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PESO PROBLEM AND DEVALUATION EXPECTATIONS: EVIDENCE FROM LATIN AMERICA

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ABSTRACT

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This study examines peso problem and devaluation expectations in the following Latin American countries: Argentina, Brazil, Costa Rica, Uruguay and Venezuela. On the other hand, we investigate if the anomalous development of interest rates prior to the actual devaluation could be explained with peso problem phenomenon. In order to investigate these issues, we have to estimate the expected devaluation probability prior to actual event in the examined countries.

Expected devaluation probability is estimated using two different procedures for time period from January 1996 to December 2006. Interest rate differential model states that the interest rate differential reflects markets´ devaluation expectations. Secondly, Probit model uses several macroeconomic variables as explanatory variables to examine expected devaluation probability. In addition, we examine how the development of an individual macroeconomic variable affects expected devaluation probability.

The empirical results of this thesis show that there was a peso problem in these examined Latin American countries. The results of interest rate differential model prove that there was a peso problem in all the other countries but not in Argentina. Correspondingly, Probit model shows that there was a peso problem in all the examined countries. These results also prove that the irrational development of interest rates prior to actual development could be explained with peso problem phenomenon. Furthermore, the results of Probit model show that there is no certain formula how the development of macroeconomic variables in Latin American countries affects market´s expected devaluation expectations. Rather, effects seem to vary depending on country.

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Tämän tutkielman tavoitteena on tutkia peso-ongelmaa sekä devalvaatio-odotuksia seuraavissa Latinalaisen Amerikan maissa: Argentiina, Brasilia, Costa Rica, Uruguay ja Venezuela. Lisäksi tutkitaan, onko peso-ongelmalla mahdollista selittää korkojen epäsäännöllistä käyttäytymistä ennen todellisen devalvaation tapahtumista. Jotta näiden tutkiminen olisi mahdollista, lasketaan markkinoiden odotettu devalvaation todennäköisyys tutkittavissa maissa.

Odotettu devalvaation todennäköisyys lasketaan aikavälillä tammikuusta 1996 joulukuuhun 2006 käyttäen kahta erilaista mallia. Korkoero-mallin mukaan maiden välisestä korkoerosta on mahdollista laskea markkinoiden devalvaatio-odotukset. Toiseksi, Probit-mallissa käytetään useita makrotaloudellisia tekijöitä selittävinä muuttujina laskettaessa odotettua devalvaation todennäköisyyttä. Lisäksi tutkitaan, miten yksittäisten makrotaloudellisten muuttujien kehitys vaikuttaa odotettuun devalvaation todennäköisyyteen.

Empiiriset tulokset osoittavat, että tutkituissa Latinalaisen Amerikan maissa oli peso-ongelma aikavälillä tammikuusta 1996 joulukuuhun 2006. Korkoero-mallin tulosten mukaan peso-ongelma löytyi kaikista muista tutkituista maista lukuun ottamatta Argentiinaa. Vastaavasti Probit-mallin mukaan peso-ongelma löytyi kaikista tutkituista maista. Tulokset osoittavat myös, että korkojen epäsäännöllinen kehitys ennen varsinaista devalvaatiota on mahdollista selittää peso-ongelmalla. Probit-mallin tulokset osoittavat lisäksi, että makrotaloudellisten muuttujien kehityksellä ei ole mitään tiettyä kaavaa liittyen siihen, kuinka ne vaikuttavat markkinoiden devalvaatio-odotuksiin Latinalaisessa Amerikassa. Pikemmin vaikutukset näyttävät olevan maakohtaisia.

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1. INTRODUCTION

1.1 Background

Recently, there has been a lot of discussion about the economic development of Latin America. Some of the countries are considered to be in a transitional stage between developing and developed assets and they can be called as emerging markets. But at the same time, some countries are still living in the poverty and their economy is tightly dependent on the international development aid. Interest to invest in to Latin America has grown all the time but part of it is secured with trade blocks. Although, trade is becoming freer constantly and it means that big companies from the foreign countries are investing to Latin America even more in the near future. Among others, Finnish companies (e.g. Botnia´s pulp mill in Uruguay) have also started to invest to Latin America with increasing speed. Despite the fact that the economy has been growing during the last decades, part of the Latin America has been suffering major economical crisis.

Some of the countries in Latin America have still fixed or crawling exchange rate policy, whereas other have abandoned such an exchange rate regime. Those countries are often expected to devaluate their currencies in order to improve the competitiveness of their industry and exports. Basically, devaluation has been a commonly used strategy in Latin America in 1990s and 2000s. At least in six countries the currencies have been devalued recently and the two biggest countries has experienced even major economical crisis. On that account, devaluation expectations have been continually on a high level in the near history of Latin America and the trend seems to continue.

Markets´ devaluation expectations and occurrence of the actual devaluation are complicated issues for the market participants. Despite the expectations, devaluation may occur or it may not occur. But at any point in time, it may be that the market participants are factoring the improbable event into the assets in spite of the real appearance of devaluation in the future. Besides the dependence on the most likely future outcome, exchange rates, interest rates and prices of assets such as stocks and bonds, are also dependent on possible but less likely outcomes. Sometimes a possible outcome, for example devaluation, can be so different from today's conditions that asset prices, which incorporate such extreme possibilities, make financial markets look flawed, even if they are not. Hence, the rates and assets are reacting to this possible event beforehand although it is not certain that this event occurs. Economists call such a phenomenon as a peso problem. (Evans, 1996)

There have been several studies concerning the peso problem and the devaluation expectations in various markets. Rogoff (1980) was the first researcher who made a written paper about the issue in his investigations about the Mexican spot and futures markets. The more specific examination of the foreign exchange rate related peso problem analysis has been offered in Krasker (1980), Lizondo (1983), Kaminsky (1993), Hallwood et al., (2000), and Flood and Rose (1996). Among others, peso problems caused by the risk of a regime switch in the interest rate markets are examined by Hamilton (1988), Lewis (1991), Evans and Lewis (1994), and Bekaert, Hodrick and Marshall (1997). Edin and Vredin (1991) studied the relationship between devaluation risk and related macroeconomic variables. Bertola and Svensson (1991) examined the affiliation between exchange rates and interest rates differential. In addition, peso problems have also been found to exist in the stock and derivatives market. Rietz (1988) and Brown, Goetzmann and Ross (1995) studied peso problems in the stock market. Discrete regime switches in the dividend process have been analysed by Kandel, Stambaugh (1990) and Evans (1996). Berglund and Löflund (1996) examined peso phenomenon as an explanation to the seemingly anomalous development of stock prices. Penttinen (2001) examined devaluation-risk-related peso problems in the stock returns.

However, according to the author´s knowledge, there have not been studies that concentrate on the peso problem and devaluation expectations in the Latin America in the end of 1990s and in the 2000s. In the previous studies, there is a consistent finding that markets´ devaluation expectations affect interest rates and asset prices. The anomalous development of these assets is difficult to explain using traditional theories based on market efficiency. However, it has been shown that the abnormal movement of assets could be explained by peso problem phenomenon. In order to find evidence of peso problem and, on the other hand, to approve peso problem as an explanation to this anomalous development of interest rates prior to actual devaluation, we have to show that market participants expected devaluation to occur prior to actual event with positive probability.

1.2 Objectives and research methodology

Our purpose in this thesis is to investigate devaluation expectations and peso problem in a certain Latin American countries. We investigate if the selected countries experienced peso problem and on the other hand, whether the anomalous development in interest rates prior to actual devaluation could be explained by peso problem. We investigate also how the development of individual macroeconomic variables affects market´s devaluation expectations. These findings are contrasted to the findings of previous studies. The continent of Latin America is interesting in this case, because many of the countries in the continent have experienced devaluations recently and possibly biased devaluation expectations may cause such a peso problem. Some of the countries in Latin America have experienced major pressures to devaluate their currencies and this fact makes it interesting to investigate how these expectations affect and what is the probability that devaluation occurs.

In order to find evidence of peso problem and to accept the peso problem at least as a partial explanation to the anomalous development of assets, market participants should expect devaluation with a positive probability. Hence, the research questions of this study are as follows:

> Q1: Does devaluation expectations and the actual appearance of devaluation cause peso problem in the examined countries in Latin America?
>
> Q2: What is the expected probability that devaluation occurs in the examined countries?
>
> Q3: Could the anomalous development of interest rates, prior to actual event, be explained with peso problem?
>
> Q4: If the central bank refuses to adjust the exchange rate, is the peso problem substantial?
>
> Q5: How a development of certain individual variable affects the markets´ devaluation expectations?

The empirical part of this study is accomplished by using two different procedures: interest rate differential model and Probit model. With interest rate differential model we estimate firstly the expected size of devaluation and then the expected probability of devaluation. With the Probit model we examine the expected devaluation probabilities directly using a Probit model with key macroeconomic indicators as explanatory variables. In addition, using Probit model we are able to investigate how the development of an examined country's certain individual variable affects the expected probability of devaluation in the same country and furthermore, how the development of the variables of the other examined countries affects country´s expected devaluation probability.

1.3 Limitations

Empirical part of this thesis concerns the investigation of peso problem in specific countries in Latin America with pegged exchange rate or crawling band rate. We also investigate if peso problem can be the rational explanation to the irrational behaviour of interest rates prior to the actual devaluation. The character of methodology in this study requires that devaluation have to occur at least in some level and that is the reason why there are some limitations when selecting the countries and currencies to the empirical investigation. Because of the character of this thesis, we have selected the most hectic and topical countries of Latin America in the end of 1990´s and in 2000´s. It means that devaluation has occurred in these countries recently or the devaluation expectations are substantial at the moment.

Time period for the empirical analysis in this study is from January 1996 to December 2006. But because of the character of empirical methodology, we concentrate mainly to the time period before monetary authorities of countries let currency to float free. Countries and currencies from the Latin America, which are included in the empirical part of this thesis, are selected as follows: Argentina´s peso, Brazil´s real, Uruguay´s peso, Costa Rica´s colón and Venezuela´s bolivar. We use assets for US dollar in terms of Argentina´s peso, Brazil´s real, Uruguay´s peso, Costa Rica´s colon and Venezuela´s bolivar; hence we act as a US investor.

1.4 Structure

The structure of this paper is organized as follows. The theoretical framework is presented in Chapter 2. In the beginning of Chapter 2 are previewed the framework of devaluation expectations and peso problem. In Chapter 2 are also presented the previous studies concerning the subject matter of this study. Chapter 3 presents the region of Latin America and the appearance of devaluations in the countries, which are included in the empirical part of this study. Chapter 4 provides the research methodology of this study. In this chapter is also presented data collection method and characteristics of data. Chapter 5 presents the empirical results of the study. Finally, Chapter 6 concludes the thesis and offers suggestion for further analysis.

2. THEORETICAL FRAMEWORK

2.1 Devaluation expectations

Devaluation has been a widely used strategy in the economy through the history. Generally, devaluation is considered as a decreasing in the value of a currency with respect to other monetary units. More precisely, such an event is often defined as an official lowering of the value of a country´s currency within a fixed or crawling exchange rate band system, by which the monetary authority formally sets a new rate with respect to a foreign reference currency. The monetary authority uses devaluation as a part of monetary policy. It may use devaluation because of many reasons, but generally there are two implications. Firstly, devaluation makes the country´s exports relatively less expensive for foreigners. Secondly, the devaluation makes foreign products relatively more expensive for domestic consumers, thus discouraging imports. Generally, this may help to improve country´s exports competitiveness and correspondingly it discourages imports, and may therefore help to reduce the country´s current account deficit. For example, in Finland, devaluation was commonly used in the near history and last time devaluation took place in the beginning of the 1990´s. Now, in the beginning of the 21st century, Latin America has been the region of devaluations. (Mundaca, 2004)

Devaluation is a commonly discussed issue in the field of a country´s economy; hence market participants are forecasting such an event and expecting it to occur continually. Those expectations of devaluation probability affects widely to the whole economy of a country. Expectations may rise suddenly and even surprisingly and there could be many different reasons why the expectations might rise. Devaluation is often expected to occur if the interaction of market forces and policy decisions has made the currency´s exchange rate untenable. In order to sustain a certain exchange rate, a country must have sufficient foreign exchange reserves and also it must be willing to spend them, to purchase all offers of its currency at the established exchange rate. When a country is unable or not willing to do so, monetary authority has to consider devaluating currency to a level that is able and willing to support with its foreign exchange reserves. In that time it is not certain if the devaluation would be successful to fix the disequilibrium in the markets. If the central bank tries to accomplish an internal adjustment in domestic costs, the disequilibrium may persist for a relatively long time. In that case, however, the market will assess a positive probability for the event that central bank will be forced to surrender; it means that the currency has to be devalued in the near future and the devaluation expectations are raising rapidly. (Mundaca, 2000; Svensson, 1993)

Devaluation expectations assessed by the market participants depend on several factors. Firstly, the monetary policy, which government and central bank are using, affects market´s devaluation expectations, although often in opposite way than desired. The monetary authority might be willing to emphasize the argument that longer the sequence of periods in which monetary authority has been successful in preventing devaluation, the higher will it´s credibility be and thus lower the devaluation expectation. However, this is not necessarily the truth. If the disequilibrium of the present exchange rate continues, or worsens, the market may rationally infer that the expected costs of restoring the equilibrium, without recourse to devaluation, have grown and the markets devaluation expectations may rationally grow. Monetary authority might also try to affect market´s devaluation expectations with other expedients as well. To show that devaluation expectations depend on central macroeconomic variables, the government may influence devaluation expectations and the domestic interest rate by conducting the appropriate policy. On the other hand, if no such relationship exists, the government´s possibilities to influence devaluation expectations and the interest rate might be rather small. (Berglung and Löflund, 1996; Williams et al., 1998)

The decision to accomplish devaluation is a complicated issue for a monetary authority. Though, sometimes there is no other choice for the central bank than devaluation. But the uncertainty of the result on devaluation makes it difficult to handle, whether devaluation is successful in stabilising the economy or it may not. And in any case, it may have other consequences as well. A significant danger is that by increasing the price of imports and simulating greater demand for domestic products, devaluation can make inflation worse. This is actually what has happened in Venezuela. If the scenario mentioned above takes place, the government may have to raise interest rates to control inflation, but it means that the economic growth slows down. Another unwanted aspect of devaluation is more psychological. Investors may lose their confidence in the country´s economy and hurt the country´s ability to secure foreign investment. (Latin Focus, 2007; Rochon, 2006)

Despite whether the actual devaluation takes place or not, mere devaluation expectations may have influences in different ways. Under a fixed or crawling exchange rate band system, devaluation expectations may affect the assets, such as interest rates, and make them develop anomalously. Expectations might also induce a loss of foreign reserves and threaten the stability of the present exchange rate regime. Through changes in the interest rate and other assets, the real economy may also be influenced. (Bernhardsen, 1998)

2.2 Peso problem

Devaluation expectations might arise in markets when the economy starts to exhibit signs of an external imbalance. The markets are then not in equilibrium and it might be possible to make arbitrage profits. Hence, sooner or later, relative prices have to adjust, or to be adjusted, to make exports more profitable and imports less profitable. It means that then market starts to anticipate devaluation. (Berglund and Löflund, 1996)

Regardless of markets expectations, devaluation will occur or it will not occur. But at this point in time, it may just be that the market is factoring the improbable event into the assets and it makes markets look like anomalous. In the economists jargon this situation is called peso problem. (Lewis, 1991)

Generally, financial economists have presumed that differences between expectations and realizations cancel out over the period of study and can, therefore, be ignored. Actually this assumption dates from 19th century, if not earlier, and has been a constant element of financial economics since then.[1] However, nowadays when many empirical studies concerning the issue have been done, the assertion has got another aspect. Thus, since empirical research is conducted on smaller samples, potential peso problem should not be pushed away. The reason why economists have commonly ignored it is likely due to the fact that the majority of modern econometric methods are based on the assumption of a symmetrical distributed error term. But actually, if we combine the relatively short period of financial market data available with the existence of low probability events with great impact on prices, even before they occur, makes it likely that many data samples are subject to a peso problem. (Bachelier, 1964; Penttinen, 2000)

2.2.1 Origin of term peso problem

Term peso problem has been the issue of many researches in the history of finance. Actually, no one knows the precise origin of the concept peso problem, but it has been maintained that the first use of the term peso problem was by Nobel laureate Milton Friedman[2] who used it in his

[1] Assumption was made by Bachelier (1900) and after that, the seminal work on asset returns by Mandelbrot (1963) and Fama (1965) was build on this assumption.
[2] Milton Friedman was 1976 Nobel laureate in economics for his achievements in the field of consumption analysis, monetary history and theory and for his demonstration of the complexity of stabilization policy.

investigations of the Mexican interest rate market in the beginning of the 1970s. During the period from 1954 to August 1976, Mexican deposit rates remained substantially above US dollar interest rates even though the exchange rate remained fixed against dollar. The markets´ devaluation expectations were continuously on a high level, which at least partly explains why the interest rate level on peso denominated instruments remained much higher than the US rate. (Evans, 1996; Penttinen, 2001)

Generally, some market observers argued that this was evidence against the efficient market hypothesis and the situation looked like a flaw in the financial markets. According to them, it would have been possible to make arbitrage profits during this period by borrowing in USD and lending in MXP. According to Friedman, however, market participants investing in Mexican peso-denominated assets had to be compensated, in the form of a higher interest rate, for bearing the risk of a possible devaluation of the Mexican peso. Friedman argued that this interest rate differential reflected the market´s expectations of devaluation of the peso; otherwise the interest rate differential would soon disappear as investors increasingly tool advantage of it. (Evans and Lewis, 1992)

In August 1976, the expectation became subsequently justified when the peso was allowed to float and it fell in value by 46% to a new rate of 0.05 dollars per peso. This devaluation caused considerable losses for investors being long in MXP-denominated assets. The difference in return on comparable US and Mexican assets, which looked like an anomaly to analysts who thought the exchange rate would remain fixed because it had been fixed for 20 years, could be explained once investors´ recognition of the possibility of a large drop in the value of the peso was factored in. (Evans, 1996; Hallwood et al., 2000)

However, the market participants did not know *ex ante* when the possible devaluation would take place. Despite, viewed *ex post*, the period up to the 1976 devaluation does indeed seem a perfect opportunity for arbitrage profits. In the data sample that do not include the devaluation of the Mexican peso; the interest paid on MXP deposits will appear excessively high in relation to USD interest rates. This difference reflects a compensation for the possibility of a highly negative return caused by devaluation, not an opportunity to make excessive returns. Generally, this explanation of the anomalous development of the interest rates in MXP and USD became later known as peso problem. It is nowadays used to describe a situation where there is a small chance of occurrence of some future event and the expectations of this event affect the behaviour of market participants. (Krasker, 1980)

2.2.2 Term peso problem

After Milton Friedman used the term peso problem in his investigations, term has been a widely used in the field of economy. Furthermore, economists have shown that peso problem might exist in the markets and, on the other hand, researchers have shown that with the concept of peso problem it is possible to explain some anomalous events that cannot be explained with traditional economical theories.

However, the concept peso problem refers to the situation where economic agents have rationally formed expectations about discrete shifts or jumps in the values of some important economic variables like exchange rates. These expectations may be a reflection of the poor credibility of economic policymakers or they may be based for example on the anticipated outcome of future parliamentary election that can lead to substantial changes in the general economic policy. Since asset prices are based on the expected future paths of these economic variables, the possibility of discrete changes directly affects asset price behaviour. In addition, it can induce asset price movements that *ex post* seem to contradict the conventional rational expectations assumptions. (Kaminsky, 1993)

However, the discrete shifts are usually thought to be rare events, hence the probability of occurrence is low. It means that the observation of such a shift is unlikely in a small sample of data. It is possible to claim that in a data sample where the *ex ante* probability of occurrence assessed by the relevant economic agents differ from the observed frequency of such events, the economic phenomenon studied may be affected in a way that, a first look, could seem, anomalous. Hence, the market´s biased expectations affect the asset prices and make them appear anomalous. But actually this could be explained by peso problem. (Evans, 1996; Mattila, 1998)

In order to explain the character of peso problem we can use an analysis such as the following. This analysis is originally presented by Krasker (1980) and Lizondo (1983). In particular, suppose that agents and market participants attach a probability ℓ_t to there being a shift in regime next period, represented by shifting from M_1 to M_2. M_1 and M_2 are the old and the new regime respectively. Then the expected exchange rate will be as in the following equation:

$$E_t(s_{t+1}) = \ell_t E_t(s_{t+1} | M_2) + (1-\ell_t) E_t(s_{t+1} | M_1) \quad (1)$$

where $E_t(s_{t+1})$ is the expected rate of return on asset *i* in period *t*. $E_t(s_{t+1} | M_2)$ is the expected return on asset *i* in period *t* conditional on devaluation, and $E_t(s_{t+1} | M_1)$ is the expected return on asset *i* in period *t* conditional on no devaluation. (Krasker, 1980; Lizondo, 1983)

The forecast error, assuming the regime shift does not in fact occur will be given in equation (2):

$$\begin{aligned} s_{t+1} - E_t(s_{t+1}) &= \left[s_{t+1} - E_t(s_{t+1} | M_1)\right] - l_t\left[E_t(s_{t+1} | M_2) - E_t(s_{t+1} | M_1)\right] \\ &= \eta_{t+1} + (1-\ell_t)\nabla s_{t+1} \end{aligned} \quad (2)$$

where $\nabla s_{t+1} = \left[E_t(s_{t+1}|M_1) - E_t(s_{t+1}|M_2)\right]$ represents the difference in the expected value of the future exchange rate under the different regimes. There is a skew in the distribution of forecast errors, which confounds the econometric analysis, since even a small probability of a large regime shift may generate a large skew. Even if the regime shift does not occur, there is still a forecast error over and above the usual rational expectations forecast error as follows:

$$\begin{aligned} s_{t+1} - E_t(s_{t+1}) &= \left[s_{t+1} - E_t(s_{t+1}|M_2)\right] - (1 - l_t)\left[E_t(s_{t+1}|M_2) - E_t(s_{t+1}|M_1)\right] \\ &= \eta_{t+1} + (1 - \ell_t)\nabla s_{t+1} \end{aligned} \tag{3}$$

However, if there is instantaneous learning, such as when the regime is fully public knowledge, the skew in the distribution of forecast errors disappears for expectations formed from time $t+1$ onwards. It is in this sense that the peso problem is a small-sample problem. (Krasker, 1980; Lizondo, 1983)

2.2.3 Effects of peso problem

As mentioned, peso problem phenomenon could be used to explain the irrational behaviour of certain assets such as interest rates, stock prices and dividends. But on the other hand, peso problem might be a serious problem to investors who forecast economical events. Hence, the effects seem to vary depending on what is purpose of the investigation. Basically, peso problem could arise when the possibility that some infrequent or unprecedented event may occur affects the asset prices. The event must be difficult, perhaps even impossible, to predict accurately using econometric history. (Kaminsky, 1993; Sercu and Vinaimont, 1999)

Peso problems present a serious difficulty for economists who like to build and estimate models of the economy and financial market and then use them to interpret economic data. Empirical economic models are designed to match features of the economy. They are calibrated or estimated using current and historical data on economic variables. If the historical data used to calibrate or estimate models do not accurately reflect the probabilities of unwanted happening, model-based forecasts can prove inaccurate and the policy advice that rests on them can suffer. (Veronesi, 2004)

Generally, irrational behaviour of assets prior to devaluation has been found in the financial markets. But this anomalous development of assets such as interest rates, stock prices and dividends could be explained with peso problem. As shown earlier, when the market participants have *ex ante* positive expectations of devaluation and it differs from the observed actual event, the reactions of markets may look anomalous. As Lewis (1988, 1991) showed, peso problem can potentially generate biased forecasts of exchange rates, even after the policy regime shift has occurred. Also, during the peso problem period, exchange rates may experience bubbles and systematically deviate from the levels implied by the observed fundamentals. [3] (Hamilton, 1988)

The expectations hypothesis fails to explain the term structure behaviour of interest rates. But a rational answer could still be given under economic theory. It has been shown that peso effect explains the majority of the interest rate differential. In an economic crisis, it is common that the devaluation expectations affect the interest rates. Market participants start to expect a depreciation of the currency and the central bank tries to defend the currency rate by raising the domestic interest rates. If it is possible to say that the interest rate differential is caused by the devaluation expectations, it is possible to make arbitrage profits. In the post-devaluation period the market only gradually learns whether the

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[3] There is similarity between rational bubbles and peso problems: They both are phenomena consistent with rational behaviour by agents in the economy and have similar effects on the forecast error distribution. But the difference is that rational bubbles occur as deviations from the fundamentals whereas peso problems arise because of an expected shift in the fundamentals. (Hallwood et al., 2000)

devaluation is successful or not. If the devaluation *ex post* turns out to be successful, it is possible to expect to see a sequence of returns, which exceed the expected market return. (Hallwood et al., 2000)

In addition to the interest rate differential and exchange rates, peso problem may affect the stock markets as well. Peso problem hypothesis has often been advocated in the financial literature to explain the historically puzzlingly high risk premium of stock returns. Since no catastrophic event ever realized during the sampling period, *ex post* realized returns are high even if *ex ante* expected returns are low. It has been also stated that if the central bank refuses to adjust a certain exchange rate in response to the disequilibrium, stock returns are expected to remain below their equilibrium level. It has been also showed that even a long, non-random, negative trend in the stock markets could be explained. Since traditional asset pricing theory fails to explain this phenomenon, an alternative peso problem hypothesis could do it. (Berglund and Hörlund, 1998; Penttinen, 2001)

2.3 Empirical results of earlier studies

During the history, peso problems and devaluation expectations have been the subject of many studies and researches. Majority of the previous studies concentrate on the foreign exchange, stock market and interest rate market. Generally, most of the studies focus on the US market or European markets. In this section we present empirical results of previous studies, which are relevant to this thesis. Studies are presented in chronological order.

Krasker (1980) laid the foundation for foreign exchange related peso problem analysis. He investigated the German mark/pound sterling forward market during the German hyperinflation. Using data from that hyperinflation, he showed that an alternative test can sometimes be constructed in cases where the usual tests are not valid. In this case it means peso problem hypothesis. The results reverse the conclusion of earlier researches that the mark pound forward market during the hyperinflation was not efficient.

Lizondo (1983) developed in his examination three models for the determination of foreign exchange futures process under fixed exchange rates and expectations of devaluation. These models showed that certain characteristics of futures prices behaviour that have been used as proof of inefficiency may be present even if the market is efficient.

Hamilton (1988) examined systems subject to changes in regime, interpreted here as occasional, discrete shifts in the parameters governing the time series behaviour of exogenous economic variables. The technique was used to analyze yields on three-month Treasury bonds during 1962-1987. A constant-parameter linear model for short-term rates is shown to be inconsistent both with the univariate time series properties of short rates and with the observed bivariate relation between long and short rates under the expectations hypothesis of the term structure.

Lewis (1991) studied peso problem in the U.S. term structure of interest rates in the period 1979-1982. Investigation addresses whether market anticipation of a switch in monetary policy systematically affects the *ex post* returns on longer-term relative to short-term U.S. interest rates. In the case of the 1979 to 1982 period, a persistent belief that the Fed[4] would allow interest rates to continue to increase would have lowered the *ex post* returns on longer term relative to short-term interest rates. Lewis proves in the investigations that these returns were lower because of peso problem.

Engel and Hamilton (1990) examined whether in fact the exchange rate follows a switching regime process. The empirical evidence in their paper

[4] The Federal Reserve System is the central banking system of the United States.

strongly supports the hypothesis that the true model of the exchange rate is evolving over time.

Edin and Vredin (1991) estimated an empirical model of devaluation risk in target zones utilizing data from four countries: Denmark, Sweden, Finland and Norway in 1978-1989. They used a model in their investigations, which was an extension of models by Svensson (1991) and Bertola and Svensson (1993) which use the uncovered interest parity as the main determinant of expected rate of depreciation. In contrast, Edin and Vredin used a model which links a devaluation of the exchange rate from one target zone to another to macroeconomic fundamentals other than interest rate differential. They found that the probability as well as the size of devaluations seems to be systematically related to a relation between the money stock, industrial output, foreign exchange reserves and the prevailing central parity.

Kaminsky (1993) examined if there was a peso problem in the US dollar/pound sterling exchange rate in the time period 1976-1987. She investigated whether exchange-rate forecasts, although biased, are rational. The idea was that investors can be rational and yet make repeated mistakes if the true model of exchange rate is evolving over time. The author´s results supported the hypothesis that the exchange rate has followed a switching-regime process. Moreover, the switching-regime model can explain about 75 % of the bias implied by the forward market and the survey data.

In many studies devaluation expectations are also measured by the drift-adjustment method, for example Bertola and Svensson (1993), where the expected change of the central parity is estimated as the difference between the interest rate differential and the expected exchange rate movement within the currency band. They found that the interest rate differential reflects the markets´ expected devaluation probability.

Flood and Rose (1996) found that regressions of *ex post* changes in floating exchange rates on appropriate interest differentials typically imply that the high-interest rate currency tends to appreciate the forward discount puzzle. Using data from the European Monetary System (EMS), they found that a large part of the forward discount puzzle vanishes for regimes of fixed exchange rates. It means that deviations from uncovered interest parity appear to vary in a way, which is dependent upon the exchange rate regime. By using the many EMS realignments, they were able to quantify also the peso problem.

Evans studied (1996) how the theoretical and empirical implications of the asset pricing models are affected by the presence of peso problem. The paper examined the ways in which peso problems can induce behaviour in asset prices that apparently contradicts conventional rational expectations assumptions. The examination covers the relationship between realised and expected returns, asset prices and fundamentals, and the determination of risk premium.

Berglund and Löflund (1996) examined how a prolonged external disequilibrium, that may arise if the exchange rate is pegged, affects the stock market. They showed that if the central bank refuses to adjust the peg in response to disequilibrium, stock returns are expected to remain below their equilibrium level. The empirical case of the study concerned the dramatic experiences of the Finnish economy in the 1989-1994 period. They showed that the pre-devaluation peso phenomenon is able to account for the seemingly anomalous pattern of systematically dropping stock prices prior the decision to let the Finnish markka float in the end of the period.

Hallwood et al. (2000) provided a peso problem explanation for the strength of the US dollar between 1890 and 1908. They investigated US dollar/pound sterling exchange rate expectations during the period 1890-1908. They showed that the dollar faced a peso problem in that for much of the period financial markets expected it to depreciate against sterling, but in fact this never happened. It means that the expectations were persistently biased. Drawing on the economic history of the period they identified 11 events which probably gave rise to realignment expectations.

Bakaert, Hodrick and Marshall (2001) extended the empirical evidence to include Germany and UK, assuming that these countries face the same choices between regimes as those in the United States. They concluded that for the peso phenomenon augmented expectations hypothesis to be consistent with the US data in particular, investors´ expected inflation rates for the high inflation regime should have been considerably higher that the rates realized in the sample.

Penttinen (2001) studied that both stock returns as well as the volatilities implicit in option prices may be subject to peso problem. In the study he asserted that the seemingly anomalous negative trend in Finnish stock prices in the period from 1989 to 1992 cannot be explained by traditional asset pricing theories. He maintains that it is argued that this phenomenon could have been caused by a devaluation-risk-related peso problem. In this examination, cross-sectional regression analysis on the individual company level has been used to test this hypothesis. Author concludes that there is strong evidence supporting the peso problem hypothesis.

Mundaca (2004) drew attention to a possible drawback of the widely used drift adjustment method and showed that this method cannot yield consistent estimates. Mundaca provided an alternative approach to solve peso problem. Author showed why, when the realized rates of depreciation within the exchange rate band are regressed on a given information set and conditioned on actual no realignment, a peso problem is still encountered. The reason is that the frequencies of realignments in the data need not to be the same as the frequency of the subjective probabilities that realignment may take place.

3. LATIN AMERICA AND DEVALUATIONS

Economy of Latin America is one of the fastest growing continents in the world nowadays. Most of the countries have adjourned from a developing country to an emerging country and the interest to invest to Latin America grows all the time. Economy of Latin America has been growing since 2003 and the growth cycle is expected to last. Even though, the growth of GDP has slowed in couple of previous years. But according to the IMF´s forecasts of the development in Latin America, the trend will change and the growth of GDP will increase again. Despite the growth of Latin America´s economy, it has been the region of devaluations and economical crisis in the 1990s and 2000s. At least in six countries the currency has been devalued recently and two biggest countries, Argentina and Brazil, have experienced a major economical crisis recently. (IMF, 2006c)

Many Latin American countries have reduced public debt rations, their current accounts are in surplus, and external reserves have increased. As macroeconomic policies in most countries rest on the adoption of inflation targets and the commitment to exchange rate flexibility, external shocks are expected to be smoothly absorbed. Hence, it can be generally claimed that pegged exchange rates, especially in countries that are liberalizing their economies, are recipes for disaster. This has been clear since at least the outbreak of the Mexican peso crisis, when Mexico tried to maintain both a pegged rate and an expansionary monetary policy, and the Asian crisis, when the accumulation of investments and government liabilities became a problem too large to ignore. (Becker et al., 2001; IMF, 2006c)

In the following sections there is a preview of the countries, which are included in the empirical part of this thesis. Preview presents the economical situation at the moment and in the near history. Section shows the explanations why and how devaluation occurred and affected in these countries and what were the consequences after the devaluation occurred.

Argentina

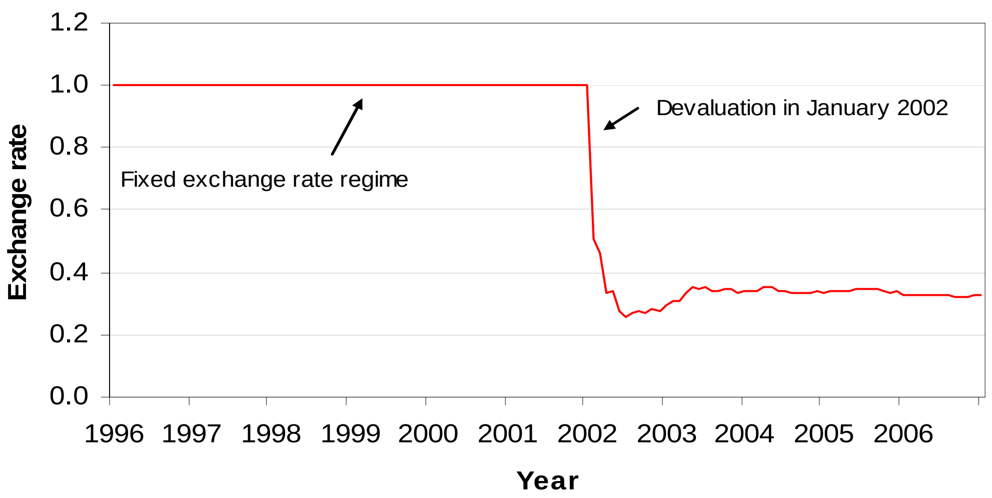
During the late 1990s and early 2000s Argentina´s economy faced a major crisis, which affected the economy of a country dramatically and the consequences can still be sensed. The culmination of the crisis in between 2001 and 2002 was the worst economic crisis in the history of Argentina. Generally, people state that the critical period started in 1999 and ended in 2002, but actually the origins of the collapse of Argentina´s economy can be found from the events in the history.

During the time period from 1976 to 1988, Argentina´s government´s debt was increasing with tremendous speed. In that time, Argentina was under a military dictatorship and basically, this huge debt was originally acquired for the money that was later lost in different unfinished projects like Falklands War, and the state´s takeover of private debt. In the beginning of the 1980´s, the new government promised to stable the economy, but state was eventually unable to pay interest of this debt. As a results economy collapsed and inflation started to increase. By the end of 1980s the inflation was a huge problem; inflation rate reached nearly 200% per month and annually the rate was as high as 3000%. (Cuevas, 2003; Schumacher, 2000)

Argentina spent a lot of effort to the fight against inflation. In 1991, the Argentine peso´s monetary value was fixed by law to the value of the US dollar. Because of the character of the law, inflation dropped sharply, prices were assured, and the value of the currency was preserved. Less than five years before the crisis, Argentina was generally appreciated as a model of successful economic reform: inflation, which was during the 1980s reached desperate levels, was in again in the control and output growth was at significant level. Despite the boom, the Argentine economy became increasingly vulnerable to crisis during the 1990s. Argentina had still international debts to pay, and the need to borrow money was unavoidable. The fixed exchange rate made imports cheap, and as a consequence dollars drew to foreign countries and a progressive loss of Argentina's industrial infrastructure started, which led to an increase of the unemployment. Logically, this action raised the devaluation expectations. However, following a strong recovery from the slight depression in 1995 and strong growth in 1997, the economy slid into depression in the latter half of 1998. In 1999 Argentina´s GDP dropped 4% and the country entered a recession. (Calomiris, 2007)

In 2001 peso was fixed on 1 to 1 basis with the US dollar, but finally in the beginning of 2002, Argentina decided to devalue peso and it lost a large part of its value and the official exchange rate was set at 1.4 pesos per dollar. Since January 2002 the exchange rate fluctuated widely up to a peak of four pesos to one dollar, which is 75% devaluation. Figure 1 shows the movements of exchange rate for peso in terms of US dollar between years 1996 and 2006. Figure 1 presents how the exchange rate decreased rapidly in the beginning of 2002. (Calomiris, 2007)

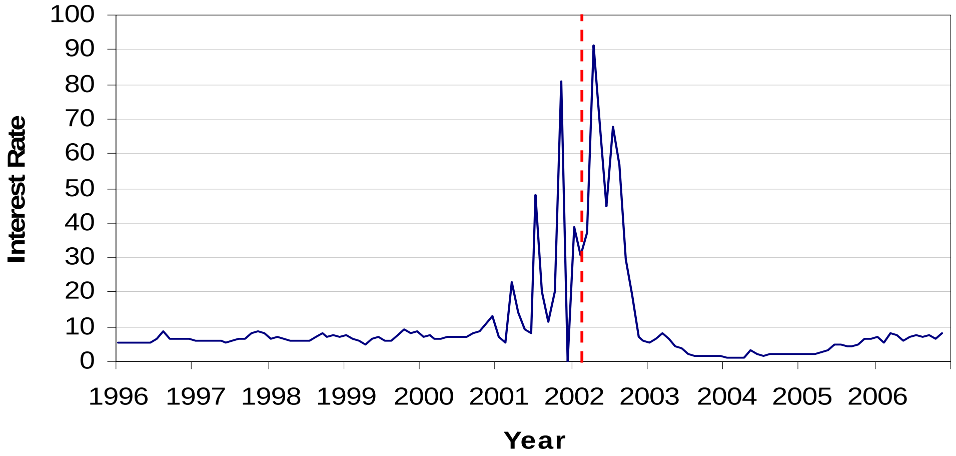
Figure 1. Argentine peso exchange rate.
Graph presents the movements of Argentine peso exchange rate for the time period from January 1996 to December 2006. From the figure can be seen how much we have to pay domestic currency (US dollars) to get one foreign currency (Argentine peso).



As predicted, devaluation encouraged exports and the boom then produced a massive inflow of dollars into the Argentine economy, which helped lower their price. In that time, the current monetary authority had publicly acknowledged a strategy of keeping the exchange rate between 2.90 to 3.10 pesos per US dollar, in order to maintain the competitiveness of exports. However, the interest rates started to develop irrationally already in the beginning of 2001. Figure 2 presents the movement of interest rate in Argentina during the time period 1996-2006. Figure reveals that interest rate developed irrationally before devaluation took place in the beginning of 2002. The anomalous movement continued until end of 2002, when the interest rates stabilised. (Central Bank of Argentina, 2006)

Figure 2. Interest Rates in Argentina.

Graph presents one month interest rates in Argentina for the time period from January 1996 to December 2006. The rates are monthly money market interest rates. The broken line describes the actual devaluation.



Devaluation in Argentina had terrible consequences. Many businesses fell down and even the agriculture was affected: Argentine products were rejected in some international markets. The immediate macroeconomic consequences of the crisis are easy to see. Real GDP fell by about 11 percent in 2002, and the unemployment rate rose above 20 percent. Inflation peaked at a monthly rate of about 10 percent in April 2002. But the crisis was not only economical. It affected also the political and the social life of Argentina and it still affects the life in Argentina. (Calomiris, 2007; IMF, 2006b)

Brazil

In the time period before devaluation, Brazil was affected by a major inflation. The real initially appreciated against US dollar as a result of large amount of capital inflows in the late 1994 and 1995. It started a gradual depreciation process, which culminated in January 1999 to the Brazilian currency crisis which can still be sensed in the economy of Brazil.

After a several years of huge inflation, Brazil started a stabilization program to control the inflation in 1994. One of the main stages of the stabilization program was the introduction of a new currency, the Brazilian real, pegged to the US dollar. The new monetary policy affected several years, from 1994 to January 1999. In that time period, monetary authority fixed the exchange rate to the US dollar. In 1994, the exchange rate was pegged 1 to 1 to the US dollar, but no fluctuation band was set and the market rate was allowed to fluctuate substantially. Real remained at a premium to the dollar for two years, but the inflation rates still remained high and in March 1995, following the Mexican crisis, the central bank adopted a crawling band[5] without preannounced depreciations. Originally, monetary authority decided to do this change because they wanted more flexibility to exchange rate but still keep inflation in control. (Bae and Ratti, 2000; Central bank of Brazil, 2006)

Despite the previous changes in the monetary policy, in the late 1990s inflation was still a problem in the Brazilian economy and the government was forced to make some transitions in the current exchange rate regime. To defend the currency, interest rates in Brazil raised up to near 40% (See Figure 3). The new policy stabilized inflation for the first time in decades. High interest rates lowered inflationary pressures, by reducing the monetary authority´s incentives to hold currency. Furthermore, the investors, attracted by high interest rates, invested money to Brazilian

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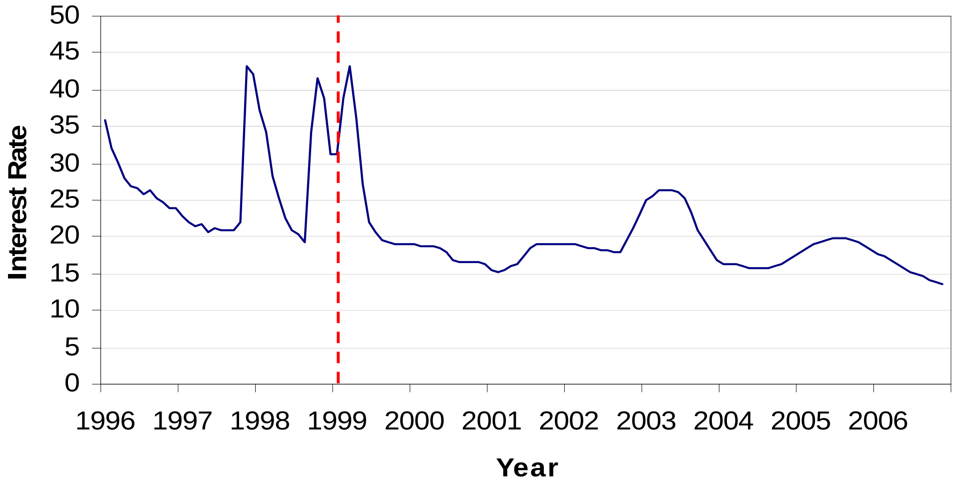
[5] An exchange rate crawling-band can be defined as a system in which the exchange rate is forced to move inside a band and the band is adjusted in small steps with a view to keeping it in line with the fundamentals.

economy at unprecedented rates. Despite successfully lowering inflation, Brazil still faced many economic problems. In order to be capable to reach the IMF conditions[6], Brazil planned to cut its federal budget deficit from 5.6 % to 3.6% of Gross Domestic Product between 1998 and 1999. Actually this effect was an introduction to a recession. Figure 3 presents the movements of interest rates in Brazil during the time period 1996-2006. From the Figure 3 can be seen the anomalous movement of interest rates before the actual devaluation occurred. (Goldfajn, 2000)

Figure 3. Interest Rates in Brazil.
Graph presents one month interest rates in Brazil for the time period from January 1996 to December 2006. The rates are monthly money market interest rates. The broken line describes the actual devaluation.



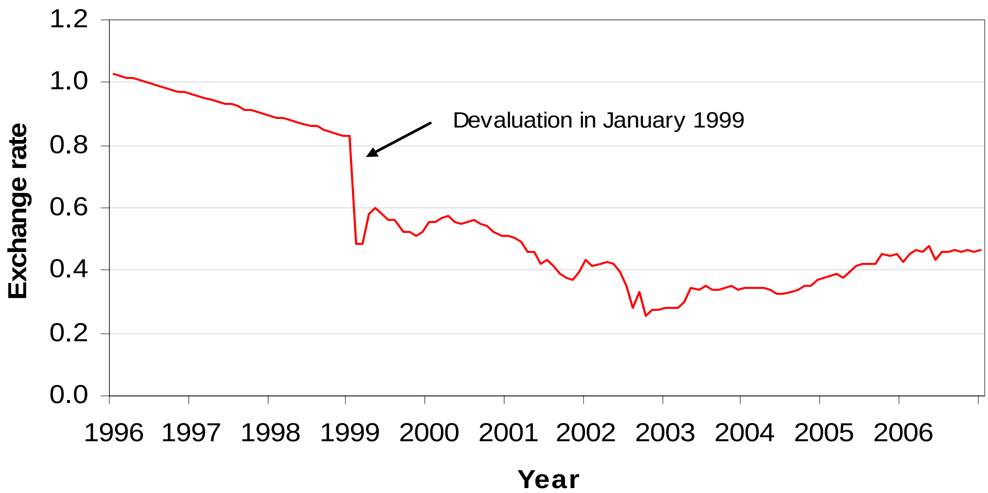
In January 1999, the probability of a major economic crisis was easy to sense. Basically, people feared that the federal government would not be able to implement its austerity programme, thus risking the continuation of its IMF loan package. Slowly the fears came true and the government realized that it could no longer allow defending the level of the real, because the IMF loan was so important to the country. Previously the central bank of Brazil was able to use its foreign exchange reserves to prevent the currency from drastically depreciating. As a consequence of this kind of policy, in between 1996 and 1998, Brazil´s reserves dropped

[6] To deserve IMF´s loan and development programs, country must follow IMF´s structural adjustment programs, which rules are accurately defined by IMF. (IMF, 2006d)

by 24 billion US dollars or 40%. While IMF provided a 41 billion US dollar loan in 1998 to help Brazil defend its currency, the central bank decided to devalue the real by 8% in January 1999. But actually, the fears of further fall of real rose quickly and it was clear that Brazil would not be able to defend its currency at the new band. Finally, in the middle of January, 1999 monetary authority gave up its effort to maintain the band and instead floated the currency. Rapidly the rate fell and the depreciation was 15% immediately and by the end of the month, the real depreciated totally 66% against the US dollar. (Goldfajn, 2000; Nazmi, 2002)

In the early February 1999, the Brazilian central bank announced that the real would no longer be pegged to the U.S. dollar, which entailed a major devaluation of the Brazilian currency. Hence, real was allowed to float in the world monetary markets, which resulted in a major devaluation of the real to the US dollar. Figure 4 presents the movements of exchange rate of real in terms of US dollar between 1996 and 2006. Figure reveals how strong devaluation was in the beginning of 1999. (Amann and Baer, 2003)

Figure 4. Brazilian real exchange rate.
Graph presents the movements of Brazilian real exchange rate for the time period from January 1996 to December 2006. From the figure can be seen how much we have to pay domestic currency (US dollars) to get one foreign currency (Brazilian real).



Devaluation of Brazilian real affected all around the world. Basically it raised fears of a new round of financial instability that could delay recovery in Asia.[7] Furthermore, devaluation in Brazil was also a shock to IMF, who had maintained that free trade and capital inflows and outflows in developing countries should be introduced, despite the damaging effects. (Goldfajn, 2000)

Costa Rica

Colón is the currency of Costa Rica.[8] For a long time, Costa Rica´s monetary authority accomplished unusual monetary policy, while colón was continually devalued against US dollar. Basically, the rate can be described as a crawling peg, which means that instead of being defined by a constant value to the US dollar, the colón grew progressively weaker at a fixed rate. However, in October 2006 a new currency system was introduced in Costa Rica. (Central Bank of Costa Rica, 2006)

During the history, colón had been weakening strongly. In the spring 1992, after the government of Costa Rica eliminated exchange controls, the central bank lowered interest rates as an attempt to slow the colón’s rise. As a consequence, the exchange rate stabilized for a while of approximately 135 colónes to the dollar, and predictions were that the dollar would be worth 200 colónes by early 1996. In January 1995 actually it was worth 166.5 colóns per dollar. The trend continued and by May 2000 it was 305 to the dollar and was devaluating at around 17 % per day. (Cattaneo et al., 2001)

In the 2000s, the central bank of Costa Rica decided to accomplish policy where colón was devalued continually to avoid bigger crisis. The central bank supervised a tiny daily reduction in the dollar exchange rate to avoid a surprising drop of the rate. As a result, its value has fallen steadily

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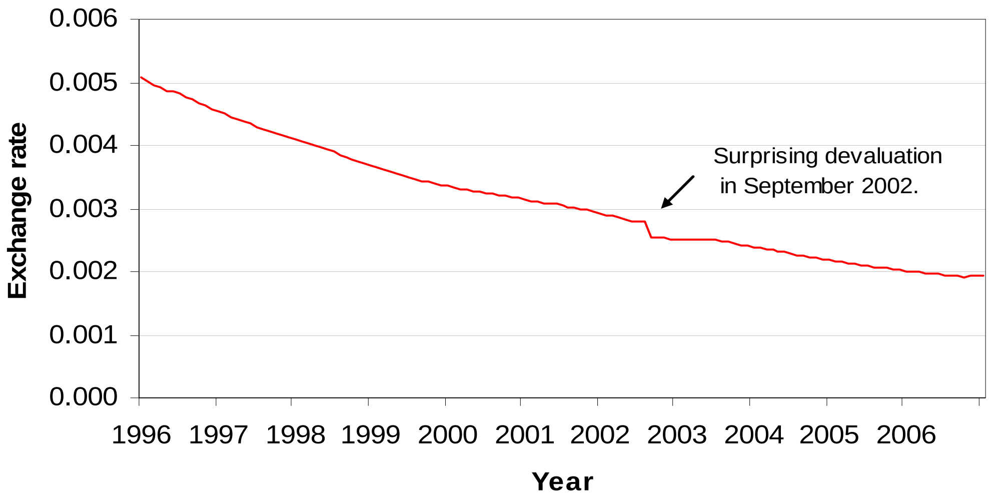
[7] In July 1997 started the Asian financial crisis which affected currencies, stock markets, and other asset prices in several Asian countries.
[8] The currency is named after Christopher Columbus, known as Cristobal Colón in Spanish.

against the US dollar over the past few years. During that time, monetary authority named the daily exchange rate as the *tipo de cambio*, and it had a small spread, only 2.5-4 colónes. The rate changed every day, increasing a fraction of a colon and thus devaluing the currency against the US dollar. However, surprisingly in September 2002 monetary authority decided to devalue colón faster than expected and it caused decreasing of the colón exchange rate. Figure 5 presents the movements of exchange rate for Costa Rican colón in terms of US dollar from January 1996 to December 2006. In the Figure 5 we can see how the nearly constant devaluation has affected the exchange rate and how the major economical crisis has been successfully prevented in Costa Rica. (IMF and Costa Rica, 2006)

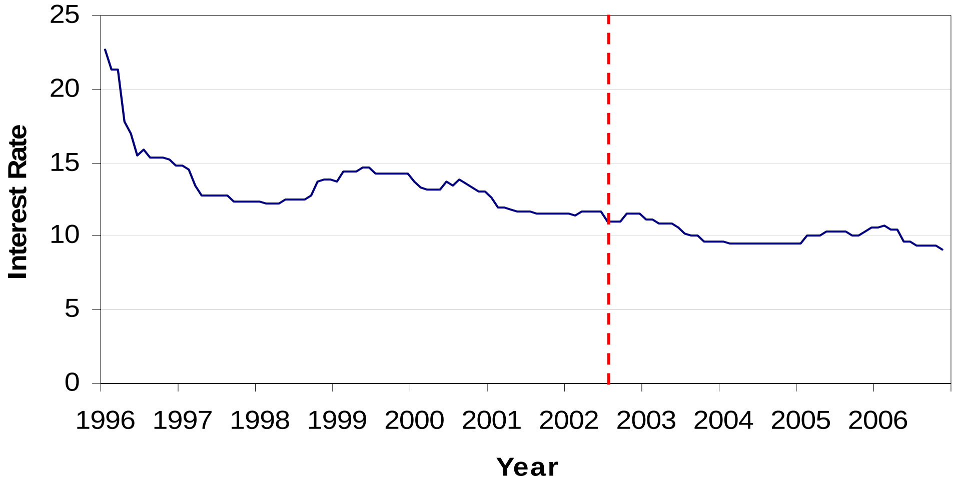
Figure 5. Costa Rican colón exchange rate.
Graph presents the movements of Costa Rican colón exchange rate for the time period from January 1996 to December 2006. From the figure can be seen how much we have to pay domestic currency (US dollars) to get one foreign currency (Costa Rica).



Near to constant devaluation has kept the local economy away form the fears that there could be an unexpected cut in the value of the colón. The speed up of devaluation in September 2002 was small, but still some foreigners and certainly some Costa Ricans are expecting the appearance of a larger devaluation. These same people argue that Costa Rica's foreign and internal debt is too high and imports to Costa Rica are much greater than exports. This puts pressure on the local currency and also increases the expectations of possible devaluation. Hence, the devaluation expectations are extremely high all the time. Others argue equally as strong that the current daily devaluation is sufficient to avoid a big change. (Central Bank of Costa Rica, 2006; IMF, 2006a)

This close to constant devaluation of colón has also consequences. To compensate for the daily decline in the value of the colón against the dollar, bankers and businessmen had to pay higher interest rates on loans denominated in colóns. Higher rates can be negotiated by lenders for larger sums. Some real estate buyers are using the possibility of devaluation as an incentive to make investments in real property with a fixed rate mortgage denominated in colóns. Figure 6 presents the movement of interest rates in Costa Rica during the time period 1996-2006. (IMF, 2006a)

Figure 6. Interest Rates in Costa Rica.
Graph presents one month interest rates in Costa Rica for the time period from January 1996 to December 2006. The rates are monthly money market interest rates. The broken line describes the actual devaluation.



After a several years of devaluation and weakening of colón against US dollar, the central bank of Costa Rica decided to make some transitions in the monetary policy. In October 2006 monetary authority decided to stop the old policy of setting a daily exchange rate. On October 16th 2006, a new currency exchange system was introduced, allowing the value of the colón to float between two bands. The main reason to change the system is to help central bank to control the inflation and also discourage the use of US dollars in Costa Rica. Therefore, central bank decided to publish wider spread, approximately 20-30 colónes, and also allowed the financial institutions to set their own spread to colón. With the new system, the exchange rates posted by the central bank are reference and each authorized financial institution can determine their value independently in hopes that the free market provides a mechanism to keep them reasonable. It has been forecasted that this new mechanism will stop the weakening of the colón. (Central Bank of Costa Rica, 2006)

Uruguay

The "peso uruguayo" is the official currency of Uruguay. The exchange rate of peso has been varying a lot during the last couple of decades. Currency has experienced many crises and recently, in 2002, after a banking crisis and amid a huge budget deficit, Uruguay let the currency to float, losing almost 50 % of its value in a couple of weeks. Nowadays, Uruguayans have become accustomed to wide fluctuations of their currency.

In the time period from 1976 to 1985, which can be also called as the time of military rule in Uruguay, the peso was pegged to the US dollar. During that time, a table of the future value of the dollar was published daily by the government.[9] However, in 1982 the currency was devalued throwing thousands of companies and individuals into bankruptcy. As a consequence, in 1990s the government introduced a new mechanism to provide more predictability. The mechanism was a one type of crawling exchange regime, with a top and bottom margins, at which the government would intervene. (Anderson, 1998; Kamin and Babson, 1999)

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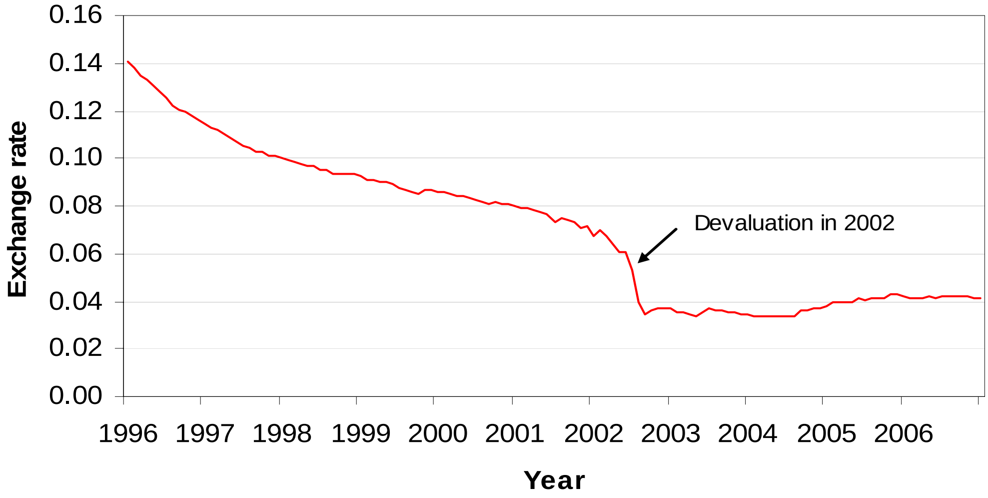
[9] The government released the value in *tablita*. The *tablita* broke in 1982 when peso devalued.

This monetary system controlled long time, until in 2002 Uruguay introduced a new monetary mechanism.

Uruguay experienced a major crisis when banking crisis hit in the summer 2002. In that time, the government planned to eliminate its decade long exchange rate band, allowing the peso to float freely.[10] Finally, on June 2002 Uruguay abandoned exchange rate controls which kept the peso´s fluctuations against the US dollar within 12 % band. As a consequence, the currency fell 11.9 % to 19.5 pesos per dollar shortly after the controls were scrapped. The value kept falling down after banking operations were suspended to try to stem a crippling run on deposits. Because of the banking crisis later in that year, the US dollar rose 60% against the peso. Figure 7 illustrates the movements of exchange rate for peso in terms of US dollar between years 1996 and 2006. From the figure we can see how the banking crisis affected the exchange rate and the decreasing of peso in 2002 and 2003. (Central Bank of Uruguay, 2006)

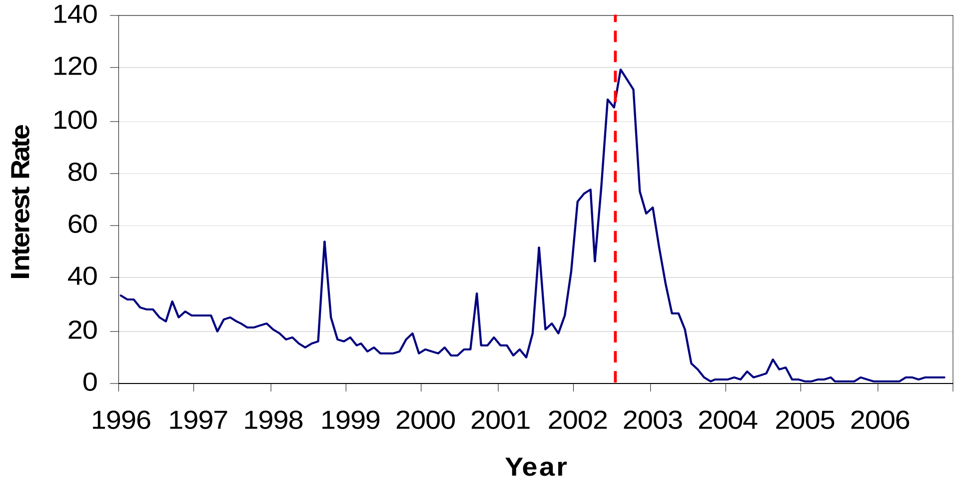
Figure 7. Uruguayan peso exchange rate.
Graph presents the movements of Uruguayan peso exchange rate for the time period from January 1996 to December 2006. From the figure can be seen how much we have to pay domestic currency (US dollars) to get one foreign currency (Uruguay).



[10] Usually after a country abandons the exchange band, it loses an anchor for exchange rate expectations, but it gets the benefit that it monetary policy no longer has to be committed to keep the exchange rate within certain limits.

The crisis had terrible consequences when a massive run on banks by depositors forced the government to freeze banking operations. The crisis was caused by a considerable contraction in Uruguay's economy and by over-dependence on neighboring Argentina, which experienced an economic crisis itself in 2001. Basically, almost 35% of the country's deposits were taken out of financial system and five major financial institutions had terrible problems with payments. Furthermore, this devaluation also lowered consumer purchasing power and increased inflation from about 4% in 2001 to 26% in 2002. Figure 8 presents the movement of interest rates in Uruguay during the time period 1996-2006. In the figure can be seen the anomalous development of interest rates prior to the devaluation occurred. (Central Bank of Uruguay, 2006)

Figure 8. Interest Rates in Uruguay.
Graph presents one interest rates in Uruguay for the time period from January 1996 to December 2006. The rates are monthly money market interest rates. The broken line describes the actual devaluation.



Surprisingly, in 2004 a phenomenon completely new to most Uruguayans developed: the currency appreciated in nominal terms against the US dollar, going from 30 to 24 pesos to the dollar. Figure 7 reveals also this slight revaluation in 2004. This revaluation brought protests from the industrial sector, which felt that it lost competitiveness. Generally, Uruguayan monetary authority has failed to find a reliable monetary policy, which could provide stable exchange rate and at the same time allowing the country to adapt its prices so that its exports remain competitive. (Central Bank of Uruguay, 2006)

Venezuela

Venezuela is one of the most interesting countries in the economy of Latin America at the moment. The currency, bolivar, has experienced many surprising events during the last decade. [11] In 1995 the Venezuelan bolivar was devalued and this caused a crisis in the country. After this, Venezuelan government has carried out devaluation several times, last time in the spring 2002 and in the beginning of 2004. Many economists claim that the bolivar is currently overvalued by around 25% and the devaluation expectations are extremely high at the moment.

Venezuelan bolivar had experienced wide fluctuations through its history. In 1979 Venezuela faced a financial crisis and the crisis ended to the devaluation of bolivar and it dropped to one-third of its previous value against US dollar. The Venezuelan economy fell into a recession in 1993, which continued or even worsen over the next four years. The crisis culminated in 1995 when inflation raised to 103%. In November 1995 Venezuela´s monetary authority decided to devalue bolivar. Devaluing the currency brought inflation to 70.8 % and price and exchange controls were imposed again. (Jackson et al., 2005)

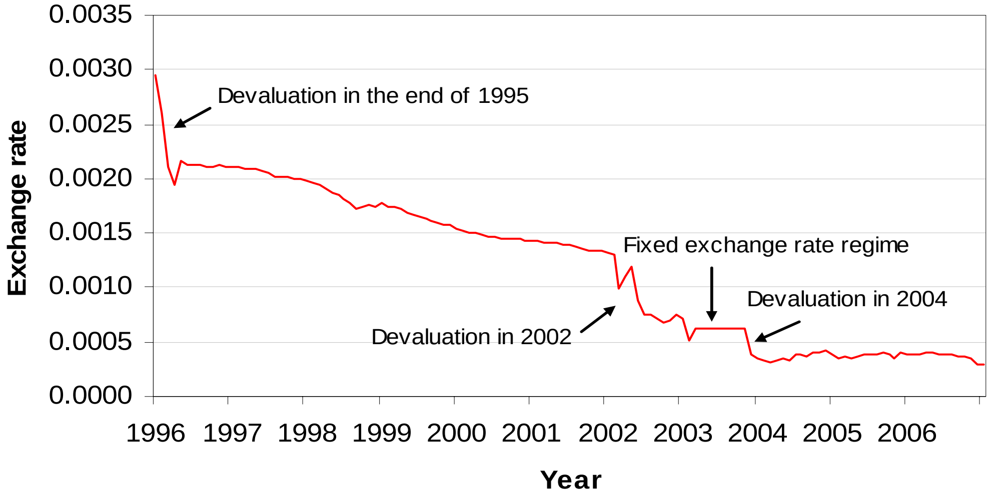
In the summer 1996, monetary authority entered a crawling exchange rate band system in order to manage the exchange rate. The rate was forced to move inside a fluctuation band with an increasing central parity, significantly lower than the expected inflation. The fluctuation band was set in a trading range of 7.5 percent on both sides of the parity exchange rate. The crawling peg regime helped to bring inflation to a 14 year low in 2001; which, brought about an overvalued bolivar. However, after a recession in 1999, overall negative balance of payments led the central

[11] The currency is named after Simón Bolivar, who was a leader of several independence movements in Latin America.

bank of Venezuela to change current the exchange rate regime from a crawling peg to a free floating one in the spring 2002. This action caused the bolivar to depreciate dramatically. (Central Bank of Venezuela, 2006)

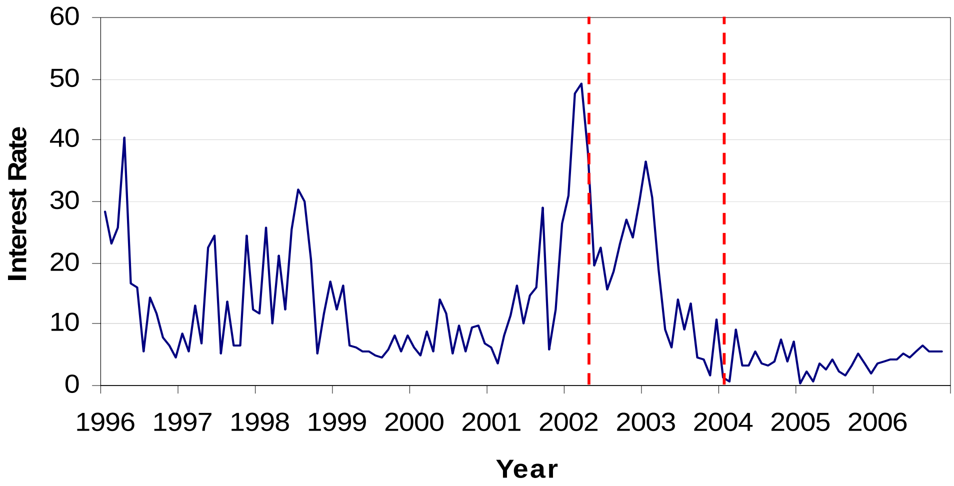
Surprisingly, in February 2003, the government fixed the exchange rate. The decision to fix the exchange rate was meant to help complete the reserves and pay major of the national debt. This allowed the government and central bank to change the currency rate if it was needed. Figure 9 presents the movements of exchange rate of bolivar in terms of US dollar between years 1996 and 2006. In the Figure 9 we can see the devaluations during the time period. (Central Bank of Venezuela, 2006)

Figure 9. Venezuelan Bolivar exchange rate.
Graph presents the movements of Venezuelan bolivar exchange rate for the time period from January 1996 to December 2006. From the figure can be seen how much we have to pay domestic currency (US dollars) to get one foreign currency (Venezuela).



After a short time period of fixed exchange rate regime, the Venezuelan government restricted foreign currency trading in January 2003 and decided to devalue bolivar again in the beginning of 2004. During the year 2004 inflation was a problem in the economy and the inflation rate was on a high level, despite the devaluation in February 2004. In the Figure 10 is presented the movement of interest rates in Venezuela during the time period 1996-2006. In the figure can be seen the anomalous movement of interest rate during the time of devaluations. Especially the anomalous movement of rate before the depreciation in 2002 can be seen extremely strongly. (Central Bank of Venezuela, 2006)

Figure 10. Interest Rates in Venezuela.
Graph presents one month interest rates in Venezuela for the time period from January 1996 to December 2006. The rates are monthly money market interest rates. The broken line describes the actual devaluation.



After several devaluations, the situation in Venezuela is once again very hectic at the moment and the devaluation expectations are discussed all the time. Thus, in October 7, 2006 the Venezuelan Vice Minister of Finance Eudomar Tovar gave a statement to the media that he sees no reason to devalue Venezuela´s currency in 2007 despite some economists´ recommendations and expectations due to inflationary pressures in the Venezuelan economy. Unlike the many other countries, devaluation has an inflationary effect in Venezuela because Venezuela imports up to 70% of its consumer goods and these become more expensive with the devaluation of the currency. (Central Bank of Venezuela, 2006; Latin Focus, 2007)

4. RESEARCH METHODOLOGY AND DATA

In this thesis we investigate if the devaluation expectations may cause peso problem in the examined countries of Latin America. In addition, we examine if the anomalous development of interest rates prior to devaluation in the examined countries could be explained with peso problem. Furthermore, we investigate how the development of individual macroeconomic variables affects markets´ devaluation expectations. In order to examine existence of peso problem and to accept it, at least as a partial explanation to the irrational development of interest rates, we have to show that the devaluation was expected by the market participants prior to actual event. Hence, our problem in the empirical part of this study is to find a proxy for the markets´ expectations of the probability of devaluation. In this thesis we use two different procedures in order to examine these issues.

The first procedure involves using the interest rate differential between instruments denominated in a foreign currency and those denominated in a domestic currency. In the model based on the interest rate differential, we firstly estimate the expected size of devaluation. Once a proxy for the expected size of the devaluation is obtained, it is possible to back out the expected devaluation probability from the interest rate differential. (Berglund and Löflund, 1996) The second model is based on the markets´ devaluation expectations on macroeconomic fundamentals. Using this model we investigate the expected devaluation probabilities directly using Probit model with key macroeconomic indicators as explanatory variables.

4.1 Research questions and hypotheses

The following research questions are formulated to assign the research problem, which is related to the theoretical framework, and to present it in an understandable way:

Q1: Does devaluation expectations and the actual appearance of devaluation cause peso problem in the examined countries in Latin America?

Q2: What is the expected probability that devaluation occurs in the examined countries?

Q3: Could the anomalous development of interest rates, prior to actual event, be explained with peso problem?

Q4: If the central bank refuses to adjust the exchange rate, is the peso problem substantial?

Q5: How a development of certain individual variable affects the markets´ devaluation expectations?

Hence, if the investors anticipated devaluation with a positive probability and if such devaluation expectations affects the interest rates and asset prices in a negative way and the devaluation expectations still exist but the market is factoring the improbable event into the assets in spite of the real appearance of the event in the future, the markets may look flawed. This is exactly the kind of a bias that is known as a peso problem.

The first research question concerns if possibly biased devaluation expectations could arise peso problem in the examined countries. In order to investigate peso problem, we have to estimate the expected devaluation probability in the examined countries prior to actual devaluation took place. The second research question is basically handling those markets´ expectations of devaluation probability. According to the previous studies, the anomalous development of assets could be explained with peso problem. Hence, the third research question is formulated to investigate if this irrational development of interest rates prior to actual devaluation could be explained with peso problem in Latin America as well. It is interesting to examine if there was a peso problem, especially when there has been major crisis recently and some countries have devalued the currencies to make exports more profitable. Especially the situation in Venezuela is very interesting at the moment when the president Hugo Chavez claims that the country will not devaluate in 2007, even though many economists say that the devaluation in Venezuela is unavoidable. This is especially relevant point to the fourth research question and also it gives a possibility for the appearance of peso problem in Venezuela in the near future. (Becker et al., 2001; Latin Focus, 2007) The fifth research question is formulated to investigate how the development of an examined country's certain individual variable affects the expected probability of devaluation in the same country and on the other hand to examine how the development of the variables of the other examined countries in the continent affects country´s expected devaluation probability.

In order to prove that peso problem exists and to approve peso problem as an explanation to the irrational development of interest rates, we have to show that devaluation was expected to occur by the market participants prior to the monetary authority´s decision to devaluate the currency. In order to reject the null and accept the peso problem hypothesis, we need to show that devaluation was, at least to some degree, expected by the market participants in the time period before the actual devaluation took place. This is investigated by estimating the expected probability of devaluation prior devaluation occurred. In order to show that peso problem exist and, on the other hand, to prove that the irrational development of interest rates could be explained with peso problem, we have formulated null and peso problem hypothesis. Founded on these arguments and to articulate hypothesis in a conventional and testable form, the null hypothesis can be presented as follows:

Null hypothesis: Devaluation was not expected by the market participants prior to actual devaluation.

Generally this means period before the monetary authority let the currency to float. In order to articulate the peso problem hypotheses in a conventional and testable form, the hypothesis can be presented as follows:

Peso problem hypothesis: Devaluation was expected by the market participants prior to actual devaluation.

If the null hypothesis can be rejected and the peso problem hypothesis accepted, it could be asserted that the anomalous development of interest rates could be explained with peso problem phenomenon. In order to accept the peso problem hypothesis and to reject the null hypothesis we have to estimate the expected probability of devaluation. To find a proxy for the market´s expectations of devaluation probability we use two different procedures; the first procedure uses interest rate differential. By using interest rate differential we are able to estimate first the expected size of devaluation and then the expected probability of devaluation. The second procedure is modelled using market´s expected devaluation probability based on macroeconomic variables. Therefore, we estimate Probit model, which relates devaluations to important macroeconomic variables. The sample period is from January 1996 to December 2006. This period is selected because the end of 1990´s and 2000´s has been the period of devaluations in Latin America. However, we are mainly interested in markets devaluation expectations before the actual event took place. A wide sample period is important, as there have to be a certain amount of observations in order to get accurate and relevant results.

4.2 Interest rate differential model

When investigating peso problem, we have to estimate the expected probability of devaluation that market assessed prior to actual happening of devaluation. In this thesis we use same kind of estimation as used in the examination by Berglund and Löflund (1996). Using this kind of method, it is possible to estimate firstly the expected size of devaluation and secondly the expected probability of devaluation. The technique is close to the method used by Bertola and Svensson (1991). Bertola and Svensson derived the implications of stochastic devaluation risk for the instantaneous interest rate differentials and for the term structure of interest rate differentials. The key idea in this method is to extract devaluation expectations by adjusting interest rate differentials for expected rates of depreciation of the exchange rate. But as a difference comparing to Bertola and Svensson model, we use also an assumption about the devaluation size, which allows us to derive the markets´s subjective probability that devaluation will take place. Besides Berglund and Löflund, this kind of method has also been used by Holden and Vikoren (1994).

As mentioned above, we use applied model of the technique suggested by Bertola and Svensson. They claimed that exchange rates and interest rate differentials are endogenous and jointly determined by fluctuations in fundamentals and devaluation risks. The analysis relies on the assumption of uncovered interest rate parity (UIP)[12]:

$$(1+i_t) = (1+i_t^*)\left[E\left(\frac{e_{t+1}}{e_t}\right)\right] \tag{4}$$

where i_t is the local interest rate, i_t^* the foreign interest rate and e the exchange rate. In other words, interest rate on a domestic currency in the foreign market should be equal to the interest rate on foreign currencies in the foreign market, plus the expected rate of devaluation. Therefore UIP implies that the interest rates differential reflects the markets´ devaluation expectations. UIP assumes the existence of arbitrage in international markets linking the interest and exchange rates in such a way that changes in one rate should imply a same direction change in the other rate. (Bertola and Svensson, 1991)

[12] A parity condition stating that the difference in interest rates between two countries is equal to the expected change in exchange rates between countries currencies. If this parity does not exist, there is an opportunity to make a profit. (Brooks, 2004)

However, even if the UIP hypothesis may operate well at a theoretical level, it might not perform well at an empirical level. It is well known that deviations from UIP are pervasive and persistent. In particular, currencies with high interest rates tend to appreciate relative to those with lower interest rates, contrary to the hypothesis of UIP. Despite those deviations the interest rate differential model used in this thesis assumes that UIP holds. On the other hand, markets´ expectations of devaluation may lead to bias in UIP. For instance, a sample of data, which ends before an anticipated devaluation shows high interest rate differentials (since there was an anticipated devaluation) unmatched in the sample by a comparable exchange rate change, leading to bias in the assets even if UIP holds. However, if the UIP holds and bias exists, it is still possible to give a rational explanation as form of peso problem. (Flood and Rose, 1996) An explanation for UIP failure, even if it holds, is that most countries do not work with a pure floating exchange rate regime. In a fixed or crawling band rate regime this phenomenon can be explained by the peso problem. As explained previously, it occurs when there is a small probability of a large alternation in the exchange rate. (Sachsida et al., 2001)

The expected devaluation probability can roughly be divided into the conditional expectation for the size of this devaluation, given that it occurs, and into assessed probability of devaluation. In this model we use the relative purchasing power parity to proxy the expected size of devaluation. Once the expected size of devaluation has been estimated, we estimate the market´s devaluation expectations using the difference between the domestic and foreign level of interest rates. Assuming that uncovered interest rate parity holds and using the assumption that expected devaluation size and market´s devaluation expectations are independent terms, we are able to estimate the expected probability of devaluation. (Berglund and Löflund, 1996)

4.2.1 Expected size of devaluation

The first step in this approach is to approximate the expected size of devaluation. This can be estimated using deviations from relative purchasing power parity. Purchasing power parity is a theory which states that exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries. This means that the exchange rate between two countries should equal the ratio of the two countries´ price level. When a country´s domestic price level is increasing (country experiences inflation), that country´s exchange rate must be depreciated in order to return to PPP. (Sarno and Valente, 2006) Using backward accumulation of the rate of change in the real exchange rate can be described as in the following equation:

$$e_t = \Delta S_t + (i_{ft} - i_{dt}) \tag{5}$$

where ΔS_t is the logarithmic change in the spot exchange rate in a currency, and $(i_{ft} - i_{dt})$ is the difference between foreign and domestic inflation. The logarithmic change can be estimated as in the following equation:

$$\Delta S_t = \ln \frac{p_t}{p_{t-1}} \tag{6}$$

where p_t denotes spot exchange rate. Once the expected size of devaluation is estimated, the next step investigating the expected devaluation probability with interest rate differential model is to calculate markets devaluation expectations and then finally we are able to estimate the expected probability of devaluation. (Berglund & Löflund, 1996; Holden and Vikoren, 1994)

4.2.2 Markets´ devaluation expectations and expected probability of devaluation

Assuming that uncovered interest rate parity holds the observed difference in interest rates between the domestic and the foreign country reflects the market´s devaluation expectation until the time to maturity of the instrument. Most of the literature trying to assess the credibility of fixed or crawling exchange rate band regimes relies strongly on the validity of UIP and this interest rate differential model, used in this thesis relies also on that assumption. To obtain a proxy for the markets´ devaluation expectations, money market interest rates can be used. As we then assume that the uncovered interest rate parity holds, the markets´ devaluation expectations can be computed from the difference between domestic and foreign interest rates. (Berglund and Löflund, 1996) The relation is simply as in the following equation:

$$E[d_t \times p_t] = r_{d,t} - r_{f,t} \tag{7}$$

where r_{dt} is the domestic interest rate and r_{ft} is foreign interest rate. Once the markets´ devaluation expectations and the expected size of devaluation have been defined, we are able to estimate the expected devaluation probability. As mentioned earlier, the expected devaluation probability is the expectation of a product of the devaluation size d_t and its probability p_t. Using the estimations above and, on the other hand, making the simplifying assumption that these two terms are independent, we can solve for the expected probability of devaluation as in the following equation:

$$E[p_t] = \frac{r_{dt} - r_{ft}}{E[d_t]} \tag{8}$$

Once we have estimated the expected devaluation probability as in the equation (8), it is possible to make implications if the devaluation was expected by the market participants. Using this estimation of expected devaluation probability, we are then able to investigate if peso problem exists in the data sample and, on the other hand, if the irrational behaviour of interest rates prior to devaluation could be explained by peso problem. (Berglund and Löflund, 1996; Holden and Vikoren, 1994)

4.3 Probit model

As explained previously, to investigate existence of peso problem and to accept peso problem as an explanation to the anomalous development of interest rates and asset prices, we have to estimate the expected devaluation probability. In addition to interest rate differential model, alternative model can apply as well. As a difference comparing to the interest rate differential model, now we estimate the expected devaluation probability as a function of several macroeconomic variables. Furthermore, we investigate how the development of a certain individual variable affects devaluation probability. In order that it could be possible, we have to use estimation which allows us to model a relationship between the devaluation probability and several macroeconomic variables. Discrete choice models are suitable for this kind of estimation.

Discrete choice models are econometric models in which the actors are presumed to have made a choice from a discrete set. Their decision is modelled as endogenous. The most typical discrete choice models are Logit, generalized extreme value (GEV), Nested Logit and Probit models, which are used to model a relationship between a dependent variable *Y* (in this case devaluation) and one or more independent variables *X* (macroeconomic variables). The dependent variable, *Y*, is a discrete variable that represents a choice, or a category, from a set of mutually exclusive choices or categories. The independent variables are presumed to affect the choice or category or the choice maker, and represent a priori beliefs about the causal or associative elements important in the choice or classification process. (Greene, 2003; Train, 2003)

Amongst the discrete choice models, we have selected Probit model and we examine the expected devaluation probabilities directly using a Probit model with key macroeconomic indicators as explanatory variables almost the same way as Edin and Vredin (1993). The examination made by Edin and Vredin was done using data for all Nordic countries during 1970-1989. Edin and Vredin estimated Probit model which related devaluations to important fundamentals. The model used by Edin and Vredin was an extension of models by Svensson (1991) and Bertola and Svensson (1993) which used the uncovered interest parity as the main determinant of expected rate of depreciation. In contrast, the Edin-Vredin model links devaluation of the exchange rate to macroeconomic fundamentals other than only interest rate differential. The devaluation probability by Edin and Vredin was given by a Probit model with the following explanatory variables observed at time t-1: money stock, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. We use same kind of variables as used by Edin and Vredin, but we have made some variations according to the fact that the empirical part in this thesis concerns Latin American countries. (Edin and Vredin, 1993)

4.3.1 Implementation of Probit model

Implementing the interest rate differential model, the analysis was based on the assumption which stated that the interest rate differential between domestic and foreign rates reflects the total expected devaluation of the exchange rate. Implementing Probit[13] model it is possible to estimate the

[13] The term Probit was coined in the 1930´s by Chester Bliss and stands for probability unit.

expected devaluation probability with more than one macroeconomic fundamental. Furthermore, we are able to investigate how the development of an examined country's certain individual variable affects the expected probability of devaluation in the same country and on the other hand, how the development of the variables of the other examined countries in the continent affects country´s expected devaluation probability. Probit model is an alternative log-linear approach to handling categorical dependent variables. Its assumptions are consistent with having a categorical dependent variable assumed to be a proxy for a true underlying continuous normal distribution. In this model, the hypothesis is that devaluation, which involves a change from one regime to another, is related to macroeconomic fundamentals, just like the change in the exchange rate is determined by such fundamentals. (Edin and Vredin, 1993; Train, 2003)

We suppose that a binary dependent value, Y_i, takes on values of zero and one. As mentioned, the dependent value is considered as devaluation in this case. One means that devaluation occurs and zero means that devaluation does not occur. However, then we are able to model the probability of observing a value of one as follows:

$$\Pr(Y_i = 1 | x_i, \beta) = 1 - F(-x_1{'}\beta) \tag{9}$$

where *F* is a continuous, strictly increasing function that takes a real value and returns a value ranging from zero to one. (Maddala, 1983) The choice of the function *F* determines the type of binary model, which is Probit model in this case. It follows that:

$$\Pr(Y_i = 0 | x_i \beta) = F(-x_i{'}\beta). \tag{10}$$

Given such a specification, we can estimate the parameters of this model using the method of maximum likelihood. The principle of maximum likelihood provides a means of choosing an asymptotically efficient estimator for a parameter or a set of parameters. The idea behind maximum likelihood parameter estimation is to determine the parameters that maximize the probability of the sample data. From a statistical point of view, the method of maximum likelihood is considered to be more robust and yields estimators with good statistical properties. (Pickles et al., 2005) However, the likelihood function is then given by:

$$l(\beta) = \sum_{i=0}^{n} Y_i \log(1 - F(-x_i{}'\beta)) + (1 - Y)\log(F(-x_i{}'\beta)) . \qquad (11)$$

There are two alternative interpretations of this specification that are of interest. First, the binary model is often motivated as a latent variables specification. Suppose that there is an unobserved latent variable Y_i^* that is linearly related to *x*:

$$Y_i^* = x\beta + u \qquad (12)$$

where *u* is a random disturbance and $x\beta$ is called the Probit score or index. Then the observed dependent variable is determined by whether Y_i^* exceeds a threshold value:

$$Y = 1 \text{ if } Y_i^* > 0 \qquad (13)$$

$$Y = 0 \text{ if } Y_i^* < 0.$$

Then we are able to write as:

$$\Pr(Y_i = 1 | x_i\beta) = \Pr(Y_i^* > 0) = \Pr(x_i{}'\beta + u > 0) = F(-x_i{}'\beta) . \qquad (14)$$

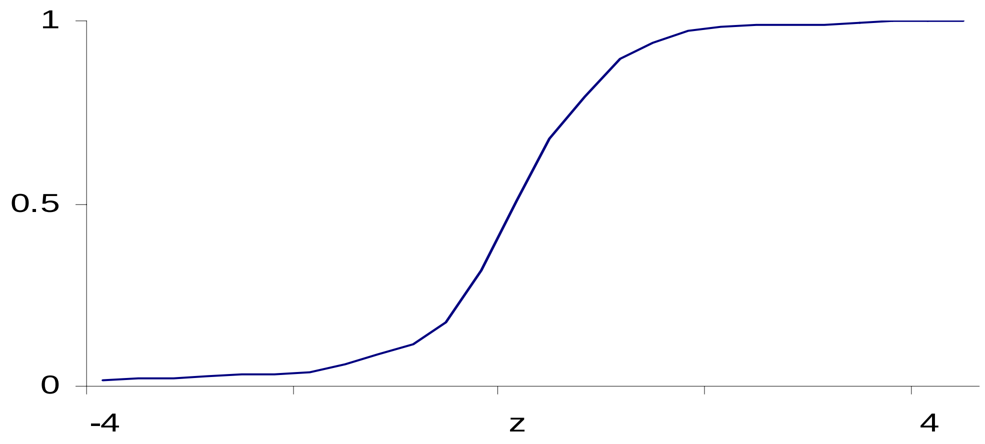
As we have selected Probit model, the function *F* is considered to be, the cumulative distribution function of the standard normal distribution. Then it is possible to write as:

$$\Pr(Y_i = 1 | x_i \beta) = 1 - \Phi(-x_i{'}\beta) = \Phi(x_i{'}\beta)\,. \tag{15}$$

where Φ is the cumulative distribution function of the standard normal distribution and the parameters of β are typically estimated by maximum likelihood using the log-likelihood function. (Greene, 2003; Train, 2003)

Probit analysis is based on the cumulative normal probability distribution. The cumulative normal distribution function calculates the probability that a value exists, which is less than the input in a series with mean of 0 and a standard deviation of 1. The curve of cumulative normal distribution looks like S-shaped curve that runs from zero to one. Actually it is very similar to the graph of the Logit function. In the Figure 11 is presented the cumulative normal distribution curve, which shows that the curve runs between zero and one. (Ronning, 2005)

Figure 11. Cumulative normal distribution.
The horizontal axis is the allowable domain for the given probability function. Since the vertical axis is probability, it must fall between zero and one. It increases from zero to one as we go from left to right on the horizontal axis.



Once the definition of the Probit model and dependent value is defined we also have to determine the independent variables. In this case the independent variables are considered as macroeconomic variables, which could be related to devaluation expectations in Latin America.

4.3.2 Selection of macroeconomic variables

The selection of explanatory variables is not based on any theoretical consideration. Consequently, the selection of variables has been influenced by the paper done by Edin and Vredin (1993) and also experiences from the Latin American money and foreign exchange markets. We have selected the macroeconomic variables, which could mostly influence the devaluation expectations in Latin American countries. Likewise, we have also taken influences from the previous investigations, which considered the exchange rate expectations. It seems warranted, however, to assume that the fundamentals, which in general affect the exchange rate expectations, are likewise affecting the devaluation expectations at least to a certain extent.

In order to estimate the expected probability of devaluation with Probit model we have selected the following explanatory variables observed at time period: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. The character of these fundamentals and the possible affiliation to devaluation expectations can be found from the following lines. In the empirical part of this study, is examined how these variables affects market´s devaluation probability using Latin American data.

Money supply

Money supply can considered as the amount of money available in the economy. Under the framework of the standard monetary model, one of the most important devaluation fundamentals is money supply. If we assume that the private sector has some kind of monetary model behind their thinking of the rule the central bank is following, changes in the money supply influences their expectations. In this framework an increase in the domestic money supply could lead to devaluation. Correspondingly, an increase in the domestic real income should lead to a revaluation. Therefore, if the market participants observe domestic money supply increasing, the expected probability of devaluation is assumed to rise. (Vajanne, 1993)

However, monetary authority may try to manipulate money supply to avoid devaluation. With the pegged exchange rates, the rates are usually maintained by a combination of legally enforced capital controls or trough government trading of foreign currency reserves to manipulate the money supply. Under fixed exchange rates, persistent capital outflows or trade deficits may lead countries to lower or abandon their fixed rate policy, resulting devaluation. This affects also to market participant´s devaluation expectations. (Davradakis, 2005)

Level of foreign exchange reserves

Foreign exchange reserves are the foreign currency deposits held by central bank and monetary authority. The level of foreign exchange rates has a significant role and it affects directly to the expected probability of devaluation. When a country´s imports are increasing, the foreign exchange reserves are decreasing, because monetary authority is using them to keep the exchange rate at equilibrium and to avoid devaluation. At the same time, market´s devaluation expectations are assumed to rise. (Davradakis, 2005)

Usually, government decides to devalue currency to support exports of domestic companies. When the amount of exports is increasing, the level of foreign exchange reserves is increasing as well. For the government, it is extremely important to have enough of foreign exchange reserves to keep exchange rate at equilibrium. It means that when the government´s need to increase exports rises the expected probability of devaluation is presumed to increase as well. (Aguiar and Broner, 2006; Davradakis, 2005)

Industrial output

Industry has a significant role in the economy of a country. Industrial output is nearly connected also to the possible devaluation of country´s currency. It can be asserted that devaluation affects the domestic industry as devaluation is fastening the growth of industrial output because currency depreciation improves country´s export competitiveness by making its goods cheaper abroad. (Mundaca, 2004)

Correspondingly, the appreciation of a currency is then slowing the growth of industrial output, and to prevent this outcome, the monetary authority is supposed to take several possible steps to prevent the further currency appreciation. Generally, it means that expected probability of devaluation is supposed then to rise. Therefore, when the number of industrial output is decreasing, the expected probability of devaluation is assumed to rise. (Heckman, 1976)

Foreign interest rates

As explained in the model based on the interest rate differential, the expected probability of devaluation can be estimated also using the differential between domestic and foreign interest rates. But for Probit model we have selected only foreign interest rates as it has been showed that an increase in the foreign interest rate calls for currency depreciation. Hence, if the market participants observe rising foreign interest rate level, the expected probability of devaluation starts to rise. (Bernhardsen, 1998; Castillo, 1992) As we act as a US investor, the increasing of the foreign interest rates (the interest rate in Latin American country) is presumed to raise also the expected probability of devaluation.

Foreign price levels

The price level is the weighted average of the prices of all goods and services in an economic system. It is often measured with a consumer price index, which is one particular type of price index. The level of foreign price level has a significant role as a macroeconomic variable in the investigation of the expected devaluation probability. A decrease in the foreign price level may lead to the currency depreciation. Therefore, when market observer starts to notice that the foreign price level is decreasing, the expected probability of devaluation starts to rise. This affects also in opposite way: an increase in the foreign price level leads to currency appreciation and therefore decreasing of the expected probability of devaluation. (Mundaca, 2004; Vajanne, 1993)

The assertion can be proved with the purchasing power parity. Assuming that the purchasing power parity holds, the exchange rate must adjust so that the foreign price level translated at the spot rate is the same as domestic price level. Hence, when the foreign price level is decreasing and the parity does not hold, the market participants start to expect devaluation, because the price level is then higher in the domestic country and makes the exchange rate unstable. (Mundaca, 2004)

Real exchange rate

When investigating the relationship between macroeconomic variables and devaluation expectations, it is important also to give attention to such fundamental as the real exchange rate. The real exchange rate is an important concept in economics generally. It is a broad summary measure of the prices of one country´s goods and services relative to those of another country. (Sarno and Taylor, 2002) Incorporating the real exchange rate into the model implies that a higher real exchange rate indicates an expected devaluation. The reason for this relation is that a real exchange rate is associated with a low domestic price level and thus with high level of the real money stock. The return to equilibrium is achieved through a corresponding increase in the price level which introduces an expected devaluation. Hence, when speculators notice that the real exchange rate is on high level, the devaluation expectations are assumed to be also on high level. (Kaminsky, 1986; Vajanne, 1993)

4.4 Problems with models

Despite the fact that interest rate differential model and Probit model are widely used methods in the field of finance, both of them are subjects to problems, which should be noticed. These models are tightly depended on the country´s monetary authority policy. If the policy differs from the commonness, the results might be biased. Both models might produce biased estimates, although in opposite ways. This is also one reason why we have selected both of these models to estimate expected probability of devaluation in Latin America. Firstly are presented the possible problems in the interest rate differential model and secondly the problems with Probit model.

4.4.1 Problems with interest rate differential model

In order to produce relevant results with interest rate differential model we have to assume that government operates with neutral policy. The interest rate differential model is assumed to produce downward biased estimates. If the monetary authority does it utmost to keep the rate as low as possible, the outcome of the model could be downward biased. Hence, if the interest rate level is lower than it would have been under a neutral government policy, the estimation with interest rate differential model might produce downward biased results. (Berglund and Löflund, 1996)

Traditionally economists have relied on interest-parity conditions to investigate devaluation expectations. However, this approach is subject to a number of empirical limitations. For example, the general evidence for uncovered interest parity is mixed, and in practice it is often difficult to find two securities denominated in domestic and foreign currency that carry the same default risk. Similarly, the new literature on leading indicators has also met with limited success. Despite these deviations, we assume that uncovered interest rate parity holds. Using the Probit model we do not have to assume that UIP holds, but correspondingly Probit model suffers because of some other problems that do not exist in interest rate differential model. (Berk and Knot, 2001; Craine, 2002)

4.4.2 Problems with Probit model

Probit model is also suffering because of some remarkable problems. Correspondingly to the interest rate differential model, Probit model might produce upward results if the monetary authority is not operating neutrally. Edin and Vredin (1993) showed that model might produce upward biased results, if the monetary authority is less determined to fight against devaluation.[14] If the monetary authority gives continually commitments that the currency will not be devalued, it reduces the markets expectation of the probability that devaluation is imminent. (Edin and Vredin, 1993)

It is also important to observe that including the money supply and foreign exchange reserves in the same model may lead to potential multicollinearity problems.[15] Multicollinearity is not a violation of models explicitly; however it does cause problems in the mathematics of solving for the regression parameters. In essence, highly collinear variables cause regression parameters to be inefficient, and can cause signs of the regression coefficients to be counter-intuitive. (Train, 2003) Similar types of problems might appear if the unemployment rate is included in the model, which can be seen as a proxy for the money supply as well. That is also a reason why we do not include unemployment rate in to the model.

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[14] As it seems to happen now in Venezuela, where the monetary authority refuses to devaluate currency, even the exchange rate is not in the equilibrium.
[15] In an open economy, the money supply is the sum of foreign exchange reserves and central bank credit for the private sector in the balance sheet of the central bank.

Solutions for these possible multicollinearity problems are handled in the chapters later. (Vajanne, 1993)

4.5 Data

For the empirical investigation in this thesis we have selected several topical currencies of the countries in the Latin America. According to the character of this thesis and limitations caused by the empirical methodology in the study there are some limitations for the data as well. Countries and currencies have experienced devaluation at least once during the sample period. It means that the exchange rates have to fluctuate at least once to acquire acceptable results from the empirical part of this study. Therefore, we have selected countries, which have recently devalued their currency. (Berglund and Löflund, 1996)

The time period for the empirical analysis in this study is from January 1996 to December 2006. But because we examine devaluation expectations and the existence of peso problem, we are mainly interested in the time period until the country entered floating currency system. The time period in the empirical part is divided in three categories: before devaluation, after devaluation and the full sample. For the empirical analysis in this thesis, we have selected exchange rates of the following currencies: Argentina´s peso, Brazil´s real, Costa Rica´s colón, Uruguay´s peso, and Venezuela´s bolivar. The data is collected from the Thomson Financial DataStream database provided by Lappeenranta University of Technology and from the International Monetary Fund´s Financial Statistics database.

In order to estimate the expected probability of devaluation with the interest rate differential model, we need time series for exchange rates, foreign and domestic inflation and also for foreign and domestic interest rates. In order to estimate the expected size of devaluation, we use monthly spot exchange rates of US dollar in terms of Argentina peso, Brazilian real, Costa Rica colón, Uruguayan peso and Venezuelan bolivar. Inflation rate is described as monthly % change of the consumer price index, which measures the price of a selection of a goods purchased by a typical consumer. In order to estimate expected probability of devaluation we use monthly foreign and domestic money market interest rates.

The estimation with Probit models has been done using several macroeconomic variables as explanatory variables for the expected probability of devaluation. For this analysis we have selected variables as follows: money supply, industrial output, foreign interest rates, foreign price level, the real exchange rate and the level of foreign exchange reserves. Appendix 1 shows graphs and development of all the variables for all the examined countries. The money supply that we use is the monthly growth rate of money supply. This growth has been presented as percents. Industrial output is a component of nominal Gross Domestic Product and therefore it is presented as % of Gross Domestic Product. For this model we use monthly rate to describe the industrial output of a certain country. To describe the foreign interest rates we use money market interest rates of Argentina, Brazil, Costa Rica, Uruguay and Venezuela. The foreign interest rates are presented as a monthly frequency. The foreign price level is in terms of the consumer price index of Argentina, Brazil, Costa Rica, Uruguay and Venezuela. The real exchange rate is defined as in equation (16):

$$RER = e(\frac{P_t}{P_t^*}) \qquad (16)$$

where *e* is the exchange rate, as the number of foreign currency units per home currency unit. P_t is the price level of the home country and P_t^* is the foreign price level. (Cuthbertson, 1996) The level of foreign exchange reserves is presented as millions of U.S. dollars. For this model we use monthly frequency of foreign exchange reserves.

5. EMPIRICAL RESULTS

The main interest for us in this thesis is to investigate the appearance of peso problem in Argentina, Brazil, Costa Rica, Uruguay, and Venezuela. In addition, we examine also if the anomalous development of interest rates prior to devaluation can be explained with peso problem. Furthermore, we investigate how the development of a certain individual variable affects markets´ expected devaluation probability. In order to examine peso problem, we have to estimate the expected devaluation probability in the above mentioned Latin American countries. We examine expected devaluation probability with two different procedures; interest rate differential model and Probit model.

Using the interest rate differential model we are able to estimate the expected devaluation size in the first place. Once the expected devaluation size has been computed, it is possible to back out the expected devaluation probability from the interest rate differential. Applying the Probit model, we are able to estimate the expected devaluation probability based on several macroeconomic variables. These macroeconomic variables are: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. In order to estimate Probit model, we use Eviews 5.0 program.

5.1 Descriptive statistics

The purpose of this chapter is to analyze the characteristics of the collected data. For each variable minimum, maximum, mean, standard deviation, skewness, kurtosis and Kolmogorov-Smirnov normality test are presented. Minimum, maximum and standard deviation are used to describe the dispersion and mean the focus of the variables. The skewness and kurtosis are helpful in examining the normal distribution of the variables. Tables 1a, 1b, 1c and 1d present descriptive statistics for each country and variables such as real exchange rate, interest rate, price level, industrial output, money supply, and exchange reserves.

Table 1a presents minimum, maximum, mean and standard deviation for real exchange rate (q), interest rate (r) and price level (p) of each country. Venezuelan bolivar/US dollar real exchange rate has the highest mean where as Argentine peso/US dollar has the lowest mean. As we see from the Table 1a, standard deviation for real exchange rate for Brazil is near to zero. It means that the points are close to the mean and there has not been wide spread. Correspondingly, standard deviation for Venezuelan Bolivar/dollar real exchange rate is 231.26, which means that there has been a lot of variation.

Table 1a. Descriptive statistics.
Table shows the descriptive statistics for real exchange rate (q), interest rate (r) and price level (p) for each country. Table presents minimum, maximum, mean and standard deviation of each variable. The sample period collects data from January 1996 to December 2006.

Variable	N	Minimum	Maximum	Mean	Std. Dev.
q Argentina	133	-524.60	131.76	-2.49	47.86
q Brazil	133	0.12	2.32	0.83	0.49
q Costa Rica	133	22.15	179.35	78.10	37.81
q Uruguay	133	0.51	28.59	6.39	5.52
q Venezuela	133	11.92	1028.73	199.81	231.26
r Argentina	133	1.20	91.19	10.33	14.72
r Brazil	133	13.65	43.25	21.33	6.46
r Costa Rica	133	9.10	22.67	12.15	2.41
r Uruguay	133	0.70	119.40	21.37	24.85
r Venezuela	133	0.40	49.20	11.85	10.05
p Argentina	133	-2.32	40.95	5.77	10.20
p Brazil	133	1.65	22.41	7.95	4.45
p Costa Rica	133	7.54	22.63	12.01	2.69
p Uruguay	133	3.38	35.44	11.86	8.83
p Venezuela	133	10.83	115.19	31.59	25.51

In addition, Table 1a reveals that Uruguay has both the lowest and highest value of interest rate. Table also shows that Argentina has the lowest mean of interest rate and Uruguay has the highest. Standard deviations are logical comparing to means. On the other hand, results of the Table 1a show that the lowest value of price level is in Argentina and the highest is in Venezuela. Venezuela has also highest mean when the mean of price level reached 31.59%. In Costa Rica the standard deviation is lowest and in Venezuela the highest.

Table 1b presents skewness, kurtosis and one-sample Kolmogorov-Smirnov test for real exchange rate (q), interest rate (r) and price level (p) of each country. In general, if the variables are normally distributed, the values of skewness and kurtosis[16] should be close to zero. The findings in Table 1b indicate that skewness of Argentina peso/dollar real exchange rate has high negative value of skewness while all the others have positive value of skewness. Therefore we might assert that peso/dollar real exchange rate is skewed to left. The Brazilian real/dollar real exchange rate and Costa Rican colón/dollar rate are near to zero; hence they are nearly normally distributed. All the skewness values of interest rates in all countries has positive values, hence they are right skewed. Likewise, all the values of price level in all countries have positive skewness values therefore they are right skewed.

When skewness of distribution indicates the degree of symmetry in the frequency distribution, kurtosis indicates the peakedness of that distribution. All the variables that have high positive value of kurtosis suggest that the distributions of these variables are centred. (Watsham and Parramore, 1997) Table 1b reveals that Argentina peso/dollar real exchange rate has extremely high kurtosis value. While Brazilian real/dollar rate and Costa Rican colón/dollar have values close to zero, which indicates normal distribution. These results are consistent to skewness values. Kurtosis values of interest rates are all positive and

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[16] The descriptive statistics has done by SPSS program that automatically deducts 3 from original values, hence the kurtosis of the normal distribution equal to zero.

Argentina has the highest kurtosis value. Kurtosis value of price level in Uruguay has negative kurtosis value while the others have positive values. The normality of the test variables was further examined by using one-sample Kolmogorov-Smirnov test. The null hypothesis is normal distribution and the results of the normality test indicate that real exchange rates, interest rates and price levels for all the countries are not normally distributed.

Table 1b. Descriptive statistics.
Table shows the descriptive statistics for real exchange rate (q), interest rate (r) and price level (p) for each country. Table presents skewness, kurtosis and Kolmogorov-Smirnov p-value of each variable. *indicates statistical significance at 0.01 level. The sample period collects data from January 1996 to December 2006.

Variable	N	Skewness	Kurtosis	Kolmogorov-Smirnov
q Argentina	133	-9.87	110.59	<0.001*
q Brazil	133	0.89	0.72	0.006*
q Costa Rica	133	0.63	-0.08	0.002*
q Uruguay	133	1.29	1.97	<0.001*
q Venezuela	133	1.63	1.92	<0.001*
r Argentina	133	3.59	13.57	<0.001*
r Brazil	133	1.70	2.71	<0.001*
r Costa Rica	133	1.55	4.13	<0.001*
r Uruguay	133	2.21	5.16	<0.001*
r Venezuela	133	1.49	1.98	<0.001*
p Argentina	133	2.18	4.32	<0.001*
p Brazil	133	1.41	1.75	<0.001*
p Costa Rica	133	1.30	2.19	0.001*
p Uruguay	133	1.06	-0.24	<0.001*
p Venezuela	133	2.06	3.55	<0.001*

Table 1c provides minimum, maximum, mean and standard deviation for industrial output (y), money supply (m) and exchange reserves (fx) of each country. Table 1c shows that Uruguay has the lowest value of industrial output, when correspondingly Venezuela has the highest value of industrial output. Venezuela has likewise highest mean of industrial output.

Argentina and Venezuela have higher standard deviation of industrial output than Brazil, Costa Rica and Uruguay, hence Argentina and Venezuela are considered more volatile than the others.

Table 1c reports that Argentina has the lowest value of money supply, while Venezuela has the highest value of money supply. Venezuela has also the highest mean value of money supply. In addition, Table 1c reveals that Venezuela has the highest standard deviation and Brazil has the lowest standard deviation. Therefore, we can state that money supply in Venezuela is the most volatile while money supply in Brazil is the least volatile.

Table 1c. Descriptive statistics.

Table shows the descriptive statistics for industrial output (y), money supply (m) and exchange reserves (fx) in millions of US dollars for each country. Table presents minimum, maximum, mean and standard deviation of each variable. The sample period collects data from January 1996 to December 2006.

Variable	N	Minimum	Maximum	Mean	Std. Dev.
y Argentina	133	27.00	35.80	31.12	3.30
y Brazil	133	32.90	38.00	35.36	1.85
y Costa Rica	133	28.50	35.00	30.04	1.83
y Uruguay	133	26.40	34.20	28.44	1.89
y Venezuela	133	39.60	50.50	44.65	3.01
m Argentina	133	-23.79	88.12	16.85	21.32
m Brazil	133	-5.40	55.52	18.59	12.73
m Costa Rica	133	-7.95	95.17	21.83	14.25
m Uruguay	133	-13.08	37.09	15.57	13.69
m Venezuela	133	-3.16	160.66	49.01	37.45
fx Argentina	133	8296.00	28696.00	18496.00	5127.00
fx Brazil	133	27116.00	82822.00	48323.00	12109.00
fx Costa Rica	133	933.00	3092.00	1509.00	479.00
fx Uruguay	133	526.00	3476.00	1965.00	705.00
fx Venezuela	133	5688.00	27403.00	13536.00	5605.00

Table 1d presents skewness, kurtosis and Kolmogorov-Smirnov normality test for industrial output (y), money supply (m) and exchange reserves (fx) of each country. The results presented in Table 1d show that industrial output in Brazil has negative skewness value, while the other countries have positive skewness values of industrial output. Skewness values of money supply indicate that money supply time series in Uruguay are slightly left skewed while the others are slightly right skewed. In addition, skewness values of exchange reserves indicate that exchange reserves in Costa Rica are right skewed, while the others have values near to zero, hence they can be considered as normally distributed.

Table 1d. Descriptive statistics.
Table shows the descriptive statistics for industrial output (y), money supply (m) and exchange reserves (fx) in millions of US dollars for each country. Table presents skewness, kurtosis and Kolmogorov-Smirnov p-value of each variable. *indicates statistical significance at 0.01 level.The sample period collects data from January 1996 to December 2006.

Variable	N	Skewness	Kurtosis	Kolmogorov-Smirnov
y Argentina	133	0.43	-1.56	<0.001*
y Brazil	133	-0.12	-1.51	<0.001*
y Costa Rica	133	1.79	2.28	<0.001*
y Uruguay	133	1.55	2.31	<0.001*
y Venezuela	133	0.51	-0.24	<0.001*
m Argentina	133	0.81	0.68	0.004*
m Brazil	133	0.66	0.23	0.004*
m Costa Rica	133	1.87	6.70	<0.001*
m Uruguay	133	-0.34	-1.19	<0.001*
m Venezuela	133	0.97	0.70	0.002*
fx Argentina	133	-0.20	-1.07	0.012
fx Brazil	133	0.29	-0.56	0.001*
fx Costa Rica	133	1.28	1.02	<0.001*
fx Uruguay	133	0.01	-0.67	0.042
fx Venezuela	133	0.89	-0.02	<0.001*

Argentina, Brazil and Venezuela have negative kurtosis values of industrial output; hence they are platykurtic[17], while Costa Rica and Uruguay have positive kurtosis values of industrial output and are then

[17] A frequency function with coefficient of kurtosis less than zero is said to be platykurtic.

leptokurtic.[18] The kurtosis values of money supply are consistent with the skewness values. In addition, kurtosis values of exchange reserves show that Costa Rica has positive kurtosis value while the others have negative kurtosis values. The results prove that especially the exchange reserves of Brazil, Uruguay and Venezuela are normally distributed. One-sample Kolmogorov-Smirnov test reveals that exchange reserves time series in Argentina and Uruguay are normally distributed while industrial output and money supply for all the countries seems not to be normally distributed.

5.2 Results of interest rate differential model

Using the interest rate differential model we are able to estimate the expected probability of devaluation. This procedure involves using the interest rate differential between instruments denominated in a foreign currency and those denominated in a domestic currency. Using this kind of estimation, we can have results, which indicate expected devaluation probability in the markets. If we notice that the market participants expected the devaluation to occur prior to the exact event, we can state that it is evidence of peso problem and then it is also possible to explain anomalous development of interest rates prior to actual devaluation with peso problem phenomenon.

When estimating expected devaluation probability, we have to first estimate the expected size of devaluation. A proxy for the size of devaluation was obtained using deviations from relative purchasing power parity. Using the fact that the markets´ devaluation expectations can be estimated from the difference between domestic and foreign interest rate, we are able to compute the expected devaluation probability by dividing the interest rate differential with the expected devaluation size. The

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[18] A frequency function with coefficient of kurtosis greater than zero is said to be leptokurtic.

following sections present the results of interest rate differential model in Argentina, Brazil, Costa Rica, Uruguay and Venezuela.

Argentina

Figure 12 presents the expected devaluation size in Argentina. As we see from the graph, the expected devaluation size jumps rapidly near to 40 % in 2002 when the actual devaluation took place. But surprisingly, during the time period before actual devaluation, graph assigns that revaluation was expected. Once the expected size of devaluation is figured, we have to estimate market´s devaluation expectations. By using the expected devaluation size and money market interest rate differential between Argentina and United States, we are able to estimate also the expected devaluation probability.

Figure 12. Expected devaluation size in Argentina.
Expected devaluation size is computed from backward accumulated deviations from relative purchasing power parity using spot exchange rates. The broken line describes the actual devaluation.

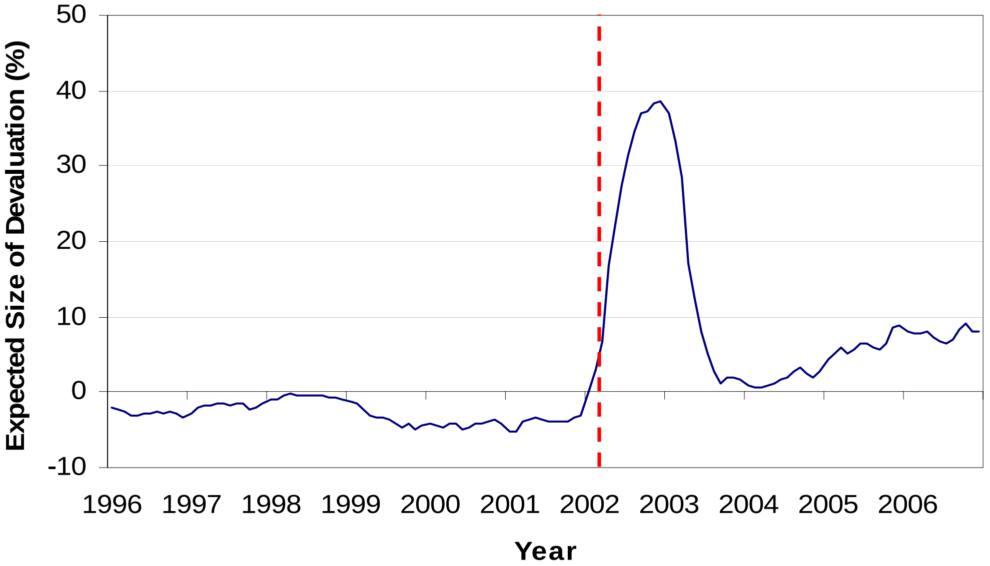


Table 2 introduces the results of the interest rate differential model in Argentina. The table provides expected devaluation size, interest rate differential and the expected probability of devaluation. For each variable minimum, maximum, mean and standard deviation are presented. Time period has been divided in three categories: before devaluation, after devaluation and the full sample. Time period before devaluation is from January 1996 to December 2001, because the actual devaluation took place in January 2002. Therefore the time period after devaluation is considered as from January 2002 to December 2006.

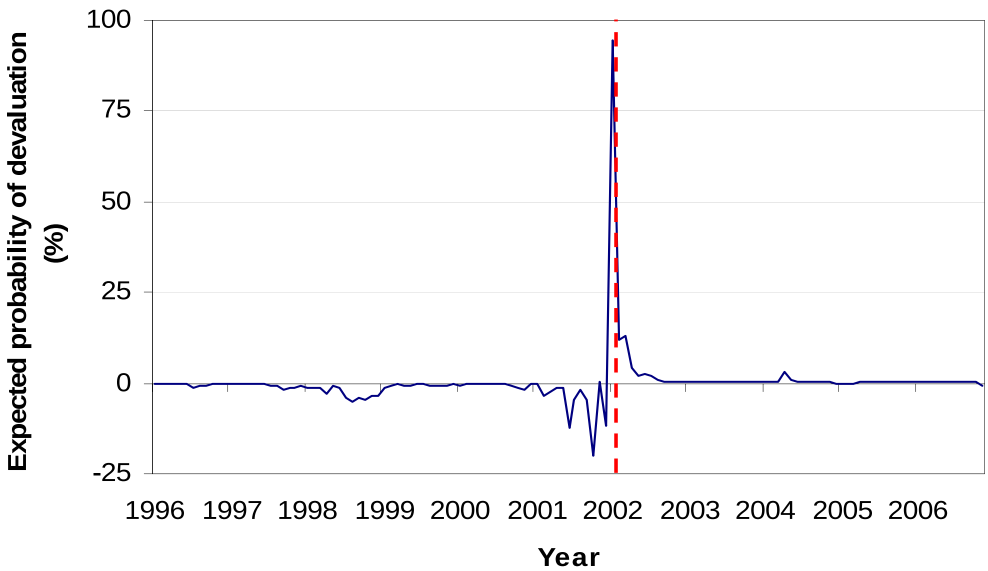
Table 2. Results of interest rate differential model in Argentina.
Expected devaluation size is estimated as backward accumulated deviations from relative purchasing parity. The interest rate differential is the differential between US and Argentina money market interest rates. The expected devaluation probability is the obtained by dividing the interest rate differential with the expected size of devaluation.

	Expected dev. size	Interest rate differential	Expected probability of dev.
Before devaluation:			
Minimum	-5.241	-2.090	-20.239
Maximum	-0.266	78.350	0.600
Mean	-2.801	4.453	-1.817
Standard deviation	1.392	11.374	3.357
After devaluation:			
Minimum	0.306	-0.170	-0.033
Maximum	38.500	89.460	94.559
Mean	10.549	8.657	2.437
Standard deviation	11.573	18.639	12.312
Full sample:			
Minimum	-5.241	-2.090	-20.239
Maximum	38.500	89.460	94.559
Mean	3.269	6.365	0.187
Standard deviation	10.289	15.169	8.825

Table 2 shows that mean of interest rate differential was 4.5 percents during the time period before devaluation. The rate started to rise in the beginning of 2001 and the highest point was near to 80 percents. The anomalous development of interest rates in Argentina prior to devaluation can also be seen in the Figure 2. Hence, as we see in the Figure 2 and Table 2, the interest rates in Argentina developed irrationally prior to devaluation in the beginning of 2002. After devaluation, interest rates in Argentina developed anomalously during the year 2003, but after that the rate developed steadily.

Table 2 reports that market participants did not expect devaluation prior to actual event. Actually the market expected revaluation, but surprisingly in the beginning of 2002 devaluation took place. As we see, the mean of the expected devaluation probability was -1.8 percents prior to devaluation, and that is revaluation. Therefore, we can maintain that the irrational behaviour of interest rates prior to devaluation cannot be explained with peso problem. On the other hand, we can also conclude that the interest rate differential model fails to show if there was peso problem in Argentina. Hence, the results of interest rate differential model in Argentina prove that we have to reject the peso problem hypothesis and accept the null hypothesis. After the devaluation market participants expected devaluation with mean of 2.43 percents. Results can also be seen from the Figure 13, which shows that the market participants expected revaluation, until in January 2002 devaluation took place surprisingly. Market´s restrained devaluation expectations after devaluation, can also be seen from the Figure 13.

Figure 13. Expected probability of devaluation in Argentina.
Expected probability of devaluation is estimated using monthly interest rate differentials between US and Argentina money market interest rates and the expected devaluation size series, as given by equation (8). The broken line describes the actual devaluation.



Brazil

Devaluation took place in Brazil in the end of January 1999. Figure 14 presents the expected devaluation size in Brazil. As we see, the expected size of devaluation was decreasing between years 1996 to the end of 1998, because new pegged currency took place in 1994 and affected until devaluation in 1999.

In the beginning of 1999 the expected devaluation size started to rise again. In the summer 2003, the expected devaluation size reached the peak, when the rate was almost 15 percents. After the estimation of expected size of devaluation, we are able to define the expected devaluation probability using the rate of expected devaluation size and interest rate differential between Brazil and United States.

Figure 14. Expected devaluation size in Brazil.
Expected devaluation size is computed from backward accumulated deviations from relative purchasing power parity using spot exchange rates. The broken line describes the actual devaluation.

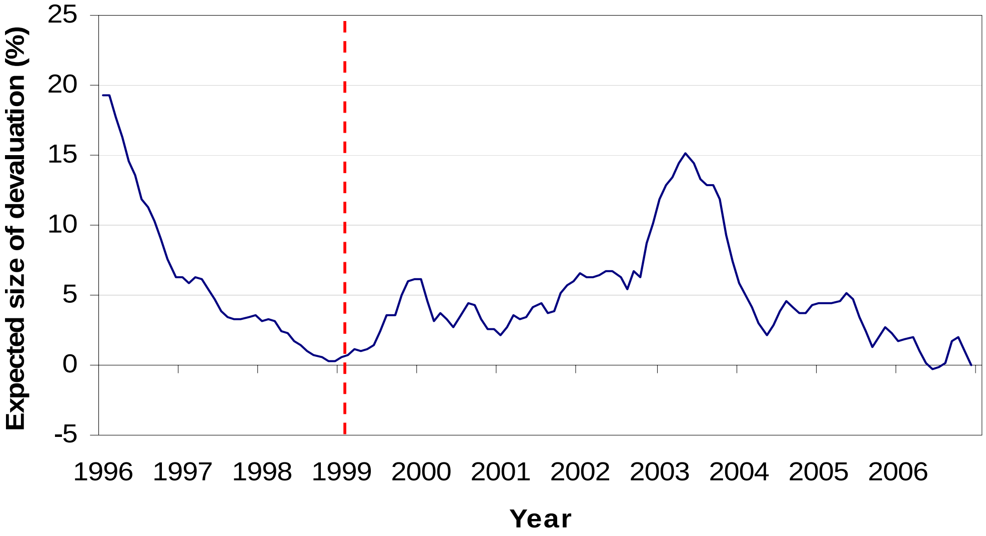


Table 3 offers the results of the interest rate differential model in Brazil. In the table are presented the expected devaluation size, the interest rate differential and lastly the expected probability of devaluation in Brazil. For each variable are presented minimum, maximum, mean and standard deviation. The results have been divided in three time periods: time period before actual devaluation, time period after the actual devaluation and full sample from January 1996 to December 2006. The time period before devaluation consider time spread from January 1996 to December 1998. Correspondingly the time period after devaluation is defined as from January 1999 to December 2006.

Table 3. Results of interest rate differential model in Brazil.
Expected devaluation size is estimated as backward accumulated deviations from relative purchasing parity. The interest rate differential is the differential between US and Brazil money market interest rates. The expected devaluation probability is the obtained by dividing the interest rate differential with the expected size of devaluation.

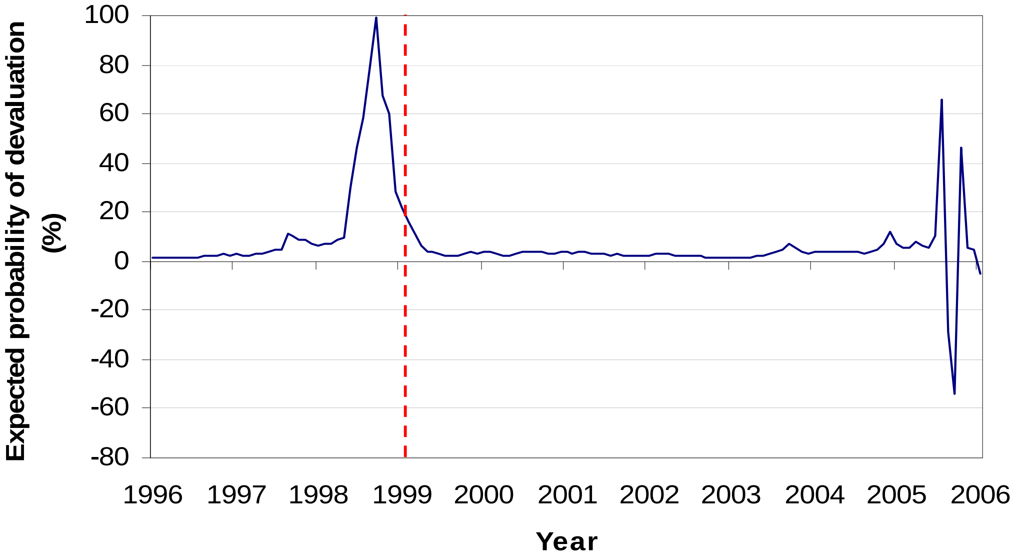
	Expected dev. size	Interest rate differential	Expected probability of dev.
Before devaluation:			
Minimum	0.267	13.690	1.275
Maximum	19.344	37.742	99.198
Mean	6.467	21.922	12.499
Standard deviation	5.578	6.937	22.587
After devaluation:			
Minimum	-0.352	-5.250	-54.121
Maximum	15.206	38.490	67.565
Mean	4.713	15.530	5.432
Standard deviation	3.614	6.132	13.913
Full sample:			
Minimum	-0.352	-5.250	-54.121
Maximum	19.344	38.490	99.198
Mean	5.184	17.260	7.435
Standard deviation	4.190	6.945	16.943

Table 3 indicates that the interest rate differential was rather large prior to devaluation in the end of January 1999. As we see, the mean of interest rate differential before devaluation is near to 22 percents. However, the interest rate differential was extremely irrational in the end of 1997 and in September 1998 when the interest rates in Brazil raised above 40 percents. This increase of the interest rates was due to huge inflation in the late 1990s and a consequence of the monetary authority´s desperate effort to defend currency. During the time before devaluation, interest rates in Brazil stayed higher than rates in the United States. According to this fact, it would have been possible to make arbitrage profits. The irrational behaviour of interest rates in Brazil can also be seen in the Figure 3. According to these results, it is possible to state that the development of interest rate in Brazil prior to devaluation was extremely anomalous and against market efficiency. Table 3 also shows that the interest rate differential was quite high after the actual devaluation. The mean is above 15 percents and the highest value is above 38 percents. Hence, the interest rate differential seemed to continue as irrational also after devaluation.

The results from the 4th column in Table 3, which presents the expected devaluation probability, indicate that devaluation was expected by the market participants before the actual devaluation took place in January 1999. The mean of the expected devaluation probability prior to devaluation is 12.5 percents, which assigns that devaluation was desperately expected before devaluation. The expected devaluation probability started increasing rapidly in July 1998 and reached the top in December 1998 when the rate was 99 percents. According to these facts, we can make an assertion that devaluation was expected to occur *ex ante* by the market participants. Hence, it is possible then to maintain that the irrational behaviour of assets can be explained with peso problem and the results are also evidence of the peso problem in Brazil. Basically, the empirical results of interest rate differential model in Brazil prove that, we can accept the peso problem hypothesis and reject the null hypothesis. In addition, Table 3 shows that the expected devaluation probability after devaluation was fairly low. The mean stays near to 5 percents, but surprisingly in 2006 the rate raised up to 65 percents. The expected probability of devaluation in Brazil can be seen in the Figure 15. In the Figure is shown the time when the expected probability of devaluation started to increase in the summer 1998, more than half a year before actual devaluation.

We can now compare these results to the analysis made by Sachsida et al., (2001), who investigated an uncovered interest rate parity and peso problem in Brazil. They examined if the uncovered interest rate parity holds in Brazil prior to devaluation in 1999, and if not, could it be explained with peso problem. The examination methodology differs somehow compared to our analysis but our results are still consistent to Sachsida´s results, who also found evidence of peso problem in Brazil. (Sachsida et al., 2001)

Figure 15. Expected probability of devaluation in Brazil.
Expected probability of devaluation is estimated using monthly interest rate differentials between US and Brazilian money market interest rates and the expected devaluation size series, as given by equation (8). The broken line describes the actual devaluation.



Costa Rica

A fact is that Costa Rica´s monetary authority operates nowadays with nearly constant devaluation. However, in September 2002 monetary authority surprisingly devalued colón more than expected. The surprising devaluation was not that big, but it can be seen in the Figure 5. In addition to devaluation in September 2002, we also examine the full sample, because it is interesting to investigate how the nearly constant devaluation affects the markets´ devaluation expectations and could there be pure peso problem in Costa Rica.

Figure 16 presents the expected size of devaluation in Costa Rica. As we see, the rate stays almost stable during the time period and there are not any surprising movements. The graph shows that the expected devaluation size was quite high in the beginning of 1996 and after that the rate started to decrease. Once the expected devaluation size is estimated, we can calculate the expected probability of devaluation using money market interest rate differential between Costa Rica and United States.

Figure 16. Expected devaluation size in Costa Rica.
Expected devaluation size is computed from backward accumulated deviations from relative purchasing power parity using spot exchange rates. The broken line describes the actual devaluation.

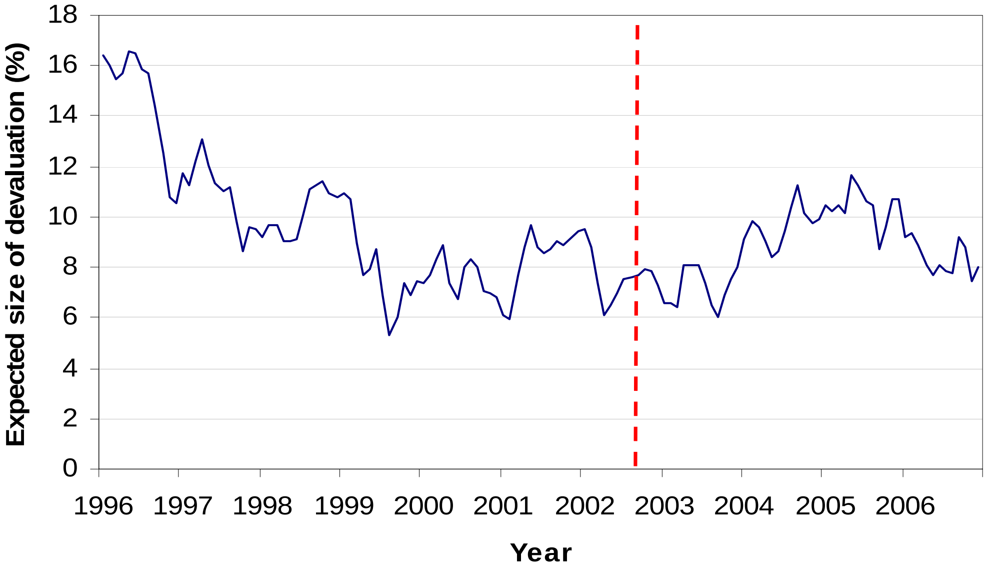


Table 4 provides the results of the interest rate differential model Costa Rica. In the table are presented the expected devaluation size, the interest rate differential and the expected probability of devaluation in Costa Rica. Table 4 presents minimum, maximum, mean and standard deviation for each variable. The time period is divided in three: before devaluation (from January 1996 to August 2002), after devaluation (from September 2002 to December 2006) and full sample.

Table 4. Results of interest rate differential model in Costa Rica.
Expected devaluation size is estimated as backward accumulated deviations from relative purchasing parity. The interest rate differential is the differential between US and Costa Rica money market interest rates. The expected devaluation probability is the obtained by dividing the interest rate differential with the expected size of devaluation.

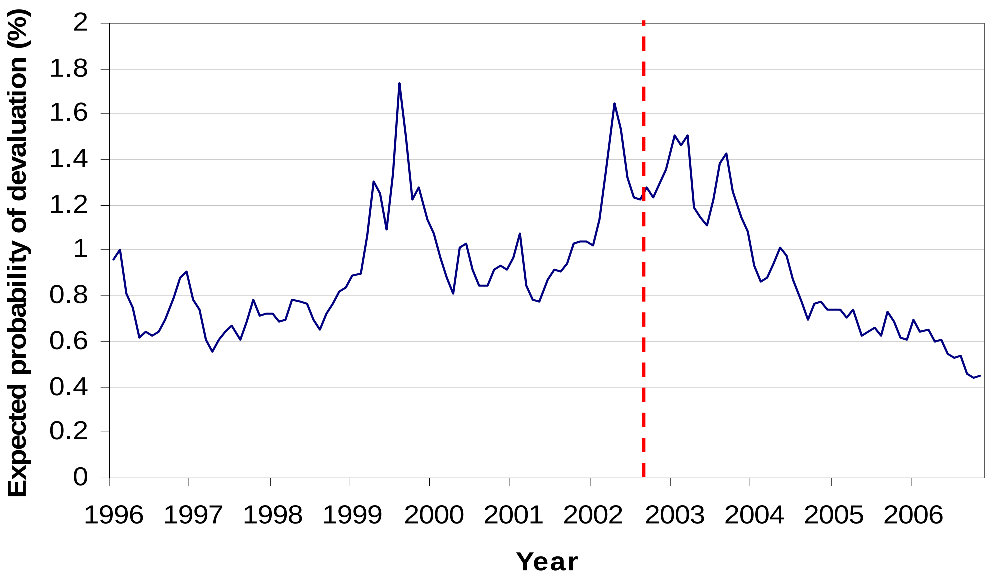
	Expected dev. size	Interest rate differential	Expected probability of dev.
Before devaluation:			
Minimum	5.279	5.940	0.560
Maximum	16.570	16.110	1.740
Mean	9.706	8.529	0.924
Standard deviation	2.778	1.857	0.253
After devaluation:			
Minimum	6.050	3.850	0.440
Maximum	11.659	10.160	1.510
Mean	8.815	7.475	0.876
Standard deviation	1.408	1.815	0.313
Full sample:			
Minimum	5.279	3.850	0.440
Maximum	16.570	17.070	1.740
Mean	9.341	8.181	0.906
Standard deviation	2.367	2.051	0.277

Table 4 reveals that the interest rates in Costa Rica stayed above the interest rates in the United States prior to devaluation in September 2002. The mean of the interest rate differential before devaluation is 8.5 percents while after devaluation it is 7.5 percents. According to these results, it is possible to maintain the development of interest rates prior to devaluation in September 2002 was irrational and against the market efficiency. During the full sample period, the mean of interest rate differential is 8.2 percents which proves that the interest rates in Costa Rica stayed above the rates in United States during the full sample period. The movement of interest rates in Costa Rica can be also seen in the Figure 6.

Moreover, Table 4 shows that market participants expected devaluation with positive probability before the actual devaluation. The evidence is not strong but still supportive of the peso problem hypothesis in Costa Rica prior to devaluation in September 2002. The mean of expected devaluation probability before devaluation is approximately one percent and this positive probability is evidence of peso problem in Costa Rica in the time period before devaluation. In addition, the results prove that the development of interest rates in Costa Rica before devaluation could be explained with peso problem. If we investigate the full sample, Table 4 proves that the market expected devaluation with mean of 0.9 percents, which is also evidence of peso problem in Costa Rica.

Figure 17 presents the expected probability of devaluation in Costa Rica. As we see, the expected probability of devaluation started to increase in the beginning of 1999, but decreased also rapidly after August 1999. As we see the graph rises just before devaluation in 2002. After devaluation, the graph started to decrease slowly.

Figure 17. Expected probability of devaluation in Costa Rica.
Expected probability of devaluation is estimated using monthly interest rate differentials between US and Costa Rican money market interest rates and the expected devaluation size series, as given by equation (8). The broken line describes the actual devaluation.



Uruguay

Figure 18 presents the expected devaluation size in Uruguay. As we know, the crawling exchange rate band was used in Uruguay till 2002 when Uruguayan peso devalued strongly and the major banking crisis hit the country. As we see, the rate is falling continually from January 1996 to January 2000 until in December 2001 the rate started to rise suddenly. The decreasing expected devaluation size is a consequence from the exchange rate control, which kept peso´s fluctuations within 12 % band. Once we have estimated the expected devaluation size, we are able to calculate the expected devaluation probability using interest rate differential between Uruguay and the United States.

Figure 18. Expected devaluation size in Uruguay.
Expected devaluation size is computed from backward accumulated deviations from relative purchasing power parity using spot exchange rates. The broken line describes the actual devaluation.

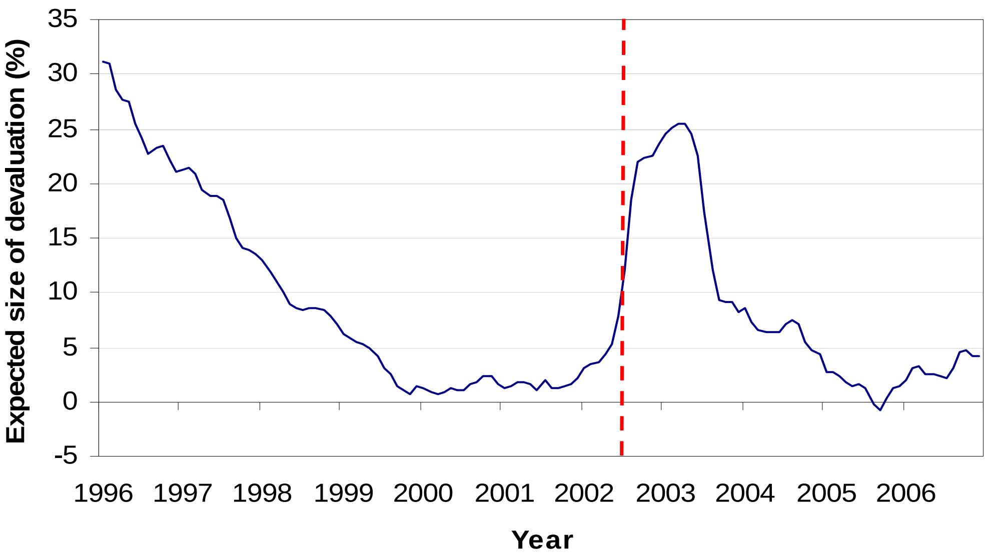


Table 5 provides the results of interest rate differential model in Uruguay. In the table the expected devaluation size, the interest rate differential and finally the expected probability of devaluation in Uruguay are presented. The time period has been divided in three: before devaluation (from January 1996 to June 2002), after devaluation (from July 2002 to December 2006) and the full sample. For each time period are presented minimum, maximum, mean and standard deviation.

Table 5. Results of interest rate differential model in Uruguay.
Expected devaluation size is estimated as backward accumulated deviations from relative purchasing parity. The interest rate differential is the differential between US and Uruguay money market interest rates. The expected devaluation probability is the obtained by dividing the interest rate differential with the expected size of devaluation.

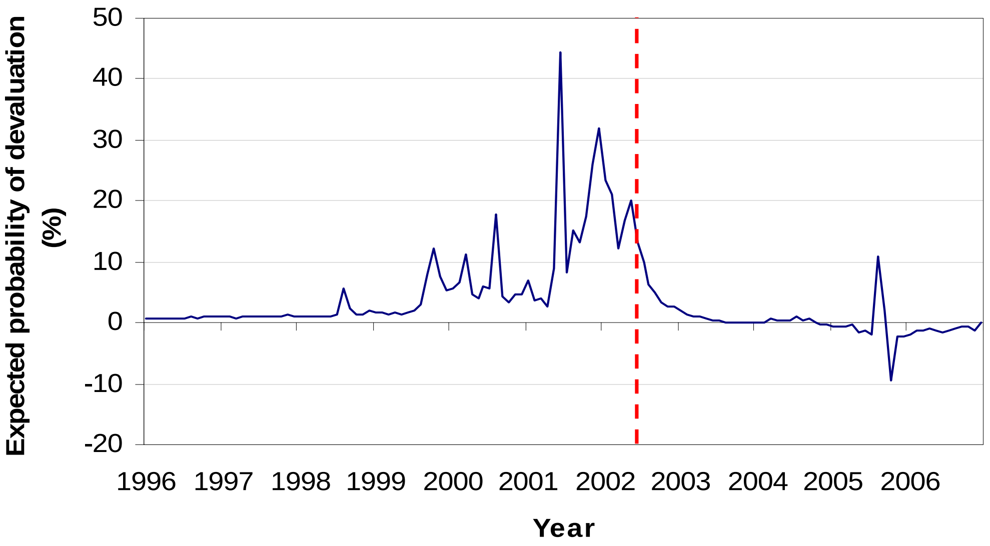
	Expected dev. size	Interest rate differential	Expected probability of dev.
Before devaluation:			
Minimum	0.717	4.600	0.698
Maximum	31.143	106.600	44.505
Mean	9.425	20.723	5.821
Standard deviation	9.063	20.492	8.044
After devaluation:			
Minimum	-0.747	-3.688	-9.591
Maximum	25.504	117.716	10.780
Mean	8.626	12.558	0.364
Standard deviation	8.249	30.626	2.872
Full sample:			
Minimum	-0.747	-3.700	-9.592
Maximum	31.143	117.700	44.505
Mean	9.081	17.408	3.606
Standard deviation	8.726	25.317	6.985

Table 5 reveals that the interest rate differential was large before devaluation occurred in the summer 2002. The mean of interest rate differential is above 20 percents, which indicates that interest rates in Uruguay were above the rates in United Stated prior to devaluation. The development was irrational even in summer 1998 when the interest rates in Uruguay increased near to 60 %. This peak can be seen in the Figure 8. In addition, in 2000 and 2001 the development of interest rates in Uruguay was particularly anomalous. According to these findings, it is possible to assert that the development of interest rate in Uruguay was abnormal prior to devaluation. After devaluation the interest rates in Uruguay started to decrease, what can be seen in the Figure 8.

Table 5 reports that devaluation was expected by the market participants before the actual event. The mean of the expected devaluation probability before devaluation is 5.8 percents, which proves that market expected devaluation with positive probability. Especially in June 2001, almost a year before the actual devaluation, the market participants expected devaluation with 44.5 %. Hence, the results of the interest rate differential model gives strong evidence that there was a peso problem prior to devaluation in Uruguay and it was caused by the biased devaluation expectations in the market. Table 5 also reveals that the anomalous development of interest rates prior to devaluation can be explained with peso problem. Hence, it is possible to reject null hypothesis and accept peso problem hypothesis in Uruguay.

Figure 19 presents the expected probability of devaluation in Uruguay. The figure reveals that the market expected devaluation desperately to occur prior to event. As we see in the Figure 19, right after the devaluation, the expected devaluation probability started to decrease rapidly until in the middle of 2005 the rate raised again. Also Table 5 reveals the fact that market expected devaluation to occur after actual event with mean of only 0.36 percents.

Figure 19. Expected probability of devaluation in Uruguay.
Expected probability of devaluation is estimated using monthly interest rate differentials between US and Uruguayan money market interest rates and the expected devaluation size series, as given by equation (8). The broken line describes the actual devaluation.



Venezuela

Figure 20 performs the expected size of devaluation in Venezuela. The graph shows that the expected size of devaluation was over 100 percents in 1996, but after that it started to decrease. The extremely high rate of the expected devaluation size in 1996 shows also how strong the devaluation was in November 1995. After the devaluation inflation was extremely high and prices and exchange were imposed and those events can be seen as a decreasing expected devaluation size after 1996. In the beginning of 2002 the size started to increase reaching the top again in the beginning of 2003. When we have estimated the expected size of devaluation we are able to estimate the expected devaluation probability using interest rate differential between Venezuela and the United States.

Figure 20. Expected devaluation size in Venezuela.
Expected devaluation size is computed from backward accumulated deviations from relative purchasing power parity using spot exchange rates. The broken lines describe the actual devaluation.

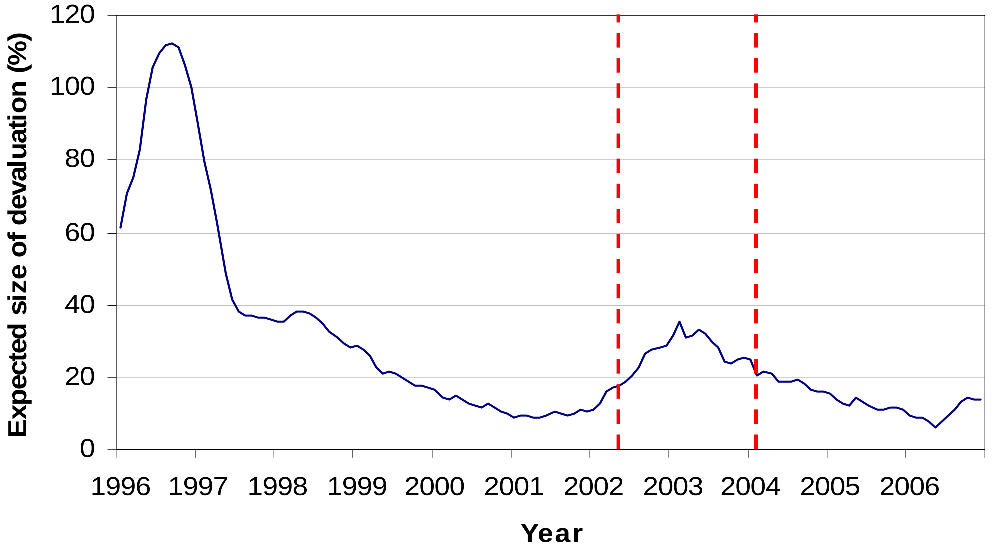


Table 6a provides the results of the interest rate differential model for Venezuela. Table provides expected size of devaluation, interest rate differential and the expected probability of devaluation. The results in Table 6 are based on the devaluation in 2002, but also the full sample period is handled in this table. The results of the devaluation in 2004 are presented in Table 6b. The time period in Table 6a is divided in three:

before devaluation, after devaluation and the full sample. Time period before devaluation is then from January 1996 to May 2002 and correspondingly after devaluation from June 2002 to December 2006. For each variable minimum, maximum, mean and standard deviation are presented.

Table 6a. Results of interest rate differential model in Venezuela.
Expected devaluation size is estimated as backward accumulated deviations from relative purchasing parity. The interest rate differential is the differential between US and Venezuela money market interest rates. The expected devaluation probability is the obtained by dividing the interest rate differential with the expected size of devaluation.

	Expected dev. size	Interest rate differential	Expected probability of dev.
Before devaluation:			
Minimum	8.790	-2.380	-0.268
Maximum	112.170	47.460	4.120
Mean	36.081	9.336	0.464
Standard deviation	30.892	11.029	0.809
After devaluation:			
Minimum	6.228	-2.100	-0.179
Maximum	35.513	35.360	1.224
Mean	18.708	5.612	0.217
Standard deviation	7.851	8.990	0.334
Full sample:			
Minimum	6.228	-2.380	-0.268
Maximum	112.170	47.460	4.119
Mean	28.731	7.881	0.368
Standard deviation	25.489	10.378	0.667

The findings in the Table 6a indicate that interest rate differential was quite wide prior to devaluation in 2002. The mean of interest rate differential before devaluation is 9.4 percents which proves that the interest rates remained continually higher in Venezuela than in the United States. The development of the interest rates in Venezuela can be seen also in the Figure 10. When we interpret the results of Table 6a and Figure 10, it is possible to state that the development of interest rates was irrational prior to devaluation in 2002. After devaluation, interest rate differential stayed wide, but calmer than time period before devaluation.

In addition, Table 6a reveals that the devaluation was expected at least to some degree by the market participants prior to actual event. As we see in the Figure 21, the expected probability of devaluation reached four percents in December 2001. The rising rate of devaluation probability started to increase in the beginning of 2001, more than a year before the actual devaluation. Table 6a reports that mean of expected devaluation probability is 0.5 percents prior to devaluation. The evidence is not that strong, but still we can state that market expected devaluation to occur prior to devaluation in the summer 2002. Therefore it is possible to assert that the biased devaluation expectation before the devaluation in 2002 arised peso problem. Furthermore, it is possible to explain the anomalous development of interest rates with peso problem in Venezuela. On that account, we are able to accept the peso problem hypothesis and reject the null hypothesis in Venezuela prior to devaluation in the summer 2002.

In addition to the devaluation in 2002, Venezuelan bolivar devalued in February 2004. This devaluation can also be seen in the Figure 9. In Table 6b are presented the results of the interest rate differential model based on devaluation in the beginning of 2004. In Table 6b are presented expected size of devaluation, interest rate differential and expected probability of devaluation. For each variable are reported minimum, maximum, mean and standard deviation. The time period before devaluation is from June 2002 to January 2004. Then time period after devaluation is considered as from February 2004 to December 2006.

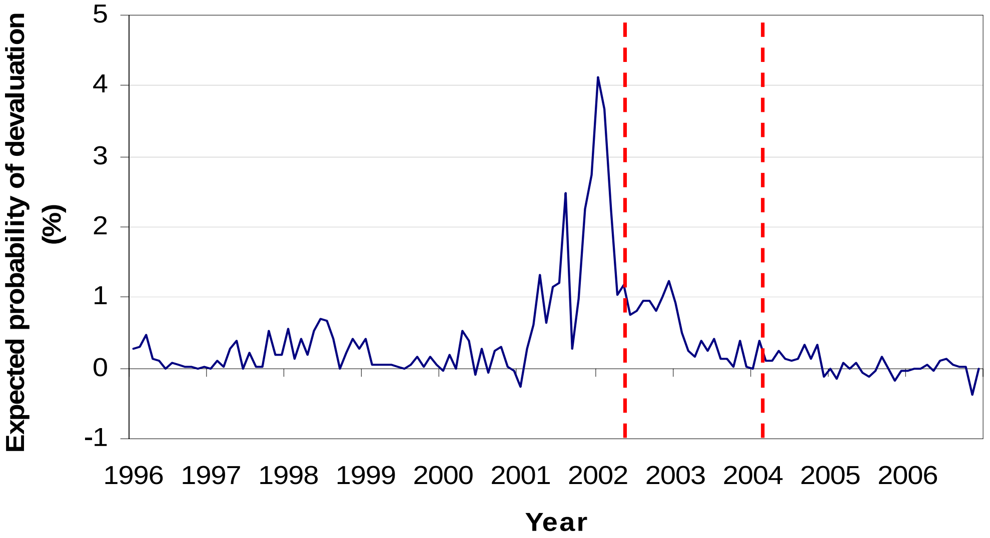
Table 6b. Results of interest rate differential model in Venezuela.
Expected devaluation size is estimated as backward accumulated deviations from relative purchasing parity. The interest rate differential is the differential between US and Venezuela money market interest rates. The expected devaluation probability is the obtained by dividing the interest rate differential with the expected size of devaluation.

	Expected dev. size	Interest rate differential	Expected probability of dev.
Before devaluation:			
Minimum	20.559	-0.300	-0.012
Maximum	35.513	35.360	1.224
Mean	27.770	13.663	0.502
Standard deviation	3.905	10.660	0.391
After devaluation:			
Minimum	6.228	-2.100	-0.179
Maximum	21.758	8.090	0.399
Mean	13.720	1.012	0.055
Standard deviation	4.092	2.224	0.131

Table 6b indicates that the development of interest rate differential before devaluation in 2004 was anomalous. The mean of the interest rate differential is 13.6 percents while the maximum of 35.4 percents was reached in the beginning of 2003. After devaluation, the interest rate differential seemed to calm and stayed near to mean of one percent.

Table 6b reveals that the devaluation was expected by the market participants before the actual event in the beginning of 2004. The evidence is not strong as the mean remains as low as 0.5 percents, but still it is possible to assert that market participants expected devaluation with positive probability. These results give support that the anomalous development of assets prior to devaluation in 2004 can be explained with peso problem. On the other hand the results are evidence of the peso problem as well. Therefore, it is possible to accept the peso problem hypothesis and reject the null hypothesis also for the time period before devaluation in the beginning of 2004. Markets´ expected devaluation probability for the full sample period can also be seen in the Figure 21. In the figure can be seen the rapidly rising expectations in 2001-2002 and also markets´ expected positive devaluation probability in the time period before devaluation in 2004.

Figure 21. Expected probability of devaluation in Venezuela.
Expected probability of devaluation is estimated using monthly interest rate differentials between US and Venezuelan money market interest rates and the expected devaluation size series, as given by equation (8). The broken line describes the actual devaluation.



The fourth research question considered the issue, if central bank refuses to adjust the exchange rate, could the peso problem be substantial. This question is extremely interesting in the case of Venezuela because as we know that Venezuelan President Hugo Chavez gives continually statements that Venezuelan bolivar will not be devalued in 2007. However, some economists assert that bolivar is highly over valued at the moment and devaluation is unavoidable. (Latin Focus, 2007) Despite these statements the central bank refuses to adjust the rate. Still, Table 6b reveals that the market expects devaluation only with a mean of 0.055 percents. Furthermore, as we see in the Figure 21, market participants expected actually revaluation in the end of 2006. Therefore, it is possible to state that the results of interest rate differential model in Venezuela fail to show that the peso problem is substantial if the central bank refuses to adjust the exchange rate.

5.3 Results of Probit model

By applying the Probit model, we are able to estimate the expected devaluation probability prior to actual devaluation using several macroeconomic variables as explanatory variables. We have selected the following variables: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. Once the expected devaluation probability is estimated we are able to investigate if there was a peso problem in the examined countries.

In addition to estimation of the expected devaluation probability we also run two additional tests. Firstly, we investigate how the development of an examined country's certain individual variable affects the expected probability of devaluation in the same country. Secondly, we investigate how the development of the variables of the other examined countries in the continent affects country´s expected devaluation probability. Hence, we investigate if there is some connection between the expected devaluation probability of a certain examined country and macroeconomic variables of the other countries. For example, how the development of money supply in Brazil affects the expected devaluation probability in Argentina. All the Probit model estimations are done with EViews 5.0 program.

The coefficients of Probit model are effects on a cumulative normal function of the probabilities that the response variable equals one. If the coefficient is positive, increasing of the macroeconomic variable enhances the probability of event. Correspondingly, if the coefficient is negative, increasing of the macroeconomic variable decreases the expected probability of devaluation. When the coefficient is zero, the probability of event does not change while the values of independent variables changes. The value of coefficient is not the amount of change of probability in respect to independent variables. The coefficient of Probit model shows only the direction of the change but not the exact amount of change. (Hoetker, 2007; Train, 2003)

As mentioned earlier, an examination like this might suffer because of some multicollinearity problems. Multicollinearity means that two variables co-vary and this problem can be commonly found in non-experimental data. It is commonly said that if the correlation is more than 0.9, there is a multicollinearity problem. However, there are few solutions to the multicollinearity problem. Firstly, highly correlated variables can be left in the model and assumed to reflect the natural state of those variables in reality. In this case we must rely on the collinearity being ever-present in future observed data. A second option is to remove the less important of the two collinear variables and keep only one in the model. This is usually preferred option and that is why we handle these possible problems in that way. (Hoetker, 2007)

5.3.1 Expected devaluation probability

We use devaluation as a dependent variable which represents the occurrence of an actual event. Dependent variable could have values from zero to one, where one describes devaluation and zero means no devaluation. The explanatory variables are money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. Eviews 5.0 uses maximum likelihood as an estimation technique and we use Berndt-Hall-Hall-Hausman algorithm to obtain parameter estimates. In the following sections are presented the results of Probit model in Argentina, Brazil, Costa Rica, Uruguay and Venezuela. Probit model gives an output, which presents coefficients, standard errors[19] and p-values for each variable.

[19] The standard error of a statistic is the standard deviation of the sampling distribution of that statistic. It shows how much sampling fluctuation a statistic shows.

Argentina

Table 7 presents the statistics of Probit model in Argentina. Table shows coefficients, standard errors and p-values for each variable. As we notice, interest rate, industrial output and money supply seem to be statistically significant at 0.05 level.

Table 7. Probit model statistics in Argentina.
* indicates statistical significance at 0.05 level. Variables are: real exchange rate (q), interest rate (r), price level (p), industrial output (y), money supply (m) and exchange reserves (fx).

	q	r	p	y	m	fx
Coefficient	-0.0028	-0.0126*	0.0324	-0.1093*	0.1832*	0.0001
Std. Error	0.0018	0.0064	0.0045	0.0462	0.0373	0.0001
P-value	0.1350	0.0483	0.2581	0.0181	0.0000	0.5871

Table 8 presents the results of Probit model in Argentina. Table provides minimum, maximum, mean and standard deviations for two different time periods; before devaluation and the full sample. The time period before devaluation is considered as from January 1996 to December 2001, because devaluation took place in Argentina in January 2002. The full sample period is then presented as from January 1996 to December 2006.

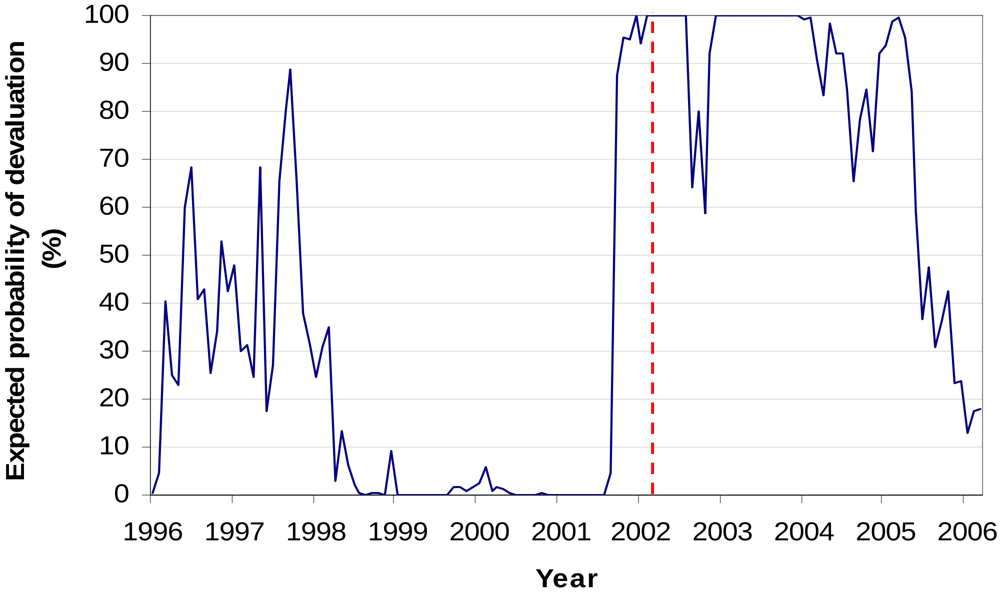
Table 8. Results of Probit model in Argentina.
The expected devaluation probability is estimated using Eviews 5.0 program, which uses technique of maximum likelihood as an estimation method.

	Expected probability of dev. (Before devaluation)	Expected probability of dev. (Full sample)
Minimum	0.00	0.00
Maximum	88.59	100.00
Mean	16.59	45.46
Standard deviation	23.31	40.81

Contrary to the results of interest rate differential model, Probit model results for Argentina reveals that market participants expected devaluation to happen prior to actual event with positive probability. Table 8 indicates that market expected devaluation with mean of 17 percents. As we see from the Figure 22, the expected probability of devaluation was on fairly high level already in the time period from January 1996 to May 1998. But still the results reveal that the devaluation became suddenly in 2002, because markets´ devaluation expectation were quite low in the time period from 1999 to the middle of 2001.

Basically, the results of Probit model in Argentina reveal that devaluation was expected prior to the actual event in 2002. Hence, this is also evidence of peso problem in Argentina prior to devaluation. Therefore, according to the results of Probit model, we can reject the null hypothesis and accept the peso problem hypothesis for Argentina. Markets´ devaluation expectations are also presented in the Figure 22.

Figure 22. Expected probability of devaluation in Argentina.
The expected probability of devaluation is estimated using Probit model with following explanatory variables: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. The broken line describes the actual devaluation.



Brazil

Table 9a presents the statistics of Probit model in Brazil. Table shows coefficients, standard errors and p-values for each variable. As we notice, real/USD real exchange rate, interest rate, industrial output and exchange reserves seem to be statistically significant at 0.05 level.

Table 9a. Probit model statistics in Brazil.
* indicates statistical significance at 0.05 level. Table presents coefficient, standard error and p-value for each variable. Variables are: real exchange rate (q), interest rate (r), price level (p), industrial output (y), money supply (m) and exchange reserves (fx).

	q	r	p	y	m	fx
Coefficient	2.6598*	-0.3094*	0.0547	0.4523*	-0.0131	-0.0002*
Std. Error	1.0606	0.0688	0.0934	0.1395	0.0264	0.0001
P-value	0.0122	0.0000	0.5576	0.0012	0.6188	0.0004

The correlation between real/USD exchange rate and industrial output is multicollinear because the correlation between these variables is 0.982. Hence, we remove real exchange rate from the model. Table 9b presents the results without variable real exchange rate.

Table 9b. Probit model statistics in Brazil.
* indicates statistical significance at 0.05 level. Table presents coefficient, standard error and p-value for each variable. Variables are: interest rate (r), price level (p), industrial output (y), money supply (m) and exchange reserves (fx).

	r	p	y	m	fx
Coefficient	-0.2636*	-0.0985	0.5057*	-0.0472*	-0.0002*
Std. Error	0.0647	0.0749	0.1076	0.0186	0.0001
P-value	0.0000	0.1886	0.0000	0.0113	0.0003

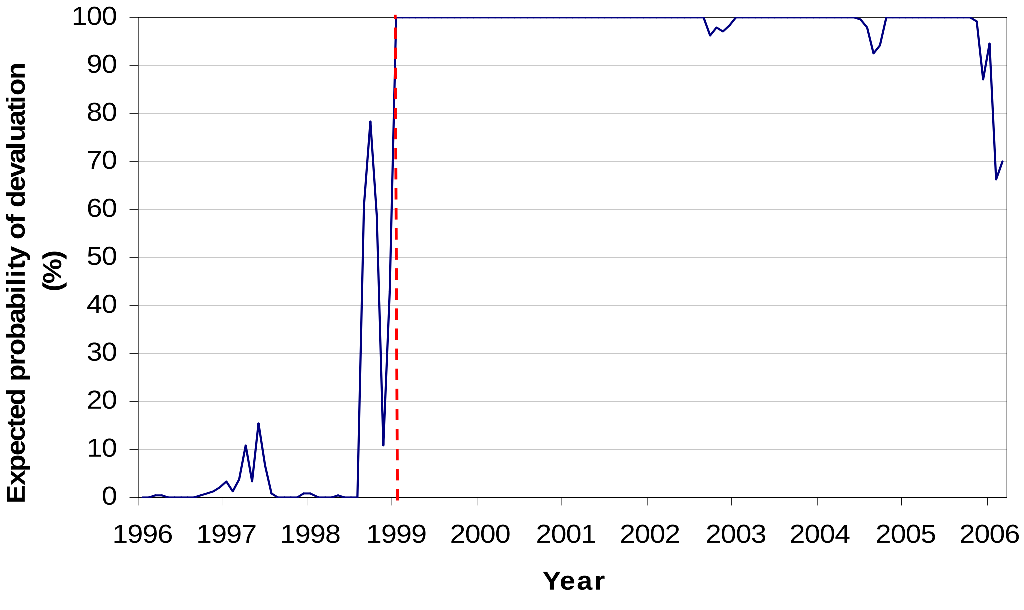
Table 10 shows the results of Probit model in Brazil. It provides minimum, maximum, mean and standard deviation for time period before devaluation and for full sample period. Devaluation happened in January 1999, hence the time period before devaluation is then defined from January 1996 to December 1998 and correspondingly the full sample is then considered as from January 1996 to December 2006.

Table 10. Results of Probit model in Brazil.
The expected devaluation probability is estimated using Eviews 5.0 program, which uses technique of maximum likelihood as an estimation method.

	Expected probability of dev. (Before devaluation)	Expected probability of dev. (Full sample)
Minimum	0.00	0.00
Maximum	78.30	100.00
Mean	5.32	72.14
Standard deviation	16.28	42.99

Table 10 reveals that market expected devaluation to happen with positive probability prior to actual event. The mean of 5.32 percents is not that high but still positive sign. The results of Probit model are consistent compared to the results of interest rate differential model, which also proved that peso problem existed in Brazil prior to devaluation. As we see from the Figure 23, there is a peak in the graph in the middle of 1997, when the expected devaluation reached 15 percents. Differently comparing to the Figure 15, which shows results of interest rate differential model, Figure 23 reveals that market expected devaluation with positive probability already in 1997. Both figures show that the expected devaluation probability jumps rapidly just before the actual devaluation happened in January 1999.

Figure 23. Expected probability of devaluation in Brazil.
The expected probability of devaluation is estimated using Probit model with following explanatory variables: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. The broken line describes the actual devaluation.



Generally, the results of Probit model also reveal that devaluation was expected with positive probability prior to actual event. Therefore, we can maintain that there was a peso problem in Brazil and on the other hand, the anomalous development of assets prior to devaluation, can be explained with peso problem phenomenon. Hence, also according to the results of Probit model, we are able to reject the null hypothesis and on the other hand, accept the peso problem hypothesis. In the Figure 23 is presented the expected probability of devaluation prior the devaluation and also for the full sample. In the graph can be seen the rapid increase of the rate of expected devaluation probability just before the actual devaluation took place in January 1999.

Costa Rica

Table 11a presents the statistics of Probit model in Costa Rica. Table shows coefficients, standard errors and p-values for each variable. As we notice, colón/USD real exchange rate, price level, industrial output and exchange reserves seem to be statistically significant at 0.05 level.

Table 11a. Probit model statistics in Costa Rica.
* indicates statistical significance at 0.05 level. Table presents coefficient, standard error and p-value for each variable. Variables are: real exchange rate (q), interest rate (r), price level (p), industrial output (y), money supply (m) and exchange reserves (fx).

	q	r	p	y	m	fx
Coefficient	0.1387*	-0.3566	0.7251*	-1.1348*	-0.2464	0.0161*
Std. Error	0.0557	0.2823	0.3553	0.3716	0.1287	0.0044
P-value	0.0127	0.2065	0.0413	0.0023	0.0557	0.0002

However, the correlation between price level and interest rate seems to be multicollinear as the correlation is 0.936. Hence, we remove price level from the model. Table 11b presents the results of the model without price level variable.

Table 11b. Probit model statistics in Costa Rica.
* indicates statistical significance at 0.05 level. Table presents coefficient, standard error and p-value for each variable. Variables are: real exchange rate (q), interest rate (r), industrial output, money supply (m) and exchange reserves (fx).

	q	r	y	m	fx
Coefficient	0.0966*	-0.5714	-0.6498*	-0.0730	0.0133*
Std. Error	0.0316	0.3803	0.2622	0.0940	0.0028
Prob.	0.0023	0.1331	0.0132	0.4375	0.0000

Table 12 reveals the results of Probit model in Costa Rica. In the table are presented minimum, maximum, mean and standard deviation for two different time periods. A surprising devaluation took place in September 2002 and then the time period before devaluation concerns time from January 1996 to August 2002. In addition, we are interested also in the full sample period because of the monetary policy in Costa Rica. Therefore, the full sample is presented as from January 1996 to December 2006.

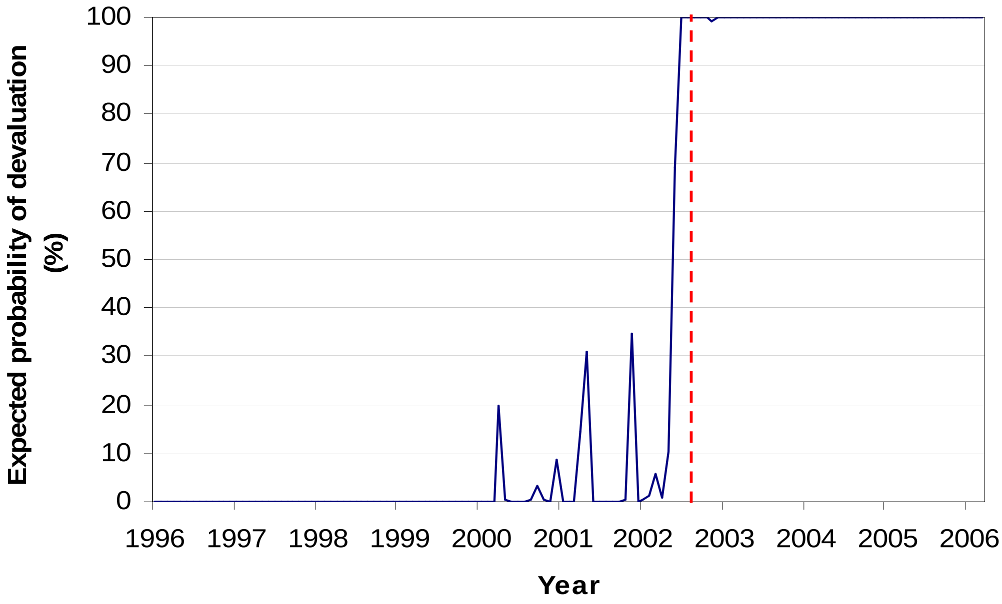
Table 12. Results of Probit model in Costa Rica.
The expected devaluation probability is estimated using Eviews 5.0 program, which uses technique of maximum likelihood as an estimation method.

	Expected probability of dev. (Before devaluation)	Expected probability of dev. (Full sample)
Minimum	0.00	0.00
Maximum	34.61	100.00
Mean	1.50	38.35
Standard deviation	5.82	47.83

Table 12 indicates that market expected devaluation with positive probability before the actual devaluation took place in September 2002. The mean of expected devaluation probability is fairly low, only 1.5 percents, but the Figure 22 reveals that in the middle of 2000 the expected devaluation probability started to rise and reached the top in the end of 2001, when the rate was at 35 percents. The results for the full sample period reveal that market expected devaluation to happen with the mean of 38 percents.

The findings of Probit model results are consistent compared to the results of interest rate differential model, which also stated that there was peso problem in Costa Rica before the actual devaluation happened. Basically, the results of Probit model are evidence for existence of peso problem in Costa Rica and, on the other hand, peso problem explains also the irrational development of interest rates prior to devaluation. Hence, based on the results of Probit model, we are able to reject the null hypothesis and accept the peso problem hypothesis.

Figure 22. Expected probability of devaluation in Costa Rica.
The expected probability of devaluation is estimated using Probit model with following explanatory variables: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. The broken line describes the actual devaluation.



Uruguay

Table 13 presents the statistics of Probit model in Uruguay. Table shows coefficients, standard errors and p-values for each variable. As we notice, peso/USD real exchange rate, interest rate, money supply and exchange reserves seem to be statistically significant at 0.05 level.

Table 13. Probit model statistics in Uruguay.

* indicates statistical significance at 0.05 level. Table presents coefficient, standard error and p-value for each variable. Variables are: real exchange rate (q), interest rate (r), price level (p), industrial output (y), money supply (m) and exchange reserves (fx).

	q	r	p	y	m	fx
Coefficient	0.4596*	0.0391*	-0.0450	-0.0904	0.1118*	-0.0011*
Std. Error	0.0947	0.0106	0.0361	0.0499	0.0193	0.0006
Prob.	0.0000	0.0002	0.2119	0.0700	0.0000	0.0417

The results of Probit model in Uruguay are presented in Table 14. In the table are presented minimum, maximum, mean and standard deviation for two time periods: before devaluation and full sample period. Devaluation happened in Uruguay in July 2002, therefore time period before devaluation is defined as from January 1996 to June 2002 and the full sample period from January 1996 to December 2006.

Table 14. Results of Probit model in Uruguay.

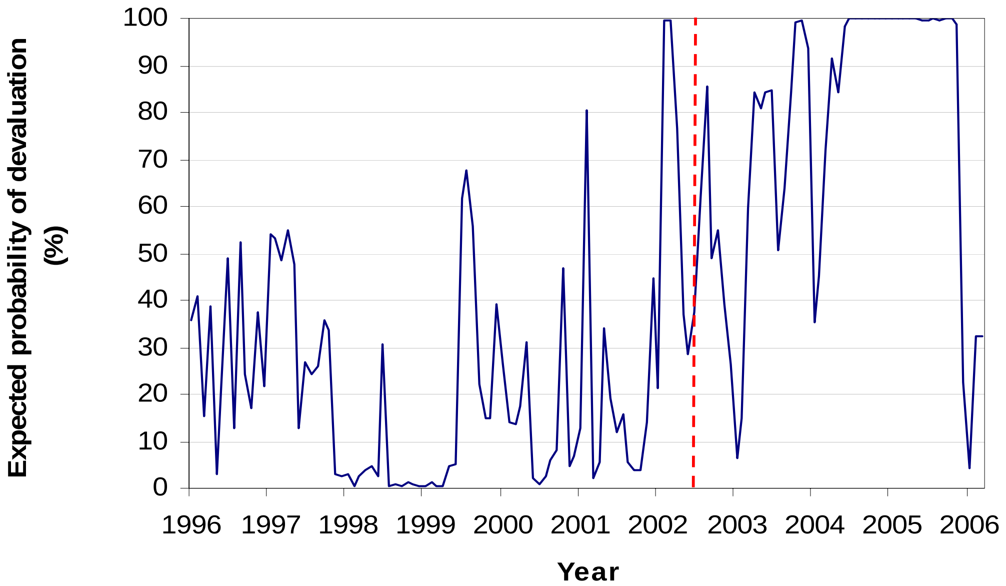
The expected devaluation probability is estimated using Eviews 5.0 program, which uses technique of maximum likelihood as an estimation method.

	Expected probability of dev. (Before devaluation)	Expected probability of dev. (Full sample)
Minimum	0.22	0.22
Maximum	80.45	100.00
Mean	20.11	42.15
Standard deviation	19.67	36.27

Table 14 reveals that devaluation was expected by the market participants prior to the actual event in the summer 2002. The mean of 20 percents proves that the market expected devaluation to happen with a strong probability. Figure 25 also proves that devaluation was strongly expected prior to the actual event in 2002. The results of Probit model are logical compared to the results of interest rate differential model, which also showed strong evidence of peso problem prior to the actual devaluation. As we see in the Figure 25, market expected devaluation with a strong probability before the actual event.

These results of Probit model prove that we can reject the null hypothesis and the accept peso problem hypothesis in Uruguay. In addition to the evidence of existence of peso problem in Uruguay, the results also indicate that we can explain the irrational development of interest rates prior to devaluation with peso problem phenomenon. Generally, both models found strong evidence of peso problem in Uruguay.

Figure 25. Expected probability of devaluation Uruguay.
The expected probability of devaluation is estimated using Probit model with following explanatory variables: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. The broken line describes the actual devaluation.



Venezuela

Table 15 presents the statistics of Probit model in Venezuela. Table shows coefficients, standard errors and p-values for each variable. As we notice, real exchange rate, interest rate, price level, and industrial output seem to be statistically significant at 0.05 level in the time period before devaluation 2002. Correspondingly before devaluation in 2004 interest rate, price level, industrial output and money supply seem to be statistically significant at 0.05 level.

Table 16. Probit model statistics in Venezuela.
* indicates statistical significance at 0.05 level. Table presents coefficient, standard error and p-value for each variable. Variables are: real exchange rate (q), interest rate (r), price level (p), industrial output (y), money supply (m) and exchange reserves (fx).

	q	r	p	y	m	fx
Dev. 2002						
Coefficient	0.0146*	0.0405*	0.0195*	-0.0849*	0.0049	0.0001
Std. Error	0.0025	0.0162	0.0094	0.0265	0.0049	0.0001
Prob.	0.0000	0.0126	0.0388	0.0015	0.8559	0.6353
Dev. 2004						
Coefficient	0.0579	-0.2720*	-0.2963*	0.0826*	0.0698*	0.0489
Std. Error	0.0539	0.0761	0.0538	0.0227	0.0131	0.0424
Prob.	0.7572	0.0003	0.0000	0.0003	0.0000	0.6932

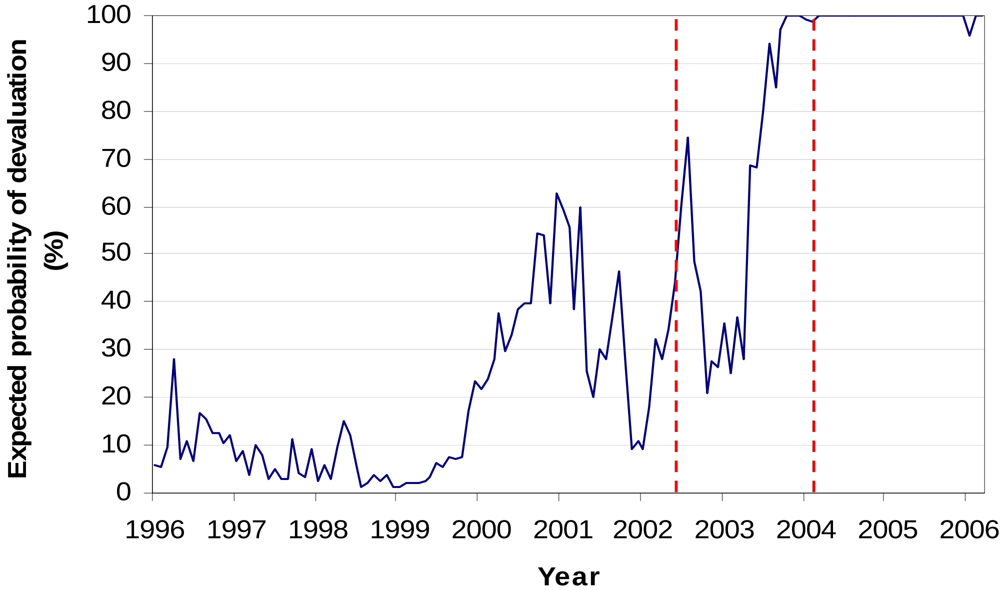
Table 17 presents the results of Probit model in Venezuela. There have been two devaluations during our time period and that is why we have divided time periods in three for Venezuela. The time period before devaluation in 2002 concerns time from January 1996 to May 2002, whereas the time period before devaluation in 2004 is defined as from June 2002 to January 2004. The full sample is then logically defined as from January 1996 to December 2006. For each time period Table 17 presents minimum, maximum, mean and standard deviation.

Table 17. Results of Probit model in Venezuela.
The expected devaluation probability is estimated using Eviews 5.0 program, which uses technique of maximum likelihood as an estimation method.

	Expected probability of dev. (Before devaluation in 2002)	Expected probability of dev. (Before devaluation in 2004)	Expected probability of dev. (Full sample)
Minimum	1.06	9.18	1.06
Maximum	62.65	80.11	100.00
Mean	17.19	40.45	42.25
Standard deviation	16.79	20.12	38.14

The findings in Table 17 suggest that market expected devaluation to happen with positive probability prior to devaluation in 2002. The mean of 17 percents indicates that devaluation was strongly expected. These expectations can also be seen in the Figure 26, which proves that the expected probability of devaluation reached the maximum of 63 percents in end of 2000. Table 17 also reveals that market expected devaluation with positive probability prior to devaluation in the beginning of 2004. The mean is above 40 percents, which proves that expectations were desperate. However, Probit model also showed that we can reject the null hypothesis and accept the peso problem hypothesis in Venezuela. These findings also prove that the irrational development of assets before devaluations could be explained by peso problem phenomenon. These results are logical compared to results of the interest rate differential model. Both models prove that there was a peso problem in Venezuela before both devaluations.

Figure 26. Expected probability of devaluation in Venezuela.
The expected probability of devaluation is estimated using Probit model with following explanatory variables: money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves. The broken line describes the actual devaluation.



5.3.2 Additional tests

In addition to investigation using Probit model in estimating the expected devaluation probability, it is interesting to examine how the development of a certain macroeconomic variables affect market´s devaluation expectations. By implementing Probit model, we are able to investigate how the development of an examined country's certain individual variable affects the expected probability of devaluation in the same country. We try to examine if the development of those variables affects devaluation probability as assumed. On the other hand, we investigate how the development of the variables of the other examined countries in the continent affects country´s expected devaluation probability. Hence, we investigate if there is some connection between the expected devaluation probability of a certain examined country and macroeconomic variables of the other countries.

Table 18. Coefficients of the examined countries.

* indicates statistical significance at 0.05 level. Table presents coefficients of the examined countries. Variables are: real exchange rate (q), interest rate (r), price level (p), industrial output (y), money supply (m) and exchange reserves (fx).

	q	r	p	y	m	fx
Argentina	-0.0028	-0.0126*	0.0324	-0.1093*	0.1832*	0.0001
Brazil		-0.2636*	-0.0985	0.5057*	-0.0472*	-0.0002*
Costa Rica	0.0966*	-0.5714		-0.6498*	-0.0730	0.0133*
Uruguay	0.4596*	0.0391*	-0.0450	-0.0904	0.1118*	-0.0011*
Venezuela (dev. 2002)	0.0146*	0.0405*	0.0195*	-0.0849*	0.0049	0.0001
Venezuela (dev. 2004)	0.0579	-0.2720*	-0.2963*	0.0826*	0.0698*	0.0489

Table 18 reveals that in Argentina, Argentine peso/US dollar real exchange rate, interest rate and industrial output has negative coefficient value, which indicates that increasing of these variables decreases the probability of devaluation. Correspondingly, coefficients of the price level, money supply and exchange reserves indicate that increasing of these variables has an enhancing effect to the probability of devaluation.

As we noticed earlier, the correlation between Brazilian real/USD real exchange rate and industrial output seems to be multicollinear and that is why we removed real exchange rate from the model. However, Table 18 shows that interest rate, price level, money supply and exchange reserves have negative coefficient values in Brazil. This result indicates that increasing of these explanatory variables decreases the probability of devaluation. Logically, Table 18 proves that industrial output has positive coefficient value. Therefore it can be asserted that increasing of this variable increases also the probability of actual event.

However, the correlation between price level and interest rate in Costa Rica is multicollinear, hence we removed price level from the model. However, Table 18 points out that interest rate, price level and money supply have negative coefficient values in Costa Rica. Hence, increasing of these explanatory variables has a negative effect to the probability of devaluation. Colón/dollar real exchange rate and exchange reserves have positive coefficient values, which prove that increasing of these variables affects devaluation probability with positive effect.

Furthermore, the results in Table 18 prove that price level, industrial output and exchange reserves have negative coefficient values in Uruguay. Therefore, increasing of these explanatory variables has a decreasing effect to the probability of devaluation. Similarly, peso/dollar real exchange rate, interest rate and money supply have positive coefficient values, and therefore increasing of those variables has an increasing effect to the probability of event.

Finally, Table 18 reveals that only industrial output has a negative coefficient value in Venezuela prior to devaluation in 2002. Hence, increasing of industrial output has a decreasing effect to the probability of devaluation. Logically, bolivar/dollar real exchange rate, interest rate, price level, money supply and exchange reserves have positive coefficient values in Venezuela prior devaluation in 2002. Therefore, we can assert that increasing of these explanatory variables has an increasing effect to the probability of devaluation. Furthermore Table 18 reveals that interest rate and price level has negative coefficient value prior to devaluation in 2004 and then increasing of these variables has a decreasing effect to the probability of devaluation. Correspondingly, real exchange rate, industrial output, money supply and exchange reserves have positive coefficient values.

As a conclusion, we might state that there is a lot of variation how the development of an examined country's variables affects the expected probability of devaluation in the same country. Real exchange rate has positive coefficient values in all the other countries but not in Argentina. As mentioned in earlier, an increasing of real exchange rate should also have increasing effect to devaluation probability. Hence, this has been proved in all the other countries but not in Argentina. Increasing of interest rates should have increasing effect to devaluation probability. This has been proved only in Uruguay and Venezuela prior devaluation 2002. Decreasing price level should affect devaluation expectations with increasing effect. This has been proved to happen in Brazil and Uruguay. However, decreasing of industrial output should have increasing effect to devaluation probability. This has been showed to match in all the other countries but not in Brazil. Increasing of money supply should reflect to devaluation probability with increasing effect. This has been showed to come true in Argentina, Uruguay and Venezuela. Decreasing exchange reserves should have decreasing effect to devaluation probability. This has been showed to happen only in Brazil and Uruguay.

In addition to the investigation how the development of an examined country's variables affects the expected probability of devaluation in the same country, it is also interesting to examine how the development of the variables of the other examined countries in the continent affects country´s expected devaluation probability. Hence, we investigate if there is some connection between the expected devaluation probabilities of a certain examined country and the development of macroeconomic variables of the other countries. For example, how the development of interest rate in Uruguay affects the expected devaluation probability in Brazil. Estimation has been accomplished with Eviews 5.0 program for each country. We use devaluation of the examined country as a dependent variable which represents the occurrence of an actual event. The explanatory variables are money supply, industrial output, foreign interest rates, foreign price levels, the real exchange rate and the level of foreign exchange reserves of the other countries. Appendix 2 presents the coefficients of this estimation. Variables with multicollinearity problems are removed from the analysis. In addition, we include only statistically significant variables in the analysis.

Results in the Appendix 2 reveals that the expected devaluation probability in Argentina seems to enhance when bolivar/USD real exchange rate, interest rate and money supply in Uruguay, price level in Costa Rica and industrial output in Brazil increases. Correspondingly, expected devaluation probability in Argentina seems to decrease when real/USD real exchange rate, interest rate in Costa Rica, money supply in Brazil, Costa Rica and Venezuela and exchange reserves in Brazil and Uruguay increases.

Appendix 2 shows that the expected devaluation probability in Brazil seems to enhance when Uruguayan peso/USD real exchange rate, interest rate in Argentina, price level in Argentina and Costa Rica, industrial output in Argentina, money supply in Argentina and Costa Rica and exchange reserves in Uruguay and Costa Rica increases. Whereas, probability seems to decrease when bolivar/USD real exchange rate, price level in Uruguay and Venezuela, money supply in Venezuela and exchange reserves in Argentina increases.

Furthermore, the expected devaluation probability in Costa Rica seems to enhance when interest rate in Brazil, price level in Argentina and Brazil and money supply in Argentina and Uruguay increases. The probability seems to decrease when interest rate and exchange reserves in Argentina, price level in Venezuela and money supply in Brazil increases.

Appendix 2 shows that the expected devaluation probability in Uruguay seems to enhance when bolivar/USD real exchange rate, price level and industrial output in Argentina, money supply in Argentina and Venezuela and exchange reserves in Costa Rica increases. However, probability seems to decrease when interest rate in Costa Rica, price level in Venezuela, money supply in Brazil and Costa Rica and exchange reserves in Argentina increases.

Results show that the expected devaluation probability in Venezuela before devaluation in 2002 seems to enhance when Uruguayan peso/USD real exchange rate, price level in Argentina and money supply in Argentina and Uruguay increases. Correspondingly, probability seems to decrease when real/USD real exchange rate, interest rate, price level and money supply in Costa Rica, money supply in Brazil and exchange reserves in Argentina increases. In addition the expected devaluation probability in Venezuela prior to devaluation in 2004 seems to enhance when Argentine peso/USD and Uruguayan peso/USD real exchange rate, price level and money supply in Argentina, interest rate in Brazil and money supply in Uruguay increases. The probability seems to decrease when interest rate and exchange reserves in Argentina, industrial output and money supply in Costa Rica, price level in Uruguay and exchange reserves in Argentina and Brazil increases.

All in all, it seems that there is not a certain formula how the development of variables of the other countries in the continent affects country´s expected devaluation probability. Rather the effects and the consequences seem to be random. Only increasing of interest rate and price level in Brazil seems to have enhancing effect to devaluation probability in all the countries. Otherwise, the effects seem to be extremely random and the effects seem to vary depending on country.

6. CONCLUSIONS

This master´s thesis examines devaluation expectations and peso problem in Latin America. In addition, this study investigates if the anomalous development of interest rates prior to actual devaluation could be explained with peso problem phenomenon. The empirical analysis was carried out using monthly data from Argentina, Brazil, Costa Rica, Uruguay and Venezuela. Five different research questions were developed in order to examine peso problem and devaluation expectations in these countries.

Theoretical basis of the peso problem phenomenon states that if investors anticipated devaluation with a positive probability and if such devaluation expectations affect the assets in a negative way, but no devaluation occurs, the markets may look flawed. We investigate if this divergence could be explained with peso problem. In order to accept peso problem as an explanation to the irrational development of assets prior to actual event, we have to show that market expected devaluation with positive probability prior to actual event.

The empirical analysis was carried out by using two different procedures. Firstly, the interest rate differential model is based on uncovered interest rate parity, which states that interest rate differential between domestic and foreign country, reflects market´s devaluation expectations. Secondly, Probit model is used to examine expected devaluation probability using several macroeconomic variables as explanatory variables. On the other hand, using Probit model, we examine how the development of a certain individual variables affects devaluation probability. In order to estimate expected probability of devaluation using interest rate differential model, we use monthly foreign and domestic money market interest rates. Probit model uses monthly time series of money supply, industrial output, foreign interest rates, foreign price level, the real exchange rate and the level of foreign exchange reserves.

The empirical results of this study indicate that there was peso problem in these Latin American countries in the time period from January 1996 to December 2006. Only interest rate differential model for Argentina fails to find peso problem. Therefore, the interest rate differential model also could explain the anomalous development of interest rates prior to the actual devaluation in all the other countries except Argentina.

By implementing Probit model we found peso problem in all the examined countries. The evidence is fairly strong in all the countries. On the other hand, Probit model results reveal that we can explain the irrational behaviour of interest rates prior to devaluation with peso problem phenomenon. Using Probit model we also investigated how the development of an examined country's certain individual variable affects the expected probability of devaluation in the same country. The empirical results are mixed. We found that increasing of the real exchange rate have an increasing effect to devaluation probability in all the other countries but not in Argentina. In addition, we proved that the increasing of interest rates have an enhancing effect to devaluation probability only in Uruguay and Venezuela prior devaluation in 2002. Furthermore, we found that decreasing price level affects devaluation expectations with an increasing effect in Brazil and Uruguay. However, decreasing of industrial output has an increasing effect to devaluation probability in all the other countries but not in Brazil. We found that increasing of money supply reflect to devaluation probability with enhancing effect in Argentina, Uruguay and Venezuela. Finally we proved that, decreasing exchange reserves have decreasing effect to devaluation probability only in Brazil and Uruguay.

Furthermore, we examined how the development of the variables of the other examined countries in the continent affects country´s expected devaluation probability. Hence, we investigated if there is some connection between the expected devaluation probabilities of certain examined country and the development of macroeconomic variables of the other countries. Results proved that there is not a certain formula how the development of variables of the other countries in continent affects the expected devaluation probability. Rather, the connection seems to be random.

In addition to these investigations we examined whether peso problem is substantial if the central bank or monetary authority refuses to adjust exchange rate. This was especially relevant question in the case of Venezuela. Surprisingly, we did not find that peso problem is substantial in Venezuela, where central bank is currently refused to devalue their currency. Correspondingly, we found that market expected devaluation in Venezuela with fairly low probability.

Generally empirical results and conclusions of this thesis could be used to as an implement while investigating economy and financial markets of Latin America, because it has been showed that peso problems are serious difficulty for economists who like to build and estimate models of the economy and financial market and then use them to interpret economic data. On the other hand, the results could be used as an explanation of the irrational behaviour of interest rates prior to devaluation in Latin America.

Several proposals and possibilities for further research rise while processing this thesis. Firstly, this same kind of examination could be done using different kind of methodology. Drift adjustment method could be employed or some other regression. Furthermore, Probit model could be used, but with different macroeconomic variables. It would be interesting to investigate how devaluation probability would change if for example unemployment rate were included in the model. In addition, peso problem hypothesis could be examined using stock markets. It would be exiting to examine if also possibly anomalous development of stock returns could be explained with peso problem.

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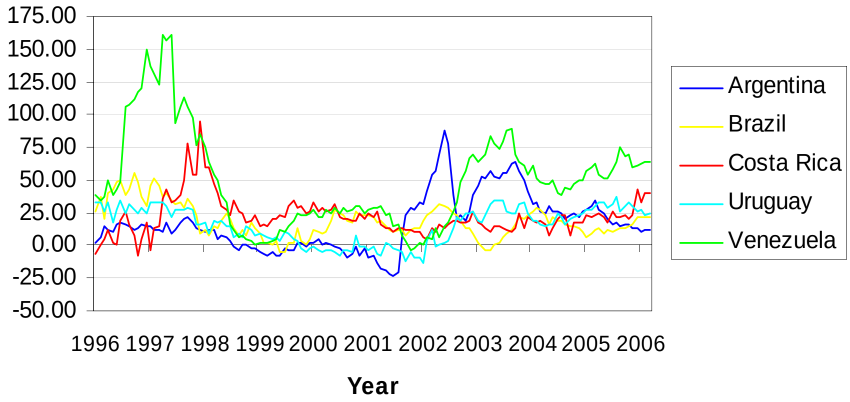
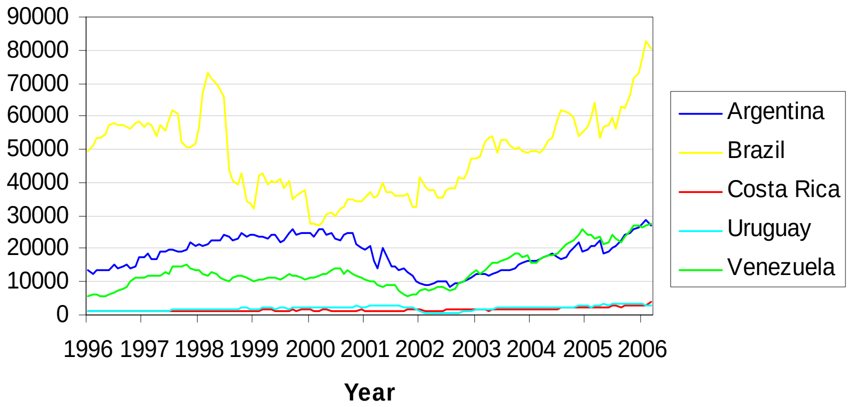
APPENDICES

Appendix 1: Figures of the macroeconomic variables.

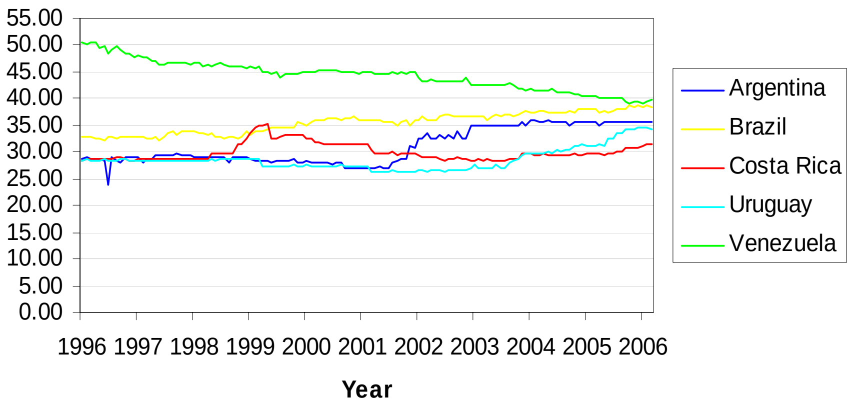
Money Supply

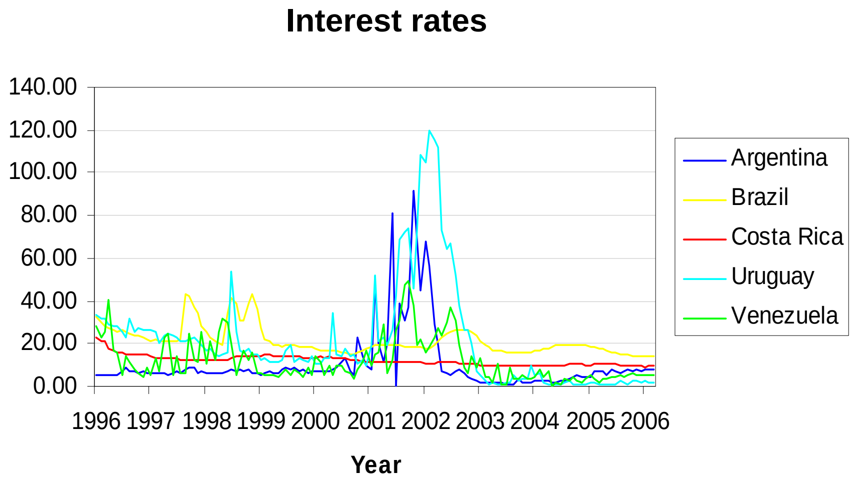


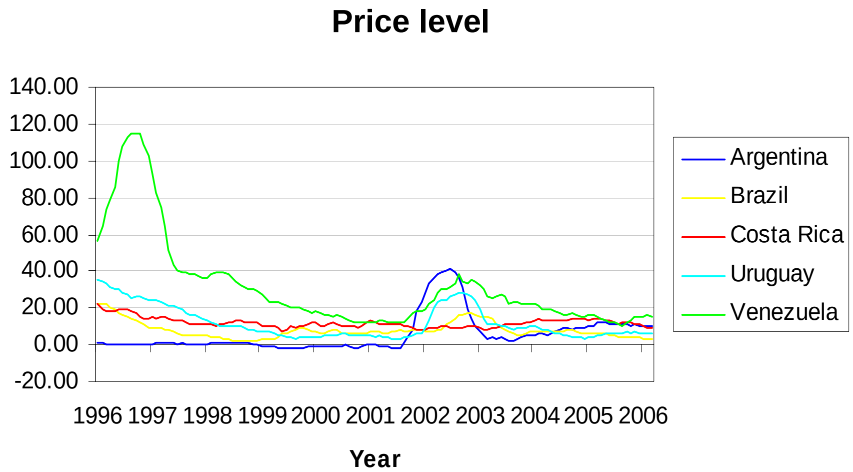
Exchange Reserves

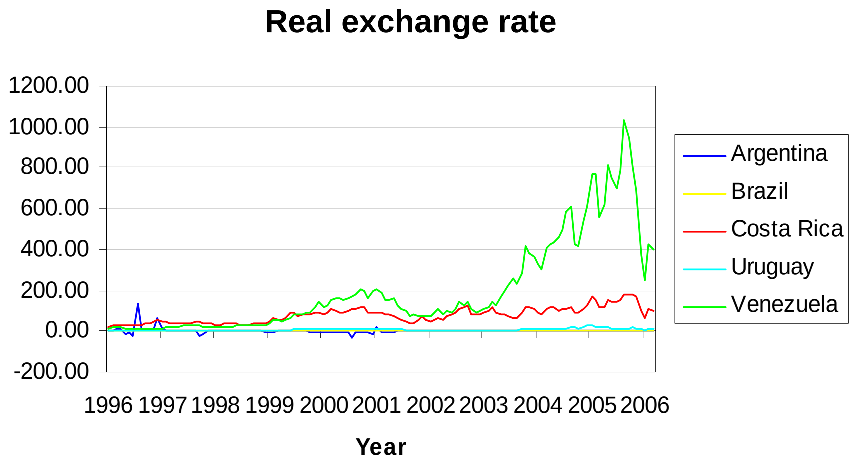


Industrial output




Interest rates
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year
Argentina
Brazil
Costa Rica
Uruguay
Venezuela


Price level
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year
Argentina
Brazil
Costa Rica
Uruguay
Venezuela


Real exchange rate
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
-200.00
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year
Argentina
Brazil
Costa Rica
Uruguay
Venezuela

Appendix 2: Coefficients for the additional tests.

* indicates statistical significance at 0.05 level. Table presents coefficients for each variable. Variables are: real exchange rate (q), interest rate (r), industrial output (y), money supply (m) and exchange reserves (fx). Variables with multicollinearity problems are presented in the parentheses.

	Argentina	Brazil	Costa Rica	Uruguay	Venezuela 2002	Venezuela 2004
q Arg		-0.0267	-0.0271*	-0.0012	0.0019	0.0023*
q Bra	-4.9698*		(-1.6160*)	(-3.4714*)	-0.6628*	-0.4609
q CR	0.0007	(-0.0180*)		(-0.0112*)	(0.0017)	(0.2893*)
q Uy	(-1.2741*)	0.6578*	(-2.9379*)		0.0812*	0.0183*
q Ve	0.0816*	-0.0157*	(0.1917*)	0.0242*		
r Arg		0.1221*	-0.1215*	0.0023	-0.0018	-0.0139*
r Bra	0.0217		0.0335*	0.0322	0.0212	0.1893*
r CR	-0.0633*	0.0171		-0.0673*	-0.0717*	-0.0923
r Uy	0.0103*	-0.0120	-0.0181		0.0032	0.0002
r Ve	-0.0201	-0.0335	-0.0088	-0.0243		
p Arg		0.4271*	0.0416*	0.2428*	0.5319*	0.2532*
p Bra	0.0527		0.0948*	0.0584	0.0476	0.0035
p CR	0.0933*	0.6194*		-0.0533	-0.1799*	-0.2548
p Uy	0.1947	-0.1233*	0.0453		-0.0017	-0.0138*
p Ve	-0.1489	-0.1936*	-0.0717*	-0.0374*		
y Arg		2.2137*	(-0.0120)	1.0671*	(0.2389*)	(0.4893*)
y Bra	1.8116*		(2.1514*)	(0.9557)	(1.9668*)	(0.0035*)
y CR	(-1.7458*)	(2.0111*)		(-1.0942)	(-2.4939*)	-0.3566*
y Uy	0.0497	(-3.0321*)	(1.3612)		(0.1169)	(0.5930)
y Ve	(-0.32149)	(-0.8612*)	(-2.6204*)	-0.7701		
m Arg		0.0461*	0.0799*	0.1182*	0.1537*	0.0189*
m Bra	-0.0254*		-0.1510*	-0.1096*	-0.1591*	-0.0234
m CR	-0.0173*	0.0228*		-0.0353*	-0.0455*	-0.1539*
m Uy	0.0588*	(-0.0191)	0.1099*		0.0998*	0.0003*
m Ve	-0.0068	-0.0117*	-0.0114	0.0168*		
fx Arg		-0.0005*	-0.0012*	-0.0006*	-0.0004*	-0.0148*
fx Bra	-0.0001*		-0.0004	(-0.0003)	-0.0005*	-0.0293*
fx CR	(0.0092*)	0.0017*		0.0061*	(0.0087*)	(0.1389)
fx Uy	-0.0051*	0.0056*	-0.0014		-0.0015*	-0.0289
fx Ve	(0.0002*)	-0.0002	(0.0018*)	(0.0007*)		