STOCKHOLM SCHOOL OF ECONOMICS
DEPARTMENT OF ECONOMICS
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# CRISIS IN EASTERN EUROPE
# –
# SELF-INFLICTED OR JUST BAD LUCK?

ABSTRACT:
Using a sample of sixteen countries in Eastern Europe, we investigate whether economic fundamentals explain why some countries have suffered more than others in the current financial crisis, or whether the variation just reflects contagion. The theory is that countries with weak fundamentals, captured by an appreciated real exchange rate and a weak banking system, and low levels of foreign exchange reserves are more vulnerable to a currency crisis, measured as an index of the nominal exchange rate depreciation and changes in reserves. Our analysis cannot confirm this theory, which could indicate that contagion is the main cause of variation in crisis vulnerability. When we then include current account and capital inflow as additional explanatory variables, the model becomes considerably better at explaining variations in the crisis index. This leads us to the conclusion that both current account and capital inflow are highly important factors behind the current crisis in Eastern Europe

KEY WORDS:
Eastern Europe, contagion, currency crisis, crisis index, fundamentals, foreign exchange reserves, current account and capital inflows.

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# 1. Introduction

## *1.1 From boom to bust*

On Sunday September 14, 2008, the prominent securities firm Lehman Brothers filed for bankruptcy protection and hurtled toward liquidation after it failed to find a buyer and the Federal Reserve Bank declined to participate in creating a financial support facility. This event marked the beginning of what would turn out to be one of the most severe financial crises in modern times. At the time of writing, the crisis is still undergoing, and many countries are suffering. One region that has attracted much attention for its deteriorating economic performance following the crisis is Eastern Europe.

However, the situation in Eastern Europe was very different only last summer. In August 2008, the IMF Survey Magazine (Vamvadakis, August 1, 2008) concluded in an article that the new EU members in Eastern Europe had made substantial progress on the structural front, reducing the role of the state in the economy and creating a business-friendly environment, which led to a wave of new investments, including foreign direct investments. In addition, these countries were found to be very open to international trade, and had labor markets that were more flexible than those of the euro area. Independent central banks across the region did also improve their credibility in safeguarding macroeconomic stability. The result of these factors in terms of growth rates has been impressive. Compared with other emerging economies, only emerging Asia has been growing faster in the current decade. This performance allowed emerging Europe[1] to start closing its large income gap with the advanced European economies.

Today, the once-booming Eastern European economy has ground to an abrupt halt. The Estonians, Latvians and Lithuanians, who for years enjoyed growth rates of between 7 and 10 percent, must resign themselves to the fact that their economies are shrinking. Hungary has already tapped the International Monetary Fund, the World Bank and the EU for $27 billion, and Romania, the country that recorded the largest number of new registrations of Porsche Cayennes worldwide in 2008, will need just as much (Puhl, March 23, 2009). In the fourth quarter of 2008 alone, the Poles produced 5 percent less than in the same period in 2007. In the Czech Republic, unemployment has risen to 12 percent. Only a year ago, the Czech Republic enjoyed almost full employment.

Many experts warned that the situation in Eastern Europe was unsustainable even before the crisis erupted. Concerns were raised toward the huge current account deficits which suggested that many of the East European countries were living beyond their means. Lane and Milesi-Ferretti (2007) concluded that the stock of external liabilities was high by international standards in several Central and East European countries, and the needed adjustment in the trade balance

[1] IMF defines emerging Europe to include (1) countries that joined the EU in 2004 or thereafter and had not joined the euro area by end-2008 (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and the Slovak Republic), and (2) the non-EU countries of Albania, Belarus, Bosnia and Herzegovina, Croatia, FYR Macedonia, Moldova, Montenegro, Russia, Serbia, Turkey and Ukraine.

over the medium term was substantial, a task not made easier by the limited room for exchange rate correction. IMFs *Regional Economic Outlook: Europe, May 2009*, supports this conclusion. Here, indicators of overheating, such as large current account deficits, fast credit growth and accelerating inflation were found to be most severe in countries most affected by the crisis.

Excessive lending has been identified as another problematic issue. Cottarelli, Dell'Ariccia and Vladkova-Hollar (2005) demonstrate how commercial banks in Eastern Europe, following a period of privatization and restructuring in the 1990s, rapidly expanded their lending to the private sector. The IMF (Tamirisa and Igan, September 25, 2007) has numerous times raised concerns about the quality of some bank portfolios and underscored the importance of forward-looking and risk-based supervision to keep the risks associated with rapid credit growth at manageable levels. In some Eastern European countries, the lending to both public and private sectors has been in foreign currency, which may be difficult to refinance. Research by the IMF (Rosenberg, October 28, 2008) showed that 15 percent of outstanding private sector credit in Eastern Europe 2008 was either denominated in, or indexed to, foreign currencies, compared with only 4 percent a decade ago. Yet another concern in emerging Europe has been inflation. Half of the countries hit double-digit inflation in 2008, with the highest rates observed in Ukraine, followed by Latvia, Belarus and Russia. The IMF concluded in its *Regional Economic Outlook: Europe, October 2008,* that global energy and food price increases is the main cause. These price shocks have affected emerging Europe substantially more than the rest of Europe due to a larger share of food and fuel in these countries' consumption baskets. In our analysis, we will come back to several of these possible indicators discussed above and see whether or not they have affected the severity of the crisis among Eastern European countries.

## *1.2 Our contribution*

The purpose of this thesis is to investigate whether economic fundamentals explain why some countries in Eastern Europe have suffered more than others in the current financial crisis, or whether the variation just reflects contagion. Do the countries that have suffered most in Eastern Europe have themselves to blame, or was it just bad luck? In order to investigate this, we will follow the method developed by Jeffrey D. Sachs, Aaron Tornell, Andrés Velasco in their paper *Financial Crises in Emerging Markets: The Lessons from 1995* (from now on referred to as STV), were they examine the financial events following the Mexican peso crisis of December 1994. STV found three variables that determine a country's vulnerability to a financial crisis: an appreciated real exchange rate, a weak banking system (together referred to as weak fundamentals) and low levels of foreign exchange reserves. We test whether the same three variables, as well as two additional variables, can explain the current financial crisis in Eastern Europe, or whether the crisis is due to contagion, that is, reasons other than economic fundamentals.

Our analysis is performed in two steps. First, we test a benchmark model with our own data, for the first five months of the crisis, on real exchange rates, bank lending and levels of reserves for

sixteen Eastern European countries. We investigate whether countries with an appreciated real exchange rate, a weak banking system and low levels of foreign exchange reserves have been more severely hit by the crisis. Our results do not support this theory. We then expand the model by including two additional variables, current accounts and capital inflows. Our results show that these two variables are important in explaining the crisis in Eastern Europe.

In the next section, we will give a theoretical background of the subjects of currency crisis and contagion. STV's model will also be presented here. We then describe our own empirical work and results in section 3. Section 4 contains our conclusion and in section 5 we discuss our results and the method used.

# 2. Theoretical framework

As mentioned above, we apply a model developed by STV in trying to determine if economic fundamentals explain why some countries in Eastern Europe have suffered more than others in the current financial crisis, or whether the variation only reflects contagion. In this section of the paper, we will account for the theory behind the model. The model has its theoretical origin in the first generation currency crisis models, developed by Krugman (1979), and second generation currency crisis models, developed by Obsfeldt (1994) and Eichengreen, Rose, and Wyplosz (1995). Breuer (2004) makes a distinction between the core mechanisms of first and second generation models. First generation models are based on macroeconomic fundamentals and speculation. Second generation models bring in speculation based on self-fulfilling expectations that is not linked to fundamentals. The model we will use contains elements of both first and second generation models. In the following subsections we will briefly describe first and second generation currency crisis models. Thereafter, we explain for the model we will use and how it is connected to earlier currency crisis models.

Before we proceed we believe it is necessary to clarify our alternating use of the terms financial crisis and currency crisis. In our paper we will treat the two types of crisis as essentially the same thing, though we are aware that a distinction between the two is sometimes made in the literature. As the current crisis is often called a financial crisis this term is also used when we describe the purpose of our paper. In this section, however, we will use the term currency crisis when describing the model we use. Although it entails introducing a new term we believe it avoids rather than adds confusion, as the model we use, STV's model, has its theoretical origin in what is widely known as currency crisis models.

## *2.1 First generation currency crisis models*

First generation currency crisis models were developed in the late 1970s and reflect the economic problems of the time in which they were created. Inflation, as the result of excessively expansionary monetary and fiscal policies, created overvalued currencies. According to Eichengreen and Jeanne (2000), this, in combination with restricted capital markets, limited the scope for central banks and governments to borrow in order to protect the pegged exchange rates.

In the first generation models, Krugman (2000) establishes that the linkage between speculation against a currency and the devaluation of that currency is mechanical. Speculation inevitably leads to a depletion of the foreign exchange reserves, which, in turn, forces the central bank to abandon the fixed parity. Speculative attacks, and thus currency crisis, occur as a result of a conflict between the stance of monetary and fiscal policies on the one hand, and the exchange rate commitment on the other hand. Expanding on this, Eichengreen and Jeanne (2000) state that an attack is assumed to take place when excessive public spending runs down the central bank's foreign exchange reserves. Drazen (2000) notes that the peg does not collapse at the date when the reserves are depleted but at an earlier date, namely, at the first point in time that optimal investor behavior implies that a speculative attack will be successful.

Breuer (2004) finds the first generation models helpful in explaining currency crises which occur as a result of unsustainable macroeconomic fundamentals, such as monetized public deficits or chronic current account deficits. These conditions can serve as an indication of a pending speculative attack on the currency. Drazen (2000) criticizes first generation models for being unrealistic in describing the decision to abandon the fixed exchange rate. In the model policy makers are passive, neither defending the exchange rate policy nor adjusting their inconsistent policy objective, to fend of a speculative attack. Furthermore, Saxena (2004) argues that the theoretical model entails a smooth adjustment of the exchange rate, as the regime shifts from fixed to flexible. Empirical observations, however, tell a different story where countries experience quick, unexpected and large devaluations.

## *2.2 Second generation currency crisis models*

In second generation models an attack against a currency can occur despite strong macroeconomic fundamentals, according to Breuer (2004). As described by Krugman (2000), the models assume that the government is able to defend the peg indefinitely by raising interest rates. The government may decide that the cost of defending the peg is greater than the political cost, in terms of credibility loss, that abandoning the peg would entail. In this model the currency crisis develops because doubts about the central banks commitment to defend the peg forces it to raise interest rates, and the need to maintain high interest rates in turn raises the cost of defending the peg to levels the government finds unacceptable.

Another central element of the second generation framework, mentioned in Saxena (2004), is that the most important trigger of a crisis is people's expectations. Despite a fundamentally strong economy, people's expectation of a pending devaluation could cause massive pressure on the central bank. If a sufficient number of people act on their expectations, devaluation is necessary. This scenario is called a self-fulfilling crisis and is the result of self-fulfilling expectations. According to Krugman (2000), self-fulfilling expectations is when a fixed exchange rate that could, and would, last indefinitely if not attacked by speculators collapses because financial markets are persuaded that the fixed exchange rate is unsustainable, perhaps by otherwise irrelevant information.

The speculative attacks of the early 1990s stimulated the development of the second generation models. These progressed in an economic environment fundamentally different from that prevailing during the 1970s, which had influenced the first generation models. When the second generation models were developed capital mobility was significant and the ability of the central banks to borrow improved, according to Eichengreen and Jeanne (2000). Moreover, the crises during the early 1990s occurred in the absence of apparent evidence of balance of payment problems that were the chief culprit of crises in the first generation models. They did however, take place in the presence of high unemployment, which in turn made governments unwilling to raise interest rates and restrict credit in order to defend their currencies.

Krugman (1996) summarizes how the driving forces of two currency crisis models are fundamentally different. In the second generation models the driver of crisis boils down to self-fulfilling expectations whereas the crisis is determined by fundamentals in the first generation model. The difference affects the predictability of a crisis. First generation deteriorating fundamentals makes a crisis inevitable whilst the self-fulfilling logic of the second generation model makes the occurrence of crisis unpredictable.

## *2.3 First and second generation vs. STV*

As earlier currency crisis models, STV's model is based on a theoretical argument. This argument will be described below. In describing the argument, theoretical links to the first and second generation currency crisis models will be discussed. The next subsection will explain the model algebraically and in greater detail.

The model is derived from the following argument which describes the effects of capital outflows from a country. As financial investors attempt to avoid short-term capital loss, they divest countries in which they expect a large, imminent nominal exchange rate depreciation. A country can meet a sudden reduction in the capital account by running down reserves. However, in order to close a sustained external gap, a reduction in the current account deficit must occur. This correction can take place through either of two mechanisms; a fall in absorption (a reduction in domestic investment and consumption) or a real exchange rate depreciation (can only be achieved through a nominal depreciation on short-term). The depreciation will be larger the more appreciated is the real exchange rate relative to the level compatible to the lower capital inflows. Moreover, a more appreciated real exchange rate makes the government less prone to endure recession since an appreciated real exchange rate often entails overvalued assets and high interest rates. A key determinant in the decision to endure recession is the health of the banking system. When banks have high bad loans ratios a recession is likely to generate many bankruptcies. Therefore, the more fragile the banking system, the less probable the government is to voluntarily set the economy in recession.

The argument above identifies three variables that characterise a country vulnerable to a crisis: a large appreciation of the real exchange rate, a weak banking system, and low levels of foreign exchange reserves. According to the STV model, only countries going into the crisis with weak

fundamentals, i.e. an appreciated real exchange rate and a weak banking system, as well as low level of reserves are vulnerable to crisis. We will continue by explaining the economic mechanisms behind the variables as well as comment on theoretical similarities with first and second generation currency crisis models.

Real exchange rate appreciation during the capital inflow period is recognized as an indicator of larger risk for currency depreciation and thus crisis in STV's argument. The link between exchange rate appreciation and capital inflow is also highlighted in a study of Latin America by Calvo, Leiderman and Reinhart (1993). They describe the mechanism by which capital inflows lead to an appreciated real exchange rate. Capital inflow from abroad brings about an increase in domestic absorption. If a fraction of the increase in spending falls on non-traded goods, their relative price will rise, and thus the real exchange rate will appreciate.

A weak banking system affects a country's vulnerability to crisis, although it is difficult to measure directly. Therefore, STV use increase in bank lending, lending boom, as compared to pre-crisis levels, as a proxy for bank system fragility. It is assumed that a banks' ability to screen projects decreases when the economy is in an expansion phase, which, in turn, leads to a larger share of weak borrowers. According to Breuer (2004), the overlending/overborrowing paradigm and the relationship to activities in the banking sector found in STV's model are typical of what is labeled third generation currency crisis models.

As in first generation models, foreign reserves are an important factor in determining crisis in STV's model. However, there is one significant difference. Instead of looking at foreign reserves in isolation it is compared to a broad measure of liquid monetary assets (M2). The reason for choosing M2 as a measure of money supply is that the government must be prepared to cover not only direct liabilities, the monetary base, but also the liabilities of commercial banks. M2 include both these types of liabilities. As Calvo (1995) notes, even though no country offers unlimited deposit insurance, it is hard to find examples where depositors have not received sizeable compensation after a banking crisis. Thus, the government becomes partially responsible for bank debt, especially short-maturity debt.

The tree variables listed above (degree of appreciation of the real exchange rate, strength of the banking system and level of foreign exchange reserves) are chosen as they are believed to explain the vulnerability of a country to crisis. In order to determine the influence of these variables a measurement of crisis is needed. To this end STV develop a crisis index, designed to measure the extent of a crisis in a particular country. The crisis index is a weighted average of the devaluation rate with respect to US dollar and the percentage change in foreign exchange reserves. The index is designed to act as proxy for cross-country interest rate data. In this, we see a link to the second generation currency crisis model, in which interest rate differentials plays a significant role in the development of a crisis.

STV's theory stipulates that only countries with weak fundamentals and low levels of reserves are vulnerable to crisis. There are consequently different equilibria for countries with weak fundamentals and low reserves and countries with strong fundamentals and high reserves. STV's framework is thus based on multiple equilibria. The shift in expectations (self-fulfilling expectations) generates a pessimistic equilibria in weak countries while strong countries do not suffer. This makes it impossible to predict the timing of a currency crisis in STV's framework.

## *2.4 STV's currency crisis model*

Below, we provide an algebraic explanation of STV's model. It is a formalization of the argument presented in the previous subsection. The model suggests that countries with real exchange rate appreciation, weak banking systems and low levels of international reserves are likely to be victims of currency crisis. The model starts with a government managing a pegged exchange rate, with nominal exchange rate $E_0$, and real exchange rate $E_0/P$, where $P$ is the ratio of the domestic price level to the foreign price level. $P$ is assumed to be equal to one. The peg is sustainable as long as foreign exchange reserves, $R$, are sufficient to cover net capital outflows, $K$. If the government runs out of reserves, when $K > R$, devaluation occurs. A new nominal exchange rate, $E^T$, is then established in order to achieve a target real exchange rate.

The new target $E^T$ must, besides reflecting variables such as the terms of trade and degree of trade and financial liberalization, also reflect the health of the banking system. STV judge banking sector vulnerability in terms of whether or not the economy has experienced a lending boom ($LB$). Hence, the target real exchange rate may be written as

$$E_T = e \ \mathrm{f}(LB), \qquad \mathrm{f}'(LB) > 0, \qquad \mathrm{f}(0) = 1,$$

which means that the new nominal exchange rate, $E_T$, equals the long run real exchange rate $e$ times some function of lending boom. When the banking sector is sound, when $LB = 0$ and hence $\mathrm{f}(0) = 1$, the government will set $E_T$ at $e$. The potential course of the exchange rate can be summarized as

$$D = \begin{cases} (e/E_0) \times \mathrm{f}(LB) - 1 & \text{if } K > R \\ 0 & \text{if } K \le R \end{cases}$$

Devaluation, $D$, occurs when the capital outflow is greater than the level of reserves. The size of the devaluation is large when the exchange rate is initially appreciated relative to its long run average, $e/E_0$ is high, or when there has been a preceding lending boom, $\mathrm{f}(LB)$ is large. The size of capital outflows depend on the investors holding the funds. The investors' rule is simply to withdraw their funds if devaluation is expected to exceed a percentage, $\theta$, and maintain funds if devaluation is expected to be less than $\theta$. Assume that there are $N$ investors, each holding asset $k$. The total capital outflow, $K$, is then

$$K = \begin{cases} 0 & \text{if } D \leq \theta \\ N \times k & \text{if } D > \theta \end{cases}$$

Two alternative cases are then considered. First, assume that fundamentals are healthy in the sense that $(e/E_0) \times f(LB) - 1 \leq \theta$. In this case, any devaluation would be smaller than the investors' threshold for capital flight. Therefore, even in if a devaluation occurs, $K = 0$. And since $K = 0 < R$, there would not be a devaluation in this case. Next, assume that fundamentals are unhealthy in the sense that $(e/E_0) \times f(LB) - 1 > \theta$. In this case, devaluation might occur, depending on whether or not investors expect exchange rate stability or not.

To summarize, the model suggests that only countries with weak fundamentals (an overvalued real exchange rate and a weak banking system) and low levels of international reserves are a likely victims of a currency crisis. Countries with strong fundamentals and high levels of international reserves, on the other hand, are not considered vulnerable.

## *2.5 Contagion*

STV's paper discusses an alternative to the hypothesis that weak fundamentals and low levels of reserves cause crisis, namely, that it is triggered by contagion. However, the paper does not specify the meaning of contagion. Claessens and Forbes (2001) point out that contagion originally is a medical term which refers to the spread of disease. Despite being widely used in economic literature there is no agreement on what contagion entails, according to Forbes and Rigobon (2001). However, some generalizations on the use of the term in economic literature can be made. Contagion, in an economic context, deals with the spread of crisis. One way to explain the process of contagion is presented by, among others, Kaminsky and Reinhart (2000). They make a distinction between what is called fundamental based contagion and true contagion. Fundamental based contagion is the spread of crisis between countries via links in trade or finance. True contagion spreads shocks through other channels than economic fundamentals. These could be due to herding behavior, which refers to a situation where one investor withdraws money from a particular country for no other reason than another investor doing so.

As STV does not specify their use of the term contagion, an apt definition has to be found elsewhere. Using Kaminsky and Reinhart's dichotomy, STV's utilization of the term translates best to true contagion. However, we believe an even more suitable definition is offered by Masson (1998). Masson applies the term contagion to a situation where a crisis in one country triggers a crisis elsewhere for reasons other than macroeconomic fundamentals, potentially because the crisis changes market sentiments or alters interpretation of existing information. For example, a crisis could instigate a reassessment of the fundamentals of other countries among investors, even though the fundamentals have not changed. It could also lead to a decrease in risk tolerance of investors.

# 3. Empirics

In the previous section we described the theory of the model we use to determine if economic fundamentals explain why some countries in Eastern Europe have suffered more than others in the current financial crisis, or whether the variation only reflects contagion. We will now continue by accounting for how the variables of the model have been constructed (additional data information can be found in the Appendix). First, however, follows a specification of which Eastern European countries that are included in our study.

We have collected data from sixteen countries in Eastern Europe. These are the Baltic States Estonia, Latvia and Lithuania, the central European countries Hungary, the Czech Republic and Poland, the former Soviet Union countries Belarus, Russia, Ukraine and Moldova and the Balkan countries Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Macedonia and Romania. Slovakia and Slovenia are not included since they have adopted the euro, a currency that we will weigh other currencies against. Serbia and Montenegro are not included since these two countries were united between 2003 and 2006, which makes it almost impossible to get individual country data during the entire estimation period.

The number of countries in the region limits our sample. In addition, countries are excluded because of statistical considerations. We are left with only sixteen countries, which potentially can pose a problem when making the statistical analysis. But as Stock and Watson (2007) notes, the difference between the Student *t* distribution, which is the distribution we will use when making statistical tests, and the normal distribution is negligible if the sample size is not too small. When the number of observations is more than fifteen, the difference in *p*-values computed using the Student *t* and standard normal distributions never exceeds 0.01. Since we have sixteen observations in our sample, our limited sample size should after all not pose a serious problem.

## *3.1 Crisis starting date*

To measure differences in the severity of the crisis between countries, STV construct a crisis index as the weighted sum of the depreciation of the exchange rate and decrease in reserves. They choose November 1994 as their starting month for the crisis index, i.e. one month before the Mexican peso crisis broke out, and calculate the index to the end of each of the months up to June 1995. They then argue, that countries suffer more from a crisis when their banking systems were weak, measured by a lending boom variable (*LB*) measuring the growth in credit to the private sector from 1990 through 1994, when the exchange rate was overvalued, measured as the degree of depreciation from 1986–89 to 1990–94 (*RER*) and when the reserve adequacy was low, measured as the ratio of the broad measure of the money supply, M2, to the stock of foreign exchange reserves in November 1994 (*M2/R*). In order to apply this method on the current crisis, we have to choose our own starting month and then construct the different variables for our sixteen countries.

We have chosen September 2008 as the starting point for the current crisis. During this month, several events occurred that can be said to have triggered the crisis. The most important one was the bankruptcy of the securities firm Lehman Brothers on September 14. As Brunnermeier (2009) explains, the effects of Lehman's bankruptcy rippled throughout the global financial markets. As many banks and other financial institutions were exposed to Lehman Brothers, uncertainty about which borrowers were creditworthy rose dramatically. The credit markets deteriorated significantly in subsequent weeks. As explained by Sveriges Riksbank (Finansiell stabilitet 2009:1), most financial markets were affected by the events in the US. Trade in many securities disappeared completely and financial institutes had a harder time financing themselves. This credit crunch was the trigger of the global recession we are experiencing today. Thus, the combination of several important events taking place in September 2008 makes it the most suitable starting date of the current crisis.

## *3.2 Dependent variable – the crisis index*

We now proceed by describing the actual crisis index (denoted *IND*), which is designed to measure severity of crisis in a country. It is an index that measures the pressure on a country's foreign exchange market. The index consists of two components. The first one is a country's nominal exchange rate devaluation rate with respect to the US dollar. The second one is the percentage change in foreign exchange reserves. Naturally, the two series have different volatilities for each country. To correct for this, a country's *IND* is weighted by the ratio of its nominal exchange rate volatility relative to the sum of all countries nominal exchange rate volatility, over the volatility in foreign exchange reserve changes relative to the sum of all countries volatility in foreign exchange reserve changes. Hence, the *IND* for country *i* is

$$IND_i = \frac{\Delta e_i}{e_i} - \frac{\sigma_i^e / \sum_i \sigma_i^e}{\sigma_i^R / \sum_i \sigma_i^R} \times \frac{\Delta R_i}{R_i}$$

The rationale for *IND* is the following. If capital starts to flow out of a country, the government has two options. It can either let the nominal exchange rate depreciate, meaning that $\Delta e_i/e_i$ will get larger. Alternatively, the government can defend the currency by running down reserves, meaning that $\Delta R_i/R_i$ will get negative. Consequently, a higher value of *IND* means a higher devaluation or a greater fall in reserves, or in other words, a more severe crisis. For each country, *IND* is calculated between the end of August 2008, one month before the start of the crisis in September, to the end of each of the following months up to January 2009. Table 1 below shows the crisis indices for our 16 countries (the indices are also illustrated in Figure 1 in the Appendix).

**Table 1: Crisis index**
Percentage changes

| Country | Aug-08 - Sep-08 | Aug-08 - Okt-08 | Aug-08 - Nov-08 | Aug-08 - Dec-08 | Aug-08 - Jan-09 |
|---|---|---|---|---|---|
| Albania | 5.7 | 20.1 | 18.0 | 8.5 | 19.1 |
| Belarus | 17.4 | 17.8 | 32.0 | 62.4 | 92.5 |
| Bosnia & Herzegovina | 6.2 | 26.4 | 31.7 | 17.9 | 25.0 |
| Bulgaria | 5.1 | 30.0 | 35.0 | 31.3 | 47.4 |
| Croatia | 8.1 | 34.6 | 38.6 | 28.4 | 50.5 |
| Czech Republic | 9.0 | 31.6 | 36.0 | 20.0 | 38.1 |
| Estonia | 13.3 | 13.5 | 26.4 | 16.6 | 25.3 |
| Hungary | 8.4 | 35.0 | 14.9 | -12.0 | 7.7 |
| Latvia | 0.9 | 16.0 | 35.7 | 20.0 | 27.0 |
| Lithuania | 6.3 | 15.7 | 30.7 | 14.3 | 23.6 |
| Macedonia | 3.2 | 15.7 | 25.7 | 17.8 | 24.6 |
| Moldova | 1.1 | 14.1 | 16.7 | 13.0 | 22.7 |
| Poland | 26.1 | 66.4 | 78.7 | 84.5 | 101.4 |
| Romania | 9.1 | 28.2 | 33.9 | 26.6 | 47.9 |
| Russia | 7.8 | 20.2 | 27.6 | 34.4 | 52.9 |
| Ukraine | 1.5 | 19.1 | 37.0 | 72.6 | 81.8 |

Source: Authors' own calculations. See appendix for data construction.

The crisis indices vary a great deal between the countries. Poland has the highest *IND* in every period. Albania, Hungary and Moldova are the countries with the lowest average *IND*, and Hungary even has a negative *IND* between August and December 2008. Hungary's positive performance has most likely to do with the massive loans the country received from the IMF, the World Bank and the EU during the fall of 2008, which increased the country's foreign exchange reserves dramatically (from $22,619 million in October to $33,788 million in December). It is important to note, that the crisis index of a country does not reflect the state of the economy as a whole, for example real variables.

## *3.3 Independent variables*

Below we will describe the three variables that are believed to influence the crisis index, the independent variables. The variables are the real exchange rate, lending boom and level of foreign exchange reserves. The theoretical background of these variables was described in section 2.

### 3.3.1 Real exchange rate

The real exchange rate index (*RER*) is calculated using domestic and foreign consumer price indices and nominal exchange rates. Of our sixteen countries, about half of them have pegged currencies. The three Baltic countries are members of the European Exchange Rate Mechanism (EMR II) and have their currencies pegged to the euro. Bosnia & Herzegovina, Bulgaria, Croatia and Macedonia have also pegged against the euro in different ways, whereas the Belarus currency has, since 2008, been pegged to the US dollar. The Russian exchange rate is managed

in order to reduce fluctuations to a basket of both the euro and the dollar. Seven countries have managed or independently floating currencies.

**Table 2. Exchange rate regimes**

| Currency board arrangement | Other conventional pegged arrangements | Managed floating with no predetermined path for the exchange rate | Independently floating |
|---|---|---|---|
| Bosnia & Herzegovina | Belarus | Ukraine | Albania |
| Bulgaria | Croatia | Moldova | Czech Republic |
| Estonia (ERM II) | Latvia (ERM II) | Romania | Hungary |
| Lithuania (ERM II) | Macedonia | | Poland |
| | Russia | | |

Source: *IMF's Annual Report on Exchange Arrangements and Exchange Restrictions 2007* and *2008*.

The *RER* is weighted in relation to the dollar, the euro and the yen. The weights sum to one and are proportional to a country's bilateral trade shares (both exports and imports) with the United States, Germany and Japan. The *RER* for country *i* is[2]

$$RER_i = \frac{CPI_i}{w_{US} \times (CPI_{US} \times E_{US}) + w_{DE} \times (CPI_{DE} \times E_{DE}) + w_{JP} \times (CPI_{JP} \times E_{JP})}$$

Source: *Valentine (2007)*

A negative value of the *RER* implies that the real exchange rate has appreciated. According to STV's model, a country with a low, or negative, *RER* is likely to be a victim of a currency crisis. We measure *RER* as the percentage change in the real exchange rate from the average of 1999-2002 to the average of 2003-07. Most of the countries studied have seen their real exchange rates depreciate, some of them substantially. For five countries, the real exchange rate has depreciated with over 100 percent as seen in Table 3 below. Two countries, Croatia and Latvia, have seen their real exchange rate appreciate.

The calculation of *RER* caused us some trouble since STV are not that explicit on how they compute the variable and why they make the choices they do. We chose to measure the *RER* with respect to the yen, the dollar and the euro, which are the same currencies as STV used, except that they used the D-mark instead of the euro. The changes between a country's exchange rate and those three exchange rates just mentioned were then weighted by the relative trade shares with Japan, the US and Germany. Of course we would have preferred to use the entire euro area instead of only Germany. But since IMF's *Direction of Trade Statistics* does not report trade data for the euro area as a whole, we chose Germany as it is the largest trading partner in the euro area for most of the countries in our sample.

[2] The *RER*-formula is essentially a modified version of the basic real exchange rate equation $\varepsilon = P / (E \times P^*)$, where $P$ is domestic price level, $P^*$ is foreign price level and $E$ is the nominal exchange rate.

In STV's case, it seems intuitive to use the yen, the dollar and the D-mark since STV use a sample of countries from all parts of the world. In our case, we have only studied countries from Eastern Europe. The benefit of including the yen and dollar in our calculations can certainly be questioned, as the trade shares with Japan and the US are negligible for many countries in Eastern Europe. We therefore considered including other currencies that are more frequently used in Eastern Europe, such as the British pound and the Swedish krona. But since we wanted to stay as close to STV method as possible, in order to maintain comparability, we decided keep the yen and the dollar.

### 3.3.2 Lending boom

The lending boom index (*LB*) is a measure of the size of the banking sector's claim on the private sector in relation to GDP. It is calculated as the percentage change in this ratio between 2003 and 2007.

As mentioned in the introduction, commercial bank lending to the private sector has increased dramatically in many Eastern European countries. This is also reflected in our own data, as shown in Table 3. For example, seven of our sixteen countries have increased their lending with more than 100 percent between 2003 and 2007. The country with the largest lending boom is Albania, with a 273.7 percent increase in lending. Croatia, with a 36.5 percent increase, is the country with the lowest increase in lending.

### 3.3.3 M2 to foreign exchange reserves

If the government is not willing to let the exchange rate devalue in the time of a crisis, it must be prepared to cover its liabilities with foreign exchange reserves. STV therefore construct a measure of reserve adequacy, measured as the ratio of money supply to reserves (*M2/R*). In our analysis, we use the ratio of M2 to reserves in August 2008 as the indicator of reserve adequacy for our sixteen countries. As can been seen in Table 3, the country with the highest reserve adequacy is Russia, with almost as much reserves as their money supply. The Czech Republic has the lowest reserve adequacy with a money supply more than four times larger than reserves.

**Table 3. Financial Indicators**
Percentage changes

| Country | Real depreciation (*RER*) | Lending boom (*LB*) | Reserve adequacy (*M2/R*) |
|---|---|---|---|
| Albania | 12.1 | 273.7 | 2.9 |
| Belarus | 15.5 | 123.0 | 1.6 |
| Bosnia & Herzegovina | 42.4 | 57.9 | 2.6 |
| Bulgaria | 16.4 | 138.8 | 1.7 |
| Croatia | -8.0 | 36.5 | 3.0 |
| Czech Republic | 82.4 | 58.5 | 4.2 |
| Estonia | 58.5 | 85.2 | 2.9 |
| Hungary | 164.8 | 48.0 | 3.3 |
| Latvia | -25.7 | 137.5 | 2.2 |
| Lithuania | 80.8 | 159.7 | 3.0 |
| Macedonia | 198.5 | 98.2 | 1.3 |
| Moldova | 156.0 | 85.3 | 1.3 |
| Poland | 49.1 | 54.2 | 3.6 |
| Romania | 109.3 | 155.2 | 1.8 |
| Russia | 147.8 | 80.5 | 1.1 |
| Ukraine | 43.7 | 136.6 | 2.6 |

Source: Authors' own calculations. See Appendix for data construction.
Shaded areas indicate strong fundamentals (when both *RER* and *LB* are shaded) and high reserve adequacy.

## *3.4 Implementation*

As explained by the model, only countries with weak fundamentals, i.e. an appreciated real exchange rate and a weak banking system, and low levels of international reserves are vulnerable to crisis. In order to implement the model, we thus need to classify countries as having strong or weak fundamentals and low or high levels of reserves. We do this by ranking them with regard to *RER*, *LB* and *M2*/*R*. STV classify countries as having strong fundamentals if their *RER* is in the highest quartile of the sample and their bank lending boom is in the lowest quartile. We classify the countries studied as having strong fundamentals if the *RER* is above the bottom quartile of the sample and their bank lending boom is in the lowest quartile. The reason why we have chosen a different classification with regard to *RER* is the following. The real exchange rates in the countries studied has depreciated much more than the countries in STV (see Appendix Table 1), and since the model suggests that countries with high *RER* are less vulnerable, a larger share of the countries studied should be classified as having strong fundamentals. Our classification regarding lending boom is not as obvious though, since the countries studied have experienced a much larger lending boom than the countries in STV. But if we would have made the classification stricter and included fewer countries, none of the countries would have been classified as having strong fundamentals. We therefore used the same classification rule regarding *LB* as STV, even though our countries generally had increased their lending much

more than STV's countries. This resulted in three of the countries studied being classified as having strong fundamentals.

When STV sort their countries with respect to reserve adequacy, they classify a country as having high foreign exchange reserves if its ratio of M2 to reserves is in the lowest quartile of the sample. We use the same classification. The reason for this is that the countries studied generally have the same amount of reserves in relation to M2 that STV's countries have. Table 4 below shows our final classifications.

**Table 4. Country classification**

| Countries with strong fundamentals ($D^{WF} = 0$) | Countries with high foreign exchange reserves ($D^{LB} = 0$) |
|---|---|
| Bosnia & Herzegovina | Belarus |
| Hungary | Macedonia |
| Poland | Moldova |
| | Russia |

From these classifications, dummy variables are created. The dummy for weak fundamentals, $D^{WF}$, is equal to one for weak fundamentals and equal to zero for strong fundamentals. The dummy for low reserves, $D^{LR}$, is equal to one for countries with low reserves and equal to zero for countries with high reserves. Our definitions of $D^{WF}$ and $D^{LR}$ deem nine of our sixteen countries as being vulnerable to a self-fulfilling reversal of capital and hence a currency crisis. These countries are Albania, Bulgaria, Croatia, Czech Republic, Estonia, Latvia, Lithuania, Romania and Ukraine. The seven countries not considered vulnerable to a currency crisis are those in Table 4.

We are well aware of the fact that these classifications are arbitrary, as there are no general rules to use as guidelines. Instead of dividing the countries into quartiles as we have done, we could have used other classification rules. For instance, we could have used absolute numbers and treated, for example, all countries with a reserve adequacy below 2.0 as having high foreign exchange reserves. We will come back to the problems associated with the classifications in the end of the paper. However, what is important to note is that we have tested several other classifications, but the results have not differed in any significant way.

## *3.5 Regression equation*

We have now described the data behind the three variables used to determine crisis vulnerability and the classification of the sixteen Eastern European countries as having either strong or weak fundamentals and high or low reserves. We proceed by describing the regression equation used to test the hypothesis that only countries with weak fundamentals and low reserves are vulnerable to crisis.

The main idea behind the regression equation is that the effects of *RER* and *LB* on *IND* should be large only when both $D^{WF}$ and $D^{LF}$ are equal to one. The equation is

$$IND = \beta_1 + \beta_2(RER) + \beta_3(LB) + \beta_4(D^{LR} \times RER) + \beta_5(D^{LR} \times LB) + \beta_6(D^{LR} \times D^{WF} \times RER) + \beta_7(D^{LB} \times D^{WF} \times LB) + \varepsilon$$

$\beta_2$ and $\beta_3$ contain the effects of the fundamentals on the crisis index in countries with high reserves ($D^{LR} = 0$) and strong fundamentals ($D^{WF} = 0$). If the model is correct, these coefficients should be zero. $\beta_2 + \beta_4$ and $\beta_3 + \beta_5$ show the effect of the fundamentals on the crisis index in countries with low reserves ($D^{LR} = 1$) but strong fundamentals ($D^{WF} = 0$). Again, the model predicts that the sum of these coefficients should be zero as countries with strong fundamentals are not likely to suffer an attack, even if they have low reserves. Finally, $\beta_2 + \beta_4 + \beta_6$ and $\beta_3 + \beta_5 + \beta_7$ contain the effects of the fundamentals on the crisis index in countries with low reserves ($D^{LR} = 1$) and weak fundamentals ($D^{WF} = 1$). Here, $\beta_2 + \beta_4 + \beta_6$ is expected to be negative as a more devalued real exchange rate should lead to a smaller value of *IND*. $\beta_3 + \beta_5 + \beta_7$ is, on the other hand, expected to be positive as a larger lending boom should lead to a larger value of *IND*.

## *3.6 Regression results*

Table 5 shows the regression results as we vary the terminal month of the dependent variable from September 2008 through January 2009. The signs of the different sets of coefficients stay constant in all but two cases, β3 and β4. The signs are not always as expected though. For example, the positive sign of β6 suggests that real exchange depreciation, in a country with both low reserves and weak fundamentals, would lead to a higher crisis index. Also, the negative sign of β7 implies that increased lending, in country with both low reserves and weak fundamentals, would lead to a lower crisis index. Among the different sets of coefficients, only the constant can be said to be significant. Apart from the constant, most other coefficients are rather close to zero and insignificant. Our $R^2$ values are rather high, around 0.5. The adjusted $R^2$ values are on the other hand, much lower.

According to STV's theory, $\beta_2 + \beta_4 + \beta_6$ should be negative and $\beta_3 + \beta_5 + \beta_7$ should be positive. Our results show almost the complete opposite. As shown in Table 6, $\beta_2 + \beta_4 + \beta_6$ is negative in only one of period, from August to December, and $\beta_3 + \beta_5 + \beta_7$ is never positive. The sums are also very close to zero which is evident when looking at the *p*-values from the *t*-tests.[3] The *p*-values show that neither $\beta_2 + \beta_4 + \beta_6$ nor $\beta_3 + \beta_5 + \beta_7$ can be said to be different from zero in any time period, hence *RER* and *LB* do not affect the severity of a crisis in countries with low reserves and weak fundamentals in our case. On the other hand, $\beta_2 + \beta_4$ is found to be different from zero, at the 10 percent significance level, in two time periods. All of these results are contrary to those found by STV (as can be seen in Appendix Table 2).

[3] STV use Wald's test to test their hypotheses. But as Gujarati (2003) notes, Wald's test does not add anything in the context of linear regression models like this one compared to a *t*-test.

In conclusion, our results indicate that Eastern European countries classified as having weak fundamentals and low reserves do not suffer more in the current financial crisis than countries with strong fundamentals and high reserves. Thus, our results are not in line with STV's theory. One possible interpretation of our results is that the alternative hypothesis presented by STV, that contagion is the cause of crisis, is true in the case of Eastern Europe. According to this hypothesis, changes in market sentiments or a new interpretation of existing information would explain why some countries in Eastern Europe suffer more than others in the current crisis. Although we cannot rule out this possibility, STV's model offers no method to control if this is actually the case.

**Table 5: Regression results – benchmark model**

| | | *Interval used to calculate crisis index* | | | | |
|---|---|---|---|---|---|---|
| | *Independent variable* | *Aug. 2008-Sep. 2008* | *Aug. 2008-Oct. 2008* | *Aug. 2008-Nov. 2008* | *Aug. 2008-Dec. 2008* | *Aug. 2008-Jan. 2008* |
| $\hat{\beta}1$ | constant | 7.673<br>(4.551) | 30.482**<br>(9.158) | 40.713**<br>(10.146) | 36.212*<br>(19.005) | 54.054**<br>(20.500) |
| $\hat{\beta}2$ | *RER* | -0.068*<br>(0.035) | -0.030<br>(0.071) | -0.067<br>(0.078) | -0.213<br>(0.147) | -0.312<br>(0.159) |
| $\hat{\beta}3$ | *LB* | 0.087<br>(0.063) | -0.100<br>(0.127) | -0.066<br>(0.140) | 0.239<br>(0.263) | 0.353<br>(0.283) |
| $\hat{\beta}4$ | $RER \times D^{LR}$ | 0.027<br>(0.065) | -0.021<br>(0.130) | -0.211<br>(0.144) | -0.234<br>(0.270) | -0.076<br>(0.291) |
| $\hat{\beta}5$ | $LB \times D^{LR}$ | 0.084<br>(0.123) | 0.400<br>(0.248) | 0.521*<br>(0.275) | 0.350<br>(0.514) | 0.079<br>(0.555) |
| $\hat{\beta}6$ | $RER \times D^{LR} \times D^{WF}$ | 0.085<br>(0.070) | 0.056<br>(0.142) | 0.278<br>(0.157) | 0.444<br>(0.294) | 0.416<br>(0.317) |
| $\hat{\beta}7$ | $LB \times D^{LR} \times D^{WF}$ | -0.192<br>(0.119) | -0.354<br>(0.240) | -0.515<br>(0.265) | -0.656<br>(0.497) | -0.538<br>(0.536) |
| *Summary statistics* | | | | | | |
| $R^2$ | | 0.502 | 0.517 | 0.499 | 0.411 | 0.444 |
| $\overline{R}^2$ | | 0.170 | 0.195 | 0.164 | 0.018 | 0.073 |
| *t-tests* | | | | *p-values* | | |
| $\hat{\beta}2+\hat{\beta}4=0$ | | 0.47 | 0.66 | 0.05 | 0.08 | 0.15 |
| $\hat{\beta}2+\hat{\beta}4+\hat{\beta}6=0$ | | 0.36 | 0.95 | 1.00 | 0.99 | 0.90 |
| $\hat{\beta}3+\hat{\beta}5=0$ | | 0.22 | 0.28 | 0.15 | 0.30 | 0.48 |
| $\hat{\beta}3+\hat{\beta}5+\hat{\beta}7=0$ | | 0.45 | 0.35 | 0.35 | 0.57 | 0.41 |

Source: Authors' own calculations. See appendix for data construction.
The crisis index is the dependent variable.
* = coefficient significant at 10 percent level.
** = coefficient significant at 5 percent level.

**Table 6: Added coefficients**

| | *Aug. 2008-Sep. 2008* | *Aug. 2008-Oct. 2008* | *Aug. 2008-Nov. 2008* | *Aug. 2008-Dec. 2008* | *Aug. 2008-Jan. 2008* |
|---|---|---|---|---|---|
| $\beta 2 + \beta 4 + \beta 6$ | 0.04 | 0.01 | 0.00 | -0.003 | 0.03 |
| $\beta 3 + \beta 5 + \beta 7$ | -0.02 | -0.05 | -0.06 | -0.07 | -0.11 |

## *3.7 Additional possible determinants of currency crisis*

The results above showed that the three original variables (real exchange rate, lending boom and reserve adequacy) cannot alone explain the crisis in Eastern Europe. Furthermore, the influence of contagion is difficult to prove conclusively. We therefore choose to continue the analysis by adding additional explanatory variables to the benchmark model. STV tests the validity of four alternative hypotheses of how a crisis is linked to capital inflows and subsequent policy reactions. These hypotheses are almost categorically rejected by STV. We intend to test two of them on our data. First, we will test whether the size of current account deficits and changes in current account explain why some countries have been hit harder by crisis then others. Second, we will do the same for size and changes in capital inflows. By using both averages, calculated from 2003 to 2007, and percentage point change, calculated between 2003 and 2007, we hope to achieve two things. The first one is to capture the effect on those countries that have had large current account and capital inflow deficits for a longer period of time. The second one is to see the effect on those countries that in recent years have seen dramatic changes in these variables. The individual country data for current account and capital inflow are shown in Appendix Table 3. The two alternative hypotheses not covered in our paper are whether the composition of capital inflows matter for the vulnerability to crisis and if expansionary government spending is associated with vulnerability to crisis. These are not included due to insufficient data.

When incorporating the alternative hypotheses in the benchmark model, STV imposes two restrictions: $\beta 2 + \beta 4 = 0$ and $\beta 3 + \beta 5 = 0$. However, STV does not specify why this is done. Our interpretation is that the restrictions are imposed because STV's results from the benchmark regression indicates that these hypotheses, $\beta 2 + \beta 4 = 0$ and $\beta 3 + \beta 5 = 0$, are indeed true. As our results differ to such a large degree from those of STV, we have chosen not to impose the restrictions. Also, when adding measures of current account and capital inflows to the benchmark model, STV only account for the results of one of the time intervals of the crisis index which limits the scope for a systematic comparison. We will, however, use all time intervals, which will enable us to compare trends and draw more well founded inferences.

The results presented below are robust to changes in the classifications of countries as having weak or strong fundamentals and low or high levels of foreign exchange reserves, as we have performed the analysis using different classifications but without different results. We therefore choose to continue with the classifications used in the benchmark model. In the conclusion we will come back to the importance of this robustness.

### 3.7.1 Current account

A current account deficit, as described in Milesi-Ferreti and Razin (1996), is a positive increase to the stock of the external liabilities of an economy. But why would it cause crisis in a country? According to Edwards (1999), conventional wisdom considers persistent current account deficits over four to five percent of GDP as a warning sign and an indication that action is needed to restore sustainability. Holding a similar view, Krugman and Obsfeld (2006) stress that current account deficits might pose a problem if the borrowed funds are not channeled into productive investments. A deficit is an issue if it represents temporary heightened consumption or badly planned investment projects financed by foreign funds. Fischer (1988) argues that the main indicator of a pending crisis is a current account deficit. In a later article, Fischer (1994) also points at the current account deficit as a culprit for the Mexican peso crisis, although reversed capital flows also was part of the explanation. However, the link between current account deficits and a subsequent crisis is controversial. Both Corden (1994) and Frankel and Rose (1996) claim that a current account deficit resulting from private sector behavior is not at all a matter of concern.

In order to test whether current account deficits can help to explain why some countries in Eastern Europe were more severely hit by the crisis than others we will include two different measures in our model, current account averages and changes in current account. Table 7 and 8 shows the average ratio of current account to GDP and the percentage point change in this ratio included in the benchmark regression separately. The variables are included without dummies (β8), and interacted with the low reserve dummy (β9) and the low reserve and weak fundamentals dummy in combination (β10). Hence, the regression equation is[4]

$$IND = \beta_1 + \beta_2(RER) + \beta_3(LB) + \beta_4(D^{LR} \times RER) + \beta_5(D^{LR} \times LB) + \beta_6(D^{LR} \times D^{WF} \times RER) + \beta_7(D^{LB} \times D^{WF} \times LB) + \beta_8(CA^{AV/CH}) + \beta_9(D^{LR} \times CA^{AV/CH}) + \beta_{10}(D^{LB} \times D^{WF} \times CA^{AV/CH}) + \varepsilon$$

Running two separate regressions, one with current account averages and one with changes in current account, we test whether current account can explain changes in the crisis index using two hypotheses. The first one, β8 + β9 = 0, tests the effect of current account on the crisis index in countries with low reserves ($D^{LR}$ = 1) but strong fundamentals ($D^{WF}$ = 0). The second hypothesis, β8 + β9 + β10 = 0, contains the effect of current account on the crisis index in countries with low reserves ($D^{LR}$ = 1) and weak fundamentals ($D^{WF}$ = 1).

Our regression results give somewhat mixed results. The null hypothesis β8 + β9 = 0, can be rejected at a 5 percent significance level in each time period. This applies for both current

[4] $CA^{AV/CH}$ indicates that two separate regressions have been run, one with current account averages and one with changes in current account.

account averages and changes in current account. For current account averages as well as changes, the coefficient sets of β9 and β10 are significant. This is not the case for the set of β8 however. What is puzzling is that the β8, β9 and β10 coefficients have different signs than expected. β8 and β9 is positive and β10 is negative when looking at the current account average regression. We expected all of these coefficients to be negative, since a higher current account should be positive for a country and lower the crisis index. When looking at the regression including changes in current account, β9 is negative whereas β8 and β10 is positive. Again, this is a puzzle as a positive increase in the current account should naturally lead to a lower crisis index in all cases. Because of the alternating signs of β8, β9 and β10, the sum of these coefficients is very close to zero. The null hypothesis that $\beta 8 + \beta 9 + \beta 10 = 0$ cannot be rejected at a 10 percent significance level for any time period except two for both current account averages and changes. The two cases where the null hypothesis can be rejected are for the current account averages for the periods ending in December and January respectively.

When including the current account coefficients into the regression, the null hypothesis $\beta 2 + \beta 4 = 0$ can be rejected in many more cases than in the benchmark model. At a 5 percent significance level the null hypotheses can be rejected in three out of five time periods when looking at current account averages and two out of five when looking at change in current account. The null hypothesis that $\beta 3 + \beta 5 = 0$ can also be rejected in more cases when current account is introduced into the model. The null hypothesis can be rejected for all but two periods at a 5 percent significance level. The fact that both $\beta 2 + \beta 4 = 0$ and $\beta 3 + \beta 5 = 0$ can be rejected is contrary to our results from the benchmark regression and the findings of STV which indicate that the effect of the real exchange rate (*RER*) on countries with low foreign reserves (*LB*) but strong fundamentals is insignificant. For current account averages, the coefficient sets of β5, β6 and β7 are all significant, for changes in current account only the coefficient set β5 is significant. Most coefficients are close to zero, though. Consistent with our previous findings, from the benchmark model, the null hypotheses that $\beta 2 + \beta 4 + \beta 6 = 0$ and $\beta 3 + \beta 5 + \beta 7 = 0$ cannot be rejected for most time periods. Again, *RER* and *LB* do not affect the severity of a crisis in countries with low reserves and weak fundamentals.

When including the current account coefficients the goodness of fit of the model is markedly improved for each time period. $R^2$ values are consistently higher than 0.7 and above 0.8 when only looking at current account averages. This can be compared with the benchmark model where the $R^2$ values are around 0.5 for the majority of the time periods.

Summing up, we have found that the coefficients generally become more significant and the models goodness of fit improves considerably compared to the benchmark model when current account is included. This leads us to believe that current account is an important variable in explaining the current crisis in Eastern Europe for all countries and not only for those with weak fundamentals and low levels of foreign exchange reserves. However, when current account is included in the model some of the variables behave in an unanticipated manner, for example the signs of β8, β9 and β10.

**Table 7: Regressions including current account averages ($CA^{AV}$)**

| | | *Interval used to calculate crisis index* | | | | |
|---|---|---|---|---|---|---|
| | *Independent variable* | *Aug. 2008-Sep. 2008* | *Aug. 2008-Oct. 2008* | *Aug. 2008-Nov. 2008* | *Aug. 2008-Dec. 2008* | *Aug. 2008-Jan. 2009* |
| $\hat{\beta}1$ | constant | 5.078<br>(2.982) | 32.197**<br>(7.384) | 40.654**<br>(5.939) | 52.732**<br>(15.042) | 70.995**<br>(14.368) |
| $\hat{\beta}2$ | *RER* | -0.065**<br>(0.019) | -0.034<br>(0.047) | -0.068<br>(0.038) | -0.245**<br>(0.096) | -0.346**<br>(0.092) |
| $\hat{\beta}3$ | *LB* | 0.117**<br>(0.037) | -0.107<br>(0.092) | -0.054<br>(0.074) | 0.134<br>(0.188) | 0.258<br>(0.179) |
| $\hat{\beta}4$ | $RER \times D^{LR}$ | 0.015<br>(0.035) | -0.043<br>(0.086) | -0.238**<br>(0.069) | -0.262<br>(0.175) | -0.108<br>(0.167) |
| $\hat{\beta}5$ | $LB \times D^{LR}$ | 0.419**<br>(0.097) | 1.011**<br>(0.239) | 1.283**<br>(0.192) | 1.261**<br>(0.487) | 1.106*<br>(0.466) |
| $\hat{\beta}6$ | $RER \times D^{LR} \times D^{WF}$ | 0.104**<br>(0.038) | 0.076**<br>(0.094) | 0.307**<br>(0.076) | 0.446*<br>(0.191) | 0.422*<br>(0.183) |
| $\hat{\beta}7$ | $LB \times D^{LR} \times D^{WF}$ | -0.556**<br>(0.099) | -0.952**<br>(0.245) | -1.282**<br>(0.197) | -1.438**<br>(0.499) | -1.444*<br>(0.477) |
| $\hat{\beta}8$ | $CA^{AV}$ | 0.354<br>(0.244) | 0.255**<br>(0.633) | 0.419<br>(0.485) | 1.002<br>(1.229) | 1.520<br>(1.174) |
| $\hat{\beta}9$ | $CA^{AV} \times D^{LR}$ | 1.528**<br>(0.466) | 3.454**<br>(1.155) | 4.106**<br>(0.929) | 5.350*<br>(2.353) | 5.618**<br>(2.248) |
| $\hat{\beta}10$ | $CA^{AV} \times D^{LR} \times D^{WF}$ | -2.121**<br>(0.450) | -3.411**<br>(1.113) | -4.406**<br>(0.895) | -4.214<br>(2.268) | -4.900*<br>(2.166) |
| *Summary statistics* | | | | | | |
| $R^2$ | | 0.905 | 0.861 | 0.924 | 0.836 | 0.879 |
| $\overline{R}^2$ | | 0.763 | 0.651 | 0.809 | 0.590 | 0.697 |
| *t-tests* | | | | *p-values* | | |
| $\hat{\beta}2+\hat{\beta}4=0$ | | 0.14 | 0.33 | 0.00 | 0.01 | 0.02 |
| $\hat{\beta}2+\hat{\beta}4+\hat{\beta}6=0$ | | 0.08 | 0.99 | 0.98 | 0.65 | 0.80 |
| $\hat{\beta}3+\hat{\beta}5=0$ | | 0.00 | 0.01 | 0.00 | 0.04 | 0.03 |
| $\hat{\beta}3+\hat{\beta}5+\hat{\beta}7=0$ | | 0.22 | 0.23 | 0.12 | 0.58 | 0.30 |
| $\hat{\beta}8+\hat{\beta}9=0$ | | 0.00 | 0.01 | 0.00 | 0.02 | 0.01 |
| $\hat{\beta}8+\hat{\beta}9+\hat{\beta}10=0$ | | 0.28 | 0.57 | 0.78 | 0.08 | 0.06 |

Source: Authors' own calculations. See appendix for data construction.
The crisis index is the dependent variable.
* = coefficient significant at 10 percent level.
** = coefficient significant at 5 percent level.

**Table 8: Regressions including current account changes ($CA^{CH}$)**

| | | *Interval used to calculate crisis index* | | | | |
|---|---|---|---|---|---|---|
| | *Independent variable* | *Aug. 2008-Sep. 2008* | *Aug. 2008-Oct. 2008* | *Aug. 2008-Nov. 2008* | *Aug. 2008-Dec. 2008* | *Aug. 2008-Jan. 2008* |
| $\hat{\beta}1$ | constant | 8.681** | 31.912** | 38.163** | 29.878 | 49.003** |
| | | (2.896) | (6.516) | (4.034) | (17.160) | (18.207) |
| $\hat{\beta}2$ | *RER* | -0.069** | -0.032 | -0.062* | -0.202 | -0.302* |
| | | (0.021) | (0.046) | (0.029) | (0.122) | (0.129) |
| $\hat{\beta}3$ | *LB* | 0.096* | -0.095 | -0.003 | 0.333 | 0.443 |
| | | (0.040) | (0.091) | (0.056) | (0.238) | (0.253) |
| $\hat{\beta}4$ | $RER \times D^{LR}$ | 0.012 | -0.050 | -0.249** | -0.289 | -0.137 |
| | | (0.038) | (0.085) | (0.053) | (0.224) | (0.237) |
| $\hat{\beta}5$ | $LB \times D^{LR}$ | 0.187* | 0.625** | 0.811** | 0.805 | 0.570 |
| | | (0.081) | (0.181) | (0.112) | (0.477) | (0.506) |
| $\hat{\beta}6$ | $RER \times D^{LR} \times D^{WF}$ | 0.094* | 0.076 | 0.328** | 0.531* | 0.502 |
| | | (0.042) | (0.094) | (0.058) | (0.247) | (0.262) |
| $\hat{\beta}7$ | $LB \times D^{LR} \times D^{WF}$ | -0.299** | -0.576** | -0.873** | -1.218** | -1.127* |
| | | (0.079) | (0.178) | (0.110) | (0.469) | (0.498) |
| $\hat{\beta}8$ | $CA^{CH}$ | 0.415 | 0.415 | 1.080 | 1.089 | 1.250 |
| | | (0.405) | (0.911) | (0.564) | (2.398) | (2.544) |
| $\hat{\beta}9$ | $CA^{CH} \times D^{LR}$ | -3.026** | -5.610** | -7.434** | -10.141* | -11.398** |
| | | (0.728) | (1.638) | (1.014) | (4.314) | (4.578) |
| $\hat{\beta}10$ | $CA^{CH} \times D^{LR} \times D^{WF}$ | 2.793** | 5.500** | 5.990** | 8.139* | 9.450* |
| | | (0.631) | (1.421) | (0.880) | (3.742) | (3.970) |
| *Summary statistics* | | | | | | |
| $R^2$ | | 0.888 | 0.864 | 0.956 | 0.733 | 0.756 |
| $\overline{R}^2$ | | 0.720 | 0.660 | 0.890 | 0.332 | 0.390 |
| *t-tests* | | | | *p-values* | | |
| $\hat{\beta}2+\hat{\beta}4=0$ | | 0.13 | 0.30 | 0.00 | 0.04 | 0.07 |
| $\hat{\beta}2+\hat{\beta}4+\hat{\beta}6=0$ | | 0.23 | 0.93 | 0.68 | 0.82 | 0.73 |
| $\hat{\beta}3+\hat{\beta}5=0$ | | 0.02 | 0.03 | 0.00 | 0.06 | 0.10 |
| $\hat{\beta}3+\hat{\beta}5+\hat{\beta}7=0$ | | 0.36 | 0.25 | 0.03 | 0.44 | 0.31 |
| $\hat{\beta}8+\hat{\beta}9=0$ | | 0.01 | 0.01 | 0.00 | 0.05 | 0.04 |
| $\hat{\beta}8+\hat{\beta}9+\hat{\beta}10=0$ | | 0.36 | 0.49 | 0.21 | 0.44 | 0.57 |

Source: Authors' own calculations. See appendix for data construction.
The crisis index is the dependent variable.
* = coefficient significant at 10 percent level.
** = coefficient significant at 5 percent level.

### 3.7.2 Capital inflows

As shown by Felices, Hoggarth and Madouros (2008), capital inflows to emerging market economies have risen markedly in recent years and were in 2007 higher than prior to the East Asian and Russian crises in the second half of the 1990s. According to the authors, this should bring benefits to growth over the longer run but, as has been seen in previous crises, also has the potential to reverse quickly causing losses to both emerging market economies and foreign investors. Some countries, especially in Central and Eastern Europe, have attracted large foreign-currency debt inflows into their private sectors, including lower credit-rated borrowers, to finance the very large current account deficits associated with the strong growth in domestic demand. Guillermo, Hoggarth and Madouros (2008) postulate that if the recent fall in global risk appetite persists or world GDP growth halts, it could result in a reduction in international investors' demand for these countries assets.

We will test if variations in capital inflows can help explain why some countries in Eastern Europe are more severely hit by the crisis than others. We will do this by including two different measures of capital inflows in our model. In Table 9 and 10 we include in our benchmark regression the average ratio of capital inflows to GDP and the percentage point change in capital inflows to GDP. The variables are included without dummies, and interacted with the low reserve dummy and the low reserve and weak fundamentals dummy in combination. The coefficients are denoted β8, β9 and β10, respectively. Hence the equation is[5]

$$IND = \beta_1 + \beta_2(RER) + \beta_3(LB) + \beta_4(D^{LR} \times RER) + \beta_5(D^{LR} \times LB) + \beta_6(D^{LR} \times D^{WF} \times RER) + \beta_7(D^{LB} \times D^{WF} \times LB) + \beta_8(CI^{AV/CH}) + \beta_9(D^{LR} \times CI^{AV/CH}) + \beta_{10}(D^{LB} \times D^{WF} \times CI^{AV/CH}) + \varepsilon$$

We proceed by testing if capital inflows can explain changes in the crisis index using two hypotheses. The first one, β8 + β9 = 0, tests the effect of capital inflow on the crisis index in countries with low reserves ($D^{LR}$ = 1) but strong fundamentals ($D^{WF}$ = 0). The second hypothesis, β8 + β9 + β10 = 0, contains the effect of capital inflow on the crisis index in countries with low reserves ($D^{LR}$ = 1) and weak fundamentals ($D^{WF}$ = 1).

The null hypothesis that β8 + β9 = 0 can be rejected at a 5 percent significance level for all time intervals and for both capital inflow measurements. Most of the coefficients β8, β9 and β10 are significant and their respective coefficient sets carry the same signs. But as was the case with the current account measures, β8, β9 and β10 have different signs than expected. β8 and β9 is negative and β10 is positive when looking at the capital inflow average regression. We expected all of these coefficients to be positive, since a larger capital inflow should be negative for a

[5] $CI^{AV/CH}$ indicates that two separate regressions have been run, one with capital inflow averages and one with changes in capital inflow.

country and increase the crisis index. When looking at the regression with changes in capital inflow, β9 is positive whereas β8 and β10 is negative. Again, this is a puzzle as an increase in the capital inflow should naturally lead to a higher crisis index in all cases. Because of the shifting signs of β8, β9 and β10, the sum of these coefficients is very close to zero. The null hypotheses that $\beta 8 + \beta 9 + \beta 10 = 0$ can therefore not be rejected for any time interval, neither for capital inflow averages nor changes in capital inflow.

We cannot reject the majority of the other null hypotheses. $\beta 2 + \beta 4 + \beta 6 = 0$ and $\beta 3 + \beta 5 + \beta 7 = 0$ cannot be rejected at a 10 percent significance level in all except two cases. As before, *RER* and *LB* do not affect the severity of a crisis in countries with low reserves and weak fundamentals. A discrepancy from the norm is that the null hypothesis $\beta 3 + \beta 5 = 0$ can be rejected at a 10 percent significance level in all time intervals for averages in capital inflows. Not all coefficients are significant, and when looking at coefficient sets only β7 is significant across the board. The goodness of fit of the model improves considerably when including capital inflows. The extended model's $R^2$ values are always above 0.7 and their average is higher than 0.8.

In summary, our findings lead us to believe that capital inflow is an important variable in explaining the current crisis in Eastern Europe. This holds for all countries and not only for those with weak fundamentals and low levels of foreign exchange reserves. We draw this conclusion as the coefficients generally become more significant and the models goodness of fit improves considerably compared to the benchmark model. As was the case when current account was included in the model, the inclusion of capital inflow causes some of the variables behave unpredictably, for example the signs of β8, β9 and β10.

**Table 9: Regressions including capital inflow averages ($CI^{AV}$)**

| | | *Interval used to calculate crisis index* | | | | |
|---|---|---|---|---|---|---|
| | *Independent variable* | *Aug. 2008-Sep. 2008* | *Aug. 2008-Oct. 2008* | *Aug. 2008-Nov. 2008* | *Aug. 2008-Dec. 2008* | *Aug. 2008-Jan. 2008* |
| $\hat{\beta}1$ | constant | 5.969<br>(3.480) | 31.662**<br>(8.177) | 38.931**<br>(6.166) | 47.904*<br>(20.082) | 66.174**<br>(19.944) |
| $\hat{\beta}2$ | *RER* | -0.054**<br>(0.022) | -0.023<br>(0.051) | -0.048<br>(0.039) | -0.201<br>(0.126) | -0.288*<br>(0.125) |
| $\hat{\beta}3$ | *LB* | 0.123**<br>(0.044) | -0.091<br>(0.103) | -0.016<br>(0.078) | 0.214<br>(0.253) | 0.353<br>(0.251) |
| $\hat{\beta}4$ | $RER \times D^{LR}$ | -0.009<br>(0.038) | -0.077<br>(0.090) | -0.287**<br>(0.068) | -0.342<br>(0.220) | -0.208<br>(0.219) |
| $\hat{\beta}5$ | $LB \times D^{LR}$ | 0.428**<br>(0.110) | 1.065**<br>(0.259) | 1.348**<br>(0.195) | 1.368*<br>(0.636) | 1.212<br>(0.631) |
| $\hat{\beta}6$ | $RER \times D^{LR} \times D^{WF}$ | 0.113**<br>(0.041) | 0.103<br>(0.096) | 0.341**<br>(0.072) | 0.505*<br>(0.236) | 0.487*<br>(0.234) |
| $\hat{\beta}7$ | $LB \times D^{LR} \times D^{WF}$ | -0.571**<br>(0.114) | -1.021**<br>(0.268) | -1.388**<br>(0.202) | -1.630**<br>(0.658) | -1.649**<br>(0.653) |
| $\hat{\beta}8$ | $CI^{AV}$ | -0.553<br>(0.396) | -0.448<br>(0.930) | -0.870<br>(0.701) | -1.683<br>(2.285) | -2.374<br>(2.269) |
| $\hat{\beta}9$ | $CI^{AV} \times D^{LR}$ | -0.937<br>(0.520) | -2.497*<br>(1.223) | -2.727**<br>(0.922) | -3.376<br>(3.003) | -3.310<br>(2.983) |
| $\hat{\beta}10$ | $CI^{AV} \times D^{LR} \times D^{WF}$ | 1.597**<br>(0.394) | 2.784**<br>(0.925) | 3.666**<br>(0.698) | 3.964<br>(2.272) | 4.531*<br>(2.256) |
| *Summary statistics* | | | | | | |
| $R^2$ | | 0.891 | 0.856 | 0.931 | 0.755 | 0.804 |
| $\overline{R}^2$ | | 0.728 | 0.641 | 0.827 | 0.387 | 0.509 |
| *t-tests* | | | | *p-values* | | |
| $\hat{\beta}2+\hat{\beta}4=0$ | | 0.10 | 0.23 | 0.00 | 0.03 | 0.04 |
| $\hat{\beta}2+\hat{\beta}4+\hat{\beta}6=0$ | | 0.11 | 0.97 | 0.90 | 0.81 | 0.96 |
| $\hat{\beta}3+\hat{\beta}5=0$ | | 0.00 | 0.01 | 0.00 | 0.06 | 0.06 |
| $\hat{\beta}3+\hat{\beta}5+\hat{\beta}7=0$ | | 0.26 | 0.24 | 0.09 | 0.62 | 0.39 |
| $\hat{\beta}8+\hat{\beta}9=0$ | | 0.00 | 0.01 | 0.00 | 0.04 | 0.03 |
| $\hat{\beta}8+\hat{\beta}9+\hat{\beta}10=0$ | | 0.60 | 0.73 | 0.85 | 0.36 | 0.34 |

Source: Authors' own calculations. See appendix for data construction.
The crisis index is the dependent variable.
* = coefficient significant at 10 percent level.
** = coefficient significant at 5 percent level.

**Table 10: Regressions including capital inflow changes ($CI^{CH}$)**

| | | *Interval used to calculate crisis index* | | | | |
|---|---|---|---|---|---|---|
| | *Independent variable* | *Aug. 2008-Sep. 2008* | *Aug. 2008-Oct. 2008* | *Aug. 2008-Nov. 2008* | *Aug. 2008-Dec. 2008* | *Aug. 2008-Jan. 2008* |
| $\hat{\beta}1$ | constant | 8.582** | 30.781** | 38.559** | 30.571 | 49.033** |
| | | (2.799) | (6.562) | (3.896) | (16.590) | (17.572) |
| $\hat{\beta}2$ | *RER* | -0.068** | -0.029 | -0.061* | -0.202 | -0.301* |
| | | (0.020) | (0.048) | (0.028) | (0.121) | (0.128) |
| $\hat{\beta}3$ | *LB* | 0.100* | -0.083 | 0.007 | 0.334 | 0.447 |
| | | (0.042) | (0.097) | (0.058) | (0.246) | (0.261) |
| $\hat{\beta}4$ | $RER \times D^{LR}$ | 0.066 | -0.058 | -0.117* | -0.101 | -0.074 |
| | | (0.038) | (0.090) | (0.054) | (0.228) | (0.241) |
| $\hat{\beta}5$ | $LB \times D^{LR}$ | 0.012 | 0.289 | 0.376** | 0.195 | -0.104 |
| | | (0.076) | (0.178) | (0.106) | (0.449) | (0.476) |
| $\hat{\beta}6$ | $RER \times D^{LR} \times D^{WF}$ | 0.039 | -0.027 | 0.194** | 0.340 | 0.291 |
| | | (0.042) | (0.099) | (0.059) | (0.249) | (0.264) |
| $\hat{\beta}7$ | $LB \times D^{LR} \times D^{WF}$ | -0.128 | -0.255 | 0.448** | -0.610 | -0.460 |
| | | (0.072) | (0.169) | (0.100) | (0.426) | (0.452) |
| $\hat{\beta}8$ | $CI^{CH}$ | -0.220 | -0.219 | -0.618 | -0.559 | -0.602 |
| | | (0.234) | (0.548) | (0.326) | (1.386) | (1.468) |
| $\hat{\beta}9$ | $CI^{CH} \times D^{LR}$ | 2.836** | 5.432* | 6.981** | 9.623** | 10.769** |
| | | (0.647) | (1.516) | (0.900) | (3.833) | (4.059) |
| $\hat{\beta}10$ | $CI^{CH} \times D^{LR} \times D^{WF}$ | -2.766 | -5.324* | -6.084** | -8.342* | -9.548** |
| | | (0.617) | (1.446) | (0.858) | (3.655) | (3.872) |
| *Summary statistics* | | | | | | |
| $R^2$ | | 0.889 | 0.854 | 0.957 | 0.736 | 0.760 |
| $\overline{R}^2$ | | 0.723 | 0.636 | 0.891 | 0.341 | 0.399 |
| *t-tests* | | | | *p-values* | | |
| $\hat{\beta}2+\hat{\beta}4=0$ | | 0.95 | 0.72 | 0.01 | 0.17 | 0.32 |
| $\hat{\beta}2+\hat{\beta}4+\hat{\beta}6=0$ | | 0.23 | 0.98 | 0.69 | 0.82 | 0.72 |
| $\hat{\beta}3+\hat{\beta}5=0$ | | 0.20 | 0.30 | 0.01 | 0.29 | 0.51 |
| $\hat{\beta}3+\hat{\beta}5+\hat{\beta}7=0$ | | 0.34 | 0.25 | 0.03 | 0.43 | 0.29 |
| $\hat{\beta}8+\hat{\beta}9=0$ | | 0.00 | 0.01 | 0.00 | 0.04 | 0.02 |
| $\hat{\beta}8+\hat{\beta}9+\hat{\beta}10=0$ | | 0.31 | 0.74 | 0.18 | 0.40 | 0.49 |

Source: Authors' own calculations. See appendix for data construction.
The crisis index is the dependent variable.
* = coefficient significant at 10 percent level.
** = coefficient significant at 5 percent level.

# 4. Conclusion

The purpose of this paper was to investigate whether economic fundamentals explain why some countries in Eastern Europe have suffered more than others in the current financial crisis, or whether the variation just reflects contagion. Our result from the benchmark regression showed that economic fundamentals, captured by real exchange rate, lending boom and level of foreign exchange reserves has not alone affect the severity of the crisis in Eastern Europe. We could not explain why some countries in Eastern Europe have suffered more in the current crisis than others using STV's benchmark model. None of the results that STV found were confirmed in our analysis. Most importantly, we did not find support for the central hypothesis that only countries with weak fundamentals and low levels of reserves are the only ones vulnerable to a currency crisis. This could indicate that contagion is the cause of the crisis in Eastern Europe. However, we do not have a suitable method of confirming this alternative hypothesis.

We then expanded the benchmark model by including measures of current account and capital inflow, the model's goodness of fit improved considerably and the coefficients generally became more significant. The conclusion is therefore that both current account and capital inflow are highly important factors behind the current crisis in Eastern Europe. The results were not quite as expected though. The *t*-tests gave puzzling results and the signs of some of the coefficients were not as anticipated. Therefore, we were not able to determine the exact way in which current account and capital inflow influence the crisis. Further research is needed to investigate how these variables have contributed to the crisis. Our findings, highlighting the importance of current account and capital inflows in explaining the crisis, provide quantitative support for the concerns aired in media of Easter Europe's mounting external deficits also mentioned in our introduction. This provides support for the conclusion that an adjustment of these imbalances could have lead to a less severe crisis in Eastern Europe.

# 5. Discussion

Our results showed that the benchmark model was not applicable to the current crisis in Eastern Europe. This does not mean, however, that the model is only relevant for the crisis it was designed to explain, the Mexican peso crisis in 1995. STV's model has been applied successfully in several papers analyzing the Asian crisis. Tornell (1998) concludes, in his paper on the Asian crisis, that the cross country variation in the severity of the crisis was mainly determined by the strength of the banking system, the real appreciation, and the international liquidity of the country. These three fundamentals are the same as those STV found important. In addition, Tornell (1998) finds that the rule that links fundamentals to the crises severity was the same in both the Tequila and the Asian crises. Another study was made in IMF's *World Economic Outlook, May 2008*, were it was concluded that real exchange rate appreciation, excessive domestic credit expansion, and a rapidly rising ratio of broad money to international reserves generally are signals of currency crisis vulnerability. Again, this is a conclusion in line with

STV's result. Berg and Pattillo (1999), on the other hand, do not find STV's model that useful in explaining the Asian crisis. As in our case, they find that the effect of *RER* with low reserves and weak fundamentals ($\beta 2 + \beta 4 + \beta 6$) is insignificantly different from zero. In Karfakis and Moschos (2004), STV's model is applied to the speculative episodes experienced by the Czech Republic and Poland during the 1990s. They find, just as STV, that the probability of a currency crisis depends on the growth rate of the reserve adequacy ratio, the growth rate of the domestic credit, and the growth rate of the real exchange rate.

The question is then, why do some studies support STV's model and method whereas other finds it inadequate? We believe that the classification of countries, as having a low or high reserve ratio and weak or strong fundamentals, is essential. STV does not give any explanation to why they make the classifications they do. This leads us to believe that they tested several different classifications and basically took the one that gave the best outcome. A similar view is expressed by Cooper (1996), as he raises the question of how many experiments were run, and whether an effort was made to maximize the $R^2$. In any case, we tried several different classifications, but none of our other classifications gave us a result more in line with STV's. Hence, we chose the classification we felt were as close to STV as possible, but with some modifications as explained in section 3.3. One possible explanation to our rejection of STV's hypothesis has to do with the classification of countries. It could be the case that all countries in our sample had weak fundamentals and low reserves. This could explain the failure to make a distinction between the performance of strong and weak countries in a crisis.

Another reason to why STV's model is not relevant in the current east European crisis may be the simple fact that the model does not incorporate the most important causes of the current crisis. In the present crisis, our findings indicate that external imbalances are important determinant, but the explanatory variables in STV's benchmark model mainly reflect internal imbalances. Both the lending boom and the reserve adequacy variables are primarily determined by domestic policy decisions, such as the degree of financial liberalization and monetary policy. The real exchange rate variable can also be said to be largely determined by internal factors, as the domestic price level plays an important role. The two variables we found most significant, the current account and capital inflow, are not included in the STV's benchmark model. This may be one explanation to why the model is inadequate in explaining the present crisis.

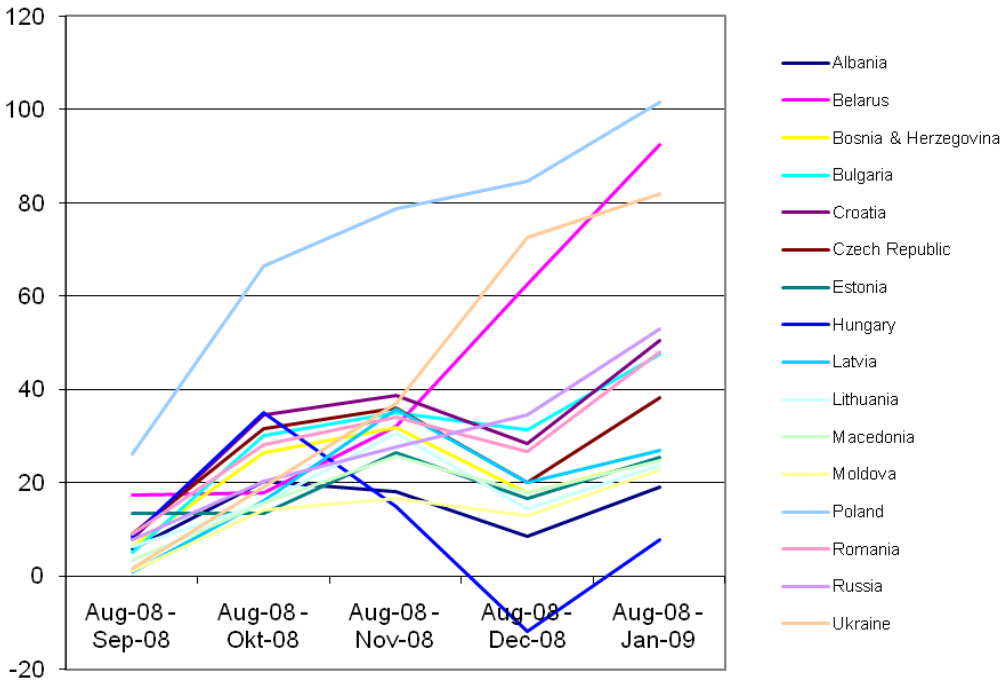
There are of course other ways an analysis of the causes of crisis can be performed, and other explanatory variables can be included. Berg and Pattillo (1999) offer an evaluation of STV and two additional models by Kaminsky, Lizondo and Reinhart (1998) and Frankel and Rose (1996). Reviewing the three currency crisis models it is evident that the indicators, and their definitions, used to predict crisis vary slightly between the models but are fundamentally quite similar. All models include different measures of real exchange rate, debt, reserves and money supply. As for variables unique for the respective models, Kaminsky, Lizondo and Reinhart (1998) use change in real interest rate and in the stock price index growth rate. Frankel and Rose (1996), include, among other variables, the level of public sector spending. Both these models also incorporate

measures of current account as an explanatory variable. This review shows that the explanatory variables used in STV's model does not constitute an exception but, with some variations, are similar to other contemporary currency crisis models. However, we can also conclude that it is possible to extend the model by including additional explanatory variables, such as real interest rate, stock price index, public sector spending and current account.

# Appendix

## *Figures*

**Figure 1: The crisis index**



## *Tables*

### Table 1: STV's individual country data (page 160)

**Table 1. Crisis and Financial Indicators**
Percentage change, except where indicated

| Country | *Crisis index*[a] *(IND)* | *Real depreciation*[b] *(RER)* | *Lending boom*[c] *(LB)* | *Reserves adequacy*[d] *(M2/R)* |
|---|---|---|---|---|
| Argentina | 20.2 | −48.0 | 57.1 | 3.6 |
| Brazil | 17.7 | −29.6 | 68.3 | 3.6 |
| Chile | −5.7 | −7.5 | 13.3 | 1.4 |
| Colombia | 4.2 | 9.2 | 20.5 | 1.5 |
| India | −1.2 | 43.0 | −3.1 | 6.3 |
| Indonesia | 1.3 | 11.8 | 0.7 | 4.6 |
| Jordan | −1.5 | 35.5 | 4.2 | 2.5 |
| Korea | −3.7 | −10.3 | 8.4 | 6.5 |
| Malaysia | −2.6 | 9.8 | 4.0 | 2.1 |
| Mexico | 79.1 | −28.5 | 116.2 | 9.1 |
| Pakistan | 0.7 | 20.4 | −7.7 | 6.6 |
| Peru | −2.9 | −45.4 | 156.1 | 1.5 |
| Philippines | 7.2 | −6.7 | 50.0 | 4.1 |
| South Africa | 1.1 | −6.8 | 8.1 | 21.5 |
| Sri Lanka | 0.7 | 1.2 | 28.9 | 2.0 |
| Taiwan | 4.4 | 16.2 | 46.0 | 4.7 |
| Thailand | −1.8 | 0.2 | 39.2 | 3.7 |
| Turkey | −2.5 | −12.1 | −32.8 | 3.2 |
| Venezuela | 7.6 | 16.2 | −38.5 | 1.4 |
| Zimbabwe | 1.6 | 44.2 | 55.7 | 2.6 |

Source: See appendix A.

a. The crisis index (*IND*) is a weighted average of the exchange rate devaluation rate with respect to the U.S. dollar and the percentage change in foreign exchange reserves between November 1994 and April 1995. Because the two series have different volatilities, the weights applied to each series (for each country) are given by the relative precision (the inverse of the variance) of each series over the past ten years.

b. Real depreciation of the exchange rate (*RER*) is the percentage point change in the real exchange rate index between the average of 1986–89 and the average of 1990–94. The real exchange rate index is a weighted sum of bilateral exchange rates (using domestic and foreign (CPI) vis-à-vis the dollar, the DM, and the yen). The weights sum to one and are proportional to a country's bilateral trade share with the United States, the European Union, and Japan. Note that a positive (negative) value of *RER* signifies that the real exchange rate is depreciated (appreciated), relative to the base period.

c. Lending boom (*LB*) is the percentage change between 1990 and 1994 in the ratio of the size of the claims of the banking sector (demand deposit banks and monetary authorities) on the private sector to GDP.

d. Reserve adequacy (*M2/R*) is the ratio of the broad measure of the money stock, M2, to the stock of foreign exchange reserves in November 1994.

**Table 2. Explaining the Crisis Index[a]**

| *Estimated coefficient and summary statistic* | *Independent variable* | *Interval used to calculate crisis index* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Nov. 1994–Jan. 1995* | *Nov. 1994–Feb. 1995* | *Nov. 1994–Mar. 1995* | *Nov. 1994–Apr. 1995* | *Nov. 1994–May 1995* | *Nov. 1994–June 1995* |
| $\hat{\beta}1$ | constant | −21.927 | −21.198 | −27.783 | −37.039 | −32.179 | −35.735 |
| | | (33.116) | (30.341) | (41.622) | (36.678) | (33.577) | (37.724) |
| $\hat{\beta}2$ | *RER* | 3.540 | 3.818 | 5.171 | 6.393 | 6.992 | 8.779 |
| | | (2.420) | (2.343) | (3.046) | (2.727) | (2.723) | (3.665) |
| $\hat{\beta}3$ | *LB* | 1.026 | 1.089 | 1.450 | 1.770 | 1.739 | 1.973 |
| | | (0.865) | (0.805) | (1.071) | (0.950) | (0.931) | (1.143) |
| $\hat{\beta}4$ | $RER \times D^{LR}$ | −3.328 | −3.692 | −5.026 | −6.165 | −6.774 | −8.339 |
| | | (1.948) | (1.969) | (2.486) | (2.276) | (2.321) | (3.435) |
| $\hat{\beta}5$ | $LB \times D^{LR}$ | −4.041 | −4.427 | −5.565 | −6.835 | −6.342 | −6.730 |
| | | (3.601) | (3.287) | (4.507) | (3.954) | (3.655) | (4.028) |
| $\hat{\beta}6$ | $RER \times D^{LR} \times D^{WF}$ | −1.442 | −1.577 | −3.401 | −2.886 | −2.821 | −2.014 |
| | | (1.407) | (1.354) | (1.695) | (1.542) | (1.283) | (1.623) |
| $\hat{\beta}7$ | $LB \times D^{LR} \times D^{WF}$ | 5.573 | 6.053 | 8.232 | 8.895 | 7.998 | 8.700 |
| | | (4.121) | (3.827) | (5.100) | (4.407) | (3.909) | (4.507) |
| *Summary statistic* | | | | | | | |
| $R^2$ | | 0.516 | 0.564 | 0.665 | 0.690 | 0.714 | 0.675 |
| $\overline{R}^2$ | | 0.292 | 0.363 | 0.510 | 0.546 | 0.583 | 0.512 |
| *Addendum: Wald tests* | | | | | | | |
| Null hypothesis | | | | *p* values | | | |
| $\hat{\beta}2 + \hat{\beta}4 = 0$ | | 0.71 | 0.81 | 0.84 | 0.72 | 0.71 | 0.51 |
| $\hat{\beta}2 + \hat{\beta}4 + \hat{\beta}6 = 0$ | | 0.38 | 0.26 | 0.05 | 0.07 | 0.03 | 0.34 |
| $\hat{\beta}3 + \hat{\beta}5 = 0$ | | 0.30 | 0.21 | 0.26 | 0.12 | 0.13 | 0.16 |
| $\hat{\beta}3 + \hat{\beta}5 + \hat{\beta}7 = 0$ | | 0.14 | 0.11 | 0.07 | 0.04 | 0.03 | 0.05 |

Source: See appendix A for sources for all regression variables.

a. The dependent variable is the crisis index, *IND*. $D^{LR}$ is a dummy variable for low reserves equal to one for countries above the bottom quartile of the sample for the ratio of money to foreign exchange reserves (*M2/R*) and equal to zero otherwise. $D^{WF}$ is a dummy variable for weak fundamentals equal to zero for countries in the highest quartile of the sample for real depreciation of the exchange rate (*RER*) and also in the lowest quartile of the sample for bank lending booms (*LB*); it is equal to one otherwise. See table 1 for definitions of the other variables. The regressions reported use the full sample of twenty countries discussed in the text. Standard errors are shown in parentheses.

**Table 3: Current account and capital inflow data**

| Country | Current account (average)* | Current account (change)** | Capital inflows (average)* | Capital inflows (change)** |
|---|---|---|---|---|
| Albania | -6,77 | -0,39 | 9,11 | 0,05 |
| Belarus | -3,37 | -4,44 | 5,25 | 10,23 |
| Bosnia & Herzegovina | -14,82 | 6,31 | 19,50 | -3,37 |
| Bulgaria | -12,82 | -16,92 | 21,31 | 24,73 |
| Croatia | -6,21 | -1,21 | 8,57 | -1,26 |
| Czech Republic | -3,47 | 4,47 | 4,35 | -4,46 |
| Estonia | -13,60 | -6,69 | 15,81 | 5,48 |
| Hungary | -7,56 | 1,72 | 9,14 | -2,00 |
| Latvia | -16,00 | -15,64 | 20,09 | 18,55 |
| Lithuania | -9,38 | -7,77 | 12,12 | 7,60 |
| Macedonia | -3,85 | 0,76 | 7,33 | 0,64 |
| Moldova | -8,99 | -10,43 | 12,51 | 19,79 |
| Poland | -2,98 | -1,88 | 4,45 | 4,42 |
| Romania | -9,34 | -8,04 | 14,51 | 10,04 |
| Russia | 8,95 | -2,32 | 0,12 | 7,27 |
| Ukraine | 2,83 | -9,46 | 3,07 | 11,72 |

* = ratio of current account and capital inflows to GDP from 2003 to 2007

** = percentage point change in current account and capital inflows to GDP from 2003 to 2007

## *Data construction*

When nothing else is specified, data is taken from the International Financial Statistics database (IFS). Line references refer to the specific classifications in the IFS.

### Crisis index

The crisis index is calculated using the change in nominal exchange rate (line RF) plus the negative of the change in reserves (line 1L) between August 2008 and the months up to January 2009. The components are weighted using the volatilities of exchange rate and reserve changes. The volatilities are calculated using monthly data from January 1999 to December 2008.

### Real exchange rate

The real exchange rate index is calculated using domestic and foreign consumer price indices (line 64) and nominal exchange rates (line RF). The CPIs for the United States, Germany and Japan are taken from OECD.Stat and the CPI for Bosnia & Herzegovina is taken from IMF's World Economic Outlook Database.

The real exchange rates are weighted in relation to the dollar, the euro and the yen. The weights sum to one and are proportional to a country's bilateral trade shares (both exports and imports) with the United States, Germany and Japan. Trade shares are computed using IMF's *Direction of Trade Statistics 2006* and *2008*.

### Lending boom

The measure of lending boom is calculated as the ratio of claims on the private sector (line 32D) to GDP (line 99B). When inflation is high, this ratio is biased upward because the annual data for claims on the private sector is from December each year, while GDP reflects the average price level over the entire year. To correct for this, the biased ratio is multiplied with the ratio of the average price level to price level for December. The variable used in the regression is the percentage change in lending from 2003 to 2007.

For Albania and Macedonia, GDP data are not available in the IFS for the entire estimation period. We therefore use IMF's World Economic Outlook Database to obtain this data.

### Ratio of M2 to Reserves

The data on reserves (line 1L) are converted to national currency using the nominal exchange rate (line RF). For M2, we use line 59MB. The ration of M2 to reserves is calculated for August 2008.

### Current account

The current account (line 78AL) is converted to national currency using the exchange rate (line RF). It is measured as a share of GDP (line 99B), and enters the regression in two different ways, both as the average over the period 2003-07, and as the percentage change from 2003 to 2007.

## Capital inflows

Capital inflows are constructed by adding capital account (line 78BC), financial account (line 78BJ) and net errors and omissions (line 78CA). The sum is converted to national currency using the exchange rate (line RF). As with the current account, capital inflows are measured as a share of GDP (line 99B), and enters the regression in two different ways, both as the average over the period 2003-07, and as the percentage point change from 2003 to 2007.

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