10-year Treasury Bill. The observed positive reaction of the spread to changes in the US interest rates is lost under the period of the financial crisis. The explanation is that investors substitute the emerging bond for a more secure US bond, resulting in higher spreads, in spite of the lower US rates. During the crisis period, the co-movement between emerging markets is stronger, as country shocks hit each other with more strength. This could be evidence of contagion or the revelation of information about future prospects.

In summary, the literature finds a significant relationship between macroeconomic variables and country spreads. The sign of the coefficients tend to be as expected but there are exceptions. Explanatory variables in the GUM differ between studies but there seems to be a consensus that the general model should include solvency and liquidity indicators as well as measures for the real economy, shocks and contagion. We do not present a survey but studies on currency crises [Krugman (1979), Obstfeld (1995), Corsetti et al. (1999), Milesi-Ferretti and Razin (1998)] reached similar conclusions about the role of fundamentals on the exchange rate or the default risk [see also "Early Warning Signals" in IMF (2002), Kaminsky and Reinhart (2000) and IMF (2001)].

5.3 Methodology

Below, we rewrite excess returns from equation (4.8)

$$\xi_t = i_t - i_t^* - \Delta s_{t+1} \tag{5.1}$$

The notations are as in previous Chapters: the parameter ξ_t represents excess returns, i_t is the domestic interest rate and i_t^* is the exogenously determined foreign interest rate that matures at time $t+1$. The exchange rate is the domestic price of the foreign currency and the logarithmic rate of growth (depreciation) is $\Delta s_{t+1} = s_{t+1} - s_t$. The first difference operator is represented by Δ. Logarithms are represented by lower case variables with the exception of interest rates. Equation (5.2) represents the assumption of rational expectations

$$\Delta s_{t+1}^e = \Delta s_{t+1} + \varepsilon_{t+1} \tag{5.2}$$

where ε_{t+1} is a disturbance term that exhibits the classical properties, i.e. ε_{t+1} is iid $N(0,\sigma_\varepsilon^2)$, σ_ε^2 represents variance and with the superscript e denotes expected values. Rearranging equation (5.2) and substituting into (5.1) gives

$$\xi_t = i_t - i_t^* - \Delta s_{t+1}^e + \varepsilon_{t+1} \qquad (5.3)$$

If the hypothesis of *ex ante* UIP under rational expectations holds, then $i_t - i_t^* = \Delta s_{t+1}^e$ and $\xi_t = \varepsilon_{t+1}$. However, a great number of authors found that ξ_t follows an autoregressive process. Excess returns, ξ_t, could stem from any violation of the assumptions that are underlying both UIP and rational expectations. Hence, not only perfect capital mobility, but the presence of transaction costs, imperfect information, other simultaneous relationships between exchange rates and interest rates, Peso problems, bubbles etc. However, many authors have interpreted, ξ_t as being a risk premium.

Recall that covered interest parity

$$i_t - i_t^* = f_t - s_t \qquad (5.4)$$

substituted into (5.1) gives

$$\xi_t = f_t - s_t - \Delta s_{t+1} \qquad (5.5)$$

This result means that excess returns are equivalent to the forward rate unbiasedness hypothesis if the former follows a white noise process

$$\xi_t = f_t - s_{t+1} \qquad (5.6)$$

One can hypothesize that ξ_t corresponds to the sum of a risk premium and a rational expectations forecast error (of exchange rate depreciation), then $\xi_t = rp_t + \varepsilon_{t+1}$, where rp_t is the overall risk premium, comprising both the currency and the default risk. Engel (1996), for instance, has stated that if the forward premium is a rational expectations risk premium, then it should respond to the variables that are theoretically supposed to affect it. This idea is similar to the one underlying the literature on the causes of dollar-denominated bond spreads, which correspond to excess returns free of default risk. Following Edwards (1984) and Edwards (1985), we relate ξ_t to a set of n economic fundamentals:

$$\xi_t = \sum_{i=1}^{p} \alpha_i \xi_{t-i} + \sum_{j=1}^{n} \sum_{i=1}^{p_j} \beta_{ji} F_{t-i}^{(j)} + \mu_t \qquad (5.7)$$

where $F^{(j)}$ is the j^{th} fundamental, α_i and β_{ji} are parameters. The GUM was formulated using the relationship between excess returns and fundamentals represented in (5.7) assuming that excess returns can be captured by the autoregressive distributed lag model. We use excess returns instead of the forward premium to be consistent with the previous chapters. This additionally constitutes as a contribution to the literature since most tests are performed using the forward premium.

As explained in the next section, we first perform the tests with the algorithm calibrated for all misspecification the tests. We further exclude the test of conditional heteroscedasticty. The problem with the estimation of (5.7) is to find the combination of fundamentals and lagged variables, in which the parameters are significant, the error term is white noise, and both the explanatory power and the degrees of freedom are reasonable. Support for the idea that excess returns correspond to a rational expectations risk would be found if the algorithm selects a model that passes all diagnostic tests (residuals are white-noise), if fundamentals are chosen and significant and the results are consistent with economic theory.

5.2.1. Automated Selection - PcGets

As mentioned earlier, we use the automated selection procedure embedded in the algorithm of the econometric package PcGets. PcGets is a general-to-specific modelling approach based on the theory of reduction [for a summary discussion of this theory see Hendry and Krolzig (2003)]. Designed to simplify dynamic and linear model regressions, the software automates the processes put forward by Hoover and Perez (1999). PcGets selects the relevant variables from those that compose a general unrestricted model (GUM), according to pre-specified diagnostic tests and significance levels, and delivers a terminal model that is encompassing.

Krolzig and Hendry (2001) provide a summary explanation of the automated selection algorithm:

"Given an initial general model, many reduction paths could be considered, and different selection strategies adopted for each path. Some of these searches may lead to different terminal specifications, between each a choice must be made. [...]. Should multiple congruent contenders eventuate after reduction round, encompassing can be used to test between them, with only the surviving – usually non-nested – specifications retained. If multiple models still remain after this "*testimation*" process, a new general model is formed from their union, and the simplification process re-applied. Should that union repeat, a final selection is made using information criteria, otherwise a unique congruent and encompassing reduction has been located." (p. 832, emphasis from the authors).

Economic theory helps us to specify the variables in the GUM, to ensure that variables are orthogonalized, to perform appropriate data transformations (for example, we use ratio transformations and also have estimated variables), to calibrate the algorithm and, finally, to interpret the results. The importance of the specification is that the larger the number of regressors, the more likely irrelevant variables will be retained in the terminal selection because the variables that are present in the GUM determine the multiple search paths that deliver the contender models. On the other hand, the smaller the GUM, the higher is the chance that important variables will be omitted.

An application of the algorithm is Krolzig and Hendry (2004)[60]. They explain that the validity of a selected model depends on the adequacy of the GUM as an approximation of the DGP which involves the measurement accuracy of the data, the representation of the underlying causal effects, the completeness of the

[60] The procedure is relatively new and there are few applications. One applied work of PcGets to monetary problems is Sanchez-Fung (2005)

information (variables and observations), the homogeneity of the sample, the weak exogeneity of the regressors or instruments and the constancy of the parameters across the observations. They affirm that "...when the data generation process is a special case of the general model postulated at the outset and a Gets approach is adopted, despite a large number of possible model specifications, finding many variables significant is unlikely to be due to chance" (p. 7). The formulation of the GUM is further emphasised by Hendry and Mizon (2000) who focus on the importance of a congruent representation, which comprises the available knowledge and encompassing previous empirical findings.

An evaluation of alternative approaches for model selection can be found in Hendry and Krolzig (2003). We considered that the method was appropriate because it released us from manually testing a great number of models using a general to specific *t* or *F*-test. We were also able to use a standardised testing procedure for all countries and benefited from the rigour of the "theory of reduction". The procedure considers multiple path searches which are tested until a dominant encompassing reduction is selected[61]. The objective is to find a congruent model which satisfies six criteria: homoscedastic errors, weakly exogenous conditioning variables for the parameters of interest, constant and invariant parameters of interest, theory-consistent and identifiable structures, data-admissible formulations on accurate observations and encompassing rival models. In order words, a congruent model is absent of mis-specification [see PcGets (2005)].

The outcome of the estimation process depends on the choice of the GUM as well as on the calibration of the algorithm for a number of possible tests. The

[61] Dominance happens when a model nests all contending explanations as special cases and encompassing requires a simple model to explain a more general one within which it is nested [Hendry and Krolzig (2003a)].

selection starts with pre-search simplification F-tests, which are suggested at a loose significance level in order to increase the probability of eliminating the most irrelevant variables and also to diminish the costs of search (retaining improper variables). Then simplification tests are performed on the multiple possible paths which are determined by insignificant deletions based on *t*-tests as well as block deletions (*F*-tests). Their corresponding significance levels are supposed to be tighter. The significance levels of the encompassing tests and finally a sub-sample split – to test the constancy of the parameters.

The significance levels and the number of diagnostic tests are very important because they are able to terminate search-paths. The tests were performed using the built in "liberal" strategy[62]. The liberal strategy follows a search procedure for which the algorithm is already calibrated [see PcGets (2005)] and aims to keep the maximum number of variables that matter in the DGP. The performance of the liberal strategy depends on the number of irrelevant variables in the GUM [Hendry and Krolzig (2005)]. We used the option "quick modelling", in which the program automatically selects the lag length and then checks the congruence of the resulting GUM. The pre-programmed selection was set with outlier correction. The size of the marginal outlier is defined according to the area under the normal distribution that gives the probability of a "rare event". In the liberal strategy it is set to be 2.56, which gives a probability of 1%.

[62] We also tested a modified version without mis-specification tests for ARCH effects. The justification is that heterocedasticity would influence efficiency but the OLS estimator would still be linear and unbiased, if the model passed other diagnostic tests. However, the liberal strategy without ARCH effects delivered the same terminal selections as the pre-calibrated liberal strategy, meaning that volatility was not the binding constraint. In any case, few ARCH problems remain in the final models.

5.4. Data

Our selection of fundamentals was influenced by the literature that analyse the relationship between macroeconomic variables and dollar denominated bonds spreads. A plot of the complete series for all countries is presented from Figure 5.1 to Figure 5.10, descriptive statistics are reported in Table 5.1, from Table 5.1.1 to Table 5.1.10, and the data are explained in more detail below.

We have searched for data on the IFS, ESDS (Economic and Social Data Service), OECD, UNCTAD, Central Banks, governmental agencies, international banks (such as the BIS) and, finally other databases on the Internet. Ultimately, we have chosen to use quarterly data according to availability on the IFS. We were not able to construct a sample of monthly observations that includes all of the most important fundamentals using other data sources and for this reason we opted to work with the quarterly data from the IFS. For example, information on the current account deficit, a variable regarded to be crucial for the GUM (as seen in the literature review) was only available on a quarterly basis. The period is slightly different for each country but the sample lies between 1990Q1 and 2004Q2, hence, the number of observations is around 56. The justification for the use of the earlier 1990s is the smaller frequency of the data which gives too few observations if the mid 1990s were used instead. In any case, this immediately follows the period after the financial and trade liberalisation which is the interval focused by the thesis. The exception for the frequency is Brazil, for which we found statistics for all relevant variables on a monthly basis. The data was obtained from http://www.ipeadata.gov.br/, a website maintained by IPEA (the Institute of

Applied Economic Research) from the Ministry of Planning of the Brazilian Government. Because of the measurement problems related to the interest rate before 1995 and to be consistent with previous chapters, we decided to use monthly observations from 1995M3 to 2004M9 (the most recent data available). Following the literature, we divided the variables into categories: a) liquidity and solvency b) macroeconomic factors c) international shocks and d) contagion or dummy variables. For the first category we used the current account deficit to GDP ratio, the public deficit to GDP ratio and the ratio of imports to foreign exchange reserves. For the macroeconomic factors we employed the growth of real GDP and the growth of industrial production, when the data on GDP is not available. Terms of trade and an estimated measure of exchange rate misalignment were used to capture international shocks. Dummies are employed to test for contagion with the exception of Brazil, for which we could use the mean and the variance of dollar-bond spreads.

Ex post Excess returns were calculated by subtracting the (three month) change in the nominal exchange rate from the *nid*[63]. The quarterly value was then obtained by taking the three month average. The calculation of the quarterly exchange rate change is explained in detail in chapter 3[64]. Interest rates are calculated in the same way as in other chapters and France for which we extended the sample from 2002Q4 until 2003Q4 using deposit rates.

Quarterly data on current account deficit was available in the IFS in dollars for all countries. For the calculation of the current account deficit to GDP ratio, we first divided the quarterly GPD, which is available in national currency, by the average

[63] We used the **three** month change in the exchange rate because the *nid* corresponds to the **three** month yield spread between the domestic and the interest rate of the US.

[64] Recall that for the European countries in the monetary union we used Euro rates from 1999.

exchange rate of the quarter. The ratio was then obtained by dividing the current account deficit by the GDP in dollar of the quarter multiplied by 4. The availability of GDP data is limited for Argentina and Chile for which we had to use annual observations until 1994 and 1995, respectively, in order to calculate the ratios. According to the IFS, the data on GDP is seasonally adjusted for all developed economies, but not for emerging countries. A positive value implies an increase in the current account deficit to GDP ratio, hence, one would expect risk to rise with increases in the variable.

Another variable that is related to liquidity and solvency characteristics of an economy is the ratio of imports to foreign exchange reserves. This variable is important for those countries with current account problems and limited access to capital markets. Quarterly observations on foreign exchange reserves and imports were available in dollars for all countries. An increase in the ratio is expected to enlarge risk as more foreign currency is needed to pay for imports.

The ratio of export to import prices was used as a measure of terms of trade. The rationale is that if export prices increase relative to import prices, then there is more revenue accruing from international trade and one would expect a decrease in both the country and currency risk. However, if export prices increase the economy is less competitive and, hence, exports will be harder to sell. The final effect depends upon the export and import elasticity of demand. Quarterly observations were obtained by averaging monthly values. Data on export and import prices were not available for Chile and Mexico while for Argentina the time span is too short. Data for Italy is also limited, finishing in 2003Q2[65].

[65] There are two interpolated observations for Argentina and one for Spain (because of missing data).

We performed an OLS estimation of the exchange rate changes on inflation differentials. The objective was to construct a measure of exchange rate misalignment:

$$\Delta s_t = \alpha + \beta_0 \Delta p_t + \beta_1 \Delta p_t^* + l_t \tag{5.8}$$

where α represents the constant term, Δp_t and Δp_t^*, represent inflation, which was calculated as the quarterly percentage change in the consumer price index, β_0 and β_1 are the corresponding parameters and the residual, l_t, is the estimated measure of misalignment. Notice that equation (5.8) corresponds to an estimation of relative PPP and, therefore, the variable l_t, or misalignment, is equal to the estimated deviations from relative PPP. A positive residual means that the exchange rate should have depreciated by less than what it actually did. Hence, a high positive value means that the exchange rate is highly depreciated which improves the competitiveness of a country but it also raises concerns about inflation. However, we used the residuals of (5.8) in absolute values, hence a rise in l_t increases misalignment. The sign of the coefficient depends on the perceived impact of the increase on competitiveness and inflation, which is an empirical question.

We used the public deficit to GDP ratio as an indicative measure of the health of the public accounts. The data is available in national currency and on a monthly basis, with the exception of Chile and Turkey. Quarterly values were obtained by averaging monthly observations[66]. Because there was no availability of statistics on public deficit for the UK in the IFS, we used OCDE data on the "Public Sector Net Cash Requirement" which was obtained from the ESDS. A positive value corresponds to a deficit on the public accounts, therefore an increase in the ratio should increase risk.

The growth rate of real GDP provides a measure of the real economy and it was calculated using the GDP volume of the quarter. Data is available for all countries with the exception of Argentina, for which the sample period starts in 1993Q2. We employed the percentage change in the index of manufacturing production for this country (seasonally adjusted). If systematic increases in real GDP are perceived by agents as rises in potential output and in the ability of the economy to generate income and to pay for its bonds at the maturity time, the sign of the parameter would be negative.

On the monetary side, we used the growth of aggregates such as M1, M2, M3 and M4 which were selected according to availability. When more than one monetary aggregate is available, we decided to test using either M1 or M4 in the GUM on the belief that they represent a more accurate measure of monetary stance. When monetary aggregates are not available we use the quarterly rate of inflation, which is supposed to indicate the degree of credibility and the quality of the monetary policy implemented by the Central Bank. The expected sign of the parameter is supposed to be positive. Jahjah and Yue (1994), for instance, claim that inflation indicates a higher probability of a Balance-of-payments crisis and thus a larger probability of default. Other authors such as Cantor and Parker (1996) suggest that a high inflation points out to structural problems in government

[66] We interpolated 4 observations in Argentina in 1995.

finances, and public dissatisfaction with price increases may raise political instability.

We used dummies for the quarterly series in order to capture contagion. The dummies are: 1995Q1 for the Tequila (Mexican) crisis, 1997Q4 for the Asian crisis, 1998Q3 for the Russian, 1999Q2 for the Brazilian and, finally, 2001Q1 for the Argentinean. The dummies are chosen to be one-period ahead of the known start date of the crisis in order to avoid using leads instead of lags into the estimation, as the algorithm searches for lags in the dummies. We could not use dollar-denominated bond spreads (EMBI+) as a measure of contagion because of the shorter availability of the data. Our option also finds correspondence on a series of works that also used dummies in order to account for financial contagion [see, for instance, Min (1998), Nogués and Grandes (2001), Baig and Goldfajn (2000) and Fontaine (2005)]

As explained before, Brazil is the unique exception for the choice of data. We did not have to build statistics on the current account deficit to GDP ratio as the series could be found at IPEA. For the public deficit to GDP ratio we used the first difference of the total public debt to GDP ratio, which is also available at IPEA's website. We used information on current account deficit and GDP in order to build a small part of the series (from 1995M3 to 1995M12) as this period was not available. The ratio of imports to foreign exchange reserves was constructed using data from the IFS as well as the terms of trade and the growth of industrial production. Notice in Figure 5.2 that the ratio import/reserves is calculated as the monthly imports divided by the total reserves, which explains the relatively lower value for Brazil as compared to other countries. Because the series of EMBI+

(Emerging Markets Bond Index Plus) is available after 1992, we were also able to use this data for the tests of Brazil. Daily statistics from 1995M3 to 2004M9 were provided by JPMorgan on the EMBI+ of Argentina, Brazil, Mexico and Asia. We divided the EMBI+ by 1000 in order to obtain a percentage measure comparable to Excess returns, and then calculated the monthly average. We also constructed a series of the volatility of the spread, by taking the monthly variance of the EMBI+ using daily data. The plot of these series can also be seen in Figure 5.2. Data on the EMBI+ variance of Argentina, Mexico and Asia were used to capture contagion[67] from the financial crises. We have also used the level of the EMBI+ as a measure for contagion, however, this approach is more problematic. There is a correlation between excess returns and the spreads because of the presence of the foreign interest rate in both sides of the equation. In addition, as there could be a UIP relationship between interest rates of the emerging countries of our sample, we would not be able to distinguish whether we are testing the degree of capital mobility and financial integration or financial contagion.

Other variables, such as the level of public debt and foreign debt did not make part of the GUM because their first difference is supposed to be equal to the public deficit and the current account deficit, respectively. The exclusion of these variables

[67] According to the World Bank, the broad definition of contagion is the cross-country transmission of shocks or the spillover effects which can take place both during both tranquil and crises periods. The restrictive definition is the transmission of shocks beyond any fundamental link among the countries, usually explained by herding behaviour. The fundamental links among countries that can explain contagion are: financial, real and political links. A negative shock in one country, for example, causes a firm to increase reserves by selling assets on the countries that are still unaffected by the initial shock. Real links are usually associated with international trade, for which the real exchange rate and terms of trade are thought to be important, or variables such as foreign direct investment. There are political links when a country belongs to an association, an exchange rate arrangement, or a geographical region that share common characteristics.

also relieved us from concerns about the order of integration as deficits are theoretically expected to be I(0). There are several other variables which could also be included in the GUM. For example, export growth, investment to GDP ratio and net capital inflows. However, we believe that they are either captured by the variables that we had already chosen or they would raise concerns about correlation and simultaneity problems between the explanatory variables. Finally, we have to explain that with the exception of those variables that were seasonally adjusted in the IFS database, the other seasonally adjusted variables were created using seasonal dummies. Note that graphs are constructed using the variables without our seasonally adjustment.

5.5. Results

5.5.1. Quarterly Data

The GUM comprises excess returns as the dependent variable and, generally, a number of approximately six fundamentals as regressors. We first present OLS results for the countries where we have to use quarterly data.

The findings for Argentina are shown in Table 5.2. Note that the number of observations is 49, because of the smaller availability of data. This is due to measurement problems with interest rates, as explained in chapter 2. Five out of six fundamentals were selected and two of the contagion dummies. The sign of the coefficients are not as expected for the current account deficit and imports/reserves which is puzzling. For example, graphical analysis in Figure 6.1 suggests that excess returns and current account deficits followed reversed paths. The increase in the current account deficit from 1991 to 1995 seems to have been accompanied by a decrease in the interest spread between Argentina and the US. On the other hand, it is possible to observe a sharp decrease in the current account deficit to GDP ratio close to the period of the financial crisis in 2002, and there is also a large negative excess return. The exchange rate misalignment was high for almost the whole period, and there is indication that the currency was appreciating (an impact of the currency board). The trough of the excess returns series correspond to the peak of both the misalignment and inflation and can help to explain the negative sign of the parameter. Because there was a currency board during most of the sample period, one would expect the interest rate spread to have a component of country risk (default) greater than the component of currency risk (due to the fact that the exchange rate predictably remains unchanged). Diagnostic tests indicate that the model passes most tests. If the effect of the foreign financial crisis on the exchange rate was unpredictable and if interest rates did not react at the time of the shock, then there would be a negative outlier as reflected on the value of the dummy. On the other hand, an anticipated rise in the exchange rate would increase interest rates before the actual change.

As reported in Table 5.3, for the GUM of Chile, excess returns respond to the current account deficit to GDP ratio, GDP growth, inflation and there is evidence of contagion from the Argentinean and Tequila crises. The sign of the parameters are not as expected with the exception of inflation (which can be better seen in the long-run static solution, which is not reported). Note that the number of observations is also small, 51, due to the restricted availability of data on current account deficit and imports over reserves. The model passes all but the ARCH tests. As can be seen in Table 5.4, the fundamentals selected for Mexico are GDP growth (seasonally adjusted), current account deficit to GDP ratio and misalignment. The sign of the current account deficit is not as expected, with the exception of GDP growth but the model passes all tests. For Turkey, as seen in Table 5.5, the liberal strategy selects a final model in which excess returns negatively respond to the current account deficit, inflation and the lagged terms of trade. The latter has a strong positive impact on excess returns. The model passes all tests but heteroscedasticity.

Table 5.6 presents the results for France. The algorithm delivers a congruent model in which excess returns respond to the current account deficit to GDP ratio and the import/reserves ratio with the expected signs. Table 5.7 shows that fundamentals can explain the excess returns of Italy. Misalignment and GDP growth affect excess returns with a negative sign, while public deficit to GDP is significant and has the expected sign. The terminal selection is congruent.

No model was selected for the excess returns in Spain. For excess returns in the UK, the final model comprises a dummy for 1992Q4 and another one for 1990Q2. Results for these countries are not reported. As can be seen in Table 5.8, findings using both GUMs show that current account, public account deficit GDP and terms of trade affect excess returns of Germany. The first three fundamentals have a negative sign. A negative constant is also present in the two terminal selections. The model is congruent.

We have additionally tested the same GUMs using different options in the algorithm. For example, we ran tests without selection of contemporaneous variables and also without outlier correction. We performed tested using bonds spreads (*nids*) instead of excess returns. Apart from differences in the magnitude of coefficients and few changes of signs, results were similar with respect to the findings of the negative relationship between many macroeconomic fundamentals and excess returns or uncovered bond spreads. For this reason, results are not reported.

The results show that excess returns can be explained by economic fundamentals. However, the signs of the parameters are often from the unexpected sign showing that the relationship between excess returns and fundamentals is not as commonly thought. As well as risk, exchange rates are also related to fundamentals. Unexpected changes in fundamentals that depreciate the exchange rate would also generate a negative excess return. However, the unexpected change would be reflected in a forecast error if rational expectations hold. Instead, the results seem to show that this relationship is reflected by the estimated parameter. This finding is puzzling and can be showing a systematic association between unexpected changes in fundamentals (thus unexpected changes in exchange rates) and excess returns.

5.5.2. Monthly Data (Brazil)

Following, we present the findings using data for Brazil and also with a different measure for misalignment. We obtained misalignment by subtracting the log of the real exchange rate series by its detrended value, which was estimated using the HP filter [as in Jahjah and Yue (2004)]. The real effective exchange rate, calculated using wholesale prices of Brazil and its major trading partners, was obtained from IPEA. The first GUM includes the variance of the EMBI+ for Argentina, Mexico and Asia in addition to the fundamentals. The number of observations is larger than other tests because of the higher availability of monthly data. In comparison to the previous results, more dynamics is found in the terminal selection. This happens, perhaps, because of the higher frequency of the data. Table 5.9 shows that the terms of trade, public deficit, misalignment and the variances of the Argentinean, Asian and Mexican EMBI+ enter the final model. However, the terminal selection is not congruent as the residuals did not pass the normality test[68]. One dummy is clearly associated with the Brazilian crisis (which culminated free floating of the Brazilian Real) and the other is related to the financial turmoil that happened before the Presidential election in which the leftwing candidate was the favourite. The static long-run equation, which was solved using the estimated coefficients from the terminal selection, show that the parameter of the single fundamental, public deficit, is also of the unexpected sign. The parameters of the variance are mostly as expected, as an increase in the variance of returns should increase risk.

We used the monthly average of the EMBI+ in the place of the variance in the second GUM of Brazil (see Table 5.10). The static long-run equation shows that public deficit to GDP ratio and the measure of misalignment are inversely related to the excess returns. The EMBI+ of Argentina, Asia and Mexico are positively related to *ex post* excess returns. However, there is a problem of conditional volatility in the residuals. No important change is noticed when we decreased the size of the marginal outlier to two standard deviations.

In order to isolate risk from exchange rate changes we also ran a regression of the EMBI+ on the fundamentals. The EMBI+ is supposed to reflect the country risk (default) as there is no currency risk on a dollar denominated bond. The findings in

[68] When we decreased the size of the marginal outlier for 2 standard deviations, four dummies were included in the model and the normality problem is eliminated (results are not reported).

Table 5.11 show that the EMBI+ has a positive relationship with the current account deficit to GDP ratio, public deficit and terms of trade. It can also be explained by the variance of the EMBI+ of Argentina, Mexico, Asia and Brazil itself. The terminal model passes all tests. A dummy is selected for 1998M12 which coincides with the Russian crisis, i.e. the effect of this crisis is not captured by the change in the variances of the EMBI+ that are included in the GUM. Results presented in Table 5.12 are different. The second GUM includes the monthly average of the EMBI+ in the place of the variance. The main difference in relation to the fundamentals is the inclusion of the current account deficit as a percentage of GDP.

We also tested whether the EMBI+ and excess returns are related. The results are presented in Table 5.13. They show that, accounting for a positive constant, excess returns and EMBI+ are inversely related. This result is puzzling and shows that the currency and default risk either do not move together, or that there are other factors influencing excess returns. For example, the autoregressive lags that we found previously imply that the current deviation depends on its previous value. This does not necessarily reflect that agents commit systematic forecast errors. It could mean that the risk perception of the present day can be influenced by agents' evaluation of some period ago. However, there are large and frequent outliers in the series of excess returns which are likely to be associated with forecast errors of exchange rate depreciations rather than shocks to risk. For example, there was a major fall in the value of the excess returns for four consecutive months during the Tequila crisis, and a sharp decline in excess returns for three successive months in Brazil. Is it reasonable to interpret this fact as a sudden decrease in risk or as a large forecast error of exchange rate depreciation? More interestingly, the Argentina crisis was not an unanticipated event[69] and, even taking into account the fact that the moment of the rupture was unknown and the magnitude of the shock was unpredictable, excess returns were largely negative for more than seven months after the fluctuation of the Peso. The finding of unexpected signs for the ratios of the current account deficit and the public deficit to GDP, for example, is also recurrent and puzzling. Does it mirror the fact that fundamentals deteriorate for some time before there is an impact on risk?

The finding that misalignment is related to the created variable "deviations" means that excess returns and deviations from relative PPP are correlated. Again exchange rates might be playing an important role in explaining these results as the variable is present in both sides of the estimated equation. Alternatively, there could also be international Fisher effects in which *nids* would follow inflation differentials. The finding that the negative sign is the same across countries and sample periods is also interesting.

As there could be simultaneity between risk and fundamentals we additionally tested the specifications above using lags as instruments for the variables that could possibly be endogenous. PcGets also has an option for tests with instrumental variables. We do not report the results as the majority of the terminal selections using quarterly and monthly data correspond to a single dummy, possibly because the instrumental variables implies less dynamics. As done for quarterly data, we also tested the GUMs without selection of contemporaneous variables and outlier correction. We additionally performed tested using uncovered bonds spreads (*nids*) instead of excess returns and an alternative measure for the public deficit, using the

[69] For example, Hall and Taylor (2002), among other explanations, attribute the limited contagion (from Argentina to the region) to this anticipation.

public sector net cash requirement as a percentage of GDP. Findings were analogous as they show a negative relationship between macroeconomic fundamentals and excess returns and, for this reason, results are not reported. Splitting the sample and testing before and after the floating period does not change the conclusions with respect to the unexpected sign of some parameters. We also ran OLS tests for Brazil using level and multiplicative dummies for the floating period, however, the coefficients of some variables still presented unexpected signs and the estimated model was not congruent.

5.5. Concluding Remarks

We ran regressions of *ex post* excess returns against a set of economic fundamentals drawing insights from papers that test the relationship between *nids* and fundamentals and also from the works that investigated the determinants of dollar denominated bond spreads.

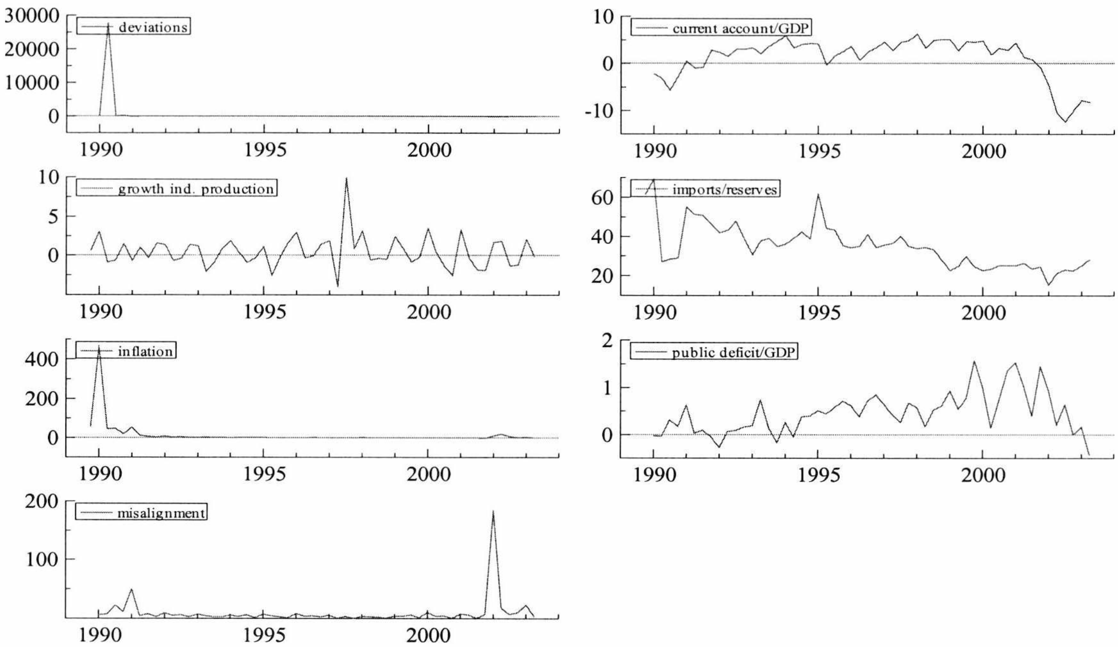
Our results show that excess returns can be explained by economic fundamentals. However, the signs of the parameters are often unexpected showing that the relationship between excess returns and fundamentals is more complex. We can think of two explanations for our findings. First, a leptokurtic distribution of forecast errors, i.e. a distribution where there is a high probability of "rare events", can explain the finding of significant outliers. The association between exchange rates and macroeconomic fundamentals imply that unexpected changes in fundamentals cause unexpected changes in exchange rates. Under rational expectations, the unexpected changes in exchange rates would be reflected in random, normal excess returns. However, the finding of large and significant outliers shows that the distribution of forecast errors does not strictly follow a normal distribution. A second explanation could be the rigidity of bond prices due, for example, to interest rate smoothing (slow change in interest rates). For instance, if fundamentals deteriorate but the interest rate does not rise accordingly to the tendency of the exchange rate to depreciate, perhaps because of slow adjustment in interest rates, then a negative relationship between changes in macroeconomic fundamentals and an excess return arise. This is in accordance with the finding of a negative equilibrium relationship between *nids* and exchange rate changes arising from a monetary policy reaction. Fundamentals deteriorate, the exchange rate depreciates (increases), equilibrium *nids* decrease and there is an *ex post* corresponding negative excess return. Because the variance of exchange rate changes is higher than the variance of *nids*, the first dominates the results. The explanation is also compatible with the fact that fundamentals are generally found to impact the default risk premia, measured by the dollar-denominated spread, with the correct sign. The negative correlation takes place provided that the change in exchange rates is larger than the impact of the worsened fundamentals on the probability of default. The existence of large forecast errors can thus be in accordance with rational expectations because, if there was no interest rate smoothing, bond prices would have reflected the expected change in the exchange rate.

Figures

Figure 5. *Ex post* Excess returns and Fundamentals

Figure 5.1. Argentina

Sample period 1991Q3 until 2003Q2



Sample period: 1991Q3 until 2001Q4

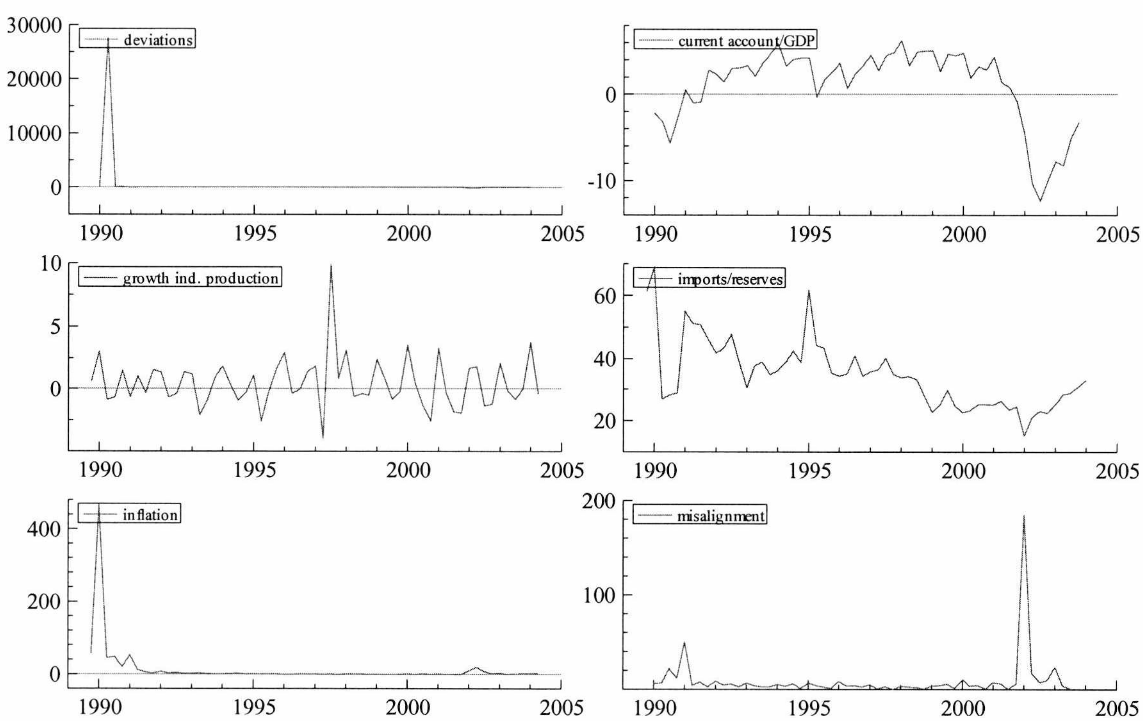
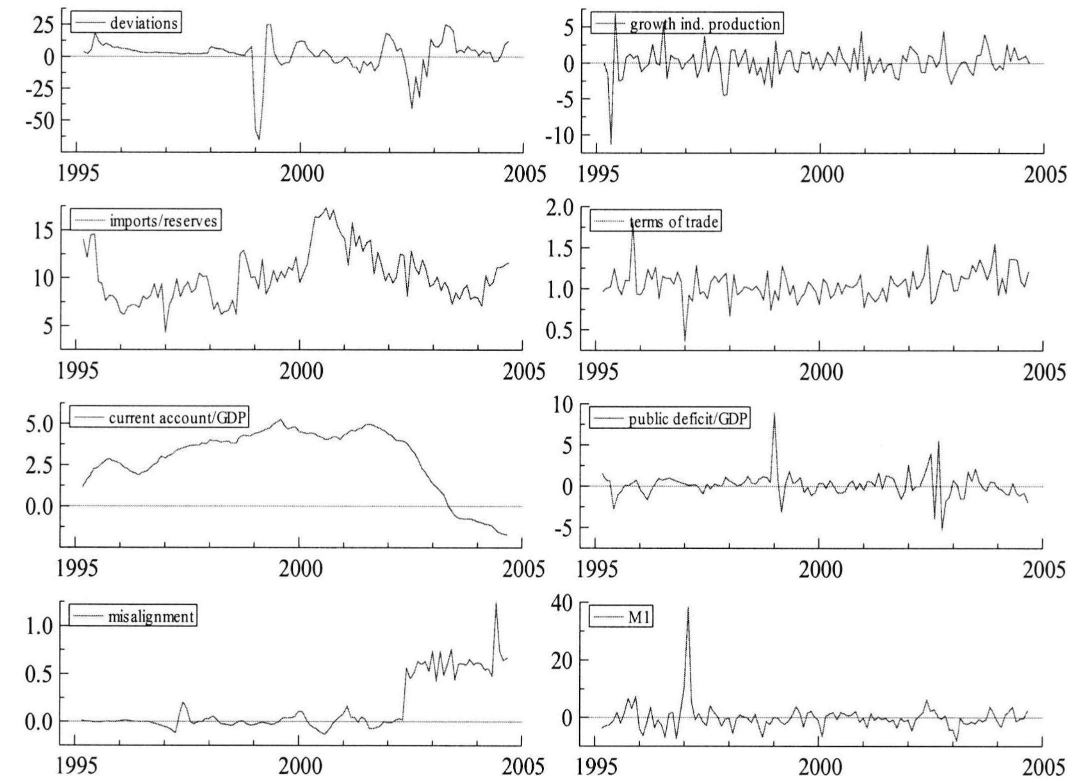


Figure 5.2. Brazil

Excess returns and Fundamentals



Excess returns and EMBI+ Variance

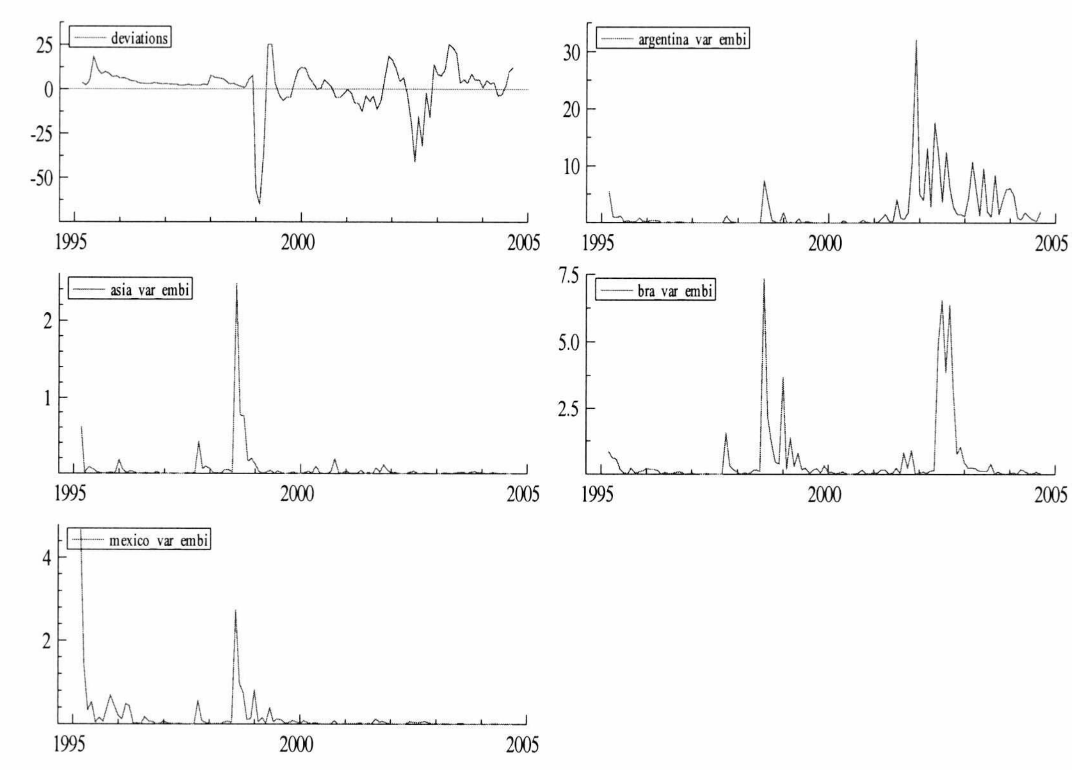
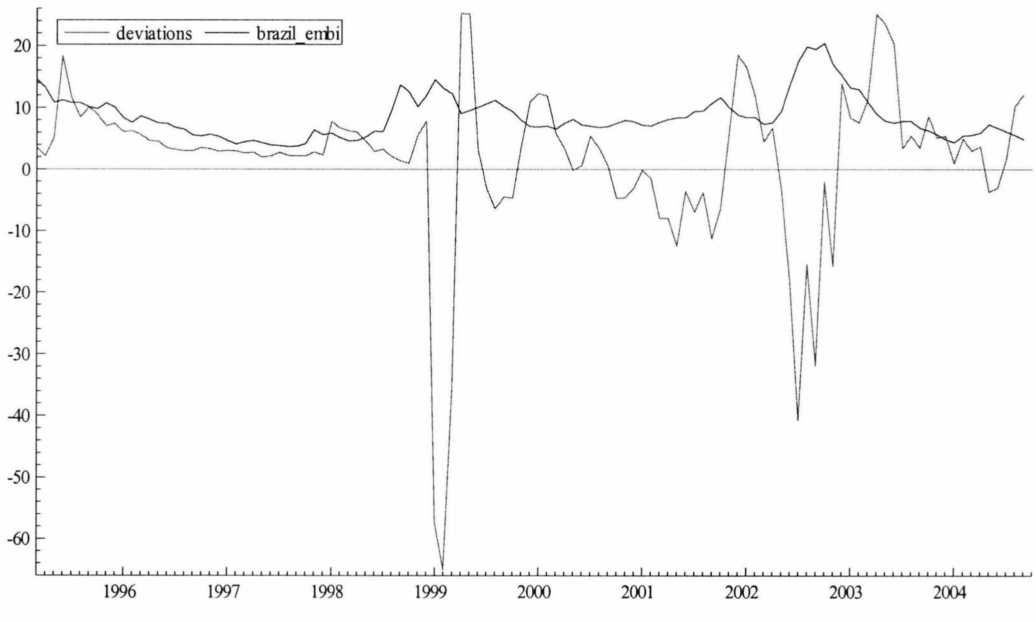


Figure 5.2. Brazil (cont.)

Excess returns and EMBI+ of Brazil



Excess returns and other EMBI+

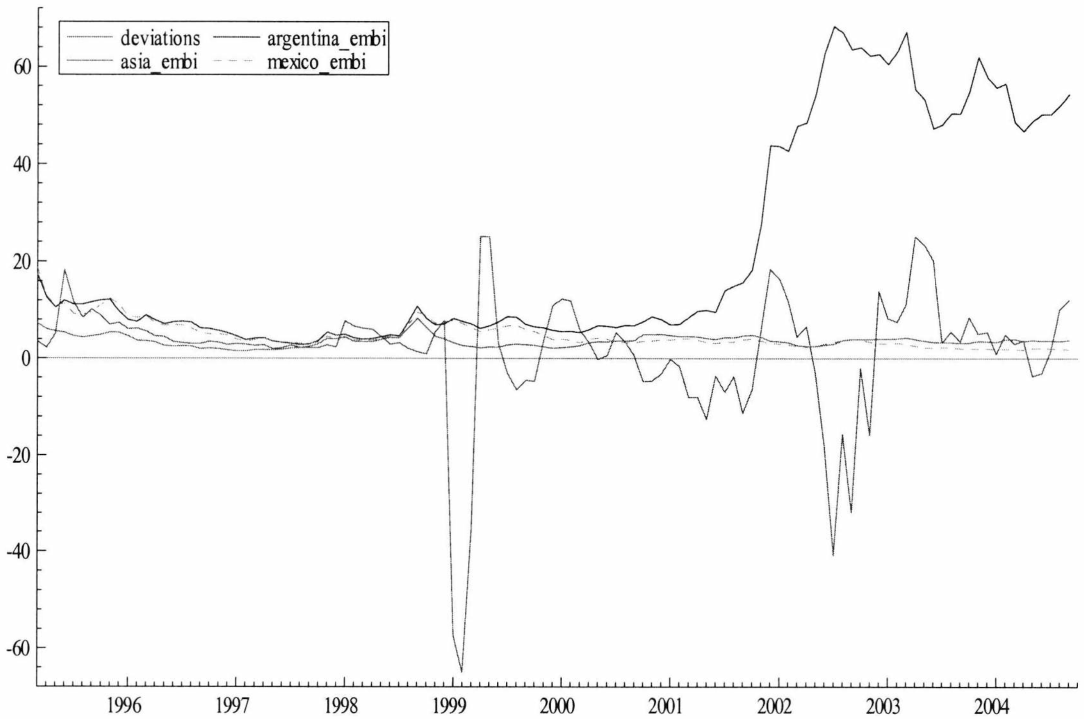


Figure 5.3. Chile

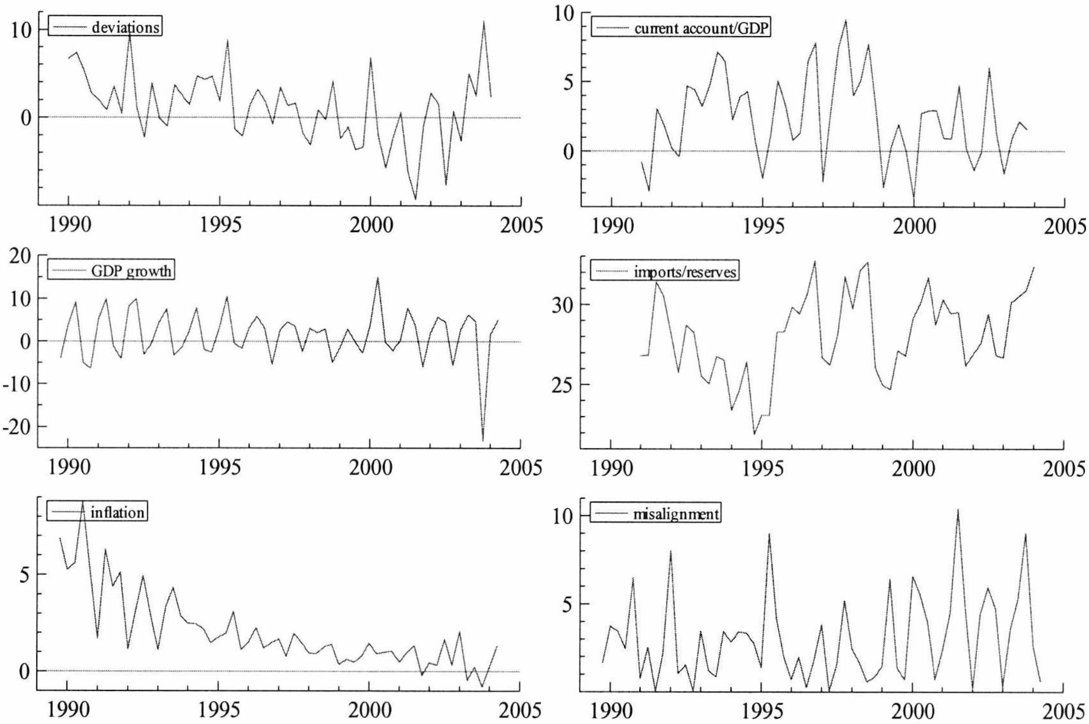


Figure 5.4. Mexico

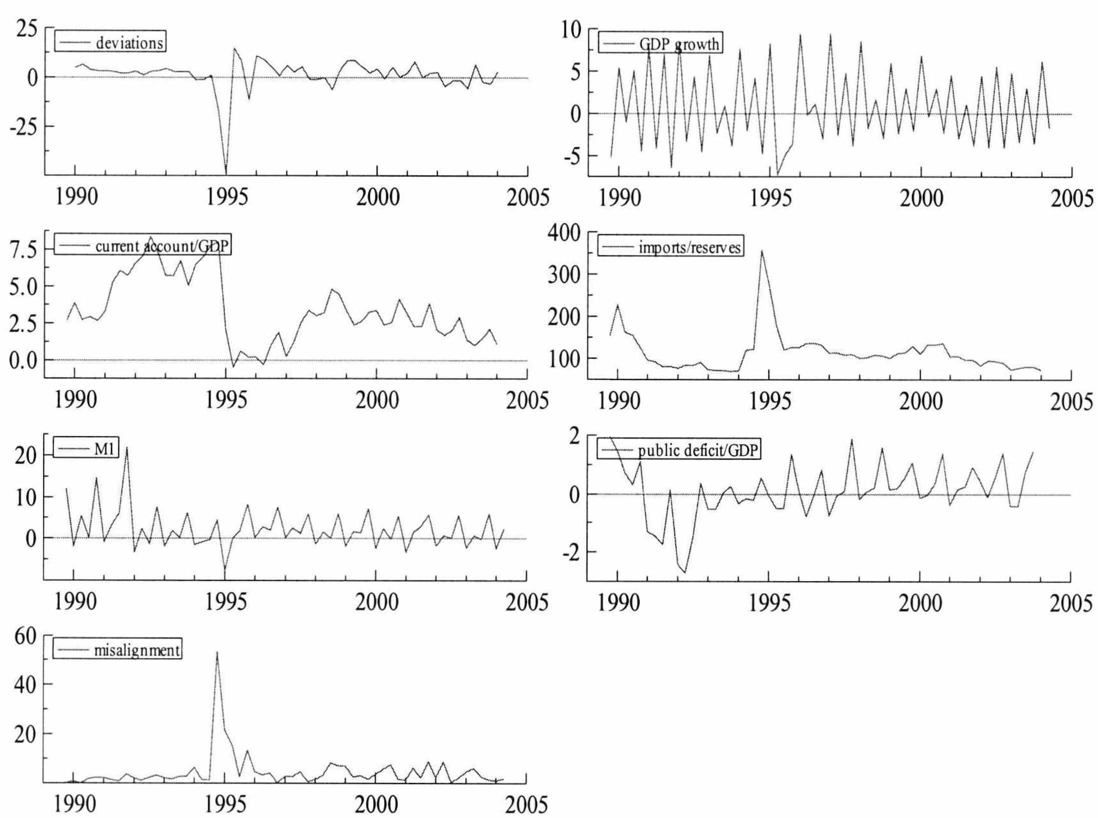


Figure 5.5. Turkey

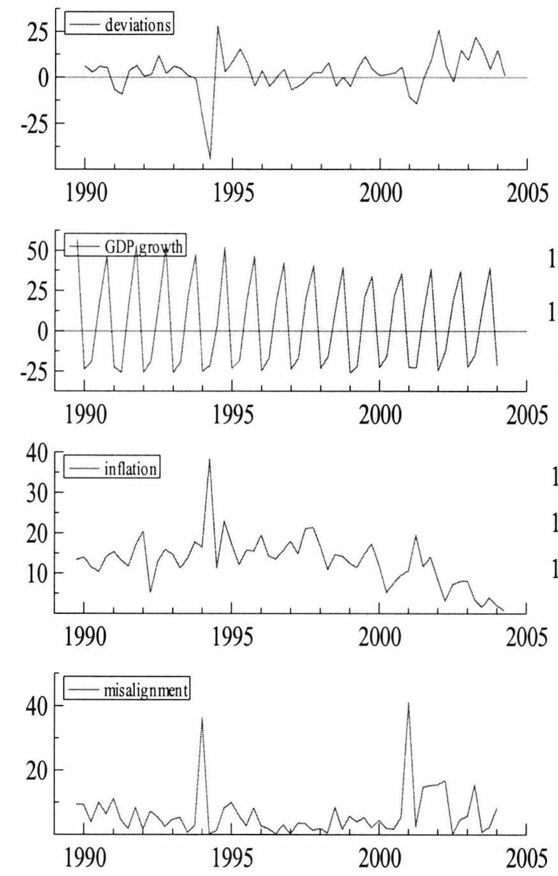


Figure 5.6. France

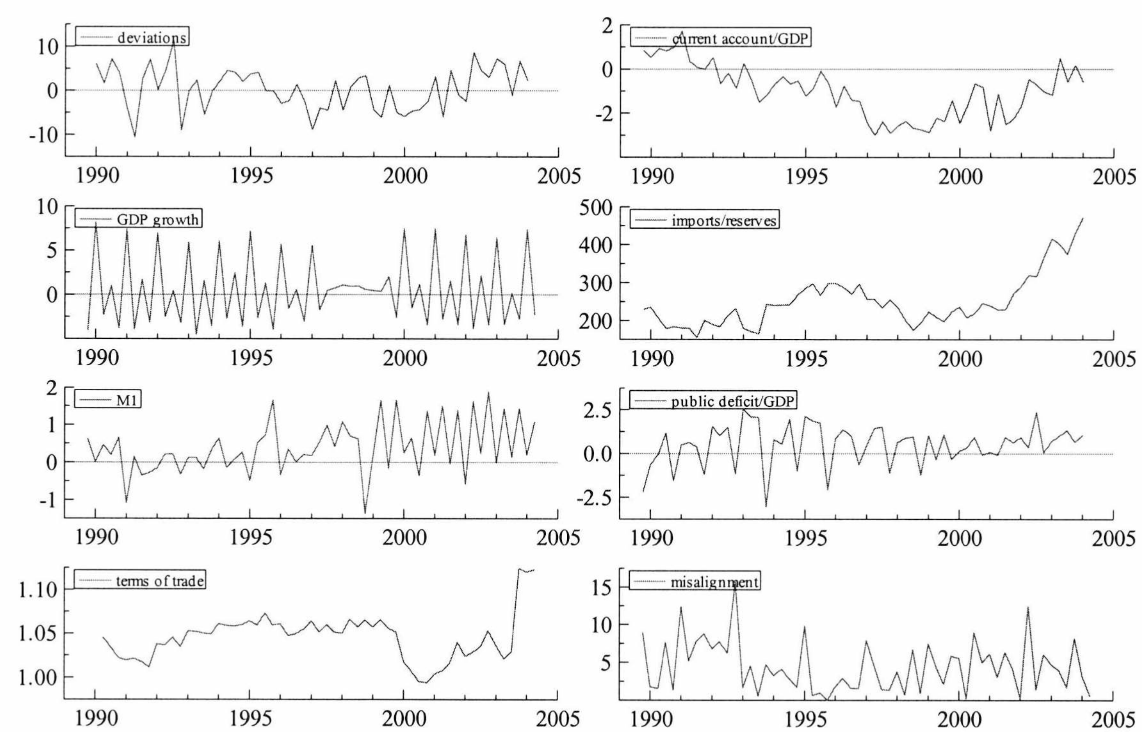


Figure 5.7. Italy

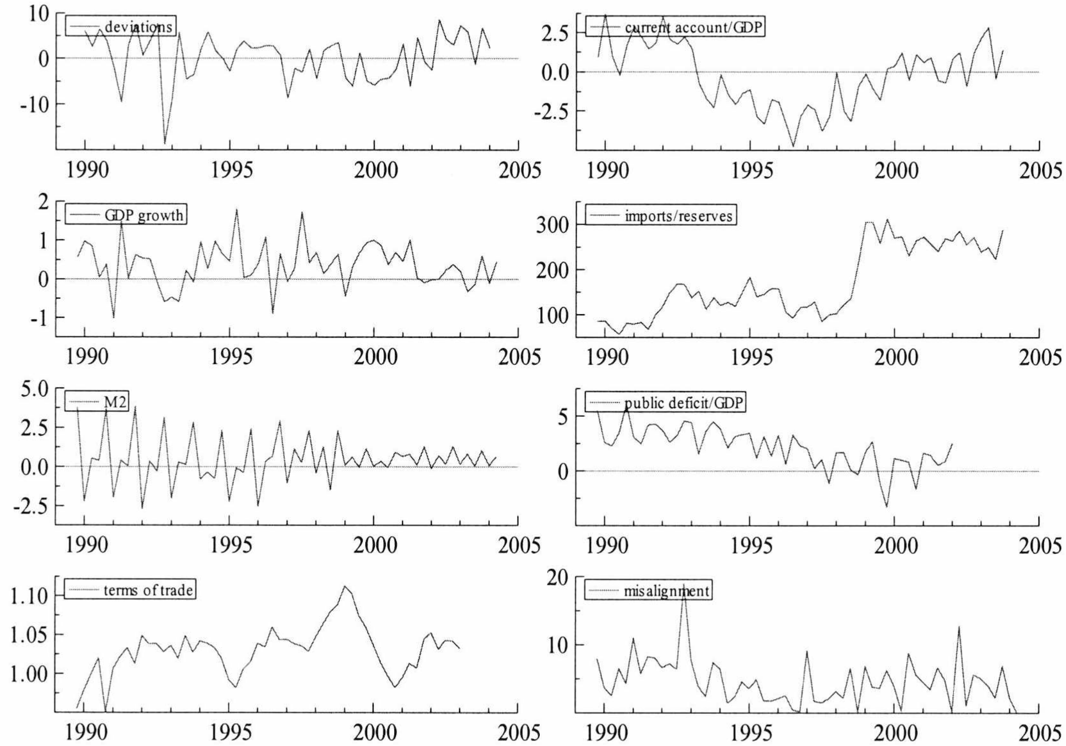


Figure 5.8. Spain

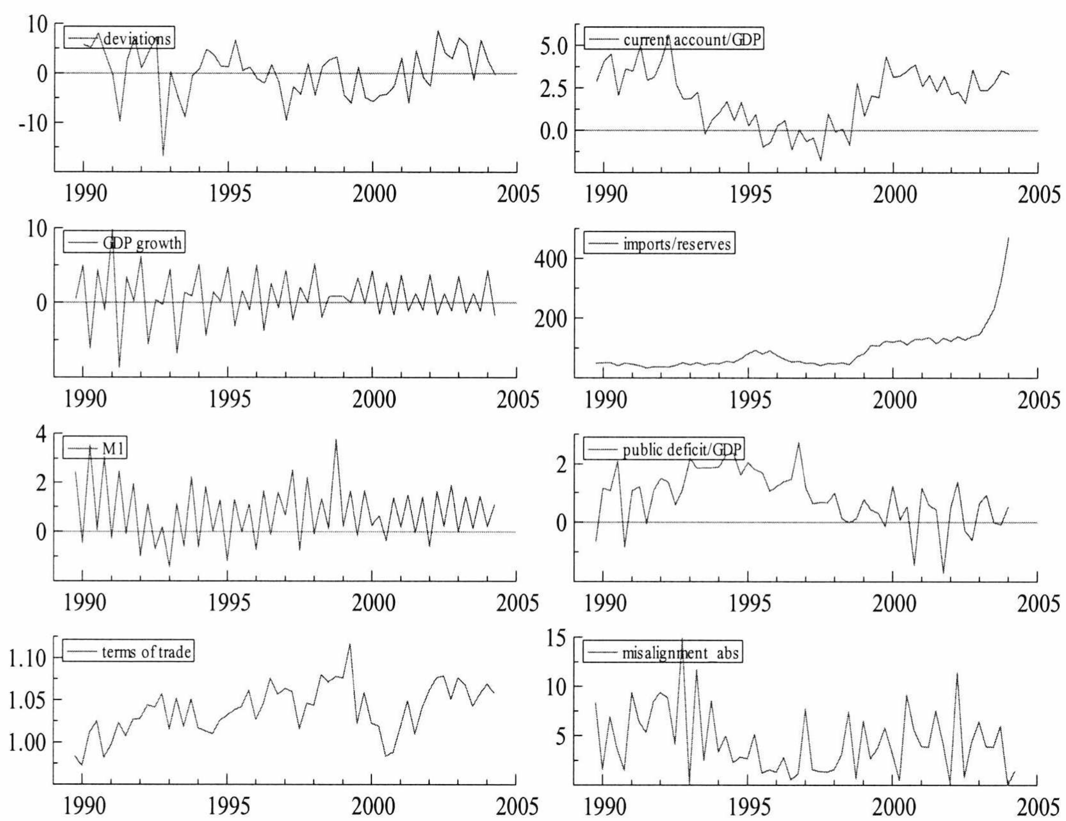


Figure 5.9. UK

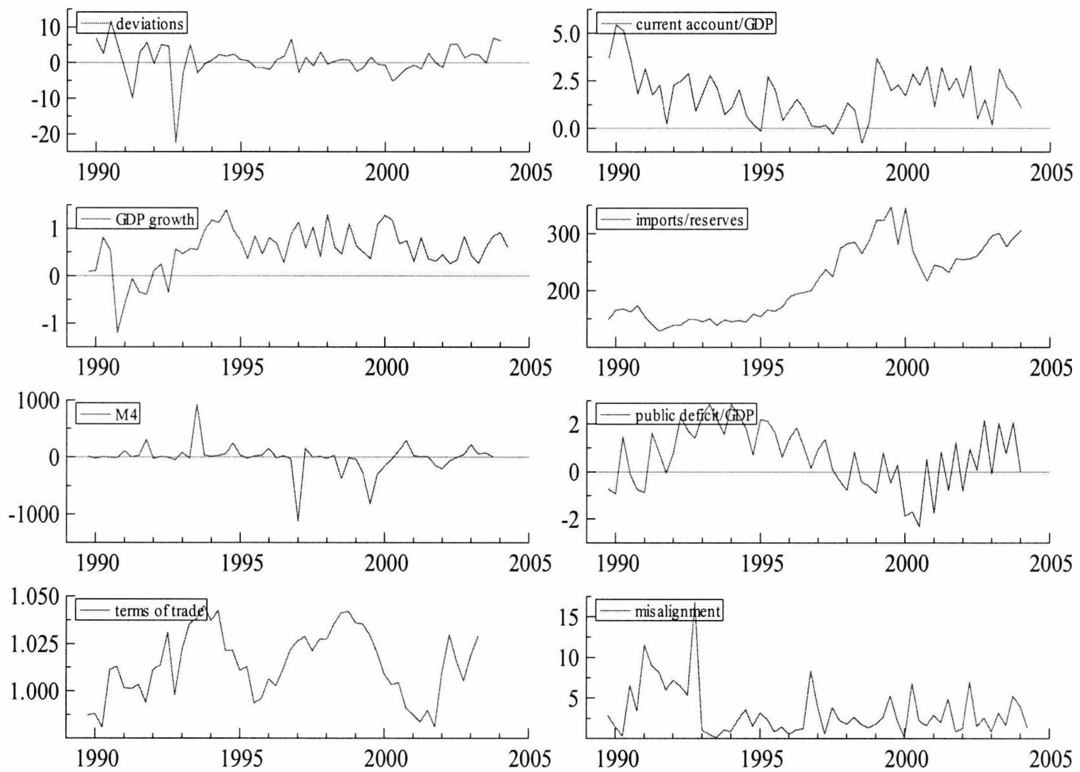
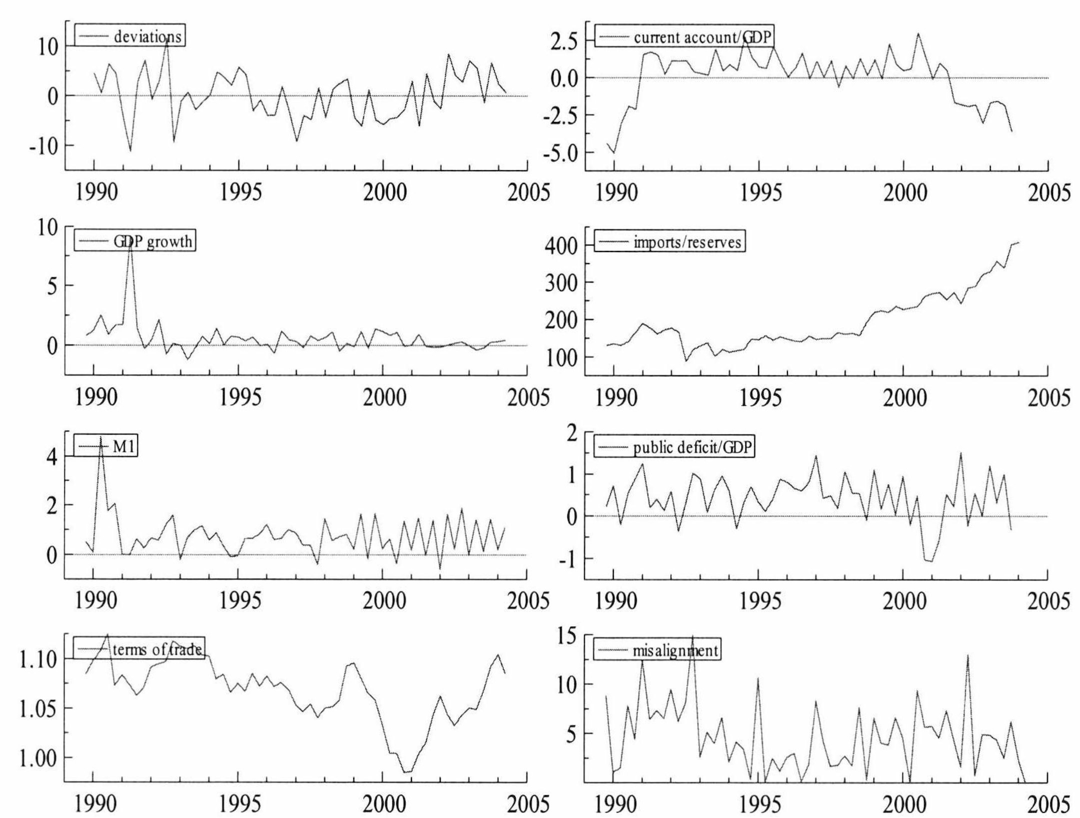


Figure 5.10. Germany



Tables

Table 5.1. Descriptive Statistics of Fundamentals

5.1.1. Brazil

Sample period: 1995M5 until 2004M9, n=115

	Mean	Std Error	Minimum	Maximum
Excess returns	1.6	13.1	-65.0	25.2
Growth of industrial production	0.2	2.2	-11.2	6.8
Imports over reserves	10.2	2.7	4.3	17.3
M1	1.8	5.9	-7.2	39.6
Terms of trade	1.1	0.2	0.4	1.8
Exchange rate changes	3.9	12.9	-18.0	71.9
Inflation	2.1	1.6	-0.8	7.6
Current account/GDP	0.2	0.3	-0.1	1.2
Public deficit/GDP	2.9	1.9	-1.7	5.3
Misalignment	-0.2	10.1	-43.2	62.2
Argentina - Variance of EMBI+	0.2	1.5	-5.2	8.9
Asia - Variance of EMBI+	2.1	4.3	0.0	32.1
Brazil - Variance of EMBI+	0.1	0.3	0.0	2.5
Mexico - Variance of EMBI+	0.5	1.3	0.0	7.3
Argentina - EMBI+	0.1	0.3	0.0	2.7
Asia - EMBI+	21.9	22.3	2.9	68.3
Brazil - EMBI+	3.6	1.1	1.6	8.3
Mexico - EMBI+	8.4	3.4	3.7	20.4

5.1.2. Argentina

1991Q3 until 2003Q3; n=49

	Mean	Std Error	Minimum	Maximum
excess returns	-1.1	19.1	-111.7	17.0
Current account/GDP	1.5	4.5	-12.4	6.3
GDP growth	0.7	6.8	-12.9	16.1
Growth industrial production	0.4	2.2	-4.0	9.9
imports/reserves	33.3	9.2	15.2	61.8
inflation	1.5	3.4	-0.8	19.0
misalignment	8.5	26.1	0.1	185.0
public deficit/GDP	0.5	0.4	-0.4	1.6

Table 5.1. Descriptive Statistics of Fundamentals (cont.)

5.1.3. Chile

Sample period: 1990Q1 until 2004Q1 ; n=57

	Mean	Std Error	Minimum	Maximum
Excess returns	1.2	4.0	-9.3	11.0
Current account/GDP	2.4	3.0	-3.4	9.5
GDP growth	1.5	5.8	-23.2	15.1
imports/reserves	28.0	2.6	21.9	32.7
Inflation	2.0	1.9	-0.8	8.8
Misalignment	3.1	2.5	0.0	10.4

5.1.4. Mexico

Sample period: 1990Q2 until 2003Q4; n=55

	Mean	Std Error	Minimum	Maximum
excess returns	1.22	8.57	-49.93	14.90
current account/GDP	3.41	2.26	-0.48	8.37
GDP growth	0.94	4.84	-7.26	9.44
imports/reserves	114.56	49.22	69.66	357.23
inflation	3.66	3.09	-0.07	16.05
M1	2.08	4.62	-7.65	21.88
misalignment	4.75	7.60	0.07	53.29
public deficit/GDP	0.07	0.93	-2.71	1.88

5.1.5. Turkey

Estimation sample: 1990Q2 until 2003Q4; n=55

	Mean	Std Error	Minimum	Maximum
excess returns	2.39	2.62	2.53	2.48
current account/GDP	1.16	1.15	1.15	1.14
GDP growth	4.87	4.82	4.58	3.79
imports/reserves	75.74	75.23	74.84	73.99
inflation	13.48	13.31	13.14	13.12
misalignment	6.33	6.40	6.33	6.33
terms of trade	1.08	1.08	1.08	1.08

Table 5.1. Descriptive Statistics of Fundamentals (cont.)

5.1.6. France

Estimation sample: 1990Q3 until 2004Q1; n = 56

	Mean	**Std Error**	**Minimum**	**Maximum**
excess returns	0.29	4.82	-10.62	11.38
current account/GDP	-1.10	1.14	-3.00	1.71
GDP growth	0.56	3.82	-4.52	7.50
imports/reserves	252.19	70.13	155.53	471.04
M1	0.38	0.71	-1.36	1.88
Misalignment	4.56	3.44	0.00	15.74
public deficit/GDP	0.57	1.14	-3.04	2.51
terms of trade	1.04	0.03	0.99	1.12

5.1.7. Italy

Estimation sample: 1990Q2 until 2002Q1; n=48

	Mean	**Std Error**	**Minimum**	**Maximum**
Excess returns	-0.48	5.14	-18.77	7.60
current account/GDP	-0.57	1.96	-4.74	3.52
GDP growth	0.38	0.60	-1.02	1.80
imports/reserves	163.22	73.69	56.90	312.12
M2	0.43	1.53	-2.67	3.83
misalignment	4.70	3.41	0.16	18.95
Public deficit/GDP	0.24	1.66	-3.75	3.99
terms of trade	1.03	0.03	0.95	1.11

5.1.8. Spain

Estimation sample: 1990Q1 until 2004Q1; n=57

	Mean	**Std Error**	**Minimum**	**Maximum**
excess returns	0.25	5.12	-16.71	8.63
current account/GDP	1.93	1.72	-1.78	5.63
GDP growth	0.77	3.48	-8.71	9.78
imports/reserves	92.06	73.99	33.17	469.63
M1	0.73	1.19	-1.43	3.78
misalignment	4.43	3.33	0.02	14.90
public deficit/GDP	0.88	0.92	-1.71	2.74
terms of trade	1.04	0.03	0.97	1.12

Table 5.1. Descriptive Statistics of Fundamentals (cont.)

5.1.9. UK

Estimation sample: 1990Q2 until 2003Q2; n=53

	Mean	Std Error	Minimum	Maximum
excess returns	0.37	4.65	-22.53	11.72
current account/GDP	1.68	1.24	-0.79	5.16
GDP growth	0.55	0.50	-1.19	1.40
imports/reserves	213.06	64.10	128.42	347.10
M4	-11.50	261.92	-1123.39	927.62
misalignment	3.37	3.24	0.07	16.82
public deficit/GDP	0.67	1.29	-2.32	2.83
terms of trade	1.02	0.02	0.98	1.05

5.1.10. Germany

Estimation sample: 1990Q2 until 2003Q4; n=55

	Mean	Std Error	Minimum	Maximum
excess returns	0.02	4.87	-11.19	11.66
current account/GDP	0.23	1.49	-3.59	3.02
GDP growth	0.59	1.39	-1.22	9.20
imports/reserves	193.45	71.20	88.89	401.36
M3	0.60	0.75	-0.28	5.43
misalignment	4.82	3.38	0.01	14.98
Public deficit/GDP	0.42	0.55	-1.07	1.52
terms of trade	1.07	0.03	0.99	1.12

Table 5.2. Modelling excess returns of Argentina

Estimation sample: 1991 (3) - 2003 (3); n=49
GUM: current account/GDP, imports/reserves, inflation, public deficit/GDP, Asian, Brazilian, Tequila, growth of manufacturing production, Russian, misalignment.

	Coefficient	Std.Error	t-value	t-prob
excess returns lag(1)	0.09963	0.03120	3.193	0.0029
Constant	13.37405	1.70055	7.865	0.0000
current account/GDP lag(1)	-1.17963	0.08972	-13.148	0.0000
Growth ind production lag(1)	0.73759	0.19034	3.875	0.0004
imports/reserves lag(1)	-0.14228	0.05274	-2.697	0.0105
Inflation	0.59303	0.22454	2.641	0.0120
Misalignment	-0.67513	0.01764	-38.275	0.0000
Misalignment lag(1)	-0.37355	0.02556	-14.616	0.0000
Asian	-8.17260	2.79057	-2.929	0.0058
Tequila lag(1)	7.26380	2.54635	2.853	0.0071
I2003:1	10.53528	2.35390	4.476	0.0001
I2003:3	-20.76039	2.22675	-9.323	0.0000

R^2 0.99175
$Radj^2$ 0.98930

Diagnostic Tests

	value	prob
Chow(2002:3) F(5,32)	3.9430	0.0067
Normality χ^2 (2)	0.4793	0.7869
AR(1-4) F(4,33)	2.9032	0.0366
ARCH(1-4) F(4,41)	0.6676	0.6182
hetero F(18,30)	1.3356	0.2353

Table 5.3. Modelling excess returns of Chile

Estimation sample: 1991 (1) - 2003 (4); n=52
GUM: current account/GDP, GDP growth seasonally adjusted, imports/reserves, inflation, misalignment, Asian, Brazilian, Argentinean, Tequila, Russian.

	Coefficient	Std.Error	t-value	t-prob
Excess returns lag(1)	0.38053	0.11609	3.278	0.0021
Current account/GDP	-0.40092	0.13860	-2.893	0.0060
Current account/GDP lag(1)	0.20596	0.13779	1.495	0.1425
GDP growth	-0.38372	0.10590	-3.623	0.0008
inflation	-0.88465	0.31874	-2.775	0.0082
inflation lag(1)	1.48257	0.32571	4.552	0.0000
Argentinean lag(1)	-6.02542	2.75743	-2.185	0.0345
tequila lag(1)	9.27908	2.82339	3.287	0.0021
D4I1999:1	-8.10272	2.06065	-3.932	0.0003

R^2 0.60591
$Radj^2$ 0.53084

Diagnostic Tests

	value	prob
Chow(2002:3) F(6, 36)	1.2871	0.2878
Normality χ^2 (2)	0.9196	0.6314
AR(1-4) F(4, 38)	0.4729	0.7553
ARCH(1-4) F(4, 43)	2.6471	0.0462
hetero χ^2 (16)	14.4291	0.5668

Table 5.4. Modelling excess returns of Mexico

Estimation sample: 1990 (2) - 2003 (4); n=55
GUM: GUM: current account/GDP, imports/reserves, public deficit/GDP, Asian, Argentinean, Brazilian, Russian, GDP growth and M1 seasonally adjusted and misalignment.

	Coefficient	Std.Error	t-value	t-prob
excess returns lag(1)	-0.36794	0.10306	-3.570	0.0008
Constant	9.94170	1.51504	6.562	0.0000
current account/GDP lag(1)	-0.78096	0.34202	-2.283	0.0269
Brazilian	10.99604	5.63723	1.951	0.0570
GDP growth	-0.86377	0.39381	-2.193	0.0332
Misalignment	-0.44272	0.10630	-4.165	0.0001
Misalignment lag(1)	-0.74471	0.11606	-6.416	0.0000

R^2 0.64359
$Radj^2$ 0.59904

Diagnostic Tests

	value	prob
Chow(1997:1) F(28, 20)	1.3157	0.2654
Chow(2002:3) F(6, 42)	2.7285	0.0250
Normality χ^2 (2)	1.0328	0.5967
AR(1-4) F(4, 44)	2.2434	0.0797
ARCH(1-4) F(4, 47)	2.4878	0.0560
Hetero χ^2 (11)	18.9695	0.0616

Table 5.5. Modelling excess returns of Turkey

Estimation sample: 1990 (2) - 2003 (4); n= 55
GUM: current account/GDP, imports/reserves, inflation, terms of trade, Asian, Argentinean Brazilian, Tequila, Russian, GDP growth seasonally adjusted and misalignment.

	Coefficient	Std.Error	t-value	t-prob
current account/GDP lag(1)	-1.14208	0.37138	-3.075	0.0033
Inflation	-1.26497	0.20656	-6.124	0.0000
Terms of trade lag(1)	19.18442	2.86118	6.705	0.0000

R^2 0.45305
$Radj^2$ 0.43202

Diagnostic Tests

	value	prob
Chow(2002:3) $F(6, 46)$	1.3889	0.2394
Normality $\chi^2(2)$	0.9592	0.6190
AR(1-4) $F(4, 48)$	1.6657	0.1734
ARCH(1-4) $F(4, 47)$	0.7496	0.5633
Hetero $\chi^2(6)$	8.0993	0.2309

Table 5.6. Modelling excess returns of France

Estimation sample: 1990 (3) - 2004 (1); n= 56
GUM: current account/GDP, imports/reserves, public deficit/GDP, terms of trade, GDP growth and M1 seasonally adjusted, misalignment.

	Coefficient	Std.Error	t-value	t-prob
current account/GDP	1.34906	0.52273	2.581	0.0127
imports/reserves	0.00769	0.00314	2.446	0.0178

R^2 0.12245
$Radj^2$ 0.10589

Diagnostic Tests

	value	prob
Chow(1997:2) $F(28, 25)$	0.6593	0.8573
Chow(2002:4) $F(6, 47)$	0.5162	0.7931
Normality $\chi^2(2)$	0.8993	0.6378
AR(1-4) $F(4, 49)$	1.2580	0.2992
ARCH(1-4) $F(4, 47)$	0.4213	0.7925
Hetero $F(4, 50)$	1.0712	0.3807

Table 5.7. Modelling excess returns of Italy

Estimation sample: 1990 (2) - 2002 (1); n= 48
GUM: current account/GDP, imports/reserves, terms of trade, public deficit/GDP, misalignment and GDP growth and M2 seasonally adjusted.

	Coefficient	Std.Error	t-value	t-prob
GDP growth lag(1)	3.23586	1.05816	3.058	0.0037
Misalignment	-0.70685	0.15467	-4.570	0.0000
Public deficit/GDP lag(1)	1.23080	0.32889	3.742	0.0005

R^2 0.36539
$Radj^2$ 0.33718

Diagnostic Tests

	value	prob
Chow(1996:2) F(24, 21)	0.7088	0.7927
Chow(2001:1) F(5, 40)	1.8996	0.1160
Normality χ^2 (2)	0.3958	0.8205
AR(1-4) F(4, 41)	0.7031	0.5944
ARCH(1-4) F(4, 40)	0.7184	0.5844
Hetero χ^2 (6)	9.0973	0.1682

Table 5.8. Modelling excess returns of Germany

Estimation sample: 1990 (2) - 2003 (4); n= 55
GUM: current account/GDP, imports/reserves, public deficit/GDP, terms of trade, M1 and GDP growth seasonally adjusted, misalignment.

	Coefficient	Std.Error	t-value	t-prob
Constant	-49.57254	20.79145	-2.384	0.0210
current account/GDP	-1.15969	0.39136	-2.963	0.0047
GDP growth	-1.01321	0.42546	-2.381	0.0212
Public deficit/GDP	-2.92378	1.07345	-2.724	0.0089
Public deficit/GDP lag(1)	-2.54586	1.14249	-2.228	0.0305
Terms of trade lag(1)	48.96566	19.82002	2.471	0.0170

R^2 0.36276
$Radj^2$ 0.29774

Diagnostic Tests

	value	prob
Chow(1997:1) F(28, 21)	1.2135	0.3274
Chow(2002:3) F(6, 43)	0.8752	0.5210
Normality χ^2 (2)	0.0786	0.9615
AR(1-4) F(4, 45)	0.7529	0.5614
ARCH(1-4) F(4, 47)	1.2410	0.3065
Hetero F(10, 44)	0.9100	0.5325

Table 5.9. Modelling excess returns of Brazil (GUM 1)

Estimation sample: 1995 (5) - 2004 (9); n= 113
GUM: growth industrial production (seasonally adjusted – from IFS), imports/reserves, M1 seasonally adjusted, terms of trade, current account/GDP, misalignment (HP filter), public deficit/GDP, variance of EMBI+ (Argentina, Asia, Brazil and Mexico).

	Coefficient	Std.Error	t-value	t-prob
excess returns lag(1)	0.94855	0.04598	20.630	0.0000
excess returns lag(1)	-0.25051	0.04781	-5.239	0.0000
public deficit/GDP	-4.73902	0.32073	-14.776	0.0000
Variance EMBI+ Argentina lag(1)	0.47023	0.10552	4.456	0.0000
Variance EMBI+ Asia	5.79654	2.20586	2.628	0.0099
Variance EMBI+ Mexico lag(1)	1.72156	0.77086	2.233	0.0277
Variance EMBI+ Brazil	-1.74664	0.51356	-3.401	0.0010
I1999:4	43.82578	5.34638	8.197	0.0000
DI2002:11	-26.86586	3.32244	-8.086	0.0000

R^2 0.89043
$Radj^2$ 0.88200

Diagnostic Tests

	value	prob
Chow(2000:1) F(57, 47)	0.9761	0.5380
Chow(2003:10) F(12, 92)	0.8355	0.6139
Normality χ^2 (2)	7.9071	0.0192
AR(1-4) F(4, 100)	1.5369	0.1973
ARCH(1-4) F(4, 105)	0.4096	0.8014

Static long-run equation

	Coefficient	Std.Error	t-value	t-prob
Public deficit/GDP	-15.69433	3.08136	-5.093	0.0000
Variance EMBI+ Argentina	1.55728	0.36762	4.236	0.0000
Variance EMBI+ Asia	19.19653	6.80030	2.823	0.0057
Variance EMBI+ Mexico	5.70134	2.73240	2.087	0.0393
Variance EMBI+ Brazil	-5.78437	1.43330	-4.036	0.0001
I1999:4	145.13878	35.46759	4.092	0.0001
DI2002:11	-88.97225	17.37540	-5.121	0.0000

Table 5.10. Modelling excess returns of Brazil (GUM 2)

Estimation sample: 1995 (5) - 2004 (9); n= 113
GUM: growth industrial production (seasonally adjusted – from IFS), imports/reserves, M1 seasonally adjusted, terms of trade, current account/GDP, misalignment (HP filter), public deficit/GDP, variance of EMBI+ of Brazil and EMBI+ (Argentina, Asia and Mexico).

	Coefficient	Std.Error	t-value	t-prob
excess returns lag(1)	0.79282	0.05742	13.808	0.0000
excess returns lag(1)	-0.16095	0.05582	-2.884	0.0049
imports/reserves lag(1)	-0.62641	0.16017	-3.911	0.0002
Terms of trade	2.20020	1.86127	1.182	0.2401
Terms of trade lag(1)	4.01603	1.86166	2.157	0.0335
public deficit/GDP	-3.36739	0.35995	-9.355	0.0000
public deficit/GDP lag(1)	-0.67602	0.37794	-1.789	0.0768
public deficit/GDP lag(2)	-1.23637	0.31726	-3.897	0.0002
misalignment lag(1)	-5.77297	2.02592	-2.850	0.0054
Variance EMBI+ Brazil	-1.08812	0.39677	-2.742	0.0073
Variance EMBI+ Brazil lag(1)	1.58286	0.44921	3.524	0.0007
EMBI+ Asia	1.29277	0.43861	2.947	0.0040
EMBI+ Mexico lag(1)	-2.43023	0.64336	-3.777	0.0003
EMBI+ Mexico lag(1)	1.82379	0.52567	3.469	0.0008
I1999:1	-26.85008	5.07402	-5.292	0.0000
I1999:4	41.12209	5.39197	7.627	0.0000
I2002:11	-31.16160	5.23061	-5.958	0.0000

R^2 0.91508
$Radj^2$ 0.90093

Diagnostic Tests

	value	prob
Chow(2003:10) F(12, 84)	1.5184	0.1337
Normality χ^2 (2)	0.9790	0.6129
ARCH(1-4) F(4, 105)	3.2965	0.0138
Hetero χ^2 (31)	37.6186	0.1920

Static long-run equation

	Coefficient	Std.Error	t-value	t-prob
imports/reserves	-1.70160	0.41625	-4.088	0.0001
Terms of trade	16.88592	5.01589	3.366	0.0011
Public deficit/GDP	-14.34211	2.58050	-5.558	0.0000
misalignment lag(1)	-15.68182	5.98120	-2.622	0.0101
Variance EMBI+ Brazil	1.34393	1.53576	0.875	0.3836
EMBI+ Asia	3.51171	1.20860	2.906	0.0045
EMBI+ Mexico	-1.64734	0.65767	-2.505	0.0138
I1999:1	-72.93616	17.03032	-4.283	0.0000
I1999:4	111.70499	28.16937	3.965	0.0001
I2002:11	-84.64807	20.22152	-4.186	0.0001

Table 5.11. Modelling EMBI+ of Brazil (GUM 1)

Estimation sample: 1995 (5) - 2004 (9); n= 113
GUM: growth industrial production (seasonally adjusted – from IFS), imports/reserves, M1 seasonally adjusted, terms of trade, current account/GDP, misalignment (HP filter), public deficit/GDP, variance of EMBI+ (Argentina, Asia, Brazil and Mexico).

	Coefficient	Std.Error	t-value	t-prob
EMBI+ Brazil lag(1)	1.03744	0.07942	13.063	0.0000
EMBI+ Brazil lag(1)	-0.21288	0.06998	-3.042	0.0030
imports/reserves	0.10434	0.01640	6.361	0.0000
public deficit/GDP lag(1)	0.16424	0.04484	3.663	0.0004
public deficit/GDP lag(2)	-0.11331	0.04496	-2.521	0.0133
Variance EMBI+ Brazil	0.58678	0.08243	7.119	0.0000
Variance EMBI+ Mexico	2.65420	0.53670	4.945	0.0000
Variance EMBI+ Mexico lag(1)	-0.94349	0.40958	-2.304	0.0233
Variance EMBI+ Asia	-3.10261	0.66212	-4.686	0.0000
Variance EMBI+ Asia lag(1)	1.97403	0.49859	3.959	0.0001
Variance EMBI+ Asia lag(1)	-1.02780	0.30152	-3.409	0.0009
I1998:12	3.61495	0.74924	4.825	0.0000

R^2 0.96477
$Radj^2$ 0.96093

Diagnostic Tests

	value	prob
Chow(2000:1) F(57, 44)	1.1547	0.3120
Chow(2003:10) F(12, 89)	1.0701	0.3947
Normality χ^2 (2)	3.0578	0.2168
AR(1-4) F(4, 97)	0.9902	0.4167
ARCH(1-4) F(4, 105)	0.7494	0.5606
Hetero χ^2 (23)	39.4038	0.0179

Static long-run equation

	Coefficient	Std.Error	t-value	t-prob
imports/reserves	0.59471	0.04282	13.887	0.0000
Public deficit/GDP	0.29026	0.39191	0.741	0.4606
Variance EMBI+ Brazil	3.34456	0.41838	7.994	0.0000
Variance EMBI+ Mexico	9.75077	2.96706	3.286	0.0014
Variance EMBI+ Asia	-12.29097	3.98335	-3.086	0.0026
I1998:12	20.60468	5.07923	4.057	0.0001

Table 5.12. Modelling EMBI+ of Brazil (GUM 2)

Estimation sample: 1995 (5) - 2004 (9); n=13
GUM: growth industrial production (seasonally adjusted – from IFS), imports/reserves, M1 seasonally adjusted, terms of trade, current account/GDP, misalignment (HP filter), public deficit/GDP, variance of EMBI+ of Brazil and EMBI+ (Argentina, Asia and Mexico).

	Coefficient	Std.Error	t-value	t-prob
EMBI+ Brazil lag(1)	0.87930	0.06345	13.858	0.0000
EMBI+ Brazil lag(1)	-0.16851	0.05721	-2.945	0.0040
Constant	-1.21154	0.40356	-3.002	0.0034
imports/reserves lag(1)	0.09341	0.02546	3.670	0.0004
current account/GDP lag(1)	0.23200	0.06822	3.401	0.0010
deficit/GDP lag(1)	0.15658	0.04183	3.744	0.0003
Variance EMBI+ Brazil	0.39453	0.06325	6.237	0.0000
EMBI+ Argentina	0.01782	0.01378	1.293	0.1990
EMBI+ Argentina lag(1)	0.01510	0.01611	0.937	0.3508
EMBI+ Mexico	0.90253	0.10456	8.632	0.0000
EMBI+ Mexico lag(1)	-0.66873	0.10593	-6.313	0.0000

R^2 0.96794
$Radj^2$ 0.96479

Diagnostic Tests

	value	prob
Chow(2000:1) F(57, 45)	1.3922	0.1258
Chow(2003:10) F(12, 90)	0.9576	0.4948
Normality χ^2 (2)	0.4458	0.8002
AR(1-4) F(4, 98)	0.7974	0.5297
Hetero χ^2 (20)	38.3928	0.0079

Static long-run equation

	Coefficient	Std.Error	t-value	t-prob
Constant	-4.18918	1.22444	-3.421	0.0009
imports/reserves	0.32299	0.08625	3.745	0.0003
current account/GDP	0.80219	0.18207	4.406	0.0000
Public deficit/GDP	0.54140	0.16325	3.316	0.0013
Variance EMBI+ Brazil	1.36417	0.27005	5.052	0.0000
EMBI+ Argentina	0.11383	0.01747	6.516	0.0000
EMBI+ Mexico	0.80842	0.10717	7.543	0.0000

Table 5.13. Excess returns and the EMBI+

Estimation sample: 1995 (3) - 2004 (9); n= 115
OLS Estimation: dependent variable is excess returns

	Coefficient	Std.Error	t-value	t-prob
Constant	14.54043	2.96345	4.907	0.0000
EMBI+ Brazil	-1.51652	0.32221	-4.707	0.0000

R^2 0.16391
$Radj^2$ 0.15651

Diagnostic Tests

	value	prob
Chow(1999:12) F(58, 55)	0.5344	0.9902
Chow(2003:10) F(12, 101)	0.1315	0.9998
normality χ^2 (2)	33.8288	0.0000
AR(1-4) F(4, 109)	20.7104	0.0000
ARCH(1-4) F(4, 107)	22.1600	0.0000
hetero F(2, 112)	7.5601	0.0008

Static long-run equation for excess returns, using the EMBI+ and the variance of the EMBI + in the GUM.

	Coefficient	Std.Error	t-value	t-prob
EMBI+ Brazil	-1.10438	0.39608	-2.788	0.0063
Variance EMBI+ Brazil	4.54419	1.72912	2.628	0.0099
Constant	7.59320	2.75417	2.757	0.0069
I1999:2	-75.26741	11.38711	-6.610	0.0000
I2002:9	-60.00284	11.05268	-5.429	0.0000

Conclusion

Overview

RIPH is based on the three pillars of International Finance and their breakdown implies the existence of interest rate differentials across countries. Transport costs, risk premiums and the failure of rational expectations hypothesis (given by the irrationality of expectations, bubbles, Peso problems etc) are the most alluded examples of frictions in goods and assets markets, i.e., of PPP and UIP violations.

The importance of this hypothesis stems from the fact that empirical evidence can be interpreted as a measure of international integration in goods and assets markets. Because the real interest equality is based on the existence of frictionless markets, a test of the RIPH is a test of the degree of market integration. That is, in integrated goods and capital markets factor price equalisation would occur, leading to equal returns to capital across the world.

We presented evidence on the RIPH for a sample of developed and emerging markets for the period that spans from the mid-1990s until the beginning of the 2000s. We investigated the existence of *ex post* real interest rate differentials (*rids*) in Argentina, Brazil, Chile, Mexico, Turkey, France, Italy, Spain, the UK and Germany using the US as the reference large economy. The heterogeneous sample of countries allowed for inter-group comparisons and the detection of similar patterns between them. The period was determined by the data availability of emerging economies but it was also adequate for tests of market integration as it followed the trade and liberalisation process.

We carried out a set of unit root tests in order to characterise the dynamic behaviour of *rids*. Our findings showed that *rids* are quickly mean reverting, with a positive mean for emerging markets and zero or close to zero for developed ones. We also revealed that *rids* show strong features of asymmetry, that is, whenever *rids* grow above or below a certain threshold they tend to behave differently. For emerging markets, the adjustment is quicker when *rids* grow fast, while for countries such as France and the UK adjustment is quicker when *rids* grow below the threshold. Despite the short time span, we were able to find mean reversion in *rids*, in other words, we could either reject the unit root hypothesis or accept the null of stationarity for all countries, excluding Spain. The speed of mean reversion was found to be especially high when we allowed for the likely possibility of structural breaks in the series. Our results suggest that foreign financial crises may have impacted the dynamic process of *rids*. The overall evidence supports the hypothesis of a high degree of market integration, which is consistent with financial liberalisation and the emergence of global capital markets.

In summary, the long-run mean of emerging market economies tends to be higher than developed ones, for which it is zero or close to zero. All these features point out to the existence of frictions in emerging markets, but not in developed economies. Because *rids* follow an autoregressive process, its equilibrium depends not only on the constant term but also on the parameter of the first lag or alternatively, the equilibrium is the general solution to the difference equation. Hence, a study on the dynamics of *rids* was essential to unveil its fundamental causes.

The dynamics of *rids*, in turn, depend on *ex post* deviations from relative PPP and UIP, as the failure of the rational expectations hypothesis is already embedded in excess returns. We then investigated which of the individual parity conditions was more important to explain deviations from RIPH. The study was focused on emerging economies, since evidence on the existence of *rids* was stronger for that group of countries. Once the nature of the real interest parity's violation was identified, we directed our efforts towards the verification of the more specific or the underlying causes of the differentials. We asked whether *rids* are caused by frictions in goods or assets markets. We also posed a related question, whether real shocks (changes in risk perception, productivity increases, or unexpected changes in non-monetary fundamentals, for example) were more important than nominal shocks (such as unexpected changes in money supply, for instance) to explain deviations from interest parity. We presented evidence on a higher degree of friction in assets rather than goods' markets and the predominance of real shocks in the path of *rids* for our set of emerging economies. Deviations from international parity conditions are heavily influenced by the volatility of exchange rates. The variance of both UIP deviations and *nids* explain most part of the volatility of *rids* for all countries, except Turkey.

We also found evidence of stationarity for all *nids* in the sample, with the exception of Turkey. Forecast error variance decomposition showed that real shocks explain most part of the variation in *rids* of emerging economies. We have shown that results were robust to either form of identifying restriction, the contemporaneous and the structural or long-run. We found that the effect of a real shock tends to be amplified in the long-run, reflecting the fact that, whenever differentials of developing economies start to grow, the tendency is for them to accumulate by more than the initial increase. This reinforced the findings of frictions in assets markets. The sign of the impact of real shocks on *nids* is ambivalent, but they are positive for *rids* of all countries with the exception of Chile. These results point out to increases in risk or to unexpected appreciations of the exchange rate (due to unanticipated productivity increases and Balassa-Samuelson effects, for example). The 1990s was a period of various financial crises and the results of endogenous date breaks seem to reflect this fact. Finally, nominal shocks can have different sorts of effects on *rids* and *nids* in the short-run.

Arbitrage is supposed to be largely enforced by increased market integration. As our sample period followed the trade and financial liberalisation, the prediction of RIPH is that departures from parity conditions would have played a minor role on the composition of *rids*. This prediction, however, was not entirely verified. The results regarding variance decompositions led to the compelling suspicion that the causes of *nids* and UIP deviations were also the underlying reasons of *rids*.

UIP, under the assumption of frictionless markets, predicts that *nids* between two economies will be equal to expected changes in the exchange rate. However, the vast majority of the empirical literature has found a robust negative relationship between the two variables. Estimates suggest that an expected appreciation of the domestic currency leads to an increase in domestic interest rates, or otherwise, that an expected depreciation decreases the *nid*. In spite of the lack of support, UIP is still used as the cornerstone of many macroeconomic models. These findings directed our efforts towards the task of finding out the causes of *nids*. Hence, "what determines *nids* or UIP deviations?" was the final objective of the thesis. We followed two parallel lines of research in order to answer this question.

The first line of investigation was motivated by the incipient literature emphasising the role of monetary policy on equilibrium *nids* and UIP *ex post* deviations, especially in emerging economies. We used the idea put forward by McCallum (1994a), who developed a model that considers the effect of policy making on the determination of *nids*. UIP's failure can be explained by the simultaneous relationship between two factors: a policy reaction function and UIP itself. The distinguishing features of the policy function is that monetary authorities slowly change interest rates, in other words, they practice "interest rate smoothing", and also resist exchange rate changes, or put in another way, they "lean against the wind". The simultaneous interaction between the two factors implies an equilibrium *nid* that, under certain parameter values, can explain the empirical failure of the UIP.

We applied McCallum's (1994) model for our sample of emerging markets and also to developed economies, in order to compare the results. We also checked whether and how our findings changed when the policy reaction function was modified to include other variables besides exchange rate changes, as the general understanding is that monetary authorities pay attention to other variables such as inflation, output gap or output changes. Furthermore, it is also known that many emerging economies have recently embarked into inflation target regimes. Finally, we performed estimations considering possible structural breaks. The reason is that changes in exchange rate systems, as experienced by the countries of our sample, may have implied changes in the way monetary authorities react to macroeconomic variables.

The findings using the original model of McCallum (1994a) do not support his intuition as there is no evidence of leaning against the wind for most countries in most periods. The version of the policy reaction function with reaction against prices lends support to the idea of leaning against the parity but only for emerging markets. The size and the sign of the parameters surprisingly resemble the values guessed by McCallum (1994a). The model gives similar results when heteroscedasticity and normality problems are taken into consideration. Then, we tested a policy reaction function including exchange rate changes, output gap and we also checked whether parameter values changed by considering structural breaks (which were identified by changes in exchange rate regimes). We found evidence of leaning against the parity in all emerging countries in at least one period. Finally, evidence of interest rate smoothing was found to be robust for all countries and the dynamic properties of excess returns influenced the equilibrium *nid* of emerging economies to a reasonable extent. The impact of positive and negative shocks on the conditional variance is asymmetric. Furthermore, there is evidence that monetary authorities allow for uncertainty and/or risk in the policy reaction function.

The dynamics of *nids* was explained without abandoning either *ex ante* UIP or rational expectations. Results lent support to the view that policy actions simultaneously interact with the decisions of arbitrageurs and change the result predicted by international parity conditions, such as UIP and also, by consequence, the RIPH. McCallum (1994a) showed that smoothing interest rates and leaning against the wind under certain assumptions about parameter values imply that high nominal returns are associated with exchange rate appreciations, instead of (*ex post*) depreciations. We have shown that monetary authorities play a role in the determination of *nids* in emerging countries if reaction against prices and exchange rate regime changes are taken into account into the estimation of the monetary policy reaction function. In other words, results can explain the possibility of a policy driven forward rate puzzle.

We finally verified whether other factors, rather than monetary policy, could explain excess returns. If excess returns are risk, then they should vary according to the factors that are supposed to influence risk, such as economic fundamentals. The final question of the thesis was: "are excess returns explained by economic fundamentals?". This led to another interrelated issue: if excess returns are indeed explained by the fundamentals, then can our results be concealed with models of risk-fundamentals? In other words, can the size and the sign of the parameters be reasonably explained by macroeconomic theory? The answers to those questions unveiled other important determinants of *rids*.

We ran regressions of *ex post* excess returns against a set of economic fundamentals drawing insights from the literature that investigated the determinants of dollar denominated bond spreads. Our work complemented this literature in two ways. First, we investigated whether returns on uncovered bond spreads (excess returns) instead of dollar-denominated bond spreads, can be explained by economic fundamentals. There is a literature that verifies whether the forward premium, which is analogous to *ex post* excess returns, corresponds to risk from the perspective of consumption-based models of risk. There is a class of models suggesting that risk depends on other fundamentals, for example, studies that examine the determinants of debt crises in the 1980s and currency crises in the 1990s. However, there is no research addressing the question that we have proposed. Second, we applied the most recent methodology of automated model selection (PCGets) for a sample of not only emerging, but also developed economies. PcGets outperforms a simple general-to-specific approach as it pays special attention not only to the significance of the parameters but also to diagnostic tests, in order to ensure that the model selected has a high explanatory power and the residuals are white-noise, i.e. the model is congruent.

Using insights from the related literature in order to construct the general unrestricted model and perform the appropriate data transformations, we found that excess returns can be explained by economic fundamentals. However, the signs of the parameters are often not as expected showing that the relationship between excess returns and fundamentals is more complex. We can think of two explanations for our findings. First, a leptokurtic distribution of forecast errors, i.e. a distribution in which there is a high probability of "rare events", can explain the finding of significant outliers. The association between exchange rates and macroeconomic fundamentals imply that unexpected changes in fundamentals cause unexpected changes in exchange rates. Under rational expectations, the unexpected changes in exchange rates would be reflected in random, normal excess returns. However, the finding of large and significant outliers shows that the distribution of forecast errors does not strictly follow a normal distribution. A second explanation could be the rigidity of bond prices due, for example, to interest rate smoothing. For instance, if fundamentals deteriorate but the interest rate does not rise according to the expected exchange rate depreciation, perhaps because of slow adjustment of interest rates, then a negative relationship between changes in macroeconomic fundamentals and an excess return arise. This is in accordance with the finding of a negative equilibrium relationship between *nids* and exchange rate changes arising from a monetary policy reaction. Fundamentals deteriorate, the exchange rate depreciates (increases), equilibrium *nids* decrease and there is a corresponding *ex post* negative excess return. The variance of exchange rates is higher than the variance of *nids* and, thus, dominates the results. The explanation is also compatible with the fact that fundamentals are generally found to impact the default risk premia, measured by the dollar-denominated spread, with the right sign. The negative correlation will take place provided that the change in exchange rates is larger than the impact of the worsened fundamentals on the probability of default. The existence of large forecast errors can thus be in accordance with rational expectations because, if there was no interest rate smoothing, bond prices would have reflected the expected change in the exchange rate.

Concluding Remarks and Policy Suggestions

In summary, there are two central questions in the thesis. The first one, at the heart of the famous Feldstein and Horioka (1980) low capital mobility riddle, was: **"Is there evidence on the existence of *rids* in a selected group of emerging and developed economies?"**. The answer provided in chapter 2 is affirmative, especially for emerging economies. However, the adjustment of *rids* to equilibrium is fast, a finding that is compatible with RIPH. Hence, we have shown that the parity condition is not only a matter of advanced economies long integrated in international capital markets, but it is also an arbitrage condition that emerging markets obey. Furthermore, the Feldstein and Horioka (1980) riddle is not corroborated by our results. The second question: **"What are the determinants of *rids*?"** was responded in the following three chapters. We found that the general causes are UIP deviations and *nids*. The more specific causes are: 1) persistent reaction of monetary policy to changes in prices and slow adjustment in interest rates; 2) systematic excess returns, possibly induced by anticipated changes in macroeconomic fundamentals and sticky bond prices; 3) large unexpected changes in exchange rates driven by unexpected changes in macroeconomic fundamentals; 4) risk premium. Monetary policy resistance to price and exchange rate changes introduces an element of persistence in equilibrium *nids* which can explain excess returns, in other words, the fact that high interest rates are associated with appreciating exchange rates. Fundamentals can explain excess returns on the basis of systematic excess returns due to interest rate smoothing (sticky bond prices), or large forecast errors associated with unexpected changes in exchange rates. Large unexpected exchange rate changes were common during the 1990s either because of changes in exchange rate regimes precipitated by worsened domestic fundamentals or because of contagion from financial crises. To the extent that macroeconomic fundamentals determine changes in the exchange rate, they also impact excess returns. Both the evidence presented and that found elsewhere in the literature strongly points out to risk premium as another determinant of bond spreads and, hence, the cause of *rids*. The study carried out for Brazil, in particular, showed that dollar-denominated bond spreads, which are understood as agents' compensation for the risk of default, responded to fundamentals with the sign expected by models of risk aversion. This finding is consistent with the results for other countries as in the literature of the determinants of dollar-denominated bond spreads.

Our study was relevant for a number of reasons. First, the research shed some light on the extent to which economic authorities are able to pursue independent monetary policy in an open-economy. As demonstrated by a broad range of models, the real interest rate is an important instrument of macroeconomic policy. But one implication of RIPH, as it stands on its simplest form, is that no *rids* mean no independent monetary policy. However, the finding of a significant equilibrium *rid* has shown that real interest rates in a particular small economy are not entirely decided in a larger country. Finally, as the speed of convergence of the *rid* to its equilibrium level indicate the extent of market integration between economies, we revealed that the parity condition is not only a matter of advanced economies long integrated in international capital markets, but it is also an arbitrage condition that emerging markets obey.

As the research unveiled the likely causes and shed some light on the dynamics of *rids*, we are able to suggest appropriate macroeconomic policies that can change differentials. This is important, for example, because higher *rids* imply larger interest payments on the public, domestic and foreign debt, keeping everything else constant. We found that policy makers can influence real interest rates through the conduct of monetary policy or the management of macroeconomic fundamentals. Monetary policy can influence the equilibrium *nid* through the slow adjustment of interest rates or the resistance against exchange rate or price changes. This pattern of conduct implies that an appreciating exchange rate will be associated with high *nids* in equilibrium. Authorities can also influence the *rid* to the extent to which they are able to implement policies that affect the probability of default or that generate large unexpected changes in exchange rates. The results regarding real interest parity decomposition have shown that real shocks cause a higher volatility of *rids*. Hence, if the objective is to smooth out the variability of *rids* then policy makers should also attempt to offset this type of shock.

Important questions remain for future research projects. The finding that deviations from RIPH are short-lived is puzzling, especially considering the evidence that the real exchange rate is found to mean revert slowly and that UIP is generally found not to hold. In other words, how to conceal the slow adjustment in PPP and the failure of UIP with the recent increasingly support to RIPH? This puzzle requires more investigation, in particular because real exchange rate misalignment has been subject to controversy and because there has been considerable improvement on econometric techniques. The finding of asymmetry in *rids* lead to the question of how to model a risk premium that is endogenous to interest rate changes. The result of the negative relationship between some macroeconomic fundamentals and excess returns together with the findings of the policy driven forward puzzle also need more investigation.

We may have not provided a conclusive answer about the causes of *rids* in emerging economies. However, we believe that our work shed some light on the direction that the researcher should look at in order to explain *rids*. The important aspect of our thesis is that we were able to show some empirical regularities concerning the dynamic behaviour and causes of interest rate differentials across a sample of heterogeneous countries.

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