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An empirical analysis of currency crises, fundamentals and speculative pressure

Nil R. Gunsel, Turgut Tursoy* and Husam Rjoub

Department of Banking and Finance, Faculty of Economics and Administrative Sciences, Near East University, Nicosia, P. O. Box 670, Lefkosa, North Cyprus, Mersin 10, Turkey.

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The main purpose of this paper is to investigate the linkage between economic fundamentals and currency crises for four different group of countries that experience very different growth path or crises from 1991 to 2006. For this purpose, logit model was used in identifying the determinants of the currency crises' likelihood and the market pressure index (MPI) were used in determining the currency crises of the four different groups of countries. The study selects Argentina, Brazil and Mexico from America; Malaysia, Philippines, South Korea and Thailand from East and Southeast Asia; Russia and Turkey. The empirical findings stated that: (1) real interest rate, rate of inflation, growth rate of GDP, budget balance, real exchange rate and the ratio of M2 to foreign exchange reserves were statistically significant explanatory variables; (2) however, domestic credit to GDP and various types of trade variables were not statistically significant.

Key words: Determinants of currency crises, market pressure index, Logit model.

INTRODUCTION

Recently, several crises researches have primarily focused on building indexes to identify the presence of speculative attacks on currency. The most prominent research is Eichengreen et al. (1996) which identifies the currency crises through constructing an index of exchange market pressure (EMP). This paper follows the same methodology to construct market pressure index (MPI) and then uses this index to identify the currency crises of four different groups of countries. The aim is to investigate whether these currency crises which are developed in this study are connected to economic fundamentals in the nine countries. This study focuses exclusively on the nine countries that experienced currency crises in the analyses period, namely; the Tequila crisis, the Asian crises and the recent events in Russia, Brazil, Turkey and Argentina. The annual data is collected for a panel of nine countries for the period spanning through 1991 to 2006.

*Corresponding author. E-mail: ttursoy@neu.edu.tr. Tel: 9-0392-223-6464. Fax: 9-0392-223-6461.

THE THEORETICAL LITERATURE

The theoretical literature[1] on the currency crises can be classified into three models: first, second and third - generation models.

First generation models: Balance of payment crisis models

These models view currency crises as the inevitable consequence of macroeconomic policies that are inconsistent with the maintenance of a pegged exchange rate. Krugman's model (1979) and its extensions represent the first-generation models of balance-of-payment crises. Krugman (1979) states how a standard crisis occurs: "A country will have a pegged exchange rate for simplicity, by assuming that the pegging was done solely through direct intervention in the foreign exchange market. At that exchange rate, the government's reserves

[1] For detailed surveys of theoretical literature, see Kaminsky et al. (1998), Esquivel and Larrain (1998).

gradually decline and then at some point, generally well before the gradual depletion of reserves would have exhausted them; there is a sudden speculative attack that rapidly eliminates the last of the reserves. Consequently, the government would no longer be able to defend the exchange rate." A speculative attack on a government's reserve can be viewed as a process by which investors change the composition of their portfolios, thereby reducing the proportion of domestic currency and raising that of foreign currency. This change in composition is then justified by a change in relative yields, for when the government is no longer able to defend the exchange rate, the currency begins to depreciate. More specifically, Krugman's model assumes that investors have a choice between two assets only, namely domestic and foreign money in the asset market. In this model, these two assets are bearing zero nominal interest and the expected rate of inflation is also the expected rate of the currency's depreciation. Therefore, if inflation rate is increased, domestic money will be less attractive.

Thus, there is the assumption that there are two types of exchange rate systems (flexible and pegged). Under the flexible one, change in expectations are reflected in the short run by change in the exchange rate; whereas, under pegged exchange rate system, it is directly reflected by changes in the government's reserves. Krugman argues that crises occur when a continuous deterioration in the economic fundamentals becomes inconsistent with an attempt to fix the exchange rate. Esquivel and Larrain (1998) address the fact that the original source of problems in Krugman's model is the excessive creation of domestic credit to either finance deficits or provide assistance to a weak banking system.

Also, it is assumed that the government had no access to capital market, thereby forcing it to monetize its expenditures. Within this context, the interest rate parity conditions would induce capital outflows and a gradual loss of foreign exchange reserves and then the economy becomes the victim of a speculative attack on its foreign reserves which triggers the collapse of the pegged exchange rate system. Krugman's model suggests that the timing of the speculative attack is dependent on a critical level in the amount of official foreign reserves. Once reserves reach such a critical or threshold level, speculators are induced to exhaust the remaining reserves in a short period of time to avoid capital losses.

Second generation models: Self-fulfilling models

There are a number of studies[2] that provide alternative explanations of currency crises. These models focus on the possibility of currency crises even without any continuous deterioration in economic fundamentals. Also, they represent alternative explanations of currency crises that are known as second-generation models of balance-of-payments crises. The second-generation models evolve largely as a response to the two-stage crisis which breaks down the European exchange rate mechanism (ERM) in 1991 and 1992. Copeland (2005) stressed that disastrous events related to ERM appeared to raise an important question which the existing literature (first-generation models) could not answer. Could speculators successfully destroy a fixed exchange rate regime which was not being undermined by irresponsible monetary policy? Most likely, the answer is yes in the perspective of second-generation models. Also, Copeland (2005) addresses the fact that it were not only the main victims of ERM crises (UK, Spain and especially France), but at that time was said to have sound fundamentals. They also enjoyed the benefit of an explicit guarantee from the Bundesbank, which meant that, at least in principle, they could draw from the infinite reserve of Deutsche mark to protect their bilateral exchange rate.

Esquivel and Larrain (1998) stress that two key characteristics of second-generation models are: (a) the government is an active agent that maximizes an objective function and (b) that a circular process exists, leading to multiple-equilibrium. Second-generation models with the assumption of pure expectations leading to one equilibrium or another, accept the possibility of self-fulfilling crises. This kind of crises occurs when the sheer pessimism of a significant group of investors provokes a capital outflow that leads to the eventual collapse of exchange rate system (Esquivel and Larrain, 1998).

Third generation models: Contagion models

Copeland (2005) stated that, although, there were a number of questions which second generation models seemed incapable of answering, the need for a third generation only became apparent later in the 1990s, with the Mexican Tequila crisis, as it was called of 1994 and even more obviously with the turmoil in Asia that started in mid-1997.

Third-generation models have focused on contagion effects as a cause of currency crisis. For instance, Gerlach and Smets (1994) present a model in which the devaluation by one country leads its trading partners to devalue in order to avoid a loss of competitiveness (Kaminsky et al., 1998). Contagion effects may arise when investors pay little attention to the host countries' economic fundamentals. If contagion effects are present, crisis in a country may be an indicator of a future crisis in the neighboring country[3]. Also, these models show that speculative attacks on one country could spill over to another if the international reserves available to defend

[2] For instance, Obstfeld (1996), Cole and Kehoe (1996).

[3] Calvo and Reinhart (1996) and Eichengreen et al. (1996) discuss the channels for transmission of contagion effect.

the peg in the second country are not enough (Kruger et al., 1998). Consequently, currency crisis in one country results with devaluation and this affects the competitiveness of that country's trading partners and as a result, trading partner countries are forced to devaluate their currencies in order to avoid a loss in their competitiveness.

THE EMPIRICAL LITERATURE REVIEW

In the 1990s and early 2000s, several countries experienced severe currency crises. Specifically, the 1990s witnessed a significant number of currency crises, namely; the exchange rate mechanism (ERM) crisis (1992 - 1993) in Europe, the Mexican (Tequila) crisis from 1994 - 1995, the Turkish crisis in 1994, the Asian crisis from 1997 - 1998, the Russian crisis in 1998 and the Latin America (Brazil) crisis from 1998 - 1999. Also in the early 2000s, the particular countries experienced continuous currency crises such as currency and banking crisis in Turkey during the period of 2001 - 2002 and the Argentinean crisis from 2001 - 2002. In the literature, it can be seen that empirical studies which attempt to explain currency crises is fairly large[4]. The researches' main attempt is to construct a single index for identifying the currency crises or speculative attacks on a currency. Studies like Eichengreen et al. (1995 and 1996), Sachs et al. (1996) and Kaminsky et al. (1998) have proposed different constructions of EMP index. Generally, this index is a weighted average of the depreciation's rate of local currency against US dollars, usually by percentage change in international reserves and interest rates. Eichengreen et al. (1996) address the fact that speculative attacks tend to be temporarily correlated and currency crises appear to pass "contagiously" from one country to another. Their findings about a variety of tests and a battery of sensitivity analysis, uniformly suggest that a crisis elsewhere in the world increases the probability of a speculative attack by an economically and statistically significant amount (their best estimate is eight percent), even after controlling economic and political fundamentals in the country concerned. Sachs et al. (1996) examine the financial events following the devaluation of the Mexican peso to uncover lessons about the nature of financial crises. They explore why some emerging markets were hit by financial crises during 1995, while others were not. They found that for a set of twenty emerging markets, difference in these fundamentals goes far in explaining the difference in the experiences of emerging market in 1995. Also, they found that many of the alternative hypotheses that have been put forth to explain such crises are not supported by this study data. In their interpretation, Mexico was subjected to a self-fulfilling speculative attack in late December, 1994. There is ample evidence to show that the attack was unexpected and represented by a self-fulfilling panic.

In the literature, there are also a number of studies that examine the determinants of the currency crises. For instance, Kruger et al. (1998) examine the determinants of currency crises in Latin America, Asia and Africa. Their findings suggest that currency crises cannot be explained solely by looking at economic fundamentals and the regional contagion effects as well as the speculative behavior of investors are important determinants. Esquivel and Larrain (1998) test the main predictions of two generations models of currency crises and evaluate the explanatory power of some of the key variables proposed in the literature. Explanatory variables are defined in close correspondence with the factors highlighted in the theoretical literature. The study considers that a currency crisis exists only when there is an abrupt (sudden) change in the nominal exchange rate and they exclude unsuccessful speculative attacks from their definition of crisis. Cesmeci and Onder (2008) examine the possible determinants of currency crises in Turkey. Their results show that money market pressure index, real–sector confidence index and public–sector variables are significant in explaining currency crises. Licchetta (2009) investigates the role of external balance sheet variables as determinants of currency crises in emerging market and advanced economies. He also found that the likelihood of a crisis is increased with, the extent to which the real exchange rate rises above its trend, faster growth in broad money (relative to the level of international reserves), larger current account, budget balance deficits and lower GDP growth, if a neighboring country already has a crisis. Also in this study, economic fundamentals are found to be more important in explaining the onset of currency crises during the 1980s than the 1990s, suggesting that more recent crises are less fundamentally driven.

METHODOLOGY

Identifying currency crises with market pressure index

Currency crises are identified as extreme values of the speculative pressure index. Following Eichengreen et al. (1995 and 1996), a measure of speculative pressure on currency crises (exchange rate pressure index) is constructed as a weighted average of changes in the exchange rate, the international reserve and the interest rate. To examine currency crises, an index of the weighted average of changes in the exchange rates, foreign exchange reserves and interest rates are calculated. The market pressure index is then calculated as follows:

$$MPI_{i,t} = (\alpha\%\Delta e_{i,t}) + (\beta\Delta i_{i,t}) - (\gamma\%\Delta r_{i,t})$$

[4] Krugman (1979), Eichengreen et al. (1995, 1996), Sachs et al. (1996), Frankel and Rose (1996), Kaminsky et al. (1998), Esquivel & Larrain (1998), Kruger et al. (1998), Gaston and Sahay (2000), Cerra et al. (2000) and Cramazza et al. (2004), and Hagen and Ho (2007)

(Eichengreen et al., 1996).
Where,
e: denotes the nominal exchange rate vis-à-vis the USA[5].
i: denotes short-term interest rates.
r: denotes foreign exchange reserves.
α, β and γ: + are weights.

A higher index is reflected in higher values of these three variables, therefore, this indicates greater pressure on the exchange market depending on the nature of the intervention of the respective Central Banks, that is, speculative pressures are either accommodated by a loss of reserves or can be prevented by the monetary authorities through an increase in interest rates[6]. As with Eichengreen et al. (1996), a crisis episode is defined as a month in which MPI exceeds its overall mean of the index by 1.5 times the pooled standard deviation of the calculated index.
The crisis is defined in the following index:

Crises (T) = 1 If MPI (C) >μ MPI (T) + 1.5 * σ MPI (T)
Crisis (T) = 0 Otherwise

Where C is the country, μ is the sample means and σ is the standard deviation of MPI. In order to prevent the destabilizing effect for the crisis countries, such as the 1997 Southeast Asian crisis, this model first allows the calculation of speculative attacks and then forms crisis dummy in the logit model, which will allow the estimation of the likelihood of speculative attacks in selected countries.

Estimation methodology (Logit model)

This paper uses a logit model in a panel data framework. The one-step probability ahead of failure is estimated as a function of a set of macro variables. From this perspective, the panel considers potentially the combination of time-series and cross-sectional data before running the estimation techniques.

In the context of logit model, the binary dependent variable Y_{it} takes the value of 1 if the exchange rate pressure index is higher than the average level during the year and 0 represents otherwise. In practice, Y_{it}^* is the latent variable, which is not observable by the researcher and assumed to depend on k explanatory variables, ranging from - ∞ to ∞. The latent variable Y_{it}^* is linked to the observable categorical Y_i variable by a measurement equation and is shown as follows:

$$Y_{it} = \begin{cases} 1 & \text{If individual fail} \quad \text{if } Y_{it}^* > 0 \\ 0 & \text{otherwise} \quad \text{if } Y_{it}^* \leq 0 \end{cases}$$

(see Maddala (2001))

The latent variable is linked to the explanatory variables as follows:

$$Y_{it}^* = \beta_0 + \sum_{j=1}^{k} \beta_j X_{itj} + u_{it}$$

Where,
Y_{it}^* : represents latent variable and its scale cannot be determined.
u_{it} : is a composite error term.
β_j : coefficient of j independent variable and measures the effects on the odds of failure of a unit change in the corresponding independent variables.
X_{itj}: is a vector of k number of explanatory variables in period t for each country i.

The above equation implies that the larger values of Y_{it}^* are observed as Y_{it}=1 (that is, there is a high market pressure index), while those with smaller values are observed as Y_{it} =0 (that is, there is no market pressure).

In the logit model, the log-odds ratio is a linear function of the explanatory variables (See Maddala (2001)). The estimated multivariate logit model links the likelihood of currency crisis to a set of variables.

$$\text{Log}\left(\frac{P_i}{1-P_i}\right) = \beta_O + \sum_{j=1}^{k} \beta_j X_{itj}$$

Where,
P_i : represents the probability that country i will have high market pressure.
$1-P_i$: represents the probability that country i will have no market pressure.

Data and Explanatory variables

The data of this study were obtained from the Economic Intelligence Unit (EIU) and are available from 1991 to 2006. This period was determined by limited data availability in an annual basis. The data constitute a panel dataset for four different groups of countries namely; Argentina, Brazil and Mexico from America, Malaysia, Philippines, South Korea and Thailand from East and Southeast Asia, Russia and Turkey.

The explanatory variables can be divided into four groups: macroeconomic environment (growth rate of GDP, real interest rate and rate of inflation), external shocks or competitiveness (real exchange rate and terms of trade, trade openness and the ratio of export to GDP), the fiscal and monetary policies (budget deficit and domestic credit to GDP) and reserve adequacy (M2 to reserves) variables. The choice of explanatory variables is guided by both existing literature[7] and data availability. The growth rate of GDP and the rate of inflation are used to represent the macroeconomic developments. Also, real interest rate and government budget deficit (surplus) are added to capture fiscal and domestic policies. The ratio of domestic credit to GDP is used as an indicator of monetary expansion and credit growth (Lending Booms). Lending Booms variables in the literature are playing important role to explain the currency crises episodes. Theoretically, it increases the ratio of bad loans to total assets in bank's balance sheet; thereby weakening the banking sector. A weak banking sector increases the probability of a speculative attack, because investors know that government will be reluctant to resist an attack by increasing interest rates since this would result in bankruptcies and recession. Furthermore, past studies argued that governments usually lose substantial reserves prior to currency crises. The ratio of M2 (broad measure of money) to official foreign reserves is a measure of reserve adequacy. It measures the potential amount of liquid monetary assets that authorities can use to convert into foreign exchange. The variables

[5] Local currency divided by foreign currency.
[6] See, for instance, Eichengreen et al. (1996). See also Sachs et al. (1996), Frankel and Rose (1996), Kaminsky et al. (1998), Gaston and Sahay (2000), Cerra et al. (2000) and Cramazza et al. (2004) for similar construction of exchange rate pressure.
[7] See Sachs et al. (1996), Kaminsky and Reinhart (1999), Hagen and Ho (2007).

Table 1. Logit analysis of determinants of currency crises.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Macroeconomic variables				
Real ınterest rate	0.6793***	0.6901***	0.7263***	0.7285***	0.7371***	0.7525***	0.7747***
	(0.235)	(0.241)	(0.196)	(0.208)	(0.202)	(0.221)	(0.227)
Inflation rate	1.5714**	1.6500**	1.9308**	1.7499***	1.9426***	2.0175***	2.0862***
	(0.719)	(0.775)	(0.697)	(0.712)	(0.700)	(0.7735)	(0.786)
Growth of GDP	0.0002***	0.0002***	0.0002***	0.0000***	0.0002***	0.0002***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Budget balance	-0.0002**	-0.0002**	-0.0001**	-0.0000**	-0.0002**	-0.0000**	-0.0000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
			Financial variables				
Domestic credit to GDP	-0.0007	-0.0008					
	(0.000)	(0.000)					
Ratio of M2 to FER	-7.066	-7.7991		-0.4097*			
	(5.149)	(5.710)		(0.241)			
Exchange rate	-0.0691***	-0.0692***	-0.058***	-0.0716***	-	-	-
	(0.019)	(0.019)	(0.015)	(0,017)	0.0692***	0.0591***	0.0593***
					(0.019)	(0.015)	(0.0015)
Terms of trade	0.0018	0.0229			0.0039		
	(0.022)	(0.022)			(0.0167)		
Trade openness						0.0016	
						(0.006)	
Export/GDP							0.0005
							(0.011)
Dummy Asia		0.2269					
		(0.763)					
Constant	0.5715	0.5715	-1.048	0.2847	-1.4075	-1.286	-1.4912
	(2.647)	(2.711)	(1.282)	(1.423)	(2.006)	(1.570)	(1.630)
Model statistics:							
Wald Chi^2	22.2***	22.13***	17.20***	20.43***	16.36**	17.24***	17.30***
Log Pseudo-lik	-48.3040	-48.2608	-58.3853	-51.3244	-58.3577	-58.3477	-58.2764
AIC	56.304	57.2608	63.3853	57.3244	64.3577	64.3477	64.2764

Notes: (1) ***, **, * indicates significance at the 1, 5 and 10%, level respectively.
(2) Standard errors are given in parentheses for the Logit model.
(3) Specification from 1 - 7 is the likelihood of currency crises.

of various types of trade and real exchange rate are indicators of external competitiveness and shocks.

RESULTS AND DISCUSSION

Logit estimator was used to estimate the models and indicates the results from empirical analysis. The model can be interpreted as explaining the likelihood of a currency crisis to occur for given values of explanatory variables. Seven models which include macroeconomic and financial variables were estimated as explanatory variables to investigate the determinants of currency crises in the sample countries. The results of the univariate analysis revealed that there was a very low level of correlation among variables. Specifically, Table 1 presented the logit regression results for nine countries and the number of observations was 130. The quality of model specification was assessed based on the model chi-square and AIC criteria. A chi-square likelihood ratio test of the significance of the overall model indicated that all specification models were highly significant (prob>chi-square: 0.000). The AIC[8] compared the model with and eliminates its specification, when irrelevant model with explanatory variables were added into different degrees

[8] The use of AIC criterion introduces a statistic that gives a measure of the precision of the estimate and a measure of the parameterization of the model. According to this criterion a model with the lowest AIC is chosen. The AIC is computed as minus the log likelihood plus the number of estimated parameters of explanatory variables. Then, as is obvious from the model, as the number of variables increases it is less advantageous to the value of the AIC.

of freedom the regression.

A lower value of the AIC was judged to be preferable from Table 1 and Models 1, 2 and 4 which appeared to have the lower AIC's. An increase in the real interest rate caused an increase in the likelihood of currency crises and as a result, the real interest rate was significant at one percent level in all models and had a positive sign. Theoretically, an unexpected increase in interest rates affects the existing credits inversely and this leads to an increase in the amount of bad loans in the banking sector.

Moreover, a positive and significant coefficient on the rate of inflation in the results, suggested that an increase in rate of inflation increased the crisis probability. Past studies suggest that an increase in the growth of GDP reduce the probability of a currency crisis. Surprisingly, the researchers' estimation showed that the growth rate of GDP had a positive sign and significance at one percent level.

Also, it found that large budget deficit increased the probability of a currency crisis. Contrary to the expected sign, the coefficient of the budget deficit variable was negative and significant at five percent level, while the coefficient of the domestic credit to GDP had a negative sign, but it was not significant in any level. The literature stress that countries with low level of reserves (in relation to a broad measure of money) are more likely to experience currency crises.

Past studies argue that governments usually lose substantial reserves prior to currency crisis and it suggested that M2 to official foreign reserves is a good indicator to reflect the vulnerability of the central bank to possible runs against the currency. The literature provide evidences that there is a positive relation between reserve adequacy and probability of a crisis. However, the results showed that the reserve adequacy variable had a negative sign and was significant at 10% level in Model 4. The literature emphasizes that currency crises are usually preceded by periods of overvaluation in exchange rate and crises are strongly associated with over-valued real exchange rate.

In contrast with the existing literature, the real exchange rate variable was found to have a negative sign and significance at one percent level. Lastly, there is evidence that the possibility of deterioration in terms of trade increases the probability of currency crises and the term of trade variable was not statistically significant. Also, alternative explanatory variables for trade (trade openness and ratio of export to GDP) tested in the empirical analysis, however showed that all trade variables were found to be statistically insignificant.

In Model 2, dummy of Asian countries was added to the model to check whether Asian countries have any effects on the other countries in the analysis. Despite the coefficient of the dummy been positive, it was however, not statistically significant.

Conclusion

The main purpose of this study is to identify currency crises with MPI estimation and then analyze the linkage between currency crises and economic fundamentals. Empirically, the models are estimated with logit estimation to explain the likelihood of currency crises with an annual panel dataset of nine countries in the period of 1991-2006. In this study, eight variables (real interest rate, rate of inflation, growth rate of GDP, budget deficit and domestic credit to GDP, M2 to official foreign reserves, real exchange rate and various types of trade variables) are used as economic variables to analyze the linkage between economic fundamentals and currency crises. The findings show five significant variables – namely; real interest rate, rate of inflation, budget balance, growth rate of GDP, real exchange rate and the ratio of M2 to foreign exchange, but just only two coefficients satisfied the expected signs (real interest rate and rate of inflation). Unfortunately, growth rate of GDP, budget balance, real exchange rate and the ratio of M2 to Foreign exchange reserves coefficients' are not the same as expected. The empirical findings indicate that increases in real interest rate, rate of inflation, growth rate of GDP are closely and positively related with the likelihood of currency crises. Therefore, decreases in budget balance deficit, real exchange rate and the ratio of M2 to foreign exchange reserves increase the probability of currency crises. As a result, it can be suggested that real interest rate and rate of inflation are the only two variables that can be consistently linked to currency crises in the sample countries, where the common findings in the literature are concerned.

This study supposes that currency crises are solely linked to the economic fundamentals and authors tried to explain it with macroeconomic variables. In future research, it would be interesting to examine not just the economic fundamentals and probability of crises connection, but also, the source of the contagion effect using the approach of Eichengreen et al. (1996).

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