IS THERE A ROLE FOR THE BALASSA-SAMUELSON EFFECT IN CURRENCY CRISES PREDICTION MODELS?

By

Silvia Elena Anastasiu

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Supervisor: Professor Andri Chassamboulli

Second reader: Professor László Halpern

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Abstract

The present thesis addresses the economic subject of currency crises by developing an empirical model similar with the standard framework proposed by Bussiere(2002). It also assesses whether the Balassa-Samuelson effect is accounted for when measuring overvaluation, a fact that has been neglected by previous research. I find that the model is able to identify correctly 63% of the crises that took place in the analyzed time span, pointing to overvaluation of the currency and the CA/GDP as the main factors that influence the occurrence of a crisis. Moreover I find that the appreciation of the currency due to productivity gains is not accounted when measuring overvaluation, therefore potentially biasing this variable and decreasing the accurateness of the model. The current thesis pointed to an existing gap between currency crises prediction models and the BS effect and showed that these are not two different issues. On the contrary, relating them and considering productivity gains appreciations may in fact produce a better model in terms of prediction

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Introduction

Currency crises have been examined to a great extent in the empirical literature as in the last two decades we witnessed a large number of financial crises that hit emerging market economies spreading through contagion to the other economies in the area[1]. There is not "one explanation fits all" that can shed light upon the causes of crises, but rather the contrary: the crises had diverse causes. Still a common denominator can be reached, that is their devastating consequences on the countries that were affected. These crises reawakened the interest of researchers and international organizations like the IMF, regarding the potential causes and "symptoms" of currency crises. This interest resulted in a growing number of papers addressing the need to assess the likelihood of a crisis. The main focus is on the development and improvement of Early Warning System models, in order to be able to better anticipate such events and to allow the policy makers to take the necessary preemptive measures to avoid or lessen the effects of the crises.

The Balassa-Samuelson effect implies that in the process of catching up, developing countries experience higher productivity which is expected to be related with rises in wages. If productivity related wage increases in the traded sector pour out into the non-tradable sector, this sector will have to allow for higher prices increases, leading therefore to higher price inflation in the non-traded sector which can be translated in a rising CPI level (ITM) or nominal exchange rate appreciation (ETM).

This thesis addresses the economic subject of currency crises by developing an empirical model based on a multinomial logit model similar with the "standard" framework proposed Bussiere (2002) that analyzes the probability predictability of a crisis in twenty-four Emerging Market

[1] According to Aziz it is said to occur when a "speculative attack on the exchange value of a currency results in a depreciation/devaluation of the currency or forces the authorities to defend it by rapidly increasing interest rates or spending international reserves".

countries from Europe, South America and Asia. The novelty brought by this thesis is assessing whether productivity driven appreciation of the real exchange rate are considered when measuring overvaluation, a fact that has been neglected in previous research. Affecting how overvaluation is measured could potentially bias the results. To check whether the RER^{BS} is contained in the subtracted trend I employ a graphic analysis that compares the evolution of the RER and RER^{BS} and find that the two measures behave differently. For the currency crises model, as explanatory variables I use a series of factors that according to Peltonen (2006) are specific to emerging market economies and other specific variables that proved to be significant in foreseeing previous crises. The variables chosen are a blend of the variables used by Peltonen (2006), Bussiere (2002), Copaciu (2006) and Kaminsky (1997), thus employing the leading indicators (that signaled the occurrence of all major crises in countries with a similar economic environment) in order to analyze the probability of a crisis is an appropriate way of detecting the vulnerability of a country to a currency. Moreover the paper analyses the factors that have an important impact on the probability of a currency crises.

With every crisis that occurred economists' knowledge on the topic of currency crisis expanded rapidly, as new revolutionary models and techniques were developed to attempt to foresee a future crisis. Nevertheless, currency crisis continued to occur, therefore leaving us still with a series of open questions: are currency crises predictable? What is the optimal design of EWS? Recently, the main breakthrough was made by Bussiere (2002) who proposed a multinomial EWS logit model, instead of the classical binomial model, which deals with what they call the "post crisis bias" which accounts for the fact that after the crisis, economic fundamentals *"go through an adjustment process"* and they do not behave the same as in tranquil periods. Another method frequently employed in designing EWS model is Kaminsky's (1997) leading indicator approach, based on the concept of "noise to signal ratio" which represents the number of "false alarms" over correctly called crises: the lower the noise-to-signal ratio, the more reliable is the

indicator. However, this approach does not employ any model for predicting a crisis; it just "proposes" a method of choosing the "right" indicators.

This thesis adds to the currency crises literature by pointing to an existing gap between currency crises models and the BS effect. The present model(employing the standard measure of overvaluation) is able to identify correctly 63% of the crises that took place, indicating the overvaluation of the currency and the ratio between CA and GDP as the main factors that have an influence on the occurrence of a crisis. Moreover I find that the appreciation of the currency due to productivity gains is not accounted when measuring overvaluation therefore casting a shadow of doubt on the accuracy of the currency crises models.

The remainder of the thesis is organized as follows: the literature review sketches some theoretical and empirical issues in currency crises as well as those related with the BS effect, chapter II develops the empirical framework and discusses the results obtain from the multinomial analysis, chapter III verifies if the BS effect is accounted for when measuring overvaluation and the last section concludes.

CHAPTER 1- Literature Review

This chapter provides a short overview of currency crises that took place over the last two decades. Moreover it reviews theoretical and empirical issues related to currency crises as well as issue related to the BS effect, trying to present a brief overview of the main topics and developments that took place in both areas.

1.1. Currency crises

1.1.1. Overview of crises and their effects

As pointed out by Bordo (1998) low-income economies have a higher likelihood to be hit by a crisis in comparison with developed countries, however one can not dismiss the fact that advanced economies are not exempt from crisis. The most obvious example is the Exchange Rate Mechanism (ERM henceforth) crisis in 1992-1993. The ERM was in essence a managed float exchange rate system in which the currencies of the countries taking part in the system were allowed to fluctuate within pre-specified bands with respect to the German Mark. What are the reasons behind the occurrence of the crisis? After reunification, Germany experienced an increase in the fiscal deficit and went from trade surplus to trade deficit. In order to get the needed money, borrowing was a must. Therefore the Bundesbank increased the interest rate which put upward pressure on the other participating countries currencies as they had to raise their interest rates in order to avoid large capital outflows[2]. Expecting a devaluation of the other currencies against the German mark, speculators started selling "the other currencies" and buying German marks. Despite the efforts of the Central banks (which incurred large reserves losses) and the Bundesbank, the countries that experienced speculative attacks had to devaluate their currencies, some of them choosing to float or leaving ERM altogether and they experience

[2] interest rates were too high for their economic conditions

decrease in the GDP growth rates. This crisis put an end to ERM I while the bands in the new ERM increased from 2.25% to 15%.

Another significant crisis was the Mexican Crisis (1994-1995). Due to the fact that the Mexican peso was pegged to the US dollar large amounts of capital inflows were attracted in the country. This in turn encouraged a lending boom which coupled with slipshod banking and corrupt practices that were prevailing at that time did not prove to be a good mix. In addition there were the large fiscal deficit and the rebellions that took place in the country that also added to the crisis. Another key ingredient to the crisis was Banco de México decision to buy the Mexican Treasury Securities (which were previously sold by "panicking" investors) which caused a further decline of the dollar reserves. The crisis was triggered by the devaluation of the peso in December 1994 which brought an end to these capital inflows and rash the financial crisis. As Bordo (1998) stated, the domestic policies at that time were inconsistent with the peg exchange rate regime which is a classic sign of currency crisis, where the utmost "contribution" to the occurrence of the crisis was played by the mishmash of the exchange-rate regime corroborated with a rapid expansion of credit. The consequences of the crisis were rather severe as Mexico experienced its highest GDP contraction in history and most Mexican businesses, with US dollar denominated debts, went bankrupt.

Before the 1997-1998 crisis the Asian countries experienced high growth rates and things seemed to run smoothly for them. Huge amount of capital were pouring into the countries, attracted by rather high interest rates. This encouraged a lending boom (corporations borrowed large amounts of international capital, which was mainly short-term and denominated in foreign currency) which in the context of a relatively fixed exchange rate regime lead to an over valuated exchange rate. The above coupled with a financial and banking system that was far from being sound, poor management of financial risk and a government guarantee of loans lead to a massive

speculative attack on their currencies. All the countries experienced huge output contraction which plunged the economies into recession and sharp reductions in the values of their currencies and stock markets. Moreover the crisis has left its mark on emerging markets outside the region and added to contagion and volatility in international financial markets. To the above crises is only fair to mention the Russian Crisis (1998), the Turkish crisis (2000) the Argentinean crisis (2001), the list remaining open for many other crises. The common denominator is that they all proved to be very costly in economic terms and have had important social and political consequences making it hard for the countries involved to recover.

1.1.2. Overview of currency crises models

Before presenting what currency crises models are trying to asses it is useful to have in mind Rodrick's critique about the performance of these models, namely: "*a sad commentary on our understanding of what drives capital flows is that every crisis spans a new generation of economic models. When a crisis hits it turns out that the previous generation of models was hardly adequate* ". However his critique is accurate up to a certain point. It is true that some of these models employed variables that proved to be significant in the previous crises and signal a crisis ex-post but we can not infer that they are of little use. There are certain macroeconomic and financial variables that might signal pretty accurately a forthcoming crisis and it is useful to rely on their predictive power. Moreover, so far these models represent one of the main methods that can help policy makers to asses the vulnerability of a country to currency crises. Improvement has been made in this area, both as regard to the econometric techniques employed and to their predictability power. However work still needs to be done.

Since Krugman's (1979) seminal contribution, the literature on currency crises has developed a great deal, nowadays being recognized "three generations" of models. In the ***first generation models*** the key determinant of currency crises is stated to be the role played by fundamentals

which are predicted to deteriorate prior to the crisis[3]. As Bordo (1998) argues, the speculative attacks are driven by the incompatibility between the pegged exchange rate regime and inconsistency in domestic policies (like monetization of fiscal deficits). The first generation models basically argue that under a fix exchange rate regime if money demand is surpass by domestic credit expansion, this will lead to loss of international reserves and a final speculative attack on the currency, forcing the monetary authorities to abandon the parity. The speculative attack is predicted to take place when the shadow price of exchange rates (the price that would prevail after the speculative attack takes place) equals the exchange rate. That is the moment when the reserves are driven to zero therefore forcing the monetary authorities to abandon the fixed exchange rate and switch to a floating one, inferring that the time of the speculative attack is perfectly known. According to Aziz(2000) macroeconomic factors were responsible to a great extent for the financial sector vulnerability in many Latin American countries. .

After the European Monetary System crisis (1992-1993) a ***second generation of models*** appeared which can mainly be attributed to Obstfeld (1994). As stated by Flood (1996) second generation models "*approach the crisis from the opposite direction*" as compared to first generation models. These types of models generally exhibit multiple equilibria, making it possible for speculative attacks to occur due to self-fulfilling prophesies and heard behavior of investors. The basic idea is that fundamentals are not necessarily inconsistent with the pegged exchange rate regime but if markets believe them to be, they will act accordingly therefore forcing the monetary authority to abandon it. How does this work? If agents attached a higher probability of devaluation this will trigger an increase in the interest rates, making it more costly for the monetary authorities to defend the peg, therefore they may decide that it is not worth maintaining the peg exchange rate as it became more costly, vice versa being also true. So, as Aziz (2000) pointed out regardless of sound fundamentals if investors believe that a strong

[3] According to Aziz (2000) this are: an overvaluation of the exchange rate, high fiscal deficits, large current account deficits and so on

enough speculative attack will force the government to abandon the peg they will act accordingly (withdrawing funds from the country) therefore triggering a "self-fulfilling crisis".

The **third generation of currency crises** models addresses the subject of contagion and develops upon the transmission channels trying to identify what is the "speed" and area covered by contagion. The most important contribution in this area belong to Kaminsky (2000) which identifies common adverse shocks as the main cause of contagion and to Calvo (1999) who argues that real linkages between countries are the ones that make currency crises spread from one country to another.

Every new generation of models was trying to use variables that were not encompassed in the previous and that might have signaled and prevented the crisis. However these models appeared only after the crisis and the variables used to signal the crisis were chosen for their "bad behavior" during the crisis. So the choice of the right variables seemed to be of crucial importance. The more recent contributions on this topic belong to Kaminsky's et al (1997) who proposed a new technique - **leading indicator approach**. Based on a comprehensive evaluation of the empirical literature on currency crises, she developed a system that involves the monitoring of several indicators that tend to exhibit unusual behavior prior to a crisis. If a certain variable is above a chosen threshold than a signal is issued; Kaminsky argues that this is to be interpreted as a warning signal that the crisis will in fact occur. The threshold level is chosen to minimize noise-to signal ratio, meaning the ratio of false signal to good ones. The variable is considered a good leading indicator if it gives a correct signal before the crisis. She finds that the most reliable indicators are deviation of real exchange rate from trend, exports, the ratio of broad money to reserves and others.

The most recent approach of currency crises belongs to Peltonen (2006) which uses an ANN model, to attempt, to predict currency crisis. However it can not be stated which model: ANN or multinomial probit (logit) performs better, as the author chooses to compare the predictive power of the ANN model with a binary probit one. Another contribution of Peltonen is his critique as regard to the signal-based approach: loss of information for independent variables and endogeneity of the threshold.

Beside the signal-based approach another leading method for Early Warning System is **the limited dependent variable approach**. The most often model was a binary logit or probit, until Bussiere (2002) multinomial logit model that solved the post-crisis bias by allowing to differentiate between tranquil, pre-crisis and post-crisis periods. As compared to a binary model their model performs better: higher percentage of correctly predicted crises and lower percentage of missed crisis and false signals, the model being able to predict the majority of crises. The Early Warning System developed by Bussiere employs a panel data analysis for 32 countries and find that among the variables tested in the model, overvaluation, lending boom, the ratio between current account and GDP have an important predictive power for the crisis probability. However this thesis considers the issue of productivity driven appreciation of the real exchange rate when looking at overvaluation, a fact that has been neglected in previous research. This can affect how the overvaluation is measured, therefore potentially biasing the results. I do this by employing a graphic analysis that compares the evolution of the RER and RER^{BS} to check whether the RER^{BS} is contained in the subtracted trend.

1.2 The BS effect

The BS hypothesis as argued by Egert(2002b) is often labeled "*the productivity bias hypothesis*". Among the main assumptions behind the model are: capital is perfectly mobile across countries

and across the tradable sector and the non-tradable sector of the economy whereas labor is perfectly mobile only nationally across the sectors and internationally immobile. In short the BS effect states that a faster productivity growth in the tradable sector for the developing country as compared to the developed country is reflected in an "extra inflation" for the developing country and into the real exchange rate appreciation.

When it comes to the BS effect one can talk about the Internal Transmission Mechanism (ITM henceforth) and the External Transmission mechanism (ETM henceforth). ITM implies that higher productivity growth in the traded sector compared to the non-traded sector lead to a higher price inflation in the non-traded sector, which is translated into a rising domestic CPI level causing therefore differences in inflation rates across countries. ETM can be briefly summarized as appreciation of the nominal exchange rate which in turn puts pressure on the real exchange rate to appreciate. This is caused by higher productivity growth in the traded sector as compared to non-traded in the home country weigh against the foreign one.

The assumptions of the model and the different monetary policy and exchange rate regimes make identifying the magnitude of the BS effect quite difficult. Moreover, as stated by ECB (2003) structural rigidities and different levels of competition between economic sectors can generate productivity differentials, this in turn being reflected in inflation differentials. Therefore estimating the BS effect it is not by far a trivial exercise. There is a growing literature on the empirical evidence of the different implications of the BS effect especially in the Central and Eastern European countries. The BS effect is of crucial importance as it has significant implications on inflation differentials and real exchange rate appreciation especially for developing countries. When it comes to empirical evidence as regard to the existence of the BS effect evidence is somewhat mixed. There are papers that prove the existence of the BS both in its "internal form" as well as in its "external form" some that prove only the existence of the

"internal transmission mechanism" and some that fail to prove its existence. The studies that assess the BS effect differ as regard to countries analyzed, frequency of data, what to include in the tradable and non tradable sector, productivity issues and so on.

On the "pro side" of the BS effect there are several papers that should be mentioned. Egert(2004) finds that productivity growth in the tradable sectors generates appreciation of the real exchange rate. Halpern (2001) finds that there is a 3.5% annual average appreciation due to the BS effect. Egert (2002b) using Germany, USA and a synthetic basket of data which represents a combination between the two countries and defining the traded sector to be represented by industrial goods and the non-traded by services, finds that the BS effect works quite well for Hungary, Czech Republic, Poland, Slovakia and Slovenia for the period 19991-2001. Still the appreciation of the currency was higher than what could be justified by the BS effect. He quantifies the impact of the productivity growth differences on RER appreciation and finds it to be around 1% for Hungary, 2% for Poland and similar figures for the other countries. The author distinguishes between the ITM, where he is able to establish a cointegration relationship between dual productivity and relative prices by using a bivariate VECM and the ETM where he tries to find a cointegration relationship between dual productivity and relative prices and between relative prices and CPI deflated RER, by employing a multivariate VECM.

Egert (2005) investigates the importance of the BS effect for Romania, Bulgaria, Croatia, Turkey and Russia and finds that it only plays a partial role in exchange rate determination. Moreover he derives the size of the BS effect to quantify the appreciation of RER due to dual productivity differentials. He finds that in Romania, Russia, Croatia and Ukraine the equilibrium exchange rate appreciates while in Bulgaria it depreciates. Analyzing 9 CEE countries Egert (2002b) finds strong support in favor of the ITM and argues that only to a small extent appreciation of the currency can be attribute to the BS effect. Moreover he argues that the appreciation of due to BS

effect is not influenced by the current exchange rate regime as it describes a micro equilibrium process. Among other factors that can contribute to the appreciation of the currency he points to changes in administrate prices which can give a "*cost push factor for non-tradable prices".*

Solanes (2005) et al, taking USA as a benchmark country find that the BS effect holds in both its forms for a series of Latin American countries (they prove that PPP holds for the tradables sector), however the authors do not provide an estimate of the size of the BS effect[4]. The authors find a cointegration relationship between relative prices and relative productivities as well as between price differentials and the nominal exchange rate (ETM). In their analysis of the assumptions behind the BS effect they employ both the panel data unit-root test proposed by Levin and Lin(1993) and also the more recent IPS test(2002) and to estimate the cointegration vector use OLS and DOLS. As regard to what is considered to be the traded sector the author employs all tradable economic activities except for agriculture, due to data issues, while for the non-traded he uses six categories of private services. Choudhri et al(2004), taking the USA as a benchmark, also find support in favor of the BS effect for several developing countries, including Columbia, Philippines ,Chile, Korea, Malaysia, Mexico, Singapore and Turkey. For the traded sector they use the manufacturing and agriculture sector, whereas for the non-traded they consider the rest of the sectors.

Klau et al (2003) find strong support for the BS effect in both its forms for Croatia, the Czech Republic, Hungary, Poland, Slovakia and Slovenia. The novelty employed by the authors is the fact that they consider a disaggregate set of tradable and non-tradables that allows them to account for the increase in productivity in the non-tradable sector therefore allowing them to get more precise estimates of the BS effect.

[4] Relevant for the present thesis are: Chile, Columbia, Mexico

Canzoneri et al. (1999) do not find support for the entire BS effect for a series of OECD countries. They prove that there is a long run relationship between relative prices and relative productivities but that the Purchasing Power Parity (PPP henceforth) does not hold for the tradable sector and therefore argues that the failure of the BS model as a long run equilibrium exchange rate model is due to the failure of the PPP. Thomas et al (2005) using both USA and Japan as the foreign countries and using the manufacturing sector as the tradable sector and services, construction and utilities as the non-tradable sector, find no evidence in favor of the BS effect for a series of Pacific-Asian economies. The authors argue that the previous study of Chinn (2000) who found support in favor of the BS effect was able to do so due to a set o simplifying assumption that once relaxed, do not provide support anymore.

None of the above papers connects the BS effect with currency crises; their focus is on proving the assumptions of the model for different set of countries and providing an estimate of the ETM and ITM. This present thesis will focus only on the estimate of the external BS in order to assess if it is captured in the overvaluation variable.

CHAPTER 2- The Empirical Framework

2.1. The dependent variable

The models on currency crises employ the ***Exchange Market Pressure Index*** (EMP henceforth) as a dependent variable in predicting crises. This represents the weighted average of the change of the real effective exchange rate, the change in interest rate and the change in reserves. As argued by Bussiere(2002) the reason for which the EMP is thus defined is that in the case of a currency attack the monetary authority has two options: either it tries to maintain the exchange rate peg (in fixed currency regime by diminishing the reserves and/or increasing the interest rate), either the currency is strongly devaluated. As pointed out by Aziz (2001) the crises identified by this index include both the occasions in which the currency depreciated significantly but also those in which the authorities averted devaluation/ depreciation or abandoned a fixed peg. Constructing the dependent variable involves several steps:

1) Definition of the crisis

In this thesis, currency crises are also defined using the concept of "exchange market pressure" which as argued by Peltonen (2006) this has the advantage of considering both successful and unsuccessful speculative attacks.

Following the earlier study of Bussiere (2002) the exchange market pressure is defined as:

$$EMP = 1/\sigma^2_{REER}(REER_t - REER_{t-1})/REER_{t-1} + 1/\sigma^2_{r}(r_t - r_{t-1})/r_{t-1} - 1/\sigma^2_{res}(res_t - res_{t-1})/res_{t-1}$$

The term σ^2 represents the volatility of the respective series. It is worth mentioning that this is a rather standard approach for computing EMP however there are studies that do not include interest rate in the calculation of EMP due to data unavailability (Pelton 2006) and others that include only the reserves.

2) The next step is defining a **currency crisis indicator**: $\mathbf{CC_t}$

Usually is defined in relationship with the mean and standard deviation of the EMP. In this paper is defined as the event where the exchange market pressure index is two standard deviation or more above the average(a rather standard approach).

$$\mathbf{CC_t} = \begin{cases} 1 \text{ if } EMP > \mu_{EMP} + 2\,SD_{EMP} \\ 0 \text{ otherwise} \end{cases}$$

This approach is trying to predict the occurrence of a crisis in a specific time horizon and not the exact timing of the crisis, which as argued by Bussiere (2002) is a too ambitious goal.

3) Following Bussiere (2002) I transform the contemporaneous variable CC_t into a forward variable Y_t which attempts to predict if a crisis will occur in the next 12 months:

$$Y_t^i = \begin{cases} 1 \text{ if there is } k = 1 \ldots\ldots\ldots 12 \text{ st. } CC^i{}_{t+k} = 1 \\ 2 \text{ if there is } k = 1 \ldots\ldots\ldots 12 \text{ st. } CC^i_{t-k} = 1 \\ 0 \text{ otherwise} \end{cases}$$

This model was introduced by Bussiere (2002) and solved the post-crisis bias by allowing differentiating between tranquil, pre-crisis and post-crisis periods. As compared to a binary model their model performs better: higher percentage of correctly predicted crises and lower percentage of missed crisis and false signals. Usually the length period is chosen to strike a balance between not postponing the signaling of the crisis until it is obvious (as argued by Bussiere economic fundamentals tend to weaken before a crisis and therefore are able to signal a crisis more accurately, closer to the crisis) and signaling a crisis in time for the policy makers to take the necessary preemptive measures.

2.2. The multinomial Logit Model

As regard to the theoretical framework the multinomial logit represents an extension of the simple binary logit model, where as argued by Wooldridge (2002) *"the unordered response has more*

than two outcomes". The interest lies primarily in the response probability, more specifically: how changes in the independent variables affect the response probabilities, ceteris paribus. Applying the equations proposed by Wooldridge (2002) to this three outcome case, the response probabilities can be written: $P(y = j|x)$ where j = 0, 1, 2 and as probabilities have to sum to unity $P(y = 0|x)$ can be determined once the probabilities for j=1, 2 are known.

The multinomial logit, in this case has the response probabilities:

$$P(y = j|x) = \frac{\exp(x\beta_j)}{1 + \sum_{h=1}^{2} \exp(x\beta_h)} \quad \textbf{, j = 1, 2} \qquad \text{and} \qquad P(y = 0|x) = \frac{1}{1 + \sum_{h=1}^{2} \exp(x\beta_h)}$$

As stated by Wooldridge the partial effects can be written as:

$$\frac{\partial P(y = j|x)}{\partial x_k} = P(y = j|x)\left\{\beta_{jk} - \left[\sum_{h=1}^{2} \beta_{hk} \exp(x\beta_h\right]/(1 + \sum \exp(x\beta_h))\right\}$$

The scope is to explain the effects of the xj on the response probability, however this is complicated by the nonlinear nature, making the magnitudes of each βj not very useful by themselves, still they give the signs of the partial effects. When it comes to prediction Wooldridge(2002) argues that the percent correctly predicted by each category this can be obtain from the fitted probabilities.

2.3. Estimating the Multinomial Logit Model

This section presents the estimation results from the "standard approach" without accounting for the BS effect when measuring overvaluation. The BS effect issues will be discussed later in this thesis. The choice of the present set of variables, which can correctly signal a fore coming

crisis by their behavior prior to the crises, is based on the previous empirical literature in the area. The estimated model is:

$$y_t = \beta_0 + \beta_1 \text{overvaluation} + \beta_2 \text{CA/GDP} + \beta_3 \text{Lending boom} + \beta_4 \text{M2/reserves} + u_t$$

Table 1: Variable Descriptions

Overvaluation	The measure of under or overvaluation of REER was calculated subtracting from REER the trend, which was calculate using the Hodrick-Prescott filter with a parameter of 14400 and dividing the result by the trend and finally multiplying it with 100
M2/Reserves	Was calculated as the ratio of money and quasi money to total Reserves minus Gold
CA/GDP	Was calculated as the ratio of Current Account to Gross Domestic Product
Lending boom	Was calculated as Nongovernmental credit over Gross Domestic Product

2.3.1 The data

The data for the present thesis study was gathered for a sample of 24 emerging market countries from Central and Eastern Europe, Latin America and Asia and consists of a monthly data set with a time span of: 1/1994 — 12/2006. As argued by Bussiere(2002) this time span is appropriate due to the fact that it excludes early transition years for Eastern and Central Europe and early periods when capital accounts were still not liberalized. The choice of the independent variables was based on fact that they were found to be related to currency crises in earlier empirical literature.

The IMF International Financial Statistics was the primary source of data for the whole period as regards the real effective exchange rate (for a series of countries the data source was the OECD database), nominal exchange rate, CPI, non-governmental credit, GDP, Current Account(CA henceforth) , M2, total reserves minus gold and interest rate. The short term debt series (STD henceforth) was taken from the Joint BIS-IMF-OECD-WB Statistics on External Debt(a more detailed description of the data sources can be seen in Appendix 1b).

Due to the fact that GDP was not available in a monthly series it was linearly interpolated from the quarterly series using Denton interpolation method with industrial production as an indicator. Moreover also the CA series and STD series were interpolated. The resulting series remains subject to the bias induced by such econometric techniques.[5] Due to the fact that discrete choice models require stationary variables the independent variables were constructed as ratio of GDP and panel unit root tests were perform for all of them, rejecting the hypothesis of a unit root(a more detailed exposition of the panel unit root tests can be seen in the Appendix4-table4). The Levin, Lin and Im, Pesaran and Shin W tests were applied and the null hypothesis of a unit root was rejected at a 1 percent level of significance for all the series (with the Levin, Lin test the null was not rejected for CA/GDP). The variables were seasonally adjusted in Eviews in order to avoid any seasonal fluctuations and the ones expressed in national currency or Euro were transformed in US dollars using exchange rate period average.

2.3.2 The results

The factors affecting the probability of a currency crisis were estimated using a multinomial logit model which employs the maximum likelihood estimation. This type of model breaks the regression up into a series of binary regressions comparing each group to the baseline group. The multinomial logit analysis was performed on a sample of twenty-four emerging market countries with a maximum time span: 1994-2006, which captures several main crisis that took place in the analyzed countries: Mexico(1994) , Bulgaria(1996) the Czech Republic(1997), the Asian Crisis (1997), Romania(1997, 1999), Russia (1998), Brazil(1999), Turkey(2000) and Argentina(2001). The results shown in Table 2 are for the four variables that were chosen for the final model. The model as a whole fits well, with a likelihood ratio chi-square of 347.07 and a p-value of 0.0. All the variables enter the equation with the correct sign and are highly significant. Overvaluation of

[5] As discuses by Peltonen (2006) the main economic problem is the use of information that is not available to the public at that date. He used the variable lagged by one month in order to alleviate this problem

the currency, the M2 to reserves ratio and the CA to GDP ratio at 1% significance level and the lending boom significant at 15% significance level(the significance test can be seen in Appendix 4-Table 1) ; when trying to interpret the coefficients one must bear in mind that this is not such a trivial task as this coefficients do not represent marginal effects(these can be seen in table 5). Their interpretation can be a bit awkward : for example, for 1% increase in lending boom relative to the normal periods, the log odds of a crisis to occur increase by 0.0019. There are several alternatives to interpret the regression results, namely in terms of relative risk (the model employing this approach can be seen in Table 1-Appendix 2)

Table 2: Multinomial Logit Model: 1994-2006

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Multinomial logistic regression                 Number of obs   =       2514
                                                LR chi2(8)      =     347.07
                                                Prob > chi2     =     0.0000
Log likelihood = -2133.0395                     Pseudo R2       =     0.0752

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
overvaluat~n |   .0924498   .0115826     7.98   0.000     .0697484    .1151513
      m2_res |   .0009655   .0003657     2.64   0.008     .0002488    .0016823
lending_boom |    .001915   .0041162     0.47   0.642    -.0061525    .0099826
      ca_gdp |  -.0515208   .0091376    -5.64   0.000    -.0694302   -.0336113
       _cons |   -1.99716   .1322231   -15.10   0.000    -2.256312   -1.738007
-------------+----------------------------------------------------------------
2            |
overvaluat~n |  -.1226793   .0108544   -11.30   0.000    -.1439535   -.1014052
      m2_res |   .0013825   .0003233     4.28   0.000     .0007488    .0020161
lending_boom |  -.0088135   .0031536    -2.79   0.005    -.0149945   -.0026325
      ca_gdp |  -.0414153     .00788    -5.26   0.000    -.0568598   -.0259708
       _cons |  -1.603384    .115207   -13.92   0.000    -1.829186   -1.377583
------------------------------------------------------------------------------
(y==0 is the base outcome)
```

► **Overvaluation-** An over valuated currency contributes to the growth of the crisis probability. This is not at odds with Bussiere(2002) who argues that over valuated exchange rate may well be seen by the market participants as a signal that in upcoming period the country currency will depreciate. As for the post crisis period ($Y_{i,t}$ =2) the coefficient on overvaluation changes its sign, which is to be expected. After the crisis the currency is expected to depreciate/devaluate.

The sign on the overvaluation coefficient as well as it is magnitude are in line with the previous findings of Bussiere (2002) and Copaciu(2006).

► **CA (Deficit)/ GDP ratio** is used for the following reason: a country with a high CA deficit is more likely to have problems in generating external revenue which in turn can be used for financing a possible balance of payments problem. We should bear in mind that it represents borrowing from the rest of the world and as pointed out by Pesenti (2000) can put the country in a vulnerable position as it depends on foreign sources of capital. The variable is significant and has the correct negative sign as expected. Similar results were obtain by Bussiere(2002) and Copaciu(2006).

►**M2/reserves ratio** (liquidity ratio) captures an economy ability to withstand a speculative attack and as Aziz (2000) indicated it can be seen as an indicator of investors' confidence in the domestic financial system. In this model the variable is significant and has the intuitive positive sign.

►**A Lending boom** is another important indicator because as noted by Bussiere (2002) the increase of the credit to the private sector can give an indication that a country is over-heating. In this model the variable has the correct positive sign in the (pre)crisis period although is insignificant becoming significant only in the post crisis period. If a country experiences a too fast increase in the credits it is possible that some will go into unsound investment projects. Still as mentioned by the above mention author a sharp decrease can also be a sign of weakness. The results are in line with the previous findings in empirical currency crisis literature.

In terms of predictive power, Table 2a shows the goodness-of-fit of the model. It can be seen that 85% of the observations and 63 % of the crises are correctly estimated. This is in line with previous findings in this area of research.

Table 2a: Multinomial logit, goodness of fit

S				% observations correctly called	85.91%
y	0	1	Total	% crises correctly called	63.24%
0	1,437	133	1,570	% false alarms in total alarms	35.09%
1	143	246	389	% crisis given an alarm	64.91%
Total	1,580	379	1,959	% of crisis given no alarm	9.05%

In order to take advantage of the panel nature of the data an alternative model was use which employs country dummies. This is presented in table 3, where the _Iid's stand for the countries dummies (taking Argentina (_Iid1) as reference group). This will show which country is more prone to a crisis and which is less prone (Mexico being most prone to a crisis while Chile least prone to a crisis). The model's general degree of explanation is better now, while all the other explanatory variables keep their sign and significance (Overvaluation of the currency and the M2 to reserves ratio are significant at 1% significance level the CA to GDP ratio at 10% significance level and the lending boom significant at 5% significance level); moreover the dummy variables are jointly significant (significance tests can be seen in Table 2-Appendix 4). Furthermore another extension to this model was considered, namely one that provides an interaction between the overvaluation variable and country dummies. As overvaluation is less likely to have the same impact on each country analyzed the interaction will show for which country overvaluation matters more(this model can be seen in Table 3- Appendix 2).

Table 3 Multinomial Logit Model with country dummies: 1994-2006

```
Multinomial logistic regression                 Number of obs   =       2514
                                                LR chi2(48)     =    1720.46
                                                Prob > chi2     =     0.0000
Log likelihood = -1901.6819                     Pseudo R2       =     0.3115
------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
overvaluat~n |   .1520419   .0151218    10.05   0.000     .1224037      .18168
```

```
      m2_res |   .0026531   .0005492     4.83   0.000     .0015768    .0037295
      ca_gdp |  -.0282526   .0117864    -2.40   0.017    -.0513534   -.0051518
lending_boom |   .0027324   .0045994     0.59   0.552    -.0062823    .0117471
      _Iid_2 |  -2.550674   .3242763    -7.87   0.000    -3.186244   -1.915104
      _Iid_3 |  -4.500186   .4041385   -11.14   0.000    -5.292282   -3.708089
      _Iid_4 |  -1.795182   .2525671    -7.11   0.000    -2.290204    -1.30016
      _Iid_5 |  -1.884839   .2905833    -6.49   0.000    -2.454372   -1.315306
      _Iid_6 |  -2.100119   .2844791    -7.38   0.000    -2.657688    -1.54255
      _Iid_7 |  -2.092826   .2768783    -7.56   0.000    -2.635497   -1.550154
      _Iid_8 |  -1.709579   .2546797    -6.71   0.000    -2.208742   -1.210416
     _Iid_10 |  -1.998343   .2703991    -7.39   0.000    -2.528315    -1.46837
     _Iid_11 |  -3.041797   .3474264    -8.76   0.000     -3.72274   -2.360854
     _Iid_12 |  -39.76505   4.09e+07    -0.00   1.000    -8.02e+07    8.02e+07
     _Iid_13 |  -4.163238   .4351992    -9.57   0.000    -5.016212   -3.310263
     _Iid_14 |  -2.716839    .331991    -8.18   0.000     -3.36753   -2.066149
     _Iid_15 |   22.66683   1.142037    19.85   0.000     20.42848    24.90518
     _Iid_16 |  -3.144873   .4009131    -7.84   0.000    -3.930648   -2.359097
     _Iid_17 |  -4.132504   .4844413    -8.53   0.000    -5.081991   -3.183016
     _Iid_19 |  -1.317785   .3315355    -3.97   0.000    -1.967583   -.6679877
     _Iid_20 |  -.4339205   .2818452    -1.54   0.124     -.986327     .118486
     _Iid_22 |  -3.827929   .4220378    -9.07   0.000    -4.655108    -3.00075
     _Iid_23 |  -2.084381   .2989169    -6.97   0.000    -2.670247   -1.498514
     _Iid_24 |  -4.071931   .4338202    -9.39   0.000    -4.922203   -3.221659
-------------+----------------------------------------------------------------
2            |
overvaluat~n |  -.1340683   .0122761   -10.92   0.000    -.1581291   -.1100075
      m2_res |   .0027341   .0004975     5.50   0.000     .0017591    .0037092
      ca_gdp |  -.0080313   .0098961    -0.81   0.417    -.0274274    .0113648
lending_boom |  -.0106214   .0033073    -3.21   0.001    -.0171036   -.0041391
      _Iid_2 |  -1.608976   .2753622    -5.84   0.000    -2.148676   -1.069276
      _Iid_3 |  -1.766223   .3012768    -5.86   0.000    -2.356715   -1.175731
      _Iid_4 |  -1.577081   .2366112    -6.67   0.000     -2.04083   -1.113331
      _Iid_5 |  -1.477804   .2593209    -5.70   0.000    -1.986063    -.969544
      _Iid_6 |  -1.637923   .2473932    -6.62   0.000    -2.122804   -1.153041
      _Iid_7 |  -1.842405   .2673575    -6.89   0.000    -2.366416   -1.318394
      _Iid_8 |  -1.368205   .2414463    -5.67   0.000    -1.841431    -.894979
     _Iid_10 |  -1.821549    .259501    -7.02   0.000    -2.330161   -1.312936
     _Iid_11 |  -2.319706   .2822759    -8.22   0.000    -2.872956   -1.766455
     _Iid_12 |  -39.70756   4.15e+07    -0.00   1.000    -8.12e+07    8.12e+07
     _Iid_13 |  -3.819273   .3930993    -9.72   0.000    -4.589733   -3.048812
     _Iid_14 |  -2.195298   .2814549    -7.80   0.000     -2.74694   -1.643657
     _Iid_15 |   21.07406          .        .       .            .           .
     _Iid_16 |  -1.857692   .2874755    -6.46   0.000    -2.421134    -1.29425
     _Iid_17 |  -3.919574   .4454648    -8.80   0.000    -4.792669   -3.046479
     _Iid_19 |  -.6554557    .295584    -2.22   0.027     -1.23479   -.0761217
     _Iid_20 |   .0398313   .2588614     0.15   0.878    -.4675278    .5471903
     _Iid_22 |  -2.486292   .2967531    -8.38   0.000    -3.067917   -1.904667
     _Iid_23 |  -1.437369   .2575368    -5.58   0.000    -1.942132   -.9326058
     _Iid_24 |  -3.725187   .3944164    -9.44   0.000    -4.498229   -2.952145
------------------------------------------------------------------------------
(y==0 is the base outcome)
```


2.4. Discussion of results

The logit model divides the periods into those preceding a crisis, normal periods and those following a crisis. Table 4 shows the average values of the indicators in normal and pre-crisis and

post-crisis periods. Pre-crisis periods are characterized by overvaluation of the national currency and a higher deficit of the current account. The growth of nongovernmental credit /GDP has a slightly higher value in pre-crisis periods because as it is known, these periods are characterized by increasing lending boom. The ratio between M2 and reserves is at a higher value in pre-crisis periods either to diminishing reserves (used to attempt to soften the crisis) or increase in M2, compared to the normal period. After the crisis the counties experience a depreciation/devaluation of their currency a diminishing lending boom and a reduced current account deficit. Another important fact mentioned by Bussiere (2002) is that the variables are quite different in normal periods as compared to periods following a crisis, therefore a binomial model, which does not account for "the post crisis bias" will yield less precise estimates.

Table 4: Mean values of key indicators

Variables	Average all periods	Average, normal period Y=0	Average, year preceding crisis Y=1	Average, year following crisis Y=2
Overvaluation	0.207656	0.525153	2.77714	-2.679325
M2/RES	301.82803	284.0465	311.8142	309.6234
CA/GDP	-1.74508	-0.9117705	-3.168625	-1.154866
Lending boom	5.70654	5.30357	6.338606	5.477452

Table 5: Marginal effects from the model without country dummies

```
Marginal effects after mlogit
y  = Pr(y==1) (predict, outcome(1))
   = 0.13797389
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
overva~n |   .0144411      .00128   11.25   0.000   .011926  .016957   .203004
  m2_res |    .000076      .00004    1.81   0.070  -6.1e-06  .000158   293.655
  ca_gdp |  -.0049646      .00104   -4.78   0.000  -.007001 -.002928   -2.3543
lendin~m |   .0004753      .00048    0.99   0.325   -.00047  .001421   5.58476
------------------------------------------------------------------------------
```

The most significant factors from an economic point of view that contribute to increasing the probability of a currency crisis to occur are overvaluation and an increasing current account

deficit (this factors have the largest marginal effects). As can be seen from table 5 a one percent increases in the overvaluation of the currency is predicted to increase the probability of a crisis by around 0.15%. Moreover an increase of the ratio between M2 and reserves is estimated to increase the probability of the occurrence of a crisis; however the coefficient is rather small. An increase in the level of the CA to GDP (that is a reduction in the CA deficit) is estimated to decrease the probability of a crisis. This is not at odds with Peltonen (2006) who finds similar results.

Another way of assessing which variable has the greatest impact on the probability of a crisis to occur and to see the probability of a crisis occurring in the near future is to employ crisis scenarios. As mentioned above, the coefficients can not be interpreted as marginal effects, due to the logistic distribution, for this reason they are computed at the mean values of the explanatory variables and inserted in the logistic function to estimate the probability of a crisis. Further a reference scenario is chosen; usually the one with the variables set at their average values from the normal period and the crisis probability for the following twelve months is estimated. To see the impact of a certain variable on the crisis probability the variables are set at their normal average period or at a specific period and one of them undergo specific changes.

CHAPTER 3- Approaching a Different Angle: A Possible Improvement to Current Currency Crises Prediction Models

3.1. The BS framework

The BS effect can be summarized as working in the following way: given that productivity differentials in the home county outpaces the one in the foreign economy, higher domestic non-tradable inflation is transmitted to overall inflation as compared to foreign and this will lead to an appreciation of RER between the two countries.

There are several assumptions that have to be checked for the BS effect, the most important ones being summarized below:

- PPP holds for the tradable sector
- There is a high positive correlation between wages and productivity in the tradable sector
- There is a productivity differential between the developed country and the developing country (where the developing country experiences a higher productivity growth in the tradable sector)
- There is a tendency to equalize nominal wages in the tradable and non-tradable sector

In papers dealing with the BS effect there are several methodological differences that make the comparison of results quite difficult. The main differences are with respect to:

- **the period of time analyzed and frequency of data-** usually short time spans are considered due to lack of date or structural breaks in the time series. The frequency of data is not uniform as some studies employ monthly data some quarterly some annual and some a mix of frequency. Even though monthly data may enhance the credibility of econometric results, using this kind of data might lead to an overestimation of the BS effect. The reason is that for computing average productivity in the tradable sector usually the data for the industrial production is used however for the non-tradable sector

it is assumed that there is no difference in productivity as compared to the reference country

- **tradable vs. non-tradable** –the issue here is related to what constitutes each category. A criterion for delimitating the two is the weight of exports in the total good produced in that sector. Another arbitrary distinction implies that the industry and the agriculture are part of the tradable sector whereas the service sector and the construction sector constitutes the non-tradable
- **weight of the non-tradable in the Consumer Price Index** -some studies assume equal weights although developing countries have a lower weight of non-tradable. Egert(2005) analyses this aspect, which implies an overestimation of the BS effect.
- **productivity issues**- although total factor productivity should be used due to lack of data most studies use instead the average labor productivity

As regard to the BS effect the focus of this thesis is not to try to prove the assumptions (therefore whether the assumptions behind the BS framework hold in the context of the analyzed countries are taken as proven by different authors, mentioned in the literature review chapter) of the BS model but just on the so called ***"external transmission mechanism***". This mechanism implies that higher productivity growth in the tradable sector as compared to the non-tradable in the "home country" as compared to abroad translates into nominal exchange rate appreciation. As Egert (2002b) states "*productivity induced increase in the price level through relative price adjustments will result in an appreciation of the CPI based exchange rate"*. In the context of this thesis the BS effect can be shortly "referred" to as: ***productivity driven real appreciation***.

This section tries to link the BS effect with currency crises model and sets out to find whether the BS effect is captured in the trend and therefore to some extent accounted for, or not and therefore must be subtracted. This is done by analyzing the evolution of real exchange rate and

the appreciation of currency given by productivity gains (RER^{BS}).The standard empiric equation for the RER^{BS} that was used in this thesis is among the ones employed by Egert(2002b) :

$$\mathbf{RER^{BS} = -[(1-\acute{a})(prod^{T} - prod^{NT}) - (1-\acute{a}^{*})(prod^{T*} - prod^{NT*})]}$$

$Prod^{T}$ stand for the productivity in the tradable sector where as $prod^{NT}$ stands for the productivity in the non tradable sector. The variables marked with and asterix stand for the productivity of the tradable and non tradable sector in the foreign country, which for the current analysis was chosen to be Germany**.** The term (1-ά) represents the share of non-tradables in CPI which was computed based on Harmonized Indices of Consumer Prices (weight items).

3.1.1. The data

The data set for the BS part consists of quarterly observations for Central and Eastern European countries. As the foreign benchmark, Germany was chosen for European countries due its proximity to the countries in the sample and high trade volume. The series cover the 1996(2001)-2006 time period, which was dictated by the availability of data.

Like the majority of the papers this thesis uses average labor productivity as proxy for total factor productivity. Quarterly indices of the gross value added per economic sector and employment data were taken from publicly available Eurostat database and the OECD (MEI) database. As no consensus has been reached so far as regards what should be included in the tradable and in the on-tradable sector I construct three types of productivity measures, this will also provide a robustness check to the results. First industry is considered to represent the tradable sector where as services are considered to represent the non-tradable sector. Second industry and agriculture represents the tradable sector, a classification also employed by Egert(2002a) whereas services represent the non-tradable sector. And third industry stands for the tradable sector whereas services and construction stand for the non-tradable sector (a more detailed description

of the data can be found in Appendix 1b). Average labor productivity was computed as the ratio between gross value added in the respective economic sector and number of employees in that sector, afterwards it was transformed in an index with the average of 1995(2001) as the base.

3.2 Graphic Analysis

This section presents a graphic analysis of the evolution of RER and RER^{BS} so as to compare their evolutions. In order to ensure a robustness of results three different types of productivity measures were considered (a more detailed description of these measures can be found in Appendix 1b). Finally RER^{BS} was computed for a sub sample of countries from Central and Eastern Europe, this being dictated by the availability of data.

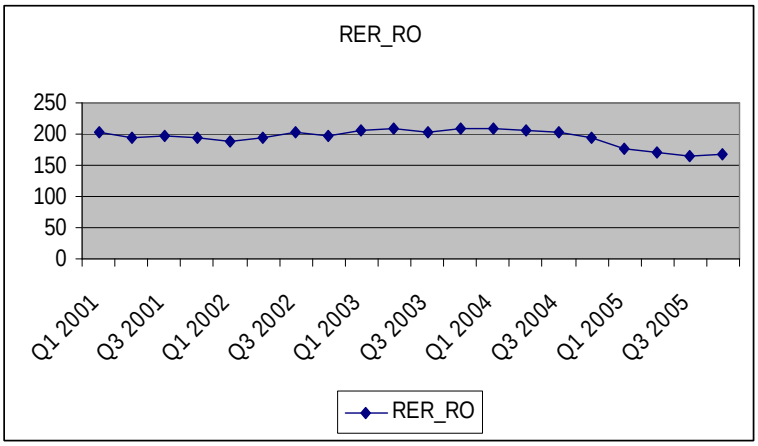

Fig. 1 Real exchange rate evolution in Romania

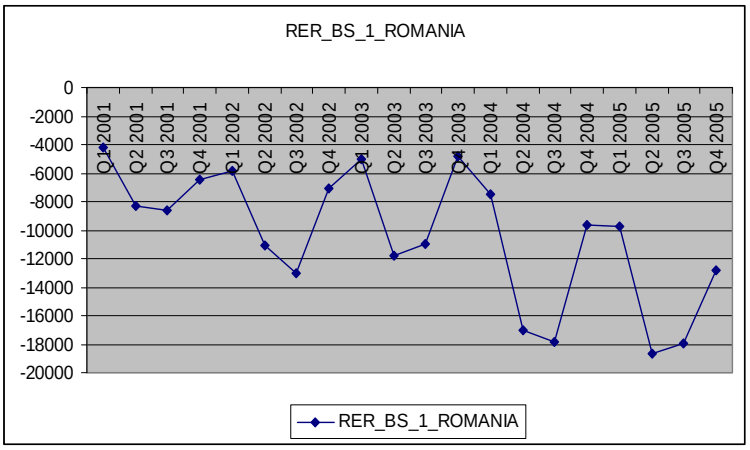

Fig. 2 RER_BS (industry=T; services=NT)

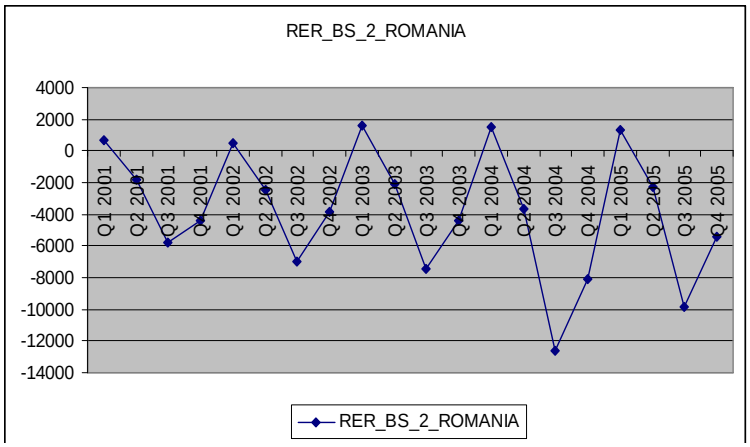

Fig. 3 RER_BS (industry and agriculture=T; services=NT)

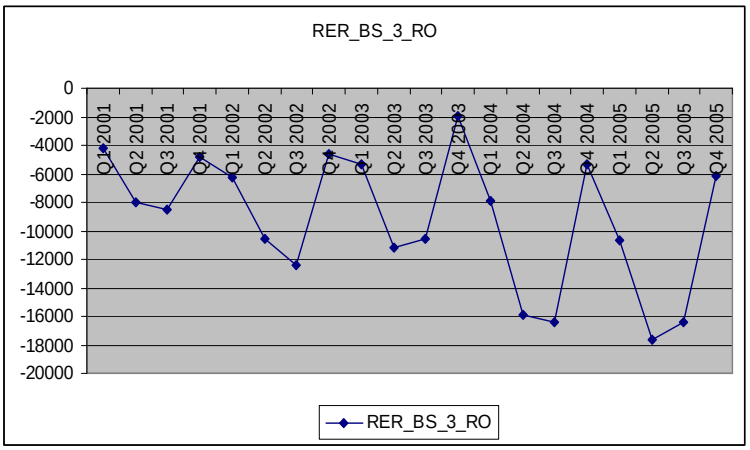

Fig. 4 RER_BS(industry=T; services and construction=NT)

From the above graphs it can bee seen that RER and RER^{BS} have different evolutions (the above graphs analyze the evolution for Romania, the rest of the graphs can be found in Appendix 3). Therefore it can be inferred that appreciation of the currency due to productivity gains as it follows a different evolution as compared to the real exchange rate is not accounted when measuring overvaluation (this remains subject to a potential bias due to the rather small sample for which this analysis was performed). When measuring overvaluation the subtracted linear trend does not contain the real appreciation justified by the BS effect therefore the overvaluation measure is to some extent inaccurate as it does not account for the equilibrium appreciation given by the BS effect. Accounting for the BS effect when measuring overvaluation can

constitute an improvement to current currency crises models as it will make the overvaluation variable a more accurate predictor of fore coming currency crises.

Because the RER^{BS} is not part of the trend and the analyzed countries experienced an appreciation of the currency as compared to the foreign benchmark not subtracting it leads to an overestimate impact of the overvaluation variable. This makes the appreciation of the currency due to catch up growth to be labeled as "artificial". Therefore the model will signal a crisis when one is not about to occur. In consequence, accounting for the BS effect, will lead to less "false crises" will be signaled which means the prediction of the model will be improved. If countries experience a depreciation of the currency as compared to the foreign benchmark (the coefficient of the RER^{BS} is positive) and it is not accounted for, the impact of overvaluation will be underestimated and the model can fail to spot some crises. Considering the real exchange rate appreciation attributable to the BS effect, particularly in the context of emerging markets is a must, because as Egert(2002b) argues this appreciation can not be avoided as it reflects rising productivity(this is expected to be the case for the majority of the Central and Eastern European countries).

The current section pointed to an existing gap between currency crises prediction models and the BS effect and showed that these are not two different issues. On the contrary, relating them and considering productivity gains appreciations may in fact produce a better model in terms of prediction. The further step of actually inserting the coefficient of the RER^{BS} in overvaluation was not undertaken in this thesis mainly due to data issues and remains an open subject of future research.

Conclusion

The present thesis had developed a model for predicting currency crises based on a multinomial logit model approach while it also assesses whether the BS effect is accounted for when measuring overvaluation, a fact that has been neglected by previous research in this area. Providing a link between currency crises prediction models and the BS effect it can be of particular interest especially for developing countries which experience a catch up growth and a real appreciation of the currency, which should not be seen as artificial and trigger a crisis. It finds that the appreciation of the currency due to productivity gains is not accounted when measuring overvaluation, therefore potentially biasing this variable and decreasing the accurateness of the model. Therefore incorporating the BS effect in currency crisis prediction models is an important step which will lead to fewer false crises being signaled and also fewer crises not being spotted.

It is difficult to be able to fit all the characteristics of crises into a single model; however there are macroeconomic and financial variables that signal a crisis accurately and which are appropriate to be used for the development and improvement of Early Warning Systems. Moreover when trying to account for the BS effect, when predicting currency crises, involves dealing with the issues raised by both the BS effect and currency crises models. According to the results the model was able to signal correctly around 63% of the crises in the sample. From the indicators used in the sample overvaluation of the national currency and the ratio between CA and GDP have the highest effect on crisis probability (marginal effects, estimated for model 1) This findings are confirmed by Bussiere(2002) and Coapciu(2006) which obtained similar results.

The present thesis pointed to a potential improvement of currency crises prediction models by considering the potential role that could be played the Balassa–Samuelson effect. As the

appreciation of the currency which can be justifiable by the BS effect is not part of the linear subtracted trend from the overvaluation variables, making this further step in order to offer a new measure for overvaluation, more accurate, remains subject to future research. Such an extension of the present models can prove to be a very important step in improving their predictive power.

References

- Aziz, Jahangir, Francesco Caramazza, and Ranil Salgado.2000. "Currency crises in search of common elements", IMF Working Paper, WP/00/67
- Bordo, Michael, D. 1998. "Currency Crises (and Banking Crises) in Historical perspective", IEHF, Research Report No 10
- Bussiere, Matthieu, and Marcel Fratzscher. 2002. "Towards a new early warning system of financial crisis", European Central Bank Working Paper No 145
- Canzoneri, Matthew B., Robert Cumby, and Behzad Diba. 1998. "Trends in European Productivity: Implications for Real Exchange Rates, Real Interest Rates and Inflation Differentials", Oesterreichische Nationalbank, Working Paper
- Chinn, Menzine David. 2000. "The unusual suspects? Productivity and demand shocks and Asia-Pacific Real exchange rates", Review of International Economics,8, pp.20-43.
- Choudhri, Ehsan, and Mohsin Khan. 2004. "Real Exchange Rates In Developing Countries: Are Balassa-Samuelson Effects Present?", IMF Working Paper
- Copaciu, Mihai, and Irina Racaru. 2006. "Early Warning Systems on Currency Crisis", National Bank of Romania, Working Paper
- Égert, Balazs, Imed Drine, Kristen Lommatzsch, and Christophe Rault. 2002a. "The Balassa-Samuelson Effect in Central and Eastern Europe: Myth or Reality?" William Davidson Institute Working Paper No.483.
- Égert, Balazs. 2002b. "Investigating the Balassa-Samuelson hypothesis in transition: Do we understand what we see?", BOFIT Working paper No 2
- Égert, Balazs, A.mina Lahrèche-Révil and Kristen Lommatzsch. 2004. "The Stock-Flow Approach to the Real Exchange Rate of Transition Economies", CEPII Working Paper No. 14.
- Égert, Balazs. 2005. "Balassa-Samuelson Meets South Eastern Europe, the CIS and Turkey : A Close Encounter of the Third Kind?", European Journal of Comparative Economics, Vol.2, 221-243
- European Central Bank. 2003. "Inflation Differentials in the Euro Area: Potential Causes and Policy Implications ECB Report".
- Eurostat, http://epp.eurostat.ec.europa.eu/portal
- Flood, Robert, and Nancy Marion.1996. "Policy Implications of "Second-Generation" Crisis Models", IMF Working Paper
- Halpern, Laszlo, and Charles Wyplosz. 2001. "Economic Transformation and Real Exchange Rates in the 2000s: The Balassa-Samuelson Connection", UNO Economic Survey of Europe. 227–239
- IMF, International Financial Statistics, http://ifs.apdi.net/imf/about.asp
- Kaminsky Graciela, and Saul Lizondo. 1998. "Leading Indicators of Currency Crises", IMF Staff Papers.
- Kaminsky Graciela and Carmen Reinhart. 2000. "On Crises, Contagion, and Confusion", Journal of International Economics

- Mihaljek, Dubravako, and Mark Klau. 2004. "The Balassa-Samuelson Effect in Central Europe: A Disaggregated Analysis". Comparative Economic Studies, 46(1): 63-94
- Obstfeld, Maurice. 1994. "The Logic of Currency crises", NBER, Working Paper NO.4640
- Peltonen, Tumos. 2006. "Are Emerging Market Currency Crises Predictable? A Test", European Central Bank, Working Paper No 571
- Solanes, Jose Garcia, and Fernando Flores. 2005. "Testing the Balassa -Samuelson hypothesis in two different groups of countries: OECD and Latin America", FEDEA Working Paper
- Thomas, Alastair, and Alan King. 2005. "The Balassa –Samuelson effect in the Asia – Pacific region: Now you see it now you don't", Working paper
- Wooldridge, Jeffery M. 2002. Econometric Analysis of Cross Section and Panel Data.

Appendix 1a – Data sources

	Country	Exchange rate (end of period)	Exchange rate (avg) USD	exchange rate (avg)-EUR	REER	CPI	Interest rate-money_mkt_rate/ Lending_60days	NGC	M2 (money + Quasi-money)	CA	GDP	STD	International reserves	Gross Value Added by sector	Employees	HICP(weight items)
1	Argentina	IFS line AE	IFS line RF			IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
2	Brazil	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
3	Bulgaria	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
4	Chile	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60P	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
5	Columbia	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60P	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
6	Croatia	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
7	Estonia	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
8	Hungary	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	IFS line 60P	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
9	Indonesia	IFS line AE	IFS line RF			IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
10	Latvia	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
11	Lithuania	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
12	Malaysia	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
13	Mexico	IFS line AE	IFS line RF		OECD	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
14	Philippines	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
15	Poland	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
16	Romania	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	NBR	NBR	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	NBR	NBR	EUROSTAT
17	Russia	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
18	Singapore	IFS line AE	IFS line RF		IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
19	Slovak Republic	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	IFS line 60P	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
20	Slovenia	IFS line AE	IFS line RF	EUROSTAT	IFS line REC	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
21	Thailand	IFS line AE	IFS line RF			IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
22	Turkey	IFS line AE	IFS line RF		OECD	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			
23	Czech Rep	IFS line AE	IFS line RF	EUROSTAT	OECD	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD	EUROSTAT	EUROSTAT	EUROSTAT
24	Korea	IFS line AE	IFS line RF		OECD	IFS line 64	IFS line 60B	IFS line 32 D	IFS lines 34+35	IFS line 78ALD	IFS line 99B	BIS Table 9	IFS line 1LD			

Appendix 1b – Data description

Raw data used to compute EMP

The EMP index was computed using the real exchange rate (exchange rate end of period over CPI) the international reserves minus gold series and as interest rate , the money market rate or lending rate.

Independent variables

The overvaluation variable was computed as: $\text{Overvaluation}_t^i = \frac{REER_t^i - TREND_t^i}{TREND_t^i}$, where the trend was calculated using the Hodrick-Prescott filter whit a parameter of 14400.

The CA/GDP variable, the lending boom variable and the M2/Reserves variable were computed as percentage of GDP

The productivity variables

The data for the productivity variables were taken from the Eurostat quarterly national accounts both as regard to gross value added by economic sector but and number of employees. The share of non-tradables in CPI was computed using HICP (weight items).

The productivity variables were computed as:

a) prod = gross value added by economic sector/number of employees in that sector

b) index of productivity = prod/average of base year(1995 or 2001)

Table 1 –Classification of tradables and non tradables

Alternative	Tradables	Non-tradables
1	industry	services
2	industry and agriculture	services
3	industry	services and constructions

Appendix 2 – Alternative models

Table 1-Final model in terms of relative risk

```
Multinomial logistic regression                 Number of obs   =       2514
                                                LR chi2(8)      =     347.07
                                                Prob > chi2     =     0.0000
Log likelihood = -2133.0395                     Pseudo R2       =     0.0752

------------------------------------------------------------------------------
           y |        RRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
overvaluat~n |   1.096858   .0127045     7.98   0.000     1.072238    1.122043
      m2_res |   1.000966   .0003661     2.64   0.008     1.000249    1.001684
      ca_gdp |   .9497839   .0086788    -5.64   0.000     .9329252    .9669473
lending_boom |   1.001917   .0041241     0.47   0.642     .9938663    1.010033
-------------+----------------------------------------------------------------
2            |
overvaluat~n |   .8845473   .0096012   -11.30   0.000      .865928    .9035669
      m2_res |   1.001383   .0003238     4.28   0.000     1.000749    1.002018
      ca_gdp |   .9594306   .0075603    -5.26   0.000     .9447265    .9743636
lending_boom |   .9912252    .003126    -2.79   0.005     .9851173     .997371
------------------------------------------------------------------------------
(y==0 is the base outcome)
```

This presents the ratio of the probability of choosing one outcome category over the probability of choosing another one and is referred to as relative risk.

Table 2 -Model including STD_RES

```
Multinomial logistic regression                 Number of obs   =       2388
                                                LR chi2(8)      =     287.67
                                                Prob > chi2     =     0.0000
Log likelihood = -2121.2206                     Pseudo R2       =     0.0635

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
overvaluat~n |   .0756257   .0111857     6.76   0.000     .0537021    .0975493
      m2_res |   .0010017   .0004047     2.48   0.013     .0002086    .0017948
      ca_gdp |  -.0542074   .0097189    -5.58   0.000    -.0732561   -.0351588
     std_res |   .0009934   .0038079     0.26   0.794    -.0064699    .0084568
       _cons |  -1.872445   .1295303   -14.46   0.000     -2.12632    -1.61857
-------------+----------------------------------------------------------------
2            |
overvaluat~n |  -.0997085   .0103147    -9.67   0.000    -.1199249   -.0794922
      m2_res |   .0008706   .0003739     2.33   0.020     .0001378    .0016034
      ca_gdp |  -.0344271   .0082641    -4.17   0.000    -.0506244   -.0182299
     std_res |   .0061856   .0032312     1.91   0.056    -.0001475    .0125186
       _cons |  -1.487779   .1154309   -12.89   0.000     -1.71402   -1.261539
------------------------------------------------------------------------------
(y==0 is the base outcome)
```

This variable was dropped due to the fact that is was found to be insignificant

Table 3 –Final model with country dummies and interaction between overvaluation and country dummies

Multinomial logistic regression — Number of obs = 2514; LR chi2(86) = 1990.93; Prob > chi2 = 0.0000; Log likelihood = -1766.4452; Pseudo R2 = 0.3604

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
overvaluat~n	-.1499064	.951619	-0.16	0.875	-2.015045	1.715233
m2_res	.00187	.0006486	2.88	0.004	.0005987	.0031412
ca_gdp	-.0213822	.0119946	-1.78	0.075	-.0448911	.0021267
lending_boom	.0034777	.0045801	0.76	0.448	-.005499	.0124545
_Iid_2	-2.18453	.3931903	-5.56	0.000	-2.955169	-1.413891
_Iid_3	-3.74632	.5894082	-6.36	0.000	-4.901539	-2.591101
_Iid_4	-1.464093	.2644324	-5.54	0.000	-1.982371	-.9458149
_Iid_5	-1.825011	.3531257	-5.17	0.000	-2.517124	-1.132897
_Iid_6	-1.869797	.3052477	-6.13	0.000	-2.468072	-1.271523
_Iid_7	-1.893423	.308235	-6.14	0.000	-2.497552	-1.289293
_Iid_8	-1.596121	.2596649	-6.15	0.000	-2.105055	-1.087187
_Iid_10	-1.810663	.2967027	-6.10	0.000	-2.39219	-1.229137
_Iid_11	-2.808232	.3622013	-7.75	0.000	-3.518134	-2.09833
_Iid_12	-33.43716	2158496	-0.00	1.000	-4230607	4230540
_Iid_13	-14.49859	5.654105	-2.56	0.010	-25.58043	-3.416749
_Iid_14	-2.509979	.3883523	-6.46	0.000	-3.271135	-1.748822
_Iid_16	-4.35415	.9712354	-4.48	0.000	-6.257736	-2.450564
_Iid_15	23.07237	2.152055	10.72	0.000	18.85442	27.29032
_Iid_17	-10.10971	3.474182	-2.91	0.004	-16.91898	-3.30044
_Iid_19	-.8854403	.360131	-2.46	0.014	-1.591284	-.1795965
_Iid_20	-.2997302	.3034808	-0.99	0.323	-.8945415	.2950812
_Iid_22	-3.700039	.5623879	-6.58	0.000	-4.802299	-2.597778
_Iid_23	-2.28747	.3990986	-5.73	0.000	-3.069688	-1.505251
_Iid_24	-9.53451	2.563943	-3.72	0.000	-14.55975	-4.509274
_IidXover_2	.3019671	.9528386	0.32	0.751	-1.565562	2.169497
_IidXover_3	.2567191	.9527526	0.27	0.788	-1.610642	2.12408
_IidXover_4	.0624039	.9538376	0.07	0.948	-1.807083	1.931891
_IidXover_5	.351591	.9534691	0.37	0.712	-1.517174	2.220356
_IidXover_6	.3760859	.9556026	0.39	0.694	-1.496861	2.249033
_IidXover_7	.3265053	.9536332	0.34	0.732	-1.542582	2.195592
_IidXover_8	.163592	.9578257	0.17	0.864	-1.713712	2.040896
_IidXover_10	.3376051	.9548828	0.35	0.724	-1.533931	2.209141
_IidXover_11	.2735227	.9603274	0.28	0.776	-1.608684	2.15573
_IidXover_12	.107424	985469	0.00	1.000	-1931484	1931484
_IidXover_13	1.688829	1.168839	1.44	0.148	-.6020525	3.979711
_IidXover_14	.3290047	.9535432	0.35	0.730	-1.539906	2.197915
_IidXover_16	-.4253888	.9654085	-0.44	0.659	-2.317555	1.466777
_IidXover_17	.9372688	1.011618	0.93	0.354	-1.045465	2.920003
_IidXover_19	.326103	.9561193	0.34	0.733	-1.547856	2.200062
_IidXover_20	.3469853	.9565116	0.36	0.717	-1.527743	2.221714
_IidXover_22	.3325957	.9532264	0.35	0.727	-1.535694	2.200885
_IidXover_23	.6591214	.9575213	0.69	0.491	-1.217586	2.535829
_IidXover_24	1.267884	1.018783	1.24	0.213	-.7288927	3.264661
2						
overvaluat~n	.5074702	.1390234	3.65	0.000	.2349893	.7799511
m2_res	.0024864	.0005213	4.77	0.000	.0014647	.0035082
ca_gdp	-.0127922	.0101978	-1.25	0.210	-.0327796	.0071952
lending_boom	-.0064477	.0034247	-1.88	0.060	-.01316	.0002647

```
      _Iid_2 |  -1.435533   .2795523    -5.14   0.000    -1.983445   -.8876204
      _Iid_3 |    -1.8692   .3158266    -5.92   0.000    -2.488209   -1.250191
      _Iid_4 |  -1.558606   .2539884    -6.14   0.000    -2.056414   -1.060798
      _Iid_5 |  -1.421462   .2807899    -5.06   0.000      -1.9718   -.8711243
      _Iid_6 |  -1.687215   .2669893    -6.32   0.000    -2.210505   -1.163926
      _Iid_7 |  -1.877092   .2887867    -6.50   0.000    -2.443103    -1.31108
      _Iid_8 |  -1.738169   .3080026    -5.64   0.000    -2.341843   -1.134495
     _Iid_10 |  -1.859039   .2814561    -6.61   0.000    -2.410683   -1.307395
     _Iid_11 |  -2.285228   .2846397    -8.03   0.000    -2.843112   -1.727345
     _Iid_12 |  -33.65208    2156590    -0.00   1.000     -4226873     4226805
     _Iid_13 |  -5.526198   .8635527    -6.40   0.000     -7.21873   -3.833666
     _Iid_14 |  -2.222012   .3117356    -7.13   0.000    -2.833003   -1.611022
     _Iid_16 |  -1.608641   .2849178    -5.65   0.000     -2.16707   -1.050213
     _Iid_15 |   20.34378          .        .       .            .           .
     _Iid_17 |  -5.160081   1.013884    -5.09   0.000    -7.147258   -3.172904
     _Iid_19 |  -.5182356    .304063    -1.70   0.088    -1.114188    .0777169
     _Iid_20 |  -.0018736   .2705396    -0.01   0.994    -.5321214    .5283743
     _Iid_22 |  -2.308323   .3130354    -7.37   0.000    -2.921861   -1.694785
     _Iid_23 |   -1.39087   .2780616    -5.00   0.000    -1.935861   -.8458792
     _Iid_24 |  -5.766332    .944378    -6.11   0.000    -7.617279   -3.915385
 _IidXover_2 |  -.5809407    .141408    -4.11   0.000    -.8580953    -.303786
 _IidXover_3 |  -.5866927   .1420951    -4.13   0.000     -.865194   -.3081914
 _IidXover_4 |  -.7295249   .1544758    -4.72   0.000    -1.032292   -.4267579
 _IidXover_5 |   -.622238   .1485565    -4.19   0.000    -.9134035   -.3310725
 _IidXover_6 |  -.7650956          .        .       .            .           .
 _IidXover_7 |  -.6525521   .1554674    -4.20   0.000    -.9572625   -.3478416
 _IidXover_8 |  -.9898856   .1820215    -5.44   0.000    -1.346641   -.6331301
_IidXover_10 |  -.6835662   .1629604    -4.19   0.000    -1.002963   -.3641696
_IidXover_11 |  -.5094892    .177674    -2.87   0.004    -.8577239   -.1612546
_IidXover_12 |   -.543616   979581.1    -0.00   1.000     -1919944     1919943
_IidXover_13 |  -.9847693    .180036    -5.47   0.000    -1.337633   -.6319053
_IidXover_14 |  -.7039608   .1502119    -4.69   0.000    -.9983706   -.4095509
_IidXover_16 |  -.5427113   .1453126    -3.73   0.000    -.8275187   -.2579039
_IidXover_17 |  -.7406786   .1508169    -4.91   0.000    -1.036274    -.445083
_IidXover_19 |  -.4121666   .1590799    -2.59   0.010    -.7239574   -.1003758
_IidXover_20 |  -.7651812   .1755429    -4.36   0.000    -1.109239   -.4211234
_IidXover_22 |  -.6044582   .1428692    -4.23   0.000    -.8844767   -.3244397
_IidXover_23 |  -.5876302   .1657895    -3.54   0.000    -.9125716   -.2626888
_IidXover_24 |  -1.194826   .2399773    -4.98   0.000    -1.665173   -.7244794
------------------------------------------------------------------------------
(y==0 is the base outcome)
```

As it can be seen things change a little for some counties the overvaluation variable being insignificant or having the wrong sign. Therefore it can be inferred that overvaluation is not equally important for all countries in signaling a fore coming crisis. However the test shows that both the overall country dummy and the overvaluation variable well as the interaction terms are statistically significant. The models general degree of explanation is relatively the same as the model employing only country dummies.

Appendix 3 – Balassa-Samuelson Graphs

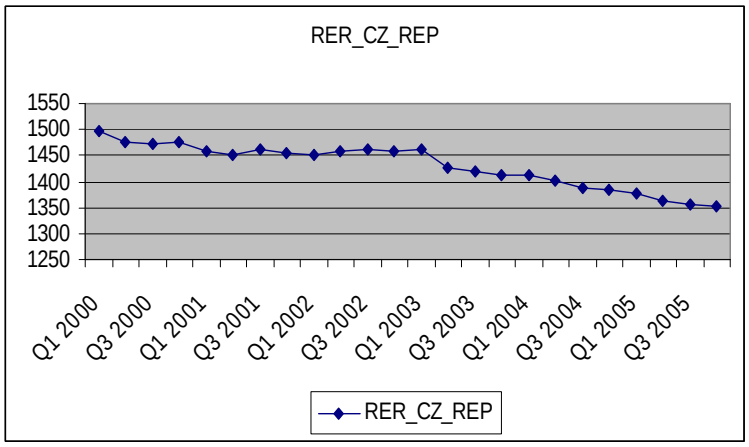

Fig. 1 Real exchange rate evolution in The Czech Republic

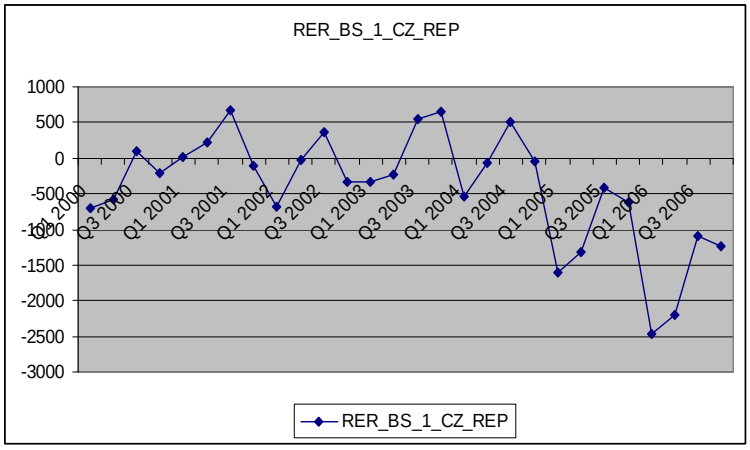

Fig. 2 RER_BS (industry=T; services=NT)

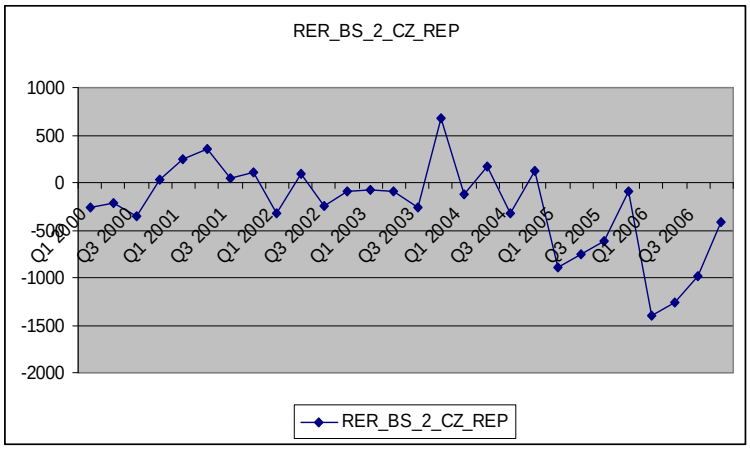

Fig. 3 RER_BS (industry and agriculture=T; services=NT)

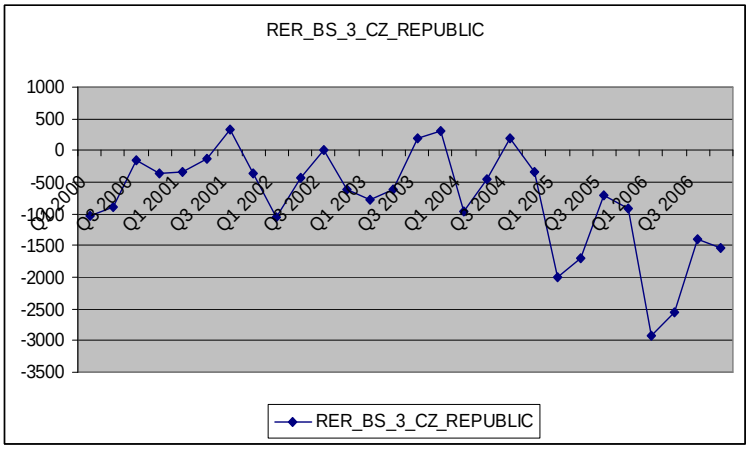

Fig. 5 RER_BS (industry=T; services and construction=NT)

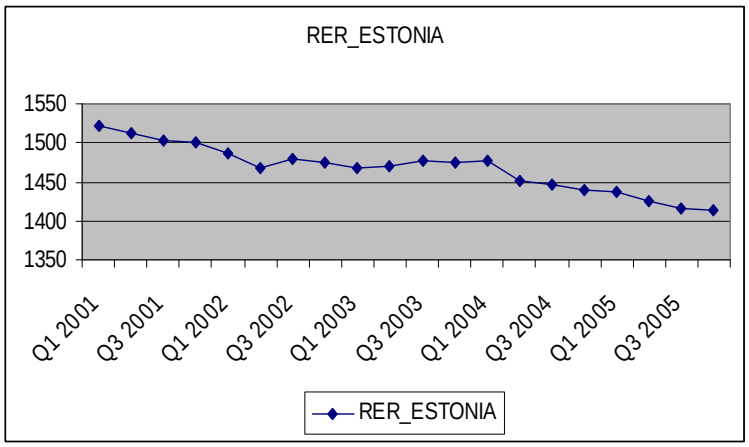

Fig. 5 Real exchange rate evolution in Estonia

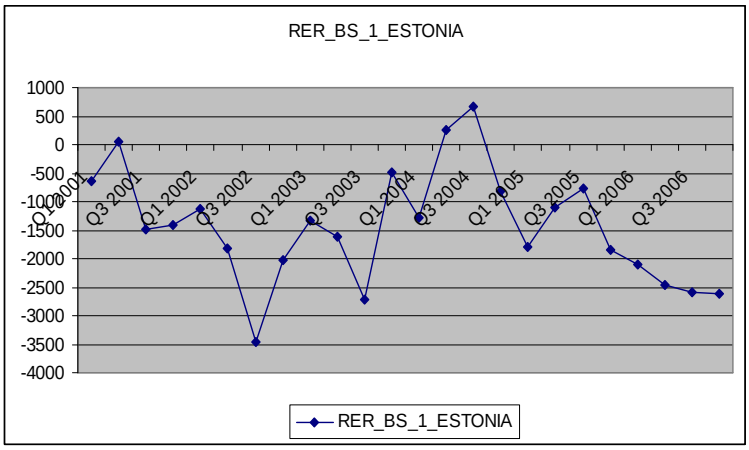

Fig. 6 RER_BS (industry=T; services=NT)

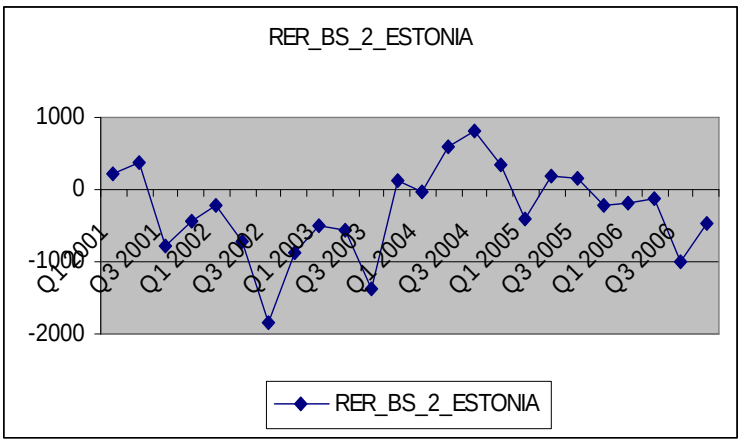

Fig. 7 RER_BS (industry and agriculture=T; services=NT)

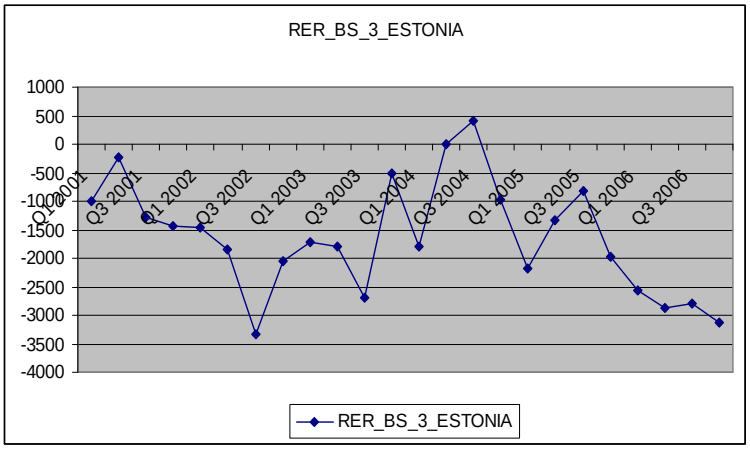

Fig. 8 RER_BS (industry=T; services and construction=NT)

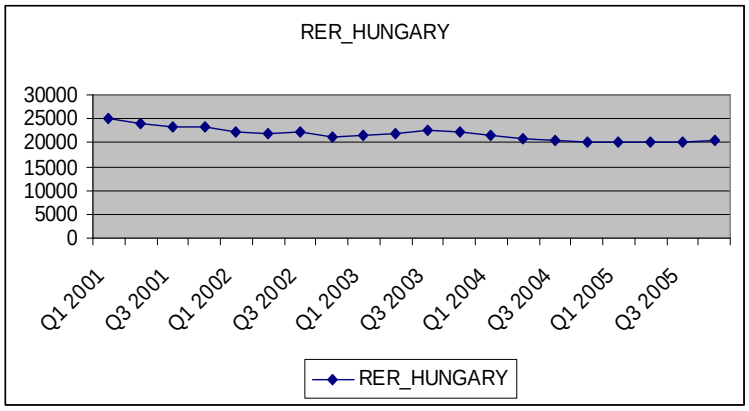

Fig. 9 Real exchange rate evolution in Hungary

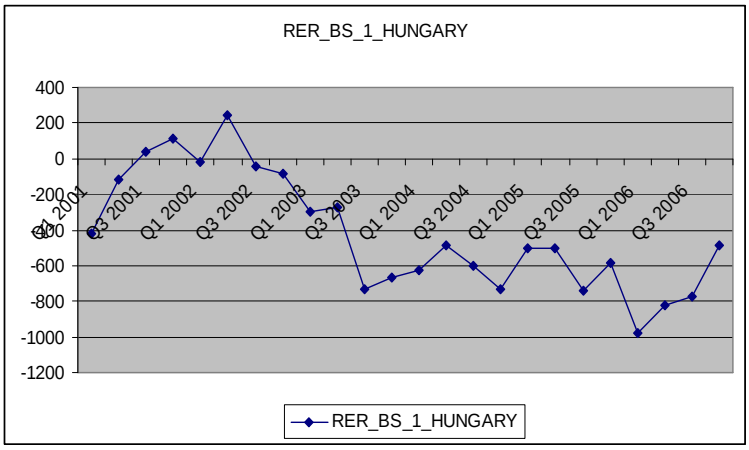

Fig. 10 RER_BS (industry=T; services=NT)

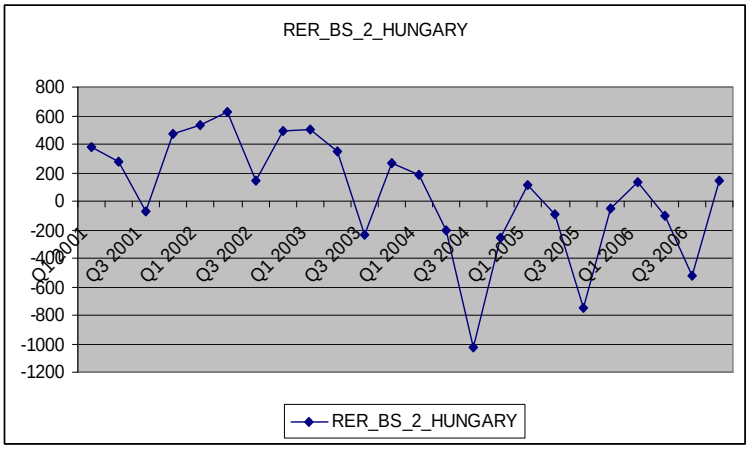

Fig. 11 RER_BS (industry and agriculture=T; services=NT)

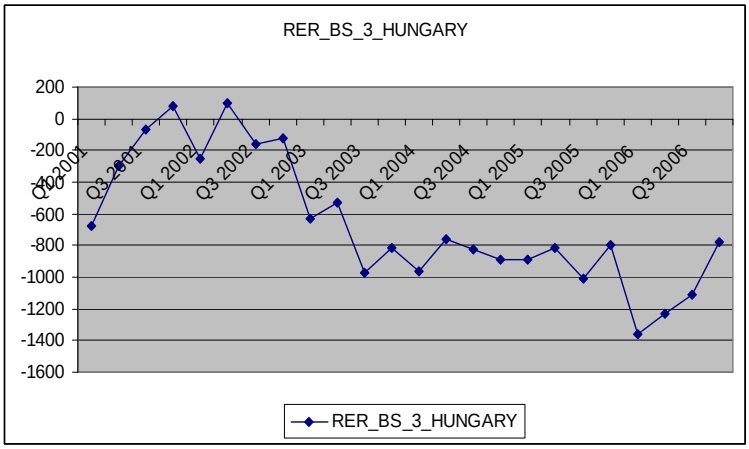

Fig. 12 RER_BS (industry=T; services and construction=NT)

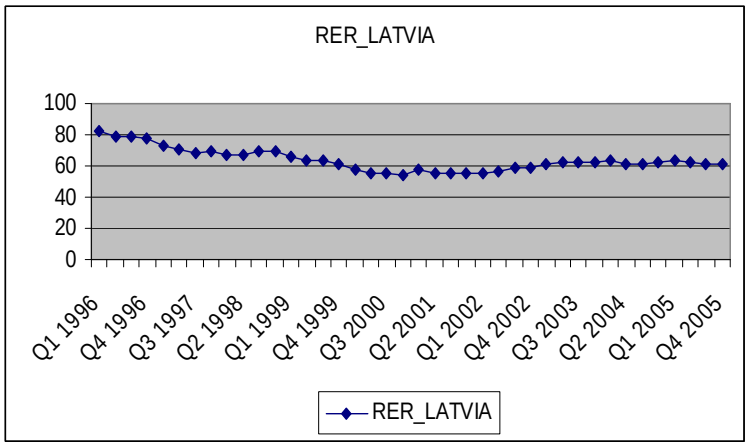

Fig. 13 Real exchange rate evolution in Latvia

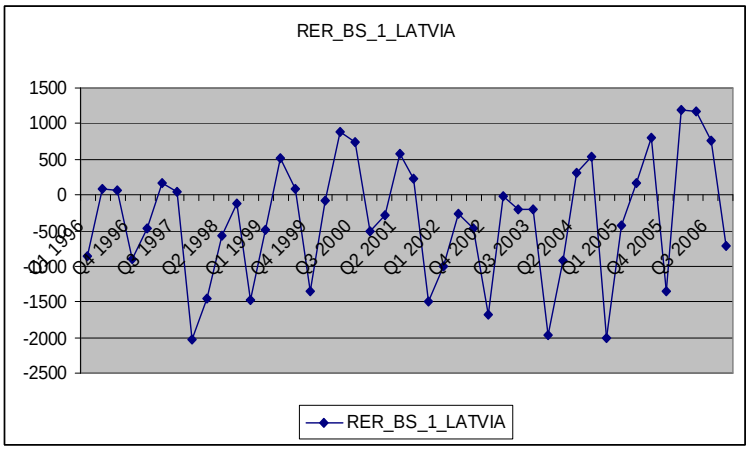

Fig. 14 RER_BS (industry=T; services=NT)

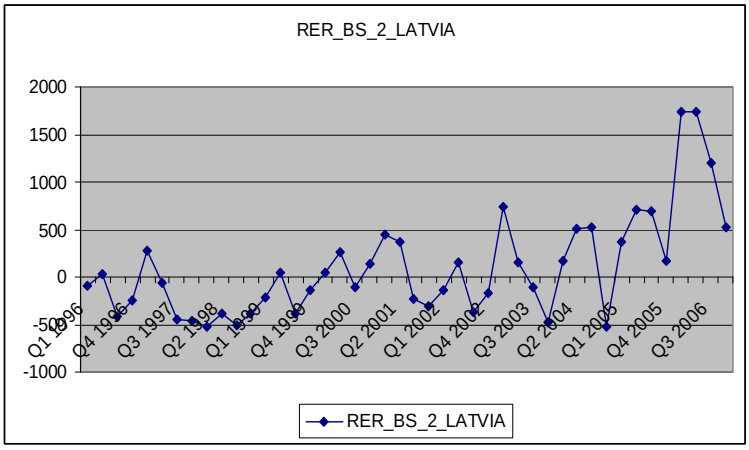

Fig. 15 RER_BS (industry and agriculture=T; services=NT)

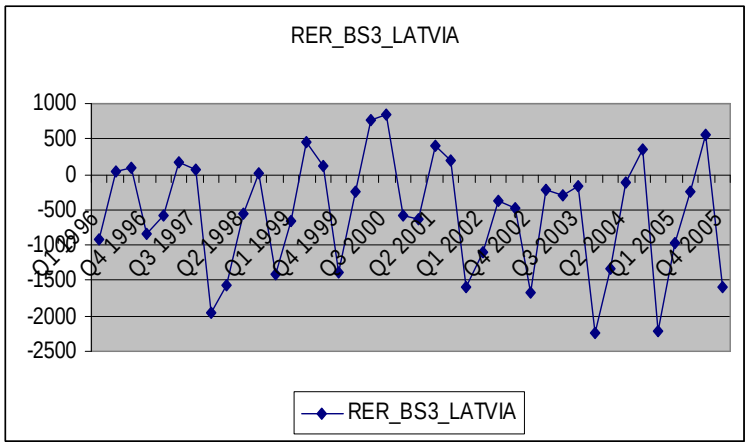

Fig. 16 RER_BS (industry=T; services and construction=NT)

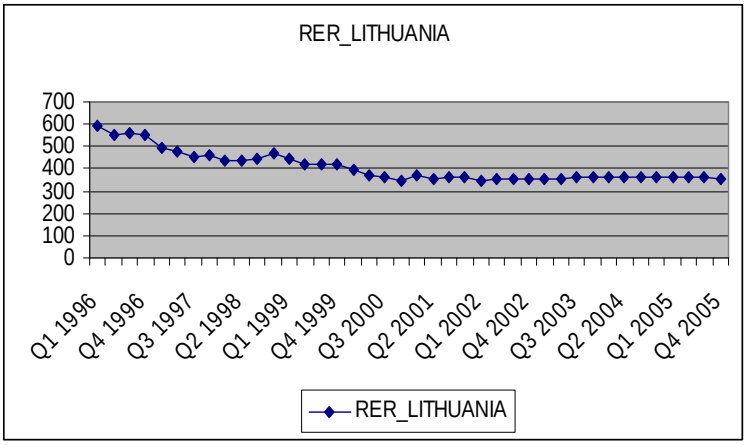

Fig. 17 Real exchange rate evolution in Lithuania

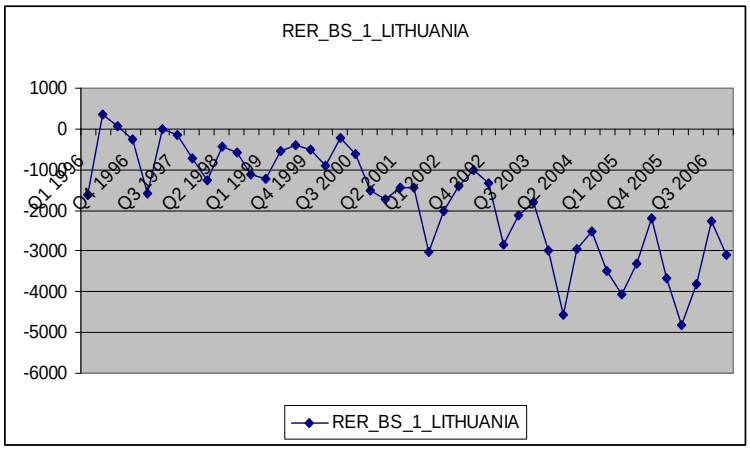

Fig. 18 RER_BS (industry=T; services=NT)

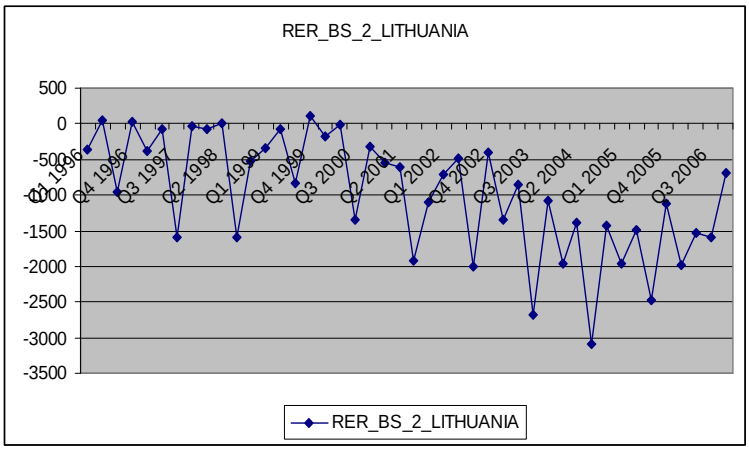

Fig. 19 RER_BS (industry and agriculture=T; services=NT)

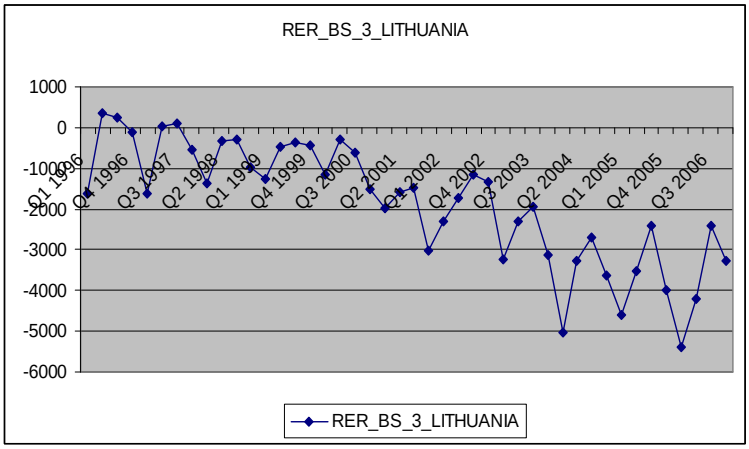

Fig. 20 RER_BS (industry=T; services and construction=NT)

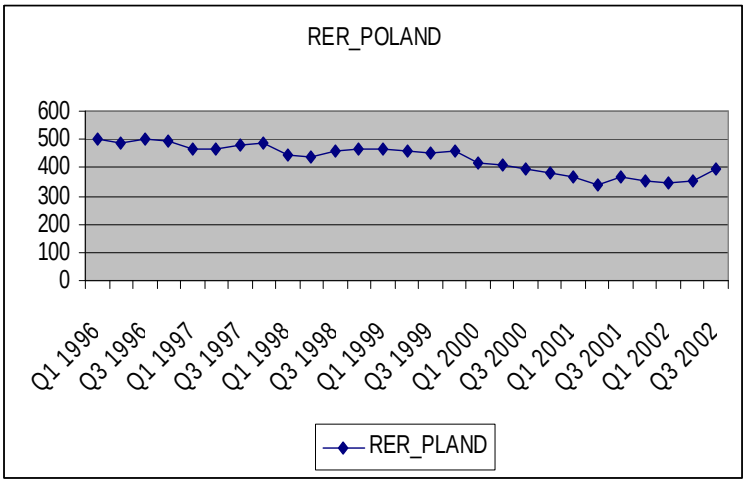

Fig. 21 Real exchange rate evolution in Poland

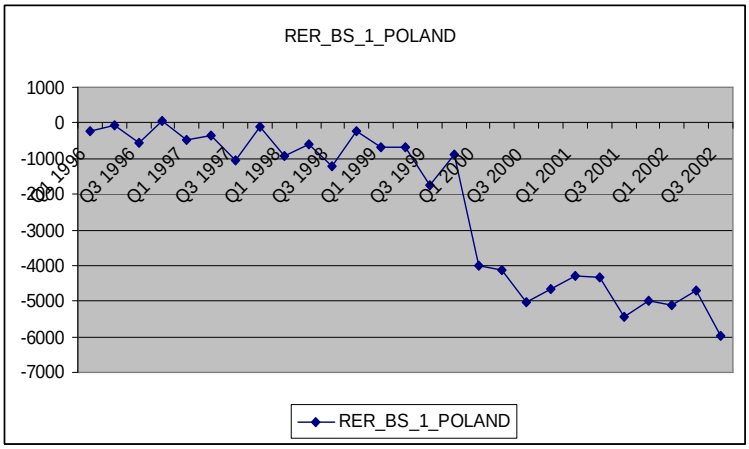

Fig. 22 RER_BS (industry=T; services=NT)

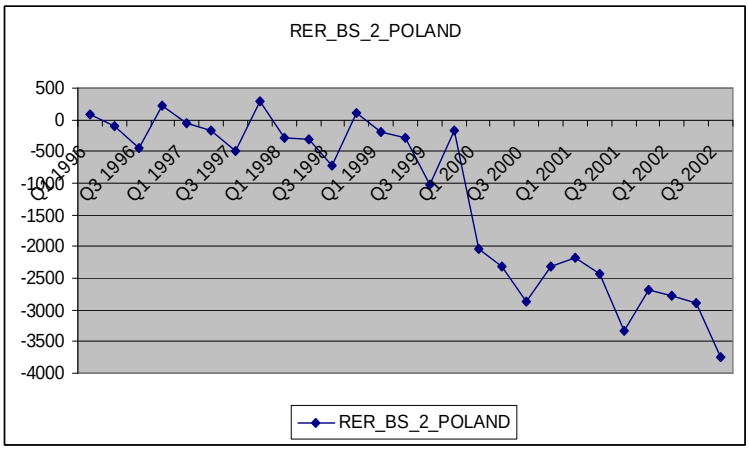

Fig. 23 RER_BS (industry and agriculture=T; services=NT)

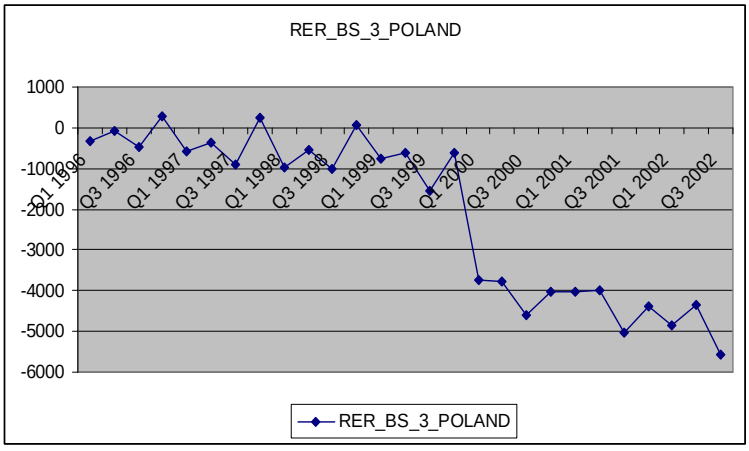

Fig. 24 RER_BS (industry=T; services and construction=NT)

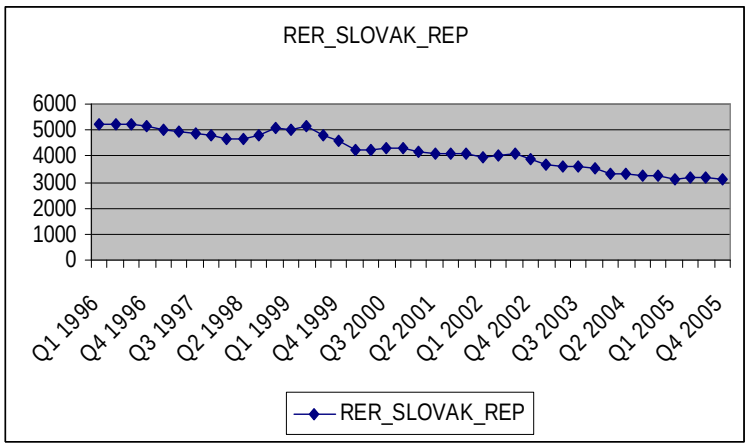

Fig. 25 Real exchange rate evolution in The Slovak Republic

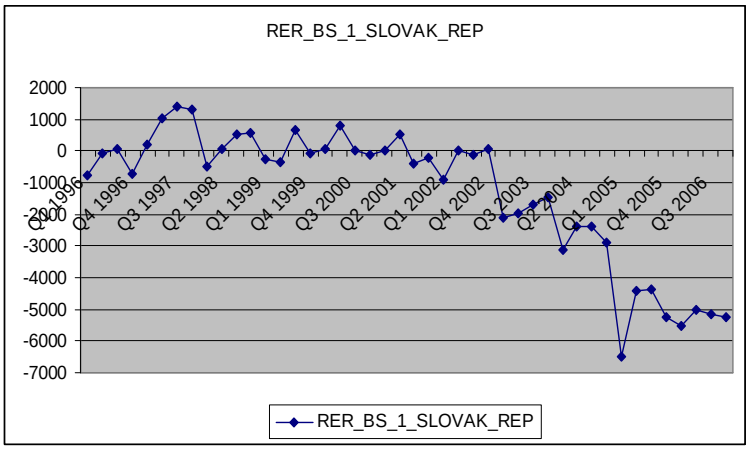

Fig. 26 RER_BS (industry=T; services=NT)

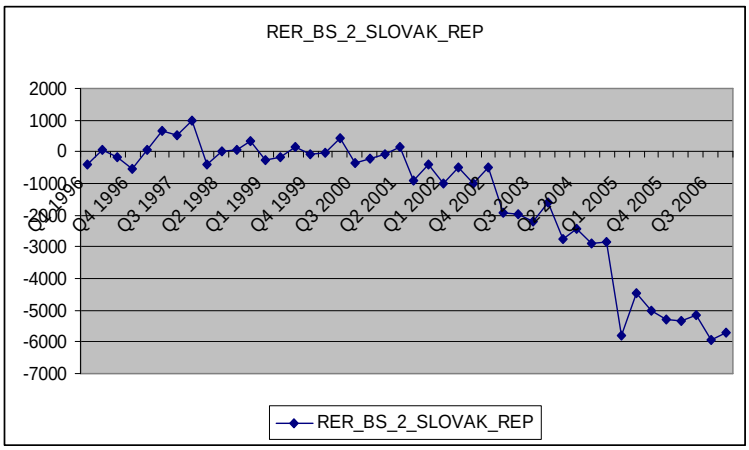

Fig. 27 RER_BS (industry and agriculture=T; services=NT)

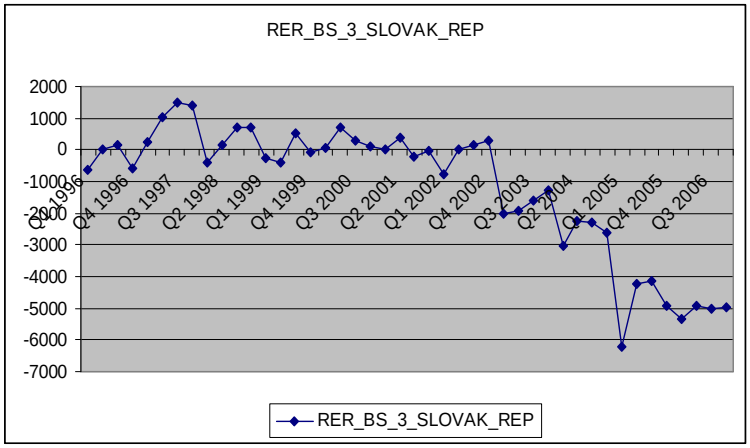

Fig. 28 RER_BS (industry=T; services and construction=NT)

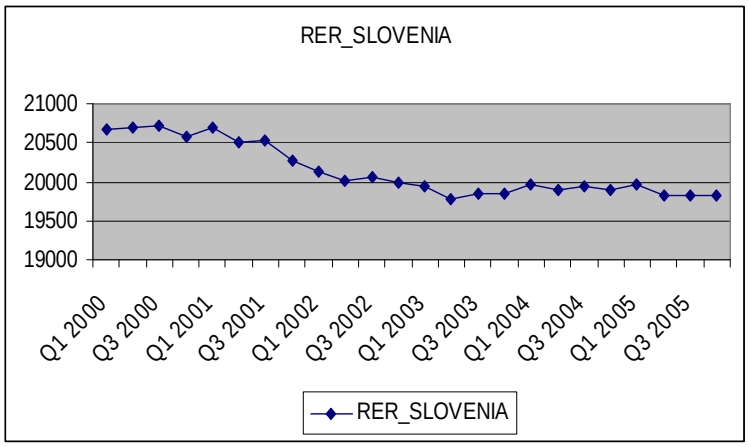

Fig. 29 Real exchange rate evolution in Slovenia

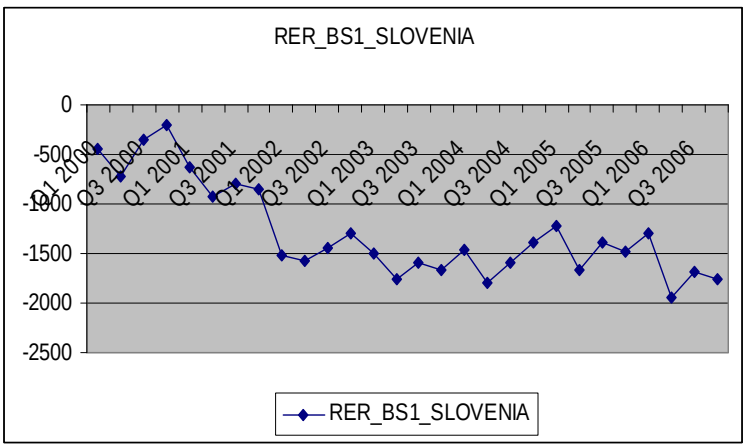

Fig. 30 RER_BS (industry=T; services=NT)

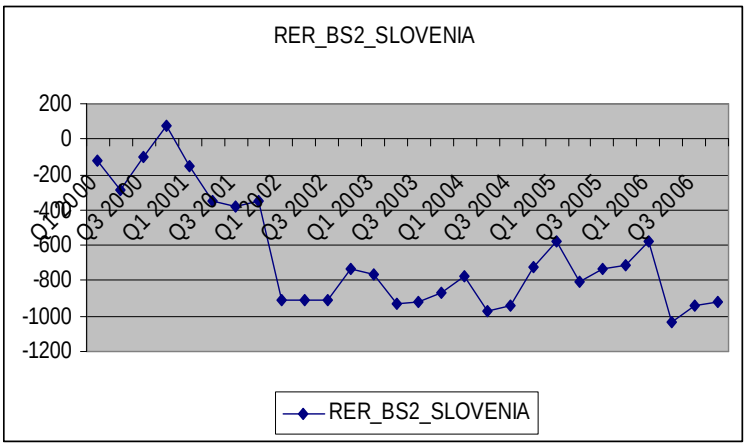

Fig. 31 RER_BS (industry and agriculture=T; services=NT)

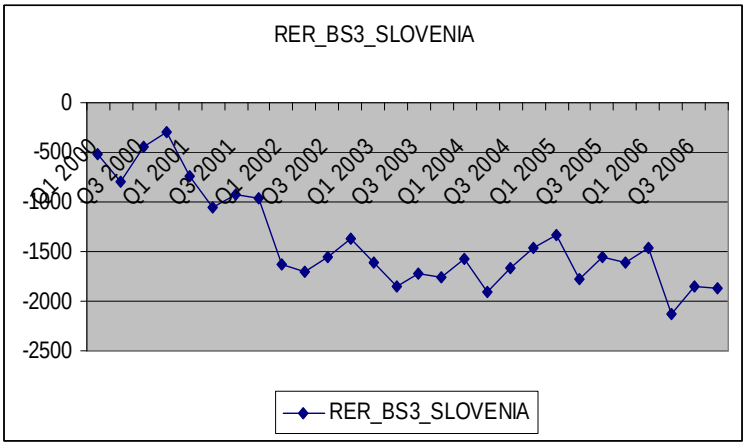

Fig. 32 RER_BS (industry=T; services and construction=NT)

Appendix 4 – Statistics

Significance tests

Table 1- Model without country dummies

Overvaluation	m2_res	ca_gdp	lending_boom
chi2(2)=215.17	chi2(2) = 20.40	chi2(2) = 49.02	chi2(2) = 8.71
Prob>chi2=0.0000	Prob>chi2=0.0000	Prob>chi2=0.0000	Prob>chi2=0.0128

Table 2a- Model with country dummies

overvaluation	m2_res	ca_gdp	lending_boom	Id's
chi2(2)=245.42	chi2(2)=34.89	chi2(2)=5.82	chi2(2)=11.84	chi2(39) = 930.13
Prob>chi2=0.0000	Prob>chi2=0.0000	Prob>chi2=0.0546	Prob>chi2 =0.0027	Prob>chi2=0.0000

Table 2b- Model with country dummies and interaction terms

overvaluation	m2_res	ca_gdp	Iid_'s	lending_boom	Iid_'s*overval.
chi2(2)=13.81	chi2(2)=23.03	chi2(2)=3.93	chi2(39)=930.13	chi2(2)=5.05	chi2(37)=142.25
Prob>chi2=0.0010	Prob>chi2=0.00	Prob>chi2= 0.1404	Prob>chi2=0.00	Prob>chi2=0.0799	Prob>chi2=0.0000

Table 3 Unit root tests

Table 3a- Overvaluation

Panel unit root test: Summary
Sample: 1994M01 2006M12
Exogenous variables: Individual effects
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.26034	0.0000	21	2896
Breitung t-stat	-8.12070	0.0000	21	2875
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-14.1747	0.0000	21	2896
ADF - Fisher Chi-square	308.483	0.0000	21	2896
PP - Fisher Chi-square	253.738	0.0000	21	2912

Table 3b-M2/Reserves

Sample: 1994M01 2006M12
Exogenous variables: Individual effects
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-4.51044	0.0000	24	3576
Breitung t-stat	1.32826	0.9080	24	3552
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.21933	0.0000	24	3576
ADF - Fisher Chi-square	143.185	0.0000	24	3576
PP - Fisher Chi-square	141.221	0.0000	24	3599

Table 3c-NGC/GDP

Sample: 1994M01 2006M12
Exogenous variables: Individual effects
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-28.3254	0.0000	24	3324
Breitung t-stat	-7.46281	0.0000	24	3300
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-32.9847	0.0000	24	3324
ADF - Fisher Chi-square	1009.10	0.0000	24	3324
PP - Fisher Chi-square	1527.79	0.0000	24	3368

Table 3d-CA/GDP

Sample: 1994M01 2006M12
Exogenous variables: Individual effects
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	3.65463	0.9999	24	3080
Breitung t-stat	-0.88633	0.1877	24	3056
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.13050	0.0009	24	3080
ADF - Fisher Chi-square	76.4020	0.0056	24	3080
PP - Fisher Chi-square	112.605	0.0000	24	3239