THEORETICAL AND EMPIRICAL ISSUES IN ASSESSING EXCHANGE MARKET PRESSURE FOR DEVELOPING COUNTRIES[1]

by

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This paper attempts to highlight the shortcomings in the application of the Exchange Market Pressure index, developed by Eichengreen et al. [1994], to the study of currency crises in developing countries. The main innovation of this index relies on its ability to signal those pressures on a currency that are softened or warded off through monetary authorities' interventions, thus avoiding a bias in the selection of crisis episodes due to the missing observation of unsuccessful speculative attacks, as it would happen if the selection rested merely on nominal exchange rate movements. Different kinds of problems in adopting this index have been detected. First, we discuss the statistical issues that arise with the use of an index with a multi-dimensional informational basis. We point out how arbitrary, and often hidden, choices are required to aggregate the information conveyed by the three components of the index. Then, we highlight the *ad hoc* assumptions introduced to build a binary crisis variable that is based on the EMP. In an attempt to tackle the problems to which the indirect use of the EMP gives rise to, we propose a different rule for the identification of crisis episodes. The proposed crisis identification rule retains the spatial relativity introduced by Eichengreen et al. [1994], but it differentiates from their definition as it is also characterized by temporal relativity and by the independence of the identification of past observations from future values of the index. In a preliminary attempt to show how methodological choices do matter and are able to affect the econometric analysis on currency crises determinants, we finally employ data from a sample of 26 countries - that comprises both developed and emerging economies - to test the sensitivity of the EMP index and of the crisis indicator with respect to issues that we are raised in this paper.

Keywords: Currency Crises, Exchange Market Pressure

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1. Introduction

There is a recent and fast growing literature that studies financial crises[2] in emerging and developing economies. Different tools have been developed to identify crisis episodes. The purpose of this paper is to show the theoretical and empirical issues that arise from one of the most widely adopted index: the Exchange Market Pressure, thereafter EMP, introduced in a seminal paper by Girton and Roper [1977] and then developed by Eichengreen, Rose and Wyplosz [1994, 1996], ERW thereafter.

The model proposed by Girton and Roper [1977] has given rise to a vast line of research that tries to identify an index that could signal the degree of the central bank intervention on the exchange market to counteract the pressure a currency is subject to. Whenever the policy followed by the monetary authorities differs from the un-interventionism prescribed in text-book models of flexible exchange rate regimes, an excess demand for foreign currency needs not to produce a depreciation of the exchange rate. The central bank can attempt to defend the value of the domestic currency through interventions on the exchange market, a tightening of its monetary policy or through the imposition of restrictions on cross border capital movements. Girton and Roper [1977] identifies the level of foreign reserve as the variable that could be deployed by the central bank in defence of its currency, and thus they include the movements of reserves, scaled by domestic base money, in their index of EMP that is defined as a *non-weighted* sum of exchange rate depreciation and reserves outflows. *Thus, the EMP is a one-dimensional index that rests on a multi-dimensional informational basis.* It is worth noting that the model - and later works that build on it [Roper and Turnovsky 1980; Weymark 1995, 1997a, 1997b, 1998] - was developed to depict the monetary interventions rather than to analyse currency crises.

As Weymark [1997a] points out, Girton and Roper's measure suffers from two major shortcomings: first, it is the outcome of a model that is embedded within a monetary approach; second, it is model-dependent, hence all the empirical research that relies on its use, is strictly dependent on the assumptions that underlie the model. To overcome these limitations, Weymark [1995, 1997a, 1997b, 1998] proposes a generalized "*model-dependent exchange market pressure indices based on a general model-independent definition of the concept of the exchange market pressure*" version of Girton and Roper's measure. The definition of EMP developed by Weymark [ibid.] is able to achieve a "*model-consistent measures of EMP from models that do not emphasize the monetary approach to exchange rate determination, as well as from those that do*". However, at the end of the 1995 article Weymark claimed that "*owing to the simplicity of the model used to generate the model consistent estimates, the values obtained in this paper must be viewed with a certain degree of scepticism. One hopes of course that the essential features of the model reflect the real world well enough to provide reasonable estimates of the exchange market pressure and the degree of intervention. The extent to which the results obtained here are sensitive to changes in model specification will have to be established empirically in future studies*".

In the empirical analysis, the indexes built by Weymark have the advantage to employ parameters that allow precise economic interpretations; nevertheless, they have the drawback that their construction is model-dependent. As it is suggested by ERW [1994], this exposes these studies to the critique advanced by Meese and Rogoff [1983] to the models that link the determination of the exchange rate to macroeconomic fundamentals: "*ideally, such an index would*

[2] Following the distinction developed in Kaminshy [2003], our analysis focus on the currency crises. Thereafter we use the terms financial crisis and currency crisis as synonyms .

derive the excess demand for foreign exchange from a model of exchange rate determination", as "*a particular set of weights and fundamentals is only as defensible as the theoretical model used to generate it.*"

Our analysis is focused on the EMP version developed by ERW. To the best of our knowledge, they were the first to employ the EMP as a base for the analysis of currency crises. As it will discussed in detail in later sections, the EMP is used in an indirect way, to build a binary variable that signals the emergence of a currency crisis. In contrast with Girton and Roper and Weymark, their EMP is model-independent, as all the variables included in the index and the way in which they are combined are not derived from a structural model. However, as Weymark [1998] indicates, some issues arise from the ERW index: first, it does not come from a model-independent definition of exchange market pressure; second, the magnitude of the variables chosen depends strictly on the structure of the economy and - as we will show in this paper - the way in which the variables are combined is *arbitrary and strongly sample-dependent*. While we take a neutral stance with respect to the first issue, we will focus on the methodological issues that the use of the index gives rise to, as it has been adopted in significant articles of the literature on currency crises [Eichengreen et al. 1994; Kaminsky et al. 1998; Kaminsky and Reinhart 1998; Tudela 2004].

We will try to argue that, even if one is to believe to the general theoretical framework the index belongs to, the EMP nevertheless suffers from some weaknesses that cast doubts on its reliability. Moreover, it is an index that possesses some built-in characteristics that render its extension to the analysis of currency crises in emerging countries a troublesome task. Methodologically, we try to point out how seemingly harmless - and often hidden - choices that required to aggregate the information conveyed by the components of the index, are likely to affect the results of subsequent empirical analysis. Moreover, differences in the structure of the economic system, such as those observed in developing countries, strongly affect the consistency of the assumptions and, consequently, the results that are achieved.

Different kinds of issues connected with the adoption of the EMP index have been detected in our paper. In the second section we discuss the way in which the EMP was built, pointing out the statistical issues that are raised by the use of an index with a multi-dimensional informational basis. In the third section, we highlight the *ad hoc* assumptions required to build a binary crisis variable that is based on the EMP. In addition, we propose a different *rule* to identify crises episodes that satisfies a set of properties that are needed to overcome the shortcomings of previous EMP-based crisis definitions. In a preliminary attempt to show how methodological choices do matter and are able to affect the econometric analysis on currency crises determinants, we employ data from a sample of 26 countries to test the sensitivity of the EMP index and of the crisis indicator with respect to issues that we are raised in this paper. Differently from ERW, this sample comprises a set of developing and emerging countries, in order to highlight how some statistical and theoretical choices inherent to the construction of EMP index cannot be made regardless of an analysis of the economic characteristics of the countries that included in the sample.

2. The Exchange Market Pressure index

To avoid an overlapping of the issues that arise from the construction of the EMP itself with those that emerge from the use of the EMP as crises indicator we will focus on the former in this section and devote the next section to the latter. Particularly, after providing the EMP formal definition, we will discuss in this section how four important *fine tuning* issues influence the index: the weighting procedure of the variables; the method of computation of the percentage change of the exchange rate; the inclusion of gross versus net foreign reserves and finally the choice of the reference country.

2.1 ERW's definition of EMP

Adopting the EMP, ERW declared purpose is to capture those pressures on a currency that have been softened or warded off through monetary authorities' interventions, thus preventing a bias in the selection of crisis episodes due to the missing observation of unsuccessful speculative attacks, as it would happen if the selection rested on nominal exchange rate movements alone. As claimed above, their index is not strictly linked to a model but it is the linear combination of the exchange rate changes and of two channels through which the policy maker intervenes to deal with a speculative attack: interest rates and reserves.

The EMP proposed by ERW[3] is defined as:

$$[1] \qquad EMP_t = \alpha\Delta e_t + \beta\Delta(i_t - i_t^f) + \gamma\Delta(r_t^f - r_t)$$

where e_t is the percentage change in the nominal exchange rate against a reference country, i_t is the domestic interest rate and r_t the foreign reserves - scaled by the monetary base - and i_t^f and r_t^f the corresponding variables for a reference country. Finally, α, β and γ are the weights employed to combine the three variables. In a simple index – as the version proposed by Girton and Roper [1977] - the three weights would be equal to one-third. As the three variables significantly differ in their variances, a non-weighted index would be driven by the most volatile variable. ERW suggest equalizing the unconditional volatility of each of the three components. Higher values of the index reveal a greater pressure on the domestic currency, that can be signalled by a nominal depreciation, a widening of the interest rate spread or a loss of foreign reserves.

2.2 Fine Tuning Issues

The purpose of this section is to highlight some characteristics of the index, which cast some doubt on the soundness of the results it can produce even if one is to accept its theoretical foundations. These characteristics relate to the weighting scheme that is adopted to combine the three variables, to the some statistical and theoretical issues referring to the variables themselves and to the selection of the appropriate reference country. The EMP appears to be an index that is notably sensitive to seemingly minor choices, and this poses the problem of its *fine tuning*, as it is not always possible to rank possible alternatives, and different choices can be defended on different empirical or theoretical grounds.[4]

[3] As already pointed out above, different works have adopted the EMP. Particularly a two-component version, that excludes the interest rate differential, has been included in Kaminsky et al. [1998], Kaminsky and Reinhart [1999] and Tanner [2001], while ERW proposed to add a third variable to the index, to describe possible monetary policy responses to a disequilibrium in the foreign exchange market. In this paper, we always adopt the definition proposed by ERW [1994].

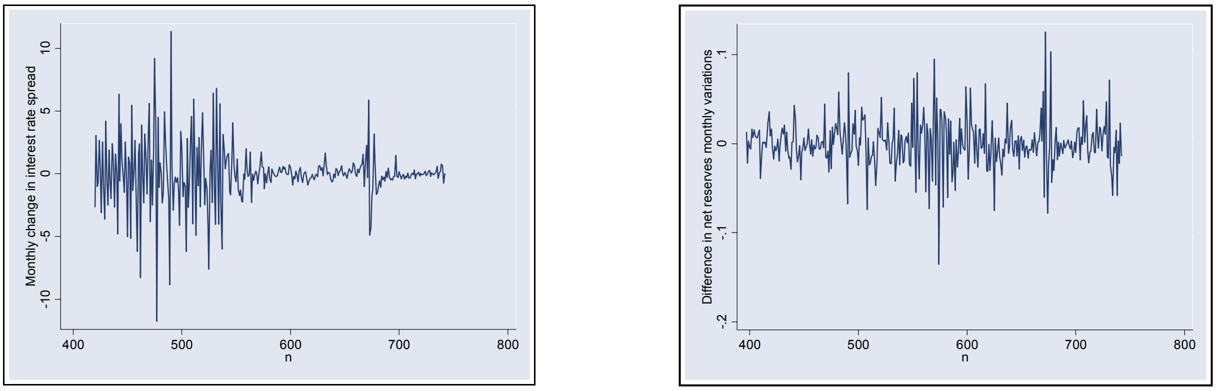
[4] In the next subsections, we will identify these choices and provide illustrative examples of their bearings on the index, even though a fuller understanding of their relevance can be more easily obtained when the index is used to build a binary indicator of crisis periods. However, for the clarity of the exposition, we will focus on the impact of *fine tuning* issues on the EMP alone. Examples are drawn from a dataset that is presented in the Appendix, A1.

2.2.1 Weighting

The EMP is a one-dimensional index that aggregates data coming from three underlying variables. As these are usually characterized by different volatilities, their aggregation has to be conducted in such a way that prevents the most volatile component from dominating the whole index.[5] ERW suggest weighting the three components in order to equalize their conditional volatilities, and this volatility-smoothing procedure is commonly adopted in the literature. This can be done simply standardizing each component, i.e. replacing the weights that appear in [1] with the reciprocal of the country-specific standard deviation of each of the three series. Even though this approach might appear unproblematic, it nevertheless introduces some questionable features in the EMP. The *time invariance of the weight set* does not allow capturing structural changes in the volatility of the variables, changes that are most likely to occur when the analysis spreads over a long time horizon. Moreover, the use of the sample variances of the underlying variables implies that the weight system is sensitive to the presence of outliers in the series.

Figure [1] reports the monthly change in the interest rate and foreign reserves over monetary base spread between Canada and the US since 1970 to 2002. In the early 80s, a structural breakdown in the volatility is observed, and another high volatility cluster is recorded in the mid 90s. The standardization of interest rate spread through its sample variance implies that the evolution of the series does not convey much information to the overall index during periods of low structural volatility.

Figure 1. Monthly variations in the interest rate spread (left)
and in foreign reserves over the monetary base (right), Canada, 1970-2002.



The volatility clustering of the different series could be consistent with changes over time of the preferred instruments that are chosen by the monetary authorities in order to face pressure on the domestic currency. The figure on the right reveals how the reduction in the volatility of interest rate spread for Canada, was followed by an increase in the volatility of the ratio of international reserves over the monetary base.

It is thus questionable whether the standardization of the underlying variables reaches its declared target, which is preserving the implicit multidimensional character of the index. When there are structural breaks in the variance of its components and the weights are time invariant, it is indeed the variable that shows a volatility cluster to drive the index.

[5] The interest rate differential presents the highest volatility for all sample countries, while the rank between the volatilities of exchange rate variations and foreign reserves movements is not constant.

The Argentinean case can be recalled to show the relevance of the first point raised above. In February 1990, in an extreme attempt to stop the free fall of the peso, the interest rate was raised to 4,670,000 percentage points, and further increased to 6,970,000 percentage points the following months. As the exchange rate stabilized and international reserves recovered, the interest rate was down to 180 percent in April. The spikes of the domestic interest rate recorded in Argentina in the early 1990 imply that the standard deviation of the series of the interest rate differential is extremely high, and hence its weight is close to zero in the index. The EMP for Argentina thus virtually loses one of its dimensions, as it fails to incorporate the information that comes from the interest rate for the whole period except for the two outlying observations of February and March 1990. Even though the Argentinean example is clearly an extreme one, it nevertheless reveals the sensitivity of the EMP to outliers, which should be carefully treated.

2.2.2 Exchange rate variations

The first component of the EMP that appears in [1] is given by the rate of change of the nominal exchange rate of the domestic currency against the currency of the reference country. With a few exceptions, the method used to compute the rate of variation is left unspecified.[6] It is well known that the difference in computing a rate of variation in continuous or in discrete time is negligible when the rate of change is sufficiently small, that is $Ln(E_t/E_{t-1}) \approx (E_t-E_{t-1})/E_{t-1}$ when E_t is *close* to E_{t-1}. This is the reason why often the specification of the method used is not worth even a footnote. But the structural differences that characterize the distribution of the monthly rate of variations of the nominal value of developed and developing countries' currencies imply that the method of computation used does matter.

Looking at the long term trend of the nominal exchange rate between a developing country's currency a developed country's currency, almost invariably a trend of long run depreciation is found, coupled with periods of sharp depreciations. This long term trend may be due to various reasons, but for many countries the main factor can be traced to the existence of a positive inflation differential with the reference country. On the other hand, the nominal exchange rate between a pair of developed countries tends often to be fairly stable if a sufficiently long time span is considered, and monthly variations tend to be smaller in absolute value.

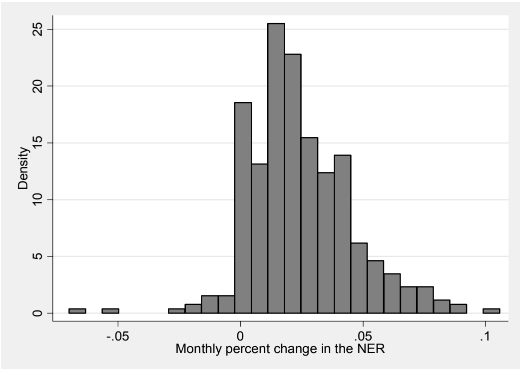
Figure [2] presents the distribution of the monthly rate of variation of nominal exchange rate with the US dollar for the Uruguayan peso and the British pound, to provide a telling example of the structural differences that we have just described. The distribution of the monthly rate of change of the exchange rate between the pound and the US dollar has a mean of 0.13 percent, and it is symmetric. On the other hand, the distribution of the rate of change of the Uruguayan peso against the US dollar has a much higher mean, equal to 5.28 percent; it is asymmetric, with the vast majority of the observations lying above zero, and with a thicker upper tail. For the pound, just one observation lies above ten percent, outside the range that is shown in the plot, while for the peso we find ten observations above that threshold.

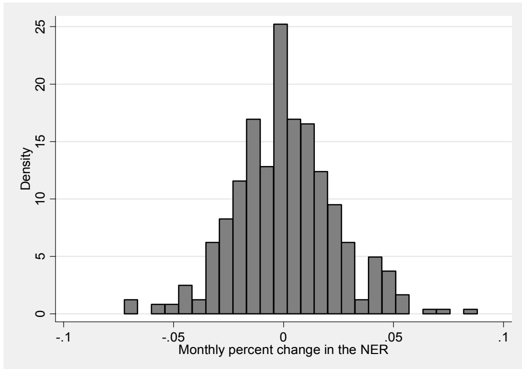
The relevance of the method used to compute the variation of the exchange rate stems from the fact that the two methods produce a significantly different *variance* for the sample distribution of the rate of variations for developing countries. For the Uruguayan peso, the standard deviation of its monthly rate of change is 0.4734 when the rate is computed in discrete time and 0.1732 when the computation is done assuming continuous time. For the British pound

[6] Eichengreen et al. (1996) define the rate of variation of the exchange rate e as $[Ln(E_t) - Ln(E_{t-1})]$, while Pontines and Siregar [2004] define it as $(E_t-E_{t-1})/E_{t-1}$.

we need a four-digit precision to appreciate a difference between the two cases, as the standard deviation goes from 0.0242 to 0.0241.

Figure [2] Distribution of monthly rate of variation of nominal exchange rate with the US dollar for the Uruguayan peso (left) and the British pound (right), 1970-2002[7]





Why the standard deviation is almost unchanged for the pound, while it decreases substantially for the peso? *A priori*, it is not possible to say whether the use of logarithms will generate a distribution with a higher or smaller variance, as the logarithm reduces the dispersion of values that are greater than one but increases the dispersion of those that are less than one. That is to say, that the logarithmic function is a contraction mapping on the domain (1, +∞), while it is an expansion mapping in the domain (0, 1). If the distribution of the monthly rate of change of the exchange rate is almost equally distributed between positive and negative values, i.e. E_t/E_{t-1} is equally divided between values above and below unity, and then the transformation of the distribution of E_t/E_{t-1} through the logarithm does not significantly modify the variance of the distribution. But, as it is the case for the Uruguayan peso, if the distribution skewed above unity, then the transformation through the logarithm does significantly reduce its variance.[8] This effect is further magnified in the presence of values in the upper tail of the distribution, which are determined by the occurrence of large short run devaluations against the reference country.

When the three components of the index are standardized, a *higher* weight will be attached to the variation of the nominal exchange rate when this is computed using logarithms if the distribution of the rate of variations is skewed above zero. Table [1] shows how the method of computation of the exchange rate variations affects its standard deviation. In our sample, the weight increases or remains unchanged in 23 cases out of 25. The only two (slight) exceptions are given by Germany and Japan, whose currencies did not show sharp short run fluctuations against the US dollar, and also experienced long periods of nominal appreciation. The most notable differences are reported for Latin American countries. Many of these countries were prone to episodes of hyperinflation in the '80s and in the '90s, and this caused sharp and prolonged devaluations of their currencies. For Chile, Peru and Uruguay, the use of logarithm reduces the standard deviation of the exchange rate variable to less than *half* of the value that is found when rates of variation are computed in discrete time. Thus, the country-specific weight set for developing countries is extremely

[7] The rate of change is computed as $(E_t-E_{t-1})/E_{t-1}$.
[8] See the Appendix, A2.

sensitive to this (seemingly) harmless choice, and this implies that the EMP itself is exposed to the influence of this choice.[9]

Table [1] Computation of the exchange rate variation and of its standard deviation

Country	Standard deviation of the monthly rate of change of the exchange rate		
	$e_t=ln(E_t/E_{t-1})$	$e_t=(E_t/E_{t-1})-1$	*ratio*
Canada	0.0103	0.0103	100.00
Denmark	0.0257	0.0257	100.00
Finland	0.0235	0.0237	99.16
France	0.0258	0.0260	99.23
Germany	0.0273	0.0272	100.37
Italy	0.0246	0.0248	99.19
Netherlands	0.0266	0.0266	100.00
Spain	0.0248	0.0251	98.80
Sweden	0.0239	0.0243	98.35
Turkey	0.0531	0.0648	81.94
United Kingdom	0.0241	0.0242	99.59
Argentina	0.1478	0.2439	60.60
Chile	0.1058	0.2361	44.81
Colombia	0.0150	0.0151	99.34
Indonesia	0.0589	0.0710	82.96
Japan	0.0279	0.0277	100.72
Korea	0.0269	0.0301	89.37
Malaysia	0.0200	0.0203	98.52
Mexico	0.0541	0.0631	85.74
Peru	0.1500	0.4017	37.34
Philippines	0.0298	0.0336	88.69
Singapore	0.0139	0.0139	100.00
Thailand	0.0221	0.0229	96.51
Uruguay	0.1732	0.4734	36.59
Venezuela	0.0695	0.0993	69.99

[9] To assess to what extent the index is actually sensitive to this choice, we computed the EMP for the 25 sample countries applying both specifications of the exchange rate variations, and then we regressed one on the other. In 21 cases, the adjusted R^2 is above 0.99, signaling that the two indices closely mirror each other, while it is lower than this threshold for 4 Latin American countries: 0.9845 for Argentina, 0.958 for Chile, 0.973 for Peru and 0.845 for Uruguay. This means that for these four countries the two indices diverge to some extent, and this divergence can be fully traced back to the method of computation of the exchange rate variations. The relevance of this difference is further magnified when the EMP is used in an indirect way (see below).

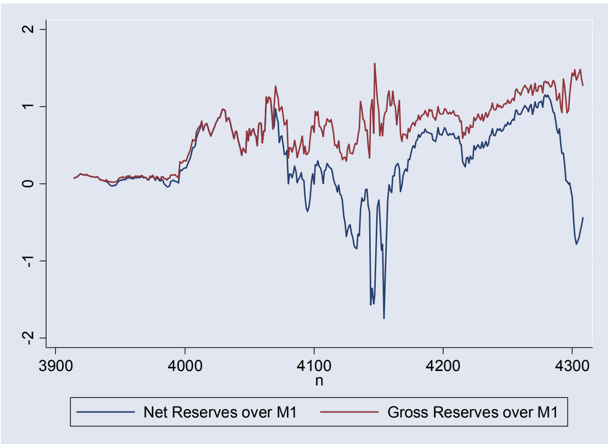
2.2.3 International reserves

The inclusion of international reserves in the EMP index is intended to capture those speculative pressures on a currency that lead to central bank's interventions on the foreign exchange market. However, just a part of central bank's operations translate in to a variation in the level of international reserves. A central bank can attempt to defend its currency by drawing on stand-by credits or through off-balance-sheet transactions, as forward market interventions, thus not committing any of its foreign assets on the spot market. Thailand's gross international reserves had remained fairly stable in the first six months of 1997, but a severe currency crisis broke out on the 2nd of July, with a large devaluation of the *baht*, when it became apparent that all of its foreign assets had already been committed on the forward market. This episode shows clearly the limitations of inferring of the magnitude of monetary authorities' interventions on foreign exchange markets from variations in the level of reserves, but this remains the only feasible option as central banks do not give notice of their off-balance-sheet operations.

A central bank's foreign assets can be considered net or gross of its international liabilities. This choice is often constrained by data availability, as monetary authorities sometimes report just variations in their gross assets. ERW state that their EMP index includes "*international reserves (line 1l) corrected for international liabilities (line 16c) wherever possible*" scaled by the monetary base, while Tudela [2004] uses "*a ratio of reserves (excluding gold) to narrow money (M1)*". Thus, while Tudela works with gross reserves, ERW prefer to use net reserves, but resort to gross series if the relevant data are not disclosed by the monetary authorities.

Movements of gross and net reserves sometimes convey conflicting information, and they can thus lead to different perceptions of the pressure a currency is subject to. To provide a concrete example, Figure [3] shows the evolution of the ratio of international reserves – both gross and net of the liabilities towards the IMF – over the monetary base for Argentina over the period 1970-2002. Even though the figure reveals prolonged period of assistance of the Fund, we can focus on the crisis of 2001. While the pattern follow by gross reserves signals a reduction of the level of reserves followed by a rapid recovery and stabilization, the steady fall of net reserves reveals an enduring lack of confidence in the Argentinean peso. Clearly, the inclusion of either series in the EMP will provide a different picture of the evolution of the recent Argentinean crisis.

Figure [3] Foreign Reserves, Gross and Net of liabilities towards the IMF, Argentina,, 1970-2002



If it is not precluded by lack of relevant data, the choice between gross and net series should be dependent on the focus of the study for which the EMP is adopted. The inclusion of gross reserves may be preferable if one is interested in liquidity crises, while net reserves may be better suited for studies on the determinants of solvency crises. More often, just a loose definition of what a crisis means is provided in the literature, as can be observed in Tudela [2004], where "*the terms of currency crises, speculative attack and exchange rate crises* [are used] *interchangeably.*"

If the choice between gross and net reserves is not guided by a clear cut definition of financial crisis, this should be influenced by the need to treat in a consistent way the countries that are included in the sample. Countries may differ with respect to the frequency with which they activate credit lines in foreign currencies, and the same country can change over time its reliance on off-balance-sheet operations to face speculative pressure on its currency. When gross reserves are chosen as a component of the EMP index, the index will reveal, *ceteris paribus*, a softer pressure on a currency whose exchange rate is backed by the activation of credit lines in foreign currencies.[10] If the monetary authorities can draw resources from these credit lines, they can face speculative pressure on their currency without having to deplete their gross foreign assets.

In particular, countries can activate a stand-by arrangement or a loan with the International Monetary Fund when they experience Balance of Payments need. The amount of *Fund credit and loans outstanding* is reported for each member country by the IFS (line 2tl), and this series – that is published on a monthly basis by the IMF - can be used to account for a specific form of international liabilities that is extremely significant for developing countries.

This series does not include the undrawn balance of a stand-by agreement with the IMF. In principle, this voice could be considered, if this contributed to have a fuller measure of the capacity of a central bank to defend its currency through interventions on the foreign exchange market. But, as Mussa and Savastano [2001] point out, "*more than a third of all Fund arrangements approved between 1973 and 1997 ended with a disbursement of less than an half of the initially agreed support. (...) Mainly these were cases were the program went off track because policies deviated significantly from those agreed with the IMF and subsequent negotiations failed to reach agreement on a modified program.*" This reflects the strong conditionality of Fund credit, which does not allow considering the undrawn balance of a stand-by agreement with the IMF as resources that can be freely used by a central bank to defend its currency.

When international reserves are considered net of monetary authorities' liabilities towards the IMF, this allows for the inclusion in the same sample of countries that receive significant financial assistance from the IMF before or in the aftermath of a crisis, and countries that do not. The different paths followed by Malaysia and South Korea in 1997, after the crises had broken out in Thailand, constitute a good example of the need for a consistent treatment of international reserves variations for countries that have to be included in the same sample. As it is well known, Malaysia pursued its own adjustment program, introducing temporary restrictions to capital movements, without drawing resources from the IMF. On the other hand, South Korea received 11,014 millions of US dollars in December 1997, and its debt towards the IMF kept on rising till October 1998, when it reached 18,754 millions, well above 1,600 percent of its Fund quota. The resources South Korea received from the Fund in December 1997 amounted to more than an half of its gross international reserves.

[10] The choice between net and gross reserves implies a change in the weights, if the weights of the three components of the index are chosen so to equalize their conditional volatility. However, from our sample it does not emerge any systematic difference in the volatility of gross or net reserves, and changes in the weights are rather small.

If reserves are considered gross of central bank's liabilities towards the IMF, then there is the risk of underestimating the pressure a currency is subject to, when its reserves are supported by large inflows of Fund credit. Even though this point is currently relevant for developing countries, it should be noted that if the time span of the analysis covers the 70s, the need to account for liabilities towards the Fund concerns developed countries as well. In the 70s and early 80s, several European countries received credit from the IMF, often well above their respective Fund quotas. For example, in January 1976, Italian liabilities towards the IMF were almost *three times* the level of Italian gross foreign reserves, and thus its net reserves were negative.

2.2.4 Reference country

According to [1], in order to assess the exchange market pressure a currency is subject to, the relevant domestic data are confronted with those of a country that is selected as a *benchmark*. The introduction of a reference country in the definition of EMP is meant to avoid reading as signals of pressure on a currency those switches in the relevant domestic data that are actually driven by changes in the conditions prevailing on international markets. Monetary authorities interventions clearly do not solely address the exchange market, and thus an increase in the domestic interest rate could as well result from a tightening in the monetary policy of – say – the US. Ideally, the role of the reference country would be to reveal only those movements of the components of the EMP that are due to actual attempts to intervene on the foreign exchange market.

The choice of the reference country for studies that focus on developed countries has usually been rather straightforward, as Germany is taken as the benchmark for European countries, while the US is the reference country for the other OECD countries (see ERW). But when developing countries are involved, the choice becomes more open, as different criteria could be recalled to justify diverging solutions. Pontines and Siregar [2004] shows that if Japan replaces the US as the reference country, the EMP for the Thai baht changes significantly, along with its capacity to signal the actual crisis episodes that hit the East Asian country in the late 90s. But, as Pontines and Siregar [2004] suggests, "*hardly any studies have tested the sensitivity of this crisis index to the various possible choices of "the anchor" currencies*". Their paper, providing a convincing and thorough example of the significance of an often overlooked choice, suggests that is worth investigating in a systematic way the effects that derive from a switch in the anchor currency. We have the following proposition:[11]

Proposition [1] - Take three countries A, B and C, and denote with EMP_{AB} the exchange market pressure for country A when country B is assigned the role of reference country. Assume that logarithmic differences are employed to compute the variations of the nominal exchange rate. If the EMP is given by an unweighted summation of its three components, then the following relation holds:

$$[2] \qquad EMP_{AC} = EMP_{AB} + EMP_{BC}$$

More generally, if each component has the *same* weight in the three indexes, the above relation applies.

[11] See the Appendix, A3, for a formal – and rather straightforward – proof.

The above proposition suggests that a change of the reference country from B to C implies that the new EMP is equal to the previous one plus the EMP for country B, taking C as the reference country. If we relax the hypothesis of identical sets of weights in the three indexes, we have to include a residual term in [2], whose relevance increases the greater is the divergence among the sets of weights of the three indexes.

What does the previous proposition suggest? The change of the reference country can actually be expected to produce significant effects on the exchange market pressure index, as it implies the *addition* to the original EMP of the index that signals the pressure between the two candidate reference countries. Clearly, the empirical relevance of Proposition [1] needs to be assessed, as it rests on an assumption – the identity of the weight sets – that is unlikely to be met in reality, as the weights are dependent on the sample values of the three variables.

The data relative to the seven Asian countries that are included in our dataset are well suited to test the relevance of Proposition [1]. As Pontines and Siregar [2004] points out, it is an open question whether the US dollar of the Japanese yen should be given the role of the anchor currency when assessing exchange market pressure for Asian countries, and we will revise below the criteria that could inform the choice. Thus, it is interesting to verify to what extent this choice actually matters, as the above proposition suggests that its influence is indeed significant. We thus propose a simple test, which involves the two following regressions:

[3] $EMP_{XUS,t} = \delta_0 + \delta_1 EMP_{XJ,t} + \varepsilon_{X,\,t}$

[4] $EMP_{XUS,t} = \delta_0 + \delta_1 (EMP_{XJ,t} + EMP_{JUS,t}) + \varepsilon_{X,\,t}$

Where J stands for Japan, US for United States and X represents one of the other six Asian countries included in the sample. According to [2], the second regression should have a better goodness of fit, δ_0 should not be statistically different from zero and δ_1 should be close to unity. However, Proposition [1] also states that this results should be more closely mirrored by the data the smaller is the distance among the weight sets of the three indexes. Thus, we compare the results of the six pairs of regressions with a measure of this distance, which is defined as follows:

[5] $D(X, Y, Z) = [D(X, Y) + D(X, Z) + D(Y, Z)]/3$

where $D(X, Y) = (|\alpha_X - \alpha_Y| + |\beta_X - \beta_Y| + |\gamma_X - \gamma_Y|)$, and $D(X, Z)$ and $D(Y, Z)$ are analogously defined.

That is, we define the distance between the sets of weights as the average of the distances between each pair of sets.

The results of the regressions – that are reported in the Appendix, A4 – are highly consistent with the predictions of Proposition [1]: the adjusted R^2 increases markedly when $(EMP_{XJ} + EMP_{JUS})$ replaces EMP_{XJ}, the constant term is never significant. The estimated coefficient of $(EMP_{XJ} + EMP_{JUS})$ is close to unity only for Korea - the regression with the highest fit - while it is significantly below unity for the remaining five countries. Moreover, there is an apparent inverse relation between the measured distance and both the adjusted R^2 and δ_1: both get closer to unity the lower is the distance among the sets of weights. These results suggest that, although it rests on a rather unrealistic and stylized hypothesis that cannot be met by actual data, the main implication of Proposition [1] appear to be borne by actual data: the change of a reference country produces a not negligible effect on the EMP, and the differences between the two indexes is equal to the EMP between the two reference countries. Thus, there is no wonder that the choice of the anchor currency as a bearing on subsequent analysis that build on the EMP.

As the choice of the reference country does matter, which is the way to choose the *right* one? Pontines and Siregar [2004] suggest that the answer can be advanced by the analysis of the trade, investment and financial flows of each country. The *thickness* of these flows would provide the clue to choose among different potential reference countries.[12] Even though their suggestion might fail to provide a definitive solution (as the different data might deliver conflicting information about the choice of the reference country), it highlights nevertheless a central methodological point. The EMP index is not a tool that can be employed to different countries, irrespective of the characteristics of their economies.

3. EMP-based definitions of currency crises

In Table [2] we report some indexes that have been employed in empirical work to detect currency crises. An approach to the study of exchange rate crises entails the division of sample observations between episodes of crisis and periods of tranquillity. Hence a classifying rule has to be identified. The crises can be defined either as the transition between two different exchange rate regimes, as the floatation of a pegged exchange rate, or as exceptional movements of the nominal exchange rate or as of a broader index of excess demand for foreign currency, as the EMP. The latter, as already pointed out, is useful because those pressures on a currency that have been softened or warded off through monetary authorities' interventions can be captured.

Frankel and Rose [1996] do not consider the transition between two different regimes, but rather define a crisis as a period of high and accelerating depreciation of the nominal exchange rate. A crisis is identified when the depreciation of the nominal exchange rate for the period of reference exceeds the threshold of 25 percent, and it is at least 10 percent points above previous period depreciation rate. The threshold they provide is thus *absolute*, as it is constant in time and in space. On the other hand Kumar et al. [1998] depict a currency crises building an index that, depending on the magnitude, use either the nominal exchange rate variation weighted by interest rate differential or they simply use the nominal exchange rate devaluation.

ERW, Kaminsky et al. [1998] and Kaminsky and Reinhart [1999] follow an approach that is similar to that adopted by Frankel and Rose [1996], as they look at exceptional upward movements of the EMP. A crises is signalled when the EMP is above a critical threshold, that is defined as a function of country-specific sample mean and standard deviation of the index. ERW set the threshold equal to the sample mean of the index plus 1.5 times its standard deviation. Hence the binary Index of currency crises (IC) they adopt is:

$$[6] \qquad \begin{cases} IC = 1 \text{ if } \dfrac{EMP - \mu_{EMP}}{\sigma_{EMP}} > 1.5 & \text{(crisis)} \\ IC = 0 \text{ if } \dfrac{EMP - \mu_{EMP}}{\sigma_{EMP}} \leq 1.5 & \text{(tranquillity)} \end{cases}$$

[12] A possible alternative guideline to the selection of the most appropriate reference country could be represented by the composition of the international reserves held by the Central Bank.

Table 2. Crises Definition adopted in some important empirical works

Article	Index of Crises (IC)	Time Frame and Countries
Frankel and Rose [1996]	$IC_t = \ln(e_t - e_{t-1})$ where *e* is the nominal exchange rate referred to the US dollar. The crises is observed if: $IC_t > 25\%$ and $IC_t - IC_{t-1} > 10\%$	Annual Data for the period: 1975-1996 105 Countries
Kumar et al. [1998]	Devaluation of the nominal exchange rate vs. US dollar weighted for the differential of the interest rates: $IC_1 = 100\left[\left(e_{t+\Delta} - e_t\right)/e_t\right]\left[\left(1+r_t\right)/\left(1+r_t^*\right)\right] > \gamma_1$ where $\gamma_1 = 5\%, 10\%$. Otherwise the simple devaluation of the nominal exchange rate: $IC_2 = 100\left[\left(e_{t+\Delta} - e_t\right)/e_t\right] > \gamma_2$ e $\left[\left(e_{t+\Delta} - e_t\right)/e_t\right] > \left(1+\gamma_3\right)\left[\left(e_t - e_{t-\Delta}\right)/e_{t-\Delta}\right]$ where $\gamma_2 = 5\%, 10\%, 15\%$ and $\gamma_3 = 100\%$	Monthly Data for the period: 1985-1998 32 Emerging Countries
Eichengreen et al. [1994, 1996]	$EMP_t = \alpha\Delta e_t + \beta\Delta(i_t - i_t^f) + \gamma\Delta(r_t^f - r_t)$ There is a crises when: $IC > MeanEMP + 1.5\sigma$ where σ is the EMP standard deviation	Quarterly Data: 1959-1993 22 OECD Countries
Kaminsky et al. [1998] Kaminsky and Reinhart [1999]	They do not use the interest rates differential in the EMP: $EMP_t = \alpha\Delta e_t + \gamma\Delta(r_t^f - r_t)$. There is a crises when: $IC > MeanEMP + 3\sigma$ where σ is the EMP standard deviation	Monthly Data: 1970-half 1995 20 Countries (Asia, Latin America and Middle East)
Tudela [2001]	The three components of the EMP are observed separately; a crisis band is set for each variable, and a crisis is detected when at least two variable lie outside the band.	Quarterly Data: 1970-1997 20 Developed Countries

Source: Our elaboration from Bubula and Otker-Robe [2003].

As in Frankel and Rose [1996], the definition of the critical threshold is an arbitrary "rule of thumb" for the identification of a currency crisis, and the set of episodes that are identified as crises is clearly sensitive to the choice of the width of the tranquillity band. However, a major innovation introduced by the EMP-based crises indicators is that the critical threshold is *relative*, as it is country specific and it is dependent on the sample values of the index. Thus, a wider band is attributed to countries that have a higher mean or a more volatile index. The same value of the EMP can be classified in different ways according to the country it refers to. Moreover, while following Frankel and Rose [1996] it is sufficient to consider three consecutive observations to decide whether the third one is a crisis episode, no subset of observations that can be used to discriminate among crises and tranquil periods according to the EMP-based definitions, as the mean and variances are computed over the whole sample.

Table [3] presents the number of crisis episodes that are detected according to ERW definition, considering both the inclusion of gross and net international reserves.

Table 3. Crises episodes over 1970-2002

ERW definition of crisis

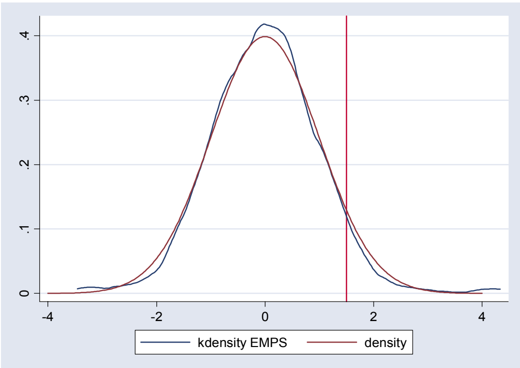
	Country	Gross Reserves	Net Reserves
Developed Countries	Canada	26	26
	Denmark	19	19
	Finland	21	21
	France	23	23
	Germany	23	23
	Italy	23	23
	Japan	18	18
	Netherlands	22	22
	Spain	20	20
	Sweden	16	16
	United Kingdom	30	30
	Average	**21.90**	**21.90**
Developing and Emerging Countries	Argentina	21	20
	Chile	13	15
	Colombia	15	15
	Indonesia	17	15
	Korea	17	20
	Malaysia	19	19
	Mexico	23	22
	Peru	13	16
	Philippines	19	20
	Singapore	19	19
	Thailand	12	10
	Turkey	20	21
	Uruguay	14	11
	Venezuela	14	16
	Average	**16.86**	**17.07**

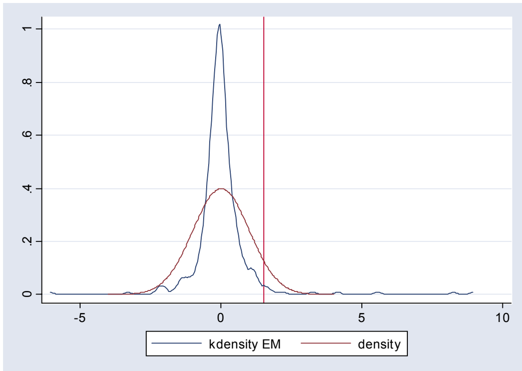
At least two features of Table 3 are worth pointing out: first, as it has been emphasized in section 2.2.3, netting international reserves from the liabilities towards the IMF, has a bearing on the observations that are labelled as crises for developing countries;[13] second, the definition advanced by ERW signals on average a larger number of crises for developed than for developing countries.[14] This latter characteristic is striking, as one may plausibly expect developing

[13] It can be pointed out that the difference is deeper than what emerges at first sight from Table 3, as even an identical number of crises may hide the fact that different observations are labelled as such.
[14] It has to be recalled that for the countries that adopted the euro, the series interrupt on December 1998. Hence, if we had weighted the two averages according to the number of observations included in the sample for developing and developed countries, the difference in the average would have been even larger.

countries to be more crisis prone than developed ones. But it is precisely the fact that developing countries are more often subject to violent currency crises that leads to the paradoxical result of the identification of a smaller crisis set. Figure [4] provides the Kernel density distribution of the standardized EMP index for Sweden and Thailand: while for Sweden this is close to the normal distribution, this is not true for Thailand. In this case, the distribution of the standardized EMP has a much higher kurtosis and it presents values in the right tail of the distribution, in correspondence with violent episodes of currency crisis signalled by sharp increases in the EMP index. The identification of crisis through a cut-off point as in [6] thus leads to signal an higher number of crisis episodes for developed than for developing countries.

Figure [4] Distribution of the EMP index for Sweden (left) and Thailand (right), 1970-2002.





Even though a country-specific definition of crisis has some flexibility that is lacking to absolute definitions, it is nevertheless characterized by the arbitrariness of a parametric definition of crisis. As Pontines and Siregar [2004, p. 8] point out, due *"to the non-normality of the statistical distribution of the EMP indices in general, we have to avoid relying too much on parametric assumptions in identifying speculative attacks. Studies as early as the 60s have clearly established that short-term foreign currency fluctuations/returns and interest rates are non-normal and displaying fat and heavy-tails"*. The critique advanced by Pontines and Siregar [2004] appears to be more relevant for developing than for developed countries, as the latter present a distribution of the index that more closely resemble the Gaussian curve.

As we saw, Table 3 provides an illustrative example of how the binary crisis variable is sensitive to one of the four *fine tuning* issues that have been discussed in the previous subsections. But, to the best of our knowledge, no empirical study so far has tested the robustness of its results to changing definitions of crisis or to different choices related to the underlying index.[15]

3.1 A possible alternative

As we pointed out above, the *spatial relativity* of the EMP-based definition of currency crisis is, at the same time, the innovation and the weakness of this approach proposed by ERW. The critique advanced by Pontines and Siregar [2004]

[15] Because of lack of space we have not discussed an issue related with the data collection. As it is already pointed out by ERW, "*monthly observations may not be a sufficiently fine periodicity to identify every speculative attack, especially unsuccessful ones*." An attack can be launched and concluded in a few days, and the behaviour of yearly averages of the relevant variables might fail to reveal it. As shown in the Table [2], several empirical works have used quarterly or yearly data.

suggests that the spatial relativity of the crisis selection rule can lead to paradoxical results because it is attained through a parametric definition of the upper tail of the EMP sample distribution. Thus, we propose an alternative EMP-based definition of crisis that is still country-specific, and that satisfies two additional properties that do not belong to previous definitions. The properties that characterize the proposed definition are:

1- Spatial relativity
2- Temporal relativity
3- Future data do not affect the identification of past observations.

While the first property is shared by ERW definition, the other two represent an attempt to overcome two weaknesses of their crisis indicator. Indeed, the time invariance of the crisis threshold can constitute an undesirable feature if the EMP index presents some clusters of high volatility. These drive up the threshold, and render the index insensitive to those speculative pressures that occur during period of low structural volatility. Thus, instead of taking sample mean and standard deviation over the whole sample, moving average and standard deviation can be employed, computed over a period that is long enough to detect structural breaks in volatility from periods of increasing pressure. However, this possible approach suffers from two main shortcomings: first, it shrinks the sample size and information is lost, as a centred moving average is a function of lags and leads and thus missing values are generated for the initial and final observations. Second, it is not consistent with the third property, as the classification of an observation is still dependent on future values.

At least two reasons can be advanced to justify the desirability of the independence of the identification of past observations from future data, a property that is satisfied by the definitions employed by Frankel and Rose [1996] and Kumar et al. [1998]. First, an instrumental one, as the dependence of past identifications on future observations gives rise to a never-ending process of data revision,[16] while a second reason relates to the analytical perspective from which currency crises are observed. While subsequent data are useful to put the conditions prevailing on the exchange market in an historical perspective, these should not be relevant in a more policy-oriented approach, that is more interested on the evaluation that economic agents give of current events.

We thus propose the following crisis detector, where the crisis threshold changes on an yearly basis: the threshold for the observations belonging to the year *t* is defined as the 95th percentile of the distribution of the EMP index over the years (*t*-s, *t*-1), where *s* is the year length of a time interval that is considered to be well suited to reflect structural breaks in the volatility of the index. In a first application to our dataset, we take a 10-year interval. As we are aware that this definition is highly *data demanding*, as its strict application would remove 120 monthly observations from the data set, it can be amended taking the 95th percentile of the first ten years as the threshold for those same years.[17]

In addition to the three properties presented above, the proposal we advance to the definition of a crisis threshold has the merit to avoid an arbitrary pre-specification of the number of crisis episodes, as it would be obtained if we set the threshold at the 95th percentile of the whole sample distribution.

Table [4] displays a comparison between ERW IC and our crisis indicator. The first column are reported the "common" crises identified by both ICs. In the second column, the number of crises recognized by the ERW index but not with

[16] Appendix A5 provides two examples of how the set of crisis episodes changes as we modify the time frame of the analysis.
[17] We are aware that this violates the third proposed property of the crisis index, but this amendment was rendered necessary by the willingness to compare the results obtained from this definition with those derived from ERW.

our IC, and the opposite in the third. Finally the fourth and the fifth columns reports respectively the number of the period with tranquillity for both ICs and the periods analysed.

It is worth noting that our index reveals a smaller number of crisis episodes for developed countries, the opposite is true for developing ones. On average, our IC identifies as crises ten more observations for each country than ERW IC does. While ERW IC signals 16.86 crisis episodes, our IC reveals 27.21 episodes. Even though these results deserve a more thorough scrutiny, we could assert that our IC has a greater capability to signal those (relatively) minor crisis episodes affecting emerging economies that ERW IC fails to reveal, as they are *hided* by the most violent crises that hit these countries.

Table 4. Comparison between ERW IC and our IC based on the 95th percentile rule

Developed Countries

Country	CC	CN	NC	NN	total obs
Canada	19	7	3	366	395
Denmark	18	1	1	327	347
Finland	16	5	5	321	347
France	16	7	3	321	347
Germany	15	8	0	324	347
Italy	18	5	0	324	347
Japan	17	1	6	371	395
Netherlands	17	5	0	325	347
Spain	13	7	1	326	347
Sweden	16	0	3	328	347
United Kingdom	21	9	0	365	395
Average	**16.91**	**5.00**	**2.00**	**336.18**	

Developing and Emerging Countries

Country	CC	CN	NC	NN	total obs
Argentina	19	2	4	370	395
Chile	10	3	2	380	395
Colombia	13	2	33	347	395
Indonesia	16	1	8	370	395
Korea	17	0	6	372	395
Malaysia	19	0	5	371	395
Mexico	19	4	14	358	395
Peru	10	3	14	368	395
Philippines	17	2	8	368	395
Singapore	17	2	5	371	395
Thailand	12	0	19	364	395
Turkey	18	2	14	313	347
Uruguay	14	0	18	363	395
Venezuela	13	1	17	364	395
Average	**15.29**	**1.57**	**11.93**	**362.79**	

4 Conclusions

This paper attempted to provide a detailed description of the issues that arise from the adoption of the EMP index to study currency crises. Although this index represents a step forward from previous studies that relied on exchange rate movements alone to identify speculative pressure on a currency, it presents some problematic characteristics that deserve a thorough scrutiny.

Four *fine tuning* issues related to the index construction were reported, regarding: the weighting scheme adopted to combine the three underlying variables, the suitability of logarithmic differences to compute the percentage change of the exchange rate, the theoretical issues that arise from the inclusion of net rather than gross reserves and finally the selection of an appropriate reference country. Whenever possible, we have indicated a rank in the possible alternatives, or the criteria that should inform the choice. Since the EMP, as we have rather extensively argued, is notably sensitive to these seemingly minor choices, these should be explicitly stated and described, and the robustness of the results of following econometric analysis should be carefully assessed. Furthermore, we have shown that differences in the structure of the economic system, such as those observed in developing countries, strongly affect the consistency of the assumptions and, consequently, the results that can be achieved. Even the widely accepted use of logarithms can quite significantly distort the EMP index for these countries. This simple example is revealing of how an analytical tool that has been first created for OECD countries is not well suited for a straightforward application to developing countries.

Finally, the shortcomings of existing EMP-based crisis definitions, were reported. A different IC has been proposed, through the selection of three desirable properties: spatial and time relativity, and an adaptive mechanism to classify past observations. Even though our results deserve a more thorough inspection, we could assert that our IC has a greater capability to signal those (relatively) minor crisis episodes affecting emerging economies that ERW IC fails to reveal, as they are *shaded* by the most severe crises that hit these countries.

This paper suggests that existing EMP-based crisis indicators may not be well suited for the study of currency crises in developing countries, as they lead to a questionable selection of crisis episodes, and suggest that developing countries are much less crisis-prone that developed countries. In order to test the actual relevance of this intuition, we intend to deepen this research in two complementary directions: first, to understand *punctually* and clarify the differences between ERW IC and our proposed crisis selection rule; second, to build different crisis sets according to diverging crisis selection rule, and to employ these sets as regressands in an econometric analysis – a logit or a duration model - on currency crises determinants.

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Appendix

A1 – Outline of the dataset

We have collected monthly data for a sample of 26 countries over the period 1970-2002. The sample is made up of ten European countries (Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, Turkey and the United Kingdom), seven Latin American (Argentina, Chile, Colombia, Mexico, Peru, Uruguay and Venezuela), seven Asian (Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea and Thailand), the United States of America and Canada. For the European countries that have adopted the euro, the series are interrupted in December 1998.

The data source is given by IMF's International Financial Statistics, IFS. The data include:

- monthly average of the nominal exchange rates, line rf IFS, with three reference countries (Germany, Japan, US);
- short term deposit interest rate, line 60b IFS;[18]
- total reserves excluding gold, line 11.d IFS;
- restricted money base, line 34 IFS;
- IMF credit and loans outstanding, line 2tl IFS.

If not otherwise specified, the EMP is computed under the following default choices: the US is the reference country, the series are weighted by the reciprocal of their sample standard deviation, exchange rate variations are computed as logarithmic differences, reserves are considered gross of the liabilities towards the IMF. A crisis is detected – in accordance with ERW – whenever the EMP is above its mean plus 1.5 times its standard deviation.

A2 – Contraction Mappings and variance of the transformed distribution

A function g is said to be a Lipschitz function over the domain $D \subseteq R$, if it exists $c > 0$ such that:

$$|g(x) - g(y)| \leq c|x - y| \text{ for every } x, y \in D \subseteq R.$$

If $0 < c < 1$, then g is said to be a contraction mapping over the domain D.

We want to show that the variance of a distribution X belonging to D is greater than the variance of the distribution that is obtained applying the function g to X. The above definition of a contraction mapping implies that:

$$|g(X) - g[E(X)]| \leq c|X - E(X)|$$

$$\{g(X) - g[E(X)]\}^2 \leq c^2[X - E(X)]^2$$

Taking the expected value of both sides, we obtain:

$$E\{\{g(X) - g[E(X)]\}^2\} \leq c^2 E\{[X - E(X)]^2\}$$

The r.h.s. is the variance of the X distribution, V(X). The l.h.s. can be rewritten adding and subtracting the mean of the transformed distribution, i.e. $E[g(x)]$, within the inner parenthesis.

$$E\{\{g(X) - g[E(X)]\}^2\} = E\{\{g(X) - E[g(x)] + E[g(x)] - g[E(X)]\}^2\}$$

$$= E\{\{[g(X) - E[g(X)]\}^2\} + E\{\{E[g(X)] - g[E(X)]\}^2\} + + 2E\{\{g(x) - E[g(x)]\}*E\{g(x) - g[E(x)]\}\}$$

$$= V[g(X)] + \{E[g(X)] - g[E(X)]\}^2$$

as $E\{\{g(x) - E[g(x)]\}*E\{g(x) - g[E(x)]\}\} = 0$ and $E\{\{g(X) - E[g(X)]\}^2\} = V[g(x)]$, the variance of the transformed distribution. This implies:

$$V[g(X)] + \{E[g(X)] - g[E(X)]\}^2 \leq c^2 V(X)$$

[18] If unavailable, we have the three months lending rate; for the US, we have used the Treasury Bill Rate.

that is:

$$V[g(X)] \leq c^2V(X) - \{E[g(X)] - g[E(X)]\}^2 \leq c^2 V(X)$$

As g is a contraction mapping, i.e. $0 < c < 1$, then $V[g(x)] < V(X)$. Q.E.D.

A3 - Proof of Proposition [1]

According to the definition of exchange market pressure, and assuming an identical set of weights in the three indexes, we have:

$$EMP_{AC} = \alpha\left(\frac{\Delta E^{AC}_t}{E^{AC}_t}\right) + \beta\Delta(i^A_t - i^C_t) + \gamma\Delta(r^C_t - r^A_t)$$

$$EMP_{AB} = \alpha\left(\frac{\Delta E^{AB}_t}{E^{AB}_t}\right) + \beta\Delta(i^A_t - i^B_t) + \gamma\Delta(r^B_t - r^A_t)$$

$$EMP_{BC} = \alpha\left(\frac{\Delta E^{BC}_t}{E^{BC}_t}\right) + \beta\Delta(i^B_t - i^C_t) + \gamma\Delta(r^C_t - r^B_t)$$

Where the superscripts denote the country to which the variable is referred, and E^{AB} is the value of currency B expressed in units of currency A. We want to show that the hypothesis of identity of weights implies that the index satisfies a transitive property, that is to say $EMP_{AC} = EMP_{AB} + EMP_{BC}$. The r.h.s of this identity is given by:

$$EMP_{AB} + EMP_{BC} = \alpha\left(\frac{\Delta E^{AB}_t}{E^{AB}_t}\right) + \beta\Delta(i^A_t - i^B_t) + \gamma\Delta(r^B_t - r^A_t) + \alpha\left(\frac{\Delta E^{BC}_t}{E^{BC}_t}\right) + \beta\Delta(i^B_t - i^C_t) + \gamma\Delta(r^C_t - r^B_t)$$

$$EMP_{AB} + EMP_{BC} = \alpha\left[\left(\frac{\Delta E^{AB}_t}{E^{AB}_t}\right) + \left(\frac{\Delta E^{AC}_t}{E^{AC}_t}\right)\right] + \beta\Delta(i^A_t - i^C_t) + \gamma\Delta(r^C_t - r^A_t)$$

As we have assumed that $\left(\frac{\Delta E^{AB}_t}{E^{AB}_t}\right) = \ln\left(\frac{E^{AB}_t}{E^{AB}_{t-1}}\right)$, we have:

$$\alpha\left[\left(\frac{\Delta E^{AB}_t}{E^{AB}_t}\right) + \left(\frac{\Delta E^{AC}_t}{E^{AC}_t}\right)\right] = \alpha[\ln\left(\frac{E^{AB}_t}{E^{AB}_{t-1}}\right) + \ln\left(\frac{E^{AC}_t}{E^{AC}_{t-1}}\right)]$$

$$= \alpha\ln\left[\left(\frac{E^{AB}_t}{E^{AB}_{t-1}}\right)\left(\frac{E^{AC}_t}{E^{AC}_{t-1}}\right)\right]$$

$$= \alpha\ln\left[\frac{E^{AB}_t * E^{AC}_t}{E^{AB}_{t-1} * E^{AC}_{t-1}}\right]$$

$$= \alpha\ln\left(\frac{E^{AC}_t}{E^{AC}_{t-1}}\right) = \alpha\left(\frac{\Delta E^{AC}_t}{E^{AC}_t}\right)$$

As $E^{AB}_t * E^{BC}_t = E^{AC}_t$. Hence:

$$EMP_{AB} + EMP_{BC} = \alpha\left(\frac{\Delta E^{AC}_t}{E^{AC}_t}\right) + \beta\Delta(i^A_t - i^C_t) + \gamma\Delta(r^C_t - r^A_t) = EMP_{AC} \quad \text{Q.E.D.}$$

A4 - Regression output

	Korea		Indonesia		Malaysia		Philippines		Singapore		Thailand	
Distance	0.543		0.729		0.730		0.673		0.941		0.793	
constant	-0.0010	-0.0007	-0.0002	-0.0002	-0.0008	-0.0009	0.0008	0.0006	-0.0014	-0.0015	-0.0008	-0.0008
	(-1.09)	(-1.10)	(-0.15)	(-0.30)	(-0.90)	(-1.39)	(0.90)	(1.02)	(-1.55)	(2.01)	(-0.92)	(-1.26)
EMP_{XJ}	0.9539		0.7229		0.5983		0.7375		0.3217		0.7051	
	(77.51)		(31.04)		(23.96)		(41.49)		(11.51)		(35.41)	
$EMP_{XJ} + EMP_{JUS}$		0.9612		0.8030		0.7243		0.7911		0.4706		0.7653
		(107.37)		(48.35)		(37.46)		(57.76)		(18.46)		(51.25)
Observations	394	394	394	394	394	394	394	394	394	394	394	394
Adjusted R^2	0.939	0.967	0.710	0.856	0.593	0.781	0.814	0.895	0.251	0.464	0.761	0.870

The regressions are estimated with OLS estimators. T-ratios are shown in parenthesis. Distance is computed according to [5].

A5 - Time horizon of the analysis (or How many crises hit Italy and Sweden in the 70s?*)*

The value of the crisis threshold – according to the definition proposed by ERW - depends on the set of observations that are included in the sample, and thus on the time frame that has been chosen for the analysis. Moreover, the time frame influences the index itself, when the weights of its component are determined in order to equalize their conditional volatility. This happens because the sample variance of the three components is clearly dependent on time. Both these factors imply that the set of periods that are identified as crises over a given subset of the time frame of the analysis depends on the time frame itself.
Suppose that we possess observations from time t=0 to time t=t for a certain country. We compute the EMP index for the time interval [0, t], EMP_t and we define the threshold T_t as a linear combination of the sample mean and sample standard deviation of the index, computed over the period [0, t]. This gives us a set of crises period, that we call $C[0, t]_{tt}$. The first subscript refers to the period over which the weights of the EMP are computed, while the second signals the period over which the threshold is determined. Formally, we have:

$$C[0, t]_{tt} = \{t \in [o, t] \mid EMP_t > T_t\}$$

Imagine then that observations for later periods became available, and we can thus update the analysis up to time s > t. An updated index EMP_s and threshold T_s are determined, as the sample mean and standard deviation of the EMP index and of its components are now computed over the interval [0, s]. A new set of crises for the period [0, t] is then defined. It is given by:

$$C[0, t]_{ss} = \{t \in [o, t] \mid EMP_s > T_s\}$$

A priori, it is not possible to make any statement about the relation that exists between the two sets $C[0, t]_{tt}$ and $C[0, t]_{aa}$. The computation of the relevant sample mean and variances over the extended period [0, s] can significantly change the set of observations that are identified as crises in the interval [0, t], and the revised set can be either wider or smaller than the original one.

To show how the choice of the time frame of the analysis can deeply impact on the identification of crises episodes over a given time interval, we try to assess how many crises hit Italy and Sweden in the ‘70s. The EMP for both countries is constructed taking Germany as the reference country, computing the rate of change of the nominal exchange rate as $(E_t-E_{t-1})/E_{t-1}$ and taking foreign reserves net of liabilities towards the IMF. The weights are chosen in order to equalize the conditional volatility of the three components. Then, a crisis is signalled when the EMP is above its sample mean plus 1.5 times its standard deviation.

Table [A1] Crises set for Italy and Sweden in the ‘70s.

	Italy										
	79m12	81m12	83m12	85m12	87m12	89m12	91m12	93m12	95m12	97m12	98m12
1970m2	1	1	1	1	1	1	1	1	1	1	1
1971m5	1	1	1	1	1	1	1	1	1	1	1
1972m1						1	1				
1972m6				1	1	1	1		1	1	1
1973m2	1	1	1	1	1	1	1	1	1	1	1
1973m3	1	1	1	1	1	1	1	1	1	1	1
1973m6	1	1	1	1	1	1	1	1	1	1	1
1973m7	1	1	1	1	1	1	1	1	1	1	1
1976m1					1	1	1	1	1	1	1
1976m2	1	1	1	1	1	1	1	1	1	1	1
1976m3	1	1	1	1	1	1	1	1	1	1	1
1976m4			1	1	1	1	1	1	1	1	1
1976m9						1	1				1
1977m12	1	1	1	1	1	1	1	1	1	1	1
1978m10	1	1	1	1	1	1	1	1	1	1	1
1979m9						1	1				1
1979m12	1					1	1		1	1	1
total	10	10	11	12	13	17	17	12	14	14	16
threshold	0.0451	0.0422	0.0402	0.0383	0.0366	0.0347	0.0334	0.0357	0.0368	0.0356	0.0352

Sweden

	79m12	81m12	83m12	85m12	87m12	89m12	91m12	93m12	95m12	97m12	98m12
1970m2	1	1	1	1	1	1	1	1	1	1	1
1971m5	1	1	1	1	1	1	1	1	1	1	1
1972m6	1	1	1	1	1	1	1				
1973m2	1	1	1	1	1	1	1	1	1	1	1
1973m5						1	1				
1973m8	1	1	1	1	1	1	1				
1974m4	1	1	1	1	1	1	1				
1976m3						1	1				
1977m9	1	1	1	1	1	1	1	1	1	1	1
1977m12	1	1	1	1	1	1	1				
1978m10	1	1	1	1	1	1	1	1	1	1	1
total	9	9	9	9	9	11	11	5	5	5	5
threshold	0.0348	0.0359	0.0399	0.0376	0.0368	0.0350	0.0336	0.0433	0.0432	0.0421	0.0418

The change in the composition of the crises set can be partly understood if we look at how the threshold evolves over time. For Italy, the variance of the EMP index is significantly lower in the 80s than in the 70s, hence the threshold declines as the analysis progressively includes that decade, and this implies that the dimension of the increases. Swedish data follow a similar pattern, although the decline in the variance of the EMP begins some years later than in the Italian case. For Sweden, and to a lesser extent for Italy, the break out of a financial crisis in September ’92 changes markedly the level of the threshold. That crisis rises the variance of the index significantly, and hence reduces the crises set for the ‘70s: the number of crises episodes decreases from eleven to five if the end of the analysis passes from December ’91 to December ’93.

However, the change in the threshold tells only a part, though often the main one, of the story. The crises set is affected also by the change in the underlying EMP index, as a shift in the period of reference leads to a change in the sample variance of its components and thus to modified weights. Hence, the change in the crises set can be decomposed in a component that is attributable to a change in the threshold, and in a component due to the variation of the EMP index.

Formally, we have:[19]

$$C_{ss} - C_{tt} = ½ [(C_{ss} - C_{st}) + (C_{ts} - C_{tt})] + ½ [(C_{ss} – C_{ts}) + (C_{st} - C_{tt})]$$

The first term on the right hand side represents the change in the crises set that is due to a change in the threshold, while the second term gives the change that is determined by a change in the EMP.

If we consider the crises set C[70m1, 79m12] and we set t=91m12 and s=93m12, we have the following values for Italy: $C_{ss} = 12$, $C_{tt} = C_{st} = 17$, $C_{ts}=13$. Applying the decomposition rule, we find that the change in the threshold drives almost the whole decrease of the crises set: 4.5 out of 5, with the remaining 0.5 explained by the modified EMP index.

The same decomposition on the Swedish data - $C_{ss} = 5$, $C_{tt} = 11$, $C_{st} = 8$ and $C_{ts}=9$ – reveals that in this case the greatest part of the downward variation in the crises set is given by the change in the EMP index: 3.5 out of 6 unit decrease.

The next table shows how the Italian and the Swedish cases are just two examples that are useful to highlight the great sensitivity on the analyses time frame that characterizes the identification of the crises set through a critical threshold that depends on the sample values of the EMP index.

A quick look at the table reveals how the crises set for the 70s evolves over time. The last three columns show how the change in the dimension of the crises set from December ’79 to December ’98 is driven by threshold and EMP changes.

[19] We have omitted the time period whose crises set we want to identify to simplify the notation a bit.

Table [A2] Dimension of the crises set in the 70s over various time frames of analysis

	upper limit of the analysis time frame						crises set				
	79m12	83m12	87m12	91m12	95m12	98m12	min	max	C_{98}-C_{79}	thresh.	EMP
Canada	9	9	9	9	9	9	9	9	0	0.0	0.0
Denmark	30	32	36	38	37	38	30	38	8	7.5	0.5
Finland	9	10	9	10	8	9	8	10	0	0.0	0.0
France	8	11	13	13	14	15	8	15	7	6.5	0.5
Germany	4	5	5	5	5	5	4	5	1	-3.0	4.0
Italy	10	11	13	17	13	16	10	17	6	6.0	0.0
Netherlands	10	12	12	13	13	15	10	15	5	6.5	-1.5
Spain	8	9	11	11	11	11	8	11	3	2.5	0.5
Sweden	9	9	9	11	5	5	5	11	-4	-2.5	-1.5
Turkey	8	8	9	9	5	5	5	9	-3	-2.5	-0.5
United Kingdom	10	11	13	15	15	17	10	17	7	4.0	3.0
Argentina	8	6	6	2	3	3	2	8	-5	-9.5	4.5
Brazil	*7*	*3*	*2*	*1*	*1*	*1*	*1*	*7*	-6	*-3.5*	*-2.5*
Chile	28	28	29	29	29	29	28	29	1	0.0	1.0
Colombia	1	1	1	1	1	1	1	1	0	0.0	0.0
Indonesia	16	16	18	18	18	18	16	18	2	-1.0	3.0
Japan	8	7	9	7	9	9	7	9	1	2.0	-1.0
Korea	7	5	7	7	7	4	4	7	-3	-5.0	2.0
Malaysia	9	6	6	6	7	5	5	9	-4	-5.0	1.0
Mexico	7	2	2	2	2	2	2	7	-5	-3.5	-1.5
Peru	16	15	14	12	12	12	12	16	-4	-4.0	0.0
Philippines	8	4	3	3	2	2	2	8	-6	-3.0	-3.0
Singapore	6	6	5	5	5	4	4	6	-2	-1.0	-1.0
Thailand	4	3	4	3	3	2	2	4	-2	-18.5	16.5
Uruguay	17	17	15	15	15	15	15	17	-2	-1.5	-0.5
Venezuela	2	2	4	2	1	1	1	4	-1	-27.0	26.0