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## Sovereign debt defaults and currency crises in Latin America

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## *Chapter 3*

# The Global Financial Crisis and currency crises in Latin America\*

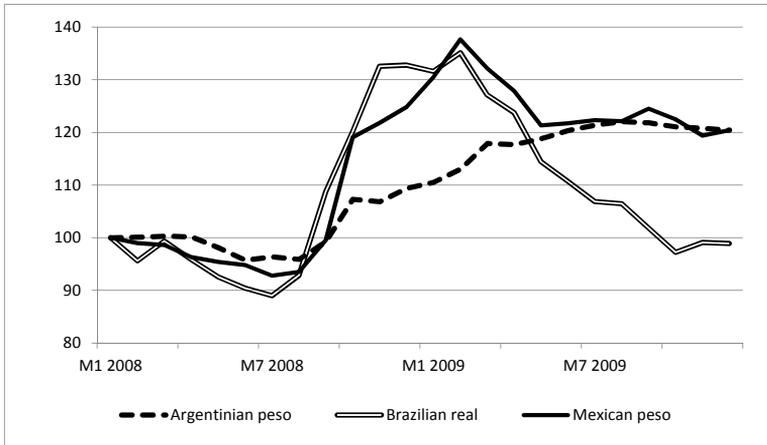
### 3.1 Introduction

In the midst of the Global Financial Crisis, the fall of Lehman Brothers in September 2008 causes a global panic that affects many emerging economies including the three largest economies in Latin America: Brazil, Mexico and Argentina. Latin American currencies depreciate sharply versus the US dollar. In Brazil and Mexico the local currencies quickly depreciate by more than 40%, and the Argentinian peso gradually depreciates by 20% vis-à-vis the US dollar (see Figure 3.1). The stock markets plunge with approximately 50%, and the sovereign bond interest rate spread in Argentina quadruple, while the interest rate spreads double in Mexico and Brazil. Ocampo (2009), Porzecanski (2009) and Jara et al. (2009) agree that the Global Financial Crisis has hit Latin America very hard, but that the financial impact has been less severe.

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\* This chapter is an extended version of Boonman, Jacobs and Kuper (2014).

Figure 3.1. Nominal exchange rates of the Argentinian peso, Brazilian real and Mexican peso, 2008–2009. Indexed (2008M1 = 100), monthly data.



Source: International Finance Statistics (IFS) from IMF.

The Global Financial Crisis and its effects on other countries and currencies have been studied extensively, with different findings. Rose and Spiegel (2011) find that countries with current account surpluses seem to suffer less from slowdowns. Fratzscher (2009) finds that countries with low foreign reserves, weak current account positions and high financial exposure vis-à-vis the USA experienced larger currency depreciations. Frankel and Saravelos (2012) select a wide range of variables from the Early Warning System (EWS) literature and find that international reserves and real exchange rate overvaluation are the most important leading indicators of the 2008–2009 crisis.

This chapter investigates the experience of the three largest Latin American countries, Brazil, Mexico and Argentina, with currency crises since the 1990s, including the currency crises in the aftermath of the fall of Lehman Brothers in September 2008. Contrary to other chapters in this dissertation, we exclude Chile, because the country does not experience currency crises in the period 1990–2007. We focus on the period since the early 1990s, because of data availability and because of the structural break with the periods of hyperinflation, sovereign debt crises and the remains of inward-looking

economic policies. The implementation of market reforms (the ‘Washington consensus’), debt restructuring (Brady plans) and successful reforms to avoid hyperinflation in Argentina (1991) and Brazil (1994) mark the start of this period—see Section 2.1.

Although the three countries under study have a lot in common for the 1990–2009 period (for example the importance of commodities, large income disparity, low domestic savings rates and the occurrence of one or more large financial crises), there are also important differences (for example in the adoption of market reforms, international trade and finance policies, exchange rate regimes, economic performance and political and institutional changes). Compared to Argentina and Brazil, Mexico has experienced relatively few currency crises in the period under study. We kept Mexico in the sample, because it provides the opportunity to see how our model performs in a country with few currency crises. There are also interactions between the three countries. Argentina and Brazil are important trade partners. And there is also contagion, such as the Mexican 1994–1995 ‘tequila’ crisis that affected various emerging markets, in particular Argentina. We estimate the model and analyze the outcomes for each country independently. In the Discussion we analyze common characteristics of the estimated Early Warning System (EWS) models of the three countries.

We model the probability of a currency crisis in an ordered logit model to account for the severity of currency crises. We distinguish three classes of currency crises (mild, deep and very deep crises) and tranquil periods (periods in which no currency crisis took place). We include a large number of possible crisis indicators, based on all three generation currency crisis models as described in Chapter 2. We use a static factor model to cope with the large number of crisis indicators. In that respect our work is related to Jacobs, Kuper and Lestano (2008), who apply factor analysis to predict the Asia crisis. We estimate the factor models and the ordered logit models up to and including 2007, and present forecasts for 2008–2009.

We contribute to the EWS literature in two ways. We combine the static factor model with the ordered logit model to construct an Early Warning

System for currency crises that accounts for the severity of the currency crises. Second, we include a wide range of variables in explaining currency crises. This allows us to investigate the role of institutional, political, global and commodity-related indicators, as suggested by Alvarez-Plata and Schrooten (2004). With respect to the former, we follow Acemoglu, Johnson, Robinson and Thaicharoen (2002, pages 4–5) in their description of institutions: “A cluster of social arrangements that include constitutional and social limits on politicians and elites power, the rule of law, provisions for mediating social cleavages, strong property rights enforcement, a minimum amount of equal opportunity and relatively broad-based access to education, etc. This cluster determines whether agents with investment opportunities will undertake these investments, whether there will be significant swings in the political and social environment leading to crises, and whether politicians will be induced to pursue unsustainable policies in order to remain in power.” Furthermore, Acemoglu et al. (2002) observe that societies with weak institutions are less able to deal with economic and political shocks. This inability seems to be related to ‘state failures’ such as civil wars or revolutions. Political indicators include absolute majority in the house, political orientation of the party in power, degree of polarization, and election years.

We find that currency crises in Argentina, Brazil and Mexico are predominantly related to debt, banking and commodity indicators. Including institutional indicators improves the fit of the model for all countries significantly. The relation between institutional indicators and the occurrence of currency crises fits within the third generation currency crisis models. In the run-up to the very deep crises in Mexico and Brazil the institutional conditions improve, which causes widespread optimism and leads to excessive booms and busts in international lending and asset price bubbles. The very deep currency crises are accompanied by debt service difficulties. These events are in line with the boom-bust mechanism for sovereign debt defaults—as described in Section 2.3.3. The model’s forecasts for Argentina and Brazil are reasonably good. The model predicts an increased proba-

bility of a crisis in the fall of 2008, although the predicted severity overestimates the actual severity (mild). For Mexico the out-of-sample performance is rather poor. The model that includes institutional indicators predicts a slightly increased probability of a mild crisis. However, in reality a very deep crisis took place. We explain the poor performance of our model for Mexico by the low number of crises and by the different conditions in the run-up to the very deep crises. Mexico experiences only three currency crises (very deep crises in 1994–1995 and 2008, and a mild crisis in 1998), while Argentina experiences five and Brazil eight currency crises in this period. The conditions prior to the very deep currency crisis in Mexico in 1994–1995 are very different than in the run-up to the very deep currency crisis in 2008, in terms of the exchange rate regime, capital inflows, banking sector regulations, and debt levels.

The remainder of this chapter is structured as follows. After a review of financial crises and models, early warning systems and empirical studies for Latin America in Section 3.2, Section 3.3 discusses our method. The data are presented in Section 3.4, followed by the empirical results, the analysis of out-of-sample performance and robustness checks in Section 3.5. We discuss our results in Section 3.6, and Section 3.7 concludes.

## **3.2 Literature review**

### **3.2.1 Early Warning Systems**

Early Warning Systems (EWSs) are models that issue signals or warnings well ahead of a potential financial crisis. The dozens of EWSs that have been developed differ widely in the definition of a currency crisis, the period of estimation, data frequency, the countries included, the inclusion of indicators, the forecast horizon, and the statistical or econometric methods used. For extensive overviews see Kaminsky et al. (1998) or Abiad (2003). Most studies use binary methods (logit or probit), the signals approach, Ordinary Least Squares, Markov Switching models, binary recursive trees, contingent claims analysis, or a combination of these methods.

The typical EWS is applied to a large number of emerging countries in order to obtain a sufficient number of crisis observations. This approach has received criticism. To quote Abiad (2003, page 45): ‘The one-size-fits-all, panel data approach used in estimating most Early Warning Systems might be one of the causes of their only moderate success’. Kaminsky (2006) confirms this. Beckmann, Menkhoff and Sawischlewski (2006) suggest that differences between geographical regions justify a regional approach. A growing number of studies focuses on a geographic region—particularly South East Asia, Central Europe and Latin America. Even within a region distinctions can be made. Van den Berg, Candelon and Urbain (2008) construct country clusters for six Latin American countries. In their study for the period 1985-2004, Argentina, Brazil and Peru are grouped into one cluster because of similar inflation patterns, while Mexico, Uruguay and Venezuela are grouped in the other cluster, due to important privatizations in the early 1990s.

### **3.2.2 Early Warning Systems: applications for Latin America**

Latin American countries—particularly Argentina, Brazil and Mexico—have been included in EWSs applied to emerging economies from all over the world. With its rich history of financial crises (Reinhart and Rogoff, 2009), empirical research on the region or even one country has surged since the late 1990s. Kamin and Babson (1999) construct an EWS to predict currency crises for a pooled data set of six Latin American countries for the period 1981–1998. They use a binomial probit model to identify the deeper causes of Latin America’s volatility of nominal exchange rates. They find that domestic policy and economic imbalances are more related with currency crises than exogenous external shocks such as an increase in international real interest rates, a recession in developed countries, or a decrease in commodity prices. Herrera and Garcia (1999) construct an EWS that contains the real effective exchange rate, domestic credit growth in real terms, the ratio of M2 to international reserves, inflation and a stock market index in real terms as regressors. They apply their model to eight Latin American countries. They

acknowledge that including external interest rates, commodity prices and the state of the real economy will probably improve the performance, but that this will add to the complexity of the model. They suggest the use of factor models.

Argentina's long history of currency crises and other financial crises is analyzed in various studies. Kaminsky, Mati and Choueiri (2009) use a Vector Autoregression (VAR) model to quantify the role of domestic and external shocks in currency crises. They analyze Argentina's currency crises from 1970 to 2001 and find that the crises have different causes. In some crises domestic fundamentals matter, in particular inconsistent monetary and exchange rate policies. Typically these policies are accompanied by hyperinflation, confiscations of bank deposits, and price and wage controls, which cause uncertainty and risk aversion of households and foreign investors. In other crises monetary tightening in industrial countries is the key variable: the resulting capital flow reversals lead to currency crises. Contagion also plays a role in some crises in the 1990s. Cerro and Iajya (2009) analyze Argentina's crises from 1862 to 2004. They use different techniques and a set of institutional and macroeconomic variables. They find that institutions and their volatility are key indicators for currency crises. Alvarez-Plata and Schrooten (2004) apply the signal approach of Kaminsky et al. (1998) and find that the Argentinian currency crisis of 2002 could not have been foreseen by the leading indicators. They suggest that in future research institutional indicators such as political turbulence and corruption should be included.

Another crisis that has been researched extensively is the Mexican 'tequila' crisis of 1994–1995. Sachs, Tornell and Velasco (1996) focus on contagion. Some countries were hit and others not. They find that countries with high real exchange rates, low reserves and a lending boom are hit by the contagion. Beziz and Petit (1997) study the use of real-time data on predicting the crisis. They find that the 1994 crisis could well have been foreseen with information available before the crisis. They use the composite leading indicator which was constructed by the OECD in 1996 and consists of financial

series (total industrial production in USA, total imports from USA, share prices, real effective exchange rate and CPP), business surveys (production and employment tendencies) and employment in manufacturing.

Our work builds upon previous empirical research on Latin America. In line with a suggestion of Herrera and Garcia (1999) we use factor models. With the factor model we have no restriction on the number of variables that we include. Our choice to include a wide range of variables instead of preselecting explanatory variables is inspired by Kaminsky et al. (2009), who find that the currency crises in Argentina from 1970 to 2001 have different causes; some are related to weak domestic fundamentals and others to external factors.

### 3.3 Methodology

We first apply factor analysis to extract the factors from a large set of indicators, use the estimated factors as regressors in the ordered logit model, with a crisis dummy as dependent variable, and then compute ex ante forecasts. Before we turn to these models, we first discuss the crisis dating.

#### 3.3.1 Crisis dating

As explained in Chapter 1, there are various alternative currency crisis definitions. We opt for the speculative pressure approach, because it does not only take into account actual devaluation or depreciation of the currency, but also includes periods of great stress of the exchange rate. This approach is considered better than the successful attack approach, because it works well under both fixed and floating exchange rate regimes (Frankel and Saravelos, 2010). We follow the Exchange Market Pressure Index (EMPI) of Kaminsky and Reinhart (1999) and Kaminsky (2006) defined as the weighted average of exchange rate changes and reserve changes, with weights such that the two components of the index have equal conditional volatilities (see Appendix A). Kaminsky and Reinhart (1999) identify a crisis when the observation exceeds the mean by more than three standard deviations. We use

this criterion to identify very deep crises. Similar to Cerro and Iajya (2009) we extend the crisis definition by introducing deep crises (which we define as two adjacent months exceeding between 2 and 3 times the standard deviation) and mild crises (which we define as two adjacent months exceeding between 1 and 2 times the standard deviation). The ordinal variable that indicates crises periods is constructed as follows: the value 0 indicates no crisis period, the value 1 is assigned to mild crises, 2 to deep crises and 3 to very deep crises. As is common in EWSs of currency crises, we assign the same dummy variable value for the run-up period to the crisis. Kaminsky et al. (1998) use a run-up period of 24 months with the argument that for policy makers the run-up period should be sufficiently long to be able to implement policies to avoid a crisis. Eichengreen et al. (1995) use a window of 2 quarters. Here we choose three different run-up periods: 6, 12 and 24 months preceding the onset of a crisis. If depths of crises overlap we assign the highest ordinal number to that crisis.

### 3.3.2 Factor models

In factor models an observable set of  $N$  variables is expressed as the sum of  $r$  common components (factors) and the idiosyncratic component. The primary reason for the popularity of factor models is that one can include a large number of variables and let the model reduce this into a much smaller number of factors ( $N \gg r$ ). This is a desirable feature since more and more data become available for policy makers and researchers at a more disaggregated level. The drawback of using factor models is the difficulty to interpret the results.

Within the static factor models we can distinguish exact and approximate models. When the factors and the idiosyncratic components are uncorrelated and i.i.d., then the model is static, exact, or strict. Exact factor models can be consistently estimated by maximum likelihood. However the restrictions on the model are often not met in empirical applications. When the number of variables goes to infinity, the correlation restrictions of the exact factor model can be relaxed and one can use the approximate factor model.

In the static, approximate factor model the idiosyncratic components are (weakly) correlated, which covers cross-correlation and heteroskedasticity between the idiosyncratic errors and correlation between the common components and the idiosyncratic components (Barhoumi, Darn and Ferrara, 2010).

We confine ourselves to a static factor model. In future research we will use a dynamic factor model, in which the factors enter with leads and lags. In theory the dynamic factor model should be superior, but empirical research (Barhoumi et al., 2010) has found that it is not necessarily better.

### The static factor model

The static factor model has the following form:

$$X_t = \Lambda F_t + u_t, \quad (3.1)$$

where  $X_t$  is an  $N \times 1$  vector of the indicators in period  $t$ , with  $t = 1, 2, \dots, T$ .  $\Lambda$  is an  $N \times r$  matrix of factor loadings,  $F_t$  is an  $r \times 1$  vector of factors in period  $t$  and  $r$  is the number of factors.  $u_t$  is an  $N \times 1$  vector with idiosyncratic terms in period  $t$ . When these idiosyncratic terms are i.i.d. and uncorrelated with the factors, then the static factor model is exact. When the idiosyncratic terms are (weakly) correlated with the factors, then (3.1) becomes an approximate static factor model.

The principal components method can be used to estimate the factors. The principal components of  $X_t$  are the factors:

$$F_t = S' X_t \quad (3.2)$$

where the factor estimates  $F_t$  are the first  $r$  principal components of  $X_t$ , and  $S$  is an  $N \times r$  matrix with the eigenvectors that correspond to the  $r$  largest eigenvalues.

### **Determination of the number of factors**

One of the issues in factor analysis is the determination of the optimal number of factors. Various procedures have been proposed, such as the Bayesian Information Criterion, the Kaiser Criterion and Cattell's scree test. With the large dimensional factor models of recent years many studies have proposed solutions and consistent estimators for the number of factors using different factor models and distributional assumptions. Here we employ the criterion of Otter, Jacobs and den Reijer (2014; henceforth OJdR), which is associated with Onatski's (2009) test statistic, and related to the scree test. The criterion looks for the number of eigenvalues for which the difference between adjacent eigenvalue-eigenvalue number blocks is maximized. The criterion outperforms other criteria including the Edge Distribution estimator of Onatski (2010), except for large samples (more than 300 variables / observations).

### **Interpreting the factors**

Using factor models comes at a cost. Determining the economic relevance of factors and interpreting the factors in a meaningful way is problematic. Many indicators enter in more than one factor, so focusing on a single factor only partially explains the full impact of an indicator on the probability of a crisis, and may even lead to counterintuitive results. We apply two ways to 'label' the factors: (i) contribution of the variable to the factor, which is obtained by squaring each individual element of the eigenvector, and (ii) correlations between the factor and the individual indicator as in Breitung and Eickmeier (2006).

#### **3.3.3 Ordered logit model**

As our dependent variable can only take four values ( $y_t = 0$ : no crisis;  $y_t = 1$ : mild crisis;  $y_t = 2$ : deep crisis, and  $y_t = 3$ : very deep crisis), we employ an ordered choice model, which extends the binary choice model, allowing

for a natural ordering in the outcomes  $y$ . Then

$$y_t = \begin{cases} 0 & \text{if } y_t^* \leq \mu_1, \\ 1 & \text{if } \mu_1 < y_t^* \leq \mu_2, \\ 2 & \text{if } \mu_2 < y_t^* \leq \mu_3 \\ 3 & \text{if } \mu_3 < y_t^*, \end{cases} \quad (3.3)$$

where  $y_t$  is the observed ordinal variable,  $\mu_i$  are the thresholds, and  $y_t^*$  is the continuous latent variable that is equal to

$$y_t^* = \alpha + X_t\beta. \quad (3.4)$$

The thresholds  $\mu_i$  which separate the various outcomes are estimated simultaneously with parameters  $\alpha$  (intercept) and  $\beta$  (slope).

We use the ordered logit model, because the logistic distribution (logit model) has wider tails than the normal distribution (probit model). This is preferable if an event has a very low frequency, as is the case with financial crises (Manasse et al., 2003).

Most institutional variables that we use have low variation. When there is limited overlap in the values of (a set of) explanatory variables and the outcomes of the dependent variable, the regressions yield large estimates and standard errors. This problem is called quasi-complete separation (Zorn, 2005), and we avoid it in the following way. For each country we estimate two versions of the ordered logit model. The first uses the factors calculated from the data set, excluding institutional variables. The second model adds (a subset of) institutional and political variables to the factors as separate regressors. We select the combination of institutional variables that does not cause quasi-complete separation (using an upper limit in absolute terms of 1.5 for the estimates corresponding to the—standardized—institutional variables and the factors), and yield the highest adjusted pseudo  $R^2$ . The choice for the upper limit in absolute terms of 1.5 is an ad hoc decision. We have performed the analysis for lower and higher upper limits. With a lower

upper limit we find that very few institutional indicators can be included, and with a higher upper limit the quasi-complete separation problem causes that forecasts become rather extreme, because of the relative large estimates of the coefficients.

### 3.3.4 Ex ante forecasts

The models are estimated using data up to and including 2007, and we test the out-of-sample performance of the estimated models for the period 2008M1–2009M12. We forecast the probabilities of a mild, deep and very deep crisis with our ordered logit model. We use realized monthly data for the indicators for the years 2008 and 2009, and extrapolate the factors without re-estimating the loadings of the static factor model.

We use the quadratic probability score (*QPS*) proposed by Diebold and Rudebusch (1989) to evaluate the out-of-sample forecasts. This measure indicates how close, on average, the predicted probabilities  $P_t$  and the observed realizations  $Z_t$  are. The *QPS* is given by

$$QPS = \frac{1}{T} \sum_{t=1}^T 2(P_t - Z_t)^2 \quad (3.5)$$

The *QPS* achieves a strict minimum under the truthful revelation probabilities by the forecaster. In addition, *QPS* is the unique proper scoring rule that is a function only of the discrepancy between realizations and assessed probabilities. The *QPS* ranges from 0 to 2, with a score of 0 corresponding to perfect accuracy if the estimated probability is 1 (0) and a crisis does (not) occur for all  $t$ . A score of 2 shows that the model indicates a perfect false signal in which the estimated probability is 0 (1) and a crisis does (not) occur for all  $t$ .

## 3.4 Data description

Our sample starts in the early 1990s, after the effects of spillovers of the 1980s Latin American debt crisis faded out. The analysis for Argentina starts

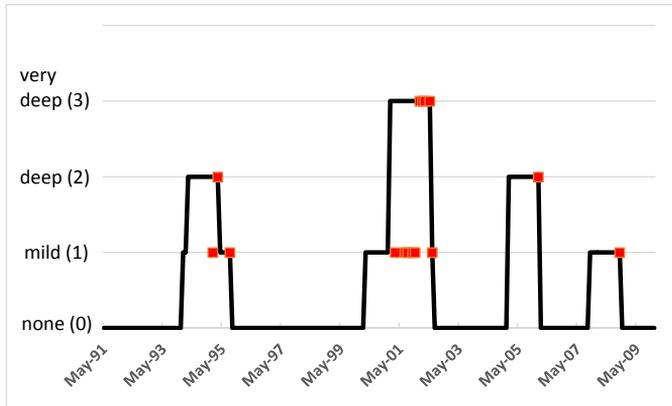
after the introduction of the Convertibility Plan (April 1991) and for Brazil after the introduction of the Real Plan (July 1994), which both can be regarded as a structural break with the hyperinflation periods. Mexico did not experience any period of hyperinflation in the 1990s, so our series start in January 1990.

As explained above, we distinguish mild, deep and very deep crises. Figures 3.2, 3.3 and 3.4 show that very deep crises are rare; each of the countries under investigation experienced only a few very deep crises: Argentina (January 2002), Brazil (January 1999) and Mexico (December 1994 and October 2008). We split the sample into two periods: the period until and including December 2007 is used to estimate the models, and the period January 2008 until and including December 2009 is used to forecast currency crises out-of-sample. We estimate the Exchange Market Pressure Index (EMPI) based on the period up to December 2007, and extend this to December 2009. For the weights we use the standard deviations from the period up to and including December 2007.

In the text we only show the results for models with a run-up period of 12 months for the crises. The run-up period is used since we are interested in an *early* warning system, so we want to detect a currency crisis before it actually occurs. Additionally, the run-up period functions as a window exclusion period, such that a crisis that takes place within 12 months after a prior crisis is not considered a separate crisis, but a continuation of the prior crisis. We use two alternative run-up periods as a robustness check, a model with a shorter run-up period (6 months) and a model with a longer run-up period (24 months).

For the explanatory variables we select the ‘usual suspects’ (the common macroeconomic and financial variables), institutional variables, commodity-related and global indicators. Some data limitations exist. Not all time series are sufficiently long which limits the selection of explanatory variables. The quality of some of Argentina’s national statistics after 2007 is doubtful (The Economist, 2012). For a complete overview of the explanatory variables used, including definitions, transformations, and sources we refer to Appendix C.

Figure 3.2. Currency crisis episodes for Argentina for the period 1991–2009 (monthly data), with a 12 months run-up period for each crisis. The red dots correspond to the months of the currency crisis. The black line includes a 12 months run-up period for each crisis.

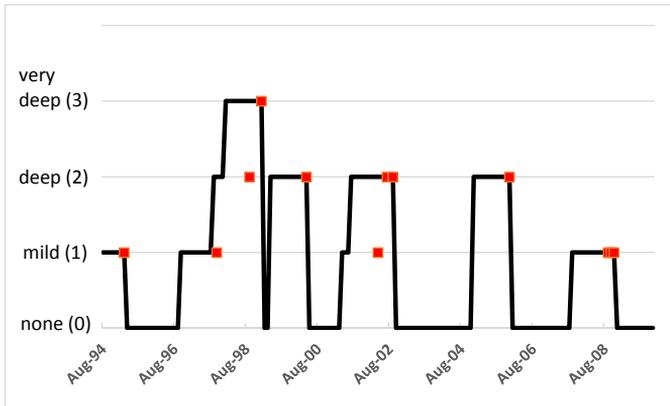


Source: Own calculations, with underlying data from IFS.

The selected indicators can be classified into separate categories:

- 13 external economic indicators, among which the deviation from real exchange rate trend, exchange rate volatility, growth of exports, imports and foreign reserves, net portfolio investments and foreign direct investments.
- 19 domestic economic indicators, among which the domestic real interest rate, inflation, M2 multiplier, industrial production, a share market index return.
- 14 institutional indicators, among which Herfindahl indices, political stability, corruption, investment profile, internal conflict, election years.
- 10 debt indicators, among which total debt, short term debt, debt service, arrears.

Figure 3.3. Currency crisis episodes for Brazil for the period 1994–2009 (monthly data), with a 12 months run-up period for each crisis. The red dots correspond to the months of the currency crisis. The black line includes a 12 months run-up period for each crisis.

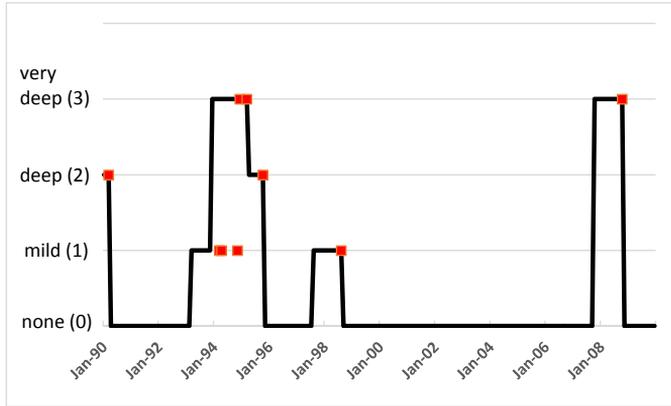


Source: Own calculations, with underlying data from IFS.

- 14 banking sector indicators, among which credit to public sector, credit to private sector, Return On Equity, deposits.
- 5 global and regional indicators, among which world economic growth, US yield, a contagion dummy.
- 12 commodity related indicators, among which prices of oil, metals, agricultural products, exports and imports of fuel, agricultural products, food and metals as percentage of GDP.

The series have been tested for non-stationarity (using Augmented Dickey-Fuller tests) and visually inspected for seasonal effects. Where necessary a transformation is made to render them stationary. To deal with mixed frequencies in series, we apply simple quadratic interpolations. All series are normalized, i.e. demeaned and divided by its sample standard deviation.

Figure 3.4. Currency crisis episodes for Mexico for the period 1990–2009 (monthly data), with a 12 months run-up period for each crisis. The red dots correspond to the months of the currency crisis. The black line includes a 12 months run-up period for each crisis.



Source: Own calculations, with underlying data from IFS.

## 3.5 Empirical results

We estimate the ordered logit model for Argentina, Brazil and Mexico for the period up to and including 2007 using monthly data. In this section we discuss both the factor model outcomes, and the estimation results for the ordered logit models. We treat institutional variables in a special way, because these cause quasi-complete separation due to their low variation. We construct two models, one with only factors and one in which a subset of the institutional variables is added to the factors in the ordered logit model. The extended model allows us to test whether the institutional variables contain additional information that is significant for currency crisis periods.

### 3.5.1 Regressions

The OJdR criterion suggests 10 factors for Argentina. Based on correlations and contributions to the factor (see tables D.1 and D.2 in Appendix D) we label the factors in the following way. Factor 1 is labeled a combined bank

and commodities factor, since the 12 commodity-related variables (out of 73 variables in total, or 16.4%) contribute 24.5% to the factor and the 22 bank-related variables (30.1%) contribute 36.7% to the factor. Factor 3 is labeled a global factor, since the three strongest correlated variables are changes in the U.S. 3 months 3 Treasury-bill interest rates, world real GDP growth and changes in the price of metal, established in the world commodity markets. The four global variables (out of 73 variables in total, or 5.5%) contribute 18.3% to the factor. Factors 4, 9 and 10 are labeled debt factors. For factor 4 the debt service payments as a percentage of foreign reserves is the variable that contributes more than any other variable (12.5%). The ten debt-related variables (out of 73 variables in total, or 13.7%) contribute 26.9% to the factor. For factor 9 the reduction of total debt and the change in ratio of foreign reserves to debt contribute most, 11.1% and 8.9% respectively. The ten debt-related variables contribute 31.1% to the factor. For factor 10 the long term public and publicly guaranteed debt as a percentage of total debt contributes more than any other variable (25.0%). The ten debt-related variables contribute 36.5% to the factor. Factor 5 is labeled a banking factor, with a total contribution of 47.4% to the factor, and the three variables with highest correlation to the factor being bank-related variables. Factor 6 is labeled an external economic factor, with change in import cover and M2 as a percentage of foreign reserves contributing 11.2% and 9.6% respectively. The total contribution of twelve external economic variables to the factor is 34.2%. Factors 2, 7 and 8 do not have a clear profile.

In Table 3.1 we present estimation results for (1) the model with only static factors, and (2) the model with both static factors and a combination of institutional variables. Interpreting the results is not straightforward, but by combining the estimation results with the labels that we assigned to the factors, we can identify which categories are most related to currency crises in Argentina. For the model with static factors only (second and third columns in Table 3.1), the significant factors are primarily debt factors (4, 9 and 10), followed by a banking factor (factor 5) and a global factor (factor 3). For the model with static factors and institutional variables (last two

Table 3.1. Ordered logit estimation results for Argentina 1991M5–2007M12, with a 12 months run-up period.

Dependent variable: currency crisis dummy				
Variable	(1) Without institutional indicators		(2) Including institutional indicators	
	coef-ficient	standard error	coef-ficient	standard error
SF1	-0.130*	0.075	-0.269**	0.121
SF2	-0.327***	0.078	-0.406***	0.114
SF3	0.249**	0.116	0.341**	0.174
SF4	0.336***	0.115	0.215**	0.104
SF5	-0.861***	0.162	-1.252***	0.247
SF6	0.223	0.145	0.064	0.183
SF7	0.650***	0.141	0.847***	0.193
SF8	0.288*	0.169	0.167	0.219
SF9	-0.514***	0.151	-0.376**	0.183
SF10	0.459***	0.166	0.234	0.271
$\Delta$ INTCONFL			1.074***	0.235
$\Delta$ LAWORD			0.542	0.380
ELECLEGYR			1.048**	0.530
Pseudo $R^2 =$	0.390		0.472	
Adj Pseudo $R^2 =$	0.344		0.411	

## Notes:

\*: significant at 10%, \*\*: significant at 5%, and \*\*\*: significant at 1%;

Explanations of the symbols used:

- SF1: Static Factor 1, SF2: Static Factor 2, et cetera;
- $\Delta$  INTCONFL: Change in internal conflict dummy variable;
- $\Delta$  LAWORD: Change in the law and order dummy variable;
- ELECLEGYR: Dummy variable that is 1 if there is an election year for the legislative power and 0 otherwise.

Pseudo  $R^2$ : Coefficient of correlation for the ordered logit regression model;

Adjusted Pseudo  $R^2$ : Coefficient of correlation, adjusted for the degrees of freedom as a consequence of including more explanatory variables.

columns in Table 3.1), the significant factors are two debt factors (4 and 9), followed by a banking factor (factor 5), a global factor (factor 3), and a combined commodities and banking factor (factor 1).

Including institutional indicators improves the adjusted pseudo  $R^2$ . The Wald test ( $F$ -value is 7.557 and the  $p$ -value is 0.000) shows that the included institutional variables contribute to explaining the currency crises in Argentina. A lower level of internal conflict and an election year (for legislative power) are associated with deeper currency crises. The first seems counter-intuitive. The latter can be explained by the political economy theory that shows that governments prefer to postpone painful decisions (including the devaluation of an overvalued currency), and a new government may see no way out then to devalue.

For Brazil the OJdR criterion suggests 8 factors, which are labeled as follows: Factor 1 is labeled as a debt factor, factor 2 a combined bank and debt factor, factor 4 a combined global and bank factor, factor 5 a commodities factor, factor 7 a combined global and external economic factor, and factor 8 is labeled as a bank factor. Factors 3 and 6 are not dominated clearly by any category (see tables D.3 and D.4 in Appendix D).

We see from the last two columns in Table 3.2 that the significant factors consist of debt (factors 1 and 2), banking (factors 2 and 8), commodities (factor 5), external economy and global indicators (factor 7). Including institutional indicators improves the adjusted pseudo  $R^2$ , which is confirmed by the Wald test ( $F$ -value is 13.305 and the  $p$ -value is 0.000). Bureaucratic quality represents the institutional strength and quality of the bureaucracy as a shock absorber that tends to minimize revisions of policy when governments change. In our model an increase or improvement in bureaucratic quality is associated with no or milder crises, which seems plausible. The other institutional variable is a scale for law and order conditions, which reflects the strength and impartiality of the legal system and the popular observance of the law. In our model an increase or improvement in law and order is associated with deeper currency crises, which seems at odds with intuition.

Table 3.2. Ordered logit estimation results for Brazil 1994M8–2007M12, with a 12 months run-up period.

Dependent variable: currency crisis dummy				
Variable	(1) Without institutional indicators		(2) Including institutional indicators	
	coef-ficient	standard error	coef-ficient	standard error
SF1	0.209***	0.044	0.243***	0.049
SF2	-0.342***	0.063	-0.318***	0.079
SF3	0.059	0.056	0.168***	0.064
SF4	-0.191**	0.076	-0.048	0.081
SF5	-0.574***	0.101	-0.627***	0.108
SF6	0.182**	0.090	-0.085	0.111
SF7	0.211**	0.094	0.589***	0.125
SF8	0.366***	0.116	0.433***	0.127
$\Delta$ BURQUAL			-1.441***	0.319
$\Delta$ LAWORLD			1.336***	0.293
Pseudo $R^2 =$	0.257		0.333	
Adj Pseudo $R^2 =$	0.221		0.287	

Notes:

\*: significant at 10%, \*\*: significant at 5%, and \*\*\*: significant at 1%;

Explanations of the symbols used:

- SF1: Static Factor 1, SF2: Static Factor 2, et cetera;
- $\Delta$  BURQUAL: Change in the bureaucratic quality dummy variable;
- $\Delta$  LAWORLD: Change in the law and order dummy variable;

Pseudo  $R^2$ : Coefficient of correlation for the ordered logit regression model;

Adjusted Pseudo  $R^2$ : Coefficient of correlation, adjusted for the degrees of freedom as a consequence of including more explanatory variables.

Mexico has 6 factors according to the OJdR criterion. We label factor 1 as a combined commodities and bank factor, factors 2 and 6 as debt factors, factor 3 as a combined external economic and bank factor and factor 4 as a global factor. Factor 5 does not receive a label since there is no dominance of any category (see tables D.5 and D.6 in Appendix D). Combining the estimation results from the model with both factors and institutional variables (last two columns in Table 3.3) with the labels that we assigned to the factors, we see that bank indicators (factors 1 and 3), debt indicators (factor 2), and to a lesser extent commodities (factor 1) and external economic indicators (factor 3) are associated with currency crises. Institutional indicators contribute significantly to the explanation of currency crises in Mexico: their inclusion increases the adjusted pseudo  $R^2$  and the Wald test has an  $F$ -value is 4.301 and the  $p$ -value is 0.001. An increase (or improvement) in bureaucratic quality and investment profile is associated with deeper crises, which seems counter-intuitive.

We conclude that currency crises in Argentina, Brazil and Mexico are associated with debt, banking and commodities indicators. Furthermore, currency crises in Argentina and Brazil are related with global indicators, and currency crises in Brazil and Mexico are related with external economy indicators. In both Argentina and Mexico the election year for the legislative power is significant. All models improve when institutional variables are included. Various institutional indicators have a counterintuitive relation with currency crises, which we will discuss in Section 3.6.

### 3.5.2 Forecast performance

In this section we investigate the out-of-sample performance in the period 2008M1–2009M12 of the estimated models. In the text we will focus on the model with the 12 months run-up period, and in section 3.5.3 we discuss the performance of the models with a 6 and 24 months run-up period.

Table 3.3. Ordered logit estimation results for Mexico 1990M1–2007M12, with a 12 months run-up period.

Dependent variable: currency crisis dummy				
Variable	(1) Without institutional indicators		(2) Including institutional indicators	
	coef-ficient	standard error	coef-ficient	standard error
SF1	-0.147**	0.059	-0.193***	0.069
SF2	0.281***	0.079	0.278**	0.110
SF3	0.682***	0.095	1.201***	0.204
SF4	-0.080	0.113	0.065	0.123
SF5	0.508***	0.112	-0.159	0.211
SF6	-0.078	0.137	0.055	0.190
$\Delta$ BURQUAL			0.724**	0.338
$\Delta$ CORRUPT			0.355	0.351
$\Delta$ INVPROF			1.340**	0.682
$\Delta$ LAWORD			0.142	0.417
ELECLEGYR			1.193*	0.617
Pseudo $R^2$	0.388		0.493	
Adj. Pseudo $R^2$	0.358		0.435	

Notes:

\*: significant at the 10% level, \*\*: significant at the 5% level, and \*\*\*: significant at the 1% level;

Explanations of the symbols used:

- SF1: Static Factor 1, SF2: Static Factor 2, et cetera;
- $\Delta$  BURQUAL: Change in the bureaucratic quality dummy variable;
- $\Delta$  CORRUPT: Change in the corruption dummy variable;
- $\Delta$  INVPROF: Change in the investment profile dummy variable;
- $\Delta$  LAWORD: Change in the law and order dummy variable;
- ELECLEGYR: Dummy variable that is 1 if there is an election year for the legislative power and 0 otherwise.

Pseudo  $R^2$ : Coefficient of correlation for the ordered logit regression model;

Adjusted Pseudo  $R^2$ : Coefficient of correlation, adjusted for the degrees of freedom as a consequence of including more explanatory variables.

The out-of-sample performance of our EWS model for Argentina is shown in Figure 3.5. The probability of no crisis decreases steadily since the beginning of 2008. In September 2008, the month of the Lehman Brothers event, the probability of no crisis is less than 50%, while the probability of a mild crisis is approximately 25%. In 2009 the probability of no crisis continues to decline and is close to zero by the end of 2009. The probability of a deep crisis continues to increase and is highest of the three severity classes in 2009. Forecasts with the model with factors only performs very similar to the forecasts of the model with factors and institutional indicators.

Figure 3.6 shows the out-of-sample performance of our EWS model for Brazil. The graph shows a modest increase in the probability of a crisis in the run-up to the mild currency crisis that initiated in September 2008. The probability of no crisis decreases rapidly after September 2008. In the same period the probability of a deep crisis rises to reach 70%. In reality a mild currency crisis occurred. For the out-of-sample period 2008–2009 the model with factors and institutional indicators (lower panel of Figure 3.6) shows a more pronounced effect, as the probability of no crisis decreases faster and the probability of a deep crisis reaches 80%.

Outcomes for Mexico differ substantially from Argentina and Brazil. Forecasts with our EWS model for the model with factors only (top panel in Figure 3.7) show virtually no increase in the probability of a crisis. Out-of-sample performance of our model with both factors and institutional indicators shows a small increase in the probability of a mild crisis in 2009. In reality a very deep crisis occurred.

Figure 3.5. Argentina: probability of a crisis for the out-of-sample period, 2008–2009, for the model with a 12 months run-up period. The upper panel contains the graph with the forecasts of the model with factors only. The lower panel contains the graph with the forecasts of the model with factors and a combination of institutional indicators.

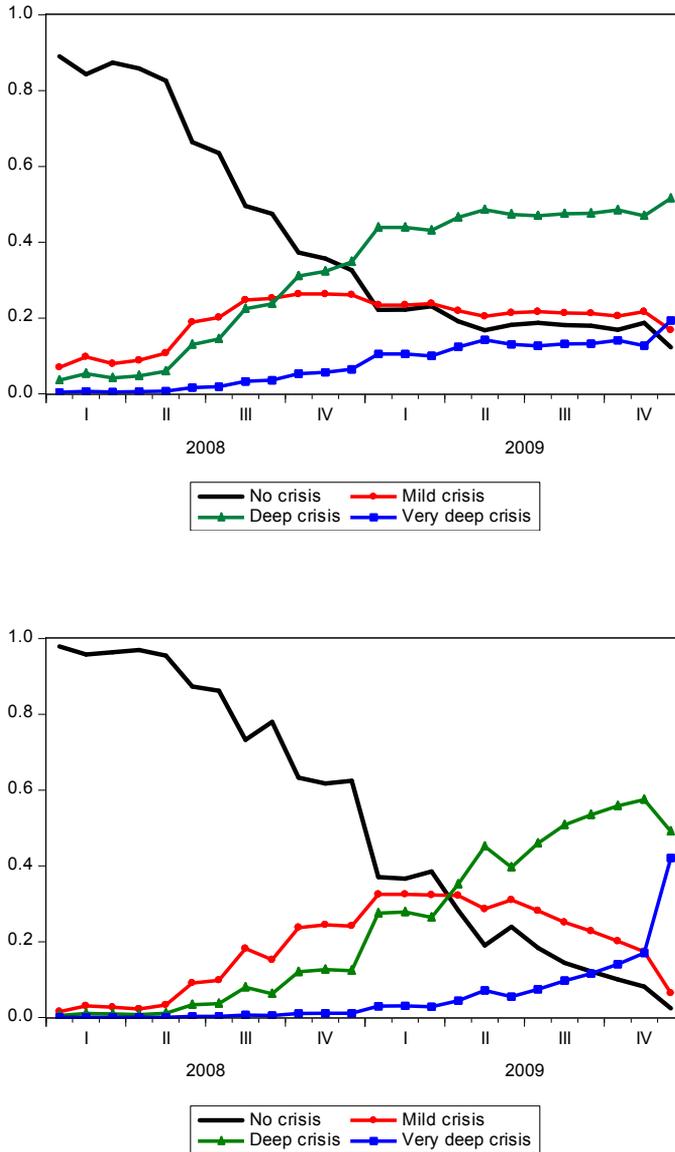


Figure 3.6. Brazil: probability of a crisis for the out-of-sample period, 2008–2009, for the model with a 12 months run-up period. The upper panel contains the graph with the forecasts of the model with factors only. The lower panel contains the graph with the forecasts of the model with factors and a combination of institutional indicators.

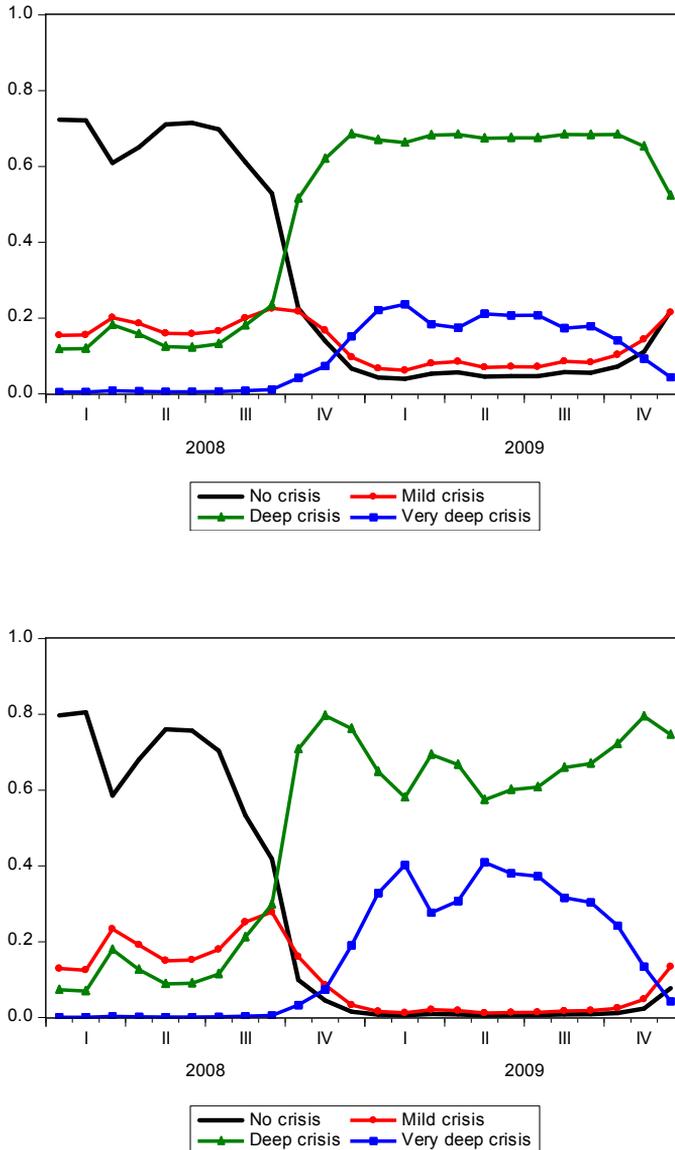
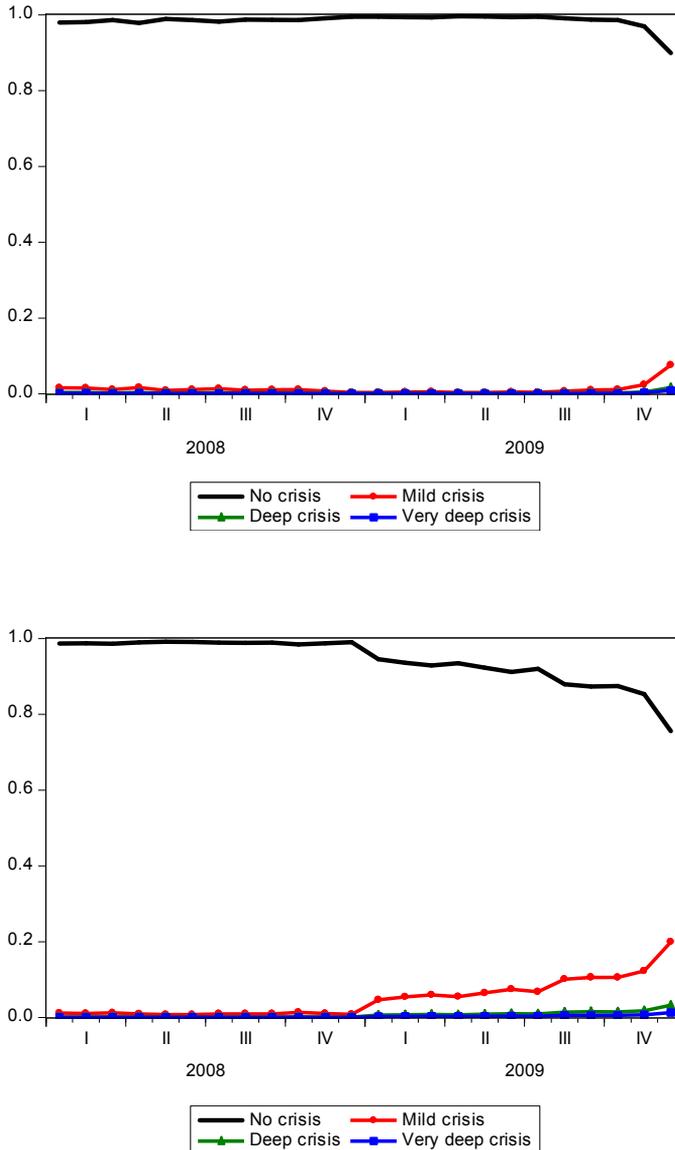


Figure 3.7. Mexico: probability of a crisis for the out-of-sample period, 2008–2009, for the model with a 12 months run-up period. The upper panel contains the graph with the forecasts of the model with factors only. The lower panel contains the graph with the forecasts of the model with factors and a combination of institutional indicators.



## Forecast evaluation

We use the Quadratic Probability Score (QPS) to evaluate the probability of a crisis out-of-sample (2008M1–2009M12) for mild, deep and very deep crises. In this period Argentina and Brazil faced a mild crisis, while Mexico experienced a very deep crisis. We show the results in Table 3.4.

Table 3.4. Out-of-sample performance of logit models with 12 months run-up, using the Quadratic Probability Score (QPS). Mild crises are identified when the EMPI is 1 to 2 times the standard deviation, deep crises when the EMPI is 2 to 3 times the standard deviation, and very deep crises when the EMPI is greater than 3 times the standard deviation.

Country		Severity of crises		
		Mild	Deep	Very deep
Argentina	Factors only	0.651	0.260	0.019
	+ Institutional indicators	0.778	0.200	0.022
Brazil	Factors only	0.627	0.553	0.035
	+ Institutional indicators	0.627	0.606	0.100
Mexico	Factors only	< 0.001	< 0.001	0.831
	+ Institutional indicators	0.010	< 0.001	0.833

Recall that the closer the score statistics in Table 3.4 are to zero, the more accurate the model predictions are. A value of 2 indicates a perfect false signal. Our EWS model performs reasonably well for Argentina. The QPS for the actual crisis severity (mild crisis) is 0.651. With a score closer to zero than to two, we interpret this as a reasonable, yet not highly accurate model prediction. The scores are much lower for the probabilities of a deep crisis and a very deep crisis, which means that our model predicts a low probability of a deep and very deep crisis reasonably well. In Figure 3.5 we observed that the probability of a currency crisis increases in 2008. Both mild and deep crises show an increased probability. The outcomes for Brazil are similar to the outcomes for Argentina. The model performs slightly better for predicting the correct severity of a crisis (mild crisis), as the QPS is lower (0.627), but it performs worse for identifying a deep and very deep crisis, as the QPS

are higher than for Argentina (0.553 versus 0.260). When we combine both the QPS outcomes and Figure 3.6, we can conclude that our EWS does a reasonably well job in indicating a currency crisis, although it indicates a more severe crisis than actually occurred. Our EWS model does not perform well for Mexico. It correctly predicts very low values for mild and deep crises, but the value for very deep crises is fairly high (0.831), which indicates that our model does not pick up the very deep crisis. In other words, our model predicts no crisis, which is in sharp contrast with reality (a very deep crisis). Figure 3.7 confirms that our model predicts a very low probability of a currency crisis in Mexico.

We conclude that our EWS model performs fairly well out-of-sample for Argentina and Brazil. Our model picks up the currency crisis in the fall of 2008, but the indication for severity is less accurate. For Mexico our model does not perform well. A second finding is that including institutional variables does not improve the forecasts. This is in contrast to our findings of the in-sample performance of our model, where including institutional indicators improves the performance in terms of a higher adjusted pseudo  $R^2$ . We can explain this result by taking a closer look at the pattern of the institutional variables in the out-of-sample period. For Argentina and Brazil there is very little variation in the indicators, while for Mexico there is more variation in the indicators.

### 3.5.3 Robustness checks

We also perform the analysis for two alternative run-up periods. An Early Warning System with a run-up period of 12 months may be too short for the authorities to implement policies to avoid a currency crisis. Therefore we construct an EWS with a run-up period of 24 months. An Early Warning System with a run-up period of 6 months is useful for investors, as this horizon is long enough to make adjustments to portfolios.

The results for the models with a 6 and 24 months run-up period are shown in Appendix E and are discussed below. Contrary to findings of Kaminsky (2006), we find that the model is sensitive for changes in the

length of the run-up period. The fit of the regression during the in-sample period differs widely from one run-up period to the other, as shown in Section E.1 of Appendix E. Argentina and Mexico have in common that the fit is better for models with a short run-up period (6 months), and worse for models with a long run-up period (24 months). For Brazil the opposite holds: the model with a 24 months run-up has a better fit than the models with a 12 and 6 months run-up period. For all countries and for all run-up periods except one (Argentina, run-up period of 6 months), the combination of institutional indicators improves the fit of the model and the Wald test confirms the statistical significance of the combination of institutional indicators.

For the forecasted period (2008–2009) the results are more homogeneous, as shown in Sections E.2 and E.3 of Appendix E. For the three countries the 24 months run-up period leads to the best possible predictions. For Argentina the model with factors only and a 24 months run-up has a good performance, with the lowest QPS score (0.502) a sharp increasing probability of a crisis in the third quarter of 2008. The model does not differentiate well between the different severity classes. The sharp increase in the possibility of a currency crisis by the end of 2009 is caused by the continued deterioration of the economic fundamentals. For Brazil all models, irrespective of the run-up period, produce an increased probability of a crisis in 2008. The model with the highest probability of a crisis, and the highest probability of a mild crisis is the model with a 24 months run-up period. The model with institutional indicators and factors shows the highest probability of a mild crisis in the last months of 2008. Also the QPS score is the lowest for this model (0.301). For Mexico only one model specification shows an increased probability of a crisis in 2008, the model with institutional indicators and factors, with a 24 months run-up period. This model has the lowest QPS score (0.460). A possible explanation is that Mexico has variation in the institutional indicators in the out-of-sample period.

### 3.6 Discussion

As mentioned in the Introduction of this chapter, we discuss common characteristics of the three countries' EWS models in this section. We also discuss the out-of-sample performance of the model.

#### **Common characteristics in currency crises in Latin America, up to 2007**

We find that currency crises in Argentina, Brazil and Mexico are primarily associated with debt, banking and commodities-related indicators. This can be explained by looking closer at the very deep currency crises that hit the countries: the Mexican 1994–1995 crisis, the Brazilian 1998–1999 crisis and the Argentinian 2001–2002 crisis are accompanied by severe debt servicing problems. While Mexico and Brazil can avoid a sovereign debt default by using IMF assistance, Argentina defaults on its sovereign debt. Mexico experiences a banking crisis in 1994–1996, as well as Argentina in 2001–2003. Brazil's banking crisis, which started in 1994 ended in 1998 (Laeven and Valencia, 2012). For all countries commodities-related indicators are associated with currency crises.

A second common feature is that a combination of institutional indicators improves the fit of the model for all countries. In most cases the institutional indicators show a counterintuitive relationship with deeper crises. A possible explanation can be found in the third generation currency crisis models, combined with elements from boom-bust and sudden-stop models. When institutional conditions improve, expectations increase, and investments increase. This attracts foreign capital and leads to a capital account surplus, accompanied by a consequent current account deficit. Additionally, the high expectations may lead to overlending and overborrowing, thus creating a bubble in debt and other asset prices. When the expectations decrease, foreign investors withdraw their investments, thus causing a sudden stop in capital flows. As a consequence, the pressure on the exchange rate to depreciate increases. Under a fixed exchange rate regime, as is the

case for the three very deep currency crises in our sample, the central bank uses foreign reserves to defend the currency. However, if the pressure on the exchange rate becomes too big, the central bank will not have enough reserves and a devaluation follows. This can trigger debt servicing difficulties if government and private sector have borrowed in foreign currency. Furthermore, lower expectations affect asset prices and increase interest rates, which has a negative influence on economic growth and the fiscal budget. The banking sector becomes fragile as funding costs increase, while the loan portfolio is affected by bankruptcies. With this scenario, a triple crisis will unfold. The clearest illustration is the Mexico 1994–1995 financial crisis, which occurred after the investment boom that followed when the country privatized state-owned companies and banks, and joined the WTO, the OECD and the NAFTA. The boom in investments and capital inflows was partially founded on the moral hazard behavior of investors and banks. Our findings confirm Kaminsky (2006) who categorizes the Mexican 1994–1995 crisis and the Brazilian 1998–1999 crisis as third generation crises, characterized by ‘excessive’ booms and busts in international lending and asset price bubbles.

### **Latin America in the period 2008–2009**

In the run-up to the crisis in the fall of 2008 the three Latin American countries experience a period of economic prosperity in the 2002–2007 boom, featuring large foreign reserves, small sovereign external debt levels, small fiscal deficits (or even surpluses), and a more flexible exchange rate regime. Considering the individual countries we observe that Brazil faces a strongly appreciated currency before the onset of the crisis and an unprecedented large amount of foreign reserves (Ocampo, 2009). Mexico depends strongly on the US economy and has a highly regulated financial sector. The Mexican peso appreciates in the summer of 2008. For Argentina key economic conditions are less favorable, in particular the high and persistent inflation, which reflects important macroeconomic imbalances (Rojas-Suarez, 2011). In addition, the central government debt is higher than in the other two

countries (Ocampo, 2009), as well as the ratio of short-term external debt to international reserves (Rojas-Suarez, 2011). Political risk increases, because of its macroeconomic and debt-servicing policies (Porzecansky, 2009), the anti-globalization policies that it shares with Ecuador and Venezuela (Rojas-Suarez, 2011), and through government's decisions such as the nationalization of its private pension regime in late 2008.

In the fall of 2008 all three countries experience a currency crisis. The Mexican peso depreciates strongly and fast. The Brazilian real depreciates in a similar magnitude as the Mexican peso, but over a longer time span. The Argentinian peso depreciates less than the other two currencies. According to our crisis classification the crises in Argentina and Brazil are mild, but in Mexico the crisis is very deep.

The picture is different for 2009. In Brazil and Mexico the exchange rates appreciate in 2009—in Brazil the exchange rate falls even below the pre-crisis level—which makes this crisis more special compared to previous currency crises. Argentina's peso does not appreciate. All three countries are hit by an unusually heavy drop in export earnings between the fourth quarter of 2008 and the first quarter of 2009. Brazil is hit by a second exogenous shock: heavy reversals in capital flows in the fourth quarter of 2008. Surprisingly, Brazil does not experience a major financial crisis, or even a worse-than-average deceleration in economic growth (Porzecanski, 2009). During the crisis Brazil implements both counter-cyclical fiscal and monetary policies (Rojas-Suarez, 2011). Mexico experiences a deep economic contraction in 2009, which heavily affects its fiscal revenues. Mexico responds by pro-cyclical fiscal policy and counter-cyclical monetary policy (Rojas-Suarez, 2011). In 2009 economic conditions prevent Argentina to undertake counter-cyclical monetary policy, but it implements counter-cyclical fiscal policy. Rating agencies downgrade Argentinian government bonds and the spread surges to even higher values than during the 2002 crisis. The institutional environment does not help to deal with the crisis. The elections scheduled for October 2009 are held already in June 2009 in order to deal with the GFC. However, the outcomes of the elections make things worse for the

ruling president's party which loses its majority in parliament.

### **Does our model predict the currency crisis of 2008?**

Our model picks up the currency crises during the GFC in Argentina and Brazil, although it does not predict the severity well. The five currency crises in Argentina in the period from 1991 to 2007 are associated with debt, banking, commodities and global indicators. With its restructuring of the 2001–2005 debt crisis the debt burden for Argentina is lower than in the previous decade. Although global indicators are adverse in the out-of-sample period 2008–2009, the country experiences only a mild currency crisis. The seven currency crises in Brazil that take place in the period 1994–2007 are associated with debt, banking, commodities, global and external economy indicators. With the fall in commodity prices and the sudden stop in external trade, Brazil is affected strongly in the second half of 2008. Although the depreciation is as high as for the Mexican peso, there are two reasons why the fall of the Brazilian real is considered a mild crisis in our definition. First because the depreciation takes place over a relatively longer period, and second because Brazil has experienced high exchange rate volatility in the period 1994–2007.

For Mexico our model does not predict a currency crisis, contrary to the actual situation. Mexico experiences only two currency crises in the period 1990–2007, in 1994 a very deep crisis (with some aftershocks in 1995) and in 1998 a mild crisis. These crises are associated with debt, banking, commodities and external economy indicators. The conditions prior to the very deep currency crisis in Mexico in 1994 are very different than in the run-up to the 2008 currency crisis. In the early 1990s a widespread hope surges that Mexico's economy would finally speed up, which leads to capital inflows, increased sovereign debts and an increase in credit offered by a poorly regulated banking sector. Mexico has adopted a fixed exchange rate regime and allows its currency to strengthen, which reduces export competitiveness and encourages speculation (Edwards, 2008). When the currency is devalued by more than 65% in December 1994 and the following months a sudden stop

occurs, a banking crisis follows, and IMF assistance is needed to avoid a sovereign debt default. In 2008 Mexico has a flexible exchange rate regime, low sovereign debt and high foreign reserves, and a sound banking system. This time the shock is external and leads to a sudden stop in both capital and trade flows, which affects economic growth heavily, particularly since its main trading partner (USA) is at the epicenter of the GFC. No banking or debt crises occur.

### 3.7 Conclusion

The financial panic that followed the fall of Lehman Brothers in September 2008 affected many countries and regions including Latin America. In Brazil and Mexico the exchange rates depreciate by more than 40%, the Argentinian peso depreciates by 20% and financial markets (stocks, bonds) are hit hard. This chapter investigates the experience of Latin America with currency crises since the 1990s.

We first determine which indicators are related to past currency crises, including the run-up to the crises. For that reason we develop an Early Warning System for currency crises. We develop an EWS consisting of an ordered logit model, using static factor models to reduce the dimension of the information set. We find that currency crises are driven by a limited number of indicator categories. Currency crises in all three countries are associated with debt, banking and commodities indicators. Additionally, currency crises in Argentina and Brazil are associated with global indicators, currency crises in Brazil and Mexico are associated with external economy indicators, and currency crises in Argentina and Mexico are associated with elections for the legislative power. Including institutional indicators improves the ability of our model to pick up the crises up to 2007. Very deep crises are associated with an improved institutional climate, which seems contradictory, but fits in with the third generation currency crisis models and the boom-bust model. The optimism of improved institutional conditions leads to excessive lending and inflated asset prices. When expecta-

tions turn bad, finance flows reverse, interest rates increase and the pressure on the exchange rate increases, which can trigger a currency crisis.

Secondly, we use our EWS to forecast the probability of currency crises in 2008 and 2009, which is the period in which the GFC hit the region the hardest. Our model predicts the currency crises in the fall of 2008 for Argentina and Brazil, but the predicted crises are more severe than actually occurred. Our model does not pick up the very deep currency crisis that occurs in Mexico. We can explain the performance of our model for Mexico with two arguments. First, Mexico has experienced few currency crises in the period 1990–2007, and second, the situation in the run-up to the very deep currency crisis in Mexico in 1994–1995 is very different than in 2008, in terms of exchange rate regime, overlending and overborrowing, international reserves levels and financial sector regulations. Contrary to the model's performance up to 2007, the forecasts of our model do not improve when institutional variables are included. This can be explained by the low variability in institutional variables, particularly for Argentina and Brazil.