Is there a relationship between fiscal sustainability and currency crises? International evidence based on causality tests

Alexis Cruz-Rodríguez[1]

Abstract

This paper uses Granger causality tests on a fiscal sustainability indicator (FSI) and currency crises for 17 countries to evaluate the direction of causality between the FSI and currency crises. The FSI developed by Croce and Juan-Ramón (2003) is used. Also, different definitions for currency crises are used to evaluate whether they induce different results in the analysis. In general, the results suggest evidence of causality between the lagged FSI and currency crises.

Keywords: Currency crisis, foreign exchange, fiscal sustainability, Granger causality

JEL Classification: F31, F33, E62

1. Introduction

The establishment of an early warning system that can anticipate the occurrence of currency crises has led to debates, both theoretical and empirical. Most of the literature on currency crises focuses on the causal role of monetary policy in a crisis. However, theoretical and empirical literature on this subject provides a useful framework for the analysis of fiscal causes. The first generation models, called speculative attack models, indicate that an immoderate fiscal policy is the main cause of currency crises (Krugman, 1979, 1996; Flood and Garber, 1984; Flood and Marion, 1996; Van Wijnbergen 1991; Daniel, 2001; Corsetti and Mackowiak, 2005, 2006; Burnside et al., 2003, 2006). The second generation models accentuate the self-fulfilling characteristics of a currency crisis and the occurrence of multiple equilibria (Obstfeld, 1986, 1996; Rangvid, 2001). In these models, the currency attacks occur when investors gain new information that government net liabilities exceed a threshold, or when the government decides to extract seigniorage, instead of undertaking a fiscal adjustment, to meet the intertemporal budget constraint. In other words, the immediate cause of the crisis is a sign that the government can only resolve policy inconsistencies abandoning the rules of the exchange rate, rather than trying to

[1] Pontificia Universidad Católica Madre y Maestra, Av. Abraham Lincoln Esq. Rómulo Betancourt, Ensanche La Julia, Santo Domingo, Dominican Republic, alexiscruz@pucmm.edu.do

contain public sector imbalances. Finally, third generation models stress the consequences of moral hazard in the banking system and the contagion effect as key determinants of a currency crisis (Burnside et al., 2000; Chang and Velasco, 2001; Marini and Piersanti, 2003). Here, a sudden loss of confidence triggers a twin crisis, combining banking and currency problems, once maturity and currency mismatches in banking balance sheets enter a zone of vulnerability. The idea is that a banking system crisis will lead to a currency crisis using the first generation models' mechanism, because government contingent liabilities (implicit guarantees) become commitments in the moments of crisis and result in unsustainable fiscal deficits, with central banks as lenders of last resort. However, the measures taken are inconsistent with the maintenance of fixed exchange rates.

Empirical studies as developed by Nashashibi and Bazzoni (1993), Eichengreen et al. (1994), Kaminsky and Reinhart (1999), Aziz et al. (2000), Siwinska (2000), and Bird and Mandilaras (2006) found that fiscal imbalances have a significant effect on the probability of a foreign exchange crisis. However, the literature on the subject has paid little attention to the role of an indicator of fiscal sustainability in assessing the likelihood of currency crises. On the contrary, there are numerous empirical studies on currency crises, which attempt to deduce the main indicators that make such crises more predictable, but from the point of view of monetary policy (Goldfajn and Valdes, 1997, Burkart and Coudert, 2002, Broome and Morley, 2004, Crepo-Cuaresma and Slacik, 2007; Frankel and Saravelos, 2012).

The aim of this paper is to assess whether a Fiscal Sustainability Indicator (FSI) can be used as a leading indicator in predicting currency crises. To do that, the alternative approach proposed by Croce and Juan-Ramón (2003) is employed to measure the fiscal sustainability of each country. Then, the direction of causality between the FSI and currency crises is investigated. In addition, three empirical definitions of currency crises are employed. Firstly, an exchange market pressure index is constructed as an indicator of currency crises. 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 quarter in which the index exceeds a certain threshold is taken to be the crisis period. Secondly, a crisis is defined as a nominal currency depreciation. Finally, from previously mentioned definitions, two binary definitions of currency crises are constructed.

To carry out the research, we used quarterly data from 17 developing countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Czech Republic, Dominican Republic, El Salvador, Honduras, Hungary, Indonesia, Malaysia, Mexico, Peru, Philippines, Thailand and Turkey. These countries were selected based on data availability and because most of these countries experienced episodes of currency crises in the period 1990-2004. Therefore, the countries and period make a good sample to test our hypothesis. Note that this paper does not give a detailed overview of the causes and development of currency crises, but instead, it focuses primarily on assessing if the FSI helps predict currency crises.

The remainder of the paper is organised as follows: Section 2 presents the different definitions of currency crises used. Section 3 describes the sets of data obtained and the

methodology. Section 4 discusses the empirical results. Finally, Section 5 presents the concluding remarks.

2. Defining Currency Crises

The definition of a currency crisis is of paramount importance in the process of identifying the leading indicators for predicting a crisis itself. Several approaches exist in the literature reviewed. In some theoretical works, a currency crisis is predominantly defined only in the context of fixed exchange rate regimes, usually as the official devaluation or abandonment of the fixed exchange rate regime. However, this definition is not flexible enough to use in empirical studies.

Other empirical studies define a currency crisis as a large (either nominal or real) devaluation or depreciation of the domestic currency. However, this last definition does not consider that monetary authorities can fight a speculative attack by intervening in the foreign exchange market or by increasing interest rates. Under these circumstances, a currency crisis (defined as a speculative attack) may not lead to an actual devaluation. As a consequence, unsuccessful speculative attacks should be included in the definition of a currency crisis since they point to the vulnerability of the system as seen in a fall in international reserves and a rise in interest rates (Girton and Roper, 1977; Eichengreen et al., 1996). This paper employs different methodologies to define a currency crisis and compares their results. Firstly, an indicator is constructed based on the movements in nominal exchange rates according to the definition of a currency crisis proposed by Frankel and Rose (1996). This definition of a currency crisis only encompasses currency devaluation without a decrease in international reserves or an increase in interest rates. We define a crisis as a nominal depreciation of the domestic currency in any given quarter that is greater than 6%, exceeding the previous year's depreciation level by at least 10%. In other words, this definition assumes that there are only successful speculative attacks. This definition is utilised to create a binary variable, a crisis indicator called Exchange Rate Depreciation (ERD), equal to one if a crisis occurs and equal to zero otherwise.

Secondly, a definition of a currency crisis is used to refer to an intense increase in speculative pressure on the country's currency. Therefore, the measure of exchange rate pressure (MPI) developed by Girton and Roper (1977) and modified by Eichengreen et al. (1996) is used. The idea being that a successful speculative attack on a currency would show up as a change in the exchange rate, but that monetary authorities can fend off these attacks either by raising interest rates or by selling off international reserves. The advantage of using this index is that both successful and unsuccessful attacks on a currency can be asserted. Then, a given episode can be classified as a speculative attack or crisis period if the MPI is greater in value than 1.5 standard deviations over the country's own mean value. Mean values and standard deviations are country-specific. As a result, the binary variable is used, identifying the speculative attack regime in the sample. 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.

3. Data and Summary Statistics

3.1 Data

The empirical analysis of this paper is performed using quarter frequencies and covers the period from the first quarter of 1990 to the fourth quarter of 2004. For the analysis of fiscal sustainability in developing countries, data was obtained from the World Bank's Global Development Finance (GDF), the IMF's Government Finance Statistics (GFS), the CD-ROM version of the IMF's International Financial Statistics (IFS), and the respective Ministry of Finance websites. The macroeconomic variables used for MPI calculations were taken from the IFS CD-ROM of the International Monetary Fund (IMF). Unfortunately, the data for Czech Republic were not available before 1993.

In order to avoid a spurious regression situation, unit root tests are performed on the Market Pressure Index (MPI) and the exchange rate to investigate whether these variables are stationary or not. If the variables are stationary, then the standard Granger causality test is appropriate. The augmented Dickey-Fuller (ADF) unit root test is used for this purpose. The results suggest that the variables are stationary (these regressions are not presented here, but are available upon request).

3.2 Descriptive Statistics

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. In addition, the movements of these variables during the sampled period are depicted in Figure 1. The exchange rates are expressed as variations of the foreign currency per US dollar.

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 exchange markets, given that the standard deviations are always more than double their mean value. Nonetheless, Table 1 shows that Chile, Costa Rica, 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. Similarly, for some countries, the maximum MPI is recorded in the first half of the 1990s when the exchange rate depreciation reached its peak (see Figure 1). In contrast, for countries which presented currency crises in the late 1990s, the maximum of MPI and exchange rate depreciation are recorded in the second half of the 1990s.

Table 1: Summary Statistics for Market Pressure Index

Country	Mean	Median	Max.	Min.	St.Dev.	Skew.	Kurtosis	Obs
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 Rep.	-1.084	-1.055	11.492	-7.881	3.163	0.947	6.970	47
Dom. Rep.	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

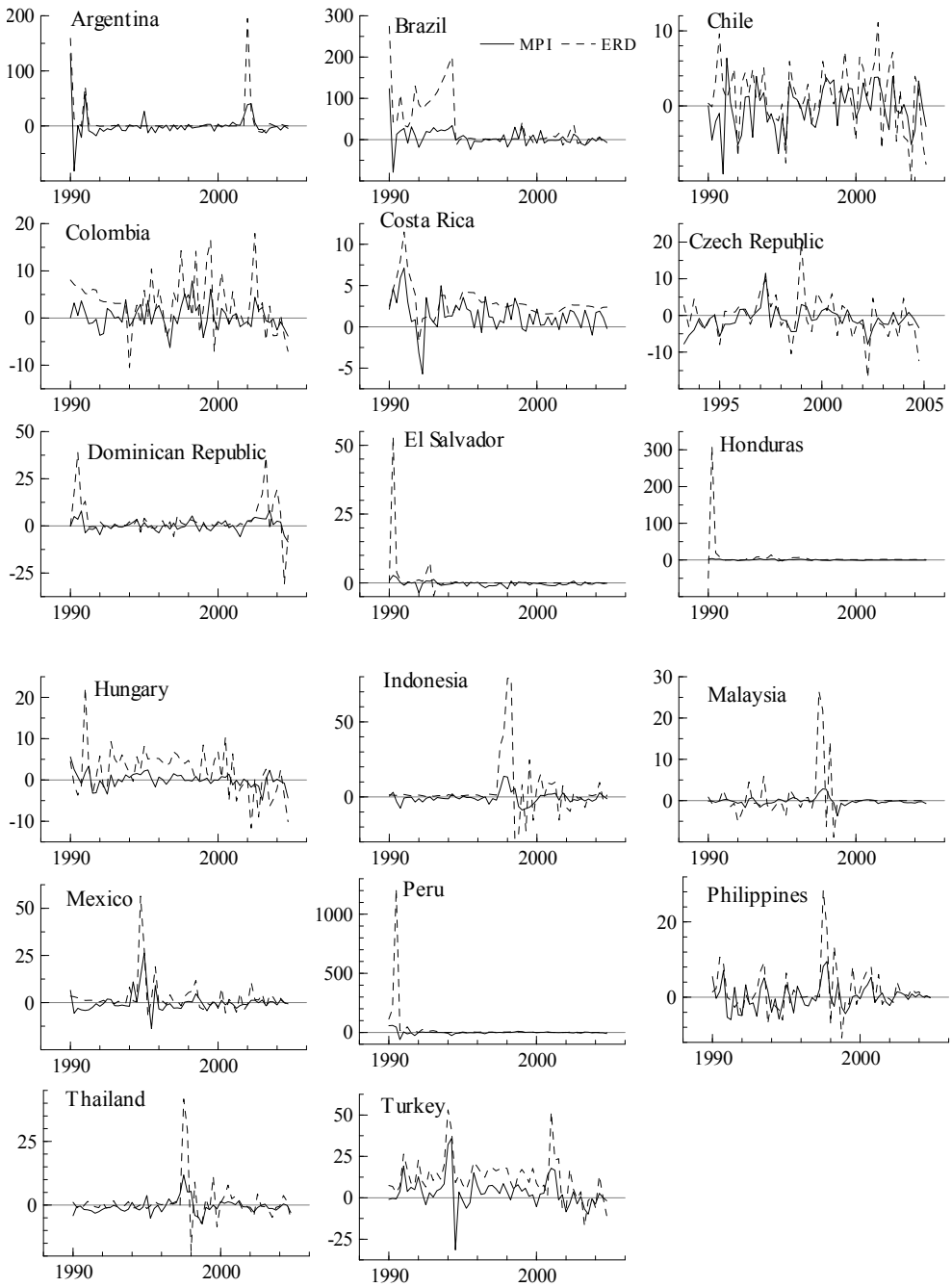
Source: Author's calculations.

Table 2: Summary Statistics for Exchange Rate Depreciation

Country	Mean	Median	Max.	Min.	St.Dev.	Skew.	Kurtosis	Obs
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 Rep.	-0.366	-0.757	20.063	-16.991	5.923	0.277	5.589	47
Dom. Rep.	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	7.583	0.000	195.147	-11.747	33.581	4.664	24.209	60

Source: Author's calculations.

Figure 1: Index of Speculative Pressure and Exchange Rate Depreciation



Source: Author's calculations.

4. Methodology

To evaluate fiscal sustainability, this paper uses the recursive algorithm developed by Croce and Juan-Ramón (2003). In order to derive a simple expression for the index of fiscal sustainability, it is assumed that the debt ratio (debt to GDP) at time $t-1$ is higher than the long-term objective for that ratio $\left(d_{t-1} > d^*\right)$. Hence, d_t would converge to d^*, if and only if $\left|\beta_t - \lambda_t\right| < 1$, where d_t is public debt as a share of GDP (the law of motion in the debt to GDP ratio), d^* is the target debt ratio, $\beta = \dfrac{1+r_t}{1+g_t}$, r_t is the real interest rate and g_t denotes the rate of growth of real output. The parameter λ_t indicates the intensity of the policy response at time t, given the debt ratio gap in the previous period. Therefore, we can use $\left(\beta_t - \lambda_t\right)$ as an indicator of fiscal sustainability. Accordingly, an alternative expression for the Fiscal Sustainability Indicator (FSI) is:

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

where ps_t is the ratio of the primary surplus to GDP. 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 (λ_t), measures the ratio between the deviation of observed and target values of the primary surplus and the public debt ratios. In addition, a fiscal position would be sustainable if $FSI_t < 1$. In contrast, if $FSI_t \geq 1$ then the fiscal position is unsustainable.

To test for the causal relationship between the FSI and the occurrence of currency crises, the standard Granger test is employed. This test is used to evaluate how much of the current currency crisis can be explained by lagged values of the FSI. Thus, the FSI is said to Granger cause the currency crisis if the FSI variable is statistically significant and therefore improves the forecasted value of the currency crisis. The test equations used are given by:

$$Y_t = \alpha + \sum_{i=1}^{k} \phi_i X_{t-i} + \varepsilon_t \tag{2}$$

$$X_t = \gamma + \sum_{i=1}^{k} \delta_i Y_{t-i} + \varepsilon_t \tag{3}$$

where Y is a currency crisis, X is a leading indicator (in this case, the FSI), α and γ are the respective intercepts, and ε_t is a white noise error term. If the inclusion of variable X with lag i in the test equation helps in the prediction of Y, then Y is said to be Granger caused by X_{t-i}. Separately, if $\sum_{i=1}^{k} \delta_i$ in equation (2) is significantly different from zero, then we conclude that currency crises cause the FSI. Granger causality in both directions

is, of course, a possibility. This can be possibly explained by high fiscal costs of defense of fixed exchange rates. The fiscal sustainability indicator is supposed to capture the state of fiscal fundamentals. Then, an unsustainable fiscal position would be expected to help in the prediction of the risk of devaluation or a speculative attack. It is important to note that Granger causality mainly concerns prediction and does not refer to real causality.

5. Empirical Results

To construct the Fiscal Sustainability Indicator (FSI), following Croce and Juan-Ramón (2003), we use d^* equal to the lowest value reached by the debt ratio during the period under study in each country. The value of β^* represents the median of the distribution of the observed values of β for the group of developing countries. Its value was set at 1.026. This implies 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 3 shows the countries with problems of fiscal sustainability during 1990Q1-2004Q4. Countries for which the FSI was above the threshold of 1 at least 75% of the times were classified as having been fiscally unsustainable $(\beta - \lambda > 1)$ during the period considered. Also, Table 3 shows the frequency of β values being higher than β^*, and the frequency of λ assuming a negative value (implying primary deficit). In general, the developing countries in the sample present an unsustainable fiscal stance explained mostly by government fiscal deficits rather than spreads between the real interest rates and the growth rates. Figure 2 presents the result of the FSI for each country considered, arranged alphabetically to facilitate the discussion. As shown in Figure 2, a higher FSI reflects fiscal unsustainability.

According to Table 3, Argentina shows an unsustainable fiscal position in 87% of the period studied, while Brazil shows an unsustainable fiscal stance in about 62%. On the contrary, Chile shows a sustainable fiscal stance in most of the period considered. The FSI for Colombia, Costa Rica and the Czech Republic has consistently maintained an unsustainable fiscal position as a result of a primary fiscal deficit and a higher real interest rate-growth gap, respectively. For El Salvador, Honduras and Hungary the FSI persistently presented an unsustainable fiscal stance, explained fundamentally by the primary government deficit. The Dominican Republic shows an unsustainable fiscal position in 40% of the period studied, while Indonesia shows a sustainable fiscal position in 50% of period. Malaysia shows a consistently sustainable fiscal balance in the period under study. However, the FSI for Mexico, Peru and Philippines presents an unsustainable fiscal position stance during most of the period consided. On contrary, the fiscal sustainability indicator for Thailand indicated sustainability in 38% of the period. Finally, the fiscal sustainability indicator for Turkey shows an unsustainable fiscal position overall in the period studied.

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

Table 3: Analysis of Fiscal Sustainability Indicators

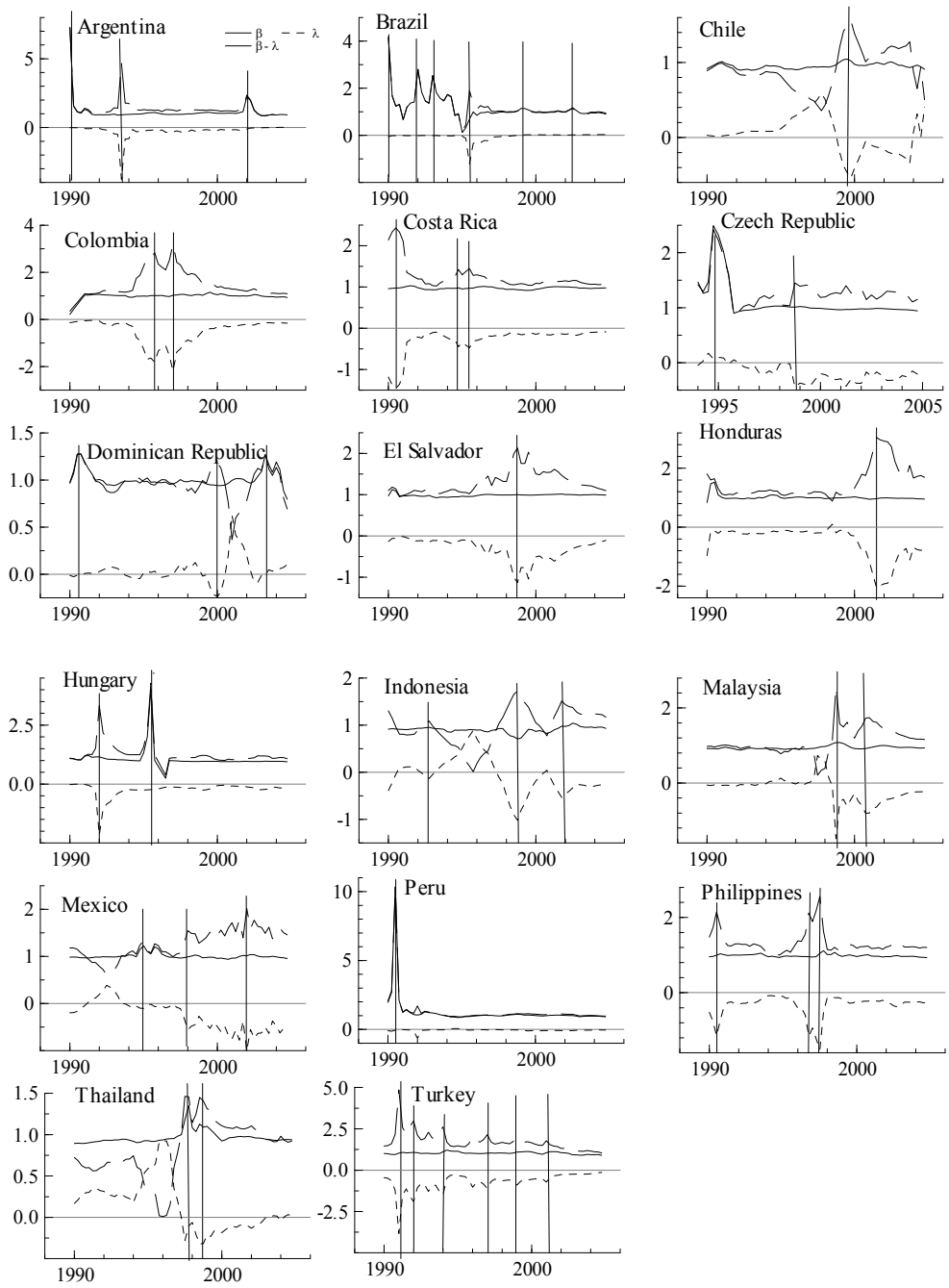
Country	Frequency		
	$\beta - \lambda > 1$	$\beta > \beta^*$	$\lambda < 0$
Argentina	87%	42%	95%
Brazil	62%	42%	60%
Chile	33%	3%	33%
Colombia	93%	37%	100%
Costa Rica	100%	2%	100%
Czech Republic	95%	20%	84%
Dominican Republic	40%	20%	40%
El Salvador	97%	3%	100%
Honduras	98%	13%	100%
Hungary	95%	30%	97%
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%
Developing Countries	76%	21%	80%

Source: Author's calculations.

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

The issue of causality between the Fiscal Sustainability Indicator and currency crises is analysed for each country and for the sample as a whole. To do this, the Granger causality test is used, as well as three different definitions of currency crises. Firstly, we use the Market Pressure Index (MPI) defined earlier. Then, we use the binary definition of currency crises (defined to be one if the deviation of the MPI exceeds 1.5 standard deviations over the country's own mean value). Finally, we use the binary definition of the exchange rate depreciation (equal to one if the nominal depreciation of the domestic currency is greater than 6%, but exceeding the previous year's depreciation level by at least 10%).

Figure 2: Fiscal Sustainability Indicators



Source: Author's calculations.

Note: Straight line indicates crisis.

The results for the Granger causality test are very sensitive to the selection of lag lengths. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag length is greater, the irrelevant lags in the equation cause the estimates to be inefficient. To deal with this problem, we use the Final Prediction Error (FPE) and the Akaike criterion. We estimated ten regressions according to equation (2) and compute the FPE for each regression as:

$$FPE = \frac{\frac{T+m+1}{T-m-1} RSS}{T}$$

where T is sample size, m is the lag length and RSS is the residual sum of squares. We choose the optimal lag length as the lag length which produces the lowest FPE.

The conventional Granger causality tests are reported in Tables 4, 5 and 6. The results for the whole sample considered in this study show that there is not causality between FSI and currency crises (see Table 4). On the contrary, when a definition of currency crises according to nominal exchange rate depreciation (ERD) is used, the Granger causality test results show that the FSI affects ERD; but nominal exchange rate depreciation does not affect the FSI in the whole sample (see Table 5). Similarly, the results demonstrate that there is a one-directional relationship between the FSI and the index of speculative pressure (see Table 6). In other words, the fiscal sustainability index helps predict the probability of currency crisis. In Argentina's case, the null hypothesis that the FSI does not Granger cause currency crises in both definitions is rejected, but not the other way around. Similarly, the results in Table 6 show that there is causality only from the FSI to the MPI. It is important to note that Argentina shows an unsustainable fiscal stance in 87% of the period studied (see Table 3).

The result of the bivariate Granger tests for Brazil show that the FSI affects the MPI and vice versa. However, the results suggest no evidence of causality from the FSI to currency crises. On the contrary, for Chile, the Granger causality test results show that the FSI causes ERD, but not the other way around. In the case of Chile, we cannot reject the null hypothesis that the FSI does not Granger cause currency crises. Similarly, the results for this country show no causality relationship from the FSI to the MPI. This is according with the results showed in Tables 1 and 2. Chile has negative skewness, which implies that more stable periods in the exchange market tend to occur more often than large speculative attacks or depreciations. For Colombia, the results of the Granger causality test show that the FSI only causes currency crises, but not ERD and MPI. Colombia has consistently maintained an unsustainable fiscal position as a result of a primary fiscal deficit and a higher real interest rate-growth gap (Table 3). Meanwhile, for Costa Rica, the FSI causes currency crises, exchange rate depreciation and speculative pressure in the exchange market. On the contrary, in the Czech Republic, the results show there is no relationship between the FSI, currency crises and the MPI. Results for the Dominican Republic show that causality runs from the FSI to crises and from the FSI to the MPI. That is, the FSI helps predict the probability of currency crisis occurrence.

Table 4: Granger Causality Tests between the FSI and Currency Crises

Country	Null Hypothesis	Obs	Lags	F-Statistic	Probability
All Countries	FSI does not Granger cause Crises Crises do not Granger cause FSI	970	2	0.092 0.159	0.912 0.853
Argentina	FSI does not Granger cause Crises Crises do not Granger cause FSI	56	4	2.714 0.496	0.041 0.738
Brazil	FSI does not Granger cause Crises Crises do not Granger cause FSI	-	-	- -	- -
Chile	FSI does not Granger cause Crises Crises do not Granger cause FSI	56	4	0.032 0.019	0.998 0.999
Colombia	FSI does not Granger cause Crises Crises do not Granger cause FSI	56	4	4.119 0.447	0.006 0.774
Costa Rica	FSI does not Granger cause Crises Crises do not Granger cause FSI	58	2	7.267 2.746	0.001 0.073
Czech Republic	FSI does not Granger cause Crises Crises do not Granger cause FSI	42	2	0.488 0.093	0.617 0.911
Dominican Republic	FSI does not Granger cause Crises Crises do not Granger cause FSI	58	2	2.477 1.385	0.094 0.259
El Salvador	FSI does not Granger cause Crises Crises do not Granger cause FSI	58	2	0.369 1.264	0.692 0.290
Honduras	FSI does not Granger cause Crises Crises do not Granger cause FSI	57	3	0.393 0.644	0.758 0.589
Hungary	FSI does not Granger cause Crises Crises do not Granger cause FSI	55	5	1.917 3.364	0.110 0.011
Indonesia	FSI does not Granger cause Crises Crises do not Granger cause FSI	56	4	1.185 2.208	0.329 0.082
Malaysia	FSI does not Granger cause Crises Crises do not Granger cause FSI	56	4	4.611 18.658	0.003 0.000
Mexico	FSI does not Granger cause Crises Crises do not Granger cause FSI	55	5	0.734 0.698	0.602 0.627
Peru	FSI does not Granger cause Crises Crises do not Granger cause FSI	59	1	78.501 996.609	0.000 0.000
Philippines	FSI does not Granger cause Crises Crises do not Granger cause FSI	56	4	7.073 6.114	0.000 0.000
Thailand	FSI does not Granger cause Crises Crises do not Granger cause FSI	56	4	6.567 1.843	0.000 0.136
Turkey	FSI does not Granger cause Crises Crises do not Granger cause FSI	59	1	0.674 6.587	0.415 0.013

Source: Author's calculations.

Table 5: Granger Causality Tests between the FSI and ERD

Country	Null Hypothesis	Obs	Lags	F-Statistic	Probability
All Countries	FSI does not Granger cause ERD	953	3	3.993	0.008
	ERD does not Granger cause FSI			0.487	0.691
Argentina	FSI does not Granger cause ERD	56	4	3.610	0.012
	ERD does not Granger cause FSI			0.365	0.832
Brazil	FSI does not Granger cause ERD	59	1	1.854	0.178
	ERD does not Granger cause FSI			5.172	0.026
Chile	FSI does not Granger cause ERD	56	4	2.521	0.053
	ERD does not Granger cause FSI			0.636	0.639
Colombia	FSI does not Granger cause ERD	57	3	0.148	0.931
	ERD does not Granger cause FSI			0.211	0.888
Costa Rica	FSI does not Granger cause ERD	55	5	24.306	0.000
	ERD does not Granger cause FSI			15.746	0.000
Czech Republic	FSI does not Granger cause ERD	40	4	0.593	0.670
	ERD does not Granger cause FSI			0.508	0.729
Dominican Republic	FSI does not Granger cause ERD	59	1	0.949	0.334
	ERD does not Granger cause FSI			0.350	0.556
El Salvador	FSI does not Granger cause ERD	58	2	0.399	0.672
	ERD does not Granger cause FSI			1.359	0.265
Honduras	FSI does not Granger cause ERD	59	1	0.518	0.474
	ERD does not Granger cause FSI			1.698	0.197
Hungary	FSI does not Granger cause ERD	59	1	0.235	0.629
	ERD does not Granger cause FSI			0.021	0.882
Indonesia	FSI does not Granger cause ERD	58	2	0.191	0.826
	ERD does not Granger cause FSI			2.455	0.095
Malaysia	FSI does not Granger cause ERD	57	3	6.489	0.000
	ERD does not Granger cause FSI			8.428	0.000
Mexico	FSI does not Granger cause ERD	56	4	3.720	0.010
	ERD does not Granger cause FSI			1.586	0.193
Peru	FSI does not Granger cause ERD	56	4	6.311	0.000
	ERD does not Granger cause FSI			19.301	0.000
Philippines	FSI does not Granger cause ERD	58	2	2.650	0.079
	ERD does not Granger cause FSI			5.885	0.004
Thailand	FSI does not Granger cause ERD	56	4	4.865	0.002
	ERD does not Granger cause FSI			1.087	0.373
Turkey	FSI does not Granger cause ERD	58	2	3.492	0.037
	ERD does not Granger cause FSI			1.197	0.309

Source: Author's calculations.

Table 6: Granger Causality Tests between the FSI and MPI

Country	Null Hypothesis	Obs	Lags	F-Statistic	Probability
All Countries	FSI does not Granger cause MPI MPI does not Granger cause FSI	919	5	6.566 0.510	0.000 0.769
Argentina	FSI does not Granger cause MPI MPI does not Granger cause FSI	59	1	6.490 0.067	0.013 0.795
Brazil	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	5.112 2.393	0.001 0.063
Chile	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	0.153 2.561	0.960 0.050
Colombia	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	1.143 2.122	0.348 0.093
Costa Rica	FSI does not Granger cause MPI MPI does not Granger cause FSI	55	5	4.799 2.309	0.001 0.060
Czech Republic	FSI does not Granger cause MPI MPI does not Granger cause FSI	42	2	1.359 0.428	0.269 0.655
Dominican Republic	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	2.867 0.454	0.033 0.769
El Salvador	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	0.092 0.998	0.984 0.418
Honduras	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	0.209 1.066	0.932 0.383
Hungary	FSI does not Granger cause MPI MPI does not Granger cause FSI	59	1	1.911 0.042	0.172 0.838
Indonesia	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	0.689 1.021	0.603 0.405
Malaysia	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	1.949 2.858	0.117 0.033
Mexico	FSI does not Granger cause MPI MPI does not Granger cause FSI	55	5	0.444 0.999	0.815 0.429
Peru	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	4.527 5.834	0.003 0.000
Philippines	FSI does not Granger cause MPI MPI does not Granger cause FSI	57	3	4.666 3.356	0.006 0.026
Thailand	FSI does not Granger cause MPI MPI does not Granger cause FSI	56	4	4.088 1.145	0.006 0.347
Turkey	FSI does not Granger cause MPI MPI does not Granger cause FSI	58	2	2.797 0.394	0.070 0.676

Source: Author's calculations.

For El Salvador, Honduras, Hungary and Indonesia, the results show that there is no causality between the variables considered, except from currency crises to the FSI in Hungary and Indonesia. Results for El Salvador and Hungary are in accordance with results showed in Tables 1 and 2. Those two countries have more stable periods than large speculative attacks or depreciations in their foreign exchange market. On the contrary, the results for Malaysia show that the Granger causality runs both ways between the FSI and currency crises, and between the FSI and the ERD. However, it only shows causality from the MPI to the FSI. While the results for Mexico reveal that the Granger causality runs one-way from the FSI to the ERD. This result indicates that a lagged FSI helps predict the risk of a currency attack.

The results of the Granger tests using four lags for Peru show that there is bi-directional causality between the FSI and the ERD, and between the FSI and the MPI. In addition, when one lag is used, the causality runs in two-ways between the FSI and currency crises. Similarly, the results for the Philippines show a bi-directional relationship between the FSI and currency crises, the FSI and the MPI, and the FSI and ERD. The Granger causality test results for Thailand show that the FSI affects currency crises, the MPI and the ERD. Those results suggest that a lagged FSI helps predict currency crises. While for Turkey, the null hypothesis that the FSI does not Granger cause currency crises cannot be rejected, but the results show that there is Granger causality from the FSI to the MPI and from the FSI to the ERD. The results for this country indicate that an unsustainable fiscal position helps predict the probability of a currency crisis.

On the other hand, it is possible that devaluation or depreciation worsens the debt burden and the fiscal sustainability through an increase in the real value of foreign currency debt. Similarly, an increase in the domestic interest rate (to defend the currency) may also affect the debt burden if it is a variable-rate or a short-term, in which case it has to be rolled-over regularly. Of course, a major concern here is the potential endogeneity of the explanatory variable. Then, the Davidson and MacKinnon (1989) version of Hausman's specification test was performed as a formal test for endogeneity of the FSI. To carry out the Hausman test, we run two simple ordinary least squares (OLS) regressions (these regressions are not presented here, but are available upon request). A set of potential instrumental variables that are correlated with the suspected FSI variable is used, including lagged values of MPI. In the first regression, we regress the potentially endogenous FSI variable on instrumental variables and retrieve the residuals. Then, the residuals were used as an additional explanatory variable in a regression of the MPI on the actual FSI. An F-statistic was used to test the null hypothesis that the estimated coefficients of the residuals are jointly equal to zero. If they are, there is no endogeneity. The results show that most of the models pass the test (see Table 7). The null hypothesis was not rejected at the 1% and 5% levels. In the case of El Salvador, the test rejected the hypothesis of no endogeneity at the 5% level. Also, a cross correlation between the lagged MPI and the error term is carried out. Results show that the lagged MPI and the error term are uncorrelated.

To summarise, the results suggest that the fiscal sustainability indicator helps predict the probability of currency crises. The analysis reveals interesting results, particularly for

those countries with large unsustainable fiscal positions in the period considered. Results for Argentina show that there are deep connections between unsustainable fiscal positions (in 87% of the period studied) and currency crises (those occurring in 1990, 1995, and 2000). Similar results are drawn for Turkey (for the crises occurring in 2000 and 2001) and countries in South-East Asia, among others. Also, we no found endogeneity between variables in most of the countries.

Table 7: Hausman Endogeneity Test

Country	Null Hypothesis	F-Statistic	Probability
Argentina	There is no endogeneity	1.829	0.073
Brazil	There is no endogeneity	-1.097	0.277
Chile	There is no endogeneity	-1.389	0.173
Colombia	There is no endogeneity	0.461	0.647
Costa Rica	There is no endogeneity	-0.645	0.521
Czech Republic	There is no endogeneity	1.270	0.211
Dominican Republic	There is no endogeneity	-1.484	0.143
El Salvador	There is no endogeneity	2.384	0.022
Honduras	There is no endogeneity	1.864	0.068
Hungary	There is no endogeneity	1.984	0.052
Indonesia	There is no endogeneity	-1.204	0.233
Malaysia	There is no endogeneity	-0.129	0.897
Mexico	There is no endogeneity	-0.609	0.544
Peru	There is no endogeneity	1.017	0.313
Philippines	There is no endogeneity	-5.002	0.618
Thailand	There is no endogeneity	-1.645	0.105
Turkey	There is no endogeneity	-0.734	0.466

Source: Author's calculations.

6. Conclusion

This paper addressed the issue of the leading indicators that can anticipate the occurrence of currency crises. None of the previous empirical studies had focused on whether a Fiscal Sustainability Indicator may predict a currency crisis. This work attempted to bridge this gap. Firstly, a Fiscal Sustainability Indicator has been constructed for 17 developing countries and we classified the countries for which the FSI was above the threshold of 1 at least 75% of the time as having been fiscally unsustainable, and then different measures of currency crises were defined. Eleven countries were identified as presenting large unsustainable fiscal positions in most of the period studied, explained basically by a primary fiscal deficit.

A Granger causality test was used in order to analyse the issue of causality between the Fiscal Sustainability Indicator and currency crises. This paper documents that the fiscal sustainability indicator helps predict the probability of currency crises, but in some cases this relationship is dependent on the definition of currency crises employed. Also, the empirical evidence is equally ambiguous. In some of the countries considered, the Granger causality tests suggest evidence of bi-causality between the FSI and currency crises. In others, there is evidence of causality running only from currency crises to the FSI. An explanation could be that changes in exchange rates can cause changes in the sustainability of fiscal policy and an unsustainable fiscal position provokes pressure on the exchange rate markets. However, in most of the countries, we found no evidence of endogeneity between the FSI and the MPI. Interestingly, for El Salvador, the results show that there is no causality between the variables considered. However, there is endogeneity between the FSI and the MPI.

Obviously, the analysis of only fiscal indicators is not enough to fully assess the probability of the occurrence of a currency crisis. Of course, the Granger causality test is at the expense of a more sophisticated econometric model that could potentially assess the quantitative relationship between the FSI and currency crises. 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.

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