Exchange Rate Prediction Using Changes in Commodity Prices

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Abstract

This dissertation aims to analyze the effect of commodity price changes on exchange rates, and to test whether they are any good in predicting the exchange rate of several currencies against the US dollar. I compare the forecast performance of models that use commodity prices with that of a random walk model, and analyze which performs better, I also analyze an economic fundamentals model. This analysis is done both in-sample and out-of-sample. My results are positive, given that all models tested outperform the random walk model for the majority of the countries tested. It is also concluded that a model that uses only commodity prices is the best performer out-of-sample. A striking result is that, in this study, the economic fundamentals model outperforms the random walk, despite past research suggesting that there is no relationship between economic fundamentals and exchange rates.

Keywords: exchange rates, commodities, international economics, international finance

Previsão de Taxas de Câmbio Utilizando Variações no Preço de Commodities

Francisco Ferrari Lampreia

Resumo

Esta tese tem como objetivo analisar efeito de variações no preço de commodities em taxas de câmbio, e testar se são uteis para prever taxas de câmbio de varias divisas contra o dolar americano. Eu comparo a performance de previsão de modelos que usam preços de commodities com um modelo de random walk, e analiso qual performa melhor, analiso também um modelo de fundamentais económicos. Esta análise é feita in-sample e out-of-sample. Os meus resultados são positivos, uma vez que todos os modelos performam melhor que o modelo de random walk para a maioria dos países testados. Também se conclui que um modelo que use apenas preços de commodities tem a melhor performance out-of-sample. Um resultado inesperado é que, nesta tese, o modelo de fundamentais económicos performa melhor que o modelo de random walk, embora pesquisa anterior sugira que não existe nenhuma relação entre fundamentais económicos e taxas de câmbio.

Palavras-chave: taxas de câmbio, commodities, economia internacional, finanças internacionais

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Francisco Lampreia

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Section 1: Introduction

Exchange rate prediction has been one of the biggest challenges of international economics ever since Meese and Rogoff (1983) first documented what came to be known as the exchange rate disconnect puzzle, having found that economic fundamentals do not predict exchange rates, despite several theoretical models saying that they should. Indeed, according to research, no monetary fundamentals model beats a random walk model. The literature has come a long way since the first documentation of this puzzle, however, there is still no clear answer as to why economic fundamentals are such a poor predictor of exchange rates, or even of what drives exchanges rates at all. Breakthroughs in the literature provide evidence that exchange rates are partially a function of unobserved shocks, which might come in several different forms. Chen and Rogoff (2003) found some evidence that commodity prices might have an impact on exchange rates, and thus might be connected to this shock. The aim of this research is to assess to which extent changes in commodity prices might fulfill the role of the shock that affects exchange rates, and how much do commodity prices explain variations in exchange rates. Volatility in commodity prices is especially relevant for countries that depend on commodity exports to some extent, which might see a big increase in their trade balance if the price of commodities that they export the most rises, and vice versa, which should then lead to an appreciation of that country's currency. It follows, then, that variation in commodity prices should have an impact on a country's currency price that is proportional to that country's dependence on commodity exports. The statistical significance of the predictability of exchange rates using commodity prices will be assessed for several currencies against the USD by testing three models: a model that predicts exchange rates only with commodity price changes, a model that predicts exchange rates based on economic fundamentals (useful for comparison purposes) and a model that combines both economic fundamentals and commodity price changes. These models' performance will be compared with a random-walk model, which is the standard benchmark in the literature, both in-sample and out-of-sample. A separate analysis shall be conducted for developed and developing countries, at a quarterly frequency.

In my study, I found that indeed commodity prices help in predicting exchange rates, beating a random-walk model for the majority of the countries studied, both in-sample and out-of-sample. An unexpected results of my research is that the economic fundamentals model also beats the random-walk model for the majority of the countries, despite not being better at doing so than a model that only commodity prices. This goes against previous findings in the literature, and is likely a consequence of the methodology used. A model that combines both economic fundamentals and commodity prices often yields results similar to an economic fundamentals only model, and is usually less significant in doing so.

The remainder of this dissertation is organized as follows: In section 2 I review literature that is relevant for this study, section 3 goes over the theory that is used in exchange rate prediction, section 4 states the research question to be answered, section 5 goes in depth into the methodology used, section 6 presents the data, in section 7 I discuss the results, section 8 concludes and section 9 presents limitations and suggestions for further research.

Section 2: Literature Review

Exchange rate puzzles: an overview

The unpredictable behavior of exchange rates was first documented by Meese and Rogoff (1983), who test the performance of several structural exchange rate models out-of-sample, and find that none of them can outperform a random walk model. This was the genesis of what came to be known as the Exchange Rate Disconnect puzzle, which states that there is no relationship of predictability between exchange rates and economic fundamentals in the data. Diebold and Nason (1990) try to overcome this poor performance of existing models by predicting exchange rates with a nonparametric method, however, they are also not successful at beating a random walk.

Given a previous consensus that forward rates are bad predictors of future spot rates, Fama (1984) tries to assess whether there are any time varying premiums in forward rates. Modelling forward rates as the expected future spot rate plus a premium, he comes to the conclusion that both the expected future spot rate and the premium component vary throughout time (most of the variation comes from the premium part) and, more strikingly, that both components vary in opposite directions, i.e. their variation through time is negatively correlated, this goes against the Interest Rate Parity condition and these results came to be the basis of the UIP puzzle. Messe and Rogoff (1988) test the relationship between real exchange rates and real interest rate differentials by applying real versions of several already tested monetary exchange rate models to the data. They find no significant relationship again, since the random walk outperforms the models assessed, adding to the puzzle that exchange rates do not behave as is predicted by theory. Hollifield and Yaron (2001) try to understand if the negative relationship between exchange rates and interest rate differentials comes from any inflation related factors by regressing exchange rates on inflation related components, real risk and a combination of both. They find that neither inflation or a combination of inflation and real risk explain the relationship between exchange rates and interest rate differentials.

Obstfeld and Rogoff (2000) provide an overview of several major puzzles in international macroeconomics, of which the purchasing power parity (PPP) puzzle and the exchange rate disconnect puzzle (which they give its name to) are relevant for my purpose. The PPP puzzle is seen by the fact that, in the data, real exchange rates (when modeled as a function of domestic and foreign prices) have too high a half-life for their high volatility. The exchange rate disconnect puzzle is the more general case of the PPP puzzle, first found by Meese and Rogoff (1983), that states that exchange rates have no relationship with any set of macroeconomic variables whatsoever. Cheung, Chinn and Pascual (2005) analyze and test several exchange rate prediction models that had been proposed in the nineties, comparing them against the random walk. The models tested include a purchasing power parity model, a sticky-price monetary model, a productivity differential model, a behavioral equilibrium exchange rate model and the uncovered interest rate parity. They find mixed results, as a certain model might be very good in a certain time interval/currency combination but perform poorly for another such combination. The authors extend this study at a later date (Cheung, Chinn, Pascual and Zhang (2019)) by including Taylor rule fundamentals, an interest rate differentials model, an interest rate model with yield curve factors and a sticky-price model with risk and liquidity. Even including these more recent models, authors still find that no one model performs best for general combinations of currency, time spawn and performance metric, and so, results are inconclusive.

An extensive overview of three puzzles in exchange rate prediction in the literature is also provided by Sarno (2005). He firstly analyzes the forward bias puzzle, which is translated into the fact that the uncovered interest rate parity (UIP) is violated in the data, that is, high interest rate currencies tend to appreciate against low interest rate currencies where, by the UIP, they should depreciate. The author then goes through the purchasing power parity puzzle: by purchasing power parity, the ratio of prices between 2 countries should be equal to their exchange rate, or, in other words, real exchange rates should revert to an equilibrium level in the long run, which is not the case according to the data. Rogoff (1996) documents how real exchange rates have high short-term volatility while deviations from the purchasing power parity take a long time to wear off, which was the basis of the purchasing power parity puzzle. Finally, the author analyzes the exchange rate disconnect puzzle, which states that there is no link between exchange rates and economic fundamentals, even though, according to theory, fundamentals are expected to predict exchange rates.

Breakthroughs and relevance of economic value

The first positive result in the exchange rate prediction literature comes from Mark (1995), who was able to prove that log exchange rates are actually predictable by the difference between log exchange rates and a combination of money supply and real income. This result was, however, only found to be valid in the long run. Using an innovative method, Evans and Lyons (2002) try to predict exchange rates using order flow, with the logic that order flow contains valuable information, such as news and shocks, that economic fundamentals cannot convey. Their results are also positive, confirming that indeed the foreign exchange market aggregates information not implicit in economic fundamentals. The authors expand their study (Evans and Lyons (2008)), arriving to the conclusion that state that there is also an indirect effect through which order flows help macroeconomic variables explain part of the variation in exchange rates, specifically in the period immediately after macro news are publicized. They find that the effect of macroeconomic variables on exchange rates comes is transmitted by 2/3 through this indirect channel, while only 1/3 of the effect is transmitted directly. Cavusoglu and Neveu (2015) study a different source of exchange rate prediction by analyzing forecasts' ability to predict exchange rates. They find that forecasts in themselves are unbiased estimators in the long run but, in line with other findings in the exchange rate literature, they are biased in the short run. Due to this, the authors try to see if forecast dispersion (the difference between the extreme forecast values available) perform better. They arrive to mixed results, given that performance is improved indeed for some currencies in the short run, but not for all, so they cannot generalize their findings.

Lustig and Verdelhan (2007) test whether consumption growth influences the violation of the UIP seen in the literature. They find that indeed the UIP does hold when domestic consumption growth is low, but not when it's high. This is attributable to the fact that investors take on increased risk when consumption growth is high, and they require compensation for this risk, which takes the form of the excess returns that UIP violating currencies yield. The authors create 8 portfolios, in the way of Fama and French (1992), sorted on interest rates, such that the first portfolio always has the lowest interest rate currencies. Following these findings, Colacito and Croce (2011) develop a model that takes into consideration both current and future consumption growth risk. This model is able to account for several international finance puzzles, such as the international equity premium puzzle, which means that consumption growth doesn't vary enough to explain movements in the exchange rate.

Most authors in the literature focus on the statistical significance of exchange rate prediction using economic fundamentals, however, Abhyankar, Sarno and Valente (2005) go on another direction, and find that there actually is economic value in predicting exchange rates with fundamentals, even if this predictability is not significant. This means that foreign exchange investors that recur to a monetary-fundamentals model have significant economic benefits from doing so, even if there is no significant statistical relationship. These findings reinforce the relevance of studying monetary fundamentals predictability for exchange rates. Backus, Foresi and Telmer (2001) provide evidence that forward exchange rates can actually be helpful in predicting spot exchange rates. Based on this, Della Corte, Sarno and Tsiakas (2008) assess the economic value of exchange rates prediction in the short run by calculating how much an investor is willing to pay to switch from a random walk model to either an economic fundamentals model or a forward premia model. They find that a fundamentals model has no economic value in-sample or out-of-sample, but a forward-premia based model beats a random walk model in terms of economic value.

Unexpected shocks and their role in exchange rate determination

Evidence that exchange rates are influenced by expectations about future monetary shocks, that might lead to magnifying and overshooting effects, led Meese and Singleton (1983) to try to assess the extent of these effects. They find that this overreaction to future expected monetary shocks does take place, which might be a reason why exchange rates have such an unpredictable volatility. Engel and West (2005) try to model exchange rates with an asset pricing approach, defining them as a linear combination of observable economic fundamentals and unobservable shocks. They find that as the discount factor of future fundamentals approaches one, the more likely it is that exchange rates follow a random walk, suggesting that the foreign exchange market weights expected future values almost as much as present values. They alternatively find that exchange rates are actually a good predictor of economic fundamentals, rather than the other way around. Lustig, Roussanov and Verdelhan (2011) identify a "slope" factor in exchange rates associated with risk that is common to all currencies, and find that the higher a currency's interest rate, the more it is exposed to this factor. They model exchange rates on a global factor and on a country specific factor. They find that the global factor is highly related to volatility in global stock markets. Overall, investors that go long on high interest rate currencies and short on low interest rate currencies earn what is called the carry trade premium, without being exposed to any country specific factor. Further innovation in exchange rate prediction models come from Farhi and Gabaix (2016) who propose a model that accounts for rare but extreme unexpected disasters, to which all countries (and therefore currencies) are exposed differently, with a probability of happening that is time-varying. This varying probability across time and across countries solves the exchange rate disconnect and the UIP puzzles respectively. This "disaster" factor is likely to be the "slope" factor common to all currencies identified by Lustig et al. (2011).

One possible cause for this difficulty in predicting exchange rates was that they depend mainly on unobservable or unknown shocks. Positing that shocks in commodity prices might be a main driver for exchange rate prediction, Chen and Rogoff (2003) were the first to document the importance of commodity prices for real exchange rates. They find a significant relationship for the exchange rates of Australia, New Zealand and Canada, three countries that are highly dependent on commodity exports, against the US dollar. The hypothesis that commodity prices might affect exchange rates is develop further by Ferraro, Rogoff and Rossi (2015), who study the effect of changes in the price of a country's major commodity export on that country's exchange rate. They find that, even though there is not a significant relationship between commodity prices and exchange rates at the monthly and quarterly frequencies, daily frequencies exhibit a relevant predictability out-of-sample.

Section 3: Theory

Purchasing Power Parity (PPP)

The theory of purchasing power parity is an extension of the law of one price, that states that, conditional on some factors, two goods sold in different countries must cost the same, otherwise an investor can buy the good in the cheaper country and sell it in the more expensive country and profit from an arbitrage condition. The PPP condition states that this is true after converting the currency of one country into the currency of the other country. This means:

$$p_t = p_t^*.s_t$$

Where s_t is the exchange rate between two countries in period t, and p_t is the price level in a country (usually measured by a general basket of goods) in period t. The asterisk differentiates between countries, meaning that the purchasing power parity states that the exchange rate between two countries should depend on the difference of price levels between both countries.

Interest Rate Parity (IRP)

Covered interest rate parity (CIRP):

The covered interest rate parity is a condition that states that the forward exchange rate should be equal to the spot rate times the ratio between both countries' interest rates, this is:

$$F_{t+k} = S_t \cdot (\frac{1 + i_{t,k}}{1 + i_{t,k}^{*}})$$

Where F_{t+k} is the forward rate for period k in period t, s_t is the spot exchange rate between two countries in period t and $i_{t,k}$ is the interest rate from period t to period k. It is a no-arbitrage condition that guarantees that investors cannot profit from borrowing in the low interest rate currency, exchanging the money into the high interest rate currency and then lending it.

Uncovered Interest Rate Parity (UIRP):

The uncovered interest rate parity condition is similar to the CIRP, with the only difference being that it considers expected future spot rates instead of the forward rate, thus being:

$$E[s_{t+k}] = S_t \cdot (\frac{1 + i_{t,k}}{1 + i_{t,k}^{*}})$$

Where s_{t+k} is the spot exchange rate in period t + k. In the hypothesis that we expect the future spot rate to be equal to the forward rate, there is no difference between the CIRP and the UIRP.

The UIRP can be approximated to:

$$E[s_{t+k}] - s_t = i_{t,k} - i_{t,k}^{*}$$

Which essentially tells us that the exchange rate between two countries should appreciate by the interest rate differential between those two countries for a given period.

Sticky Price Monetary Model

The basis of the sticky price monetary model is that exchange rates are a function of monetary economic fundamentals. As such, this model relates exchange rates to several fundamentals in the following way:

$$s_t = \alpha_0 + \alpha_1.(m_t - m_t^*) + \alpha_2.(y_t - y_t^*) + \alpha_3.(i_t - i_t^*) + \alpha_4.(\pi_t - \pi_t^*)$$

With m_t being the money supply, y_t being real GDP, i_t the interest rate and π_t the inflation rate. We can see that this model states exchange rates between two countries as a function of several economic fundamentals. This model comes from the work of Dornbusch (1976) and researchers in the literature trying to assess whether economic fundamentals predict exchange rates either recur to it or to a smaller version of it (for example, just with money supply and real GDP, as Abhyankar, Sarno and Valente (2005) do).

Random Walk

The random walk model implies that you cannot predict future values using past values in any way. In this sense, the random walk model applied to exchange rates sets predicted future values equal to observed present values, so that there is no difference in value across time.

$$\widehat{ER}_t = ER_{t-1}$$

This way, assuming that we can't predict future values using past observations, setting the previous observed value as the forecast ensures randomness in the prediction.

The difficulties in forecasting exchange rates mostly come from the fact that theoretical models are unable to beat this random model in forecasting exchange rates out-of-sample.

Section 4: Research Question and Hypothesis

The focus of this research is on whether commodity price changes help in predicting exchange rates of foreign currencies against the US dollar. It can be claimed that this is the case if a model that depends on commodity price changes to predict exchange rates outperforms a random-walk model in doing so, this model will be defined as Model 1. It is also relevant to analyze if the economic fundamentals model, theoretically supposed to predict exchange rates, is any good in doing so, I will name this Model 2. Finally, it can be the case that a model that combines both the aforementioned models is better at beating a random walk, this will be Model 3.

The main hypothesis tested will then be:

H0: Model 1 beats a random-walk model in predicting exchange rates

(1)

H1: Model 1 does not beat a random-walk model in predicting exchange rates

Regarding Model 2, the hypothesis is:

H0: Model 2 beats a random-walk model in predicting exchange rates

(2)

H1: Model 2 does not beat a random-walk model in predicting exchange rates

Regarding Model 3, the hypothesis is:

H0: Model 3 beats a random-walk model in predicting exchange rates

(3)

H1: Model 3 does not beat a random-walk model in predicting exchange rates

Section 5: Research Methodology

In order to assess the effect of changes in commodity prices on exchange rates and answer my research question, I will run a two-stage regression. Firstly, I will regress each country's major stock exchange index on the prices of several commodities, using a rolling window of 1 year of daily observations collected prior to each period, and I will obtain a vector of daily betas for each country/commodity combination, which will quantify the sensitivity of each country's stock exchange to each commodity. The reason behind this step is that it is vital to have a country specific varying factor, that represents the reaction of each country's economy to changes in commodity prices, thus guaranteeing that only the variation between countries is taken into account in the prediction. This allows for a comparison of sensitivities between countries, using the stock market as a (high frequency) proxy for each country's economy.

For each country, betas will then be subjected to a t-test that will reveal the significance of the beta of each commodity, the betas will then be pooled across commodities, using a weighted average according to their significance, thus yielding a single commodities beta for each country/day combination that takes into account which commodities affect that country the most.

The first step regression will, thus, be:

$$SI_i = \alpha + \beta Com_{i,j}.Com_j$$

The second step will test the three previously mentioned models, consisting on regressing each country's exchange rate against the USD using these models. The variable for Model 1 is the country's commodities beta differential with respect to the USA's commodities beta; Model 2 is the sticky price monetary model, that predicts exchange rates using only economic fundamentals' differentials: money supply, real GDP, interest rate and inflation rate; Model 3 will be the sticky price monetary model with the inclusion of the commodities beta. This separate analysis will allow for a better understanding of how do commodity price changes affect exchange rates, both by themselves or in combination with other components, and will also allow for a comparison of its performance with a model that theoretically should perform well.

These models will be estimated quarterly, since GDP data is only available at a quarterly frequency. It is also reasonable to assume that parties interested in predicting exchange rates want to do so at a relatively low frequency.

For the exchange rate definition, I will use the exchange rate's growth instead of the exchange rate in levels, since it better allows for checking the effect of commodity price shocks on the evolution of exchange rates. Values will be the exchange rate at the first trading day of each quarter.

$$\Delta ER_{i,t} = \frac{ER_{i,t}}{ER_{i,t-1}}$$

The models will therefore be specified, respectively, as:

Model 1: $$\Delta ER_i = \alpha + \beta_1 . D\beta Com_i$$

Model 2: $$\Delta ER_i = \alpha + \beta_1 . Dm_i + \beta_2 . Dy_i + \beta_3 . Di_i + \beta_4 . D\pi_i$$

Model 3: $$\Delta ER_i = \alpha + \beta_1 . Dm_i + \beta_2 . Dy_i + \beta_3 . Di_i + \beta_4 . D\pi_i + \beta_5 . \beta Com_i$$

where $Dv_i = v_i - v_i^*$, with v being the commodities beta, money supply, real GDP, interest rate and inflation rate. The asterisk represents the foreign country, and the absence of asterisk represents the USA.

Afterwards, I will compare the performance of these three models with a random-walk model, which shall be constructed by assigning the last observed value for each exchange rate as that exchange rate's prediction for each period. I will run this comparison both In-Sample and Out-Of-Sample.

The in-sample prediction consists of running the regressions for the whole available time spawn, obtaining the regressors for each model and applying them to the available data for each period, thus obtaining a forecast of exchange rate values for the entire data sample.

The out-of-sample prediction only runs the regressions for a window of data up to a certain period, and uses those regressors to forecast the exchange rate only for the following period, this will be done using a rolling window of 10 years (40 quarterly observations), that advances one quarter for each new forecast. The purpose of this methodology is to simulate a forecast in real time, using only information available up to the point of the desired forecast.

I will then compare the statistical significance between each model and the Random-Walk model according to their Mean Squared Error (MSE), which is the average of the differences between predicted values and observed values of exchange rates. This procedure is also used by Cheung, Chinn and Pascual (2019). The lower the MSE, the better the performance.

$$MSE = \frac{1}{n} \sum_{t=1}^{n} (\Delta ER_t - \widehat{\Delta ER_t})$$

In order to assess the statistical significance of the performance of different models, I will recur to the methodology used by Goyal and Welch (2008), which define an R2 as:

$$R^2 GW = 1 - \frac{MSE_M}{MSE_{RW}}$$

where M represents the tested model and RW represents the Random-Walk model.

A Mean Squared Error for the tested model that is smaller than that of the Random-Walk means that the tested model beats the Random-Walk, therefore, when $R^2GW > 0$, the model being tested beats the Random-Walk in predicting exchange rates.

I will also compute the MSE-F statistic used by Goyal and Welch (2008) in order to assess the R^2GW's significance.

Section 6: Data Overview

The data necessary for this study will be collected from Global Financial Data and Thomson Reuters' DataStream. The data are split into developed and developing countries so that a separate analysis can be computed.

All exchange rates were collected from GFD at a daily frequency and are denominated in US dollars. Commodity prices were also collected daily from GFD and are denominated in US dollars, I picked commodities according to their relevance and diversity in order to have an impactful and thorough analysis of the commodities' universe. Stock indexes were collected from GFD at a daily frequency and are the country's main stock exchange index at closing price, data for Bolivia, Serbia and Zimbabwe are the country's total market capitalization, since no stock exchange index was available. For money supply I used the M1 value, it was collected at a monthly frequency from DataStream, except for Trinidad and Tobago, that was collected from GFD, I use current prices that are not seasonally adjusted, denominated in each country's currency. Inflation was collected as the Core Price Index monthly value from GFD, standardized as setting the value 100 to a certain year (different for each country). GDP was collected from DataStream, at a quarterly frequency (the highest available) and is denominated in US dollars for all countries, it was collected at current prices and not seasonally adjusted. Interest rates are an instrument equivalent to a 3-month Treasury Bill for each country, expect for Costa Rica and El Salvador, that have a 6-month maturity instrument, and Macedonia, that has a 1-month maturity instrument.

My dataset encompasses information on all variables for 20 developed countries and 52 developing countries, following the data procedure used by Lustig and Verdelhan (2007), subject to availability. I also collected data for 17 commodities. The eurozone is treated as an individual country, and the methodology is applied to the eurozone as if it were a country. The exchange rate for countries that adopted the euro is treated as follows: up until the introduction of the euro in 1999, the exchange rate is that of the country's pre-euro currency, after the adoption of the euro, the exchange rate is against the euro. This method allows for a study of the countries in the eurozone up to the most recent data available.

Commodity price and stock index data, used for the first stage regression that yields commodity betas, are filtered such that the same time spawn of data is available, the data used are from 02/01/1970 to 13/04/2020 for developed countries, and from 02/01/1992 to 13/04/2020, at a daily frequency. The same data filtering is applied to the variables used in the second stage regression for the three models: in the first model, data used on exchange rates and commodity betas are from 01/04/1971 to 01/04/2020 for developed countries and 01/04/1993 to 01/04/2020 for developing countries, at a quarterly frequency; in the second model, data used on exchange rates, money supply, inflation, GDP and interest rates are from 01/05/1959 to 01/11/2019 for developed countries and from 01/02/1960 to 01/11/2019 for developing countries, at a quarterly frequency; in the third model, data used on exchange rates, money supply, inflation, GDP, interest rates and commodity betas are from 01/11/1971 to 01/11/2019 for developed countries and from 01/02/1993 to 01/11/2019 for developing countries, at a quarterly frequency. Appendix 1 and 2 go in detail into what each commodity price actually means, and which stock exchange index was used for each country.

Summary statistics on data collected on commodities and developed countries are presented below. Summary statistics for the developing countries can be seen in Appendix 4.

Table 1: Summary Statistics - Commodities

Commodities	Mean	St. Dev	Min	Max
Aluminum	917,79	630,13	300,00	4165,00
Brent Crude Oil	29,99	30,57	1,93	143,95
Cocoa	898,38	940,33	30,00	5632,00
Coffee	47,58	53,74	5,25	335,00
Copper	59,78	82,89	4,87	468,05
Corn	1,43	1,26	0,20	8,50
Cotton	31,42	23,59	5,27	177,51
Gold	183,15	343,17	20,67	1895,00
Iron Ore	20,77	32,04	2,65	197,12
Natural Gas	0,88	1,64	0,05	19,45
Platinum	251,98	385,82	4,00	2272,50
Silver	3,46	5,75	0,25	48,55
Soybeans	4,44	3,15	0,44	18,24
Sugar	8,43	6,33	1,23	65,50
Tobacco	1247,09	1367,32	108,00	5117,56
Wheat	2,05	1,49	0,42	11,95
WTI Oil	12,25	21,51	0,10	145,31

It makes sense that tobacco has the both the highest mean and the highest maximum value, since the values used are price for metric tonne, and, given that tobacco is relatively light, a metric tonne is a very significant amount of tobacco, as such, it is expected that it is expensive. Gold has a very high volatility, this can be due to the fact that, as a “safe-haven” asset for investors, the price of gold rises significantly during recessions, of which there have been several occurrences in my dataset. It is also relevant to note that both tobacco and cocoa have a very wide range.

Table 2.1: Summary Statistics – Developed Countries

Developed Countries	Stock Exchange Index				Exchange Rate			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
Australia	2589,06	2004,68	175,25	7255,20	0,72	0,39	0,14	2,09
Austria	545,71	430,29	96,44	1876,02	0,58	0,69	0,00	2,38
Belgium	5525,24	4203,73	694,42	14673,00	0,63	0,44	0,05	1,73
Canada	6551,41	5043,43	810,78	17944,10	1,05	0,16	0,39	1,61
Denmark	219,89	244,01	10,54	1035,01	5,12	1,65	1,42	12,37
Euro	177,49	132,94	18,09	466,24	0,92	0,13	0,63	1,56
France	1767,47	1387,39	121,96	4732,14	0,35	0,40	0,00	1,61
Germany	230,74	164,46	37,84	625,19	0,62	0,76	0,00	3,60
Greece	1145,02	1308,65	48,95	6355,04	0,17	0,30	0,00	1,20
Ireland	2850,35	2506,74	112,43	9981,08	0,44	0,25	0,09	1,41
Italy	771,37	563,34	54,90	2182,34	0,25	0,33	0,00	1,21
Japan	1115,96	584,63	147,08	2884,80	99,57	133,47	0,31	360,00
Netherlands	369,82	285,99	36,50	997,10	1,12	0,29	0,44	1,78
New Zealand	673,64	420,29	89,58	2015,86	0,75	0,50	0,14	2,55
Norway	157,02	140,44	13,05	523,06	5,17	1,73	1,42	11,75
Portugal	4476,20	3601,73	62,41	14822,60	0,23	0,31	0,00	1,21
Spain	533,29	444,08	38,62	1724,95	0,27	0,32	0,01	1,21
Sweden	176,62	183,64	3,25	732,67	4,78	1,69	1,46	11,02
Switzerland	257,14	195,46	36,67	731,04	3,86	1,52	0,72	6,61
United Kingdom	1748,73	1301,58	61,92	4324,41	0,34	0,18	0,07	0,95
United States	830,27	773,69	62,28	3386,15	0,72	0,39	0,14	2,09

Looking at the summary statistics of stock indexes and exchange rates for developed countries, it can be seen that no stock index used has a particularly remarking standard deviation, however, Portugal's index PSI-20 has the largest range. Japan, as expected, has the lowest valued currency against the US dollar for the developed countries, with the largest range as well.

Table 2.2: Summary Statistics – Developed Countries

Developed Countries	Money Supply				Inflation			
	Mean	**St. Dev**	**Min**	**Max**	**Mean**	**St. Dev**	**Min**	**Max**
Australia	231	269	8	1085	22,46	33,33	1,19	116,20
Austria	113900	66286	35660	272063	24,81	33,06	0,00	108,10
Belgium	128148	49037	59500	232800	25,58	33,21	0,16	109,71
Canada	389802	410494	22825	1570714	32,80	40,29	3,18	137,40
Denmark	642506	320180	190038	1324480	23,72	32,94	1,09	103,60
Euro	2343234	2334668	161100	9008720	60,83	33,58	13,05	113,26
France	462530	330675	82375	1437749	24,00	34,96	0,04	104,98
Germany	625	606	65	2348	29,51	33,16	0,00	106,20
Greece	52499	47966	815	130588	25,82	38,99	0,00	111,34
Ireland	90647	48979	12164	205040	31,57	36,87	1,04	102,80
Italy	471560	330008	65564	1282775	21,63	32,60	0,01	103,50
Japan	235390	228563	3921	821115	31,43	40,45	0,02	102,30
Netherlands	185671	131346	35116	463219	27,06	32,00	2,85	107,70
New Zealand	67817	6334	58131	80489	207,62	317,31	12,13	1044,00
Norway	1269165	579473	710245	2200446	23,38	32,60	1,29	111,60
Portugal	72328	26149	29718	145902	31,03	38,54	0,45	104,70
Spain	463503	272225	88382	1081584	20,31	33,78	0,22	105,30
Sweden	1507728	717703	627592	3168580	78,80	108,53	4,98	337,68
Switzerland	295434	185806	89321	684100	36,89	33,45	7,45	103,56
United Kingdom	725116	530007	83561	1821945	52,62	79,72	3,45	292,00
United States	1038	970	138	4043	59,63	73,84	6,76	258,68

Regarding money supply, Australia, Germany, Japan and the USA have their values expressed in billions of their currency, while the remaining countries have their values expressed in millions. Both the eurozone and the USA have the highest mean value, which makes sense, given that they are the two biggest economies in the world. Inflation is standardized as having the value for a certain year equal to 100, so, it makes sense that most means are similar, the fact that the mean for New Zealand is so high is because the year at which the New Zealand's CPI is set to 100 (1975) is way earlier than for other countries, leaving a wider time spawn for its CPI value to keep increasing until today.

Table 2.3: Summary Statistics – Developed Countries

Developed Countries	GDP				Interest Rates			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
Australia	114,95	121,85	4,39	411,62	4,91	3,97	0,15	19,40
Austria	83,72	23,78	47,37	115,33	6,63	1,66	3,61	10,38
Belgium	100,87	28,93	56,54	141,21	5,22	3,40	-0,91	14,03
Canada	171,09	148,55	9,63	482,28	4,20	3,85	0,16	20,90
Denmark	62,50	20,45	32,28	95,67	7,34	6,57	-1,10	20,70
Euro	2663,56	691,81	1576,01	3805,32	5,61	3,15	0,18	11,75
France	407,43	204,92	120,57	788,36	4,50	3,80	-1,00	18,92
Germany	729,73	177,26	465,31	1006,64	3,68	2,49	-0,98	12,05
Greece	53,97	17,54	26,71	94,95	9,88	7,01	0,82	58,32
Ireland	52,25	23,64	16,85	100,81	8,23	4,51	1,62	39,94
Italy	446,15	104,88	273,23	649,79	6,22	5,17	-0,69	22,08
Japan	1223,98	145,43	920,99	1666,26	3,12	2,69	-0,40	8,27
Netherlands	174,08	49,63	99,21	256,45	3,44	2,84	-1,09	13,80
New Zealand	26,58	14,93	9,06	53,76	7,73	5,14	0,47	27,20
Norway	57,57	39,23	10,79	135,11	5,47	4,23	0,01	15,75
Portugal	47,58	12,56	27,85	69,90	6,33	5,37	0,01	22,19
Spain	275,22	90,28	138,42	445,57	5,42	4,93	-0,75	15,27
Sweden	82,78	39,59	23,91	154,61	5,46	4,17	-0,81	18,00
Switzerland	94,67	51,46	23,68	188,12	2,36	2,66	-1,39	9,30
United Kingdom	298,58	262,70	14,80	813,95	4,49	3,60	0,17	16,27
United States	1618,31	1576,96	74,96	5517,58	3,44	3,01	0,00	15,52

As expected, both the Eurozone and the United States of America have the highest GDP's, again as they are both the biggest economies in the world. Greece has both the highest average and maximum value for the interest rate, this makes sense, as Greece is a country with a very high debt as a percentage of GDP.

Section 7: Results

In this section, I will present and analyze the results obtained using the aforementioned methodology. This methodology was applied with Python, mainly using the Pandas library, focused on data science. As mentioned earlier, a positive R2 GW for a given country means that, for that country, the model tested performed better (had a lower mean squared error) than the random walk model. It is also useful to compare between tested models, to see which model is better at beating the random walk, in order to do this, it can be claimed that a model with a higher R2 GW beats the random walk better than another model with a lower R2 GW for the same country, however, different models have a different number of observations, therefore, it is also important to take into consideration each R2 GW's significance, provided by the MSE-

F statistic, when comparing between models. A comparison between countries in the same model is also relevant, as different countries may react to models differently. Finally, I will check if there is a difference in the performance of the models between developed and developing countries.

Developed countries

Table 3.1: Results Developed – Model 1

Results – Model 1	R2 GW In-Sample	MSE-F In-Sample	R2 GW Out-of-Sample	MSE-F Out-of-Sample
Australia	0,488	188,069***	0,407	107,739***
Austria	0,484	184,670***	0,405	106,894***
Belgium	0,458	166,667***	0,367	91,132***
Canada	0,459	166,886***	0,427	116,817***
Denmark	0,466	171,781***	0,389	100,061***
Euro	0,468	173,597***	0,407	107,903***
France	0,459	167,267***	0,389	99,837***
Germany	0,464	170,502***	0,393	101,450***
Greece	0,459	167,083***	0,456	131,715***
Ireland	0,479	181,152***	0,414	110,867***
Italy	0,498	195,476***	0,441	123,629***
Japan	0,508	203,785***	0,506	161,017***
Netherlands	0,461	168,291***	0,400	104,808***
New Zealand	0,408	135,875***	0,365	90,116***
Norway	0,454	164,009***	0,426	116,723***
Portugal	0,411	137,685***	0,356	86,962***
Spain	0,456	164,946***	0,377	94,932***
Sweden	0,444	157,471***	0,390	100,319***
Switzerland	0,498	195,253***	0,452	129,273***
United Kingdom	0,461	168,240***	0,431	119,013***

*Significance level: 0.01 = ***, 0.05 = **, 0.1 = **

As can be seen in table 3.1, results for model 1, that predicts exchange rates using the commodity betas, are significantly positive for developed countries, as the model beats a random walk model for all countries. The R2 GW statistic is always positive, and usually takes a value of close to 0.5 for the in-sample forecast, this means that the prediction computed using Model 1 has roughly half the mean squared errors of the prediction computed used the random walk. Results for the out-of-sample estimation are also positive and significant, albeit less so than in the in-sample estimation, this is expected, as the in-sample estimation uses more information, and as such, usually provides better predictions.

Table 3.2: Results Developed – Model 2

Results – Model 2	R2 GW In-Sample	MSE-F In-Sample	R2 GW Out-of-Sample	MSE-F Out-of-Sample
Australia	0,561	233,810***	0,461	122,514***
Austria	0,477	166,899***	0,218	39,864***
Belgium	0,433	139,607***	0,318	66,543***
Canada	0,532	207,622***	0,388	90,836***
Denmark	0,443	145,615***	0,247	47,023***
Euro	0,436	141,645***	0,268	52,384***
France	0,397	120,503***	0,123	20,047***
Germany	0,456	153,627***	0,244	46,162***
Greece	0,470	162,492***	0,176	30,618***
Ireland	0,454	152,003***	0,366	82,383***
Italy	0,425	135,136***	0,182	31,812***
Japan	0,475	165,452***	0,291	58,772***
Netherlands	0,469	161,357***	0,275	54,141***
New Zealand	0,532	207,688***	0,387	90,093***
Norway	0,509	189,743***	0,346	75,508***
Portugal	0,470	162,060***	0,181	31,501***
Spain	0,370	107,391***	0,200	35,671***
Sweden	0,426	135,886***	0,242	45,777***
Switzerland	0,519	197,566***	0,369	83,683***
United Kingdom	0,476	166,065***	0,326	69,012***

*Significance level: 0.01 = ***, 0.05 = **, 0.1 = **

Table 3.2 exhibits the most striking result of this dissertation, that goes against prior research: my results show that Model 2, a model that predicts exchange rates using economic fundamentals, is actually able to beat a random walk model significantly, for all developed countries. This finding is contrary to the consensus in the literature, and the reasons for this are not clear, more recent data actually showing a relationship between exchange rates and economic fundamentals could be an explanation. Comparing the results in table 3.2 with the results in table 3.1, we see that the best model in beating a random walk varies across countries. In-sample, it is difficult to say which model is the best, since the model with the highest R2 GW differs almost equally across countries, however, out-of-sample, Model 1 clearly performs better most of the times, reinforcing the fact that commodity prices are relevant in predicting exchange rates.

Table 3.3: Results Developed – Model 3

Results – Model 3	R2 GW In-Sample	MSE-F In-Sample	R2 GW Out-of-Sample	MSE-F Out-of-Sample
Australia	0,562	182,548***	0,444	81,417***
Austria	0,490	136,160***	0,023	2,436*
Belgium	0,439	111,104***	0,309	45,653***
Canada	0,535	163,577***	0,406	69,673***
Denmark	0,450	116,328***	0,224	29,519***
Euro	0,444	113,246***	0,196	24,888***
France	0,409	98,189***	0,028	2,918*
Germany	0,465	123,424***	0,133	15,632***
Greece	0,482	132,044***	0,277	39,016***
Ireland	0,461	121,548***	0,311	45,948***
Italy	0,431	107,692***	0,088	9,875***
Japan	0,480	131,013***	0,231	30,702***
Netherlands	0,480	131,084***	0,161	19,623***
New Zealand	0,542	168,085***	0,341	52,669***
Norway	0,516	151,123***	0,307	45,225***
Portugal	0,474	127,860***	0,251	34,234***
Spain	0,364	81,128***	0,212	27,384***
Sweden	0,429	106,737***	0,238	31,802***
Switzerland	0,532	161,591***	0,251	34,139***
United Kingdom	0,478	130,092***	0,313	46,430***

*Significance level: 0.01 = ***, 0.05 = **, 0.1 = **

In table 3.3 we find the results for Model 3 – the model that combines both economic fundamentals and the commodity betas in predicting exchange rates. The results are, once again, positive, in that the model beats the random walk model prediction every time, but, for the first time, we see out-of-sample results that are not as significant as in the previous model: Austria and France, this means that for these countries, it is not that obvious that Model 3 outperforms a random walk. The results are almost always very similar to Model 2 expect for some cases where the out-of-sample estimation is either significantly better or significantly worse.

To sum up the results for developed countries, the forecasts of all models clearly outperform the random walk model, which are positive findings. Unexpectedly, this is the case even for a model that uses only economic fundamentals in predicting exchange rates. Regarding commodity prices, results indicate that a model that depends on the commodity betas is better at beating a random walk than the other two models, out-of-sample.

Developing countries

Table 4.1: Results Developing – Model 1

Results – Model 1	R2 GW In-Sample	MSE-F In-Sample	R2 GW Out-of-Sample	MSE-F Out-of-Sample
Argentina	0,423	80,019***	0,164	13,552***
Armenia	0,339	55,867***	-1,026	-34,947***
Bahrain	0,667	218,217***	0,652	129,227***
Bangladesh	0,497	107,793***	0,428	51,644***
Bolivia	0,062	7,262***	0,044	3,171*
Botswana	0,463	93,951***	0,459	58,648***
Brazil	-1,155	-58,424***	0,091	6,889**
Chile	0,483	101,959***	0,437	53,534***
China	0,493	106,066***	0,268	25,253***
Colombia	0,474	98,311***	0,329	33,884***
Costa Rica	0,343	56,783***	0,374	41,312***
Croatia	-1,365	-62,916***	0,411	48,178***
Czech Republic	0,520	118,023***	0,457	58,080***
Egypt	0,507	112,201***	0,486	65,228***
El Salvador	0,390	69,565***	0,344	36,177***
Ghana	0,122	15,120***	0,141	11,325***
Hong Kong	0,581	150,854***	0,550	84,382***
Hungary	0,528	121,773***	0,487	65,578***
Iceland	0,383	67,519***	0,258	24,013***
Indonesia	0,203	27,799***	0,143	11,525***
Israel	0,445	87,476***	0,374	41,154***
Jamaica	0,429	81,851***	0,275	26,190***
Kazakhstan	0,143	18,154***	0,228	20,334***
Kenya	0,224	31,511***	0,381	42,528***
Kuwait	0,331	54,024***	-0,015	-0,998
Lebanon	0,355	60,023***	0,376	41,534***
Macedonia	0,404	73,777***	0,463	59,565***
Malaysia	0,420	79,058***	0,417	49,286***
Malta	0,531	123,360***	0,500	69,029***
Mauritius	0,387	68,713***	0,310	31,036***
Mexico	0,422	79,670***	0,442	54,702***
Namibia	0,470	96,841***	0,455	57,662***
Nigeria	0,519	117,515***	0,310	30,987***
Pakistan	0,503	110,188***	0,385	43,226***
Philippines	0,436	84,325***	0,253	23,310***
Poland	0,501	109,339***	0,455	57,672***
Romania	0,078	9,182***	0,158	12,978***
Serbia	0,509	113,168***	-6,010E+16	-69,000***
Singapore	0,514	115,305***	0,451	56,646***
Slovakia	0,451	89,652***	0,433	52,782***
Slovenia	0,497	107,839***	0,411	48,210***
South Africa	0,468	95,752***	0,449	56,307***
Sri Lanka	0,398	71,940***	0,304	30,124***
Taiwan	0,519	117,624***	0,510	71,732***
Thailand	0,461	93,125***	0,138	11,019***
Trinidad And Tobago	0,478	99,952***	0,448	56,102***
Tunisia	0,488	103,743***	0,359	38,690***
Turkey	0,238	33,973***	0,067	4,951**
Ukraine	0,344	57,050***	0,290	28,125***
Uruguay	0,272	40,683***	0,208	18,129***
Venezuela	0,275	41,386***	0,282	27,066***
Zimbabwe	0,512	114,541***	0,491	66,657***

*Significance level: 0.01 = ***, 0.05 = **, 0.1 = **

Analyzing table 4.1, we can see that results are almost always positive, again, mostly with very high significance. In the in-sample forecast, only Brazil and Croatia indicate that Model 1 does not beat a random walk, this is unusual, as the out-of-sample forecast of these countries indicates that Model 1 actually does beat the random walk, this anomaly might be a coincidence of data. In the out-of-sample forecast, again most countries indicate a good performance of Model 1, only Armenia and Serbia exhibit negative R2 GW values (the extreme value for Serbia is a consequence of a very big change in exchange rates against the USD around 1994, that is met with no variation in commodity betas, and thus yields a very big squared error for a portion of the forecast). Kuwait has an insignificant negative value. The fact that Bahrain shows a very good performance of Model 1 out-of-sample makes sense, as the country's major exports are petroleum, aluminum, and iron ore, which are commodities that are present, either directly or indirectly, in my dataset.

Table 4.2: Results Developing – Model 2

Results – Model 2	R2 GW In-Sample	MSE-F In-Sample	R2 GW Out-of-Sample	MSE-F Out-of-Sample
Argentina	0,234	67,959***	0,076	14,981***
Armenia	0,415	158,389***	0,093	18,738***
Bahrain	0,517	238,755***	0,482	170,020***
Bangladesh	0,521	242,326***	0,490	176,039***
Bolivia	0,512	233,681***	-98,620	-181,163***
Botswana	0,505	227,162***	0,417	130,784***
Brazil	-0,505	-74,791***	-3,911	-145,739***
Chile	0,405	152,022***	0,286	73,150***
China	0,513	235,376***	0,307	80,902***
Colombia	0,427	165,882***	0,120	25,047***
Costa Rica	0,510	232,426***	0,470	162,021***
Croatia	-0,131	-25,836***	-2,829	-135,212***
Czech Republic	0,524	245,392***	0,457	154,104***
Egypt	0,505	227,537***	0,429	137,234***
El Salvador	0,515	237,090***	0,474	164,721***
Ghana	0,517	238,585***	0,434	140,268***
Hong Kong	0,493	217,126***	0,222	52,282***
Hungary	0,504	226,834***	0,171	37,847***
Iceland	0,460	189,991***	0,155	33,633***
Indonesia	0,489	213,637***	-0,424	-54,461***
Israel	0,066	15,634***	-1,235	-101,126***
Jamaica	0,461	191,083***	0,269	67,257***
Kazakhstan	0,501	224,307***	0,427	136,221***
Kenya	0,474	200,783***	0,130	27,270***
Kuwait	0,600	334,976***	0,547	220,727***
Lebanon	0,511	233,208***	0,065	12,728***
Macedonia	0,411	155,514***	-0,281	-40,165***
Malaysia	0,459	189,041***	0,373	108,804***
Malta	0,489	213,333***	0,390	117,125***
Mauritius	0,498	221,407***	0,396	119,800***
Mexico	0,419	160,964***	0,106	21,729***
Namibia	0,496	219,208***	0,417	130,723***
Nigeria	0,509	231,332***	0,473	164,489***
Pakistan	0,498	221,185***	0,459	155,120***
Philippines	0,443	177,621***	-0,095	-15,916***
Poland	0,279	86,376***	-0,406	-52,835***
Romania	0,508	229,891***	0,170	37,552***
Serbia	0,514	235,925***	0,448	148,610***
Singapore	0,548	270,520***	0,427	136,315***
Slovakia	0,533	254,059***	0,468	160,855***
Slovenia	-0,005	-1,199	-1,393	-106,528***
South Africa	0,514	236,143***	0,357	101,585***
Sri Lanka	0,437	173,178***	0,334	91,882***
Taiwan	0,433	170,000***	-0,092	-15,346***
Thailand	0,492	216,035***	0,231	54,945***
Trinidad And Tobago	0,527	248,631***	0,506	187,286***
Tunisia	0,482	207,406***	0,335	92,102***
Turkey	0,545	266,764***	0,248	60,241***
Ukraine	0,333	111,416***	0,176	39,130***
Uruguay	0,320	104,940***	0,279	70,798***
Venezuela	-0,217	-39,805***	-0,318	-44,180***
Zimbabwe	0,510	232,516***	0,471	163,242***

*Significance level: 0.01 = ***, 0.05 = **, 0.1 = **

Model 2 is also, overall, a better performer than the random walk for developing countries, as can be seen in table 4.2. In-sample results indicate that economic fundamentals are helpful in predicting exchange rates for the majority of developing countries as well, exceptions are Brazil, Croatia and Venezuela (Slovenia's value is insignificantly negative). Out-of-sample, performance drops significantly, as more countries indicate that model 2 does not perform better than the random walk, and the countries that say that it does have a R2 GW value that is overall lower than in Model 1, it is noteworthy that the sample size for Model 2 in the developing countries is larger than for Model 1, which means that these results are more significant than the ones in table 4.1.

Table 4.3: Results Developing – Model 3

Results – Model 3	R2 GW In-Sample	MSE-F In-Sample	R2 GW Out-of-Sample	MSE-F Out-of-Sample
Argentina	0,367	45,208***	0,300	16,294***
Armenia	0,592	113,282***	-167,245	-37,774***
Bahrain	0,673	160,867***	0,661	74,120***
Bangladesh	0,484	73,250***	0,189	8,827***
Bolivia	0,390	49,805***	-1,000	-19,000***
Botswana	0,524	86,027***	0,329	18,629***
Brazil	0,548	94,453***	-6,084	-32,636***
Chile	0,514	82,453***	0,421	27,648***
China	0,543	92,532***	-1,397	-22,144***
Colombia	0,526	86,687***	0,203	9,650***
Costa Rica	0,405	53,198***	0,144	6,386**
Croatia	0,471	69,465***	0,286	15,257***
Czech Republic	0,515	82,942***	0,378	23,111***
Egypt	0,563	100,384***	0,511	39,748***
El Salvador	0,247	25,567***	-0,011	-0,405
Ghana	0,371	46,003***	0,395	24,844***
Hong Kong	0,609	121,544***	0,607	58,621***
Hungary	0,589	111,775***	0,396	24,926***
Iceland	0,504	79,203***	0,394	24,709***
Indonesia	0,511	81,661***	-1,879	-24,800***
Israel	0,527	86,850***	0,534	43,513***
Jamaica	0,535	89,673***	0,092	3,839*
Kazakhstan	0,626	130,484***	-1,914	-24,958***
Kenya	0,480	72,104***	0,505	38,747***
Kuwait	0,525	86,041***	0,449	30,962***
Lebanon	0,613	123,484***	-0,011	-0,413
Macedonia	0,550	95,478***	0,004	0,133
Malaysia	0,594	114,242***	-0,090	-3,142*
Malta	0,516	83,278***	0,427	28,324***
Mauritius	0,555	97,247***	0,442	30,073***
Mexico	0,632	133,894***	0,266	13,760***
Namibia	0,539	91,074***	0,473	34,108***
Nigeria	0,521	84,879***	0,201	9,574***
Pakistan	0,432	59,419***	-0,131	-4,401**
Philippines	0,509	80,783***	-1,257	-21,166***
Poland	0,582	108,762***	0,553	46,947***
Romania	0,604	118,966***	-0,495	-12,589***
Serbia	0,569	102,951***	-3,462E+21	-38,000***
Singapore	0,496	76,822***	0,398	25,099***
Slovakia	0,494	76,144***	0,255	13,007***
Slovenia	0,466	68,078***	0,313	17,345***
South Africa	0,544	92,901***	0,471	33,890***
Sri Lanka	0,515	82,786***	0,440	29,860***
Taiwan	0,539	91,303***	0,536	43,818***
Thailand	0,548	94,630***	-0,040	-1,460
Trinidad And Tobago	0,440	61,276***	0,159	7,200**
Tunisia	0,469	68,882***	0,409	26,308***
Turkey	0,573	104,644***	-0,289	-8,511***
Ukraine	0,377	47,246***	0,162	7,371***
Uruguay	0,543	92,635***	0,057	2,279
Venezuela	0,112	9,829***	-0,388	-10,619***
Zimbabwe	0,526	86,453***	0,488	36,244***

*Significance level: 0.01 = ***, 0.05 = **, 0.1 = **

Finally, table 4.3 presents the results of Model 3's performance for developing countries. This model is, overall, the best in-sample, as all countries indicate that the model beats the random walk at the 0.01% significance. Out-of-sample we find, once more, that results are not so robust, as several countries have less significant values (possibly due to a smaller sample) or indicate that the random walk is better in predicting exchange rates than Model 3 by having negative R2 GW values. We find here an anomaly in the Serbia results out-of-sample once more.

Overall, for developing countries, results are also positive, as the three models are almost always good performers in-sample, and they are also the best performer more often than not, out-of-sample. Again, it is striking that Model 2, the model of economic fundamentals, has positive results, as previous research clearly states that this relationship is not found in the data. For developing countries, it is again somewhat clearer that Model 1 performs better out-of-sample, given that fewer countries indicate that the random walk outperforms this specification, when compared with both other models.

Comparing between developed and developing countries, it can be claimed that there is, overall, a higher predictability of the models for the developed countries, as they beat the random walk every time. This is possibly due to the fact that developed countries' economies suffer less shocks, and as such, their exchange rates are less subject to unpredictable events that affect them, and are, thus, easier to predict. There is also, usually, more information available for developed countries than for developing countries, this might also play a role in this discrepancy and suggests that, with more data, results for developing countries might be more positive and significant.

Section 8: Concluding remarks

The aim of this dissertation is to assess whether commodity prices have an impact in exchange rates, and if they help in predicting the exchange rates of several countries against the US dollar. I found that indeed there is a relationship between commodity prices and exchange rates, by analyzing and comparing three models: a model that depends on commodity prices, a model that depends on economic fundamentals, and a model that combines both previous models.

For the vast majority of countries in my dataset, in an in-sample analysis, all models performed better than a random walk model, both for developed and developing countries, with no particular model being strictly better than another. This is a relevant finding, as exchange rates were long documented as being nearly impossible to predict, and most models were not able to beat a random walk. In the out-of-sample forecast, much harder to achieve and, thus, much more robust, the models also outperform the random walk model for the majority of the countries studied, despite the fact that this happens for less developing countries. It can be seen that, out-of-sample, the first model, that predicts exchange rates using only commodity prices, performs better than the other two models, this indicates that commodity prices are indeed helpful in predicting exchange rates, and do so better than an economic fundamentals or a mixed model. These findings are consistent with the results of others in the literature, such as Chen and Rogoff (2003), that find that commodity prices and exchange rates are related, it is, however, extremely unexpected that a economic fundamentals based model is able to outperform a random walk model for any country, as it has been long documented in the literature that, while theoretically this should be the case, exchange rates and economic fundamentals are not related in the data.

This study is relevant for a variety of agents in economies everywhere, as exchange rates are a very important part of every economy: companies that do business abroad are subject to exchange rate fluctuations in every commercial or financial activity they engage in; governments care deeply about the exchange rate of their currency against other countries since it directly impacts their trade balance, for example, due to the incentives that a devaluation of the home currency provides; investors that hold positions in foreign assets constantly see their asset price fluctuating with exchange rates; even every day consumers and travelers are affected by exchange rates, that impact how much is their money worth in another country.

Section 9: Assumptions, limitations and future research

Some assumptions and limitations are present in this dissertation that are relevant to mention. Firstly, the forecasting method applied used contemporaneous observations of exchange rates and the independent variables, while there is relevance in these findings, a real life application of them should consider a certain lag between independent and dependent variables, since future forecasts are usually done with contemporaneous information, this is a suggestion for further research. Also, the study was done as having the United States as the home country, the whole analysis might be different when considering another country as the home country, which is a suggestion left for future researchers. Another specification used here is the window, I chose a rolling window of 40 observations, that are equivalent to 10 years of quarterly data, changing this might alter the results somewhat and might lead to different conclusions, a larger rolling window or an expanding window might be used, for example. The study might also benefit from experimenting with a different frequency, such as monthly or annual. I also used 17 commodities and, while these commodities are among the most traded and relevant commodities, experimenting with less traded commodities might yield an interesting development on this study. Another limitation is that, for the economic fundamentals model, I only use a short-term interest rate (3 months), in fact, experimenting with a longer-term interest rate might be interesting. Finally, following the research of Abhyankar, Sarno and Valente (2005), studying the economic value of investing according to a strategy that follows the commodity price model might bring valuable insights for foreign exchange investors.

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Appendices

Appendix 1: Definitions – Commodities

Commodities	Definition
Aluminum	Price per metric tonne from the LME (London Metal Exchange)
Brent Crude Oil	Price per barrel
Cocoa	Price per metric tonne from the ICCO (International Cocoa Organization)
Coffee	Price (in cents) per pound of Brazilian coffee in New York
Copper	Price per metric tonne from the LME (London Metal Exchange)
Corn	Price per bushel
Cotton	Price per pound
Gold	Price per troy ounce from the LBMA (London Bullion Market Association)
Iron Ore	Price per metric tonne of exports from Port Headland, Australia to Qingdao, China
Natural Gas	Price per million British thermal unit
Platinum	Price per troy ounce from the LME (London Metal Exchange)
Silver	Price per troy ounce from the LBMA (London Bullion Market Association)
Soybeans	Price per bushel
Sugar	Price (in cents) per pound of crystal sugar in São Paulo
Tobacco	Price per metric tonne
Wheat	Price per bushel
WTI Oil	Price per barrel

Appendix 2: Definition – Stock Exchange Index Developed Countries

Developed Countries	Stock Exchange Index
Australia	Australia ASX All-Ordinaries
Austria	Austria WBKI
Belgium	Brussels All-Share
Canada	Canada S&P/TSX 300 Composite
Denmark	OMX Copenhagen All-Share
Euro	EuroStoxx
France	France CAC All-Tradable
Germany	Germany CDAX Composite
Greece	Athens SE General
Ireland	Ireland ISEQ All-Share
Italy	Banca Commerciale Italiana
Japan	TOPIX
Netherlands	Netherlands All-Share
New Zealand	New Zealand SE All-Share
Norway	Oslo SE OBX-25
Portugal	PSI-20
Spain	Madrid SE General
Sweden	OMX Stockholm All-Share
Switzerland	Switzerland Price Index
United Kingdom	UK FTSE All-Share
United States	S&P 500/Cowles Composite

Appendix 3: Definition – Stock Exchange Index Developing Countries

Developing Countries	Stock Exchange Index
Argentina	Buenos Aires SE – IVBNG
Armenia	Armenia Sed Marsed Index
Bahrain	Bahrain BSE All-Share Index
Bangladesh	Dhaka SE General Index
Bolivia	Bolivia Stock Market Capitalization
Botswana	Botswana SE Domestic Companies Index
Brazil	Rio de Janeiro Bolsa de Valores Index (IBV)
Chile	Santiago SE S&P CLX Index
China	Shanghai Fan Equal Weighted Index (USD)
Colombia	Colombia Colcap Index
Costa Rica	Costa Rica Bolsa Nacional de Valores Index
Croatia	Croatia Bourse Index (CROBEX)
Czech Republic	Prague SE PX Index
Egypt	Cairo SE EFG General Index
El Salvador	El Salvador Stock Market Index
Ghana	Ghana SE Databank Index
Hong Kong	Hong Kong Hang Seng Composite Index
Hungary	Vienna OETEB Hungary Traded Index (Forint)
Iceland	OMX Iceland All-Share Price Index
Indonesia	Jakarta SE Composite Index
Israel	Tel Aviv SE 125 Broad Index
Jamaica	Jamaica All-Jamaican Stock Exchange Index
Kazakhstan	Kazakhstan SE KASE Index
Kenya	Nairobi SE Index
Kuwait	Kuwait SE All-Share Index
Lebanon	Beirut BLOM Stock Exchange Index
Macedonia	North Macedonia MBI-10 Index
Malaysia	Malaysia KLSE Composite
Malta	Malta SE Index
Mauritius	Securities Exchange of Mauritius Index (SEMDEX)
Mexico	Mexico SE Indice de Precios y Cotizaciones (IPC)
Namibia	Namibia Stock Exchange Overall Index
Nigeria	Nigeria SE All-Share Index
Pakistan	Pakistan Karachi SE-100 Index
Philippines	Manila SE Composite Index
Poland	Warsaw SE 20-Share Composite
Romania	Bucharest SE Index in Lei
Serbia	Serbia Market cap of listed companies (USD)
Singapore	Singapore FTSE Straits-Times Index
Slovakia	Vienna CEE Slovak Traded Index (Koruna)
Slovenia	Slovenia SE SBITOP Blue Chip Index
South Africa	FTSE/JSE All-Share Index
Sri Lanka	Colombo SE All-Share Index
Taiwan	Taiwan SE Capitalization Weighted Index
Thailand	Thailand SET General Index
Trinidad And Tobago	Trinidad and Tobago SE Composite
Tunisia	Tunisa SE Tunindex-20 Share Index
Turkey	Istanbul SE IMKB-100 Price Index
Ukraine	Ukraine PFTS OTC Index
Uruguay	Bolsa de Valores de Montevideo Index
Venezuela	Caracas SE Bursatil General Index
Zimbabwe	Zimbabwe Market cap of listed companies (USD)

Appendix 4.1: Summary Statistics – Developing Countries

Developing Countries	Stock Exchange Index				Exchange Rate			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
Argentina	247207,21	405518,37	9264,49	1909644,00	1,41	5,90	0,00	65,18
Armenia	42,47	4,80	36,10	47,70	424,18	131,81	0,50	586,92
Bahrain	1343,18	469,63	703,84	2902,68	0,39	0,03	0,37	0,48
Bangladesh	2107,50	1798,77	377,77	8918,51	22,15	26,57	2,04	96,94
Bolivia	3269,87	2770,48	24,00	10787,25	1,44	2,68	0,00	8,07
Botswana	4717,17	3587,38	268,36	11096,92	2,17	2,87	0,38	12,42
Brazil	24082,35	19088,72	2,96	72673,85	0,42	0,96	0,00	5,35
Chile	12327,20	7833,13	2365,44	29518,17	124,09	223,04	0,00	867,80
China	2661,98	884,77	1011,50	6092,06	2,16	2,88	0,00	8,74
Colombia	829,35	967,06	40,56	10826,37	658,87	1009,21	0,84	4178,00
Costa Rica	6115,45	3800,21	524,73	15115,35	105,43	186,17	1,30	651,50
Croatia	1782,22	896,42	431,10	5392,94	1,86	2,91	0,00	9,17
Czech Republic	883,62	367,15	316,00	1936,90	11,37	9,76	0,98	42,22
Egypt	239,25	220,43	9,84	904,16	1,71	3,21	0,12	19,62
El Salvador	201,25	35,77	112,11	278,75	3,46	2,93	0,94	10,00
Ghana	2806,14	3033,61	60,15	10900,80	0,41	1,26	0,00	132,91
Hong Kong	16933,52	6749,25	4301,78	33154,12	4,29	2,65	0,32	8,70
Hungary	5063,52	2532,44	357,81	10334,63	19512037,54	1770386264,20	0,00	175000000000,00
Iceland	1634,65	1617,69	314,93	8174,28	27,83	41,98	0,03	147,55
Indonesia	2301,26	2080,80	246,95	6689,29	1902,88	3875,23	0,00	16550,00
Israel	754,97	444,34	99,62	1684,12	1,28	1,74	0,00	5,01
Jamaica	94350,33	103321,61	6582,32	532325,41	15,06	32,70	0,08	157,07
Kazakhstan	1247,55	1124,48	90,78	10826,37	49,74	91,01	0,00	455,61
Kenya	3292,47	1172,28	954,03	6161,46	24,93	32,10	2,04	106,50
Kuwait	4137,43	2710,31	524,73	11799,91	0,28	0,06	0,19	0,49
Lebanon	1013,83	355,60	388,39	2119,41	511,64	708,99	0,54	2760,23
Macedonia	2534,27	1658,15	605,98	10057,77	48,78	11,15	5,90	71,20
Malaysia	1163,99	425,16	262,70	1895,18	2,29	0,91	0,32	4,68
Malta	3282,93	1260,30	900,74	6641,87	0,73	0,19	0,44	1,21
Mauritius	1116,30	745,76	148,24	2308,30	11,05	10,92	2,53	44,12
Mexico	21678,61	17391,06	1252,10	51713,38	2,39	4,96	0,00	25,34
Namibia	632,35	384,39	92,99	1460,40	2,42	3,56	0,37	18,80
Nigeria	20709,33	14568,00	785,10	66371,20	39,36	80,16	0,32	432,01
Pakistan	12988,43	14155,71	765,73	52876,46	22,88	33,31	2,04	167,60
Philippines	3682,80	2346,60	979,34	9058,62	14,23	18,01	1,83	56,42
Poland	1998,64	656,49	577,80	3917,87	1,00	1,53	0,00	4,72
Romania	4867,79	2954,20	281,24	10813,60	0,52	1,20	0,00	4,87
Serbia	7937,10	6639,28	734,28	23721,64	11,55	28,66	0,00	118,72
Singapore	2373,87	735,05	805,04	3875,77	1,85	0,66	0,32	3,09
Slovakia	607,54	230,61	310,45	1044,73	0,42	0,39	0,03	1,74
Slovenia	742,58	448,65	135,39	2674,69	0,24	0,36	0,00	1,09
South Africa	23836,93	18754,50	2684,66	61684,80	2,13	3,39	0,14	19,27
Sri Lanka	2991,19	2516,60	383,44	7811,82	32,28	46,24	2,04	193,00
Taiwan	7312,70	1926,85	3135,56	12179,81	19,70	17,50	0,00	53,20
Thailand	949,53	454,04	207,31	1838,96	14,28	13,16	0,66	55,50
Trinidad And Tobago	740,16	418,77	59,13	1518,01	2,82	2,14	0,91	7,72
Tunisia	2710,64	1847,56	1737,55	21546,96	0,58	0,65	0,00	3,14
Turkey	38784,58	35276,87	31,42	123556,10	0,32	0,92	0,00	6,86
Ukraine	360,10	286,88	16,52	1208,61	8,16	8,49	0,00	33,00
Uruguay	152,90	34,86	65,63	206,25	4,57	9,36	0,00	49,33
Venezuela	2134,21	13757,77	0,00	249098,83	311,86	4129,58	0,00	87396,82
Zimbabwe	5922,59	6194,67	628,00	26556,64	17,07	76,90	0,00	448,10

Appendix 4.2: Summary Statistics – Developing Countries

Developing Countries	Money Supply				Inflation			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
Argentina	251503	389714	440	1942902	11,90	33,72	0,00	295,67
Armenia	445280	220290	95409	996875	80,83	33,81	0,02	131,59
Bahrain	1446	1219	203	3579	62,80	23,55	16,43	100,70
Bangladesh	477689	699805	6267	2763218	61,54	71,93	1,43	276,16
Bolivia	26672625	23364113	2640715	68425691	21,82	31,82	0,00	105,51
Botswana	12529	3856	6523	19689	35,70	32,22	2,25	102,70
Brazil	239419	99422	74996	441805	705,86	1381,16	0,00	5344,75
Chile	6405	10061	0	43820	20,13	31,77	0,00	104,71
China	12404	16542	75	57601	63,74	28,33	19,60	113,70
Colombia	29153	34725	164	127882	16,13	29,13	0,00	104,94
Costa Rica	1471964	960969	237823	4208291	20,40	33,29	0,06	106,54
Croatia	76518	27736	46202	139302	31,88	41,32	0,00	103,20
Czech Republic	1495271	1114090	251000	3953052	55,99	42,35	14,07	223,67
Egypt	261330	262427	33680	1004160	9,79	19,87	0,13	105,60
El Salvador	1559	499	945	2573	33,04	41,13	0,56	113,02
Ghana	6687	10444	16	43430	11,75	24,73	0,00	112,10
Hong Kong	495414	717328	5642	2997257	41,65	35,26	5,06	111,50
Hungary	6533	5970	587	24493	262,28	415,56	0,00	1347,60
Iceland	377	126	104	561	87,17	139,07	0,01	474,10
Indonesia	279910	413658	318	1565358	22,23	38,20	0,00	139,07
Israel	78298	115407	8	434271	28,15	41,60	0,00	108,00
Jamaica	94644	57282	26565	258036	42,42	73,89	0,05	270,60
Kazakhstan	1915725	1858887	7941	6412273	324,41	222,56	0,01	802,80
Kenya	517	452	71	1575	34,26	54,93	0,43	208,24
Kuwait	4813	3413	1042	11418	62,80	27,08	18,83	115,20
Lebanon	2500	3326	2	18408	85,21	13,49	68,88	118,00
Macedonia	89814	34036	49446	175688	78,86	34,99	0,00	114,62
Malaysia	139462	132788	2033	452559	54,63	33,10	16,22	122,40
Malta	9276	4443	3782	16882	50,79	28,99	13,15	103,69
Mauritius	48723	32278	9737	114837	29,03	32,80	1,37	106,60
Mexico	1995275083	1232459257	509701873	4702061399	16,38	29,65	0,00	107,14
Namibia	26895	14349	6802	58404	45,09	41,58	2,06	139,85
Nigeria	212032	138180	65435	538947	40,24	70,02	0,06	312,60
Pakistan	7871454	3588096	3168848	15152486	23,98	32,85	1,01	133,03
Philippines	777638	1074248	14600	4500018	22,84	34,99	0,21	122,60
Poland	393945	291934	63626	1154867	1221,73	2879,59	0,01	10820,00
Romania	113364	65644	0	276936	42,39	55,18	0,00	189,43
Serbia	317028	214421	43647	903603	38,65	65,40	0,00	200,90
Singapore	47706	58418	1202	202581	54,99	26,54	18,88	101,00
Slovakia	32	12	16	58	70,71	58,67	16,98	176,50
Slovenia	10926	4842	5527	22239	33,11	41,92	0,00	105,93
South Africa	355603	510740	1482	1832143	18,06	29,31	0,45	115,20
Sri Lanka	214493	244752	6091	865467	23,41	36,20	0,41	134,60
Taiwan	1763427	2015662	7081	7529074	36,18	37,60	0,00	103,27
Thailand	1116	550	366	2223	42,78	33,33	5,38	103,31
Trinidad And Tobago	17321	16153	2058	47719	23,67	31,70	0,54	108,90
Tunisia	13331	9266	2774	34749	29,49	32,92	0,12	129,10
Turkey	244309356	182855675	57885531	847007180	37,38	87,32	0,00	448,02
Ukraine	228108	214507	4400	770043	85,11	80,71	0,00	285,00
Uruguay	66778	48553	11548	179529	5129,12	24452,6 7	0,27	256123,29
Venezuela	358260	3562221	0	58935301	8812093 1,56	630862 798,35	0,01	78810128 57,50
Zimbabwe	4061112	5200304	216333	32851569	9,43	40,58	0,00	640,20

Appendix 4.3: Summary Statistics – Developing Countries

Developing Countries	GDP				Interest Rates			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
Argentina	111,26	40,33	37,81	168,44	16,17	10,60	1,10	59,77
Armenia	2,91	0,69	1,83	4,18	16,49	16,85	3,24	80,42
Bahrain	4,36	2,86	1,05	9,41	3,77	2,36	0,63	9,98
Bangladesh	16,63	18,07	1,17	75,59	7,40	2,38	0,54	11,50
Bolivia	4,55	2,93	1,57	10,51	8,80	6,87	0,02	26,60
Botswana	3,46	0,78	1,92	4,77	8,53	4,73	1,00	14,31
Brazil	360,95	180,24	108,71	681,56	36,93	78,48	3,19	933,60
Chile	53,10	17,21	17,60	78,39	6,13	4,30	0,46	19,17
China	1225,95	1154,68	96,32	3946,64	3,34	1,18	1,21	6,46
Colombia	60,04	25,88	20,98	101,70	9,55	8,15	3,42	52,64
Costa Rica	7,87	4,49	2,53	16,29	11,19	6,21	3,12	24,50
Croatia	12,63	3,62	5,15	19,76	2,58	2,18	0,03	7,60
Czech Republic	38,31	17,50	12,98	64,80	4,03	3,95	-0,48	15,54
Egypt	51,37	24,23	16,28	91,53	11,53	3,72	1,56	20,76
El Salvador	5,23	0,96	3,35	7,09	3,83	0,90	1,68	6,99
Ghana	5,98	5,10	0,98	16,77	21,51	9,88	9,05	46,75
Hong Kong	35,72	26,64	1,82	96,25	2,43	2,36	-0,08	12,24
Hungary	26,48	10,57	11,01	43,24	12,06	9,99	-0,06	35,30
Iceland	3,85	1,39	1,81	6,79	10,73	6,41	3,12	34,30
Indonesia	233,76	25,89	173,29	288,08	5,77	1,00	2,21	7,85
Israel	52,01	23,25	23,70	103,91	5,83	5,25	0,06	17,96
Jamaica	2,99	0,65	1,75	4,11	11,76	9,71	1,25	51,98
Kazakhstan	24,84	20,10	1,47	79,48	19,67	48,59	1,24	318,78
Kenya	15,32	4,68	8,80	24,78	11,11	8,58	-0,24	70,64
Kuwait	19,50	13,50	2,71	43,78	6,12	1,78	0,60	8,87
Lebanon	6,35	4,12	0,57	14,13	10,39	6,03	2,54	34,18
Macedonia	2,15	0,74	0,87	3,37	6,32	3,26	2,25	18,00
Malaysia	79,40	8,20	58,36	95,16	4,14	1,34	1,82	9,98
Malta	2,19	0,81	0,90	3,84	3,00	1,97	-0,34	5,49
Mauritius	2,31	0,84	1,00	3,80	5,96	3,37	0,93	12,91
Mexico	222,41	74,22	83,65	335,09	23,48	25,31	2,86	153,91
Namibia	1,52	1,04	0,34	4,02	9,87	3,62	5,25	21,68
Nigeria	111,15	16,16	84,99	143,07	10,34	5,47	1,20	27,50
Pakistan	18,51	21,01	0,93	77,69	9,87	3,46	1,21	17,42
Philippines	32,17	25,13	7,69	103,59	10,10	7,20	0,10	43,39
Poland	91,41	41,33	32,68	164,92	11,54	11,82	0,05	49,02
Romania	32,06	19,86	6,62	74,63	48,65	32,35	7,82	179,94
Serbia	8,90	3,24	2,73	14,50	16,19	15,43	2,64	99,25
Singapore	30,28	29,11	1,41	95,51	1,55	1,15	0,17	4,90
Slovakia	17,22	7,71	5,83	27,62	9,36	5,90	1,95	26,00
Slovenia	9,22	3,74	3,03	15,39	3,45	3,84	0,01	12,70
South Africa	35,20	31,15	1,81	109,05	6,59	5,10	-0,17	22,15
Sri Lanka	5,21	6,70	0,35	23,07	11,79	3,57	5,32	21,30
Taiwan	52,78	49,74	0,41	162,28	4,34	3,50	0,17	14,99
Thailand	67,23	33,70	26,77	143,32	5,78	4,07	0,87	19,32
Trinidad And Tobago	4,20	2,06	1,30	7,22	5,34	2,91	0,05	12,11
Tunisia	7,74	2,99	3,12	12,61	6,65	2,24	4,02	11,63
Turkey	153,95	66,04	47,65	253,55	48,54	34,99	4,71	159,44
Ukraine	34,16	8,90	17,62	49,78	15,11	6,57	6,00	46,00
Uruguay	11,00	3,80	3,92	15,75	32,22	30,88	2,26	146,47
Venezuela	257,60	933,98	11,41	5028,58	21,98	10,40	8,89	57,05
Zimbabwe	1,86	1,51	0,26	7,75	34,97	78,92	3,05	525,00