The Relationship between Fiscal Sustainability and Currency Crises in Some Selected Countries

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Abstract: The aim of this article is to assess whether a Fiscal Sustainability Indicator (FSI) can be used to predict the probability that a currency crisis occurs. The FSI developed by Croce and Juan-Ramón (2003) is employed. Two different definitions for currency crises are used to evaluate whether they induce different results in the analysis. In general, the results suggest that the lagged FSI has an explanatory power over currency crises in some countries.

Key words: Currency crises, foreign exchange, fiscal sustainability, probit model.

JEL Classification: F31, F33, E62

Introduction

The fiscal and monetary roots of currency crises have been studied both theoretically and empirically. The first generation models, called speculative attack models, focus on the role of inconsistencies between fiscal, monetary and exchange rate policies (Krugman, 1979, 1996; Flood and Garber, 1984; Flood and Marion, 1996). In these models, inadequate macroeconomic policy is the main cause of speculative attack against the local currency which finally leads to a currency crisis. The second generation models accentuate the self-fulfilling characteristics of a currency crisis and the occurrence of multiple equilibriums (Obstfeld, 1986, 1996; Rangvid, 2001). These models emphasize the role of policymakers` preferences. The option of abandoning a fixed exchange rate regime, in order to implement an expansionary monetary and fiscal policy, may be an ex-ante optimal decision for the policymaker, considering that economic authorities face tradeoffs. However, a speculative attack becomes more likely because of the possible existence of multiple equilibriums. Finally, third generation models stress the consequences of moral hazards in the banking system and the contagion effect as key determinants of a speculative attack and currency crisis. Central Banks financing the rescue of the financial system could be inconsistent with a managed exchange rate regime (Chang and Velasco, 2001).

More recent empirical research not only focuses on explaining the causes of a currency crisis, it is mainly motivated by the need to forecast and prevent currency crises and considers a wide range of variables that can help in constructing a system for predicting a currency crisis. Numerous studies have attempted to identify those variables that can be

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the best predictors of currency crises. Literature on early warning systems (EWS) attempts to combine a number of indicators into a single measure of crises risks. Two approaches in constructing EWS models became common in early empirical works: the non-parametric signalling approach (Kaminsky et al., 1998; among others) and limited dependent variable probit-logit models (Berg and Pattillo, 1999a,b; Goldstein et al., 2000; Kumar et al., 2003; among others). Kaminsky et al. (1998) construct an early warning system using a signal model approach. The idea behind this model is that the indicators behave differently on the verge of a crisis. Therefore, when an observation exceeds a specific threshold, the indicator sends a signal. The more indicators flag signals, the higher the probability of a crisis. Alternatively, Berg and Pattillo (1999a,b) modify the probit model used in Frankel and Rose (1996) and associate a set of variables with the probability of a currency crisis. This approach provides the possibility of evaluating a formal model of relationships between various indicators and a discrete occurrence of a currency crisis. On the other hand, Crepo-Cuaresma and Slacik (2009) incorporate uncertainty in the framework of a binary choice model. They use real exchange rate misalignment and financial market indicators to predict crisis periods instead of a crisis occurrence. Similarly, Comelli (2013) compare performances of three parametric and non-parametric early warning systems for currency crises in emerging market economies using a set of explanatory macroeconomic indicators and an indicator of political risk. But the challenge has been to find an early warning indicator that allows for anticipation of these crises. Some authors use exchange rate expectations, currency overvaluation, and capital controls, among others, as predictors of currency crises (Goldfajn and Valdés, 1998; Burkart and Coudert, 2002). Other researchers use stock market, sovereign ratings, the term structure of relative interest rate, level of international reserves and exchange rate overvaluation as leading indicators of currency crises (Broome and Morley, 2004; Sy, 2004; Crepo-Cuaresma and Slacik, 2007; Frankel and Saravelos, 2012). Some of the aforementioned studies employ more than one methodology. However, none of these consider a Fiscal Sustainability Indicator (FSI).

The aim of this article is to assess whether a FSI can be used as a leading indicator in predicting currency crises. To measure the fiscal sustainability of each country considered, the alternative approach proposed by Croce and Juan-Ramón (2003) is employed. A probit model is then employed, and two empirical definitions for currency crises are used to evaluate whether they induce different results.

Quarterly data for a sample of the following 17 countries is presented: Argentina, Brazil, Chile, Colombia, Costa Rica, the Czech Republic, the Dominican Republic, El Salvador, Honduras, Hungary, Indonesia, Malaysia, Mexico, Peru, the Philippines, Thailand and Turkey. This is a heterogeneous group of countries. However, most of them have experienced episodes of currency crises or speculative attacks in the period 1990-2004. Therefore, the countries and the period considered provide a good sample to test our hypothesis. This selection of countries has been dictated by data availability. Fiscal policy was also a relevant criterion in terms of public debt as well as in terms of composition and variability of public expenditures in the sample. It should be emphasised that this paper does not attempt to give a detailed overview of the causes and unfolding of currency crises. Instead, it concentrates primarily on figuring out if the FSI helps to predict currency crises.

The remainder of this article is organised as follows: Section II discusses the FSI and presents a framework for the probit model. Section III shows the data and descriptive statistics. Section IV presents the empirical results. Finally, Section V shows some concluding remarks.

Methodology

Firstly, in this section, the recursive algorithm developed by Croce and Juan-Ramón (2003) is reviewed in detail. Government intertemporal budget constraint is the starting point. In order to facilitate the analysis, it is assumed that net privatisation proceeds, public revenue from the creation of money (seigniorage) and revaluations of assets and liabilities are equal to zero. The financing needs of the public sector are defined as:

$$PSBR_t = \left(D_t - D_{t-1}\right) = PD_t + i_t D_{t-1} \quad (1),$$

where D_t is the stock of total public debt (domestic and foreign), PD_t is the primary deficit and i_t is the nominal rate of interest payments. Equation (1) shows that the change in the stock of public debt (domestic and foreign) is induced by the public sector borrowing requirement (PSBR) at time t to finance the primary deficit and the interest payments on public debt. Multiplying both sides of equation (1) by -1, the following is obtained:

$$PS_t = i_t D_{t-1} - \left(D_t - D_{t-1}\right) \quad (2),$$

where $PS_t \equiv -PD_t$, that is PS_t is the primary surplus of the public sector. Equation (2) can be expressed as a fraction of the nominal Gross Domestic Product as:

$$d_t = \beta_t d_{t-1} - ps_t \quad (3),$$

in which d_t is public debt as a proportion of GDP (the law of motion in the debt to GDP ratio), ps_t is the ratio of the primary surplus to GDP, and $\beta_t = \dfrac{1+r_t}{1+g_t}$, r_t is the real interest rate and g_t denotes the rate of growth of real output. Equation (3) states that, in the absence of shocks and corrective policies, public debt as a proportion of GDP $\left(d_t\right)$ increases over time in the presence of persistent primary fiscal deficits in conjunction with a real interest rate higher than the growth rate of real GDP.

Intertemporal budget constraints for the public sector can be constructed from equation (3). For simplicity, it is assumed that $\beta_{t+N} = \beta$ that is, the discount factor will be constant from time t to time $t+N$, and solving equation (3) forward recursively for N periods, we obtain:

$$d_t = \beta^{-1} ps_{t+1} + \beta^{-2} ps_{t+2} + \cdots + \beta^{-N} ps_{t+N} + \beta^{-N} d_{t+N} \quad (4).$$

This intertemporal budget constraint indicates that the initial stock of public debt should be equal to the discounted present value of the sequence of public primary surpluses from time t to time $t+N$. Using equation (4), the following definition can be stated: the public sector is said to be solvent if the planned trajectory of the primary deficit, from time t to time $t+N$, satisfies the intertemporal budget constraint (equation 4). The definition stated above implies that $d_{t+N}=0$, that is, the public sector cannot be a net debtor in present value terms. This represents a strict condition for solvency, requiring the primary balance to become positive at some point. Alternatively, a less stringent condition for solvency can be derived by imposing weaker conditions on equation (4). We assume that $d_{t+N}=d^*$, where $0<d^*<d_t$. Thus, the present value of expected primary surplus ratios will reduce the debt ratio below the current level. To construct an indicator of fiscal sustainability, Croce and Hugo Juan-Ramón (2003) suggest the equation (3) and two additional equations: target variables and the government reaction function. First of all, target variables are defined as:

$$ps^* = \left(\beta^* - 1\right)d^* \qquad (5),$$

where ps^* and β^* are, respectively, the primary surplus ratio and the discount factor that would prevail once convergence to the target debt ratio $\left(d^*\right)$, is achieved. Secondly, the government reaction function is defined by:

$$ps_t = ps^* + \lambda_t\left(d_{t-1} - d^*\right) \qquad (6),$$

where the primary surplus ratio has two components: the primary surplus ratio associated with target debt ratio, and the policy response to the gap between the observed debt ratio and the target debt ratio. The parameter λ_t indicates the intensity of the policy response at time t, given the debt ratio gap in the previous period. Equation (6) characterises a fiscal rule or a policy reaction function.

Combining equations (3), (5) and (6), the public debt as a proportion of GDP including the policy reaction parameter λ_t can be obtained:

$$d_t = \left(\beta_t - \lambda_t\right)d_{t-1} - \left(\beta^* - \lambda_t - 1\right)d^* \qquad (7).$$

In order to derive a simple expression for the index of fiscal sustainability, it is assumed that the debt ratio at time $t-1$ is higher than the long-term objective for that ratio $\left(d_{t-1} > d^*\right)$. Hence equation (7) states that d_t would converge to d^*, if and only if $\left|\beta_t - \lambda_t\right| < 1$. Therefore, we can use $\left(\beta_t - \lambda_t\right)$ as an indicator of fiscal sustainability. An alternative expression for the fiscal sustainability indicator (FSI) is accordingly:

$$FSI_t = \left(\beta_t - \lambda_t\right) = \left(\frac{1+r_t}{1+g_t} - \frac{ps_t - ps^*}{d_{t-1} - d^*}\right) \qquad (8).$$

This expression states that a persistently higher spread between the observed real interest rate and the observed growth rate of real GDP would, other than being equal, lead to higher public indebtedness (high parameter β_t). The second parameter $\left(\lambda_t\right)$ measures the ratio between the deviations of the observed and target values of the primary surplus and public debt ratios. In addition, a fiscal position would be sustainable if $FSI_t < 1$.

Finally, a probit equation is then estimated to explain the probability that a currency crisis occurs $(Crisis_t = 1)$:

$$\text{Prob}(Crisis_t = 1) = F(\beta_0 + \beta_1 X_t) \quad (9),$$

where the dependent variable is a dummy that equals 1 if the economy is experiencing a currency crisis and zero otherwise, F is the normal cumulative distribution function, and X is a set of macroeconomic indicators, which are believed to be relevant in anticipating currency crises according to the literature. The choice of the explanatory variables is inspired by the literature on early warning systems. The explanatory variables are the fiscal sustainability indicator (FSI), real GDP growth (ΔGDP), the growth rate in the stock of foreign exchange reserves (ΔRI), the ratio between domestic money stock expressed in U.S. dollars and the stock of reserves (M2/RI), and the misalignment of the real exchange rate from its trend (RERDV). As a measure of trend of the real exchange rate, this paper uses a moving average of the last five years. The fiscal sustainability indicator is supposed to capture the state of fiscal fundamentals. Then, an unsustainable fiscal position would be expected to increase the risk of a devaluation or speculative attack. The real GDP growth and the growth rate in the stock of foreign exchange reserves should be negatively related to the crisis incidence. Higher economic growth should reduce the temptation to devaluate. Similarly, the ratio between domestic money stock expressed in U.S. dollars and foreign exchange reserves should be negatively related with currency crises because an unstable ratio may indicate a lending boom, which can be consistent with the expectation of currency depreciation. Delays of the real exchange rate, relative to its average over the previous five years, are considered to be associated with unsustainable external positions and, therefore, are expected to increase the probability of a devaluation or speculative attack on the currency.

Two different definitions for currency crises are used to construct the binary crisis variable or the dependent variable. The first one defines a crisis as a nominal devaluation or depreciation of the domestic currency (ERD) that is greater than 6% in any given quarter, following the definition proposed by Frankel and Rose (1996) that there are only successful speculative attacks. The second definition for currency crises is the measure of exchange rate pressure or market pressure index (MPI) developed by Girton and Roper (1977) and modified by Eichengreen et al. (1996). This indicator is calculated by computing a weighted average of the nominal depreciation rate, the change in interest rates and international reserves using the United States as the country of reference. The advantage of using this index is that both successful and unsuccessful attacks on a currency can be asserted. According to this criterion, a given episode can be classified as a successful speculative attack or a crisis period if the value of the MPI is greater than 1.5 standard deviations over the country's own mean value. Mean values and standard deviations are country-specific. The selection of the critical threshold of 1.5 times the standard deviation of the MPI from its mean captures mild crises (Aziz et al., 2000). However, a major drawback to this approach is that the weights, as well as the threshold value used to identify the speculative attacks, are somewhat arbitrary.

On the other hand, if the FSI uses all available information on fiscal stances (government budget deficit, the amount and composition of public debt, etc.), then it should help predict crises because fiscal indicators have some predictive power. Furthermore, the simple model should not be misspecified. That is, other fiscal variables proposed by the literature would already be captured by the FSI themselves. Thus, the state of fiscal fundamentals should be captured in this single indicator.

Data and Summary Statistics

The data is quarterly and covers the period from the first quarter of 1990 to the fourth quarter of 2004 for 17 countries[3], which were selected following the data availability and because many of them experienced episodes of crises in the period studied. The data was collected from the World Bank's Global Development Finance (GDF), the IMF's Government Finance Statistics (GFS), the IMF's International Financial Statistics (IFS) and the respective Ministry of Finance websites. As the Czech Republic was founded in 1993, earlier data for this country were not available.

The summary of descriptive statistics for the dependent variables (market pressure index and the exchange rate depreciation) is listed in Table 1 and 2, respectively. According to Tables 1 and 2, Brazil, Peru and Turkey show the highest quarter averages of the MPI and depreciation in their exchange rates. Most of the countries considered displayed high degrees of volatility in their foreign exchange market, given that the standard deviations are always more than double their mean value. Nonetheless, Table 1 shows that Chile, Costa Rica, the Dominican Republic, El Salvador and Hungary have negative skewness (and only Chile in Table 2), which implies that more tranquil periods in which the exchange rates remain more or less stable tend to occur more often than large speculative attacks or depreciations in their foreign exchange markets.

Empirical Results

To construct a Fiscal Sustainability Indicator (FSI), we use d^* equal to the minimum value reached by the debt ratio during the period studied. The value of β^* represents the median of the distribution for the observed values of β for the group of countries.

Its value was set at 1.026, implying that the expected value of the real interest rate is 2.6 percentage points higher than the real growth rate, in a steady state. Table 1 shows the countries with problems of fiscal sustainability during 1990Q1-2004Q4. Countries for which the FSI was above the threshold of 1 were classified as having been fiscally unsustainable $(\beta - \lambda > 1)$ at least 75% of the times during the period studied.

[3]Argentina (ARG), Brazil (BRA), Chile (CHL), Colombia (COL), Costa Rica (CRI), the Czech Republic (CZE), the Dominican Republic (DOM), El Salvador (SLV), Honduras (HND), Hungary (HUN), Indonesia (IDN), Malaysia (MYS), Mexico (MEX), Peru (PER), the Philippines (PHL), Thailand (THA) and Turkey (TUR).

Table 1: Summary Statistics for Market Pressure Index

Country	Mean	Median	Maximum	Minimum	Standard Deviations	Skewness	Kurtosis	Observations
Argentina	0.719	-1.856	131.121	-81.828	23.878	2.428	18.608	60
Brazil	5.638	1.940	123.626	-78.875	23.404	1.442	14.359	60
Chile	-0.326	-0.151	6.366	-9.064	3.017	-0.332	2.997	60
Colombia	0.320	0.025	7.878	-6.276	2.596	0.326	3.496	60
Costa Rica	1.363	1.183	7.110	-5.701	1.939	-0.186	6.037	60
Czech Republic	-1.084	-1.055	11.492	-7.881	3.163	0.947	6.970	47
Dominican Republic	0.330	0.169	8.079	-8.431	3.063	-0.003	3.714	60
El Salvador	-0.245	-0.218	2.775	-3.556	0.916	-0.072	6.449	60
Honduras	0.217	-0.117	4.017	-2.878	1.290	0.822	4.036	60
Hungary	0.039	0.066	5.0602	-4.841	1.758	-0.144	4.626	60
Indonesia	-0.606	-0.950	13.789	-8.670	3.879	1.289	7.249	60
Malaysia	-0.127	-0.184	2.841	-3.706	0.902	0.159	8.909	60
Mexico	0.056	-0.834	26.327	-13.777	5.181	2.426	13.745	60
Peru	-0.178	-0.410	59.533	-60.950	15.827	0.961	11.504	60
Philippines	0.128	0.073	9.484	-5.994	3.330	0.452	3.346	60
Thailand	-0.561	-0.852	11.781	-7.433	2.786	1.485	8.615	60
Turkey	3.381	2.708	35.815	-31.467	9.427	0.402	7.706	60
All Countries	0.554	-0.116	131.122	-81.828	9.701	4.146	75.881	1007

Source: Author's calculations.

Furthermore, Table 1 shows the frequency of β values being higher than β^*, and the frequency of λ assuming a negative value (implying a primary deficit). According to the results showed in Table 3, on average, the countries in the sample present an unsustainable fiscal stance that is mostly explained by government fiscal deficits rather than by spreads between the real interest rates and the growth rates.

Table 2: Summary Statistics for Exchange Rate Depreciation

Country	Mean	Median	Maximum	Minimum	Standard Deviations	Skewness	Kurtosis	Observations
Argentina	7.583	0.000	195.147	-11.747	33.581	4.664	24.209	60
Brazil	34.339	2.964	274.715	-14.700	60.368	1.977	6.688	60
Chile	1.153	1.548	11.103	-9.879	4.257	-0.380	3.155	60
Colombia	3.046	3.107	17.928	-10.525	5.552	0.340	3.638	60
Costa Rica	2.878	2.517	11.492	-1.784	1.866	1.995	10.279	60
Czech Republic	-0.366	-0.757	20.063	-16.991	5.923	0.277	5.589	47
Dominican Republic	3.083	1.178	38.926	-30.896	9.271	1.173	10.362	60
El Salvador	1.117	0.000	53.200	-4.798	6.972	7.125	53.694	60
Honduras	6.951	1.337	310.000	-50.000	40.531	7.094	53.935	60
Hungary	1.921	2.615	22.326	-11.627	5.425	0.321	5.424	60
Indonesia	3.987	1.197	79.032	-28.187	17.684	2.592	12.167	60
Malaysia	0.690	0.000	26.485	-8.851	5.244	3.285	15.764	60
Mexico	2.758	0.904	56.433	-7.455	8.889	4.204	24.341	60
Peru	29.157	1.651	1216.065	-3.731	158.675	7.172	53.986	60
Philippines	1.709	0.241	28.384	-10.842	6.021	1.778	8.651	60
Thailand	0.955	-0.197	41.617	-17.869	7.694	3.108	17.452	60
Turkey	11.823	10.856	53.116	-17.200	12.313	0.948	5.823	60
All Countries	6.725	1.152	1216.065	-50.000	44.725	20.687	537.112	1007

Source: Author's calculations.

In summary, Argentina, Colombia, Costa Rica, the Czech Republic, El Salvador, Honduras, Hungary, Mexico, Peru, the Philippines and Turkey present large unsustainable fiscal positions in most of the period studied, which are basically explained by primary fiscal deficits.

Table 3: FSI Analysis

Country	Frequency		
	$\beta - \lambda > 1$	$\beta > \beta^*$	$\lambda < 0$
Argentina	87%	42%	95%
Brazil	62%	42%	60%
Chile	33%	3%	33%
Colombia	93%	37%	100%
Costa Rica	100%	2%	100%
Czech Republic	95%	20%	84%
Dominican Republic	40%	20%	40%
El Salvador	97%	3%	100%
Honduras	98%	13%	100%
Hungary	95%	30%	97%
Indonesia	50%	2%	60%
Malaysia	47%	7%	77%
Mexico	83%	18%	85%
Peru	80%	42%	93%
Philippines	98%	10%	100%
Thailand	38%	13%	38%
Turkey	100%	50%	100%
All Countries	76%	21%	80%

Note: Number of quarters as a percentage of total quarters.

Source: Author's calculations.

A probit model estimation corrected for robust covariance is used to assess the effectiveness of the FSI. In order to avoid a spurious regression, unit root tests are performed on both the MPI and exchange rate, as to investigate whether these variables are stationary or not. The augmented Dickey-Fuller (ADF) unit root test is used for this purpose. The results[4] suggest that the variables are stationary. The Akaike criterion is used to select lags for the sample as a whole as well as for each individual country. The goodness-of-fit measures considered are McFadden R^2 and the Hosmer-Lemeshow (H-L) test. In addition, two modified versions of McFadden's R^2 as proposed by Estrella (1998) and Veal and Zimmerman (1992) are used. These measures compute a Log-Likelihood ratio of the model studied as compared to another model that does not take the information of the former into account. In the case of Estrella (1998), the Log-Likelihood of equation (9) is compared to the Log-Likelihood of a model where the binary series is only regressed on a constant (unconstrained model). Similarly, Veal and Zimmerman (1992) developed a pseudo-R^2 measure of goodness-of-fit (V-Z R^2) based on the ratio of the maximized

[4] These regressions are not presented here, but are available upon request.

Log-Likelihood function versus the restricted Log-Likelihood function where explanatory variable coefficients except the intercept term are set equal to zero. The version proposed by Estrella (1998) further adjusts for the number of regressors. The results of these estimates are presented in Tables 4a, 4b, 5a and 5b.

For the sample as a whole, the coefficient of the lagged FSI is positive and statistically significant at the 1% level, with a marginal effect of 8.7% for MPI. An interpretation of this marginal effect would proceed as follows; a 1% increase in the FSI will induce an 8.7% increase in the probability that a currency crisis occurs. All the coefficient estimates are statistically significant, but only the misalignment of the real exchange rate from its trend has the expected sign. When ERD is used as the dependent variable, the coefficient of the FSI is positive and statistically significant at the 1% level with a marginal predictive contribution of 10.9%. Real GDP growth, the deviations of the real exchange rate from its trend and the growth rate in the stock of foreign exchange reserves have the right sign. However, the stock of foreign exchange reserves is not significant. The McFadden R^2 for these estimates is 23.1% and 10.8%, respectively, while the results of the Estrella R^2 are 14.9% and 36.2%, respectively. The pseudo-R^2 developed by Veal and Zimmerman (1992) shows that goodness-of-fit is 32.7% when MPI is used and 18.0% when the independent variable is ERD. In order to evaluate the goodness-of-fit in both models, the Hosmer-Lemeshow (H-L) test is used. The H-L test statistics lead to not rejecting the null hypothesis of no difference between observed and predicted values. Also, the LR statistic shows the general statistical significance of the models (see Tables 4a and 5a).

In fact, the estimated results for Argentina further suggest that a lagged FSI helps predict currency crises. Here, coefficients of FSI are statistically significant at the 1% level with a marginal predictive contribution of about 9.5%. Argentina shows an unsustainable fiscal position in 87% of the period studied (see Table 3). The rest of coefficient estimates are significant in explaining currency crisis and have the expected sign. Real GDP growth, the growth rate in the stock of foreign exchange reserves and the ratio between domestic money stock expressed in U.S. dollars and the stock of reserves are negatively related with the occurrence of a currency crisis. In the case of Brazil, the results indicate that the FSI has a significantly positive effect on the probability of crisis occurrence. Brazil shows an unsustainable fiscal stance in about 62% of the period considered. The rest of the variables are not significant except for the ratio between domestic money stock and the stock of reserves when ERD is used, but it is positively related with the probability of a crisis. The results for Chile show that the coefficient of FSI is statistically significant and negatively related with the crisis, but only when the MPI is used. Chile shows a sustainable fiscal stance in most of the period considered. Real GDP growths, the growth rate in the stock of foreign exchange reserves and the ratio M2/RI have the expected sign. The misalignment of the real exchange rate from its trend is significant and positively related with probability of currency crisis, but the marginal predictive contribution is very low.

Table 4a: Do FSIs Predict MPI?

Variable	All	ARG	BRA	CHL	COL	CRI	CZE	DOM	SLV
Constant	-3.226*	-3.443^	-1.213	10.413	-15.236*	-15.874*	-6.403	-17.843*	-12.869*
	(0.311)	(1.876)	(1.164)	(6.989)	(4.287)	(6.204)	(11.919)	(7.103)	(4.772)
	[-0.408]	[-0.136]	[-0.411]	[0.258]	[-0.908]	[-0.642]	[-0.245]	[-0.655]	[-0.397]
IFS(-1)				-4.349^		2.012		3.475	1.829*
				(2.385)		(1.240)		(3.510)	(1.081)
				[-0.108]		[0.081]		[0.128]	[0.056]
IFS(-2)							-7.404^		
							(4.315)		
							[-0.283]		
IFS(-3)	0.685*				8.107*				
	(0.173)				(2.204)				
	[0.087]				[0.483]				
IFS(-4)		2.407*	1.191^						
		(0.799)	(0.674)						
		[0.095]	[0.403]						
ΔPIB	0.004^		0.002	-0.448^					
	(0.002)		(0.001)	(0.257)					
	[0.001]		[0.001]	[-0.011]					
ΔPIB(-1)					0.102*		0.364	-0.333	
					(0.044)		(0.417)	(0.214)	
					[0.006]		[0.014]	[-0.012]	
ΔPIB(-2)		-0.685*				1.184#			
		(0.231)				(0.573)			
		[-0.027]				[0.048]			
ΔPIB(-3)									1.105*
									(0.479)
									[0.034]
ΔRI			-0.002	-0.015	-0.095^	-0.073#			
			(0.004)	(0.014)	(0.054)	(0.035)			
			[-0.001]	[-0.000]	[-0.006]	[-0.003]			
ΔRI(-1)	0.002^							0.012^	0.052*
	(0.001)							(0.007)	(0.021)
	[0.000]							[0.000]	[0.002]
ΔRI(-2)		-0.0339*							
		(0.013)							
		[-0.001]							
M2/RI	0.248*		-0.079	-4.081^	-1.372*	1.500^		1.652^	
	(0.038)		(0.147)	(2.294)	(0.606)	(0.809)		(0.889)	
	[0.031]		[-0.027]	[-0.101]	[-0.082]	[0.061]		[0.061]	
M2/RI(-1)							1.915		
							(2.815)		
							[0.073]		
M2/RI(-2)		-1.177^							
		(0.714)							
		[-0.047]							
RERDV	0.024*		0.010		0.294*	0.384^			
	(0.006)		(0.012)		(0.084)	(0.384)			
	[0.003]		[0.003]		[0.018]	[0.016]			
RERDV(-1)				0.116#			-0.852		
				(0.054)			(0.786)		
				[0.003]			[-0.033]		
RERDV(-2)								-0.184	
								(0.122)	
								[-0.007]	
Prob LR	0.000	0.003	0.018	0.539	0.005	0.009	0.477	0.008	0.333
McFadden R^2	0.231	0.659	0.144	0.401	0.566	0.643	0.371	0.665	0.338
Estrella R^2	0.149	0.362	0.194	0.084	0.346	0.343	0.099	0.359	0.070
V-Z R^2	0.327	0.733	0.287	0.440	0.663	0.717	0.419	0.736	0.375
H-L Test	13.280	2.748	3.776	0.281	3.208	1.578	0.267	0.209	0.379
χ^2	0.103	0.949	0.877	1.000	0.921	0.991	1.000	1.000	1.000

*Note: Estimates are provided for each individual country. The dependent variable is a dummy variable which takes on a value of 1 if there is a currency crisis in the quarter. Standard errors and marginal effects are displayed in the parentheses and brackets, whilst *, #, and ^ represent significance level at 1%, 5% and 10%, respectively. Source: Author's calculations.*

Table 4b: Do FSIs Predict MPI?

Variable	HND	HUN	IDN	MYS	MEX	PER	PHL	THA	TUR
Constant	-35.308*	-0.136	-7.644*	-42.800*	4.535#	-2.301*	-15.509#	-12.414*	-12.671*
	(7.652)	(1.340)	(1.728)	(10.255)	(2.172)	(0.335)	(7.144)	(4.285)	(2.395)
	[-3.642]	[-0.013]	[-0.223]	[-1.289]	[0.130]	[-0.047]	[-0.599]	[-0.767]	[-0.446]
IFS(-1)			1.491^				15.316#	-2.523*	
			(0.891)				(6.010)	(0.718)	
			[0.044]				[0.592]	[-0.156]	
IFS(-2)		-7.311*			-11.655*	-0.314^			
		(2.769)			(2.567)	(0.183)			
		[-0.294]			[-0.335]	[-0.006]			
IFS(-3)	7.169*								
	(1.737)								
	[0.739]								
IFS(-4)				2.860					0.779^
				(2.005)					(0.423)
				[0.086]					[0.027]
ΔPIB			0.069#			-0.348#			
			(0.035)			(0.164)			
			[0.002]			[-0.007]			
ΔPIB(-1)		-0.145^		0.827*	-1.688*			0.784*	0.932*
		(0.008)		(0.271)	(0.480)			(0.241)	(0.224)
		[-0.006]		[0.025]	[-0.048]			[0.048]	[0.033]
ΔPIB(-2)	3.011*								
	(0.674)								
	[0.311]								
ΔPIB(-4)							-0.895#		
							(0.417)		
							[-0.035]		
ΔRI			-0.209#						
			(0.082)						
			[-0.006]						
ΔRI(-1)		0.002			-0.059*		-0.066#	-0.252*	-0.036^
		(0.004)			(0.018)		(0.032)	(0.072)	(0.021)
		[0.000]			[-0.002]		[-0.003]	[-0.016]	[-0.001]
ΔRI(-2)	0.021*								
	(0.008)								
	[0.002]								
ΔRI(-4)				0.0496*					
				(0.0184)					
				[0.002]					
M2/RI			0.772*		2.261*			2.518#	0.898*
			(0.296)		(0.706)			(1.113)	(0.317)
			[0.022]		[0.065]			[0.156]	[0.032]
M2/RI(-1)	1.605*	0.519*		8.354*			-2.049^		
	(0.326)	(0.184)		(1.925)			(1.057)		
	[0.166]	[0.021]		[0.252]			[-0.079]		
RERDV		-0.328^		0.210*	-0.084^				
		(0.192)		(0.059)	(0.049)				
		[-0.013]		[0.006]	[-0.002]				
RERDV(-1)							0.219		
							(0.137)		
							[0.008]		
Prob LR	0.000	0.415	0.002	0.004	0.000	0.073	0.009	0.000	0.000
McFadden R^2	0.828	0.496	0.727	0.734	0.777	0.518	0.655	0.625	0.742
Estrella R^2	0.591	0.112	0.406	0.425	0.529	0.120	0.359	0.434	0.503
V-Z R^2	0.879	0.536	0.789	0.796	0.839	0.558	0.729	0.725	0.814
H-L Test	0.154	0.017	0.055	0.054	0.321	0.092	1.641	2.291	1.669
χ^2	1.000	1.000	1.000	1.000	1.000	1.000	0.990	0.971	0.989

*Note: Estimates are provided for each individual country. The dependent variable is a dummy variable which takes on a value of 1 if there is a currency crisis in the quarter. Standard errors and marginal effects are displayed in the parentheses and brackets, whilst *, #, and ^ represent significance level at 1%, 5% and 10%, respectively. Source: Author's calculations.*

That is, accordingly to the results showed in Tables 1 and 2. Chile has negative skewness, which implies that more stable periods in the foreign exchange market tend to occur more often than large speculative attacks or depreciations. For Colombia, the results indicate that an unsustainable fiscal position increases the probability of a crisis when MPI is employed. The coefficient of the FSI is positive and statistically significant at the 1% level, with a marginal effect of 48.3% for MPI. Colombia has consistently maintained an unsustainable fiscal position as a result of primary fiscal deficit and higher real interest rate-growth gap (Table 3). The probability of a crisis tends to increase with real economic growth and the deviation of the exchange rate from its trend. However, accumulation of foreign exchange reserves and M2/RI ratio reduce the risk of currency attack. On the contrary, FSI is not significant when ERD is used and the rest of the variables are negatively related with crisis probability.

Results for Costa Rica show that coefficients are statistically significant at the 10% level, with a marginal effect of 53.8%, but only if ERD is used. Costa Rica presents a high frequency of unsustainable fiscal position in the period considered. The real GDP growth, the ratio between domestic money stock and foreign exchange reserves and delays of the real exchange rate, relative to its average over the previous five years, are positively related with currency crises. While the growth rate in the stock of foreign exchange reserves is negatively related with crisis incidence if MPI is employed. Similar conclusions are drawn by Frankel and Saravelos (2012) and Comelli (2013). For the Czech Republic, the coefficients of the FSI have negative signs and are statistically significant, but only when MPI is used. When ERD is employed as the dependent variable, the coefficient of the FSI is negative, but statistically insignificant. The probability of a crisis tends to reduce with real GDP growth, accumulation of foreign exchange reserves and M2/RI ratio. The misalignment of the real exchange rate from its trend is statistically insignificant.

For the Dominican Republic, the results suggest that the FSI predicts the probability of currency crises, but only when ERD is used. The marginal predictive contribution is 82.1%. The Dominican Republic shows an unsustainable fiscal position in 40% of the period studied (Table 3). The accumulation of international reserves and misalignment of the real exchange rate from its trend have the signs as expected. When MPI is used as the dependent variable, the coefficient of the FSI has the expected sign, but it is not statistically significant (see Tables 4a and 5a). In the case of El Salvador, the results suggest that lagged FSI helps predict currency crises. The FSI calculated for El Salvador persistently presented an unsustainable fiscal stance (see Table 3). However, when ERD is employed as the dependent variable, the coefficient of the FSI has a negative sign and it is statistically significant. Real GDP growths and the growth rate in the stock of foreign exchange reserves are positively related with probability of currency crisis, but when ERD is used, the stock of foreign exchange reserves shows a negative relationship with crisis incidence.

The estimated results for Honduras show that the coefficient of the FSI has a positive sign and is statistically significant at the 1% level, with a marginal effect of 73.9%, but when the MPI is used as an independent variable. Honduras persistently presents an unsustainable fiscal stance (see Table 3). Real GDP growth, the stock of foreign exchange reserves and the M2/RI are positively related with currency crisis occurrence independent of the crisis definition employed. For Hungary, the coefficient of the FSI has a negative sign and is statistically significant, particularly when MPI is used. This country presents a high frequency of unsustainable fiscal positions (95%) in the period considered. The probability of a crisis tends to reduce with real GDP growth and the misalignment of the real exchange rate from its trend. In contrast, M2/RI ratio reduces the risk of currency attack with a marginal effect of 2.2%. Accumulation of foreign exchange reserves is not significant. If ERD is used, the FSI is not statistically significant, and the growth rate in the stock of international exchange reserves and delays of the real exchange rate have the right sign. In the case of Indonesia, the results indicate that the FSI has a positive effect on the probability of crisis occurrence, but the marginal effect is 4.4% when MPI is employed. According to Table 3, Indonesia shows a sustainable fiscal position in 50% of period studied. On the contrary, when ERD is used, the FSI has a significantly negative effect on the probability of currency crisis. Accumulation of international reserves has the expected sign, independent of which definition for currency crises is used, but it is not statistically significant when ERD is employed. The real GDP growth is positively related with probability of currency crises in both definitions of crisis. Similarly, for Malaysia, the coefficient of the FSI has a negative sign and is statistically significant when ERD is used. But it has a positive sign and is not statistically significant when MPI is employed. Malaysia shows a consistently sustainable fiscal balance in the period under study (Table 3). If MPI is used, the rest of the coefficient estimates are statistically significant, but only the misalignment of the real exchange rate from its trend has the expected sign. Conversely, when ERD is used, only real economic growth and the growth rate in the stock of international reserves are statistically significant, but only the last variable has the expected sign (see Tables 4b and 5b).

The results for Mexico present a negative FSI coefficient when MPI is used. However, when ERD is employed, the coefficient of the FSI is positive, but is not significant. In most of the years under study, the FSI for Mexico presents an unsustainable fiscal position (83% of the time). The probability of a currency crisis in Mexico tends to increase with M2/RI. In contrast, real GDP growth, accumulation of foreign exchange reserves and the misalignment of the real exchange rate reduce the risk of a currency attack when MPI is employed. By contrast, when ERD is used, the ratio between domestic money stock and the stock of international reserves increases the probability of a currency crisis. The remainder of the variables are not statistically significant. For Peru, the results suggest that the FSI predicts high probabilities of ERD. The fiscal sustainability indicator for Peru shows an unsustainable fiscal stance during most of the period considered. The M2/RI ratio is negatively related with probability of currency crises. But when MPI is used, the coefficient of the FSI is negative and statistically significant at the 10% level, and the real GDP growth has a negative sign. Similarly, the results for the Philippines show that the coefficients of the FSI are statistically significant with a high marginal predictive contribution. For the Philippines, the fiscal sustainability indicator exhibits an unsustainable fiscal position during 98% of the period considered (see Table 3). When MPI is employed, all the coefficient estimates are significant in explaining currency crisis and have the expected sign. Instead, when ERD is used, only the real GDP growth and the stock of foreign exchange reserves are statistically significant and have the expected sign (see Tables 4b and 5b).

For Thailand, the results indicate that the FSI has a substantial effect on the probability of ERD, with a marginal effect of 36.2%. The fiscal sustainability indicator for Thailand indicated sustainability in the period considered. The real GDP growth and the ratio between domestic money stock and international reserves are positively related with currency crises. The growth rate in the stock of foreign exchange reserves is negatively related with the crisis incidence but it is not statistically significant. However, when MPI is used, it is statistically significant and has the right sign. Likewise, in the case of Turkey, the high significance of the FSI coefficient and its high marginal effects suggest that the FSI predicts ERD. But the marginal effect is negligible when MPI is used. The fiscal sustainability indicator for Turkey shows an unsustainable fiscal position in the overall period studied (Table 3). The real economic growth and the M2/RI are statistically significant, and are positively related with the probability of currency crises when MPI is employed. The accumulation of international reserves reduces the probability of currency crisis. However, when ERD is used, only the coefficient of FSI is statistically significant.

On the other hand, the LR statistic shows the general statistical significance of the models (zero hypothesis of no significance of most the coefficients in the models was rejected). The different pseudo-R^2 indicates relatively good goodness-of-fit in the different models. However, in order to evaluate the goodness-of-fit in the different estimation the Hosmer-Lemeshow (H-L) test is carried out. The null hypothesis is that fit is sufficient to the data. The H-L test statistics do not reject the null hypothesis, so it is reasonable to consider that the goodness-of-fit is quite acceptable.

In summary, the estimated results suggest that, for some countries, the FSI is useful in predicting the probability of currency crises. Moreover, its overall explanatory power is quite substantial, given that the different pseudo-R^2 measure surpassed the value of 20% for most specifications.

Concluding Remarks

This article addressed the issue of whether a fiscal sustainability indicator can anticipate the occurrence of currency crises. The results reveal that an unsustainable fiscal position positively affects the probability of currency crisis occurrence. In some countries, the results seldom vary when different definitions for currency crises are considered separately. In spite of these, our empirical findings seem to provide supporting evidence for some authors, who argue that fiscal policy plays an important role in generating currency crises.

The sign of the coefficients of different macroeconomic variables used is not uniform for all countries. The results obtained in the different estimations appear to be in line with some of the empirical studies on currency crises. Large accumulation of international reserves has a negative incidence on probability of currency crisis.

For future research, it would be interesting to apply the same analysis to a larger sample of countries and to a higher frequency of data, such as monthly data, as well as the refinement of the FSI to include behavioural content that would take into account endogenous private savings and investment behaviour, and thereby allow extensions to externally financed public deficits. On the other hand, one must investigate whether those fiscal imbalances in some countries reflect deeper structural shortcomings such as soft budget constraints and inefficient tax systems.

Table 5a: Do FSIs Predict ERD?

Variable	All	ARG	BRA	CHL	COL	CRI	CZE	DOM	SLV
Constant	-1.936* (0.268) [-0.394]	-3.443^ (1.876) [-0.136]	-4.432* (1.383) [-1.176]	-1.569 (3.269) [-0.185]	0.533 (1.006) [0.083]	-2.520 (3.716) [-0.250]	3.916 (4.933) [0.534]	-10.781^ (5.843) [-0.963]	-0.951 (1.197) [-0.037]
IFS(-1)			2.096# (0.968) [0.556]	1.672 (1.442) [0.197]		5.429^ (3.153) [0.538]		9.187^ (5.382) [0.821]	
IFS(-2)							-1.924 (3.786 [-0.262]		
IFS(-3)									-1.577# (0.712) [-0.062]
IFS(-4)	0.534* (0.163) [0.109]	2.407* (0.799) [0.095]			0.795 (0.494) [0.125]				
ΔPIB	-0.016# (0.008) [-0.003]		-0.013 (0.009) [-0.004]	-0.174 (0.123) [-0.020]	-0.386# (0.153) [-0.061]				
ΔPIB(-1)								0.087 (0.080) [0.008]	
ΔPIB(-2)		-0.685* (0.231) [-0.027]				-0.168 (0.110) [-0.017]	-0.121# (0.054) [-0.016]		
ΔPIB(-3)									0.207# (0.082) [0.008]
ΔRI			0.003 (0.005) [0.001]	0.009 (0.019) [0.001]	-0.013 (0.018) [-0.002]	-0.008 (0.006) [-0.001]	-0.077* (0.025) [-0.011]		
ΔRI(-1)	-0.002 (0.002) [-0.001]							-0.034* (0.013) [-0.003]	-0.025# (0.012) [-0.001]
ΔRI(-2)		-0.034* (0.013) [-0.001]							
M2/RI	0.084# (0.035) [0.017]		0.326* (0.122) [0.086]	-0.505 (1.092) [-0.059]	-1.165# (0.586) [-0.182]	-0.648* (0.226) [-0.064]	-1.609# (0.652) [-0.219]	-0.167 (0.158) [-0.015]	
M2/RI(-1)									
M2/RI(-2)		-1.177^ (0.714) [-0.047]							
RERDV	0.023* (0.006) [0.005]		0.008 (0.012) [0.002]		-0.027 (0.026) [-0.004]	0.061 (0.063) [0.006]			
RERDV(-1)				-0.011 (0.034) [-0.001]			-0.168 (0.166) [-0.023]		
RERDV(-2)								0.048# (0.021) [0.004]	
Prob LR	0.000	0.004	0.000	0.165	0.055	0.172	0.073	0.000	0.641
McFadden R^2	0.108	0.659	0.314	0.229	0.256	0.266	0.329	0.626	0.167
Estrella R^2	0.089	0.362	0.404	0.140	0.200	0.144	0.252	0.572	0.032
V-Z R^2	0.180	0.733	0.521	0.320	0.377	0.352	0.459	0.757	0.191
H-L Test	8.361	2.748	10.063	3.014	14.529	3.168	5.150	2.672	3.056
χ^2	0.399	0.949	0.261	0.934	0.069	0.923	0.742	0.953	0.931

*Note: Estimates are provided for each individual country. The dependent variable is a dummy variable which takes on a value of 1 if there is a currency crisis in the quarter. Standard errors and marginal effects are displayed in the parentheses and brackets, whilst *, #, and ^ represent significance level at 1%, 5% and 10%, respectively. Source: Author's calculations.*

Table 5b: Do FSIs Predict ERD?

Variable	HND	HUN	IDN	MYS	MEX	PER	PHL	THA	TUR
Constant	4.518	-1.728#	4.080#	-10.685#	-5.203#	-28.791#	-2.233#	-24.182*	-5.104*
	(3.973)	(0.706)	(2.051)	(4.824)	(2.352)	(11.922)	(0.939)	(7.181)	(1.364)
	[1.163]	[-0.434]	[0.717]	[-0.470]	[-0.910]	[-0.947]	[-0.513]	[-1.615]	[-0.876]
IFS(-1)			-1.736^		1.506		1.265^	5.412#	4.762*
			(0.921)		(1.154)		(0.730)	(2.749)	(1.083)
			[-0.305]		[0.263]		[0.291]	[0.362]	[0.817]
IFS(-2)						45.468#			
						(19.766)			
						[1.496]			
IFS(-3)				-3.170#					
				(1.561)					
				[-0.139]					
IFS(-4)	-7.979#	0.361							
	(3.657)	(0.361)							
	[-2.054]	[0.091]							
ΔPIB					-0.099	-0.203			
					(0.105)	(0.221)			
					[-0.017]	[-0.007]			
ΔPIB(-1)	0.475*	-0.013	0.051#				-0.182^	0.231#	
	(0.178)	(0.011)	(0.022)				(0.109)	(0.107)	
	[0.122]	[-0.003]	[0.009]				[-0.042]	[0.015]	
ΔPIB(-2)									0.018
									(0.055)
									[0.003]
ΔPIB(-3)				1.050*					
				(0.342)					
				[0.046]					
ΔRI		-0.035#	-0.016	-0.109*	0.005		-0.016^		
		(0.014)	(0.017)	(0.035)	(0.006)		(0.009)		
		[-0.009]	[-0.003]	[-0.005]	[0.001]		[-0.004]		
ΔRI(-1)								-0.041	-0.003
								(0.033)	(0.004)
								[-0.003]	[-0.001]
ΔRI(-2)	0.007#								
	(0.003)								
	[0.002]								
M2/RI			-1.160*	0.191	0.615*	-20.826#			-0.519
			(0.370)	(1.269)	(0.213)	(9.313)			(0.322)
			[-0.204]	[0.008]	[0.108]	[-0.685]			[-0.089]
M2/RI(-1)	0.375*	0.964*					0.142	4.140*	
	(0.132)	(0.306)					(0.117)	(1.467)	
	[0.097]	[0.242]					[0.033]	[0.277]	
RERDV				0.011			0.016		
				(0.074)			(0.023)		
				[0.001]			[0.004]		
RERDV(-1)		0.105#			-0.025				
		(0.047)			(0.016)				
		[0.026]			[-0.004]				
Prob LR	0.000	0.031	0.000	0.016	0.085	0.000	0.059	0.000	0.000
McFadden R^2	0.417	0.234	0.387	0.591	0.207	0.862	0.179	0.566	0.471
Estrella R^2	0.358	0.222	0.403	0.308	0.168	0.838	0.180	0.384	0.527
V-Z R^2	0.566	0.372	0.564	0.671	0.319	0.923	0.304	0.673	0.659
H-L Test	1.647	3.402	6.046	0.574	6.976	24.997	7.342	0.568	3.195
χ^2	0.990	0.907	0.642	0.999	0.539	0.005	0.500	0.999	0.922

*Note: Estimates are provided for each individual country. The dependent variable is a dummy variable which takes on a value of 1 if there is a currency crisis in the quarter. Standard errors and marginal effects are displayed in the parentheses and brackets, whilst *, #, and ^ represent significance level at 1%, 5% and 10%, respectively. Source: Author's calculations.*

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