Aalto University
School of Business

Unbiased forward rate and time horizon in emerging economies and implications to hedging practices

Finance

Master's thesis

Veli-Rasmus Varetsalo

2014

Department of Finance
Aalto University
School of Business

Aalto University
School of Business

Unbiased forward rate and time horizon in emerging economies and implications to hedging practices

Finance

Master’s Thesis

Veli-Rasmus Varetsalo

2014

Department of Finance
Aalto University
School of Business

Aalto University
School of Business

Unbiased forward rate and time horizon in emerging economies and implications to hedging practices

Master's Thesis
Veli-Rasmus Varetsalo
Fall 2014
Finance

Approved in the Department of Finance __ / __20__ and awarded the grade

____

Aalto University
School of Business

Aalto University, P.O. BOX 11000, 00076 AALTO
www.aalto.fi

Abstract of master's thesis

Author Veli-Rasmus Varetsalo	
Title of thesis Unbiased forward rate and time horizon in emerging economies and implications to hedging practices	
Degree Master of Science in Economics and Business Administration	
Degree programme Finance	
Thesis advisor Professor Markku Kaustia	
Year of approval 2014	**Number of pages** 75 **Language** English

Abstract

PURPOSE OF THE STUDY
The purpose of this study is to test the unbiased forward rate hypothesis in emerging economies and the impact of time horizon. The unbiased forward rate hypothesis tests whether a forward rate is an unbiased predictor of future exchange rate. The implications of findings on hedging foreign exchange risk are intended to be analyzed.

DATA AND METHODOLOGY
The data consists of monthly observations of exchange rates and forward premiums for the maturities of 1-, 3-, 6- and 12-months for ten emerging economies: Brazil, Chile, Czech Republic, India, Indonesia, Mexico, Russia, South Africa, South Korea and Turkey. The exchange rate data is retrieved from Bloomberg terminal and all the quotes are against US dollar. For the aforementioned maturities, the unbiased forward rate hypothesis is tested with the Fama regression model using Newey-West standard errors. The time horizon effect for maturities of one and five years is examined by a graphical depiction of the forward prediction error in exchange rate terms. The five year forward premium is approximated by a sum of five consequent one year forward premiums.

FINDINGS
On one month interval, the unbiased forward hypothesis is rejected in the emerging economies. Extending the time horizon to one year, the regression model produces increasingly biased estimates of future exchange rate. The graphical depiction of forward forecast error confirms the findings from the regression model. When comparing the one year bias to five year bias, measured in exchange rate terms, the bias is found to increase along with the extended time horizon. In the majority of the sample countries, on the five year maturity the forward prediction error becomes consistently positive implying that the five year forward rate is a systematically upwards biased predictor of future exchange rate. The impact on hedging performance depends on which currency the entity in question is selling and which currency it is buying with the forward contract. Hedging an emerging market currency denominated foreign exchange risk on a five year horizon has either been systematically profitable or unprofitable throughout the sample.

Keywords Uncovered interest rate parity, unbiased forward rate hypothesis, time horizon effect, emerging economies, foreign exchange, hedging, OTC forward contract

Aalto-yliopisto, PL 11000, 00076 AALTO
www.aalto.fi

Maisterintutkinnon tutkielman tiivistelmä

Tekijä Veli-Rasmus Varetsalo

Työn nimi Harhaton termiinikurssi ja aikahorisontti kehittyvissä talouksissa ja vaikutukset valuuttariskien hallintaan

Tutkinto Kauppatieteiden maisteri

Koulutusohjelma Rahoitus

Työn ohjaaja Professori Markku Kaustia

Hyväksymisvuosi 2014 **Sivumäärä** 75 **Kieli** Englanti

Tiivistelmä

TUTKIELMAN TAVOITTEET

Tutkielman tavoitteena on tutkia harhattoman termiinikurssin hypoteesia kehittyvien talouksien valuutoissa ja aikahorisontin vaikutusta. Tarkoituksena on siis mitata ennustaako valuuttatermiinikurssi harhaisesti vai harhattomasti tulevaisuudessa toteutuvaa valuuttakurssia. Lisäksi tutkielman tavoitteena on analysoida, mikä on tulosten vaikutus valuuttariskien hallintaan kehittyvien talouksien valuutoissa.

AINEISTO JA MENETELMÄT

Aineisto on muodostettu kuukausittaisista havainnoista valuuttakursseja ja termiinipisteitä 1-, 3-, 6- ja 12-kuukauden maturiteeteille. Aineistossa on kymmenen kehittyvää valtiota: Brasilia, Chile, Indonesia, Intia, Etelä-Afrikka, Etelä-Korea, Mexico, Tšekin tasavalta, Turkki ja Venäjä. Valuutta-aineisto on ladattu Bloombergin tietokannasta ja aineiston kaikki valuuttakurssit sekä termiinipisteet ovat noteerattuja Yhdysvaltain dollaria vastaan. Harhattoman termiinikurssin hypoteesia testataan ensin lyhyellä aikavälillä käyttäen Fama-regressiomallia, jossa hyödynnetään Newey-West keskivirhettä. Pidemmän aikahorisontin vaikutusta kokeillaan yhden ja viiden vuoden ajanjaksoilla esittämällä graafisesti valuuttakurssimääräinen ennustevirhe. Viiden vuoden termiini on synteettinen tai keinotekoinen tarkoittaen sitä, että se on estimoitu laskemalla yhteen viisi peräkkäistä yhden vuoden termiinipreemiota.

TULOKSET

Yhden kuukauden aikavälillä harhattoman termiinikurssin hypoteesi hylätään. Aikahorisontin kasvattaminen vuoden mittaiseksi aiheuttaa hypoteesin merkittävämmän hylkäämisen, koska regressiomallin mittaama harhaisuus kasvaa systemaattisesti ajanjakson kasvattamisen johdosta. Graafinen ennustevirheen tarkastelu yhden ja viiden vuoden välillä vahvistaa regressiomallissa todennetun dynamiikan: aikahorisontin kasvaessa termiinin harhaisuus kasvaa. Merkittävää viiden vuoden ennustevirheessä on se, että se on systemaattisesti positiivinen suurimmassa osassa aineiston valuutoista. Positiivinen ennustevirhe tarkoittaa, että viiden vuoden termiini ennustaa tulevaa valuuttakurssia systemaattisesti harhaisesti yläkanttiin eli ennuste on suurempi kuin toteuma. Vaikutus valuuttariskien suojaamiseen riippuu siitä, kumpaa valuuttaa (kehittyvän valtion valuuttaa vai dollaria) entiteetti ostaa ja kumpaa se myy termiinisopimuksella. Valuuttariskin suojaaminen viiden vuoden aikahorisontilla on ollut siten joko järjestelmällisesti tuottoisaa tai tappiollista.

Avainsanat Kattamaton korkopariteetti, harhaton termiinikurssi, aikahorisontti efekti, kehittyvät taloudet, valuuttakurssit, suojaaminen, valuuttatermiini, OTC johdannaismarkkinat

Table of contents

List of figures

List of tables

1 Introduction

1.1 Introduction to the topic

> "Locking in an exchange rate through a forward contract – the most common way to hedge currency risk – is rarely economic with high-yielding EM currencies"
>
> - The Financial Times[1]

Multinational companies (MNCs) operate increasingly in the emerging economies, striving to get their share of the rapid growth and profit potential. Only from 2006 to 2013 the foreign direct investment into emerging economies has increased from USD 400 billion to USD 780 billion[2]. There are many risks in entering the developing economies and one of them is the foreign exchange (FX) risk, which is completely different from what multinational companies are used to in their standard risk management practices. The predominant approach of MNCs to managing foreign exchange risk is the Over-The-Counter (OTC) foreign exchange market where different instruments, such as forward contracts and options, are available for hedging and other purposes. The OTC FX volume of non-financial customers, which includes MCNs and governments, has increased from a daily average of USD 265 billion in 1998 to a daily average of USD 465 billion in 2013[3]. Despite the OTC market becoming the prevailing avenue of foreign exchange trade for both non-financial and financial counterparties, the emerging market currencies (EM currencies) are still in their infancy in terms of e.g. market liquidity, institutional interventions as well as exchange rate (spot rate) and capital controls[4]. In addition to the market imperfections that may distort the prices in the foreign exchange market, the emerging market currencies are frequently associated with certain mathematical abnormalities.

Technically speaking one of the foremost challenges with managing, i.e. hedging, a risk in these currencies is that the OTC forward premiums for the emerging market currencies are extraordinarily large. The forward premium, which equals the difference between an exchange rate now and a forward rate agreed to a future date, has a very intuitive explanation: It is approximately equal to the

[1] FT.com. Darren Smith, HSBC head of corporate FX sales. The Financial Times, May 26, 2014.
[2] World investment report 2014, by United Nations.
[3] Triennial central bank survey of foreign exchange and derivatives market activity in 2013. Issued by Bank for International Settlements (BIS).
[4] Nordea emerging markets fact book 2013.

difference between the interest rates in two countries for the specified maturity. The problem is that for countries classified as emerging, or developing, the interest rates are high in comparison with advanced or developed economies; e.g. in 2010 the average US dollar 12-month deposit rate was 0.9% whereas the average 12-month risk-free Brazilian real rate was approximately 9.5%[5]. For Brazilian real, this a historically low rate; in 2003 it was on average 16%. This discrepancy is called the interest rate differential and it equals the forward premium. When the maturity of the forward is extended from the specified one year, the premium may grow to an even more significant scale.

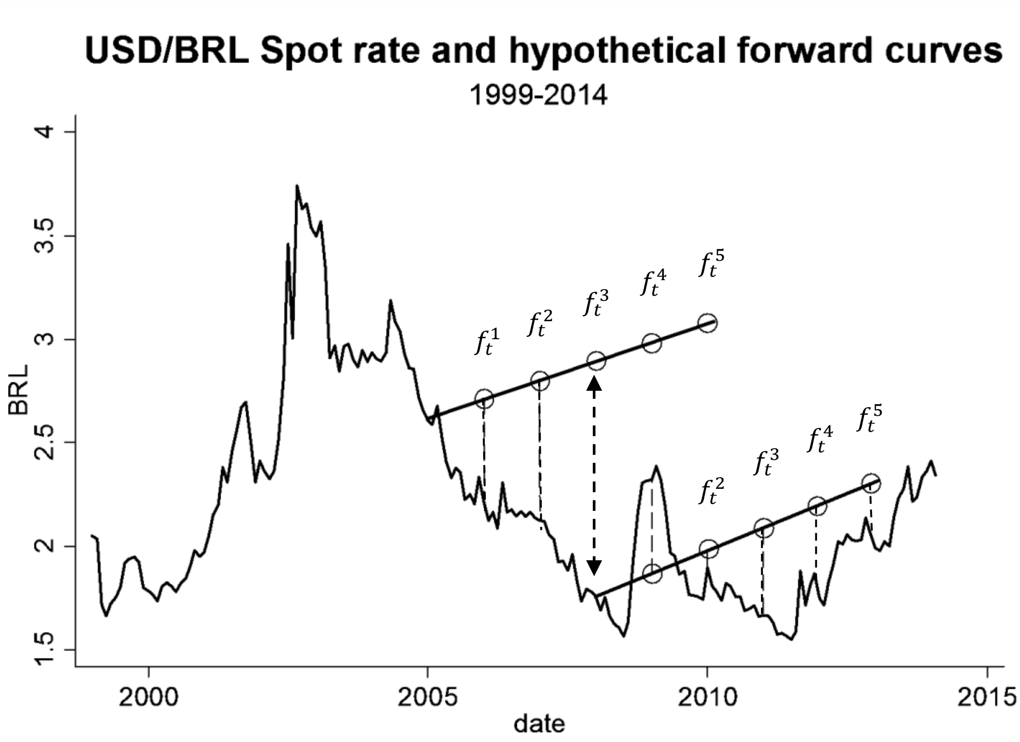
Another technical challenge in hedging with emerging market currencies is that the exchange rates are presumed to have been on a continuously declining trend. If the exchange rate is experiencing an ongoing decline, the forward rate agreed to now will be larger than the exchange rate that materializes in the future, unless, the forward premium is negative. As illustrated, the forward premium in the case of Brazilian real is nowhere near negative, on the contrary, it is positive and substantial. With these two combined, a foreign exchange risk manager is puzzled. If a forward contract is entered under a trend of exchange rate decline and the forward premium is substantial, the forward rate will be considerably higher than the exchange rate that materializes in the future. The practical implication is that the difference between a forward rate and a future exchange rate is the definition of profit or cost of a forward contract or hedge. Furthermore, when the maturity is extended to multiple years, logically, the forward premium escalates even further. This leads to the question that exactly how biased predictor of future exchange rate the forward rate is?

Figure 1 illustrates the discussed presumed challenges in hedging a foreign exchange risk in emerging market currencies using OTC forward contracts. In the figure, the historical US dollar against Brazilian real exchange rate is depicted and, in addition, hypothetical forward rates for different maturities, namely from one to five years. Especially for the first set of forward rates, when the maturity is extended from one to five years, the discrepancy between the forward rate and the future exchange rate increases substantially (see the vertical dashed lines). Depending on the size of the forward premium for different maturities and the extent of the exchange rate decline, the forward rate may be highly upwards biased predictor of future exchange rate, especially at a time horizon of multiple years. If such dynamics were to be found, the implication would be consistent profitability or costliness depending upon the entity in question.

[5] Computed from the data set. The 2010 interest rate differential is not abnormally considerable even though the US dollar rate appears historically low. On average for the full sample the interest rate differential is far greater.

Figure 1: Illustrating the research topic: USD/BRL rate and hypothetical forward rates

Figure 1 shows the actual historical USD/BRL (US dollar, Brazilian real) exchange rate during 1999-2014. In addition there are two theoretical forward rate lines starting in 2005 and 2008 respectively. They illustrate the difference between committing to one, two… or five year forward rate: marked as ($f_t^{1,2\ldots5}$), where the superscript denotes the maturity in years. The dashed lines are the differences to current spot exchange market, i.e. the forward rate prediction error or yield. The point is to show that the substantial forward premiums in conjunction with the trend of appreciating emerging market currency may result in highly costly commitments.



The controversy concerning the relationship between the forward rate and the future exchange rate is not entirely a novel idea as such. As a matter of fact, it is perhaps the most studied theory in the field of international finance, known as the uncovered interest rate parity (UIP) or the unbiased forward rate hypothesis[6] (for a review see e.g. Engel, 1996; Froot and Thaler, 1990). The reasons for its popularity as a research topic are its importance for the participants in the foreign exchange market, theory's intuitively appealing relationship and, lastly, the invariable finding that the uncovered interest rate parity fails. The OTC FX market is simply massive; in 2013 it reached a daily volume of 5.3 trillion US dollar[7], out of which the proportion of currency forwards and swap derivatives is substantial. Given the market is highly liquid, intuitively the forward rates could be assumed to have

[6] Unbiased forward rate hypothesis is analogous to uncovered interest rate parity if the covered interest rate parity is assumed to hold (Engel, 1996). The literature convention is to use these terms interchangeably which is done in this thesis as well.

[7] Reuters.com. Published Sep 5, 2013.

some meaningful relationship to the future exchange rates. However, regardless of countless of attempts, there have been surprisingly few studies finding that a forward rate would be to any degree predictive of future exchange rate (Engel, 1996; Rossi, 2013). Moreover, the abundant articles have not even reached a consensus as to why the uncovered interest rate parity systematically fails, hence the term forward premium anomaly (Engel, 1996).

A promising branch of literature has examined the impact of extending the time horizon from the traditional one month to even decades. Lothian and Wu (2011) and Snaith, Coakley and Kellard (2013) find that in the advanced economies, the uncovered interest rate parity holds well at distant horizons i.e. that the forward rate becomes an unbiased or accurate predictor of future exchange rate. Snaith, Coakley and Kellard (2013) argue that the UIP holds already at a three year interval and, furthermore, they find a continuous tendency of the forward rates to become more and more unbiased as the time horizon is extended step by step. Given that in addition Chinn (2006) finds concurring evidence, it can be concluded that the current consensus is that the UIP holds better for longer time periods in the advanced economies.

Emerging market currencies introduce a new, curious, twist to the uncovered interest rate parity. First of all, the interest rate differentials are as if from a different planet. As mentioned, the difference between the risk-free interest rates of US dollar and Brazilian real was at 9%, under a low interest rate environment. Under similar circumstances, the interest rate differential between the US dollar and euro was approximately 0.35%[8]. Moreover, according to Lothian and Wu's (2011) data set description, the interest rate differential has been relatively low between advanced economies also historically. Secondly, the emerging market currencies are mostly less liquid than the major currencies and the foreign exchange markets are frequently imperfect (Doukas and Zhang, 2013). The final characteristic making the emerging markets a unique test environment is the well-known investment strategy called carry trade. The renowned profitability of carry trade is indicative of a violation of the uncovered interest parity but it is not a direct test of the UIP as such (Menkhoff, Sarno, Schmeling and Schrimpf, 2012). Nevertheless, one could expect the forward premium anomaly to be exceptionally severe in the emerging economies given the shown profitability of carry trade. The studies of the parity theory in emerging economies are extremely scarce. In one of the few existing studies Frankel and Poonwala (2010) find, to all surprise, that the interest rate differentials are less biased predictors of future exchange rates in emerging economies in comparison to advanced

[8] 12-month average EURIBOR in 2010 was at 1.251%

economies. Therefore Frankel and Poonwala (2010) propose that the parity holds better in emerging economies.

1.2 The research question and contribution

This study examines the unbiased forward rate hypothesis and time horizon effect in emerging economies using OTC forward rates. The UIP and its relationship to time horizon has been examined in advanced economies by e.g. Snaith, Coakley and Kellard (2013) and Lothian and Wu (2011), but for emerging market currencies the time horizon effect has not been studied to best of my knowledge. However, with the regular short, one month, interval, the UIP has been already tested in the emerging economies by Frankel and Poonwala (2010). My study differs from the paper by Frankel and Poonwala (2010) not only by investigating both short and long maturities but in addition by having six years of more data. Moreover, this study differentiates from all of the aforementioned by using the actual OTC forward quotes instead of interest rates. In addition, this study intends to address more accurately the nature of the UIP failure: Will the forward rate become increasingly one-sidedly biased given the emerging market presumed tendencies as illustrated in figure 1?

I examine the unbiased forward rate hypothesis in two distinct phases. First, for short maturity data of 1-, 3-, 6- and 12-months, the literature standard test Fama regression is run. The Fama regression consist of two logarithmic variables, the change in exchange rate and the forward premium. Thus, the regression intends to explain the variation in exchange rate with the variation in forward premium. The regression is run for all maturities using monthly data which creates a data overlap problem. To address this issue, Newey-West standard errors are employed. However, according to Snaith, Coakley and Kellard (2013), the Newey-West standard errors are only a part of the answer to the data overlap issue. Because the overlap is expected to become excessively pronounced, for the maturities above 12-months the unbiased forward rate hypothesis is tested with an alternative method. Another reason for the change of methodology is that both in the previous academic literature and in this paper it is found that the Fama regression model has serious downfalls. The forward premium is known to exhibit a highly steady behaviour whereas the exchange rate is extremely volatile. In addition, potential time series breaks affect the regression specification.

In the second phase of the research, the unbiased forward rate hypothesis is tested for one and five year horizons by graphically plotting the forward rate bias or prediction error that is measured in exchange rate terms. The forward rate prediction error equals the difference between the forward rate and the exchange rate that the forward rate intended to predict (the dashed line in figure 1). It is deduced from the Fama regression variables and hence it is a comparable test of unbiased forward rate hypothesis. The strength of this approach is that the prediction error is a more accurate measure of forward rate biasedness than the regression beta estimate. Also the statistical issues related to the Fama regression including a low coefficient of determination and differences in variables variances may be neglected. Furthermore, the forward prediction error is a direct measure of forward contract yield applied by industry professionals. Hence the impact of biasedness on profitability is directly computable from the findings. In addition to the implications to profitability, the graphical depictions of one and five year biases are discussed and compared to each currency's market imperfections, foreign exchange volume, historical exchange rate development and average size of forward premium.

The five year forward rates used in this study are not actual OTC five year forward rates given the lack of data available. Instead they are synthetic in nature implying that the five year premium is approximated using the one year premiums. The five year premium is computed by adding up five consequent one year premiums, creating a seamless five year time line similarly as the actual five year premium would do. For illustration, the five year rates in figure 1 can be perceived as being constructed from subsequent one year premiums and the initial exchange rate. Alternatively, the five year forward premium could have been approximated by multiplying any given one year premium by five and the findings would not have been altered substantially because the forward premium has been so static during the sample. According to the foreign exchange risk manager of Metso Corporation, Mikko Vainikka, the selected method of computing cumulative one year premiums serves as a prudent proxy for the actual five year premium because the actual OTC traded five year premiums often carry an additional premium given the regulations on the OTC derivatives.

The sample data consists of end-of-month mid-quotes for exchange rates and forward points, extracted from the Bloomberg terminal. Time period is from the beginning of 1999 until the start of year 2014, a selection stipulated by data availability. The forward points retrieved from Bloomberg terminal range from 1-month to 12-months. The countries chosen are Chile, Brazil and Mexico (South- and Central America), Czech Republic, South Africa and Turkey (EMEA[9]) , India, Indonesia and South Korea (Asia) and Russia. Criteria included geographical diversification, foreign exchange market functionality and, especially, data availability.

[9]EMEA stands for Europe, the Middle East and Africa.

1.3 Limitations of research

The primary limitations of this research are the data availability, data overlap, incomplete time series robustness tests and the somewhat assumption based analysis of long-term results. The emerging market currency data is only available from 1999 onwards which is distinctively less than for major currencies, having valid data since 1973[10]. The small sample size introduces peso problems, referring to low probability and high impact events that do not have time to materialize in small samples. Hence, it is pivotal to utilize all information available, leading to the selection of monthly data. Regressing variables with longer than one month horizons on a monthly data creates a data overlap issue, resulting in a moving average error process. This is relieved using Newey-West robust standard errors, a technique exercised in similar studies (e.g. Snaith, Coakley and Kellard, 2013; Beber, Breedon and Buraschi, 2010). In addition to the data overlap, the time series properties of the forward premium are slightly problematic. A thorough analysis would require the application of a mean-break detection methodology given the forward premium has been shown to have structural breaks (Baille and Cho, 2014). Another challenge is that the distant time horizon examinations of the forward prediction errors are analysed against slightly presumed market frictions because explicit data on e.g. the size and frequency of institutional interventions in emerging economies are rarely available. Finally, the five year forward rates are synthetic instead of actual rates.

1.4 Empirical findings

I find that the unbiased forward rate hypothesis in emerging economies is rejected in the short-term and, moreover, that the bias increases systematically with extending the time horizon, regardless of whether it is measured with the regression or the prediction error. Firstly, the proposition of Frankel and Poonwala (2010) of lesser biased short-term forward rates in the emerging economies is rejected according to the interpretation of the Fama regression findings. Secondly, the time horizon effect is found to be reversal to advanced economies; the forward bias escalates the further the maturity is extended. Finally, when the time horizon is extended sufficiently, i.e. from one to five years, the forward rate bias becomes positive consistently throughout the sample, implying that the five year forward rate is a systematically upwards biased predictor of future exchange rate during the sample time series. Especially the last-mentioned has drastic implications to hedging profitability.

The Fama regression result interpretation is carried out by considering only the statistically significant slope coefficients. The unbiased forward rate hypothesis is rejected at the one month interval given

---

[10] However, the OTC forward data even for major currencies may not be this lengthy. Those studies frequently use interest rate data instead. 1973 is the year when the Bretton Woods fixed exchange rate regime is considered terminated.

the majority of the beta coefficient estimates are negative. The only outlier is Russian ruble, which has a beta close to unity but the exchange rate against the US dollar is highly controlled. When the maturity is lengthened incrementally to 12-months, for the currencies that the beta attains statistical significance, the bias increases systematically. In the regression, the forward bias is defined as the distance of the beta estimate from the desired unity value. In the advanced economies, the relationship has been found to be the opposite; increasing maturity inclines betas towards unity (Snaith, Coakley and Kellard, 2013). This is the main contribution: Increasing the maturity in the emerging market forward rates produces systematically more biased estimates of future exchange rate.

The increase of forward bias together with maturity is confirmed with the graphical depiction of the forward prediction error for one and five year maturities, which is measured in exchange rate terms. The prediction error of five year forward rate is consistently greater than the prediction error of the one year forward rate for the majority of countries (Brazil, Chile, Czech Republic, Indonesia, Russia, South Africa and Turkey). Furthermore, the five year bias in these markets is continuously positive nearly throughout the sample. Positive prediction error signifies that the five year forward rate is an upwards biased predictor of future exchange rate. This is exactly what is assumed in the figure 1 and the preceding discussion. The extension of maturity results in the emergence of a systematic upwards forward bias. But is the reason in the size of the forward premium or in the trend of exchange rate decline?

As the figure 1 demonstrates, there are only two mathematically plausible explanations for a consistently upwards biased forward rate; either the exchange rate has been on a declining trend all through the sample and/or the forward premium is sufficient to make a difference. These two factors vary in their significance between the currencies. For the Chilean peso and Czech koruna, the determinant of positive prediction error is mainly the trend of declining exchange rate given the average forward premiums near zero and the forward prediction error closely mimics the exchange rate developments. However, Brazilian real, Indonesian rupiah, Russian ruble, South African rand and Turkish lira experience at least some degree of exchange rate increase which means the forward premium has been sufficiently large to maintain the positive prediction error. Concurringly, for these currencies the average forward premiums are the sample highest. The most radical forward premium is in Turkey, and, interestingly enough, the Turkish lira against US dollar exchange rate has been on a remarkable surge during the sample (from USD/TRY 0.5 to USD/TRY 2.0). Nonetheless, the forward rate bias is consistently positive. The other exchange rates also experienced relatively substantial appreciation especially in the aftermath of the financial crisis in 2008 but the five year rates remain upwards biased. Thus for these countries, it is the excessive size of the forward premium that accounts for the existence of a consistent positive five year bias. Neither the diverging market imperfections nor the foreign exchange volumes appear to convincingly explain the differences in the behavior of the forward bias in different currencies.

A practical implication of a systematic positive five year forward bias is that committing to a five year forward rate has been either systematically profitable of loss-making depending on which currency the entity is selling and which buying with the forward contract. The forward has been unprofitable if the forward is agreed to sell emerging market currency and buy advanced market currency (US dollar) and profitable if the forward has been agreed to buy emerging market currency and sell USD. The profitable alternative is analogous to the profitability of carry trade because the effective impact of such forward rate is to take a speculative view, or long position, in the emerging market currency. The implication to hedging is that carrying out risk management that involves committing to the described unprofitable forward rates has been resulting in loss through the entire sample. For instance, these forwards could be used to hedge sales of an advanced economy based company that are denominated in emerging market currency. According to Metso Corporation, many industrial companies currently have well predictable distant horizon inflow from emerging economies given the increased popularity of long-term industrial service contracts. The strength of aforementioned findings does not stem from a statistical method e.g. computing an average profit or using a mean-variance optimization. Instead, it is based on the finding of a systematic and consistent positive bias, throughout the sample.

1.5 Structure

First, I will discuss the surrounding literature from forward rate unbiasedness tests to suggested explanations of the forward premium anomaly, which is followed by the presentation of the hypotheses set for this research. Then the data set is described and analysed, followed by the presentation of the methodology, including the Fama regression model and the derivative return specification. Finally, results are presented and discussed in conjunction with the findings from the existing literature. The conclusions section completes this paper.

2 Literature review

In this section I review the literature most relevant for this research. First, the uncovered interest rate parity is introduced on a general level followed by discussion of most prominent empirical results. The standard tests of the uncovered interest parity are run with a monthly data interval employing a regular regression model. Second, the impact of extending time horizon as well as the impact of employing alternate versions of the regression model are discussed. All in all, these empirical findings are mostly in agreement with each other; in short, the parity theory is rejected. Therefore, the third part of the literature review presents the main explanations of the parity failure, including central bank interventions, time-varying risk premium and econometric misspecification. The final part of this chapter introduces the few studies that deploy emerging market currency data.

2.1 Introduction to the uncovered interest rate parity

The uncovered interest rate parity belongs to the branch of international finance literature that intends to forecast exchange rates, see e.g. Rossi (2013) for a great review. Other factors often used to predict FX rates include price and inflation differentials as well as output and productivity differentials. The UIP is, however, fundamentally different from these other predictors because the interest rate differentials it examines are the basis of FX forward rates. Moreover, the OTC foreign exchange market is incredibly liquid; in 2013 it reached an average daily volume of over five trillion US dollars[11], implying that the forward rates are of significant practical importance. In addition to the interested counterparties in the foreign exchange market, the academic intrigue for studying the uncovered interest rate parity is considerable stemming from the research findings. In summary, the uncovered interest rate parity, or the unbiased forward rate hypothesis, has been consistently rejected and, moreover, the academic literature has found it difficult to explain why (Engel, 1996).

The theory behind the UIP is relatively simple: two currencies have two different interest rates and for the investments to be equally attractive, the exchange rate should be expected to appreciate or depreciate in accordance with the difference in these rates. For example suppose the one year dollar interest rate is 10% and the comparable euro interest rate is 6%, then the interest rate differential is roughly 4%[12]. Thus risk neutral and rational investors should expect the dollar to depreciate by 4% against euro over the next year (Froot and Thaler, 1990). This relationship is called the uncovered interest rate parity. From the above dynamics it results that the interest rate differential equals the

---

[11] http://www.reuters.com/article/2013/09/05/bis-survey-volumes-idUSL6N0GZ34R20130905

[12] This is not exactly correct but the presentation in corresponding literature is always similar. The correct definition is that the dollar would be excepted to depreciate by = 1 – [(1+10%)/(1+6%)] = 3.7% which is only approximately equal to the simplified calculation above.

forward premium of a forward rate that has the same maturity as the interest rates. Otherwise there would be a direct arbitrage opportunity, assuming all these instruments are accessible, a theory known as the covered interest rate parity (Engel, 1996). The foundation of the forward premium is particularly interesting since it is a pure mathematical computation and not, at least directly, reflecting the market expectations of future exchange rates.

2.2 The UIP and the time horizon effect

The forward rate unbiasedness is frequently examined with the following, previously cited as, Fama (1984) regression: $(s_{t+i} - s_t = \alpha + \beta\left(f_t^i - s_t\right) + \varepsilon_{t+i})$, where $(s_{t+i} - s_t)$ is the change in exchange rate and $\left(f_t^i - s_t\right)$ is the forward premium, i.e. the difference between spot rate now and the forward rate for time period i. In the Fama regression model the null hypothesis tested is $(\beta = 1)$ and $(a = 0)$ under the assumptions of risk neutrality and rational expectations (Froot and Thaler, 1990). Froot and Thaler (1990) survey evidence from previous studies concluding an average ($\beta =$ -0.88) over 75 studies which implies a clear rejection of the null hypothesis. In a more recent study using short horizon data and traditional methods, Frankel and Poonawala (2010) find an average $(\beta = -4)$ for developed economies with a sample of 1996 – 2004. In a survey covering mainstream currencies, Engel (1996) points out a corresponding average beta estimate over an abundance of articles. It can be concluded that slope estimates in range of $(-0.5 \leq \beta \leq -4)$ are all consensus values for advanced economies when short horizon data is used. Thus, it is difficult to establish a precise benchmark for a beta estimate for this study.

When the time horizon is extended from the traditional one month, there is a slight consensus of better performance of the uncovered interest rate parity for the established market currencies. Snaith, Coakley and Kellard (2013) suggest that the unbiasedness emerges between two to five year horizons depending on the exchange rate in question. They run the Fama regressions with monthly observations from a sample consisting of historically the most liquid currencies: Canadian dollar, Deutsche mark, Japanese yen, Swiss franc and the US dollar. Lothian and Wu (2011) provide supportive evidence of the time horizon effect as they find unbiased slope estimates using currencies French franc and the US dollar against the British pound with a sample ranging from 1803 to 1999, for both short- and long-term variables with the latter with greater predictive ability. However, on a critical note, out of these two exchange rates only one, franc against sterling attains a beta statistically not different from one, while the other does not. The USD/GBP actually remains quite far from the desired unity value with betas of 0.14 (short rate) and 0.38 (long rate). Hence, based on one currency pair out of the two possible Lothian and Wu (2011) make a conclusion that the uncovered interest rate parity holds when the period is extended sufficiently. In addition, they find that the beta estimates do become negative, concurring with the existing literature, when the sample is dominated by observations from the recent decades.

There is also evidence proposing that the uncovered interest parity does not improve with longer horizon but instead is dependent on the exchange rate. Bekaert, Wei and Yuhang (2007) find using a vector autoregression (VAR) that the parity holds well for certain currencies regardless of the time horizon, namely the US dollar against Deutsche mark, but reject the hypothesis for all maturities for GBP/USD and GBP/DEM. The sample construction is quite similar to other studies as it consists of established currencies, monthly observations and data from 1971 to 1996. Thus, at this point, the results can be interpreted quite valid evidence against any time period conditional dynamics in the parity relationship. However, again a more exact scrutiny reveals that with one of the two model specifications, Bekaert, Wei and Yuhang (2007) actually do accept the UIP for long horizon only, for the GBP/ USD pair. This leads to question of the impact of the intrinsic model specification and the variable selection to the regression output. Furthermore, Snaith, Coakley and Kellard (2013) argue that vector autoregression is not a well suited method for testing the horizon effect because, if misspecified, the interpretation of long-run results in particular becomes unclear. Nevertheless, the horizon effect did not pass the VAR inspection even with a fairly large sample.

The uncovered interest rate parity has also shown to depend on the time period of the sample given that different studies have found similar beta coefficient estimates for similar time periods. These examinations have been mainly conducted with rolling regressions with an appropriate window. With their sizable data set covering two centuries, Lothian and Wu (2011) run rolling regressions finding that the beta estimates became negative only when the subsample is dominated by the 1970s or the 1980s. In agreement, using a five year window in regressions, Baillie and Bollerslev (2000) find that slope coefficient is highly variable and that it is especially negative during the 1980s. Also Baillie and Cho (2014) verify these observations and in addition note that the 1990s experience substantial negative beta estimates that are occasionally followed by a reversal effect after the year 2008. These findings suggest significant time variation in the parity relationship. In particular, the discovery of changing dynamics after the middle 1970s concurs with the date of termination of the fixed exchange rate regime. Hence, extending the sample beyond the floating rate era which generally started in 1973[13] should be questioned and the conclusions drawn from such studies be properly challenged.

[13] The Bretton Woods regime of fixed exchange rates was terminated in 1973, see e.g. Lothian (1986).

2.3 Theories intending to explain the forward premium anomaly

Although, explaining the existence of the forward premium anomaly is not in the primary objectives of this research, it is beneficial to go through the most important articles covering this area since it allows a more thorough discussion of the results to be discovered. The proposed explanations are abundant, including a time-varying risk premium, investor estimation errors, peso problems, omitted impact of central bank interventions and econometric misspecification. None of these theories have been generally accepted as a consensus explanation for the historical failure of the uncovered interest rate parity.

One of the most popular explanations in the academic literature has been the risk premium approach, which proposes that conditional on efficient and rational forward market, any forward rate can be broken down into expected spot rate $E(s_{t+i})$ that is a rational and efficient forecast given all information available and a risk premium (Fama, 1984). Thus, in equation form the forward premium can be broken down as follows, where the first term in brackets is viewed as the risk premium: $f_t^i - s_t = [f_t^i - E(s_{t+i})] + [E(s_{t+i}) - s_t]$ (Backus, Foresi and Telmer, 2001). This definition stipulates the following statistical requirements for the risk premium: given the found negative beta coefficient estimate, variance in the risk premium should exceed the variance of expected spot return ($E(s_{t+i}) - s_t$). This property has been proven particularly difficult to document (Maynard and Phillips, 2001). The academic literature has repeatedly failed in endeavours to reconcile the Fama (1984) requirements for a risk premium and empirical findings (Engel, 1996).

The Fama's (1984) definition of a risk premium is still of academic intrigue as it has been attempted to include in novel methods of explaining the failure of uncovered interest rate parity. Backus, Foresi and Telmer (2001) test affine term structure models, which have been found to estimate well single-currency yields, by restricting the pricing kernels by the statistical conditions of the Fama's time-varying risk premium. They conclude that the affine models do not explain or have difficulty in explaining the forward premium anomaly. In addition, there have been several models that have intended to statistically model the risk premium, even general equilibrium models that consider consumer utility functions for domestic and foreign output as well as portfolio-balance models that optimize utility from domestic and foreign fixed income investments (Engel, 1996). However, with any plausible degree of risk aversion and standard models, the risk premium has been proven difficult to validate (Engel, 1996).

A logical extension of the risk premium approach has been to investigate whether foreign exchange volatility accounts for the forward premium anomaly. The studies modelling volatility have been somewhat successful, if a positive, yet different from unity, estimate can be perceived as such. Clarida, Davis and Pedersen (2009) run the one month Fama regression and find negative slope estimates only for low volatility states and positive, yet different from unity, estimates for high volatility states. Volatility is defined as the standard deviation of returns for a 3v3 carry trade portfolio. The 3v3 carry portfolio is constructed by equal weighted long positions in the three highest yielding and short positions in the three lowest yielding currencies. To define the FX volatility through carry trade returns might be slightly problematic because it takes into account only a proportion of currencies in the sample and the yields by construction consider not only the exchange rate market but also the interest rates. Another novel proponents of time-varying risk premium approach are Beber, Breedon and Buraschi (2010) who study the impact of heterogeneous beliefs on foreign exchange implied volatility and future currency returns. They find that the effect of increased funding liquidity problems[14] turns short-term Fama regression slope estimate from negative to positive while controlled with a difference in beliefs variable[15]. Given that the dispersion in beliefs attained statistical significance, it was concluded to be a risk factor in the currency markets, and thus supportive of the time-varying risk premium explanation of the forward premium anomaly.

The institutional interventions and other market imperfections are another innovative point of view. Mark and Moh (2007) examine the impact of central bank interventions on the uncovered interest rate parity. They find run the Fama regression separately for so called institutional intervention periods and non-intervention periods for USD/DM and USD/JPY with a weekly data[16]. They find betas closing the unbiased forward rate hypothesis when the interventions are excluded, proposing that the interventions account for the anomaly. The obvious problem with the study is that it employs a one week time interval which is unconventional and thus infeasible for a direct comparison. Also the amount observations in the intervention periods is extremely low. Nevertheless, the potential for an institutional intervention to substantially impact the uncovered interest rate parity condition is an interesting approach, because it seems only rational that if the central bank either intervenes directly the markets using its reserves, the exchange market is immediately distorted, or the central bank

[14] Funding liquidity is measured with TED spread: The difference between three-month London Interbank Offered Rate (LIBOR) Eurodollar rate and the three-month US T-bill rate.
[15] Measured with analyst forecasts of exchange rates in Reuters.
[16] US dollar against Japanese yen and US dollar against Deutsche mark.

adjusts its key interest rates directly altering the interest rate differential[17]. All these economic explanations appear feasible but none of them achieves a truly dominant status, resistant of acute critique. From such disparate findings emerge the controversy for the econometric foundation of the variables employed in the regressions.

2.4 Econometric properties and issues of the UIP

The empirical studies recurrently encounter similar issues in their examinations: The models have low R-squared ratios, the exchange rate has substantially greater variance than the forward premium and the forward premium displays persistent autocorrelations. Especially the extremely low variance of the forward premium is of paramount concern. In addition, small sample size is often found problematic.

One of the foremost obstacles confronted in all studies of unbiasedness or UIP is the nearly always recorded low R-squared ratio or the coefficient of determination. The R-squared measures the proportion of variance of the dependent variable that is explained with the variance of the independent variable. This ratio has often been in the scale of 1% - 5 % which means that the forward premium explains only a few percentages of the changes in the exchange rate in question (see, e.g. Backus, Foresi and Telmer, 2001; Frankel and Poonwala, 2010). Furthermore, it is indicative of low goodness of fit of the models deployed. Taking all this under consideration, it would be easy to conclude that the model specification should be improved by including omitted variables or by fitting a more advanced statistical method than the standard OLS regression. However, it needs to be emphasized that despite abundant effort there is neither single specific model that would have been proven a superior fit nor any consistent success achieved by introducing new variables (Rossi, 2013).

The notably lower variance of the forward premium has orientated a branch of the literature towards scrutinizing its impact on the time series properties of the variables. The exchange rate is often documented to have unit root and to be stationary at first difference which implies that the variable deployed, $(s_{t+i} - s_t)$, is stationary (Engel, 1996). The complication arises from the unclear nature of the forward premium and the implications of explaining changes in a stationary spot series. If the forward premium is concluded non-stationary, i.e. it has an order of integration of $(0.5 < d < 1)$, then estimates of β are inconsistent (Maynard and Phillips, 2001). On other hand, if the order of integration is in between $(0 < d < 0.5)$, $f_t^i - s_t$ is stationary and estimates of β are consistent and

[17] Assuming that risk-free deposit rates are based on central bank reference rates. On the other hand, for long-term rates oftentimes government bond interests are used which might not react equally sharply to central bank decisions.

the Fama regression is balanced (Engel, 1996; Maynard and Phillips, 2001). Maynard and Phillips (2001) find that the premium is non-stationary with estimated range: $(0.5 < d < 1)$. This result implies a fractionally integrated process where the forward premium has a long-memory and is highly persistent. Hence, Maynard and Phillips (2001) reject the unbiasedness hypothesis in the test's current construction, suggesting an introduction of some unknown omitted variable to balance the equation. There are, however, difference of opinion in the literature as the forward premium has frequently been found stationary (Engel, 1996). Baillie and Cho (2014) arrive on different implications as they propose that the premium in fact does not have a constant order integration at all but instead it fluctuates through time resulting from structural breaks.

The time series properties of the spot and forward rate are far from consensus and the possibility of omitted variable bias is often expressed but also infinite sample issue has been discussed (Maynard and Phillips, 2001). Baillie and Bollerslev (2000) take a novel approach in considering an artificially generated time series for (f_t^i) and (s_{t+i}). They suggest that the forward premium anomaly may be viewed as a statistical artefact given small sample sizes and persistent autocorrelation in the forward premium. Sakoulis, Zivot and Choi (2010) proceeds with these finite sample issues by carrying out Monte Carlo simulations of the Fama regressions with and without the inclusion of structural breaks. They find that, on the contrary, when the structural breaks in the mean of forward premium are accounted for, the forward premium is not anymore as persistent as it is perceived to be. In more detail, Sakoulis, Zivot and Choi (2010) show that the unbiasedness should not be rejected based on e.g. the traditional Augmented Dickey-Fuller tests for unit root, because they produce a distorted values as such. They also find that if the breaks are not incorporated the beta estimates are biased downwards, away from the desired unity coefficient.

The issue with the simulated sample sets of, such as Baillie and Bollerslev (2000) as well as Sakoulis, Zivot and Choi (2010), include the lack of economic explanation as well as infeasibility to time horizon effect examination. Even though the forward premium's structural breaks or the long-memory would to some extent explain the anomaly, the aforementioned studies do not properly account for the economic rationale behind the findings. Why is there a structural break and why exactly does it make the regression estimates biased? As the forward premium has a very low variance, it is difficult to accept that the one time it changes substantially the effect should be excluded from the analysis. Furthermore, I presume the simulation models always have some author sensitive, subjective restrictions on the data formation process that may lead to significantly different results between studies. The statistical properties of the sample data set in this study will be extensively discussed in the data and results sections. Especially the low variance of the forward premium and its applicability to a regression model in general are of great interest.

2.5 Forward rate unbiasedness in emerging economies

The emerging market currencies provide a novel spark to the traditional tests of forward rate unbiasedness given the exchange rates function in a fundamentally different manner and given the currencies are often used as the investment currencies in carry trades (see, e.g. FT.com[18]). The emerging market exchange rates against US dollar are presumed to have been on a declining trend and to have substantial forward premiums. Both of these indicate to an extensive failure of the uncovered interest rate parity but surprisingly, the academic literature currently suggests that the forward rates are less biased in the emerging economies in comparison to advanced economies (Frankel and Poonwala, 2010). Currently the literature examining the unbiased forward rate hypothesis in the emerging economies is extremely scarce.

The carry trade is based on a strategy of investing in high yield currencies, commonly EM currencies, and funding the investment with a low-cost currency, such as Japanese yen or US dollar (see, e.g. Menkhoff, Sarno, Schmeling and Schrimpf, 2012; Clarida, Davis and Pedersen, 2009). The profitability of the strategy is basically based on the failure of the uncovered interest rate parity: The EM currency is not expected not depreciate sufficiently to make the investment unprofitable. However, the carry trade studies are not clear tests of the uncovered interest rate parity because the portfolios are often adjusted monthly to have a basket highest yielding currencies, in which case the currencies invested in may fluctuate during the sample and the exact proportion of investment currencies during the carry are seldom reported (Menkhoff, Sarno, Schmeling and Schrimpf, 2012; Doukas and Zhang, 2013). Nevertheless, the finding of profitable carry trade strategies leads to presume that the forward bias anomaly could be fundamentally different from what has been historically documented for major currencies.

The number of studies measuring the forward rate bias in emerging economies is relatively limited. Mostly this is probably due to the scarce amount of FX data and in some cases quite regulated markets. Both the time horizon and basic monthly data comparisons have been carried out to a slight extent. Frankel and Poonwala (2010) study the short term UIP for a sample of 14 emerging market

[18] http://blogs.ft.com/beyond-brics/2014/10/01/parsing-em-vulnerability-to-carry-trade-unwinding/

currencies with non-overlapping data for a period of 1996 – 2004. They reject the null hypothesis of ($\beta = 1$) but when comparing to industrialized economies for the same time period, they find an average ($\beta = -4.3$) for the advanced economies, while for emerging economies they find β to average slightly over zero with more positive than negative coefficients. They conclude this result being indicative of less bias in the interest rate differential of developing FX markets. This interpretation defies intuition because it is common knowledge that there is less liquidity and more frictions in these markets. Furthermore the widely documented profitability of carry trade strategy suggests that the UIP should fail particularly in these examinations, not the other way around.

The volume of articles examining the term effect in emerging economies is clearly in need of complementing studies. The only studies I found where papers by Kumar and Trück (2014) exploring unbiasedness and risk premiums in the Indian currency futures markets and by Sarmidi and Norlida (2011) examining UIP for different time horizons for 15 emerging markets. Kumar and Trück (2014) run the Fama regression for 1-month through 3-month futures contracts on Indian rupee (INR) against the US dollar (USD). They reject unbiasedness for two and three months with ($\beta = 1.8$) while for the 1-month period the null hypothesis is not rejected. This finding, more in favour of the UIP for short horizons, is conflicting with the evidence from advanced economies as discussed in section 2.1. However, when more currencies are included, the impact of time horizon reverses to correspond with existing literature[19]. Sarmidi and Norlida (2011) study with interest rate differentials for one, three and twelve month intervals finding positive but rejected coefficient estimates for short horizon while the 12-month period brings β estimates close to unity as stated by the UIP. Their data set ranges from 1995-2009, and is composed of deposit rates instead of forward rates and the currency pairs are mixed and matched with three major currencies. These aforementioned studies are clearly in need of supplementing research.

All in all, the literature has found that UIP does not hold well with actual data and the explanations are abundant. For major currencies the betas are found to be significantly different from unity and even having a negative sign, which means that the parity does not even estimate correctly the direction of the change in exchange rate. However for the major currencies, long time horizons have produced some improvement in results. The explanations of the forward premium anomaly include peso problems, heterogeneous beliefs, persistent autocorrelation of the forward premium, finite sample

[19] Futures differ from forward contracts since the former are marked-to-market daily and they can only be issued for specific dates and in specific currency lots. Forwards are, on the contrary, executable for any banking day for any underlying amount and, moreover, for a hedger, their counterpart is a bank while in futures it is an exchange.

bias, institutional interventions and time-varying risk premium. Out of these, the most promising results have generated the econometric examinations and from economic perspective the effects of central bank interventions. The emerging market currencies provide a new and presumably highly fruitful testing ground for these established theories of uncovered interest rate parity since the EM currencies are novel, still quite frictional in functionality and have far greater variable values and variances to the extent that hedging the foreign exchange exposures has become a predominant source of headache for multinational companies' risk managers.

The hypotheses are formed in two distinct parts. The first set of hypotheses is more based on the aforementioned literature review; given the finding that the uncovered interest rate parity has been predominantly rejected for the standard one month maturity as well as to perform better along with extended time horizon, the same dynamics are expected to be shown in the emerging economies. The regression model is estimated to produce different from unity beta estimates at the short interval but to approach unity along with extended time horizons. The second part of the tests executed is not equally similar to previous academic papers neither in terms of methodology nor hypotheses. Given the several econometric issues that have been assumed to impair the Fama regression model, I will use a different approach for the long-term tests; for the maturities of one and five years, the forward rate biasedness is measured in exchange rate terms. It is simply a graphical depiction of the forecast error between a forward rate and the exchange rate it intended to estimate. The potential for a model misspecification, time series issues or the shown low volatility of the forward premium do not cause statistical interference for the described, simplified, inspection. On the contrary, if the behaviour of the forward premium is as highly stabile as it is assumed to be given the existing findings, the forward rate biasedness and time horizon effect will be facile and productive to analyse graphically.

3 Hypotheses

The hypotheses to be tested are presented below followed by a clarifying commentary. These are employed for the data and models explained in the following chapter. There are four hypotheses set for this study. The first two investigate the unbiased forward rate hypothesis with a regression model that employs short-term data, ranging from one to twelve months. The second two hypotheses study the UIP in extended horizons by comparing one and five year time horizons. The methodology for the latter two is a simplified graphical inspection of the difference between a forward rate and the future exchange rate, i.e. the forward prediction error. The aim is to allow for a more detailed discussion of the findings as well as to neglect issues with econometric modelling.

The unbiased forward rate hypothesis suggests, as is indicated by its title, that a forward rate agreed at time *t* for a period *i* is an unbiased predictor of the future exchange rate that realizes synchronously with the forward contract i.e. exchange rate at time $t+i$. If the statement is valid then the null hypothesis is accepted and the regression equation ($s_{t+i} - s_t = \alpha + \beta \left(f_t^i - s_t\right) + \varepsilon_{t+1}$) produces statistically significant coefficient estimates ($\beta = 1$) and ($a = 0$). The latter, ($a = 0$), is of less interest and is rarely discussed in related articles.

H_1: Statistically significant $\beta = 1$ and $a = 0$ from Fama regression for forward rate with maturity (i=1-, 3-, 6-, 12-months)

The null hypothesis is tested for the aforementioned time horizons separately with currencies exhibited in the following section. If the null is accepted for any maturity it implies that the forward quote in question consistently forecasts the future spot rate accurately. Even if this hypothesis would be rejected the beta estimate can give valuable information in comparison to vast existing literature. For instance, a negative coefficient estimate implies not only a strong bias but also a systematic tendency of an increase in forward premium to be followed by a decline in exchange and vice versa. The literature usually measures the extent of forward rate or interest rate differential bias with the magnitude and the sign of the beta. In practice, the greater the difference of the estimated beta coefficient from unity, which is proposed by the null hypothesis, the greater the bias.

H_2: β is closer to unity for longer maturity contracts: 12-months in comparison to 1-month.

The second hypothesis tested assumes that the beta approaches unity when the time horizon is extended up to one year. Hence, it tests the time horizon effect of the uncovered interest rate parity that frequently has been found to produce promising results in the advanced economies (Snaith, Coakley and Kellard 2013; Lothian and Wu, 2011). Related studies focusing on emerging markets have found concurring results, although such studies are remarkably limited (Sarmidi and Norlida, 2011). Consequently, in line with existing studies the beta is estimated to approach unity, although, not necessarily reach it. A growing discrepancy from ($\beta = 1$), on the other hand, would be suggestive of escalating bias and a clearer rejection of the uncovered interest rate parity. The maturity is restricted to 12-months in this hypothesis. The subsequent horizons are not examined with regression for two reasons: The data overlap is concluded to distort findings excessively if multiple years would be measured on a monthly interval and because the descriptive examination of the longer time periods allows for more detailed discussion. As Snaith, Coakley and Kellard (2013) argue, the Newey-West regression is not a comprehensive response to the overlapping sample issue.

H_3: Forward rate biasedness disappears at distant time horizons: from one to five years.

The third hypothesis is similar to the second one but it is formulated slightly different given the difference in methodology employed. When the time horizon is extended further from the 12-months to include five years, the methodology is changed from the Fama regression specification to graphical a depiction of forward prediction error or forward rate bias. Here, the bias is measured in exchange rate terms with the difference between the future exchange rate and a forward rate committed to in a previous period: ($f_t^i - s_{t+i}$). This examination is analogous to the original Fama regression, ($s_{t+i} = \alpha + \beta\left(f_t^i\right) + \varepsilon_{t+1}$), in that if the unbiasedness in this regression holds, then ($\beta = 1$) and ($a = 0$) resulting in ($s_{t+i} = f_t^i$) which implies a zero forward prediction error: ($f_t^i - s_{t+i} = 0$). Hence, if the unbiasedness disappears along with time horizon or the bias was to decrease, the variable values of ($f_t^i - s_{t+i}$) would approach zero.

The choice of utilizing a more simplified approach in terms of econometric complexity was a deliberate one to achieve additional objectives set for this study. The varying statistical issues related to regressing a potentially long-memory, low volatility, forward premium with a difference-stationary exchange rate may be neglected. Subsequently in this thesis, especially the low variance of the forward premium will be assumed somewhat impair the regression model. In addition, measuring the prediction error gives directly information on the profitability of the forward rates. The unique possibility to even analyse such a hypothesis stems from the exceptionally high interest rate differentials and the historical tendencies and trends assumed to characterize the emerging market currencies. The hypothesis 4 below elaborates this line of thought.

H_4: The forward bias grows substantially when the time horizon is extended from one to five years to the extent that the five year forward bias is one-sided and positive, implying that the five year forward rate is a systematically upwards biased predictor of future exchange rate.

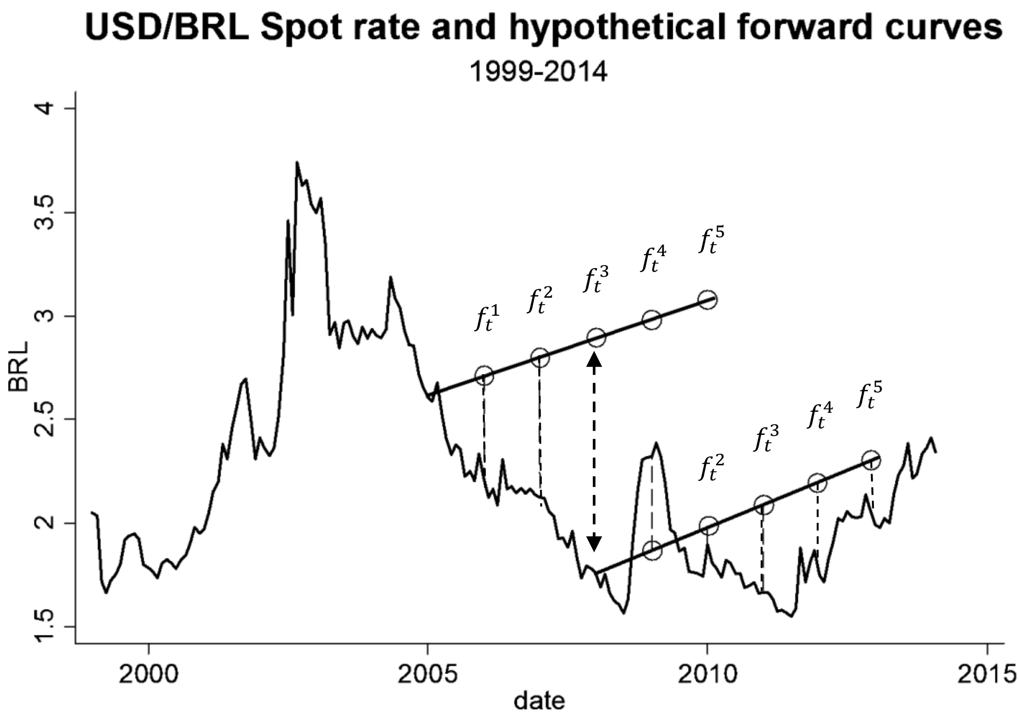
The final and fourth hypothesis studies whether the forward bias is sufficiently substantial and systematic that the prediction becomes positive consistently when the forward maturity is increased from one to five years. The only maturities explored in detail are one and five years because this method of graphical inspection requires sufficiently clear findings. This hypothesis is tested in conjunction with the hypothesis 3 which measures the forward prediction error as means to measure the forward unbiasedness at distant time horizons of one and five years. The hypothesis 4 is in a way contradictive to hypothesis 3, because it assumes that long term forward rates are actually systematically and one-sidedly biased, which means that the forward rates are assumed to predict the future exchange rate incorrectly and consistently upwards. This presumption is based on the essential characteristics of emerging market currencies.

The emerging economies allow to test such hypothesis since they are well-known to have substantial interest rate differentials against developed economies, which is a fundamental difference to exchange rates that consist of only major currencies. The direct reason for the interest rate differential is that emerging market currencies have exceptionally high interest rates and, in comparison, the interest rates for advanced economies have been historically insignificant (Lothian and Wu, 2011). The interest rate differential is equal to the forward premium assuming covered interest rate parity (Engel, 1996). Consequently, in this setting, the forward rates are substantially larger than the current exchange rates. The unusually high forward rates together with the presumed or perhaps even well-known tendency of the exchange rates to fall, inspired to construct the hypothesis 4. When the time horizon is extended sufficiently, the spot rate is expected to always end up in a smaller value than the forward contract, even if at shorter maturities this hypothesis would not materialize. The short-horizon failure of the hypothesis 4 is actually a presumption given the emerging market currency specific high volatility and sudden market movements. Hence, the longer the maturity of the derivative, the higher the probability of it ending up consistently higher than the exchange rate.

Figure 2 illustrates the foundation for the hypothesis 4. It plots the historical USD/BRL spot rate for the sample period and two completely hypothetical forward curves are drawn. The forward curves consist of five annual forward rates from one to five years. The key take-away is to understand the above contemplations in conjunction with the figure: If the exchange rate is on a trend of descending, committing to forward rate for multiple years, trading at a substantial premium, creates a high-probability of the forward rate to be higher than the future exchange rate. This, furthermore, implies a significant profitability impact. The relation between profitability or costliness and the forward bias is elaborated in methodology section. In addition, the construction of five year forward rates are discussed and presented in the methodology section because the five year forward rate used is synthetic instead of an actual OTC quote.

Figure 2: Basis for hypothesis 4: USD/BRL rate and hypothetical forward rates

Figure 2 shows the actual historical USD/BRL exchange rate during the sample time line from 1999-2014. In addition there are two theoretical forward rate lines starting in 2005 and 2008 respectively. They illustrate the difference between committing to one, two… or five year forward rates: marked similarly rest of this paper as ($f_t^{1,2\dots5}$), where the superscript denotes the maturity in years. The dashed lines are the differences to current spot market, i.e. the forward rate prediction error or the profitability compared to an unhedged position in the spot market. The point is to show that the substantial forward premiums in conjunction with the trend of exchange rate decline, may result in highly costly commitments, as in the case of the first forward curve initiated at 2005. The profitability or costliness is of course a two-way road, depending on the entity's exposure. The forward curves are not based on actual data and the underlying actual forward curve may or may not be as linear as depicted below.



In the next section, the data set and methodologies are discussed. Methodology part is dominated by the equations presented in this hypothesis section, although, also additional tests will be carried out. Data set, its properties and justification of all choices are described. Data and methodology chapter will be followed by a results section that goes through the empirical findings and compares them to abovementioned hypotheses. Will a substantial positive forward bias materialize on the one or five year maturity in emerging market currencies as is assumed in hypothesis 4? Or is the time horizon effect similar to what has been found in the advanced economies; systematically better performance of the UIP along with extending the time horizon, as stated by hypotheses 2 and 3?

4 Data and methodology

The sample data set and methodologies are presented below. The sample currencies are described in terms of data availability and foreign exchange market characteristics. Following the breakdown and comparison of currencies, the statistical properties of the spot and forward rates are presented. Their standard deviations, mean values and unit root properties are tested and the impact of the results on the feasibility of running a regression model are discussed. The data section will be frequently re-examined when the findings are discussed, in particular, the different sizes of the forward premiums among the sample currencies and the overall imperfectness of each market. The methodology section 4.2 presents the Newey-West regression selected to be employed for the short-term data as well as the forward rate forecast error which is plotted for the long-term data.

4.1 Data

First, the sample data set is described in broad terms taking into consideration the countries selected, data availability, market imperfections and monetary policies. The rationale is to understand how the exchange rates might develop or behave in relation to their foreign exchange market functionality. Furthermore, this part of the coverage is in particular useful regarding the long-term UIP findings which is a descriptive examination in nature, involving substantial target market analysis and contemplation. The second part of the data section considers the statistical properties of the variables of the Fama regression. Areas of focus include variables' mean values, standard deviations and stationarity characteristics.

4.1.1 Sample data set description

The decision is to use monthly data for ten different currencies with a common base currency the US dollar implying a quotation USD/emerging market currency. The countries chosen are Chile, Brazil and Mexico (South- and Central America), Czech Republic, South Africa and Turkey (EMEA[20]) , India, Indonesia and South Korea (Asia) and Russia. The countries were selected to get a geographically diverse group, as much data as possible and as little regulated as possible in the context of developing countries. The selection process was conducted by going through lists of countries classified as emerging[21], narrowing down to ones with as liberal exchange rate policy as possible and, finally, to check for data availability of both exchange rate and forward points in the Bloomberg terminal. E.g. China was excluded because yuan's slim fluctuation band and Peru given the scarcity of data. The data availability was especially exclusive because OTC forward data is not well available

[20] EMEA stands for Europe, the Middle East and Africa.
[21] MSCI emerging markets index, Nordea emerging markets fact book 2013 and Bloomberg list for "Best Emerging Markets Countries 2014".

for the emerging economies. Furthermore, the limited number of currencies is efficient for a thorough analysis of an unknown area.

The sample is described in table 1. The functionality of each currency is evaluated on three categories; the restrictions of forward market, general foreign exchange regime and the central bank objectives. If the forward market is restricted, the foreign exchange market is split into two, the offshore and onshore market. The offshore market is for forward contracts called the non-deliverable forward market (NDF) which means that these forwards have a cash settlement instead of a physical delivery (Doukas and Zhang, 2013). In practice, the cash settlement implies that the NDF is settled only in one currency which would be e.g. US dollar if the NDF was made for US dollar and South Korean won. The existence of the NDF market is based on the desire of offshore investors to hedge or speculate in a forward market but the local alternative is restricted by capital controls, currency convertibility restrictions or there is a lack of liquidity in the domestic market (Doukas and Zhang, 2013; Park, 2001). Hence, even the covered interest rate parity might not hold in these markets if the domestic risk-free investments are not available for foreign investors given market restrictions (Doukas and Zhang, 2013). Therefore, the forward point data used in this research, which is preferred over the alternative of actual interest rate data, is highly suitable for the purposes of examining the unbiased forward rate hypothesis.

The other two categories of market imperfections, in addition to the tradability of forward contracts, are the current foreign exchange regime and the monetary policy to the extent that what are the objectives and authorizations of the central or reserve bank. The foreign exchange regimes can be divided into floating, fixed and a managed float. An exchange rate is conventionally considered as fixed, if the bilateral exchange rate stays within +/- 2% band during a calendar year (Tamgac, 2013). The managed float, however, often has a predetermined band within which the exchange rate is let fluctuate but the band is broader than for the fixed regimes (Tamgac, 2013). Alternatively, the central bank may apply a managed float by controlling the currency's volatility with no pre-specified range of allowed values. The currencies in this sample are mostly floating which implies a free determination of exchange rate by the market forces. The final category is the monetary policy of each market because it differentiates the floating regimes from one another; is the currency truly freely determined or does the central bank intervene the markets regardless of the stated floating regime?

Table 1: FX market imperfections in sample countries and data set description

This table reports countries for which exchange rate data is used, respective currency codes, data availability and monetary policies. USD is the base (or numerator) currency for all FX quotes. Rates - column shows the maturities of forward rates in sample per currency where 1-12M implies 1, 3, 6 and 12 months. The next column (N) shows number of observations for each maturity, meaning there is an equivalent number of observations for each term per currency. In tradability column "forwards" marks regular forward market. NDF is an abbreviation of non-deliverable forward market: Offshore/foreign investors cannot move or receive the currency. NDF is thus a more restricted and frictional market. In the FX regime column "floating" means a fully market determined rate whereas "managed float" is either a policy of volatility reduction or a predetermined fluctuation band against certain currency. "CB" stands for central bank. Data retrieved from Nordea emerging markets fact book 2013 and central banks' websites.

Country	Currency	Code	Rates	N	Period	Tradability	FX regime	Central bank objectives and authority
Brazil	Real	BRL	1-12M	139	2000-2014	NDF	Floating	CB actively intervenes in both spot and forward markets
Chile	Peso	CLP	1-12M	182	1999-2014	NDF	Floating	CB has the option to intervene. Main goals: Protect the value of peso and inflation.
Czech Republic	Koruna	CZK	1-12M	181	1999-2014	Forwards	Floating	Primary objective is price stability, controlled with key interest rates.
India	Rupee	INR	1-12M	182	1999-2014	NDF	Managed Float	Market determined exchange rate but interventions occur in order to smooth volatility.
Indonesia	Rupiah	IDR	1-12M	172	1999-2014	NDF	Managed Float	One single overarching objective: to establish and maintain rupiah stability.
Mexico	Peso	MXN	1-12M	182	1999-2014	Forwards	Floating	Exchange rate is determined freely in the markets without authority intervention.
Russia	Ruble	RUB	1-12M	152	2001-2014	Forwards	Managed Float vs. currency	Basket (USD 50.5. EUR 0.45), floating in corridor RUB 32.0 - 39.0.
South Africa	Rand	ZAR	1-12M	182	1999-2014	Forwards	Floating	Inflation in the range of 3 - 6%.
South Korea	Won	KRW	1-12M	182	1999-2014	NDF	Floating	Inflation target main objective. Despite floating rate, active CB interventions.
Turkey	Lira	TRY	1-12M	182	1999-2014	Forwards	Floating	Price and financial stability central goals.

The impact of these market imperfections is rather difficult to estimate before running any examinations because the forward biasedness is a function of both exchange rate as well as the size of the forward premium. Intuitively, the more frictional the markets the more biased the forward rates are assumed to turn out to be. Moreover, the study by Doukas and Zhang (2013) finds that the carry trade is more profitable, for currencies that have non-deliverable forward market against those that have regular onshore markets. Hence, the UIP is presumed to be more violated in the NDF currencies resulting in greater forward prediction errors in the long-horizon and more distant from unity beta estimates in the short-term.

Based on the table 1 it appears that the Czech koruna, Mexican peso, South African rand and Turkish lira are the most functional markets. They all have floating rates, regular forward markets and the central/reserve banks do not actively intervene the foreign exchange markets. The next most liquid markets are grouped as Brazil, Chile and South Korea since they all have a NDF market, a floating exchange rate and, despite the floating rate, a policy for the central bank that allows active interventions. In this group the exchange rate is quite freely determined by investors but the central banks do have the authority to intervene the foreign exchange market. The least functional currencies in terms of most institutional control are concluded to be India, Indonesia and Russia. These currencies have a managed float regime in addition to the non-deliverable forward market. Managed float implies more frequent interventions with predetermined target values for either exchange rate or, in most cases, volatility.

As shown above, the time period consists of observations mainly from the start of 1999 until the beginning of the year 2014 resulting in 15 years of data. The observations are end-of-month closing mid quotes for FX spot rates and forward points, retrieved from the Bloomberg Terminal. The quotes in Bloomberg are the quotes that the Bloomberg receives from financial institutions. In practice these are assumed to be well indicative of the actual rates quoted in the highly liquid interbank market as is argued by an industry expert, in an interview presented in the appendix F. The beginning of the period is relatively recent because prior to this the FX OTC forward markets have not been active for the majority of these currencies. Excluding Russia and Indonesia 1999 is the base year, selected with the criteria that in most cases it is the first operational year. In addition, this was a year, where there were quotes for *every maturity*. Mainly common time period gives flexibility and opportunities to run tests for commonalities in the time-series.

The liquidity of each currency in the OTC markets are described in table 2. Liquidity is measured with the average daily volume of all OTC instruments denoted in US dollars. The figures reported in table 2 are averages for time period 1998-2013. Given that the overall volume in the OTC marketplace has increased and that the below average volumes are computed from the whole time period, the figures in table 2 are smaller than the current liquidity of the currencies. The volume data will be compared to the results from the forward rate biasedness tests with the presumption that the least liquid currencies show most biased results for forward rates.

Table 2: Currency liquidities (average daily volume in billion USD, 1998-2013)

Table 2 reports the volume in the OTC foreign exchange for the sample currencies. The data is retrieved from the triennial central bank survey 2013 issued by the Bank for International Settlements[22]. The volume figure includes all FX instruments (spot, forward, swap, option) and is measured in billion US dollars. The currencies are ranked in terms of market volume, starting from most liquid.

Ranking	Country	Average Volume
1	Mexico	45
2	South Korea	33
3	South Africa	28
4	Russia	25
5	India	21
6	Turkey	21
7	Brazil	19
8	Czech Republic	7
9	Chile	5
10	Indonesia	4

[22] http://www.bis.org/publ/rpfx13.htm

4.1.2 Variable construction and summary details

The data is formatted suitable for the Newey-West regression in a following manner. In Bloomberg terminal the forward points are quoted in price interest points (pips), requiring them to be divided by an appropriate figure which is determined by the particular currency. These points are added to exchange rate from the same day to produce a forward quote. When appropriate, a natural logarithm is taken from both spot and forward quote. Logarithms are deployed for the regression models, whereas the long horizon studies utilize the actual, unmodified exchange rate data.

Table 3 summarizes mean and standard deviation of realized spot rate differences as well as of forward premiums. The difference between standard deviations of the variables has important implications for the interpretation of the regression model specification. The problematic feature is that the standard deviation of the exchange rate is systematically far greater than the standard deviation of the forward premium for all currencies and maturities. A similar notion has been pointed out in literature and has been occasionally concluded to lead the forward premium to follow a long-memory process with highly persistent autocorrelations (Engel, 1996). Thus, the result is worrisome already before running any examinations, because it seems unlikely that the changes in a highly volatile exchange rate could be explained by the changes in a highly stable forward premium. Interestingly, however, along with extended time horizon, the mean values for forward premiums start to achieve the values of mean change in exchange rate. Such significant mean values for the interest rate differential are concurring with the hypothesis 4 which presumed that in the emerging market currencies, the forward rates will become upwards biased predictors, when the maturity is extended sufficiently given that the premiums are assumed to become considerable, and the overall trend in the exchange rate to be in decline.

Table 3: Regression variable mean values and standard deviations

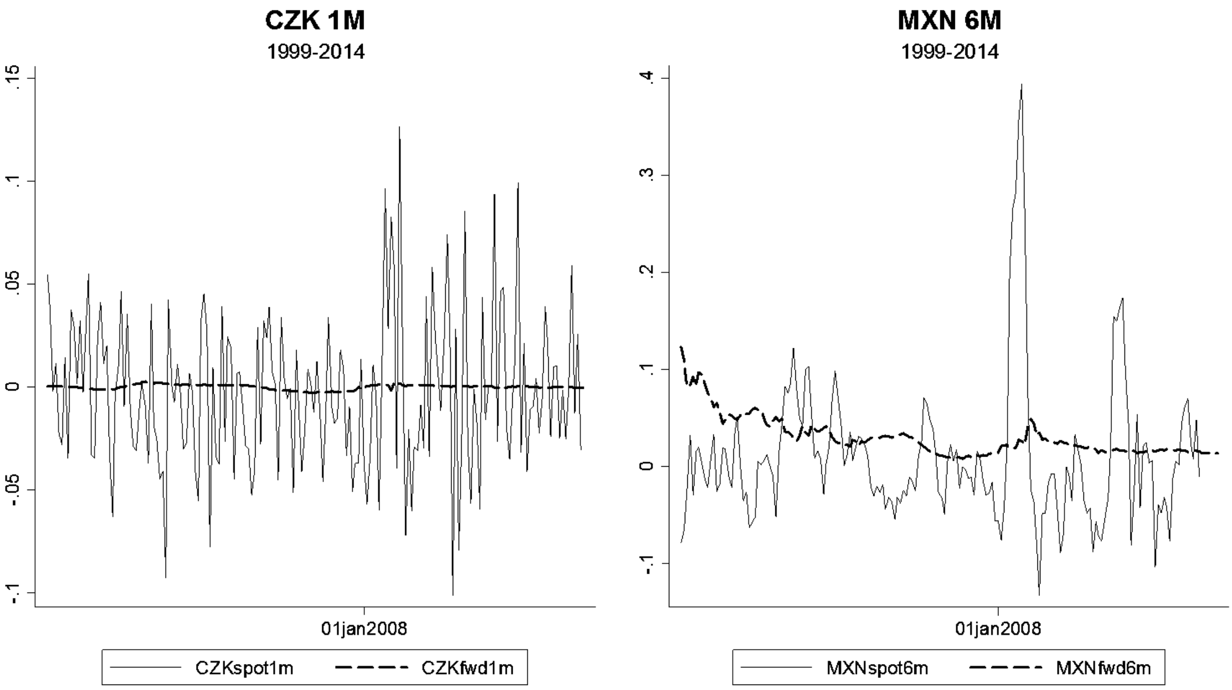
Table 3 describes the variables used in the Fama regressions, at intervals of 1- and 12-months. Maturities of 3- and 6-months are left out for the sake of clarity. The variables are logarithmic conversions of the change in spot rate $(s_{t+i} - s_t)$ and the forward premium $(f_t^i - s_t)$. The figures reported below are the mean and standard deviation for all currencies. The values appear small given the applied natural logarithm, the underlying rates and points are on a different scale.

	Variable	BRL	CLP	CZK	INR	IDR	MXN	RUB	ZAR	KRW	TRY
Mean	S_{t+1M} - S_t	0.000	0.001	-0.003	0.002	0.001	0.001	0.030	0.003	-0.001	0.010
	S_{t+12M} - S_t	0.270	0.000	-0.040	0.023	0.024	0.014	0.024	0.035	-0.006	0.109
St Dev	S_{t+1M} - S_t	0.051	0.035	0.037	0.022	0.042	0.029	0.036	0.048	0.033	0.051
	S_{t+12M} - S_t	0.430	0.116	0.122	0.087	0.126	0.181	0.074	0.180	0.116	0.228
Mean	F_t^{1M} - S_t	0.007	0.002	0.000	0.004	0.006	0.006	0.004	0.005	0.001	0.018
	F_t^{12M} - S_t	0.084	0.023	-0.001	0.035	0.068	0.038	0.051	0.059	0.007	0.202
St Dev	F_t^{1M} - S_t	0.007	0.004	0.001	0.002	0.003	0.004	0.003	0.004	0.002	0.016
	F_t^{12M} - S_t	0.033	0.019	0.013	0.021	0.031	0.015	0.009	0.021	0.012	0.173

The aforementioned finding of highly stabile forward premium and volatile spot rate is illustrated, in addition, graphically below in figure 3. Figure 3 depicts the logarithmic spot rate difference and forward premium for two currencies and terms, i.e. 1-month interval for Czech koruna and 6-month interval for Mexican peso. These were picked purely for illustrative purposes to display the difference in the magnitude of the variances of these variables. It can be observed that the CZK 1-month spot rate variable moves aggressively around zero while the changes for the forward premium are almost not visible. When the interval is extended, and the currency is substituted to MXN, the spot changes are still considerably larger in magnitude. Next the impact of the described volatility issue is discussed in terms of time-series properties of the variables. Baillie and Cho (2014) suggest that this divergence in variable variances stipulates the Fama regression to be unbalanced if the forward premium, as a consequence, has a long memory process.

Figure 3: Variable volatilities illustrated graphically

Figure 3 shows historical values of the variables $(s_{t+i} - s_t)$ and $(f_t^i - s_t)$, where i=1-month and 6-months and t=1/1999-1/2014 for the currencies Czech koruna and Mexican peso. The Czech koruna is measured on one month interval, thus the variables below are $(s_{t+1} - s_t)$ denoted with CZKspot1m and $(f_t^1 - s_t)$ denoted with CZKfwd1m. The Mexican peso is measured with the interval of 6-months, i.e. the variables are mathematically $(s_{t+6} - s_t)$ and $(f_t^6 - s_t)$. These two periods and currencies are selected purely for illustrative purposes: To show that the variance of the spot rate is clearly greater than that of the interest rate differential. The changes range roughly between -2 to 4 given the logarithmic conversion. January 2008 is marked on the x-axis to show the upcoming volatility jump.



Given the documented persistent autocorrelations in forward premium (Baillie & Bollerslev, 2000), the stationarity properties of the variables becomes of increased intrigue. However, the issue is that a regular test for unit root may lead to a false acceptation or rejection of the null hypothesis (Sakoulis, Zivot and Choi, 2010). Nevertheless, a test for unit root is conducted below but it is not given a substantial consideration. The test or unit root is carried out with a modified Dickey-Fuller test with a generalized least squares transformation (DF-GLS test). The test gives three suggestions for the optimal amount of lag operators out of which the Ng-Perron statistic is preferred, in accordance with Becketti (2013). The variables are examined for the maturities of 1-month and 12-months only, because this is concluded to be sufficient in terms of producing adequate information about the robustness of the regressions.

The results from the DG-GLS test are reported in table 4. Before running the actual tests, the variables were first depicted graphically to investigate a potential trend which needs to be included in the DF-

GLS equation if so desired. The 12-month premium in particular indicated such characteristics, which was accounted for, but did not result in significant changes in estimates. The spot rate variables were quite unanimously rejecting the unit root which is in line with the existing evidence (Engel, 1996). The forward premium, on the other hand, was more challenging to interpret. Some of the estimates changed with the inclusion of trend-term and many were not conclusive throughout the model that incorporated approximately 1-13 lag terms overall. The unit root properties were very miscellaneous because the null of unit root was particularly accepted for rearmost lag terms (10+). Yet, based on the Ng-Perron optimal lag operator, the final conclusions were made: half of the ten premiums at 1-month level rejected a unit root, including South Africa, Indonesia and Russia. Whereas for the 12-month interval only two currencies managed to reject the null of unit root. The finding of varying unit root properties for the forward premium is common in the literature likewise (Engel, 1996).

Table 4: DF-GLS test for unit root

Table 4 summarizes the unit root properties of logarithmically converted difference in exchange rate ($s_{t+i} - s_t$) and the forward premium ($f_t^i - s_t$) for the maturities of 1-month and 12-months . The test carried out is the DF-GLS i.e. Dickey-Fuller test for unit root that undergoes a GLS transformation prior the estimation of Dickey-Fuller regression. The tests for exchange rate variables have a notrend-specification because the graphical inspection indicated it is stationary around a mean instead of a linear trend. Forward premium did not denote similar characteristics, hence it was examined with the inclusion of trend term, which is a default option in the DF-GLS test. *I(0)* refers to stationary time-series and *I(1)* to stationary at first difference. The results should not be interpreted with precise scrutiny given the literature findings that the forward premium cannot be classified as a process with a constant order of integration. Furthermore, most examinations did not reject or accept the null hypothesis of unit root unanimously for all lag lengths.

Country	Exchange rate		Forward Premium	
	1M	12M	1M	12M
Brazil	*I(0)*	*I(0)*	*I(0)*	*I(I)*
Chile	*I(0)*	*I(0)*	*I(1)*	*I(I)*
Czech Republic	*I(0)*	*I(0)*	*I(0)*	*I(I)*
India	*I(0)*	*I(0)*	*I(1)*	*I(I)*
Indonesia	*I(0)*	*I(0)*	*I(0)*	*I(0)*
Mexico	*I(0)*	*I(0)*	*I(1)*	*I(I)*
Russia	*I(0)*	*I(0)*	*I(0)*	*I(I)*
South Africa	*I(0)*	*I(0)*	*I(0)*	*I(0)*
South Korea	*I(0)*	*I(0)*	*I(1)*	*I(I)*
Turkey	*I(0)*	*I(0)*	*I(1)*	*I(I)*

Per se, normally the finding of unit root in forward premium would imply that the series is non-stationary and regressing with a stationary spot rate make the Fama regression unbalanced (Baillie and Bollerslev, 2000). Furthermore, the interpretation is that the slope or beta estimates become inconsistent (Engel, 1996). This line of deduction is not encouraged for the following reasons: Historically unit root tests have produced highly variable results, the DF-GLS test presented in table 4 produced slightly inconclusive results and, finally, the forward premium has documented to have structural breaks (Engel, 1996; Baillie and Cho, 2014). Especially the latter, the structural breaks, is a strong argument against hasting into interpretations. Baillie and Cho (2014) conclude that forward premium cannot be classified as process with a constant order of integration, such as a unit root, because it actually evolves through time. Moreover, as considered in the literature review, Sakoulis, Zivot and Choi (2010) find that the standard Augmented Dickey-Fuller tests produces biased results when the structural breaks are not accounted for. They conclude that the unbiased forward rate hypothesis should not be rejected based on an ADF test and thus it is rejected in this research either.

Most of the findings above are troublesome from a regression perspective but good news for the latter section of this study which is to graphically depict and measure the forward rate bias in exchange rate terms. Both the considerable difference in variable standard deviations and the potential for unit root in the forward premium are challenging for the regression specification. As the other variable is remarkably volatile while the other experiences changes on a much smaller scale, it can be difficult to find a reasonably well fitting model. Even if the regression would produce a statistically significant slope estimate, how valid can it be because the scale of the results will probably be narrow, i.e. the horizontal axis consisting of different values of the forward premium is assumed to turn out to have a very thin range of values. From the perspective of graphical inspection of distant horizon forward rate prediction error, the low volatility of the forward premium is a rather desired property. Steady behavior in conjunction with large values presumably enable a fruitful graphical analysis.

In the next section of this research, the methodology, used for the sample described above, will be presented and commented. Firstly the short-term measurement of uncovered interest rate parity is carried out using a Newey-West regression. Secondly the long-term unbiasedness test is executed by plotting the forward rate prediction error in exchange rate terms on the sample time line. The methodology section is followed by the presentation of results and an analysis of findings linking them to existing literature as well as the notions presented in this data subchapter, ranging from the statistical properties of the forward premium to the characteristics of each foreign exchange market.

4.2 *Methodology*

The unbiased forward rate hypothesis is tested in two distinct phases similar to the two sets of hypotheses. The short horizon test is conducted with a Fama regression model that uses Newey-West (N-W) standard errors similarly to previous articles deploying an overlapping sample. The maturities of the regression variables are 1-, 3-, 6- and 12-months. Before examining the distant horizon unbiasedness, the robustness of the Newey-West regression findings is confirmed by running rolling regressions with a one month interval. Given the renowned issues with the Fama model as well as the arguably enhanced possibilities for discussion, the long-term examination is carried out by a graphical inspection of the forward bias. The distant horizon forward rates of primary focus are for one and five year maturities.

4.2.1 Newey-West regression specification

The regression is conducted is the previously mentioned Fama (1984) regression for all forward maturities and currencies. The model in this research applies the actual forward premium as the explanatory variable instead of the interest rate differential which is oftentimes used in corresponding studies. The forward rates are OTC market quotes retrieved from the Bloomberg terminal. The regression model is as follows:

$$s_{t+i} - s_t = \alpha + \beta \left(f_t^i - s_t\right) + \varepsilon_{t+i} \qquad (1)$$

Where $(s_{t+i} - s_t)$ is the difference between spot exchange rate at time *t* and *t*+*i*, where *i* is the maturity of the forward contract. $(f_t^i - s_t)$ is the forward premium or the interest rate differential of an *i* maturity forward at time *t*. β tells whether or not the latter i.e. forward premium or discount has explanatory power over the changes in a foreign exchange rate. Maturities used are common for OTC currency derivatives and they are 1-, 3-, 6- and 12-months (*i*). If the forward rate unbiasedness hypothesis holds, as described in hypothesis 1, $(\beta = 1)$ and $(\alpha = 0)$ with a statistical significance.

4.2.2 Data overlap discussed

When regressing annual forward rates on a monthly basis a moving average error process is created, which is a deliberate choice to maximize the number of observations and consequently the amount of information. Data overlap is addressed using Newey-West (1987) heteroskedastic and autocorrelation consistent (HAC) standard errors. It is a method for calculating a positive semidefinite covariance matrix that is consistent in the presence of *unknown forms* of heteroskedasticity and autocorrelation (Smith and McAleer, 1994). Also comparable academic articles frequently apply the N-W regression, whether they deploy the standard monthly horizon or extended maturities (see e.g., Snaith, Coakley and Kellard, 2013; Beber, Breedon and Buraschi, 2010; Backus, Foresi and Telmer, 2001). Snaith, Coakley and Kellard (2013) further argue that an alternative form of econometric specification, such as vector autoregression (VAR), is inadequate to test the time horizon effect because it imposes a specific model on the system under consideration which, if it is incorrectly constructed, makes result interpretation of long-run forecasts unclear. Hence, the Newey-West regression model is preferred as the methodology in the first phase of this research. However, extending the interval further appears problematic from the regression perspective. Snaith, Coakley and Kellard (2013) argue that the N-W method is not a comprehensive response to the data overlap issue. They suggest that in addition a pseudo data forming process of t-statistics would be required. Given the assumption that the data overlap would become excessive, the horizon of five years is measured with the forward prediction error instead of the Fama regression. Along with the simplified approach the additional objectives will be achieved as will be discussed subsequently in this chapter.

4.2.3 Monthly rolling regression estimation

To test whether the beta parameters estimated with the model (1) for emerging economies are consistent through time, the N-W regression is run rolling with a monthly interval. A strand of literature claim that the beta is highly time-dependent and that the negative beta estimates are mainly a product of the 1980s and the 1990s subsamples (Lothian and Wu, 2011; Baillie and Bollerslev, 2001). The N-W regression (1) is run monthly rolling for a five year window resulting in 123 rolling regressions for each country producing 123 chronological beta parameter estimates. In the first stage of regressions there were 182 observations per model, and by using monthly observations in the rolling procedure, this leaves the final five years or 60 months out. The only maturity used is the one month maturity for both forward premium and spot differential to provide a non-overlapping sample and consequently robust results.

The moving beta estimation also seeks for structural breaks which have been found to exist in the forward premiums of major currencies (Baille and Cho, 2014). A rolling regression is not perhaps the optimal method for detecting time-series breaks in the mean of the forward premium but it provides comprehensible output that is facile to compare to the beta estimates from the N-W regressions. Furthermore, an exhaustive analysis of structural breaks is slightly out of the focus of this study. The more elaborate methods to detect such breaks in mean values include a multiple mean structural break models of Bai and Perron (1998 & 2003) used both by Sakoulis, Zivot and Choi (2010) and Baille and Cho (2014). Nevertheless, the moving estimation gives information on whether the Fama regression results are robust throughout the sample, or are they only artifacts of some sub-period of the overall sample. Moreover, to graphically plot the moving regressions on the time line is potentially informative for the next section of this study; the study of distant horizon forward rate bias which also varies through time.

4.2.4 Forward prediction error for one and five year maturities

Several challenges regarding the Fama regression model as well as possibilities for alternative tests were pointed out the data and methods chapter. Even though the regression uses N-W standard errors, the comparably low volatility of the forward premium is an issue for the model specification. It is difficult to find or even presume to find a good model fit with such discrepancy in variable standard deviations. However, the steady nature of the forward premium provides productive grounds for examining the forward bias graphically. Furthermore, the emerging market currency unique high interest rate differentials were confirmed in the data subchapter, which establishes interest towards testing the effect of extending the time period further.

The distant time horizon effect is examined by plotting the forward prediction error or bias in exchange rate terms (2). The maturities presented are only one and five years to allow for a more detailed discussion.

$$f_t^i - s_{t+i} \tag{2}$$

The forward rate forecast error (2) is the difference between a forward rate (f_t^i) and the future spot rate (s_{t+i}) that the forward rate intended to forecast. The definition is directly deduced from the Fama regression, as was demonstrated in the hypothesis section. The regression model (1) explains the relationship between the difference in spot rate ($s_{t+i} - s_t$) and the forward premium ($f_t^i - s_t$). If the null hypothesis is confirmed, the slope coefficient equals one and thus on average, the variables have values in a similar magnitude ($s_{t+i} - s_t \approx f_t^i - s_t$). Hence, the unbiasedness requires that on average ($s_{t+i} \approx f_t^i$)[23]. The forward rate prediction error is a measure of forward rate bias, if the values of the forecast error are positive the forward rate for that maturity is an upwards biased predictor and vice versa.

[23] For reference, the original Fama regression took the form ($s_{t+i} = \alpha + \beta \left(f_t^i\right) + \varepsilon_{t+1}$), and was afterwards modified to the applied from to account for the first difference stationary spot rate.

I argue that the method of graphical inspection is strong because it neglects any assumption of causal relationship, in that changes in forward premium should result in similar magnitude changes in the spot rate. Such assumption is quite restrictive for the UIP because the forward premium is known to have a remarkably low variance in relation to the variance in spot rate. Thus it is even ex-ante unlikely to find a high coefficient of determination in a regression model, which would require that the variance in forward premium would explain a significant proportion of the variance in spot rate. Moreover, the potential distorting impact of structural breaks on the regression model may be neglected. The prediction error simply measures the biasedness with no intention to assume that any changes in spot rate would be actually caused or explained by the forward premium.

The avoidance of econometric issues is not yet a sufficient rationale to examine the forward bias as a simple difference between the forward rate and future exchange rate. The augmenting factor enabling such analysis is the distinct size of the forward premium in the emerging currency markets. Together with the steady behaviour of the forward premium, the method of graphical depiction becomes feasible and preferable. In particular, when extending the time horizon from one to five years, there is a high possibility that the results are graphically visible and interpretable. As was pointed out in the data chapter in table 3, already on the one year interval the average size of the forward premium appears considerable. Thus, at a five year interval, in conjunction with the presumed emerging market exchange rate decline, the forward prediction errors are expected to become consistently positive and visible.

4.2.5 The construction of the five year forward rates

There is one distinct issue with the test of the long-term uncovered interest rate parity. The five year forward rates used as variables are not actual OTC quotes of five year forward rates because data for such rates is scarcely available. Hence, the five year forward rates are synthetic or proxy in nature and they are constructed from one year forward points (forward premiums). The synthetic five year forward premiums are constructed by adding up a chronological sequence of one year forward premiums that effectively cover the period of five years, i.e. the maturity of the five year forward rate that is intended to approximate. Thus, the consequent cumulative annual forward points create a chronologically seamless proxy of a five year forward premium. Table 5 illustrates the construction of the five year forward rates.

Table 5: The construction of five year forward rates

Table 5 demonstrates the method for approximating the five year forward rates, presented in equation (3), using Brazilian real against US dollar exchange rate and forward data. It is the sum of the exchange rate at t=0 and five subsequent one year forward premiums. The forward premiums below are divided by 10 00 given the currency conventions. The illustration highlighted takes the spot rate at t=2008 and the one year premiums annually henceforth. The structure of the constructed quote covers the same period as an actual five year forward rate would have covered, which is the main criteria for selecting the method of computing cumulative sequential forward premiums. The synthetic five year rate below matures in 2013, five years from the initiation. Each five year rate is estimated five years ahead for each month.

	2008	2009	2010	2011	2012	2013
t	0	1	2	3	4	5
USD/BRL	2.1411	2.0569	1.8793	1.7143	1.895	2.3228
1y Premium	1485	1105	1178	1460	1454	1748
1y Forward	2.2896	2.1674	1.9971	1.8603	2.0404	2.4976
5y Forward						2.8093

An alternative method of approximation would have been e.g. to multiply the one year forward premium by five (above 1485 or 0.1485). However, unlike the subsequent premiums, the simple multiplication is not indicative of the risk present during the lifetime of the five year forward contract. The foremost benefit of the above described method off adding up cumulative annual premiums is that those premiums cover the exact same time period as the five year forward rate would have covered. Both an actual and the synthetic five year forward described above have the same, and only one, spot exchange rate to which the forward premiums are added (e.g. in table it is 2.1411). A question that may arise is that what is the relationship between the actual five year premium, traded on the OTC market, and the synthetic five year premium computed above? According to an industry expert, as presented in appendix F, the actual OTC five year forwards often carry an additional premium given they introduce additional accounting requirements for the financial institutions. Therefore, the deployed proxy is a prudent one.

What is beneficial about adding up the subsequent annual premiums is that such strategy is plausible to execute in the OTC foreign exchange market, effectively, to create a five year forward. Thus, the selected method of computing the cumulative premiums is not only an efficient proxy for a five year forward rate for the purposes of the empirical objectives of this study, it is also a completely plausible method of constructing a synthetic five year forward rate in the actual OTC foreign exchange market. Appendix B demonstrates the required actions to construct the artificial five year forward contract. The procedures are relatively standard for entities operating in the OTC foreign exchange market, and the aim is simply to remove the impact of the evolving exchange rate during the five year period.

$$f_t^5 = s_t + fp_t^1 + fp_{t+1}^1 + fp_{t+2}^1 + fp_{t+3}^1 + fp_{t+4}^1 \quad (3)$$

Equation (3) demonstrates how a five year forward rate is mathematically constructed. In the equation, *t* stands for time in years and the superscript stands for the maturity of the forward rate which equals one year in each case. *Fp* is used to denote forward points, or forward premium. The five year proxy is a sum of the exchange rate at time *t=0* and five subsequent one year forward points (t=0, 1, 2, 3, 4), added annually after the extraction of the spot rate. When the five one year points are added together, a forward covering a time period of five years is constructed. Thus the forward premiums create a seamless time line, equal to the maturity of an actual five year forward.

4.2.6 The forward forecast error and the impact on returns from hedging

The final benefit of the prediction error approach is that it can be utilized to estimate hedging performance. There is no separate methodology for the examination of hedging performance. Instead the returns for forwards analysed in conjunction with the findings from the long-term forecast errors given those are the exact same figures. This subchapter intends to authenticate and demonstrate the interconnectedness of a forward return and the prediction error.

All of the illustrations in this section are based on somewhat subjective assumptions on how MNCs manage their foreign exchange risk. The underlying logic is that a company knows with certainty that a cash flow, whether it is inflow or outflow, will occur on a specific date in the future. The definition of certainty over a future cash flow is of course a matter of taste but for the purposes of this demonstrative paragraph it is taken as given. If the entity in question desires the hedge the cash flow it will use a forward contract with the exact same maturity as the date of the event to lock in the exchange rate. If the cash flow denoted in foreign currency is outflow, the forward is done to buy the equal foreign currency amount from the OTC market. Thus, the foreign exchange risk caused by the introduction of a new foreign currency denominated cash flow is offset with an equal foreign currency denominated cash flow in the OTC market. The following examples use US dollar denominated cash flows to signify *foreign currency* denominated cash flow (for the MNC) because it is more illustrative, even though the foreign currency for many advanced economy based multinational companies can be considered to be the emerging market currency instead.

The forward prediction error is a direct measure of yield on an OTC forward contract, as established in the interview of Mikko Vainikka, the FX risk manager of Metso Corporation in appendix F. In the academic field, a similar definition of return can be found in carry trade studies (see e.g., Menkhoff, Sarno, Schmeling and Schrimpf, 2012; Doukas and Zhang, 2013). The connection to carry trade is that, effectively, the profit measure ($f_t^i - s_t$) can be perceived as the difference between two alternatives; to hedge with a forward rate or speculate with the future exchange rate. Either the beforehand known cash flow is committed to with a forward rate (hedge) or the future cash flow will be determined by the yet unknown future exchange rate (speculate). Thus the comparison is made to the reference point of no forward contract what so ever. What is feasible about the approach is that the future exchange rate is a plausible alternative for the forward rate. For instance, if a corporation needs to buy 1 million US dollars against Brazilian real (BRL) one month from now, it can either lock in the exchange rate with a one month forward contract or, wait for the one month to pass and then buy the dollars in the spot exchange market, with the future exchange rate.

Table 6 illustrates the relation between the forward bias (2) and the profitability of hedging (of forward contract). The presented figures will not be computed in any subsequent part of this thesis. The sole purpose is to demonstrate the interconnectedness between the employed methodology as well as practical return on foreign exchange hedging.

Table 6: The forward return and prediction error

Table 6 illustrates the connection between the forward rate bias or prediction error presented in equation (2), and the return of a forward contract. The intention is only to demonstrate the "Hedge return" as the implication of forward bias on hedging practices because the logic is used in the subsequent discussion of distant time horizon results. The main idea is that the return of a forward, or a hedge, is defined in comparison to the alternative of not having hedged at all which implies using the exchange rate at the future point of time. The calculation below illustrates the cash flow effect of a forward selling one million US dollars by the entity in question to a counterparty, either with a forward or with the future exchange rate. Against the one million US dollars used as an example, Brazilian reals are received either according to the future spot exchange rate (2.0569) or according to the one year forward rate (2.2896) committed to one year before the cash flow.

	2008	**2009**	**2010**
t	0	1	2
USD/BRL (s_t)	2.1411	2.0569	1.8793
1-year Forward ($f_t^{i=1}$)	2.2896	2.1674	1.9971
Forward bias ⇨ ($f_t^1 - s_{t+1}$) = **=Hedge return**		**0.2327**	0.2881
<u>**The cash flow effect**</u>			
USD outflow (spot/forward)		-$1 000 000	-$1 000 000
BRL inflow (USD/BRL)		2 056 900	1 879 300
BRL inflow (1y Forward)		2 289 604	2 167 390
Cost/profit of hedge BRL		**232 704**	288 090

Table 6 demonstrates how in an example situation the cash flows would realize in relation to the forward bias. As can be seen, the forward forecast error is directly usable as a profit figure if the presented logic is accepted: The profit of a forward contract can be defined as the difference to the alternative of transacting in the spot foreign exchange market in the future. The example in table 6 demonstrates cash flow effect of a forward contract that has a nominal (principal) of paying 1 million US dollars for a counterparty in the OTC market and receiving Brazilian reals in exchange. The alternative to this forward contract is to wait for the one year to pass (2008-2009) and then pay 1 million dollars and receive Brazilian reals according to the future market situation (2009).

The forward prediction error is also feasible to the opposite type of foreign exchange rate risk. If the entity in question is instead interested in committing to a forward rate with which it receives US dollars and pays with Brazilian reals, the return is exactly the inverse of the prediction error. The return framework applies to Brazilian real denominated amounts as well. It is not similarly a direct profit figure but is indicative of the size of the profit or loss. Table 7 illustrates the interpretation of the forward prediction error in different situations. As can be seen, because in each foreign exchange trade, whether its spot or forward transaction, there are always two currencies involved. Thus there is always a position effect in two currencies from making one transaction. Furthermore, the implication is that the profit figures are not, as mentioned, directly applicable to underlying amounts in both currencies of the exchange rate. The profit or loss from a forward contract, defined as the prediction error, is however indicative of the size of the profit or loss for the other currency (emerging market currency) denominated forward contracts as well.

Table 7: The connection between profitability, prediction error and hypotheses

Table 7 illustrates what is the connection between the yield of a forward, prediction error and the hypotheses set from hedging perspective. The highlighted boxes are what the hypothesis 4 expects to find: the forward bias at distant maturity is consistently positive, which implies that committing to a forward that is used to agree to sell EM currency and buy USD, is unprofitable. When analyzed from hedging perspective there is always an underlying cash flow commitment that is hedged with the forward. For a multinational company, the underlying commitment can be e.g. a receivable or payable which the company has decided to hedge beforehand. In the below example, the forward contract is made to sell EM currency and buy USD, for an exposure of -1m USD (say the company has a 1mUSD payable or other outflow occurring in the future). Thus, the impact of the action of committing to the forward contract has the foreign exchange position effect of going short in EM currency and going long in USD. An analogy to carry trade can be made that it is assumed to be profitable in the long-term as well.

	BID (LHS)	ASK (RHS)	
OTC forward agreed to: ➡	Buy emerging market currency, sell US dollars	Sell emerging market currency, buy US dollars	Nominal amount denominted in
Positive forward bias $(f_t^i - s_{t+1})>0$	Profitable: a direct profit figure	In-loss: a direct profit figure	USD
Positive forward bias $(f_t^i - s_{t+1})>0$	Profitable: not exact return	In-loss: not exact return	Emerging
Negative forward bias $(f_t^i - s_{t+1})<0$	In-loss: a direct profit figure	Profitable: a direct profit figure	USD
Negative forward bias $(f_t^i - s_{t+1})<0$	In-loss: not exact return	Profitable: not exact return	Emerging
Underlying FX position - Cash flow commitment (e.g. receivable/payable)	$1 000 000	-$1 000 000	
FX forward position effect (in cash flow)	-$1 000 000	$1 000 000	
The position effect of *committing* to a forward rate	Long in EM currency, short in USD	Short in EM currency, long in USD	

Even though it is not analysed subsequently in this thesis, the impact on cash flows of different alternatives of hedging or not to hedge may well be substantial, resulting in an impact on the operating performance of multinational companies. The theoretical framework applied for distant horizons, the measurement of forward forecast error, is interested in producing recommendations that are based on a consistent profitability of a certain maturity forward instead of modelling exact cash flows in different scenarios. As explained in the hypothesis section, one of the research questions is; does the forward bias grow, when the maturity is extended from one to five years, to such scale that the forward rate becomes consistently upwards biased predictor of future exchange rate. Such finding would imply hedges in-loss similarly as in the table 7 above. In addition to the graphical examination of forward forecast errors at distant maturities, the unbiased forward rate hypothesis is tested with the conventional Fama regression model in the following results section.

5 Results

In this section, the results from the previously illustrated models and data set are presented and discussed in correspondence to the findings from existing literature. Forward bias is first estimated for different term forward contracts with a regression using Newey-West robust standard errors, followed by rolling beta estimates on a monthly interval. The unbiased forward rate and time horizon for one and five year maturities is examined by plotting the prediction errors i.e. the forward bias in exchange rate terms. It is found that in the emerging economies, the unbiased forward rate hypothesis or uncovered interest parity is rejected, similarly to existing literature covering the advanced economies. The time horizon effect, however, is the reversal to the more established currencies as the forward bias escalates consistently along with extended maturity. The magnitude of the bias is found to increase with a rapid pace to the extent that already at a five year horizon, in most cases, the forward rate is a systematically upwards biased predictor of the future spot rate, implying forwards maturing in-loss or profit throughout the sample, depending on which currency the entity in question is buying and which selling with the forward contract (US dollar or EM currency).

5.1 Newey-West regression

The results from the Fama regression using Newey-West robust standard errors for all currencies and time horizons of 1-, 3-, 6- and 12-months are presented in table 8. For most currencies and maturities, the unbiased forward rate hypothesis is rejected in emerging economies in accordance with the existing evidence. Inspecting the one month estimates, and only the statistically significant values, shows that the beta coefficients are mostly negative, with the exception of Russian ruble. The range of significant negative beta estimates ranges from ($-0.8 \leq \beta \leq -4.0$) which can be concluded to be in similar magnitude as what has been found in previous literature for both emerging and advanced economies. In the literature review, the range of consensus beta estimates were concluded to be similarly wide because the estimates have historically varied substantially. Frankel and Poonawala (2010) suggest an average ($\beta = -4$) for advanced economies, while the survey by Froot and Thaler (1990) compute an average estimate of ($\beta =$ -0.88) over 75 studies. Also the short-term betas in Lothian and Wu's (2011) study are approximately at ($\beta =$ -0.2) for the subsample of post Bretton Woods era. Thus, in the literature review it was concluded that all slope estimates in range of ($-0.5 \leq \beta \leq -4$) are in line with the existing evidence using short-term data.

Table 8: Fama regression with Newey-West standard errors for 1-, 3-, 6- and 12-months

Results from the Fama regression model, ($s_{t+i} - s_t = \alpha + \beta\,(f_t^i - s_t) + \varepsilon_{t+i}$), are presented below. ($s_{t+i} - s_t$) is the difference between an exchange rate (spot rate) at time *t* and *i* period from *t*, in other words, the spot rate upon the maturity of the forward subtracted by the spot rate upon the initiation of the forward contract. ($f_t^i - s_t$) is the forward premium or the interest rate differential for *i* maturity forward entered at time *t*. β is the slope coefficient estimate, and *, **, *** stand for 10%, 5% and 1% significance levels respectively. SE(β) is the Newey-West robust standard error and R^2 is the coefficient of determination indicating the proportion of variance in the change of spot rate that is explained by the variance of the forward premium in question. The intercept, α values were not close to the desired zero value, thus and given the literature conventions, the alpha estimates are not redundantly presented here. Example alphas and fitted values are presented in appendix G.

	1M			3M			6M			12M		
	β	SE(β)	R^2	β	SE(β)	R^2	β	SE(β)	R^2	β	SE(β)	R^2
Brazil	0.22	0.62	0.00	-0.39*	0.23	0.01	0.14	1.05	0.00	-0.49	0.88	0.01
Chile	1.47	0.91	0.01	2.10***	0.70	0.04	2.50***	0.63	0.09	2.61***	0.59	0.18
Czech Republic	-0.18	1.97	0.00	0.09	1.38	0.00	0.45	2.09	0.00	1.36	2.03	0.02
India	0.53	0.54	0.00	1.24**	0.52	0.03	1.34**	0.67	0.06	1.31*	0.67	0.08
Indonesia	-2.04***	0.64	0.04	-2.29***	0.56	0.10	-2.59***	0.59	0.23	-2.32***	0.45	0.36
Mexico	-0.76**	0.36	0.01	-0.50*	0.3	0.01	-0.41	0.25	0.01	-0.19	0.23	0.01
Russia	1.61***	0.27	0.17	1.13***	0.33	0.13	0.18	0.28	0.00	-0.59	0.36	0.00
South Africa	-4.03***	1.35	0.03	-4.28**	1.52	0.09	-4.51**	1.38	0.15	-4.76***	1.34	0.31
South Korea	0.23	1.47	0.00	-0.97	0.96	0.01	-0.55	1.49	0.00	-1.12	1.96	0.02
Turkey	0.42*	0.22	0.02	0.49**	0.24	0.05	0.35	0.23	0.04	0.30	0.21	0.05

On the one month interval, if all the coefficients were included in the analysis, including the statistically insignificant ones, the conclusions would be different. Most of the betas that do not attain significance are positive. The exact coefficient estimates are similar to those found by Frankel and Poonwala (2010), who carry out a comparison between advanced and emerging economies for a one month maturity. The interpretation is, however, different. Frankel and Poonwala (2010) calculate an average of all beta estimates, including the insignificant ones, to arrive at a conclusion that the forward premium anomaly is less severe in the emerging markets. I argue that only the estimates attaining statistical significance should be acknowledged given the already low goodness of fit of the model indicated by the low R-squared values. Thus, in this research, the uncovered interest rate parity using the standard horizon of one month is rejected with similar values as is rejected historically for the advanced economies.

The extension of time horizon brings forth the most interesting and the most dissenting results in comparison to the academic literature. There is a moderate consensus in the literature that the uncovered interest rate parity works better when the time period is extended from the standard of one month. Both Lothian and Wu (2011) and Snaith, Coakley and Kellard (2013) as well as Chinn (2006) find that beta coefficient estimates of advanced currencies approach unity when the maturity is lengthened. Snaith, Coakley and Kellard (2013) find that the unity is reached generally at a three years interval. Regardless of the exact maturity when the unity is reached, the fundamental relationship proposed is that the UIP performs systematically better with longer horizons. The regression output in table 8 suggests a completely reversal time period effect in the emerging economies. When the time period is extended from one to twelve months, most of the betas that attain statistical significance (Chile, Indonesia and South Africa), become increasingly different from the desired value of one along with increased maturity. Thus, the forward bias becomes systematically greater along with the horizon. The coefficient for Chilean peso is positive but nevertheless the beta grows further away from the unity value which implies an increase of forward biasedness similarly to betas becoming more negative. The only outlier country is Russia which sporadically attains near unity beta estimates. Those estimates are, however, inconsistent through time and potentially highly affected by the strict managed float regime applied by the country’s central bank.

The findings in this paper are not the first evidence in the literature against the finding of decrease in forward bias along with time horizon. Bekaert, Wei and Yuhang (2007) find the uncovered interest parity to hold well for certain currencies regardless of the time horizon. Thus, implying that the UIP functions well for some of the sample exchange rates for every time horizon but that there is no difference between the beta estimates for different maturities within each currency. The aforementioned finding of this research is thus completely contradicting to the proposed point of view of Bekaert, Wei and Yuhang (2007). The unbiased forward rate hypothesis in emerging economies is found to alter as a function of maturity, with a systematic tendency of the forward bias to grow along with extended time horizon.

The result of increasing forward bias along with extended maturity in the emerging economies is intuitively appealing but the Fama regression appears to be a poorly fitting model. The R-squared ratio reported in the third column of each forward maturity shows low values as anticipated: On average the R-squared ratios are around 3% for shorter maturities. The interpretation is that the model explains only a minor proportion of changes in exchange rate suggesting, moreover, that the model employed is not well fitting to describe the underlying dynamics. Surprisingly, the coefficient of determination enhances to as high as 31% and 36% for Indonesia and South Africa for 12-month variables. Thus, it appears that the generally exercised short horizon examinations of uncovered interest rate parity are less feasible than the time horizon studies. Furthermore, appendix G illustrates this argument by presenting the fitted lines for the Indonesian rupiah with one and twelve months maturities. The issue with the standard one month models appears to be exactly what was presumed in the data and literature sections; the significantly low variance of the forward premium in comparison to the variance of the exchange rate. However, when the maturity is extended 12-months the variance of the forward premium increases comparably more, which results in better model fit measured by the R-squared and a smaller discrepancy in the scales of the explained and explanatory variables. The increase in goodness of fit along with time period, however, is substantial only for the South African rand and Indonesian rupiah.

The results from the Newey-West regression contributed to the academic literature but the regression model does not come without shortcomings. For the standard interval of one month, the forward premium anomaly is concluded to exist in the emerging economies in a similar fashion as in the advanced economies. The time horizon effect in the emerging economies is found to be completely reversal to what has been found in the advanced economies. The forward rate bias escalates along with extended maturity implying increased uncovered interest rate parity failure with the longer maturities. Next, the time period consistency of the N-W regression beta coefficient estimates is checked with the rolling regression model. In addition, breaks in the forward premium are intended to be detected.

5.2 Time-varying beta estimate: rolling regressions

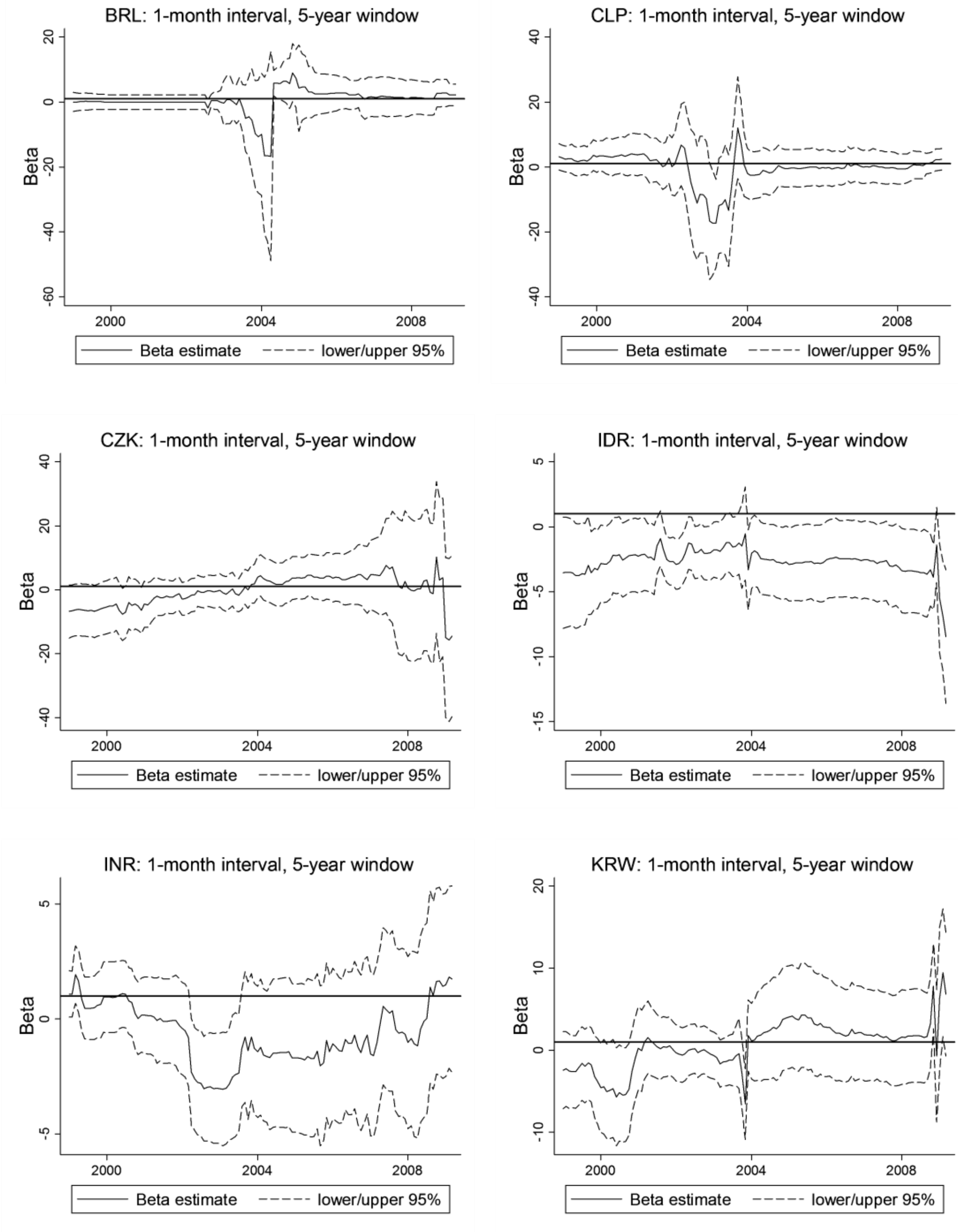
To test whether the beta estimates are consistent through time as well as to detect breaks in the mean of the one month forward premium, rolling regressions are carried out. The rationale stems from the existing literature where it has been noted that the beta estimates vary substantially through time (Lothian and Wu, 2011; Baillie and Bollerslev, 2001). Baillie and Cho (2014) further propose that, given the existence of the multiple breaks, the Fama model is only valid for specific time intervals within sample data sets. The outcome of rolling regressions is not only compared to the findings from the initial Newey-West regression but, in addition, the time varying characteristics of the forward premium anomaly will be referred to in the subsequent discussion of distant horizon forward rate biasedness which is similarly plotted on the sample time line.

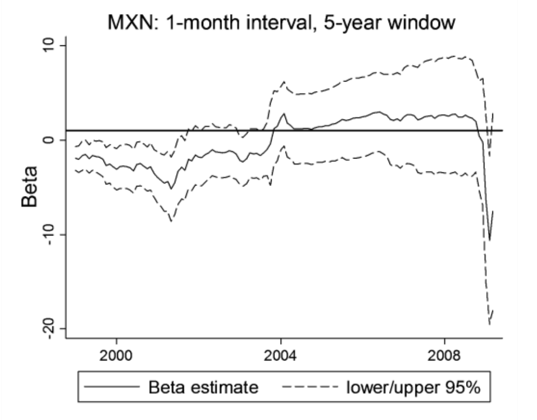
Figure 4 reports the results of the rolling regressions for all sample markets with 1-month data. In the previous section of results, it was pointed out that the statistical relationship between the Fama regression variables appears weak. The rolling regression analysis reinforces this perception: Indicative of negligible dependence between the variables, predominantly the betas fail to break zero at the 95% confidence interval, and the confidence band itself is seemingly large. Moreover, even for the currencies that achieved statistical significance in the initial N-W regression, the majority of currencies (Mexico, Russia and South Africa) fluctuate on both sides of the zero line and gaining significance only momentarily. Thus, not only does the relationship found in the Fama regressions to be weak and often biased, based on these rolling models, the statistically significant coefficients are materialized from short time periods within the sample. The only consistent currency is the Indonesian rupiah for which the beta estimates are invariability negative. Interestingly, the IDR market is also by far the least liquid as described in table 2.

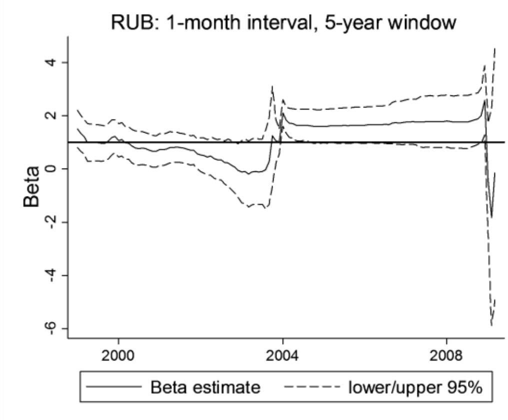
Most of the graphs in figure 4 appear to have considerable spike values, potentially indicative of time series breaks. Brazilian real and Chilean peso experience sudden and considerable changes in the beta parameters around year 2004, while the betas for the remaining currencies predominantly decline sharply around year 2008. These are only potentially breaks in the time series, because rolling regression is not an exact method of detecting breaks in the mean of the forward premium. There are nonetheless some coherence to the existing findings on the time series breaks. Sakoulis, Zivot and Choi (2010) locate one of the structural breaks in their study on the 1981-1982 US recession. Similarly, there appears to be a structural break in 2008 in the graphs in figure 4, during a recession.

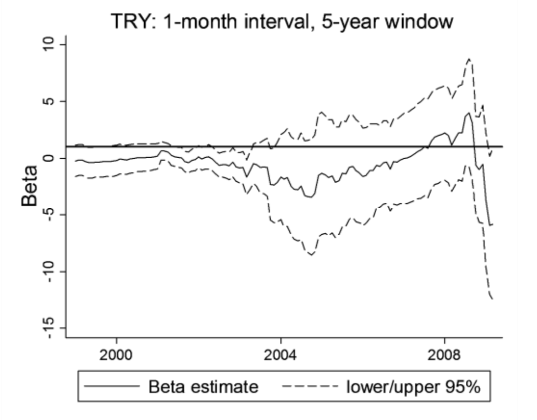
Figure 4: Rolling beta coefficient on a monthly interval for a five year window

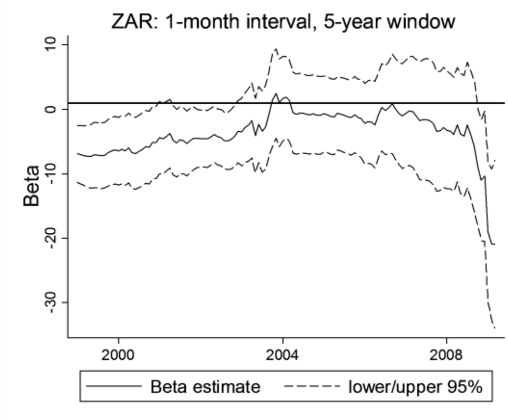
Figure 4 shows the time-varying Fama regression results. It reports the beta coefficient fluctuation through time, indicating chronological changes in forward bias and non-trivial interpretation of the standard N-W models. These equations are run explaining monthly foreign exchange rate changes ($s_{t+i} - s_t$) with one month forward premium, one month before the realized spot rate ($f_t^i - s_t$). These are logarithmic quotes. The model is estimated every month for five years ahead, resulting in 123 slope coefficient estimates.











In summary, the findings from the initial N-W regression as well as from the moving regression indicate that a regression model may not be the optimal method to investigate the unbiased forward rate hypothesis. The forward premium appears to have a disproportionately low standard deviation compared to the standard deviation of the changes in exchange rate to establish a fitting model. The steady behaviour of the forward premium appeared to result in a low goodness of fit in the regression models, since the coefficient of determination was frequently below 5%. Furthermore, the moving regressions indicated that mostly the beta parameters do not remain consistent through time. Instead the coefficients are mostly indistinguishable from zero at 95% confidence interval even if the same currency had reached statistically significant value in the intrinsic regression. The econometric issues in conjunction with the emerging market currency specific exchange rate dynamics lead to the next phase of this research; the graphical depiction of the forward bias in exchange rate terms for one and five year maturities, followed by a comprehensive discussion of the potential explaining factors. The low volatility of the forward premium is turned from a culprit of statistical interference into an advantage for the purposes of the distant horizon graphical inspection of the forward prediction error.

5.3 Unbiased forward rate hypothesis for one and five year horizons

The findings above are both interesting and concerning at the same time. It is intriguing to find that the uncovered interest rate parity has a completely novel time horizon effect in the emerging economies. Unlike has been previously proposed, the forward bias is shown to increase along with extending the maturity. The prominent finding from the advanced economies that even though the uncovered interest rate parity may not hold well on the short-term, it reinforces along with longer maturities, is definitely not materializing in the emerging market currencies. It is however slightly troublesome to draw these conclusions because the regression model appeared to fit weakly to describe the relationship between the variables, albeit the estimates of bias attained statistical significance. The most intuitive reason for the failure of the model fit is the shown low variance of the forward premium, both in the literature and in this study. From an econometric point of view it simply does not appear plausible that the extremely volatile foreign exchange rate could be explained with a forward premium that is known to behave in a highly stable manner (Maynard and Phillips, 2001; Engel, 1996). Yet, the issue of steady forward premium is advantageous for the following tests.

The final phase of this research is to test the unbiased forward rate hypothesis and time horizon in emerging economies with a graphical examination of the forward bias. The forward bias or forecast error is defined as the difference between a forward rate and the exchange rate that the forward rate intended predict ($f_t^i - s_{t+i}$). The prediction error is measured in exchange rate terms with no statistical model as such. The unbiased forward rate hypothesis is still tested because the forecast error has the same underlying variables as the Fama regression just in a simplified form[24]. If the forecast error is close to zero, the unbiased forward rate hypothesis holds well. If it is positive, the forward rate is an upwards biased predictor, and vice versa. A direct analogy to the regression model is difficult because a regression examines how the changes in the variables coexist. The measurement of bias as forecast error, though, does not take a stand on whether the changes in forward premium (which rarely occur) appear simultaneously with the changes in the exchange rate nor does it address the question that are the changes in a similar magnitude.

Two hypotheses are set for the expected behaviour of forward forecast error at longer maturities. Firstly, in hypothesis 3, it is assumed that, similarly to the hypotheses for the Newey-West regression, the forward rate bias disappears at the distant time horizons. Since the data indicated that the emerging

---

[24] The Fama regression (1984) used to take the form ($s_{t+i} = \alpha + \beta\,(f_t^i) + \varepsilon_{t+1}$), if the unbiasedness holds, then beta equals one and alpha equals zero, then ($f_t^i \approx s_{t+i}$).

market currencies appear to carry a substantial forward premium at longer maturities, hypothesis 4 is comprised substantially differently. Hypothesis 4 assumes that, on the contrary to the UIP to hold better at distant horizons, the forward rates are expected to become increasingly biased for longer maturities to such extent that the documented bias figure is consistent and one-sided. The rationales are as follows: It is presumed that the emerging market exchange rates have been historically on a declining trend and, since the premium appears to be sizable, there is a probability and grounds for the forward rate to become an upwards biased predictor of future exchange rate (see figure 2). The hypothesis is strengthened with the finding of low volatility of the forward premium; if the forward rate turns out as an upwards biased predictor, then it is likely for that phenomenon to persist because the premium component experiences considerable changes only seldom.

The forward rate maturities employed in the graphical depiction of the forward forecast error are only one and five years. The selection of one and five years is slightly arbitrary but the point is to have a sufficient time gap to achieve results that are graphically interpretable. Furthermore, the middle years (2, 3 and 4) produced similar findings, they are simply more visible in the comparison of one and five year maturities. As demonstrated in the methodology chapter, the five year rates are constructed from one year forward points. Hence, the five year rate is not an actual five year forward rate, it is a synthetic rate in that it is constructed from cumulative 12-month points. As described in methodology section in table 5, mathematically the five year forward equals the initial exchange rate and five subsequent 12-month forward points.

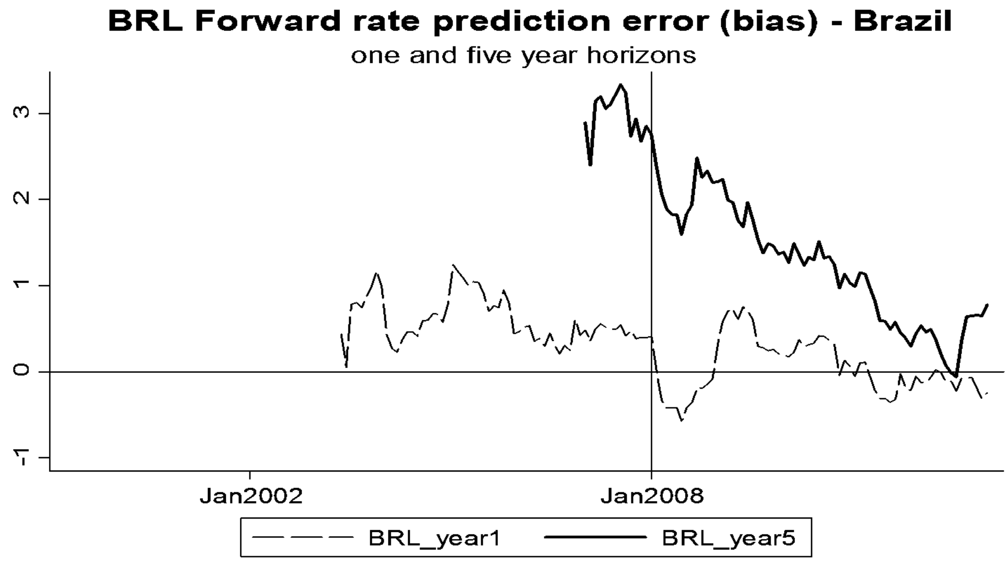
Next, the findings will be presented in three phases followed by a summary discussion. The results for the tests of long-term unbiased forward rate hypothesis are presented in three groups of sample countries. The reason is that the forward forecast error is found to behave similarly within each group but differently across the groups. The first group consists of Brazil, Czech Republic and Turkey, the second of Chile, Indonesia, Russia and South Africa and the third of India, Mexico and South Korea. For all the groups, the findings are compared to historical exchange rate graphs presented in appendix A, to the average sizes of the forward premiums presented in the data paragraph (table 3) as well as to foreign exchange market imperfections and liquidities, also introduced in the data paragraph (table 1 and 2). Following the three groups of results, a summary subchapter discusses based on the preceding contemplations, what appears to account for the findings.

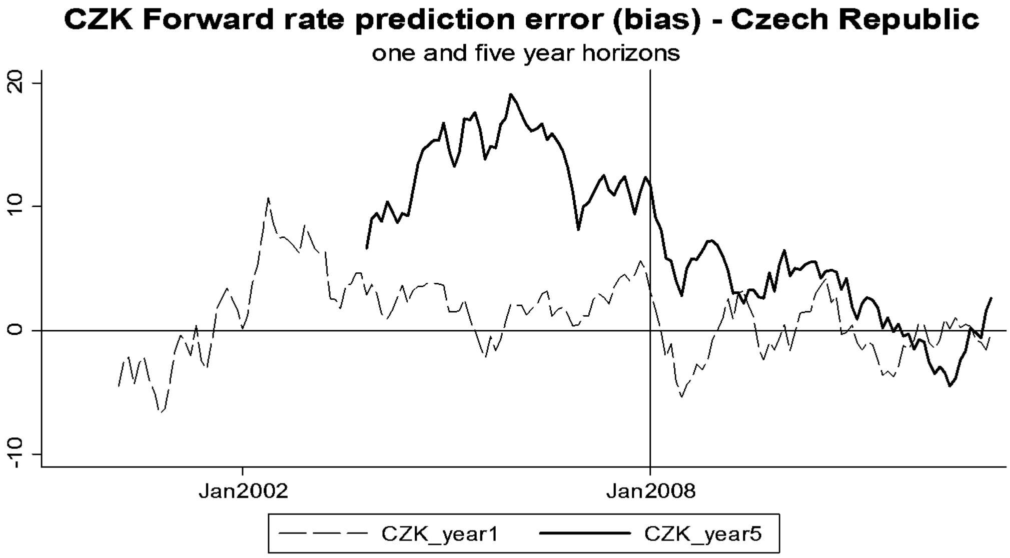
5.3.1 Long horizon UIP for Brazil, Czech Republic and Turkey

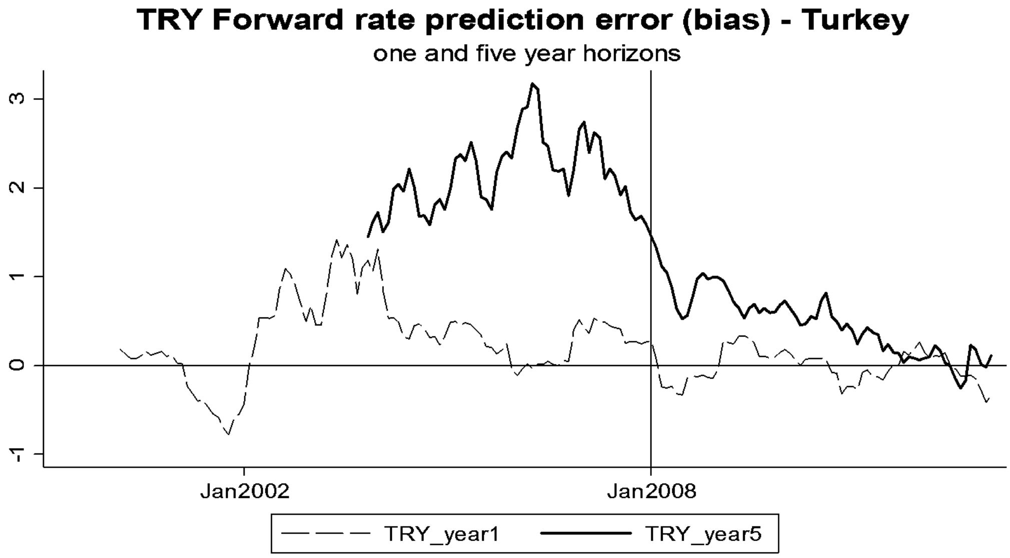
First the forward rate prediction error is presented in figure 5 for countries Brazil, Czech Republic and Turkey. The interpretation is that the unbiasedness holds at zero (horizontal reference line) and the greater the difference, the greater the bias. Analogy to bias estimated in the Fama regression is not straightforward given the difference of methods but the point of reference to forward biasedness is the literature standard, which is the difference of beta from unity.

Figure 5: UIP one and five year comparison for Brazil, Czech Republic and Turkey

Figure 5 depicts the forward rate bias or forecast error defined as $(f_t^i - s_{t+i})$ for the countries Brazil, Czech Republic and Turkey. In detail, the $(f_t^i - s_{t+i})$ measures the difference, in exchange rate terms, between the forward rate for a maturity *i* and the future spot rate that it intended to predict. Thus the spot rate is the rate realizing *i* time period away from the forward contract entry. Maturities *i* are in this case one and five years. A zero value for the forward prediction error implies it has accurately forecasted the spot rate and is thus analogous to the unbiased forward rate hypothesis examined in the regression specification previously. In the regression the extent of bias is evaluated with the sign and size of beta. From hedging perspective, the size of the forward bias is indicative of either profitable or loss-making forward rate maturity depending on which currency the entity is buying and which it is selling with the forward contract (table 7). Positive bias implies forwards winding up in loss, if the entity has agreed to sell emerging market currency and buy advanced market currency (US dollars).







For all these markets, the five year forward rates are consistently biased upwards whereas the one year rates are relatively scattered around zero. The five year prediction errors are positive and substantially larger than the one year errors throughout the sample. In addition, a common characteristic of these three currencies is the trend of reduction of the discrepancy of the five year prediction errors towards the end of the sample. The graphically visible increase in the size of the forward prediction error when the maturity is lengthened from one to five years is indicative of increase in forward bias at distant horizons. The finding in line with the conclusion from the Newey-West regression results, since the regression also showed an increase of biasedness, measured with beta, even though the above currencies did not produce statistically significant estimates. Therefore, the figures of prediction error for Brazil, Czech Republic and Turkey are also evidence against the finding from advanced economies that uncovered interest rate parity holds better for distant horizons

(Lothian and Wu, 2011). Snaith, Coakley and Kellard (2013) suggest UIP to be valid already at three years interval in advanced market currencies and a general tendency of decrease in bias, both of which are not materializing in the emerging economies based on above graphs.

There appears to be no connection between the FX market profile described in table 1 and the long-term UIP findings. In comparison of the to the market characteristics of each country, the countries above appear relatively well functional in comparison to the rest of the sample. Especially Turkey and Czech Republic are examples of unrestricted foreign exchange markets as both have floating exchange rates, regular forward markets and the main central bank objective is inflation stability. Brazil is slightly different as it has a restricted offshore forward market (NDF) and a central bank that does intervene markets, even though the FX regime is defined floating. Hence, based on this evidence the reason for the parity failure does not appear to stem from the imperfections in the foreign exchange market, because the forward bias is considerable even for these relatively unrestricted currencies.

The historical exchange rates depicted in appendix A and the differences interest rate differentials in table 3 help to explain the findings. It appears that the different size of the forward premiums in BRL, CZK and TRY has considerable impact to the existence of bias. Interestingly the Czech koruna has the sample lowest mean logarithmic annual forward premium (-0.001) and even so, the five year bias is notable. The explanation for the high prediction errors for Czech koruna stem from the historical exchange rate; it has been declining throughout the sample time line, producing the above figure. On the contrary to CZK, the sole reason for the upwards bias in the five year rate for Turkish lira is the size of the forward premium. The average forward premium is the sample highest at (0.202) and, simultaneously the exchange rate has risen during the entire sample. The lira is actually depreciating[25] heavily during the whole sample time line (from USD/TRY 0.5 to USD/TRY 2.0) and, even so, the five year rate is for the majority of the time an upwards biased predictor of future spot rate. Given the USD/TRY is increasing in value for the entire time line, the only plausible reason for the positive bias in Turkish lira is the disproportionately large forward premium.

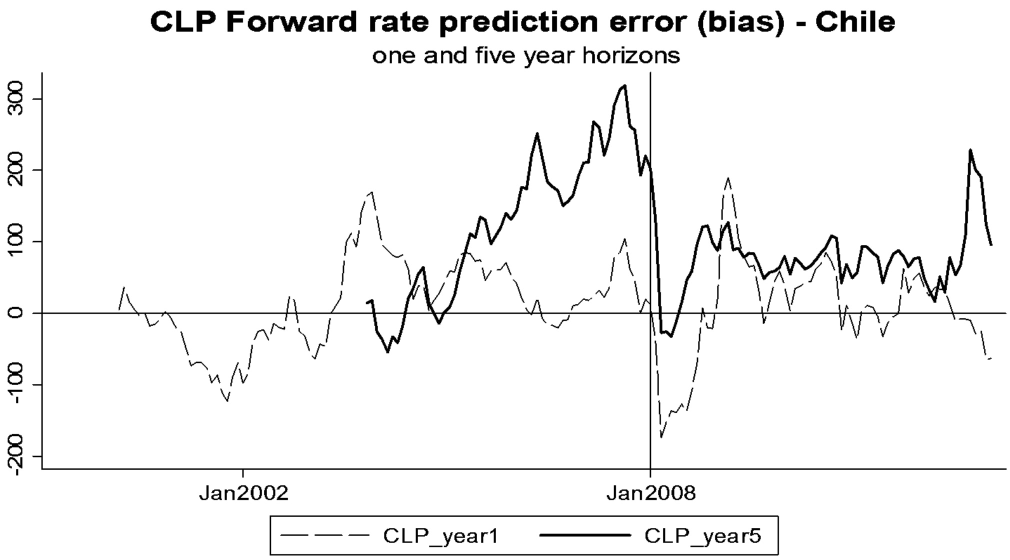
[25] Given currency quotation, depreciation of emerging market currency implies an increase in the value of the exchange rate in the historical spot rates depicted in appendix A.

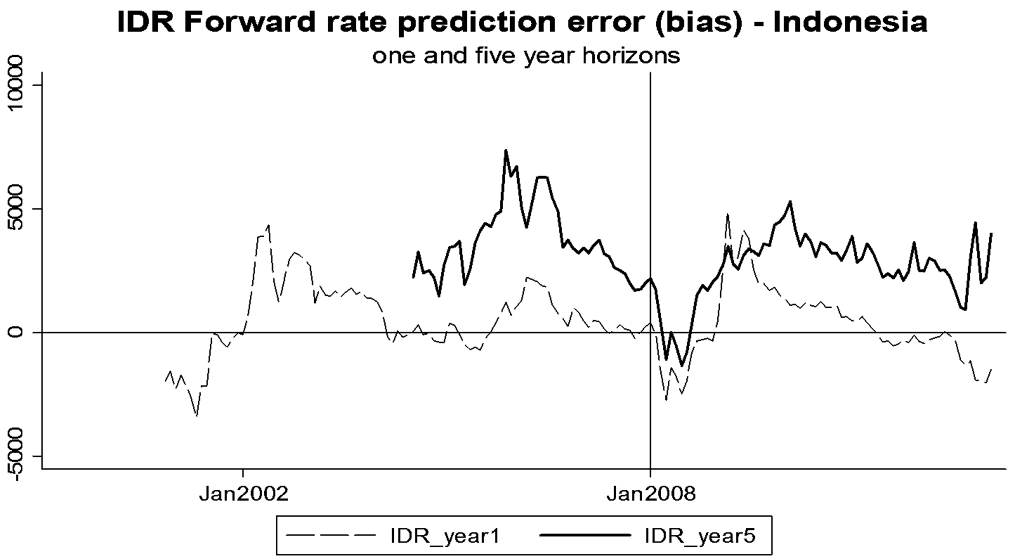
5.3.2 Long horizon UIP for Chile, Indonesia, Russia and South Africa

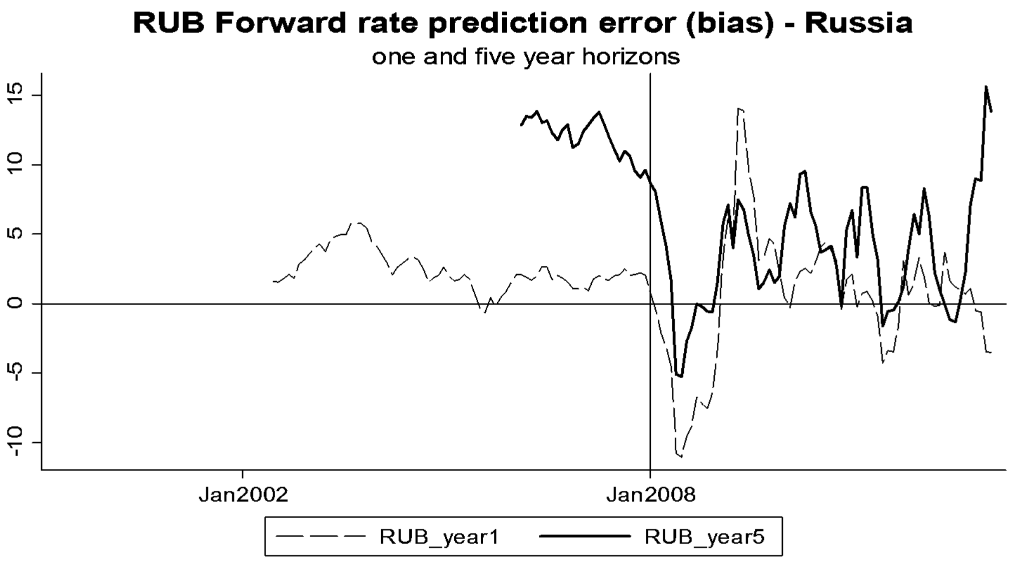
In figure 6, the distant horizon forward rate bias or forecast error is depicted for Chile, Indonesia, Russia and South Africa. For these markets, similarly to the first group, the bias is predominantly greater for the five year period compared to one year. In addition, similar is that the five year forward bias is consistently positive and the one year bias is relatively scattered around zero. The difference between these two is important. As the one year forward biases are distributed around zero, occasionally negative and occasionally positive, it implies that the one year rate does sporadically predict correctly the future spot rate and, moreover, that the bias is dispersed both upwards and downwards. Hence, there is no systematic tendency for the one year forward rate to forecast inaccurately the future spot rate as either too large or small. The five year forward rate, however, does.

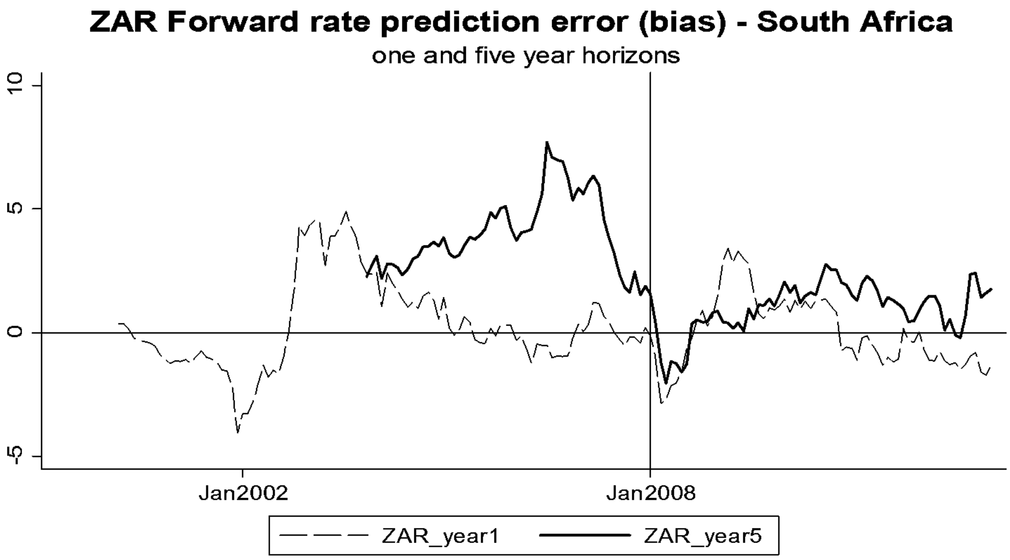
Figure 6: UIP one and five year comparison for Chile, Indonesia, Russia and South Africa

Figure 6 depicts the forward rate bias or forecast error defined as $(f_t^i - s_{t+i})$ for the countries Chile, Indonesia, Russia and South Africa. In detail, the $(f_t^i - s_{t+i})$ measures the difference, in exchange rate terms, between the forward rate for a maturity *i* and the future spot rate that it intended to predict. Thus the spot rate is the rate realizing *i* time period away from the forward contract entry. Maturities *i* are in this case one and five years. A zero value for the forward prediction error implies it has accurately forecasted the spot rate and is thus analogous to the unbiased forward rate hypothesis examined in the regression specification previously. In the regression the extent of bias is evaluated with the sign and size of beta. From hedging perspective, the size of the forward bias is indicative of either profitable or loss-making forward rate maturity depending on which currency the entity is buying and which it is selling with the forward contract (table 7). Positive bias implies forwards winding up in loss, if the entity has agreed to sell emerging market currency and buy advanced market currency (US dollars).




IDR Forward rate prediction error (bias) - Indonesia
one and five year horizons
-5000
0
5000
10000
Jan2002
Jan2008
IDR_year1
IDR_year5


RUB Forward rate prediction error (bias) - Russia
one and five year horizons
-10
-5
0
5
10
15
Jan2002
Jan2008
RUB_year1
RUB_year5


ZAR Forward rate prediction error (bias) - South Africa
one and five year horizons
-5
0
5
10
Jan2002
Jan2008
ZAR_year1
ZAR_year5

Interestingly, as for the previous group, there appears to be a clear connection between the forward bias, the historical exchange rate, presented in appendix A and mean forward premium reported in table 3. For three of the currencies, Indonesia rupiah, Russian ruble and South African rand, the five year forward bias is distinctively positive even though historically the exchange rates have been on an overall trend of increment. Consequently, the forward premium has been sufficiently large for forward rate to remain an upwards biased predictor. Moreover, as shown in appendix A, the exchange rates have experienced even quite volatile upsurges but still the five year forward bias has persisted reasonably well. Reinforcing above contemplations, the mean logarithmic 12-month interest differentials for the IDR (0.068), RUB (0.051) and ZAR (0.059) are considerable in comparison to the rest of the sample. Thus, for these currencies the exchange rates can demonstrate an increasing trend accompanied by remarkable upsurges, and still the five year forward rate remains upwards biased given the distinct interest rate differential.

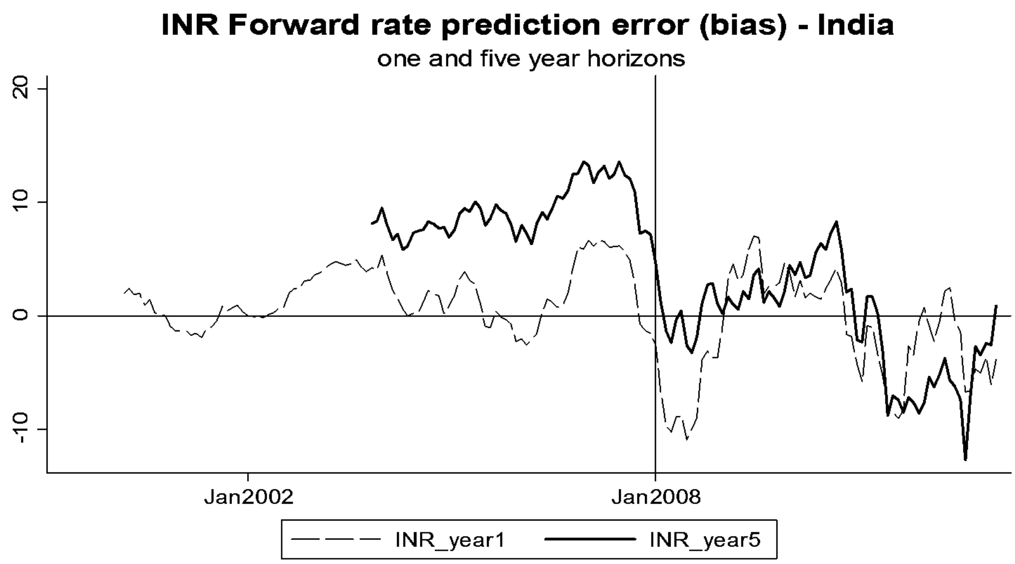
Again the foreign exchange market characteristics of the countries do not appear to explain the findings above. The Russian and Indonesian foreign exchange markets were concluded in table 1 to exercise a rigid monetary policy, whereas the Chilean and South African markets function relatively well. Nevertheless, all of them demonstrate a substantial five year forward bias. The Fama regression results, however, are well in line with the findings above. In the regressions introduced in table 8, it was noted that especially for Chile, Indonesia, Russia and South Africa, the slope coefficients drift further away from the null hypothesis of ($\beta = 1$) along with increasing the maturity from one to twelve months and they are all statistically significant. In other words, for these countries, also the regression models indicated increasingly biased forward rates along with extended time horizon, already materializing at the short-term maturities.

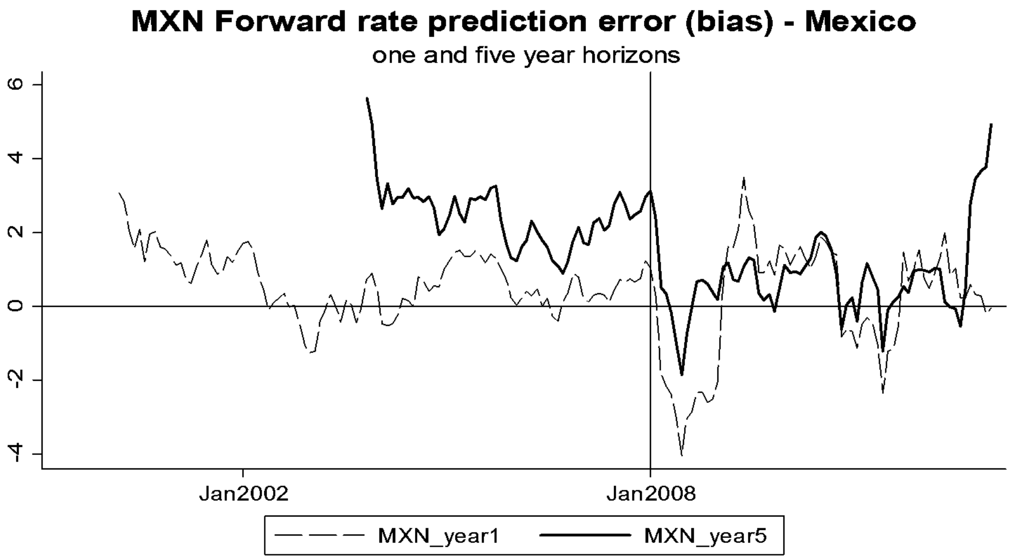
5.3.3 Long horizon UIP for India, Mexico and South Korea

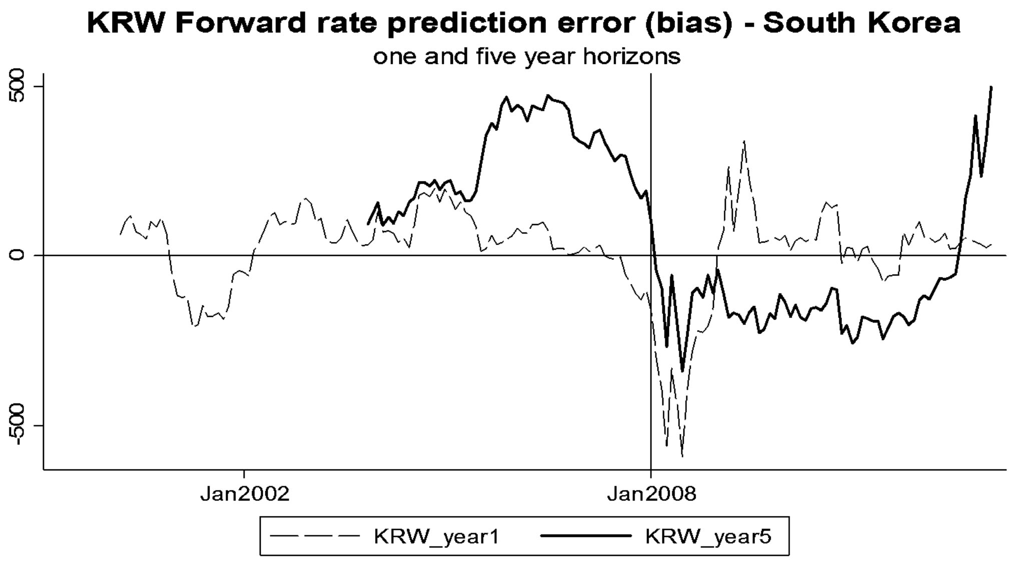
The final group consists of India, Mexico and South Korea. Figure 7 plots the forward bias. The results from this group are not equally supportive of the finding of escalating bias at distant horizons as the preceding groups are. The commonality between these markets is that the five year forward rate bias is not as evidently upwards directed and consistent than in the previous findings. For Mexican peso the bias does seem to increase from one to five years interval but the discrepancy is less unambiguous. For Indian rupee and South Korean won, the five year prediction error is not during the sample consistently biased to one direction but instead the forward rate appears to predict inaccurately the future exchange rate in both ways.

Figure 7: UIP one and five year comparison for India, Mexico and South Korea

Figure 7 depicts the forward rate bias or forecast error defined as $(f_t^i - s_{t+i})$ for the countries India, Mexico and South Korea. In detail, the $(f_t^i - s_{t+i})$ measures the difference, in exchange rate terms, between the forward rate for a maturity *i* and the future spot rate that it intended to predict. Thus the spot rate is the rate realizing *i* time period away from the forward contract entry. Maturities *i* are in this case one and five years. A zero value for the forward prediction error implies it has accurately forecasted the spot rate and is thus analogous to the unbiased forward rate hypothesis examined in the regression specification previously. In the regression the extent of bias is evaluated with the sign and size of beta. From hedging perspective, the size of the forward bias is indicative of either profitable or loss-making forward rate maturity depending on which currency the entity is buying and which it is selling with the forward contract (table 7). Positive bias implies forwards winding up in loss, if the entity has agreed to sell emerging market currency and buy advanced market currency (US dollars).







As figure 7 shows, the final group, India, Mexico and South Korea, have in common a slightly obscure impact of time horizon extension. For none of these, based on a graphical inspection, it is equally straightforward to conclude that one period dominates the other during the entire sample. Although, interestingly the five year forward bias is evidently greater than the one year bias before the year 2008 after which the results become relatively mixed.

For these currencies the average size of the forward premium is relatively small, appearing to account for the inconsistent bias. The mean one year premiums are below sample averages: Indian rupee (0.035), Mexican peso (0.038) and Korean won (0.007). In addition, the exchange rates for both rupee and peso increase in value, especially sharply after the year 2008, when also the five year bias reverses. Thus, even though the relationship between the bias, premium and exchange rate is not accurately modelled, the interpretation in consistent for the final group of results as well. For the currencies INR, KRW and MXN the forward premium does not seem to be substantially large enough to introduce a visibly consistent upwards bias for the five year forward rate, whereas in the markets of Indonesia, Russia, South Africa and Turkey, it was. Moreover, based on the historical exchange rates and the above depicted forward biases for India and Mexico, an appealing explanation is that the forward premium is not excessive enough to withhold the volatile exchange rate movements in the aftermath of the 2008 financial crisis.

For the final group, foreign exchange market liquidity and market imperfections show more association to the forward biasedness than for the first two groups. Since the five year forward bias is not consistently positive in the final group, it is concluded to represent least biased five year forward rates. As described in table 2, the Mexican peso and South Korean won are the two most liquid currencies in the sample. In addition, the Mexican peso market was determined among the least frictional currencies. The South Korean won and Indian rupee do not fit to this explanation however because both of them were defined relatively imperfect. The Indian central bank even exercises a managed float exchange rate regime. It appears that the foreign exchange market restrictions have surprisingly little impact on the forward rate biasedness results. Market volume and the size of the forward premium on the other hand are more suitable explanations to the findings.

5.3.4 Discussion of distant horizon forward biasedness

The preceding subchapters examined the hypotheses 3 and 4 by plotting the forward rate prediction error or bias on two maturities, one and five years, on the sample time line. The results were divided in three groups based on the found dynamics of the five year bias. The first group was Brazil, Czech Republic and Turkey which had in common a considerable increase in forward bias along with extending the maturity from one to five years. The five year forward bias was systematically positive during the sample while the one year biases were scattered around zero. The second group which consisted of Chile, Indonesia, Russia and South Africa, exhibited a similar escalation of forward bias. The last group comprised of India, Mexico and South Korea, did produce concurring evidence. Instead, the five and one year biases were somewhat identical with no visible systematic tendency of increasing prediction error.

Thus for the first two groups, the term effect on the unbiased forward rate hypothesis was concluded as reversal to existing evidence, i.e. escalation of bias with longer horizons instead of approaching unbiasedness. This leads to the rejection of the hypothesis 3 which stated that forward rate biasedness disappears at distant maturities. Such conclusion for the specified countries is argued given the clarity of the phenomena: the increase in forward error is consistent through time excluding only a few outliers. Hence, for the sake of the argument, there is no need to consider the variance or average of the forward biasedness at distant horizon. The current literature propose that the forward premium anomaly vanishes along with time horizon for both advanced and emerging economies (See e.g. Snaith, Coakley and Kellard, 2013; Lothian and Wu, 2011; Sarmidi and Norlida, 2011). In the previous studies, the unbiasedness is found to hold already at three years interval but regardless of the exact maturity, the existing studies suggest that the parity theory performs systematically better when the time horizon is extended (Snaith, Coakley and Kellard, 2013). There is also academic literature proposing that there is no time period sensitivity what so ever, instead a strong currency specific, time period indifferent, uncovered interest rate parity (Bekaert, Wei and Yuhang, 2007). However, none of the existing papers, to best of my knowledge, have suggested the bias to escalate along with extending the maturity. This is the contribution to the mixed line of existing findings; in the emerging economies the forward rates become increasingly biased when the time horizon is increased.

Mathematically, all of the long maturity UIP failures can be credited to one or both of the following two underlying causes: either the exchange rate has indicated a historical trend of decline (appendix A) and/or the forward premium has been excessively large for the given period (table 3). The results indicate that the relative size of the forward premium is a determinant factor of the resulting five year biasedness. For the currencies that have the highest forward premiums, Brazilian real, Indonesian rupiah, Russian ruble, South African rand and Turkish lira, the five year forward bias withholds during the entire sample time line, even though the exchange rates experience a substantial increasing trend in the aftermath of the year 2008. Concurring with the interpretation, also Indian rupiah and Mexican peso experience substantial exchange rate increase after year 2008, but for them the distant horizon forward bias disappears henceforth. A compelling explanation is that for Indian rupiah and Mexican peso the forward bias disappears because the forward premium is smaller than for BRL, IDR, RUB, ZAR and TRY. Mean premium values reported in table 3 reinforce this perception. The Czech koruna and Chilean peso also exhibit a consistently positive five year forward bias. The cause, however, appears to be assignable to historical trend of the exchange rate. The exchange rates have been declining during the majority of the sample and the average forward premiums are low. Making interpretations based on the average value of the one year forward premium is argued with frequently shown property of the forward premium to follow a highly stable behaviour. Thus the arithmetic average value is assumed to be well representative of the sample distribution. The graphs of five year forward premium for IDR, KRW, MXN and ZAR presented appendix D support the propositions above.

Overall, the market imperfections or frictions described in table 2 appeared to have little if no connection to the results. In the data section’s subchapter 4.1.1 the sample countries were divided into three categories according to their foreign exchange market restrictions. Russia and Indonesia were concluded especially frictional as they e.g. deploy a managed float regime (table 2). In addition, Brazil can be considered a relatively frictional market given the non-deliverable market and active interventions. All three exhibited substantial increase in forward rate biasedness at the five year maturity. However, currencies not entirely favouring this explanation were the Turkish lira and South African rand as the exchange rates are freely determined in the markets with no institutional intervention. Still, the forward rate bias escalation and time horizon effect were evidently present. Thus, even though there would be an endeavour for institutions to alter the way an exchange rate evolves, it appears to be the considerable forward premium that takes the blame for biasedness. Even in a fully functional market, the forward rate is consistently and substantially at such high levels that exchange rate has not achieved to attain it.

An important and plausible explanation of the findings in this study is the peso-problems, analogous to an issue of having a small sample size for an econometric study with long-run variables. The issue of peso problems is defined as low-probability high impact events not occurring in the sample. I would argue that the financial instability that began in 2008 should have or would have likely triggered any such event, as it is well known that the emerging markets have experienced several drastic sell-offs during these times that have led the EM currencies to depreciate. Nevertheless, the results are mostly consistent through the instable times as well. The suggested concrete low-probability triggers include a complete nuclear annihilation by Froot and Thaler (1990) and thus the reliability of the sample in this study gathered only from post Bretton Woods era should not be excessively questioned. Rather the argument could be targeted for those intending to extend the sample period to including the times of fixed exchange rate regimes.

Next the implication of the long-term forward bias to practical hedging of foreign exchange risk is analysed followed by concluding remarks. For the OTC foreign exchange market participants, the extent forward prediction error as well as the Newey-West regression results are of paramount interest. Not only can a multinational company hedging in the OTC markets benefit from the findings but in addition, in particular the measure of forward rate prediction error, is of pivotal importance for the financial institutions operating as the service providing dealers in the marketplace.

5.4 Hedging implications of the findings

Because the OTC foreign exchange is remarkably liquid market in terms of volume, the uncovered interest rate parity or the unbiased forward rate hypothesis does not only arise academic intrigue but also the importance of results and implications is remarkable for all the participants in the OTC FX market. Especially the measurement of the forward bias in exchange rate terms is relatively directly usable for analysing practical implications to both non-financial entities and financial institutions. On the other hand, the Fama regression results are of less practical interest, unless the model is highly functional. The conventional use of beta coefficient as a measure bias lacks a clear, applicable, connection to the practical foreign exchange OTC operations.

For the foreign exchange participants the main take-away from the Fama regression is to discover whether or not the model can be used to predict future exchange rate developments. Given the low goodness of model fit, the Newey-West regressions are not efficient forecasters of future exchange rates. As a measure of bias, as suggested in the literature of international finance, the size of the beta coefficient is in fact quite impractical. In the regression, the beta equals the estimated slope of the fitted line. The problem is that the premium experiences changes on a relatively small scale. Thus, even though the produced beta estimate is negative and significant, it only tells that the increase in the forward premium (which is small and infrequent) is associated with a decrease in the change of an exchange rate. All of the premium values may well be large and positive and all of the changes in exchange rate be negative and still produce a positive beta estimate, provided that an increase in the forward premium is associated with a change in exchange rate that is less negative. Then, according to literature practices, the forward premium would be concluded less biased than believed, even though actually the forward rates would be all the time upwards biased (see appendix G fitted lines for intuition). Only when the intercept term equals zero, the usage of beta as an estimate of biasedness is to some extent justifiable.

The long-term UIP study was carried out by measuring and depicting the forward rate prediction error defined as $(f_t^i - s_{t+i})$. In methodology section, in table 6, it was illustrated how the cash flow impact of can derived from the prediction error figure; the residual of the figure $(f_t^i - s_{t+i} = x)$, i.e. the forward prediction error itself directly can be used as a measure of hedging profitability. The theoretical premise is that a return on a forward contract can be defined as the difference between the cash flows materializing from a forward contract and the cash flows that would have, alternatively, materialized from a similar transaction carried out using the future exchange rate. Effectively, the hedging profit or loss is the comparison between the alternatives of hedging and speculating, where hedging is committing to a forward rate and speculating is waiting for the date of event and execute the trade in the future state of the foreign exchange rate market using the then real-time exchange rate. Whether a positive figure is indicative of profit or loss depends on which currency the entity in question is buying and which it is selling with the forward contract (table 7). Positive bias implies forwards winding up in loss if the entity has agreed to sell emerging market currency and buy advanced market currency (US dollars) and forwards maturing in profit if the entity is buying emerging market currency and selling USD. The connection to carry trade studies is that the foreign exchange position effect of committing to a forward contract with which is agreed to buy EM currency and sell USD is analogous to taking a speculative long position in the EM currency and short position in USD.

It is found that for the following, seven out of ten in the sample, emerging market currencies there is a consistent positive forward bias at a five year maturity: Brazilian real, Czech koruna, Turkish lira, Chilean peso, Indonesian rupiah, Russian ruble and South African rand. Historically, it has been consistently profitable to commit to forward rates that sells USD and buys EM currency while it has been systematically unprofitable to commit to forward rates that buys USD and sells EM currency. In other words, it has practically never been rationale to hedge a five year risk of that requires a forward contract of buying USD and selling EM currency. It may appear drastic to recommend to leave a foreign exchange risk exposure open and leave the return to be determined by the unknown, and highly volatile, future exchange rate. The strength of the implication, however, stems from the unanimous nature of the findings; the five year forward rate in these markets is not just on average, or for the most of time, upwards biased, it was upwards biased consistently throughout the sample time line.

The finding of the persistent upwards bias at five year horizon and consequently unprofitable hedging horizon is particularly eminent for the countries, Brazil, Turkey, Indonesia, Russia and South Africa because the reason for bias stems from the unbearably large forward premium. For these currencies there is an observable exchange rate increase simultaneously with a substantial interest rate differential. Hence, the reason for forward biasedness is not only in the exchange rate, or more explicitly in the global trend of emerging markets growth, but instead in the insupportably large forward premium that the change in the exchange rate never manages to reach. Appendix D illustrates the stable and excessive forward premium, not achieved by the changes in exchange rate. Hence, the implication of an unprofitable hedging horizon (or profitable as addressed above) is notable stronger for these countries. Given that for Chile and Czech Republic, the bias was mainly due to the overall trend of EM appreciation, a recommendation of not hedging such exposure is in future (out-of-sample) is not equally feasible because it would be effectively estimating the trend to continue, which is highly speculative.

The contemplations above are equally feasible for the comparison of one and five year horizons. For the currencies Brazilian real, Czech koruna, Turkish lira, Chilean peso, Indonesian rupiah, Russian ruble and South African rand it is found that mostly the five year forward bias is larger than the one year bias, and mostly one-sidedly positive. The one year prediction errors are mostly scattered around zero, meaning that the one year rates are neither consistently upwards nor downwards biased predictors. The five year rates, however, are and therefore the one year horizon clearly dominates the comparison when considering alternatives for hedging with a forward that buys USD and sells EM currency. An accurate estimation of an optimal hedge horizon would require some kind of utility function approach which optimizes utility in a mean-variance framework. In consideration of the conclusions in this section, however, both the mean and variance are redundant because the results are graphically visible for the entire sample.

The practical implications of the forecast error to the banking operations is a paramount. Similarly as for the non-financial counterparties, the definition of forward return is equally feasible. In addition, as presented in an interview of an industry expert in appendix F, the same forward prediction error figure $(f_t^i - s_{t+i})$ is used by banks as a measure of counterparty default loss. The reason is that if the counterparty defaults on the payment of an OTC forward (f_t^i), the financial institution needs to enter the exchange rate market upon the maturity of the forward and make a similar transaction using the current market exchange rate (s_{t+i}). Similarly to the definition of the return on a forward, the figure $(f_t^i - s_{t+i})$ equals either counterparty default loss or profit. The analysis of course includes the estimation of the probability of the counterparty default. Nevertheless, the prediction error is of great interest to financial institutions because unlike multinational companies, they have a greater variety of counterparties and therefore a greater interest for the forward bias. Without knowing the exact procedures of the financial institutions participating the OTC foreign exchange market, it is difficult to analyse the precise interconnectedness between the findings and practices.

6 Conclusions

I studied the uncovered interest rate parity (UIP) in the emerging economies, its time horizon dependence, and finally the impact of these both on the FX risk management of a multinational company that hedges its risk in the OTC forward markets. The uncovered interest rate parity, also referred to as the unbiased forward rate hypothesis, examines how well changes in the exchange rates are forecasted by the forward premium/discount. Using a sample of monthly observations for the years 1999-2014, Fama regressions with Newey-West standard errors are ran for the 1-, 3-, 6- and 12-month variables and their consistency throughout the sample is confirmed by running rolling regressions. Finally, the parity condition is examined on one and five year periods with a graphical inspection of the forward bias, an alteration of the regression variables.

The existing literature has found rather mixed results regarding the uncovered interest rate parity and the effect of extending the duration. It can be concluded that, in general, the parity does not hold in the short-term in the established currency markets while extending the period increases the performance of the theory already at an annual level (Engel, 1996; Snaith, Coakley and Kellard, 2013; Lothian and Wu, 2011; Chinn 2006). Also there is evidence of time period or sample selection conditionality in that the UIP might hold only for certain intervals within a given data set (Lothian and Wu, 2011; Baillie and Bollerslev, 2000). The emerging market currencies provide a novel spark to this old theory because they have been shown to feature completely different dynamics than the traditional exchange rates e.g. in the form of substantial interest rate differentials and the renown carry-trade (Backus, Foresi and Telmer, 2001). Counterintuitively, the literature has found less biased forward rates in the emerging economies in the short-term (Frankel and Poonwala, 2010) and parity strength already at one year horizon (Sarmidi and Norlida, 2011). These preceding studies differ in variable construction and sample size, as this paper employs OTC forward rates instead of interest rates and has up to six years of more emerging market currency data.

The findings of this study are mostly dissenting with the literature, already with the Newey-West regression model at the one month interval. The appropriate analytical process to make an overall conclusion about the forward premium anomaly in the emerging economies, is argued and selected to be the scrutiny of only statistically significant slope coefficient estimates. The coefficients attaining at least a 5% significance level on a monthly interval are Indonesia (-2.0), Mexico (-0.76), Russia (1.6) and South Africa (-4.0). The estimated bias in Russian ruble is slightly surprising, as it is not far from the desired unity value, indicating some hope to successfully model the exchange rate predictions by adding new variables to the regression such as the price of oil etc. (Rossi, 2013). The rest of the figures fall in the range of average parameter estimates from the advanced economies, i.e. in the range of $(-0.5 \leq \beta \leq -4)$, based on the existing literature (see e.g. Froot and Thaler, 1990; Engel, 1996). Thus it is argued against the prevailing evidence that the uncovered interest rate parity does not function better in the emerging economies than in the advanced economies in the short-term. The study in disagreement with these findings is the one by Frankel and Poonwala (2010) who argue the emerging economies to be less biased on a monthly interval. In fact, the exact estimates are in accordance but the disagreement arises from the interpretation of these results. They compute an average value of all slope coefficients, even the ones that are not statistically significantly different from zero to draw the conclusion of less biased forward rates in the emerging market currencies. This thought process is erroneous in my opinion, given the Fama regression's low goodness of fit (few percentages on average). When investigating only the statistically significant slope estimates, the UIP is rejected in emerging economies in accordance with the evidence from advanced economies.

Extending the time period from 1-month, to 3- and 6-months and finally to 12-months produces mainly increasingly biased beta estimates. The currencies demonstrating escalating bias, defined as the growing discrepancy from the desired unity value are Chilean peso, Indonesian rupiah, and South African rand. Also Russian ruble becomes more biased at the 6- and 12-month horizons. This finding of increasing bias along with time horizon is the main contribution of this paper. It is a completely new finding and a point of view to the existing evidence. The current suggestions for time period effect are that, along with increased maturity, the forward bias disappears and the beta coefficients become non-distinguishable from unity (Snaith, Coakley and Kellard, 2013; Lothian and Wu, 2011; Chinn, 2006) or that there is no time period effect at all, instead the uncovered interest rate parity depends on the exchange rate in question regardless of the time horizon (Bekaert, Wei and Yuhang, 2007). None of the preceding studies, however, have proposed increasingly biased forward rates along with lengthened intervals.

The econometric properties of the Fama regression variables are known to be troublesome, especially from the time series perspective. Already the sample description shows that the forward premium has a substantially lower variance than the change in exchange rate. A corresponding finding has been pointed out in the literature frequently (Engel, 1996). The problem it creates is that it is unlikely already ex-ante to find a good model fit, where the changes in the forward premium would explain the changes in the exchange rate. Unsurprisingly, the coefficients of determination for the N-W regression models are low, indicating that only a residual proportion of the variance in the exchange rate is explained by the variance in the forward premium. Furthermore, the stationarity of the forward premium may cause statistical interference to the regression. As the GL-ADF tests for unit root show, some of the forward premiums appear to have a unit root already at a monthly level. The impact on result interpretations is not drastic because a thorough investigation of time series properties would require a detection of structural breaks (Baillie and Cho, 2014). The ADF tests have actually been found to produce biased results in the existence of structural breaks (Sakoulis, Zivot and Choi, 2010). The potential time period dependence is to some degree addressed by running rolling N-W regressions.

The rolling regressions are carried out with a monthly non-overlapping data using a five year window. No substantial time period dependence is proposed to exist, since the produced running beta parameter estimates are mostly not different from zero with 95% confidence interval. However, interestingly most currencies indicate sharp changes in the slope estimates for estimation windows that include the year 2008. Thus, there appears to be a structural break in 2008, which would be in line with the study by Sakoulis, Zivot and Choi (2010) who concurringly locate a structural break at the same time as there was a recession, namely during 1981-1982 in the US. As to why it is concluded that there only appears to be a structural break in 2008 instead of stating that there is, is that the rolling regression is not a method that could directly make this kind of statement, unlike the a multiple mean structural break models of Bai and Perron (1998 & 2003). Furthermore, the way the running regression is computed always five years ahead, disables the accurate locating of the break point. Nevertheless, there appears to be a change in the dynamics of the parity relationship in 2008. The potentially altered dynamics, as well as the econometric issues and the presumable highly distinctive emerging market currency features inspired the next phase of the research; the graphical depiction of the forward bias for one and five year horizons.

A challenge with the distant horizon biasedness test is that data for five year forwards is only scarcely available for the emerging market currencies. The problem is addressed by constructing synthetic five year forward rates using one year forward premiums. The mathematical composition of the synthetic five year forward rate equals the sum of exchange rate and five subsequent one year premiums. The annual premiums cover the same time period as the actual five year forward rate would have done. The synthetic five year rate is not only an efficient proxy of the actual rate but it is also plausible to construct in the real foreign exchange OTC market. Moreover, it is a prudent proxy of the five year rate because the actual rates often carry an additional premium. Alternatively, the five year forward premium could have been approximated by simply multiplying the one year premium by five. The selection between the methods is arbitrary because the forward premium is mostly found to follow a long-memory process (Engel, 1996; Maynard and Phillips, 2001), implying that its variance is so low that it is irrelevant which method is employed; both produce coinciding results.

The final part of this research is an examination of the forward rate prediction error or bias, defined as ($f_t^i - s_{t+i}$), for the maturities of one and five years. Effectively, it is analogous to testing the unbiased forward rate hypothesis, because the forecast error is constructed from the Fama regression variables. The difference is that the econometric requirements for an effective model specification may be neglected: E.g. the lack of correlation between the variables and the low variance of the interest rate differential do not exert a statistical interference. This type of analysis is only enabled by the distinctively large forward premiums in the emerging market currencies in conjunction with presumed trend of currency appreciation, since they create the possibility that the forward bias truly is sufficiently significant to be visible from a graphical inspection. As demonstrated in the introduction, the one year interest rate differential between Brazilian real and the US dollar on annual level can easily achieve 15%, leading to the question: How biased will the forward rate become when the forward premiums are accumulated to the five year maturity?

The analysis of the forward prediction errors shows that for the majority of currencies the forward bias escalates, concurring to the N-W regression results. The forward bias escalates to such high extent that five year biases are systematically positive with practically no exceptions throughout the entire sample, whereas the one year prediction errors are mostly substantially smaller and distributed around the zero prediction error reference line. The positive bias implies that the five year forward rate has been an upwards biased predictor of the future exchange rate. The result is difficult to directly compare to the regression slope estimates. However, the finding of a five year bias that is not only consistently one-sided but also mostly greater than the one year bias in absolute terms, is an unambiguous indication of an increase of biasedness together with the extended time horizon. Interestingly, the analytical framework of simple depiction of the prediction errors provides an opportunity to find out what is the cause of the findings.

The systematically above zero five year prediction error can stem from one or both of the following factors: the exchange rate has been on a descending trend and/or the forward premium is in such magnitude that the subsequent variation in exchange rate does not matter. The analysis is straightforward: the five year forward biases are simply analysed in conjunction with the historical exchange rates and the mean forward premiums of the sample. As established frequently in this thesis, the variance of the premium is insignificant, suggesting that the average value is well indicative of the underlying distribution of forward premiums. For some currencies, it is evident that the forward premium is so low that the only factor affecting the forward rate biasedness is the difference between the two exchange rates with a five year time gap. Hence, the only cause of the parity failure is the emerging market currency appreciating trend. For some currencies the forward rates persist to be upwards biased predictors, even though the exchange rate would have ascended through the entire sample.

The most intriguing findings provided the countries Brazil, Indonesia, Russia, South Africa and Turkey. The currencies for these economies experience at least some degree of exchange rate increase and, nonetheless, the five year forward rates demonstrate a systematic upwards bias. As it happens, the Turkish lira is depreciating heavily during the entire sample (from USD/TRY 0.5 to USD/TRY 2.0). Nevertheless, the five year rates are consistently biased upwards given the remarkably large forward premium. Reinforcing this perception, also the rest of these countries have substantial mean interest rate differentials in comparison to the rest of the sample. The finding of consistent one-sided bias is already remarkable as itself because it affects the profitability of these derivatives but the additional notion that the phenomena persists even though the exchange rates would increase relatively substantially, has great impact on the interpretation of the findings. It addresses the question of how biased predictor of future exchange rate does the forward rate become given the emerging market specific, extraordinarily high, interest rate differentials. The results show that the forward premiums become so sizable at the five year interval that the exchange rate fails to attain its levels even at relatively volatile states of emerging market currency depreciation in the aftermath of the 2008 financial crisis.

The five year forward rate is found to be a consistently upwards biased predictor also for Czech koruna and Chilean peso. However dissimilarly, the main explanatory factor appears to be the historical changes in exchange rate, given the combination of a continuous exchange rate decline and nearly zero average forward premiums. As a consequence, the magnitude of the five year prediction errors in CZK and CLP is declining from high to low levels because the exchange rate has been falling during the sample. The only currencies that do not present clear evidence on behalf of increasing bias along with time horizon are Indian rupee, Mexican peso and South Korean won. They all have positive and considerable five year prediction errors before 2008 but then a strong reversal occurs. A compelling explanation is that the forward premium is not large enough to cover the exchange rate upsurge starting in 2008, while for the countries Brazil, Indonesia, Russia, South Africa and Turkey, it is. In line with this reasoning, the mean forward premiums for India, Mexico and South Korea are below sample average.

Also the local foreign exchange market restrictions and differences in the foreign exchange market volumes are compared to the diverging distant horizon biases. The regulations and market imperfections do not appear explain well the differences in the found forward biases. This is slightly surprising because for instance, Doukas and Zhang (2013) find that the countries with non-deliverable forward markets, which is one of the dimensions studied in this thesis as well, exhibit higher risk-return profiles for carry trade. There appears to be no relation between the forward biasedness and whether the currencies have non-deliverable or regular forward markets. The OTC foreign exchange market liquidities, however, appear slightly more powerful indicators of resulting biasedness. The most liquid currencies; Mexican peso and South Korean won are concluded to show least evident increase of bias at the five year horizon. In addition, Indonesian rupiah is the least liquid currency while demonstrating perhaps the most consistent and highly biased forward rates.

The five year prediction error is not only a direct measure of the unbiased forward rate hypothesis, it is also arguably an effective way of defining an OTC forward return. The prediction error is equal to the profit or loss of a forward contract (hedge) over the alternative of speculation (transaction using the future, unknown, exchange rate). The implication of the finding of systematic positive forward bias at five year maturity, is that, historically, it has practically never been profitable to hedge a five year foreign exchange risk that would have been hedged by committing to a five year forward contract with which is agreed to buy advanced market currency (US dollars) and to sell emerging market currency. It has been almost without exceptions during the sample better to speculate and leave the risk intact until the date of the event and use the then prevailing exchange rate. The outcome is drastic, it has been consistently smart to speculate and leave the faith in the hands of the unknown, and highly volatile, future exchange rate. The strength of the implication, however, stems from the unanimous nature of the findings; the five year forward rate in these markets is not just on average or for the most of time upwards biased, it is consistently throughout the sample. Therefore e.g. any mean-variance optimization is redundant for the sake of the argument.

One distinct limitation of research defines both this thesis and all other studies endeavouring the emerging market currencies; the lack of foreign exchange data. The problem created is frequently cited in the literature as peso problems, which means that small samples may fail to experience low probability and high impact events that would alter the results substantially. In favour of this research, a substantial proportion of the sample consists of observations from the turbulent post-financial crisis years starting in 2008. Instead, the argument should be pointed towards those authors intending to extend the sample excessively, for instance past the year 1973 when the exchange rates were predominantly highly controlled (Lothian, 1986). Nevertheless, only time will tell will the peso problems materialize, leading to the emerging markets currencies to depreciate substantially and persistently, thus effectively realizing the change in the exchange rate, predicted by the considerable forward premium. Until now such culmination has been far from unfolding.

There are several interesting ways of continuing the work of this thesis including the Fama regression model specification in general, simulated sample approach, structural breaks and the reason for their existence, utility function approach and the impact of horizon extension on carry trade studies. The Fama regression appeared in this research and in so many other studies ineffective as indicated by the low coefficient of determination. The Fama model could be specified so that it calculates beta coefficient as the impact of increase in forward maturity on the change in exchange rate. The current method of analyzing the effect of increase in forward premium of one maturity, often equaling one month, appears infeasible given the low volatility of the premium. Optimally, the time horizon effect would be modelled more accurately as a consequence. The low volatility of the forward premium is of paramount interest as well. When does the premium or the interest rate differential change and why? Is it due to institutional interventions, sudden changes in market sentiment or perhaps the market expectations of future exchange rate developments? The finding of structural breaks in the literature in conjunction with the low variance, lead to presume that the forward premium experiences changes infrequently but when it changes, it changes drastically. If data on central banks interventions in the spot exchange or forward market is somewhere to be found, their chronological relationship to the structural breaks could be studied.

The forward prediction error and its implications to hedging as well as speculation are also attractive areas of further study. The finding of consistent positive bias in certain markets is analogous to a consistently profitable carry trade at a five year horizon, if covered interest rate parity is assumed to hold. Therefore it would be intriguing to study further how the profitability of carry trade evolves as a function of time horizon, because according to my understanding, the carry trade studies are mostly conducted by examining returns on a monthly, short-term, horizon and with a constantly rebalanced portfolio (Menkhoff, Sarno, Schmeling and Schrimpf, 2012; Doukas and Zhang, 2013). The extension of horizon and the application of a buy and hold strategy instead of a constant rebalancing could enhance the excess returns since the findings in this research suggest that the carry trade is systematically profitable on a five year horizon in some countries of the sample. From the hedging and foreign exchange risk management perspective, a utility function approach could be employed. Taking into consideration the variance in addition to the return could be highly productive, especially for the maturities of one through five years. The five year maturity is already concluded optimal or suboptimal depending on the underlying FX exposure. Longer maturities are probably redundant to include because the conclusion regarding the five year horizon is so strong that it is not sensitive to either average or variance.

List of references

Backus, D., Foresi, S., Telmer, C., 2001. Affine tern structure models and the forward premium anomaly. Journal of Finance, Vol. 56 Issue 1, p279-304. 26p.

Bai, J., Perron, P., 1998. Estimating and testing linear models with multiple structural changes. Econometrica, 66, 47-78.

Bai, J., Perron, P., 2003. Computation and analysis of multiple structural change models. Journal of Applied Econometrics, 18-1, 1-22.

Baillie, R., Bollerslev, T., 2000. The forward premium anomaly is not as bad as you think. Journal of International Money and Finance, 19, 471–488.

Baillie, R., Cho, D., 2014. Time variation in the standard forward premium regression: some new models and tests. Journal of Empirical Finance, accepted manuscript.

Beber, A., Breedon, F., Buraschi, A., 2010. Differences in beliefs and currency risk premiums. Journal of Financial Economics, 98, 415-238.

Becketti, S., 2013. Introduction to time series using stata. Stata Press Publication.

Bekaert, G., Wei, M., Yuhang, X., 2007. Uncovered interest parity and the term structure. Journal of International Money and Finance, 26, 1038–1069.
17.

Chinn, M., D., 2006. The (partial) rehabilitation of interest rate parity in the floating era: longer horizons, alternative expectations, and emerging markets. Journal of International Money and Finance, 25, 7-21.

Clarida, R., Davis, J., Pedersen, N., 2009. Currency carry trade regimes: Beyond the Fama regression. Journal of International Money and Finance, 28, 1375-1389.

Doukas, J., Zhang, H., 2013. The performance of NDF carry trades. Journal of International Money and Finance, 36, 172-190.

Engel, C., 1996. The forward discount anomaly and the risk premium: A survey of recent evidence. Journal of Empirical Finance, 3, 123-192.

Fama, E., F., 1984. Forward and spot exchange rates. Journal of Monetary Economics, 14, 319-338.

Frankel, J., Poonawala, J., 2010. The forward market in emerging currencies: Less biased than in major currencies. Journal of International Money and Finance, 29, 585-598.

Froot, K., A., Thaler, R., H., 1990. Anomalies Foreign Exchange. Journal of Economic Perspectives, Vol 4, Issue 3, 179-192.

Kumar, S., Trück, S., 2014. Unbiasedness and risk premiums in the Indian currency futures market. Journal of International Financial Markets, Institutions and Money, 29, 12-32.

Lothian, J.,R., 1986. Real dollar exchange rates under the bretton woods and floating exchange-rate regimes. Journal of International Money and Finance, vol 5, issue 4, 429-448.

Lothian, J.,R., Wu, L., 2011. Uncovered interest-rate parity over the past two centuries. Journal of International Money and Finance, 30, 448-473.

Mark, N.C., Moh, Y.K., 2007. Official interventions and the forward premium anomaly. Journal of Empirical Finance, 14, 499-522.

Maynard, A., Phillips, P.C.B., 2001. Rethinking an old empirical puzzle: econometric evidence on the forward discount anomaly. Journal of Applied Econometrics, 16, 671–708.

Menkhoff, L., Sarno, L., Schmeling, M., Schrimpf, A., 2012. Carry trades and Global Foreign Exchange Volatility. Journal of Finance, Vol. 67 Issue 2, p681-718. 38p.

Park, J., 2001. Information flows between non-deliverable forward (NDF) and spot markets: Evidence from Korean currency. Pasific-Basin Finance Journal, 9, 363-377.

Rossi, B., 2013. Exchange rate predictability. Centre for economic policy research. Discussion Paper no. 9575, July 2013.

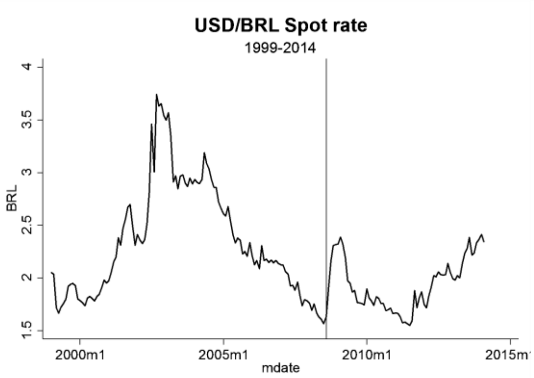
Sakoulis, G., Zivot, E., Choi, K., 2010. Structural change in the forward discount: Implications for the forward rate unbiasedness hypothesis. Journal of Empirical Finance, 17, 957-966.

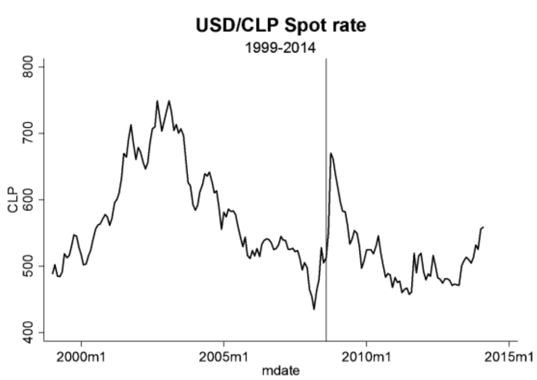
Sarmidi, T., Norlida, H., 2011. Time Horizon and Uncovered Interest Rate Parity in Emerging Economies. Asian Academy of Management Journal, Vol 16, Issue 2, 107 – 130.

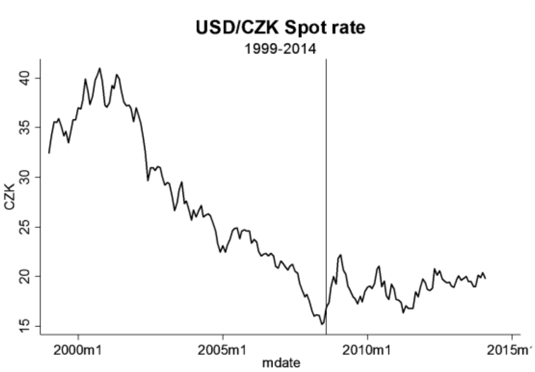
Snaith, S., Coakley, J., Kellard, N., 2013. Does the forward premium puzzle disappear over the horizon? Journal of Banking and Finance, 37, 3681-3693.

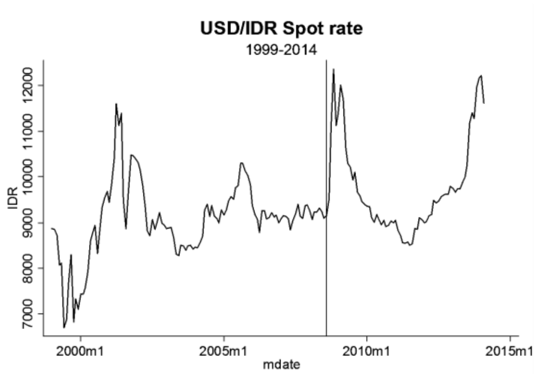
Tamgac, U., 2013. Duration of fixed exchange rate regimes in emerging economies. Journal of International Money and Finance, 37, 439-467.

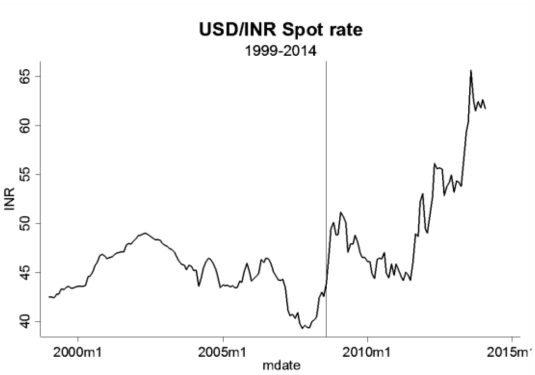
Appendix A: Sample exchange rates

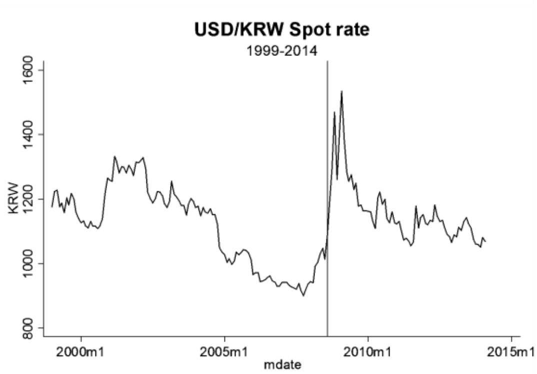


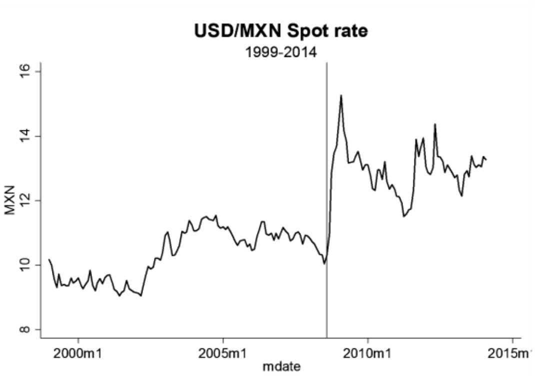


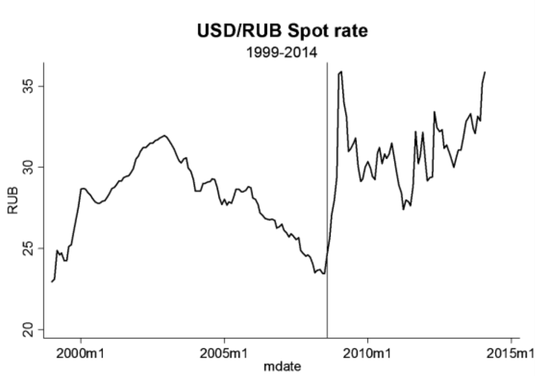


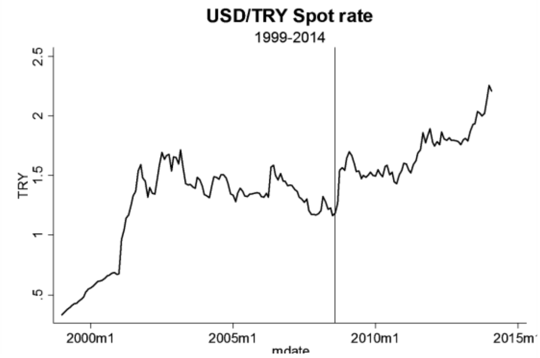


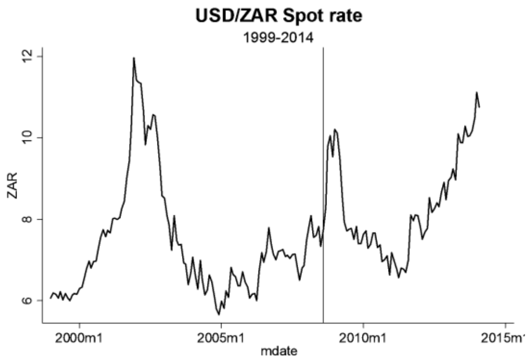









USD/TRY Spot rate
1999-2014
TRY
2.5
2
1.5
1
.5
2000m1
2005m1
2010m1
mdate


USD/ZAR Spot rate
1999-2014
ZAR
12
10
8
6
2000m1
2005m1
2010m1
mdate

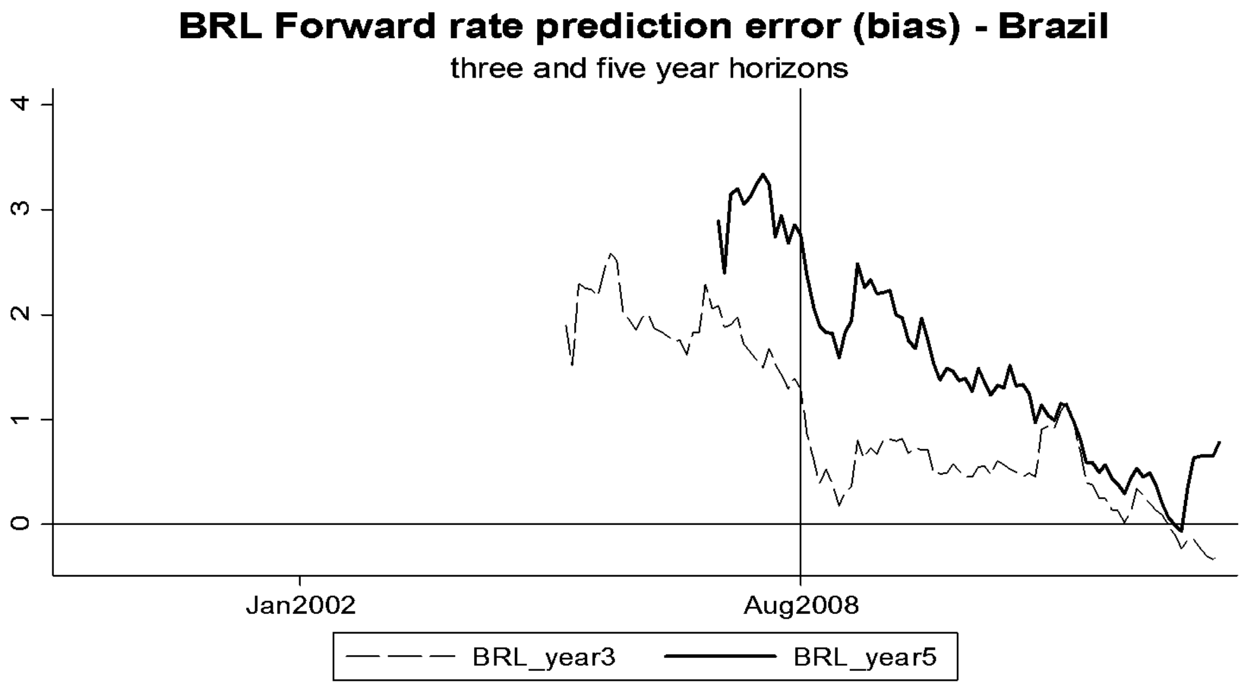
Appendix B: Five year forward rates: justification behind the construction

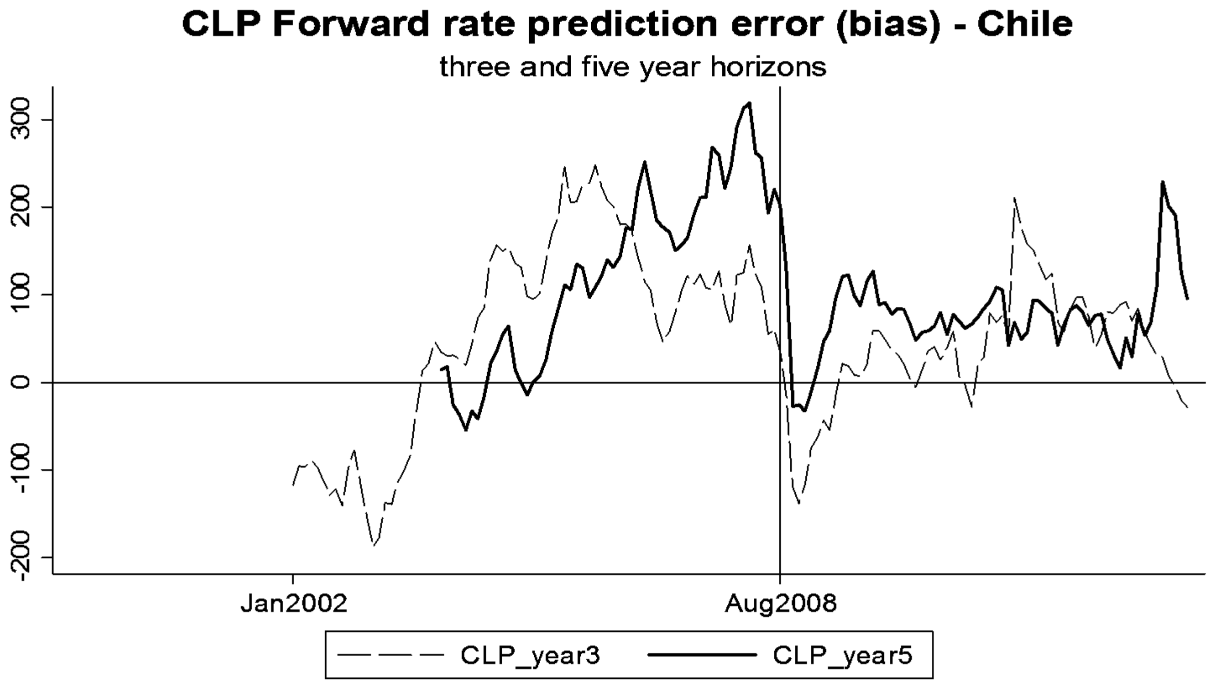
The table below shows the reasoning behind the construction of five year forward rates. The computation of five year forward rates is shown methods section and below is presented the economic rationale. Five year forward is the sum of exchange rate, i.e. USD/BRL, at t=0, and five subsequent annual forward points (1y Premiums). In the example calculation, the five year forward rate is comprised of receiving 1 million dollars five years from the initiation and paying Brazilian real according to the pre-agreed forward rate (2.8093). The construction of the five year rate according to the following description may appear complex but it is actually a standard procedure in the foreign exchange market. The five year forward rate is approximated with five, consequent, one year forward market and four spot market entries. First the 1mUSD is agreed to buy against selling Brazilian real with a one year forward (2008, rate: 2.2896). Upon the realization/maturity of the one year forward (2009), the same US dollar amount is sold in spot exchange rate (2.0569), to make US dollar cash flow to zero. Next, applying the same spot exchange rate (2.0569), another one year forward rate is committed to in 2009 that matures on 2010 (2.1674). Thus, the impact of exchange rate during the five year period is removed. This combination of a spot and forward deal that have the same underlying exchange rate equals to a foreign exchange swap, which is why it is simpler for industry experts to read the graph below. The same calculation could be made with reversal cash flows, implying the construction is also applicable to foreign exchange risk of selling the 1mUSD upon the maturity of the five year forward.

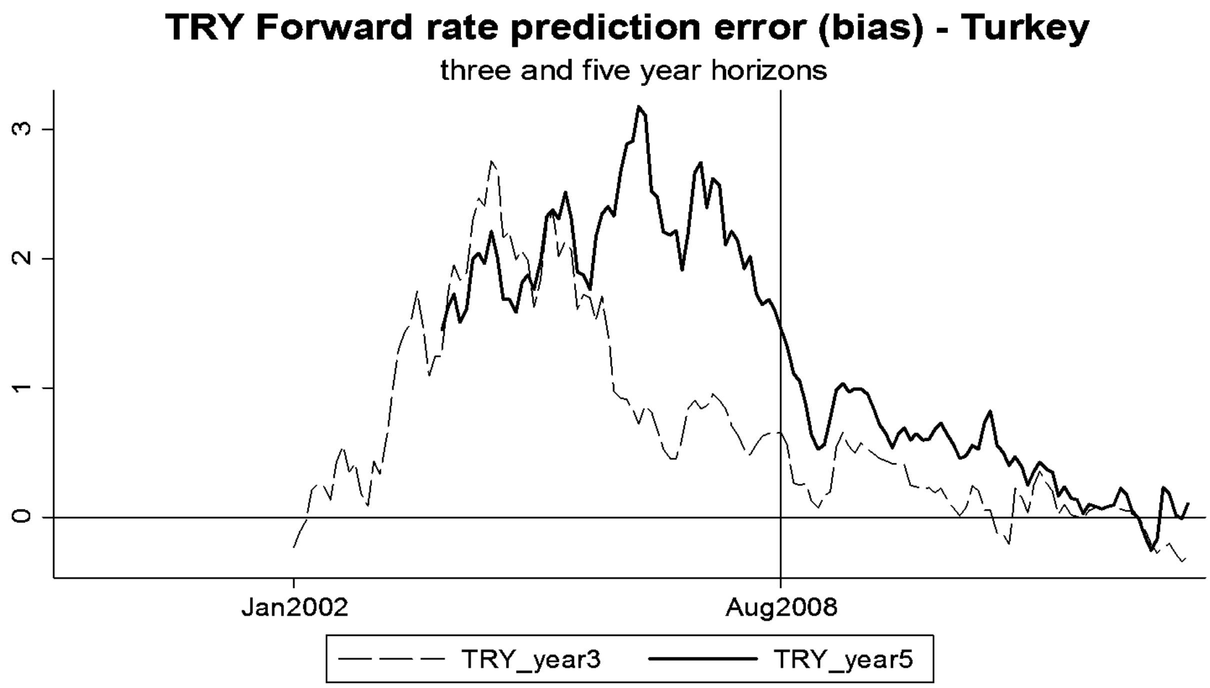
	2008	**2009**	**2010**	**2011**	**2012**	**2013**
t	0	1	2	3	4	5
USD/BRL (s_t)	2.1411	2.0569	1.8793	1.7143	1.895	2.3228
1y Premium	1485	1105	1178	1460	1454	1748
1y Forward (f_t^1)	2.2896	2.1674	1.9971	1.8603	2.0404	2.4976
Five year forward						**2.8093**
USD outflow (USD/BRL)		-$1 000 000	-$1 000 000	-$1 000 000	-$1 000 000	
USD inflow (1y Forward)		$1 000 000	$1 000 000	$1 000 000	$1 000 000	$1 000 000
Net USD cash flow		$0	$0	$0	$0	$1 000 000
BRL outflow (USD/BRL)		2 056 900	1 879 300	1 714 300	1 895 000	
BRL inflow (1y Forward)		-2 289 604	-2 167 390	-1 997 124	-1 860 300	-2 040 350
Net BRL cash flow		-232 704	-288 090	-282 824	34 700	-2 040 350
Sum of BRL cash flows						*-2 809 268*
"Synthetic" Five year forward rate						*2.8093*
Cost in BRL from from the five year forward $(-f_{t-5}^5)$*1mUSD						*-2 809 268*

Appendix C: Forward forecast error (bias) for three years maturity

The graphs below plot the same forward bias ($f_t^i - s_{t+i}$) as the results subchapter 5.5 but for three and five year intervals to illustrate that the bias increases along with maturity: For the three year maturity, the bias is smaller than for five year maturity but is still considerable. The second purpose of this appendix is to argue that given the selected method of graphical inspection, it would not be equally suitable to examine the intervals of years 2-4 similarly as the one and five years, that were studied in the results chapter. Such inspection would result in highly obscure presentation and discussion.

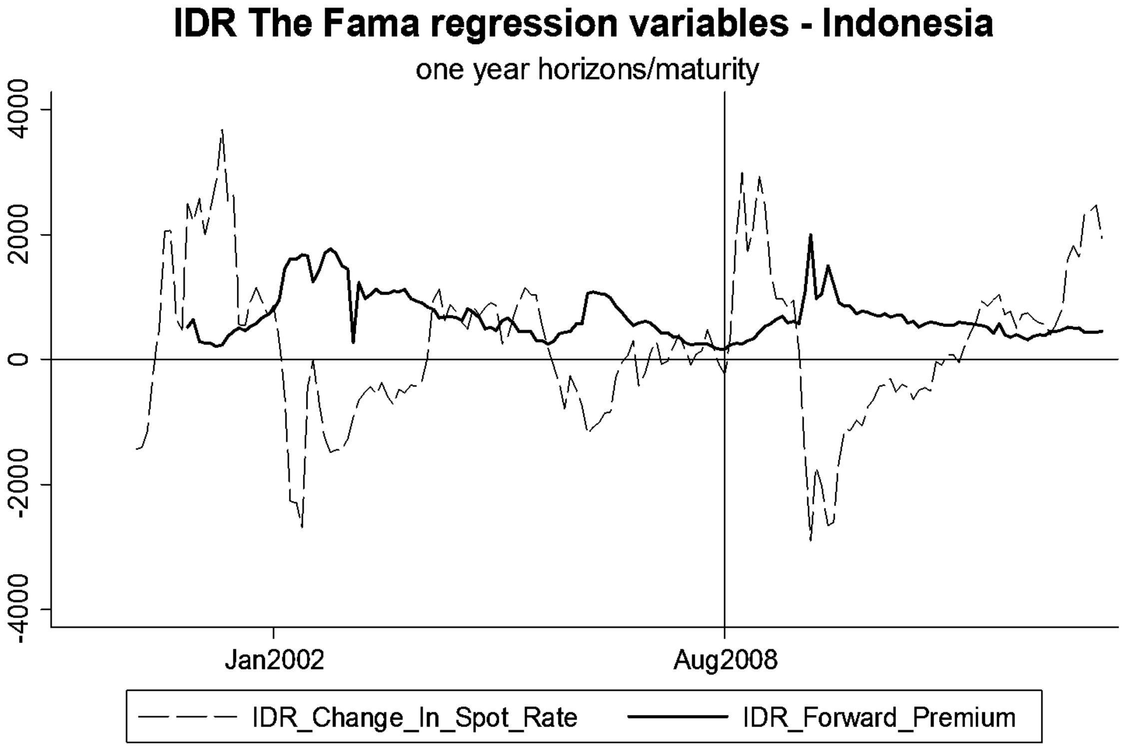


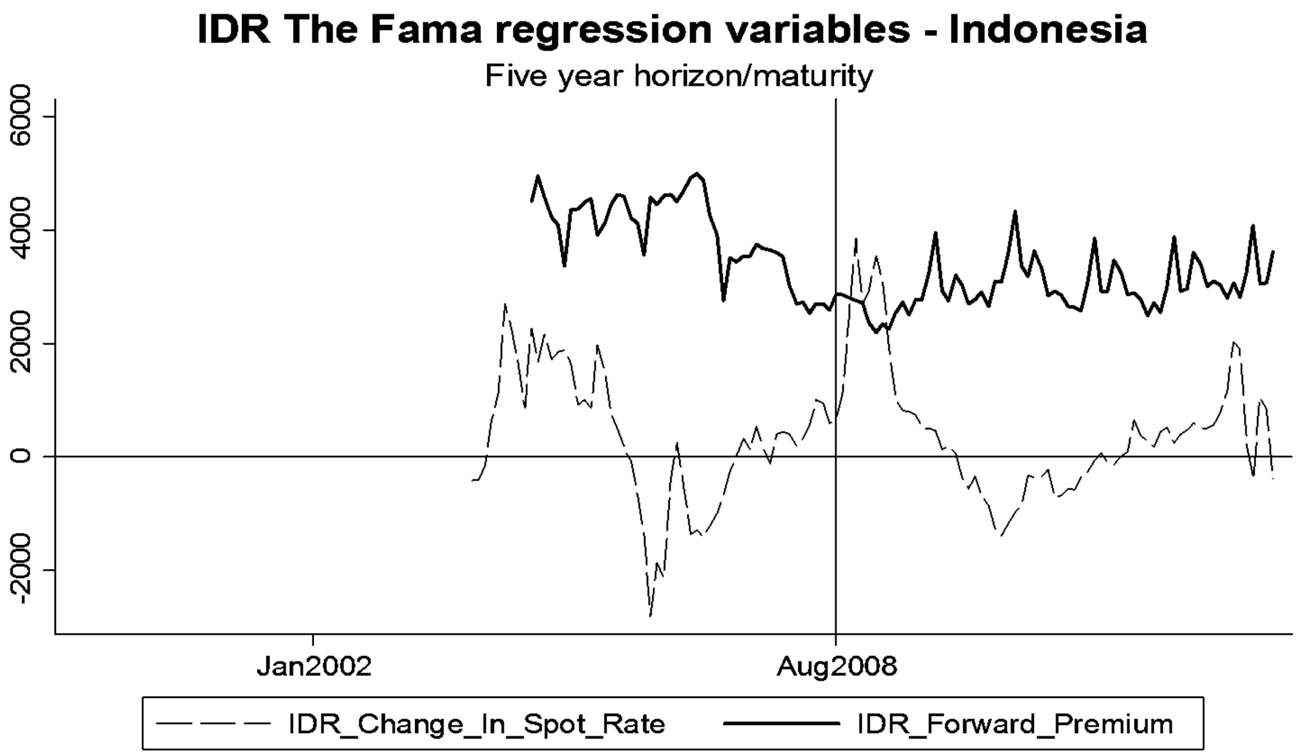

CLP Forward rate prediction error (bias) - Chile
three and five year horizons
300
200
100
0
-100
-200
Jan2002
Aug2008
CLP_year3
CLP_year5

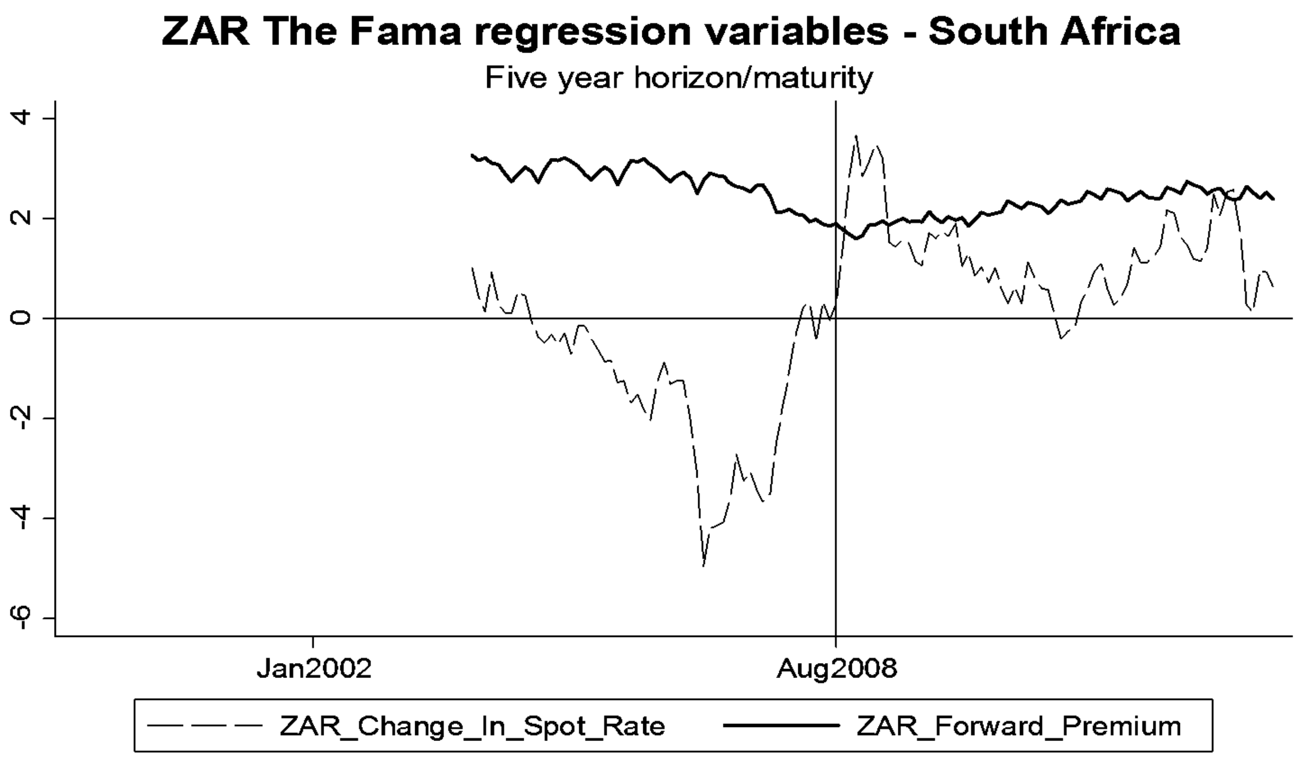

TRY Forward rate prediction error (bias) - Turkey
three and five year horizons
3
2
1
0
Jan2002
Aug2008
TRY_year3
TRY_year5

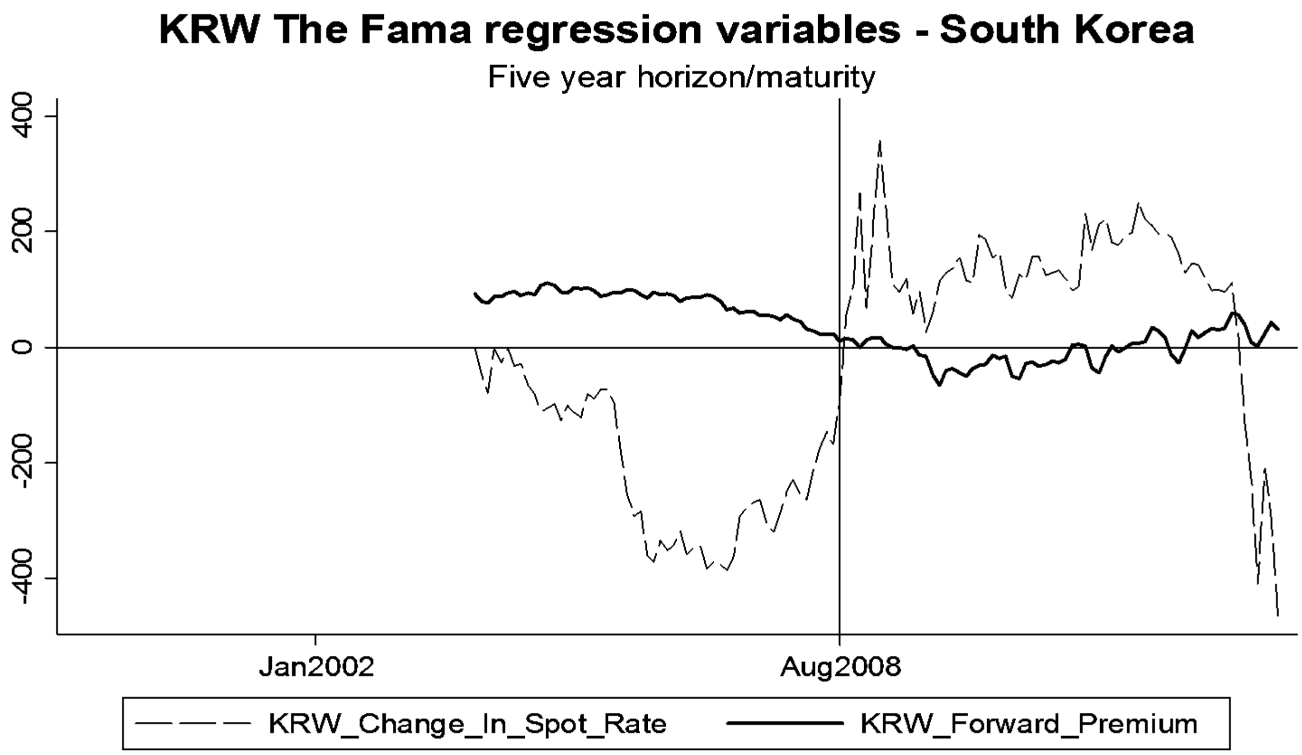
Appendix D: UIP variables depicted for one and five year intervals

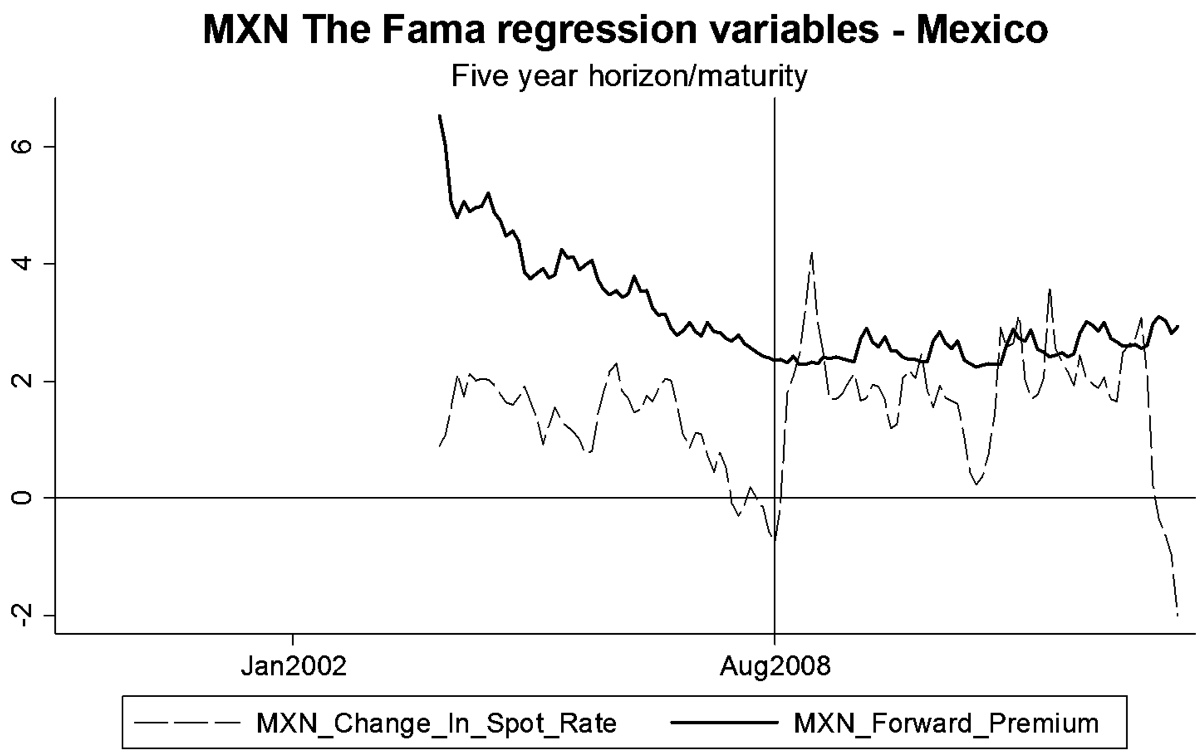
The UIP variables are the spot rate difference between today's spot value and future exchange rate $(s_{t+i} - s_t)$ and the forward premium $(f_t^i - s_t)$. In the Fama regression $(s_{t+i} - s_t)$ is the dependent variable and $(f_t^i - s_t)$ is the explanatory variable. The forward bias was defined as $f_t^i - s_{t+i}$ which is logical already by intuition as it equals the prediction error of a forward rate from the spot rate it intended to forecast. The graphs below depict the UIP variables, the spot rate change and the premium, for a few of the sample countries to illustrate the uncovered interest rate parity from this point of view as well. In addition, it demonstrates the connection between the UIP and the prediction error, why the graphs turn out as they do in the results section. As can be seen below, for the one year interval, the change in spot rate is scattered around the forward premium (the change predicted by the forward rate). This applies to all sample currencies, even to the ones not presented here. The five year interval changes the dynamics: the spot rate is still far more volatile but now it differs between countries whether the forward premium excessive enough for the spot rate to reach it even at its high levels.




IDR The Fama regression variables - Indonesia
Five year horizon/maturity
6000
4000
2000
0
-2000
Jan2002
Aug2008
IDR_Change_In_Spot_Rate
IDR_Forward_Premium

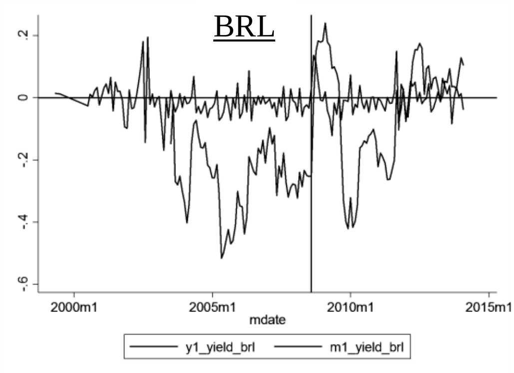

ZAR The Fama regression variables - South Africa
Five year horizon/maturity
4
2
0
-2
-4
-6
Jan2002
Aug2008
ZAR_Change_In_Spot_Rate
ZAR_Forward_Premium

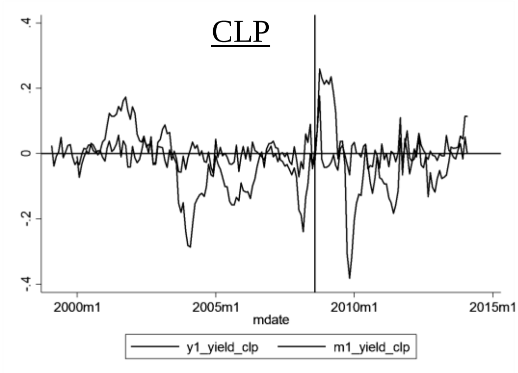

KRW The Fama regression variables - South Korea
Five year horizon/maturity
400
200
0
-200
-400
Jan2002
Aug2008
KRW_Change_In_Spot_Rate
KRW_Forward_Premium

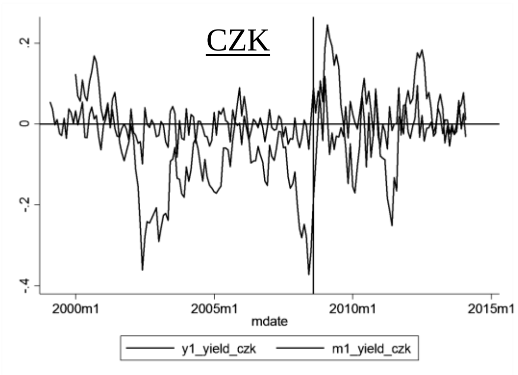

MXN The Fama regression variables - Mexico
Five year horizon/maturity
6
4
2
0
-2
Jan2002
Aug2008
MXN_Change_In_Spot_Rate
MXN_Forward_Premium

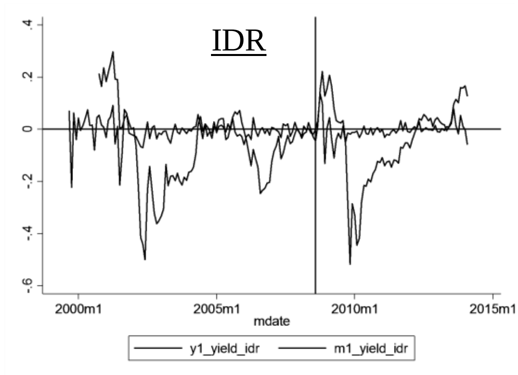
Appendix E: Forward yields: 1-month against 12-months

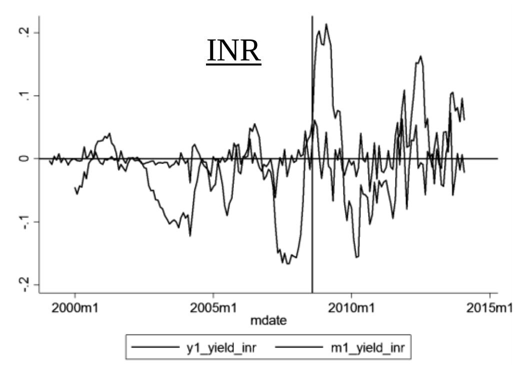
The graphs below plot yields for one and twelve month forwards for all currencies. The yield is defined as $(f_t^i - s_{t+i})$. The graphs illustrate how the one month rates are scattered around zero while the 12-month rates are as well but with a greater volatility. A similar considerable time period effect as with the comparison of one and five year variables is not observable. *In each graph, the variable that is closely spread around zero is the one-month yield and vice versa.*

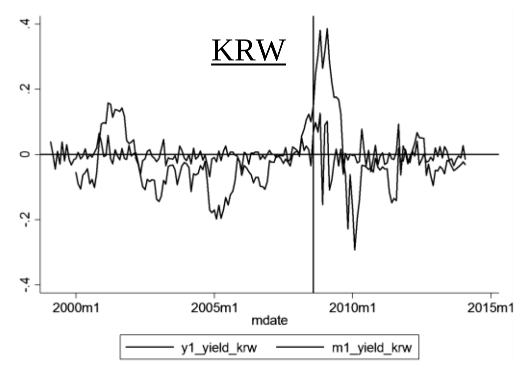


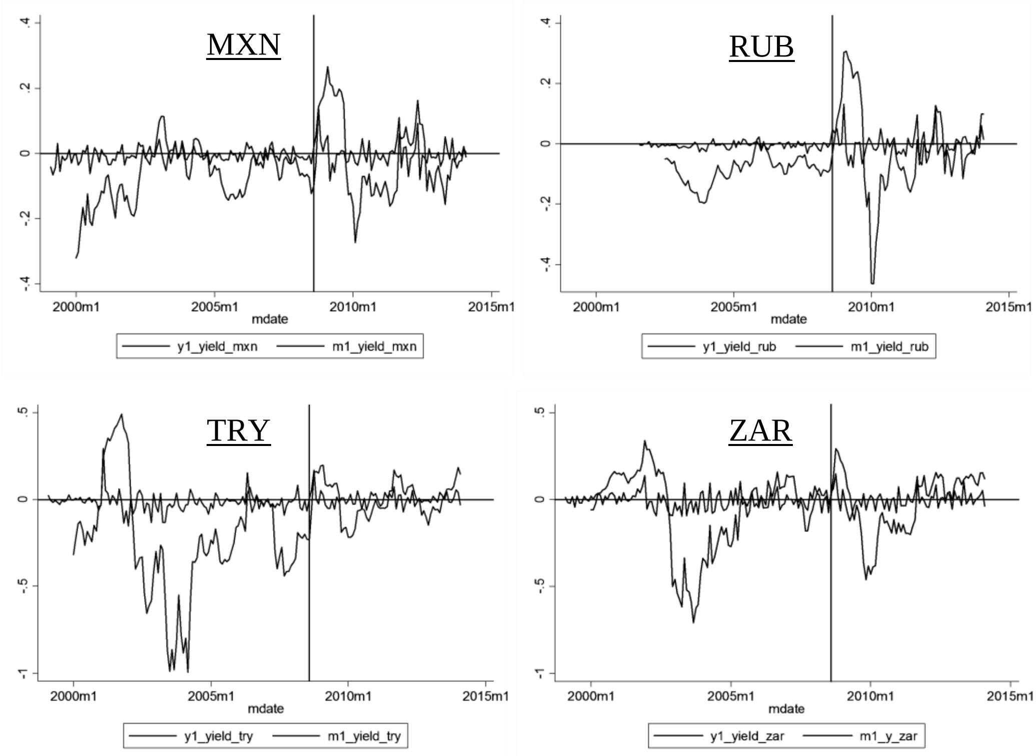











MXN
RUB
TRY
ZAR
2000m1
2005m1
2010m1
2015m1
mdate
y1_yield_mxn
m1_yield_mxn
y1_yield_rub
m1_yield_rub
y1_yield_try
m1_yield_try
y1_yield_zar
m1_y_zar

Appendix F: Interview with Metso Corporation foreign exchange risk manager

Date: 01.11.2014

Location: Fabianinkatu 9, Helsinki

Interviewer: Thesis author

Interviewee: Mikko Vainikka, Director of Treasury Market Operations in Metso Corporation

1. How are the Bloomberg Terminal daily closing mid-prices constructed for both forward and spot rates? Is the data reliable in your opinion?

The quotes in Bloomberg are averages of quotes that are reported by banks. The quotes are not actual offered rates but in general they follow closely the interbank market where the prices are extremely liquid. Furthermore, Bloomberg removes the effect of infeasible quotes that represent extreme values. The prices published by Bloomberg are live feed and the number of banks sending their quotes to Bloomberg are in most exchange rates in excess of 20 and approximately dozen for the least liquid currencies, such as the Indonesian rupiah. In addition, mostly the Bloomberg quotes have a notably thin spread. I think the spot rate and forward point data retrieved from the Bloomberg terminal is highly reliable and valid.

2. What is the relationship between computing five subsequent one year forward premiums to the taking an actual premium of a five year forward rate?

On average, the actual five year premium is higher than the cumulative annual premiums. The OTC foreign exchange market has no intermediary and the counterparty for a multinational company is always a financial institution instead of a centralized marketplace. The commitments are made directly to another counterparty introducing a counterparty default risk. The financial institutions defined as reporting dealers offer the quotes in the OTC market and they are required to price the counterparty default risk. The additional premium makes the actual five year premium to differ from the interest rate differential for five years. It is not, however, necessarily indicative of a failure of the covered interest rate parity and, thus by definition, of the presence of an arbitrage opportunity, because the bid-ask spread often disables the arbitrage to the direction in the best interest of the financial institution offering the rates.

3. What is the practical implication of the forward rate prediction error $(f_t^i - s_{t+i})$, tested for distant horizons in this study, for *financial institutions* operating in the OTC foreign exchange market?

Unlike multinational companies, financial institutions such as banks have a greater variety of counterparties and therefore the counterparty default risk is of greater interest. The implication is that basically banks measure the amount of credit default loss with the presented figure $(f_t^i - s_{t+i})$, because if the counterparty defaults on the payment, on the cash flow they have agreed to deliver according to the forward contract, the bank needs to enter the exchange rate market and cover this change in their position themselves. The exchange rate used to offset the change in the foreign exchange risk position upon the default of a customer is the future, then prevailing, exchange rate (s_{t+i}). Thus the difference between the pre-agreed forward rate and the future exchange rate is defined as the credit loss in the event of default. The actual computations by banks, however, often include some sort of sensitivity or scenario analysis to calculate the probability of the event.

4. What is the practical implication of the forward rate prediction error $(f_t^i - s_{t+i})$, tested for distant horizons in this study, for *multinational companies* (non-financial counterparties) operating in the OTC foreign exchange market?

In the absence of accounting requirements and standards the profit or loss of an OTC foreign exchange forward derivative can be defined as it has done in the research as $(f_t^i - s_{t+i})$. This the industry standard definition of yield. Accounting practices however could somewhat alter the definition of a return because the forward contracts are valued for every financial statement against current spot market.

Appendix G: Newey-West regression alphas and fitted values plotted

Appendix G reports part of the estimated alpha values, i.e. regression intercept terms, from the Newey-West regression model as well as two graphs of fitted values by the model. The alphas never equal to zero with statistical significance which would be required for the unbiased forward rate hypothesis to hold. The highlighted alpha values are the ones attaining significance. It is notable that these are especially found for the currencies that exhibited increasingly biased forward rates along with extended time horizon, when only the betas were considered. The fitted values below show infeasibility of running the Fama regression with the standard one month interval: the range of x-axis values appears far too thin in comparison to the range of exchange rate values on the y-axis to draw a meaningful fitted line and for a true statistical relationship to exist.

Alphas	1-Month		12-Month	
Brazil	0.003		0.005	-
Chile	-0.002	-	**-0.056**	***
Czech Republic	-0.003	-	-0.039	**
India	0.000	-	-0.019	-
Indonesia	**0.016**	***	**0.184**	***
Mexico	0.005	-	0.033	-
Russia	**-0.006**	***	0.010	-
South Africa	**0.025**	***	**0.319**	***
South Korea	-0.001	-	0.002	-
Turkey	0.003	-	0.045	-