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Exchange Arrangements and Currency Crises: What´s the matter with the exchange rate classification?

By Alexis CRUZ-RODRIGUEZ †

Abstract. The purpose of this paper is to empirically investigate whether certain exchange rate arrangements are more prone to currency crises using a probit model. We define a currency crisis as a period characterised by the presence of intense foreign exchange market pressure. The definition is based on a foreign exchange market pressure index (MPI). If the value of the MPI is above a certain threshold, we define that period as a crisis state; otherwise the period is defined as a tranquil state. The definition of currency crises used in this paper focuses on discrete events.
Keywords. Exchange rate regimes, currency crises, speculative attacks.
JEL. F10, F31, F32.

1. Introduction

Since the financial crises of the 1990s in emerging markets, the issue of the suitability of exchange rates regimes has returned to the international finance research agenda. More precisely, the debate over fixed and floating exchange arrangements has once again taken centre stage in academic circles. Some economists maintain that the first round of this debate was won by those advocating floating arrangements because all crisis episodes took place in countries which had adopted a variety of mechanisms for pegging their exchange regimes. Conversely, the advocates of fixed exchange regimes suggest that there are bad fixes and good fixes (like official dollarization) and good or truly fixed arrangements that allow countries to achieve credibility.

An important recent development in the debate over optimal exchange rate regimes is the recognition that the choice of an exchange rate arrangement is different between particular groups of countries. The choice of an exchange rate regime for developed countries is different from the one of developing countries or emerging economy countries. Developing countries are often beset by a lack of credibility and limited access to international capital markets. Hence, fixed exchange rate regimes play a useful role by providing policymakers with a nominal anchor for monetary policy and by helping to establish a degree of policy credibility. In contrast, emerging market economies are more integrated with global financial markets but they have encountered more currency crises under pegged exchange rate arrangements (Husain et al., 2005). Developed countries have

† Department of Economics, Pontificia Universidad Católica Madre y Maestra, Av. Abraham Lincoln Esq. Rómulo Betancourt, Ensanche La Julia, Santo Domingo, Dominican Republic.
. 1-809-879-0096
. alexiscruz@pucmm.edu.do

obtained more benefits from flexible exchange regimes because they are more developed economically and institutionally, and more integrated in global financial markets (Rogoff et al., 2003).

Contrary to a large number of theoretical studies in the literature, relatively few studies attempt to empirically investigate the impact of an exchange rate regime on currency crises in developed, emerging and developing countries, separately. This is perhaps, because such an empirical investigation is fraught with difficulties, including the problem concerning the classification of exchange arrangement. This article addresses the issue of measurement errors in the classification of exchange rate regimes by using four different classification schemes. Three *de facto* and one *de jure* classifications are used. Consequently, the sensitivity of these results to alternative exchange rate classifications is also tested. The principal conclusion emerging from this study is the following: emerging and developing countries adopting fixed exchange rate arrangements have a lower probability of currency crises.

The remainder of this article is organised in the following way: Section 2 shows a brief review on exchange arrangement classifications. Section 3 presents a brief literature review focusing on the link between exchange rate regimes and currency crises. Section 4 discusses the issues of exchange market pressure indicators and currency crises. Section 5 describes the empirical framework. A preliminary analysis of the data is presented in Section 6. Section 7 reports empirical findings. Section 8 concludes the findings of this article.

2. Regime Classification

A common problem in the empirical analysis of exchange rate systems is regime classification. The literature identifies two approaches to this problem: the *de jure* classification and the *de facto* classification. The former classifies countries by what they say they do (*de jure*). However, countries often act differently to what they declare they do. In particular, a self-declared independent floating regime, in reality, often operates a managed peg regime. This phenomenon of operating a disguised peg is referred to as "fear of floating" (Calvo & Reinhart, 2002). Classifying countries by what they actually do is a *de facto* classification. Some authors develop *de facto* classifications using various methods (Ghosh et al., 1997; Bailliu et al., 2001; Moreno, 2001; Poirson, 2002; Bubula & Otker-Rober, 2002; Reinhart & Rogoff, 2004; Shambaugh, 2004; Dubas et al., 2005; Levy-Yeyati & Sturzenergger, 2005; Bérnassy-Quéré et al., 2006; Frankel & Wei, 2008; Klein & Shambaugh, 2008; Ilzetski et al., 2010), but these are fundamentally based on data that presents the behaviour of nominal exchange rates, international reserves and interest rates[1].

Some empirical studies simply employ the de facto classification because the *de jure* classification may reach incorrect results[2], particularly about floating regimes. On the other hand, some research employs the *de jure* classification arguing that it suffers from less drawbacks than the *de facto* classification[3].

Table 1. *Classification of Exchange Rate Regime*

Fixed	Intermediate	Floating
De facto Classification by Levy-Yeyati and Sturzenerger		
(1) Fixed	(2) Crawling peg (3) Dirty floats	(4) Float
De facto Classification by Reinhart and Rogoff		
(1) No separate legal tender (2) Pre-announced peg or currency board arrangement (3) Pre-announced horizontal band that is narrower than or equal to ± 2% (4) *De facto* peg	(5) Pre-announced crawling peg (6) Pre-announced crawling band that is narrower than or equal to ± 2% (7) *De facto* crawling peg (8) *De facto* crawling band that is narrower than or equal to ± 2% (9) Pre-announced crawling band that is wide than or equal ± 2% (10) *De facto* crawling band that is narrower than or equal to ± 5% (11) Moving band that is narrower than or equal to ± 2%	(12) Managed floating (13) Freely floating (14) Freely falling (15) Hyperfloating
De facto Classification by Bailliu, Lafrance and Perrault		
(1) Currency boards (2) Single currency peg (3) Basket pegs (4) Crawling pegs with narrow bands	(5) Flexibility index ≤ 1	(6) Flexibility index ≥ 1
De jure Classification by Ghosh, Gulde and Wolf		
(1) Pegged regimes	(2) Intermediate regimes	(4) Floating regimes

Note: Inconclusive classifications from Levy-Yeyati and Sturzenergger are not considered in our analysis.
Sources: Bailliu et al. (2001); Bailliu et al. (2003); Ghosh et al. (2002); Reinhart & Rogoff (2004); and Levy-Yeyati & Sturzenergger (2005).

In this article we employ a combination of three *de facto* and one *de jure* classifications. Firstly, we use the *de facto* classification developed by Levy-Yeyati & Sturzenergger (2005), henceforth known as the "LYS classification". These authors apply a cluster analysis to a data set with three variables: changes in the nominal exchange rate, the volatility of these changes, and the volatility of international reserves from all IMF reporting countries in the period 1974-2000. Secondly, the "natural classification" developed by Reinhart & Rogoff (2004) is employed. Reinhart & Rogoff (2004) reclassified exchange rate regimes based on market determined dual and parallel exchange rates, and use official rates only if the exchange rates are unified[4]. These authors examine the chronologies of the exchange rate history for 153 countries in the period 1946-2001. They are able to distinguish among floating by high inflation countries (freely falling) from floating by others. They define the category of "freely falling" rates when the 12-month rate of inflation exceeds 40% and when, during these periods of high inflation there is no official announcement of the regime by the authorities[5]. In addition, they define hyperfloats as those episodes of macroeconomic instability that are characterised by hyperinflation where the monthly inflation rate is 50% or more. Thirdly, an alternative classification scheme developed by Bailliu et al. (2001) is used. These authors develop a Hybrid Mechanical Rule (HMR) classification. This system classifies exchange rate regimes in terms of their observed flexibility and takes into account external shocks and revaluations. Their analysis is based on a sample of 60 countries for the period 1973-1998. Finally, the *de jure* classification from the IMF is used[6].

In our analysis all the different classifications are grouped into three broader regimes: fixed, intermediate and floating exchange rate regimes (see Table 1). Managed floating is classified under the floating category, with respect to the term managed, in the context of the Reinhart-Rogoff classification, does not necessarily imply active or frequent foreign exchange market intervention.

3. Exchange Rate Regimes and Currency Crises: A Survey of the Literature

Earlier contributions to the theoretical literature on currency crises pointed almost exclusively to deteriorating economic fundamentals as the trigger for currency crises. However, few studies have made an attempt to investigate empirically whether a particular exchange rate regime is more prone to a currency crisis. Some empirical research suggests that currency crises are more likely to occur under fixed or intermediate exchange regimes. However, a study developed by the IMF (1997), based on the IMF's *de jure* classifications, finds that close to half of the currency crashes (sharp changes in the exchange rate) occur under floating regimes, implying that crises can arise under both pegged and floating regimes[7]. Similarly, Ghosh et al. (2002) find that *de jure* pegged regimes have the lowest probability of a currency crisis[8]. Likewise, Falcetti & Tudela (2006) show that currency crises in developing and emerging markets are less frequent under *de jure* fixed exchange rates than under *de jure* flexible regimes in the period 1970-1997. On the other hand, Rogoff et al. (2003) find that currency crises tend to occur more frequently in *de facto* intermediate regimes especially in emerging markets. Similar conclusions are drawn by Peltonen (2006) who finds, using the *de facto* classification from Reinhart & Rogoff (2004), that emerging markets with more rigid exchange rate regimes were less prone to currency crises during the last two decades. Empirical case studies conducted by Jakubiak (2001) demonstrate that a floating exchange rate regime does not guarantee an emerging country avoiding a currency crisis. Haile & Pozo (2006), using the IMF's *de jure* and the LYS *de facto* classifications analyse the incidence of currency crises in emerging markets according to the exchange regime in place between 1974 and 1998. Their results suggest that the *de facto* exchange regime plays no role in determining currency crisis period. As a consequence, fixed exchange regimes that are not truly fixed appear to invite speculation against the currency, increasing the likelihood of currency crisis.

In the same way, Bubula & Otker-Rober (2003), using their own *de facto* classification[9], find that pegged regimes, as a whole, are more prone to currency crises compared with floating regimes, particularly for developed and emerging market economies that are integrated with international capital markets, in the period 1990-2001[10]. On the contrary, Coulibaly (2009), using panel data of 192 countries from 1970 through 1999, and 195 currency crisis episodes, examines the effect of membership in a currency union on the probability of experiencing a currency crisis. Both parametric and non-parametric estimates suggest that membership in a currency union reduces the likelihood of a currency crash. Angkinand et al. (2009), using a logit model and a panel of 90 countries observed annually from 1990 to 2001, show that results from using Reinhart & Rogoff (2004) regime are that middle regimes such as adjustable parities, crawls, and moving bands are relatively prone to crises, while managed floats have the lowest probability of crises among intermediate regimes. However, when authors turn to LYS classification, they do not find any significant result in explaining the correlation between exchange rate regimes and currency crises.

Esaka (2010a) examines the link between *de facto* exchange rate regimes and the incidence of currency crises in 84 countries from 1980 to 2001 using probit models. The author employs the *de facto* classification of Reinhart & Rogoff (2004) and finds no evidence that intermediate regimes have a significantly higher probability of currency crises than both hard pegs and free floats. Similarly, Esaka (2010b) examines whether *de facto* exchange rate regimes affect the occurrence of currency crises in 84 countries over the 1980–2001 period by using the probit model and the *de facto* classification of Reinhart & Rogoff (2004). His results show that pegged regimes significantly decrease the likelihood of currency crises compared with floating regimes. On the other hand, Asici (2011) applied a multinomial logit framework to 163 developed and developing countries over the period from 1990 to 2007. His regression results suggest that countries experiencing currency crisis are those that have chosen regimes inconsistent with their individual features.

Karimi & Voia (2014) analyze the effect of exchange rate regimes and capital account liberalization policies on the occurrence of currency crises for 21 countries over the period of1970-1998. The authors examine changes of the likelihood of currency crises under *de jure* IMF classification and two*de facto* exchange rate regimes (Reinhart & Rogoff and LYS). Their results show that the likelihood of currency crises changes significantly under *de facto* regimes. While Reinhart and Rogoff based models show that fixed exchange rate arrangements are least susceptible to speculative attacks, LYS based models point to the intermediate exchange rate regimes as the least crisis prone. However, Esaka (2014), using data on currency crises and exchange rate regimes from 84 countries for the period of 1980–1998 and the *de jure* IMFclassification to identify official announced exchange rate regimes and the*de facto* Reinhart & Rogoff (2004) classification, evaluates the treatment effect of consistent pegs on the occurrence of currency crises to examine whether consistent pegs are indeed more prone to currency crises than other regimes. Using matching estimators as a control for the self-selection problem of regime adoption, the author finds that countries with consistent pegs have a significantly lower probability of currency crises than countries with other exchange rate policies. On the other hand, Ghosh et al. (2015) using the IMF *de facto* classification[11]and a sample of 50 emerging economies over the 1980-2011 period, show that macroeconomic and financial vulnerabilities are significantly greater under less flexible intermediate regimes, including hard pegs, as compared to floats. Conversely, Combes et al. (2016) revisit the link between crises and exchange rate regimes. Using a panel of 90 developed and developing countries over the period 1980-2009, and two *de facto* classifications (the IMF *de facto* classification and the Ilzetski et al., 2010, classification). Their results reject that intermediate regimes are more vulnerable to crises compared to the hard peg and the fully floating regimes.

4. The Exchange Market Pressure Indicator and Currency Crisis Periods

In any empirical analysis of currency crises, the first issue is to define the nature of a crisis. A currency crisis can be understood as a sudden decline in the confidence to an individual currency usually leading to a speculative attack against it. Since, in a currency crisis situation, a speculative attack may lead to sharp currency depreciation, an increase of interest rates and/or a substantial reserve loss, the most straightforward approach is to employ an index of speculative pressure[12]. This technique is common in the empirical literature on currency crises. The exchange market pressure indicator was originally developed by Girton & Roper

(1977) to describe the composite behaviour of nominal exchange rates and international reserves, and later modified by Eichengreen et al. (1996). In the interest of measuring currency crises Eichengreen et al. (1996) add a third term: changes in the nominal interest rate. The idea behind this is that an excess demand for foreign exchange can be met through several channels. Depreciation or devaluation occurs if the speculative attack is successful, but monetary authorities may instead accommodate the pressure by running down their international reserves or deter the attack by raising interest rates. This methodology, which identifies currency crises using an exchange market pressure indicator, has been followed, in principle, by Sachs et al. (1996); Kaminsky et al. (1998); Tudela (2004); Peltonen (2006); Haile & Pozo (2006); Falcetti & Tudela (2006), among others.

In this article, the exchange Market Pressure Indicator (MPI) is calculated as the weighted average of percentage changes in the exchange rate (*e*), percentage changes in the interest rate (*i*), and percentage changes in international reserves (*r*)[13], using the United States as the country of reference[14]. The exchange market pressure index is defined as follows:

$$MPI = w_1 \Delta e + w_2 \Delta i - w_3 \Delta r \tag{1}$$

where *e* represents the price of US$1 in domestic currency, *i* the interest rate, and *r* international reserves. Since the volatilities of foreign reserves, exchange rates and interest rates are very different, the weights w_1, w_2 and w_3, attached to each component are used to equalise the volatilities of each of the three MPI components, thereby preventing any one of them from dominating the index, and are defined as the inverse of the standard deviation of each of the individual series. Formally:

$$w_j = \frac{\frac{1}{StDev_j}}{\frac{1}{StDev_e} + \frac{1}{StDev_i} + \frac{1}{StDev_r}} \tag{2}$$

where *j* stands for any of the three variables and *StDev* stands for the standard deviation. According to equation (1), if a country has a fixed exchange rate regime, a speculative attack may lead to sharp currency devaluation, an increase of interest rates and/or a substantial foreign reserve loss. On the other hand, if a country has a flexible exchange rate regime, a speculative attack may lead to sharp currency depreciation, and then to an increase of interest rates and/or a substantial international reserve loss, but only if monetary authorities want to deter the attack.

A crisis period is defined to occur when the value of the MPI exceeds an arbitrary threshold[15]. Following Eichengreen et al. (1996) we define crisis periods as MPI values that are greater than 1.5 standard deviations over the mean of the series. Formally:

$$Crisis = \begin{cases} 1 \;\; if \; MPI > \mu_{MPI} + 1.5\sigma_{MPI} \\ 0 \qquad\qquad otherwise \end{cases} \tag{3}$$

where μ_{MPI} and σ_{MPI} denote the mean and the standard deviation of the sample of the MPI. Hence, a crisis takes place for an individual country when its MPI

variable takes an "extreme" positive value[16]. The total number of crises identified is 227 (43 in advanced, 52 in emerging and 132 in developing countries) and about 88% of the countries experienced at least one currency crisis over the sample period[17]. The MPI is a continuous variable, while our currency crisis definition is a discrete binary variable. Also, the last definition is sensitive to the threshold used.

5. Empirical Methodology

The analysis of the relation between exchange arrangements and currency crises will be based on the discrete choice model method (probit model). Given our indicators, the model estimates the probability of a currency crisis. The estimated model takes the form:

$$Prob.(y_{it} = 1|x_{it}, \beta_t) = F(x_{it}, \beta_t) \quad (4)$$

where x_t corresponds to our set of indicators and β_t is a vector of unknown parameters. The observed variable y_{it} assumes a value of 0 or 1 depending on whether a currency crisis has occurred or not. With a probit model, the right hand side of the model is constrained between 0 and 1, and is compared to the observed value y_{it}. The probit model assumes that the probability distribution function (y_{it} conditional on x_{it}) corresponds to normal distribution. The model with a success probability $F(x_{it}, \beta_t)$ and independent observations leads to the joint probability.

6. The Data

The sample consists of panel data for 125 countries classified by the World Bank according to their income. Advanced or developed countries are those economies classified as upper income countries. Emerging markets countries are defined according to the Morgan Stanley Capital International (MSCI) index[18] at that moment. The rest of the countries are designated as developing. Table 2 provides a list of countries classified in each group.

The data set is annual, spanning from 1974 through to 1999. Data availability differs across countries. Particularly, the data for East-European countries which starts from the 1990s.

Table 2. *List of Countries*

Advanced Countries	Emerging Markets	Developing Countries		
Australia	Argentina	Algeria	Haiti	Niger
Austria	Brazil	Antigua & Barbuda	Honduras	Nigeria
Belgium	Chile	Benin	Ivory Coast	Panama
Canada	China	Bolivia	Jamaica	Paraguay
Cyprus	Colombia	Botswana	Kazahstan	Romania
Denmark	Czech Republic	Burkina Faso	Kenya	Saudi Arabia
Finland	Egypt	Burundi	Kyrgyz Rep.	Senegal
France	Hungary	Cameron	Lao Dem. Rep.	Slovak Rep.
Germany	India	Chad	Latvia	Sri Lanka
Greece	Indonesia	Congo, Rep. of	Lebanon	St. Lucia
Iceland	Israel	Costa Rica	Lesotho	St. Kitt & Nevis
Ireland	Jordan	Croatia	Liberia	St. Vicent & Grenadines
Italy	Korea, Rep.	Dominica	Libya	Suriname
Japan	Malaysia	Dominican Rep.	Lithuania	Swaziland
Kuwait	Mexico	Ecuador	Macedonia	Tanzania
Luxembourg	Morocco	El Salvador	Madagascar	Togo
Netherlands	Pakistan	Equatorial Guinea	Malawi	Tunisia
Norway	Peru	Estonia	Mali	Uganda
Portugal	Philippines	Gabon	Malta	Ukraine
Singapore	Poland	Gambia, the	Mauritius	Uruguay
Slovenia	Rusia	Georgia	Moldova	Zambia
Spain	South Africa	Ghana	Mongolia	Zimbabwe
Sweden	Thailand	Grenada	Myanmar	

Switzerland	Turkey	Guatemala	Nepal
United Kingdom	Venezuela	Guinea-Bissau	New Zealand
United States		Guyana	Nicaragua

Note: Emerging market economies are those that are included in the Morgan Stanley Capital International (MSCI) index. Advanced economies are those that are classified as upper income economies by the World Bank, with the exception of Israel, which is in an emerging market. The remaining countries were designated as developing countries.

Most of the macroeconomic and financial variables used in our analysis are taken from the World Bank's World Development Indicators and the IMF's World Economic Outlook databases. A few series are taken from the CD-ROM version of the International Monetary Fund's International Financial Statistic (IFS). The data from the *de jure* IMF classification can be obtained from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions and Ghosh et al. (2002). For the Market Pressure Index (MPI) calculations, we employ total non-gold international reserves, average period exchange rates and short-term interest rates. Money market rates were used for all the countries where available, and t-bill rates, bank lending or deposit rates otherwise; in a number of cases, discount rates were used, when no other interest rate data were available (see Table 3).

Table 3. *Interest Rate Used for the Corresponding Countries*

Money Market	T-bill	Bank Lending	Bank Deposit	Discount
Argentina	Belgium	Antigua & Barbuda	Algeria	Benin
Australia	France	Dominica	Bolivia	Botswana
Austria	Guyana	El Salvador	Chile	Burkina Faso
Brazil	Jamaica	Er. Guinea	Dominican Rep.	Burundi
Canada	Kazakhstan	Estonia	Greece	Cameroon
Croatia	Kenya	Gabom	Guatemala	Chad
Czech Rep.	Kyrgyz Rep.	Grenada	Guinea-Bissau	China
Denmark	Lesotho	Honduras	Haiti	Colombia
Finland	Moldova	Israel	Hungary	Congo, Rep. of
Georgia	Romania	Liberia	Iceland	Costa Rica
Germany	St. Kitts & Nevis	Macedonia	Indonesia	Cyprus
Ireland		Nigeria	Korea	Ecuador
Italy		Panama	Lao Dem. Rep.	Egypt
Japan		Poland	Libya	Gambia, The
Latvia		Slovak Rep.	Lithuania	Ghana
Luxembourg		Slovenia	Madagascar	India
Malaysia		St. Lucia	Mexico	Ivory coast
Mauritius		St. Vincent & Grenadines	Mongolia	Jordan
Netherlands		Suriname	Morocco	Kuwait
Norway		Swaziland	Myanmar	Lebanon
Pakistan		Ukraine	Nicaragua	Malawi
Paraguay		Uruguay	Saudi Arabia	Mali
Philippines		Zambia	Turkey	Malta
Russia			Uganda	Nepal
Singapore				New Zealand
South Africa				Niger
Spain				Peru
Sri Lanka				Portugal
Sweden				Senegal
Switzerland				Tanzania
Thailand				Togo
Tunisia				Venezuela
United Kingdom				
United States				
Zimbabwe				

Notes: Money Market is the rate on short-term lending between financial institutions. Treasury bill rate is the rate at which short-term securities are issued or traded in the market. Lending rate is the bank rate that usually meets the short- and medium-term financing needs of the private sector. This rate is normally differentiated according to the creditworthiness of borrowers and objectives of financing. Deposit rate usually refers to rates offered to resident customers for demand, time or saving deposits. Discount rate is the rate at which the central banks lend or discount eligible paper for deposit money banks, typically shown on an end-of-period basis.

The variables used in this analysis and their descriptions are listed in Table 4. These variables were selected on the basis of previous theoretical and empirical literature. Government balance is defined as current and capital revenue and official grants received, less total expenditure and lending minus repayments. This variable considers central governments only. Short-term debt is defined as debt that has an original maturity of one year or less. Available data does not permit a distinction between public and private non-guaranteed short-term debt. The ratio of bank liquid reserves to bank assets is the ratio of domestic currency holding and deposits with the monetary authorities to claims on other governments, nonfinancial public enterprises, the private sector, and other banking institutions. Money and quasi money are defined as the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government. This definition of money supply is frequently called M2. Foreign direct investment is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. Current account balance is the sum of the credits less the debits arising from international transactions in goods, service, income, and current transfers. Unemployment refers to the share of the labour force that is without work but available for and seeking employment. International reserves are the sum of a country's monetary authorities' holdings of special drawing rights, its reserve position in the IMF, its holdings of foreign exchange, and its holdings of gold. Variables expressed in US dollar were converted to the natural logarithmic scale. The rest of variables were expressed in percentage. Finally, floating and intermediate exchange rate regimes are identified with a dummy variable that received the value of one in which these regimes prevail in a country in a particular year.

Table 4. *List of variables used in the estimations*

Variable	Description
Gov. Balance	Central government balance (% of GDP)
Stdebratio	Short-term debt/Total debt (%)
Debt	Total debt/GNI (%)
Domfin	Domestic financing, total (% of GDP)
Debtsx	Debt service/Exports of goods and services (%)
Bnkres	Ratio of bank liquid reserves to bank assets (%)
Dcrep	Domestic credit to private sector (% GDP)
M2gdp	Money and quasi money (% GDP)
M2res	Money and quasi money (% Reserves)
Resdebt	Reserves/Total debt (%)
Resimp	Reserves/Imports of goods and services (%)
Fdigni	Foreign direct investment (% of GNI)
Cagni	Current account balance (% GDP)
Inflation	The consumer price index (%)
Unempl	Unemployment, total (% of total labour force)
Usirate	USA short-term interest rate (%)
Reserves	International reserves (US$)
Per capita GDP	Per capita real GDP growth (%)
Real GDP	Real GDP growth (%)
Openness	Exports plus imports of goods and services (% GDP)
Floating	Dummy variable capturing float exchange rate regimes
Intermediate	Dummy variable capturing intermediate arrangements

Notes: The table does not include the dependent variables, which are explained in the text. Variables expressed in US dollars were converted to the natural logarithmic scale for the purpose of estimation.

7. Estimation Results

In order to examine which exchange arrangements are more prone to a currency crisis we use a probit model where the dependent variable is the probability of a currency crisis and the independent variables are all the above-mentioned variables

simultaneously (not reported), but insignificant variables were gradually eliminated, until the most parsimonious representation of the data was achieved[19].

The impact of exchange regimes on the probability of currency crises is shown in Tables 5 and 6. The signs of independent variables are mostly as expected. Also, the statistical characteristics of the models are favourable. Most variables are significant to the level of 10%. The LR statistic shows the general statistical significance of the models (zero hypothesis of no significance of all the coefficients in the models was rejected with a significance of 1%)[20]. However, McFadden R^2 indicates relatively low goodness-of-fit in the models (between 5% and 28%).

Table 5. *The Impact of Exchange Arrangements on Currency Crises in All Countries and Advanced Economies*

	All Countries				Advanced Economies			
	Natural	LYS	HMR	*De jure*	Natural	LYS	HMR	*De jure*
Constant	-1.26	-1.69	-1.08	-1.20	-1.58	-1.15	-0.86	-1.33
	(-6.80)*	(-8.31)*	(-4.99)*	(-7.08)*	(-4.94)*	(-3.23)*	(-2.46)**	(-4.59)*
Per cap. GDP	-0.01	-0.02	-0.04	-0.02	-0.05	-0.09	-0.10	-0.06
	(-1.00)	(-1.28)	(-2.85)*	(-1.84)^	(-2.31)#	(-2.02)#	(-2.46)#	(-2.41)#
Gov. balance	-0.03	-0.04	-0.04	-0.03				
	(-2.61)*	(-3.01)*	(-2.23)#	(-3.04)*				
Dcrep	0.01	0.002	0.01	0.01	0.01	0.004	0.01	0.004
	(2.32)#	(0.60)	(2.92)*	(2.05)#	(1.75)^	(1.15)	(1.47)	(1.42)
Resimp	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.04	-0.02
	(-4.84)*	(-4.11)*	(-2.92)*	(-4.97)*	(-3.29)*	(-2.83)*	(-3.41)*	(-3.08)*
Resdebt	0.004	0.001	-0.003	0.004				
	(2.357)#	(0.31)	(-0.44)	(2.16)#				
Inflation	0.0001	0.0001	0.0003	0.0002	0.02	0.01	0.02	0.02
	(2.12)#	(1.45)	(1.64)	(2.58)*	(1.55)	(1.28)	(1.66)^	(1.91)^
Openness	-0.004	-0.000	-0.004	-0.004				
	(-2.34)#	(-0.18)	(-1.68)^	(-2.28)#				
Floating	0.53	0.74	-0.03	0.39	0.19	0.16	-0.09	0.10
	(3.81)*	(4.56)*	(-0.09)	(2.63)*	(0.65)	(0.68)	(-0.38)	(0.45)
Intermediate	0.09	1.01	0.18	0.37	0.34	-0.43	-0.45	-0.06
	(0.65)	(6.32)*	(1.07)	(2.83)*	(1.39)	(-1.33)	(-1.88)^	(-0.26)
Observations	1370	1168	706	1345	581	418	472	581
Obs.= 0	1260	1079	644	1236	540	388	436	540
Obs.= 1	110	89	62	109	41	30	36	41
LR Stat.	85.558	95.553	58.586	79.946	25.644	23.243	31.088	23.987
Prob. LR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
McFaddenR^2	0.11	0.15	0.14	0.11	0.07	0.11	012	008

Notes: The dependent variable is currency crises. z -statistics are displayed in brackets. (*) denote significance at the 1 per cent level, (#) at the 5 per cent and (^) at the 10 per cent level.
Source: Author's estimates.

Table 6. *The Impact of Exchange Arrangements on Currency Crises in Emerging and Developing Countries*

	Emerging Economies				Developing Countries			
	Natural	LYS	HMR	*De jure*	Natural	LYS	HMR	*De jure*
Constant	-0.44	-1.73	-0.35	-0.32	-1.52	-1.52	-1.52	-1.46
	(-0.89)	(-2.47)#	(-0.59)	(-0.66)	(-10.95)*	(-9.76)*	(-6.16)*	(-11.09)*
Per cap. GDP	0.087	-0.10	-0.10	-0.06				
	(-3.59)*	(-3.32)*	(-2.61)*	(-2.56)*				
Gov. balance	-0.09	0.02	0.10	0.06	-0.03	-0.03	-0.07	-0.03
	(-3.59)*	(0.38)	(1.06)	(1.14)	(-3.42)*	(-2.53)#	(-3.99)*	(-3.58)*
Dcrep	0.01	0.004	0.01	0.01				
	(2.36)#	(0.91)	(1.57)	(1.42)				
Domfin	0.05	0.06	0.10	0.04				
	(0.71)	(0.84)	(0.99)	(0.54)				
Resimp	-0.06	-0.04	-0.03	-0.05	-0.01	-0.02	-0.01	-0.01
	(-4.31)*	(-3.07)*	(-2.40)#	(-4.25)*	(-2.47)#	(-2.97)*	(-0.64)	(-2.61)*
Resdebt	0.01	0.01	0.003	0.01	-0.001	-0.004	-0.02	-0.0004
	(1.27)	(0.74)	(0.21)	(1.41)	(-0.23)	(-0.89)	(-1.45)	(-0.17)
Debt	0.01	-0.03	-0.04	0.02				
	(0.29)	(-0.65)	(-0.73)	(0.62)				
Debtsx					0.001	0.0002	0.004	0.003

					(0.37)	(0.04)	(0.49)	(0.89)
Inflation	4.70e^{05}	-0.001	0.004	8.83e^{06}				
	(0.22)	(-0.78)	(1.04)	(0.04)				
Openness	-0.002	0.01	-0.0002	-0.002				
	(-0.54)	(0.89)	(-0.03)	(-0.50)*				
Floating	-0.19	1.05	-9.99	0.26	0.35	0.55	0.89	0.22
	(-0.52)	(2.10)#	(-0.88)	(0.71)	(2.62)*	(3.09)*	(1.29)	(1.39)
Intermediate	0.41	1.27	-0.34	-0.18	0.13	0.90	0.49	0.17
	(1.59)	(2.41)#	(-1.01)	(-0.59)	(0.88)	(5.79)*	(2.39)#	(1.15)
Observations	377	318	261	388	1210	1021	437	1191
Obs.= 0	345	294	241	355	1114	943	396	1095
Obs.= 1	32	24	20	33	96	78	41	96
LR Stat.	58.506	49.226	39.708	54.244	37.567	61.257	28.836	34.472
Prob. LR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
McFaddenR^2	0.27	0.24	0.28	0.24	0.06	0.11	0.11	0.05

Notes: The dependent variable is currency crises. z -statistics are displayed in brackets. (*) denote significance at the 1 per cent level, (#) at the 5 per cent and (^) at the 10 per cent level.
Source: Author's estimates.

In order to evaluate the goodness-of-fit in the models, we carry out two goodness-of-fit tests: the power of the models in predicting a currency crisis in the sample and the Hosmer-Lemeshow test. The standard method of a probit model to evaluate its predictive power is to compare the estimated probabilities of a crisis with actual occurrences. For this purpose, a probability threshold was set to serve as a criterion for the decision whether a model signals a crisis or not. In case the probability of a crisis exceeds the threshold or cut-off level, the model is considered to send a signal and vice versa. Using a cut-off level for the probability of a crisis as 50%, the models issue hardly any wrong signals, but they missed most of the crises in the sample[21]. As shown in Table 7, the probability threshold, as the value separating the crisis period from the tranquil period, was set at 15%.

Table 7. *Goodness-of-Fit of the Probit Models*

		All countries		Advanced		Emerging		Developing	
Classification	Predicts	Tranquil	Crises	Tranquil	Crises	Tranquil	Crises	Tranquil	Crises
Natural	Tranquil	1129	70	511	29	307	12	1029	79
	Crises	131	40	29	12	48	21	85	17
LYS	Tranquil	938	49	350	22	253	7	837	48
	Crises	141	40	38	8	41	17	106	30
HMR	Tranquil	567	37	385	22	213	10	343	27
	Crises	77	25	51	14	10	10	53	14
De Jure	Tranquil	1129	76	522	32	293	12	1028	81
	Crises	107	33	18	9	52	20	67	15

Source: Author's calculations.

Lowering the cut-off level to 15% leads to a strong improvement in the models' ability to predict currency crises in the sample, while the number of wrong signals rises only moderately. Also, the majority of correct predictions are for tranquil periods[22]. Given the cut-off probability of 15% the models correctly call between 15.5% and 70.8% of the crises and between 84% and 96.7% of the tranquil periods. Also, the count R^2 indicates a relatively good goodness-of-fit in the models (see Table 8)[23].

Table 8. *Measure of Goodness-of-Fit: The Count R^2*

Classification	All Countries	Advanced	Emerging	Developing
Natural	$R^2 = 0.85$	$R^2 = 0.90$	$R^2 = 0.85$	$R^2 = 0.86$
LYS	$R^2 = 0.84$	$R^2 = 0.86$	$R^2 = 0.85$	$R^2 = 0.85$
HMR	$R^2 = 0.84$	$R^2 = 0.85$	$R^2 = 0.85$	$R^2 = 0.82$
De Jure	$R^2 = 0.86$	$R^2 = 0.91$	$R^2 = 0.83$	$R^2 = 0.88$

Source: Author's calculations.

Alternatively, if the average of the predicted values approaches the average of the observed outcomes successfully, a model is considered to be well fitted. The Hosmer-Lemeshow test statistics are commonly used to assess these properties. In order to calculate these test statistics, the data set is sorted in ascending order by the predicted probability of a currency crisis. The data set is then split into the subsets by grouping the first quantile of observations into the first set, and so forth. For each subset, the difference between the observed and predicted number of currency crises is determined on which the Hosmer-Lemeshow test statistics are based. Most Hosmer-Lemeshow test statistics lead to not rejecting the null hypothesis of no difference between observed and predicted values at 10% level (see Table 9).

Table 9. *Hosmer-Lemeshow Goodness-of-Fit Test*

Classification	All Countries	Advanced	Emerging	Developing
Natural	χ^2 (8) = 4.33(0.83)	χ^2 (8) = 8.69(0.37)	χ^2 (8) = 9.28(0.32)	χ^2 (8) = 7.29(0.51)
LYS	χ^2 (8) = 2.79(0.95)	χ^2 (8) = 2.52(0.96)	χ^2 (8) = 3.76(0.88)	χ^2 (8) = 3.82(0.87)
HMR	χ^2 (8) = 5.91(0.65)	χ^2 (8) = 8.08(0.43)	χ^2 (8) = 4.49(0.81)	χ^2 (8) = 4.72(0.79)
De Jure	χ^2 (8) = 9.97(0.27)	χ^2 (8) = 7.96(0.44)	χ^2 (8) = 9.25(0.32)	χ^2 (8) = 5.71(0.68)

Source: Author's calculations.

Considering the results shown in Tables 5 and 6, can be pointed out that the probability of currency crises increases along with a low ratio of foreign reserves to import of goods and services, high inflation, increases in the ratio of domestic financing to GDP and the ratio of domestic credit to private sector to GDP, low ratio of international reserves to total debt and increases in the ratio of total debt to Gross National Income. As expected, increases in per capita GDP growth rate, among others, reduce the probability of currency crises.

Table 10. *Exchange Arrangements Performance on Currency Crises*

	Natural	LYS	HMR	De Jure
	All Countries			
Ranking from the best to the worst performance	Fixed	Fixed	Floating*	Fixed
	Intermediate*	Floating	Fixed	Intermediate
	Floating	Intermediate	Intermediate*	Floating
	Advanced Economies			
	Fixed	Intermediate*	Intermediate	Intermediate*
	Floating*	Fixed	Floating*	Fixed
	Intermediate*	Floating*	Fixed	Floating*
	Emerging Economies			
	Floating	Fixed	Floating*	Intermediate*
	Fixed	Floating	Intermediate*	Fixed
	Intermediate*	Intermediate	Fixed	Floating*
	Developing Countries			
	Fixed	Fixed	Fixed	Fixed
	Intermediate*	Floating	Intermediate	Intermediate*
	Floating	Intermediate	Floating*	Floating*

Note: (*) insignificant variables.
Source: Author's calculations.

In addition, our results suggest that floating and intermediate exchange regimes are associated with a higher probability of currency crises than fixed regimes (see Table 10). Developing countries using fixed arrangements have a lower likelihood of currency crises relative to similar countries using floating or intermediate regimes. An explanation is that countries with underdeveloped or weak financial systems are also likely to have problems accommodating large exchange rate movements under flexible regimes.

For advanced and emerging economies, our results are not clear. They are sensitive to regime classification and different classifications can lead to very different results. Notwithstanding this, when the HMR classification is used in

emerging countries, floating regimes show the best performance (not statistically significant) while emerging countries using fixed regimes increase the probability of currency crises. Conversely, when our model is applied to all the samples the results suggested that fixed arrangements are less prone to currency crises. These result are similar to findings by Ghosh et al. (2002); Falcetti & Tudela (2006), Haile & Pozo (2006) and Esaka (2010b), and contrary to Bubula & Otker-Rober (2003). However, when we use the LYS classification is found that intermediate exchange regimes are more prone to currency crises in all countries, as well as, in emerging and developing economies. These results could show a lower popularity of intermediate regimes, according to Rogoff et al. (2003). As a consequence, our results do not clarify whether floating or intermediate exchange arrangements are more prone to currency crises.

To summarise, currency crises tend to occur more frequently in countries using floating or intermediate regimes than those countries using fixed regimes, but it is not clear which exchange rate regime is more prone to currency crises. These results tend to suggest that the affirmations on emerging and developing countries should allow for more exchange rate flexibility as a means to reduce the probability of currency and financial crises is not well founded.

8. Concluding Remarks

The academic debate on the most appropriate exchange rate regime for a country or group of countries has been one of the most controversial topics in theoretical and empirical literature. Notwithstanding its increasing relevance to policy, the literature offers relatively few empirical studies about the impact of the exchange rate regime on a currency crisis in developed, emerging and developing countries, separately. This article has provided an empirical analysis of the impact of different exchange rate regimes on currency crises in advanced, emerging and developing countries. To this end, we have attempted to make two contributions. To begin with, we distinguish between the *de jure* and the three *de facto* classifications system. We have used the IMF *de jure* classification and checked the robustness of our results with three different *de facto* classifications: the LYS classification based on a clustered analysis, the natural classification based mainly on market determined dual and parallel exchange rates, and the HMR classification based on exchange rate regimes and taking into account external shocks and revaluations. The most complete *de facto* exchange rate classifications are made by Reinhart & Rogoff (2004).

Secondly, our results also suggest that currency crises tend to occur more frequently in developing countries with floating or intermediate regimes and, also, with higher ratio of domestic financing to GDP, higher ratio of domestic credit to private sector to GDP and lower ratio of international reserves to imports, among other indicators, than developing countries adopting fixed arrangements. However, the results are not clear in terms of which exchange rate regime is more prone to currency crises. Conversely, our results on which exchange rate regimes increase the probability of currency crises in emerging and advanced economies that already have well developed financial sectors are not clear. They are sensitive to regime classification because different classifications can lead to very different results.

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Notes

[1] To a literature reviews on why many countries follow *de facto* regimes different from their *de jure* regimes see Cruz-Rodríguez (2013).

[2] This could be the results of measurement error in the classification of exchange rate arrangements.

[3] The *de facto* classification has the advantage of being based on observable behaviour, but it does not capture the distinction between stable nominal exchange rates resulting from the absence of shocks, and stability that stems from policy actions offsetting shocks. More importantly, it fails to reflect the commitment of the central bank to intervene in the foreign exchange market. Although the *de jure* classification captures this formal commitment, it falls short of capturing policies inconsistent with the commitment, which lead to a collapse or frequent adjustments of the parity.

[4] In case where there are no dual or multiples rates or parallel markets are not active.

[5] In situations where the currency crisis marks a sudden transition from a fixed or quasi-fixed regime to a managed or independently floating regime, they label an exchange rate as freely falling during the six months immediately following a currency crisis.

[6] The data on the *de jure* classification of exchange rate regimes is taken from Ghosh et al. (2002) and from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions.

[7] An important observation is that many exchange rate regimes are improperly classified as flexible when they are in fact, pegged regimes.

[8] However, the impact of a currency crisis is more severe under pegged and intermediate regimes than under floating regimes.

[9] For details on this classification, see Bubula & Otker-Rober (2002).

[10] They define currency crises as episodes of severe market pressures, reflected by sharp movements in both exchange and interest rates.

[11] Critics constantly moved away from the official International Monetary Fund (IMF) classification to construct a *de facto* classification system in 1999. The new IMF classification combines the available information on exchange rates and monetary policy frameworks, and the formal or informal policy intentions of authorities, with data on actual exchange rates and reserve movements to reach an assessment of the actual exchange rate regime (Habermeier et al., 2009, provide information on revisions to this classification system in early 2009). However, it can be argued that the new IMF classification system is still one of the *de jure* regimes, since it still relies heavily on official information and looks mainly at the behaviour of official exchange rates (Reinhart & Rogoff, 2004).

[12] In theoretical literature, a currency crisis is mostly defined only in the case 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 serve a use in empirical research, since many currencies are not formally pegged to a specific currency and many countries use various forms of floating exchange rate regimes.

[13] A decrease rather than increase in international reserves is used, since an increase in speculative pressure tends to increase the exchange rate and the interest rate, but tends to reduce foreign reserves.

[14] Variables in logarithms.

[15] Unsuccessful speculative attacks are also included in our definition of a currency crisis since they point to the vulnerability of the system reflected or that can be seen in a fall in international reserves and a rise in interest rates.

[16] We use country specific thresholds because the standard deviations are computed within each-country and not for the whole sample.

[17] For an analysis of sensitivity to different threshold we use the MPI greater in value than 1.3, 1.4, 1.6, 1.7, 2.0, 2.5 and 3.0 standard deviations over the country's own mean value. The total of number of crises according to the conventional criterion of 2.5 or 3.0 standard deviations are very small (50 and 25 respectively). Similarly, the total of number of crises when we use high threshold (mean plus 1.7 or 2.0 standard deviations) are 164 and 101, respectively. On the contrary, when we use low threshold (mean plus 1.3 standard deviations) we obtained 295 crises. However, when we

use the threshold of mean plus 1.4 or 1.6 standard deviation we obtained 256 and 195 crises, these results are closer to those obtained when we use 1.5 standard deviations.

[18] The MSCI index classifies a country into an emerging market in line with a number of factors relating to international capital market access.

[19] However, in some cases the dummy variables of exchange rates were statistically not significant but they are not excluded.

[20] LR statistic is analogous to the F statistic in the models estimated OLS.

[21] Similar to the results surveyed by Berg & Pattillo (1999) our diagnostic statistics reveal that the models rarely generate a predicted probability of crises above 50%.

[22] We also used a cut-off level for the probability of a crisis as 25%, but the models accurately predicted crises in emerging and developing countries particularly using LYS and *de Jure* classifications.

[23] The count R^2 is another comparatively simple measure of goodness-of-fit. It is defined as: $Count\ R^2 = \frac{numb\ er\ of\ correct\ \ predictions}{total\ \ number\ \ of\ observations}$

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