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SPECULATIVE CURRENCY ATTACKS: ROLE OF INCONSISTENT MACROECONOMIC POLICIES AND REAL EXCHANGE RATE OVERVALUATION

Alfredo Pistelli

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SPECULATIVE CURRENCY ATTACKS: ROLE OF INCONSISTENT MACROECONOMIC POLICIES AND REAL EXCHANGE RATE OVERVALUATION

Alfredo Pistelli
Economista Senior
Gerencia de Análisis Internacional
Banco Central de Chile

Resumen

Este trabajo presenta un análisis crítico de Kaminsky y Reinhart (1999) (KR), probablemente el trabajo empírico más destacado sobre causas y predicción de crisis cambiarias. Se identifican problemas de medición y metodología y, una vez corregidos, se propone un indicador líder de crisis. Este corresponde a un indicador multivariable que está inspirado no sólo en el enfoque teórico tradicional que destaca el rol de inconsistencias entre políticas macroeconómicas como causante de crisis cambiarias, sino también en el enfoque que recalca la importancia de tradeoffs entre las distintas opciones de política que enfrentan las autoridades económicas. Comparado con un indicador agregado de los mejores seis indicadores individuales de KR, el indicador propuesto tiene menores errores de predicción y anticipa una mayor proporción de crisis. El indicador líder propuesto incluye las siguientes variables: desviación del stock actual de reservas internacionales de una estimación de demanda por reservas internacionales; el crecimiento real del crédito doméstico; la razón crédito doméstico a M2; y el comportamiento del tipo de cambio real y de la producción industrial como medida de sobre-valoración del tipo de cambio real.

Abstract

This paper provides a critical analysis of Kaminsky and Reinhart (1999) (KR), perhaps the most prominent empirical paper on causes of currency crises. After dealing with problems present in this paper, it proposes an aggregate leading indicator of crisis. The proposed indicator performs better than a composite index based on the best six individual indicators of KR, both in terms of accuracy and predictive capacity, and represents a unified version of the currency crises approach that emphasizes the role of inconsistent macroeconomic policies as an explanation of currency crises, and the approach that emphasizes the role of tradeoffs among policymakers decisions as the main cause of these crises. Variables included in the proposed leading indicator are: the deviation of the actual stock of international reserves from an estimated demand for international reserves; the real growth of domestic credit; the ratio of domestic credit to M2; and the behavior of both the real exchange rate and industrial production as a measure of overvaluation of the real exchange rate.

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E-mail: apistelli@bcentral.cl.

I. Introduction

Numerous theoretical models have been used to explain the causes and origins of speculative attacks and currency crises. First-generation models (Krugman 1979; Flood and Garber 1984; Blanco and Garber 1986) emphasize the role of inconsistencies between fiscal, monetary and exchange-rate policies. In these models the presence of inconsistent policies generates a speculative attack against the local currency, and pushes the economy into a crisis. Government decisions are state-invariant and the degree of severity of these inconsistencies will determine the timing of the crisis.

Second and third-generation models suggest that even in the presence of consistent macroeconomic policies an economy can suffer a speculative currency attack. Second-generation consider government decisions as state-dependent and emphasize the role of policymaker's preferences. The option of abandoning a fixed exchange rate regime may be an ex-ante optimal decision for the policymaker, considering that economic authorities face tradeoffs. An example of these models is Obstfeld (1996), who emphasizes the output-inflation (labor market disequilibrium-inflation) tradeoff. For instance, in the presence of a high unemployment, the authority may consider it appropriate to abandon the fixed exchange regime in order to implement an expansionary monetary and fiscal policy. Given the existence of this kind of disequilibrium a speculative attack becomes more likely, but, in the author's view, the timing of such an attack is uncertain because of the existence of multiple possible equilibriums. Third-generation models emphasize the role of moral hazard and imperfect information, highlighting the importance of banking problems and over-borrowing as determinants of a speculative attacks and currency crisis. Diaz Alejandro (1985) and Velasco (1987) model banking problems as determinants of currency crises, whereby Central Banks financing of the rescue of the financial system could be inconsistent with a managed exchange rate regime. These models suggest that the growth of banking credit may play an important role in speculative currency attacks.

More recent models highlight the relevance of capital flows as possible source of instability (Calvo, 1998, and Calvo, Izquierdo, and Talvi, 2003). A sudden stop of capital inflows can generate a liquidity crisis and trigger a significant depreciation of the domestic currency. Variables such as foreign interest rates, the amount of external debt and the composition of foreign assets and liabilities might play an important role.

Empirically, are currency crises predictable? Which indicators best anticipate these crises? Several models have tried to answer these questions but perhaps the most prominent is the one proposed by Kaminsky, Reinhart and Lisondo (1998) and Kaminsky and Reinhart (1999)[1]. The latter presents some empirical regularities for currency and

[1] According to the Social Citation Index this paper has 94 citations on Economic Journals. Also it is ranked 14 among the most downloaded AER papers on the internet, based on the information provided by Econpapers website. Since 1999 IMF's staff has been tracking several Early Warning System (EWS)

banking crisis, comparing the behavior of a set of variables around episodes of crises with their values during "tranquil" periods (months that are not within the 24 month before a crisis). The authors implement a "signal" approach to test the predicting power of individual indicators.

The objective of this paper is to address some problems that are present in Kaminsky and Reinhart's (KR) paper and propose an aggregate leading indicator of crisis. The proposed indicator represents a unified version of the currency crises approach that emphasizes the role of inconsistent macroeconomic policies as an explanation of these crises, and the approach that emphasizes the role of tradeoffs among policymaker's decisions as the main cause of these crises.

The structure of this paper is as follows. The second section presents methodological problems present in KR and proposes solutions. Considering them, the third section analyzes the performance of additional indicators and compares their performance with those analyzed by KR. The forth section presents two theoretical approaches to explain the causes of speculative currency attacks and currency crises, and recommends multivariate indicators that are consistent with each of them. The fifth section presents an aggregate indicator of crisis based on the indicators proposed in the previous section. The performance of the proposed crisis indicator is compared with the performance of an aggregate indicator that includes the best six indicators according to KR. The sixth section presents the conclusions.

II. Methodology and Problems

Kaminsky and Reinhart (1999) analyze the links between banking and currency crises. First they present some empirical regularity and later they test the performance of several indicators in terms of their capacity to predict crises. In this section I will describe the methodology used by the authors to evaluate the predicting capacity of individual indicators and later I will explain the main problems with the measures used by them and the problems with the methodology.

1. Methodology

Kaminsky and Reinhart propose monitoring several indicators that show unusual behavior previous to a crisis. An indicator is considered to be a good predictor or leading indicator of a crisis if the indicator shows a behavior significantly different ahead of a crisis compared with "normal" periods. In order to identify which indicators are good predictors, the authors propose a nonparametric approach based on signals. Indicators issue a signal when economic variables deviate from their "normal" level beyond a

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models, among which is KR. Berg, Borensztein and Patillo (2004) compare the performance of these models and finds that a model based on KR performs the best.

certain threshold value. Signals are good or false. Good signals are those issued ahead of a crisis within some specific period of time (24 months). A false signal or noise is a signal issued out of the specified period. The goal is to find indicators that issue lots of signals ahead of crises, but few during "normal" periods.

In order to implement this methodology we need to establish: (1) the conditions that determine the onset of a crisis; (2) the length of the pre-crisis signal window; and (3) the most appropriate threshold value for each indicator. To identify the date of a crisis, the authors use an index of pressure on the currency market. This index is a weighted average of monthly percentage depreciations in the exchange rate and monthly percentage declines in reserves. A currency crisis occurs when this index exceeds its mean by more than three standard deviations. The mean and standard deviation are country specific. The signal horizon considered by the authors is 24 months ahead of a crisis. The length of the window takes into account that economic authorities need enough time to implement pre-emptive measures ahead of a crisis. The threshold value is defined in relation to percentiles of the distribution of the observations for each indicator. The optimal percentile is peaked such that a noise-to-signal ratio is minimized. In order to understand what the noise-to-signal ratio is we can use the following matrix:

	Crisis within 24 months	No Crisis within 24 months
Signal was issued	A	B (type I error)
No Signal was issued	C (type II error)	D

A, B, C and D are the number of observations into each category (A+B+C+D is the total number of observations). The noise-to-signal is equal to [B/(B+D)]/[A/(A+C)]. This is the same than P(signal/no crisis within 24 months) / P(signal/crisis within 24 months) or $\beta/(1-\alpha)$, where β is the size of type II error and α is the size of the type I error.

For each country the percentile is the same, but the threshold value is country-specific. The motivation of having different threshold values for each country is to take into account that risk perception is not the same in all countries, since it depends on each country's past experience. For example, for some countries a decline of 10% in stock prices is not unusual, while in other more stable countries this decline is considered unusual and generates an increase in the risk perception.

Kaminsky and Reinhart's paper analyzes the individual performance of fifteen indicators using monthly data from 1970 to 1995. Except for the interest-rate variables, the deviations of the real exchange rate from trend, the proxy for excess real M1 balances, and the lending/deposit interest-rate ratio, which are in levels, the paper focuses on the 12-month percent changes of the remaining 10 variables: M2 multiplier, domestic credit to GDP, M2 to international reserves, bank deposits, exports, imports, terms of trade, international reserves, output and stock prices.

2. Problems with measures and methodology

2.1 Problem with the use of 12-month changes

Kaminsky and Reinhart (1999) use monthly data and, as just mentioned, most of the analyzed variables are 12-month changes. The problems that arise from using 12-month changes are mainly three: (1) there is no theoretical justification for using 12-month transformations; (2) we cannot reach conclusions about the behavior of the level of a variable by looking only at its 12-month variation; and (3) not only changes of variables should affect the probability of having an economic crisis, but also how "high" or "low" the level is.

First, economic theory does not consider 12-month changes when explaining the onset or causes of a crisis. When explaining the causes of crisis level measures are considered (i.e., level of international reserves, international reserves/GDP, international reserves/imports, international reserves/M2 and others).

Second, even if the variables considered have some theoretical justification we cannot say much about the behavior of the level of a variable ahead of a crisis by looking only at the behavior of its 12-month variation since the use of 12-month changes introduces a great deal of serial correlation to the data. This means that when we analyze the behavior of the 12-month change of an economic indicator at the onset of a crisis it captures not only the change in the level of the variable during those specific months but also its behavior is affected by how the level had behaved during the previous year. For instance, we can get a 12-month decline in international reserves during the months ahead of a crisis that coincides with an increase in the level of international reserves during the same period. This may be the case if there was a significant increase in the level of international reserves during the same months of the previous year. If this happens the level of international reserves will be low compared with previous year but this does not mean that international reserves have been falling in recent months.

Figure 1 compares the behavior of the level of a variable and the 12-month change after a change in trend at month T. Three cases are considered: (a) the variable continues growing after time T but at a lower rate, (b) the variable stops growing at time T and stays flat afterwards, and (c) the variable starts falling after month T. In all three cases the 12-month change transformation shows the same trend. Therefore, if we only look at the behavior of the 12-month change we cannot conclude anything about the behavior of the level of the variable.

FIGURE 1: Behavior of Level and 12-month change

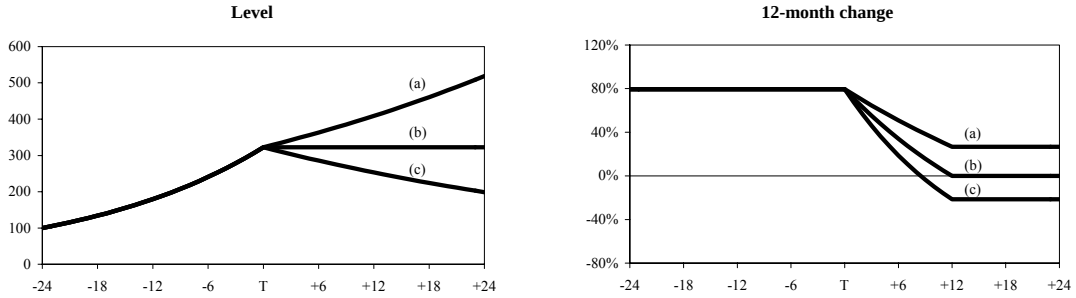
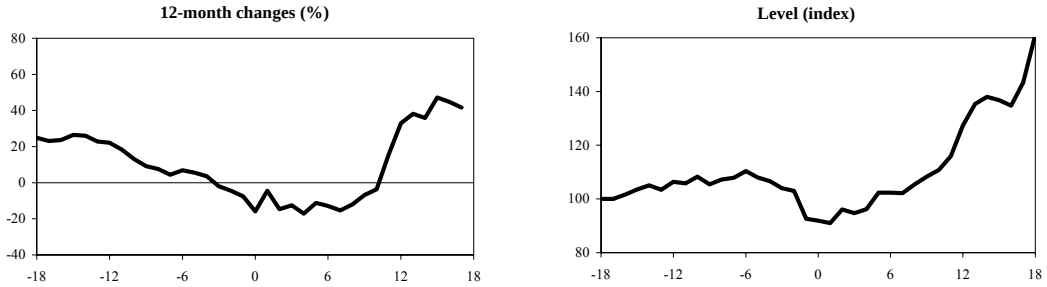


Figure 2 presents some empirical evidence about the situation just described. This figure depicts the average behavior of the 12-month change and the behavior of an index of the stock of international reserves for group of twenty seven currency crisis. The horizontal axes represent the number of months before (with a negative sign) and after the crisis.

FIGURE 2: International Reserves – Level and 12-month change
(Average data for 27 currency crises)



As shown by the figure, for most of the period ahead of the crisis, the deceleration shown by the 12-month change is not reflected in any decline in the stock of international reserves. In fact, the stock of international reserves keeps growing for most of the 18 months ahead of a crisis. The average monthly change for the 24 months ahead of a crisis is 0.3% and it only shows a declining trend 5 months ahead of the crisis. This behavior confirms that we should not trust only on the 12-month change if we want to know what is happening to the level of a variable during the months ahead of a crisis.

How important is this problem within the variables used in the paper? The problem described above becomes evident when we look at the correlation between levels and 12-month changes for some of the variables used by Kaminsky and Reinhart (1999). Table 1 presents the average correlation for 18 countries. The correlation is low for most of the variables, and is especially low for international reserves. The average value for the correlation coefficient of the level of international reserves and the 12-month change of this same indicator is almost zero (0.01).

Ignoring these problems, the authors draw misleading conclusions from looking at the 12-month changes and suggesting that the change in levels, or the level itself, goes in the same direction. An example of this problem is the following statement based on 12-month percent changes of the industrial production index: "The deterioration of the terms of trade, the overvaluation of the currency, and the weakening export performance are reflected in a marked slowing in economic activity and a **decline in output** prior to both crises." However, when one looks at the 76 currency crises episodes considered by Kaminsky and Reinhart one finds that in 49 of these episodes there is no decline in annual real GDP at all prior to or at the onset. Even in the remaining cases for which data is available for all pre-crisis period, we find that the industrial production index declines only after the crisis in almost half of the cases.

TABLE 1: Correlation between Level and 12-month change
(monthly data: Jan 1970 – Dec 1995)

	Net Int Res (US$)	Exports (US$)	Ind. Prod. (Index)	M2/M0 (ratio)	NIR/M2 (ratio)
ARG	-0.10	0.27	0.40	0.83	0.00
BOL	0.15	0.36	0.35	0.27	0.54
BRA	0.10	0.07	0.30	0.17	0.50
CHI	-0.15	0.02	0.26	0.80	0.12
DEN	0.03	-0.02	0.18	0.53	0.52
FIN	0.10	0.03	0.10	0.18	0.67
IND	-0.24	0.15	0.29	-0.31	0.25
MAL	0.08	-0.02	0.16	0.33	0.79
MEX	0.18	-0.04	-0.06	0.36	0.47
NOR	-0.18	0.17	0.01	-0.14	0.35
PER	0.07	0.29	0.51	0.58	0.30
PHI	0.03	0.35	NA	0.59	0.52
SPA	0.00	-0.01	-0.14	0.25	0.45
SWE	-0.10	0.04	0.47	0.42	-0.06
THA	-0.01	-0.11	NA	-0.51	0.64
TUR	0.23	-0.17	0.50	0.39	0.31
URU	-0.07	0.19	0.38	0.66	0.28
VEN	0.06	0.44	0.19	0.67	0.77
Average	0.01	0.11	0.24	0.34	0.41
Median	0.03	0.06	0.27	0.37	0.46

Other example of misleading conclusions is "The **beginning of the recession** is also reflected in the stock market, which **collapses the year before the crisis**: this collapse is also apparent in other asset markets, most notably real estate." Again, the authors mention a recession ahead of the crisis, and also say that the stock market collapses, clearly suggesting a significant drop in level. Their statements are based on the behavior of the 12-month change of the stock price index. However, as shown by Figure 3, when we look at the behavior of the level of the index for a group of 27 currency crises, we find that during the months ahead of a crisis, stock prices grow very much like the growth

during tranquil months. The level drops 2 months ahead of the crisis (1% and 4%) but this is nothing compared to the growth shown by the index during the rest of the months of the year before the crisis. Also, there is a rapid reversal of this drop after the crisis.

The third and last problem related with the use of 12-month changes as indicators of crises is that not only the change of the level should affect how vulnerable a country is to a crisis, but also the actual level. At least intuitively, both level and recent behavior of the level should influence the probability of crises. For instance, the effect on the probability of crisis of having falling international reserve should not be the same if a country's level of international reserves is high compared to a situation in which that reserve level is low. If the level of international reserves is high but falling the probability of a crisis should be probably much lower than the case where international reserves are falling from level that are already low.

FIGURE 3: Stock price index
(Average for 27 currency crises episodes)

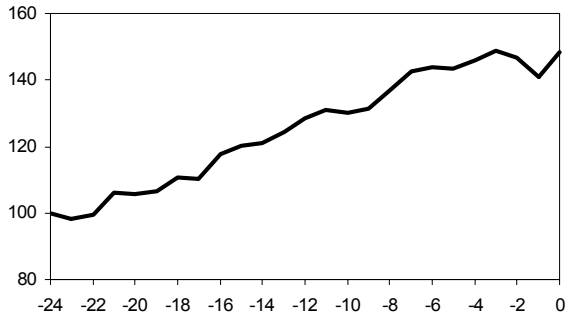


Table 2 shows why it is so important to consider the level of international reserves when assessing the vulnerability of a country to a currency crisis. Based on a sample of 18 countries (developed and developing countries) with data from January 1970 to July 1995, the table presents the probability of having a currency crisis within the next 24 months conditional on the change of international reserves (12-month change and monthly change) and the level of this indicator. The level is classified in low, normal and high according to the difference between the actual amount of international reserves and an estimate of their optimal level.

TABLE 2: Probability of Crisis: Level and Change of Int. Reserves

	Level of International Reserves (1)				
	Low (lower third)		**Normal** (middle third)		**High** (upper third)
12-Month change					
<0	27%	>	18%	>	10%
≥0	22%	>	18%	>	9%
Monthly change					
<0	26%	>	18%	>	11%
≥0	22%	>	16%	>	9%

(1) The level is classified according to the percentage difference between the actual level and an estimation for international reserves demand. See table 4 for details.

As shown by the table, the level of international reserves has a significant effect on the probability of crisis and this effect is almost independent of the change of the level (12-month change or monthly change). For instance, having low levels of international reserves increases the probability of having a crisis to more than 20%, compared to a case where the international reserves are high. In this last case the probability of having a crisis within the next 24 months is only 8%. Also, for a given stock of international reserves, having the level falling or growing has a small effect on the probability of crisis.

2.2 Problem with measure of Real Exchange Rate overvaluation

As proxy of the overvaluation of the real exchange rate the authors use the deviation of the real exchange rate from a deterministic trend, and to compute the trend they use all data available (past and future). However, independent of the good performance of this variable, this is not necessarily a good measure of how overvalued or not is the RER. One problem is that the way the trend is computed explains a significant part of the good performance of this indicator. The authors use all data available to compute a country specific trend. Given this, by construction, there will always be a big gap between trend and actual value of the RER ahead of the crisis because the trend is calculated including the "jump" or depreciation of the RER that will occur in the coming months as the crisis unfolds. Another problem is that looking at the behavior of the RER does not give us enough information to conclude if its level is overvalued or not. A country could be showing an appreciation of the RER but this could be a consistent behavior if, at the same time, there is an increase in productivity, a big rise in the world price of its mayor export(s), or a large inflow of capital.

A better discrimination of a crises situations would be obtained by considering only cases where the RER is appreciating at the same time as the country is suffering from an economic recession. Section IV provides some evidence about the importance of this distinction. Based on monthly data from 18 countries from 1970 to 1995, the evidence

confirms that the likelihood of having a crisis within the next 24 months is higher if the RER is appreciating and the industrial production is falling compared to a situation where the RER is appreciating and the industrial production shows a growing trend. In the former case the probability of crisis is 38%, while for the latter it is 22%. Also, if the RER is depreciating and industrial production is below its recent trend, the probability of a crisis is 11%. This compares to a probability of crisis of only 3% if RER is depreciating and industrial production is above its recent trend. These results confirm that we should consider not only the behavior of the RER but also, at the same time, the behavior of industrial production if we want to assess the probability of a currency crisis.

2.3 Problems with methodology: Post-crisis bias problem

In their paper, Kaminsky and Reinhart only distinguish two periods: pre-crisis and tranquil period. The pre-crisis period considers the 24 months ahead of a crisis and the tranquil periods are all the remaining months. The problem with this is that among tranquil months are crisis months and/or months that are in the recovery phase of the crisis.

This problem can result in misleading conclusions. The post-crisis bias implies that the econometric results of models that try to explain or predict crises can at least in part, or even fully be explained by the behavior of the independent variables during and directly after a crisis. Recall that an Early Warning System (EWS) model aims to analyze how vulnerable to a crisis the situation in a country is. The correct way of doing this is by comparing the behavior of the independent variables before a crisis with their behavior during periods when these variables are sustainable, i.e. during tranquil or normal times. Instead, what Kaminsky-Reinhart and other Early Warning System (EWS) models with two outcomes do is compare the pre-crisis observations with the observations both during tranquil periods and post-crisis/recovery periods.

The problem with not making this distinction is that it can lead to an important bias because the behavior of the independent variables is very different during tranquil times as compared to recovery episodes. To illustrate this bias, Table 3 provides evidence for four indicators. These are the percentage difference of actual values and the average of the last 24 months for real exchange rate (RER), ratio of net international reserves to M2 (NIR/M2), exports and industrial production. For all these indicators the average of monthly observations within the tranquil period is statistically different than the average of monthly observation within the crisis/recovery period.

TABLE 3: Post-crisis Bias

	Average of each period	
	Tranquil Period	Crisis/Recov Period
RER - RER avg 24m (%)	-1.1	12.8
NIR/M2 - NIR/M2 avg 24m (%)	0.2	3.2
Exports - Exports avg 24m (%)	12.2	6.3
Ind. Prod. - Ind. Prod. avg 24m (%)	3.3	0.8

Also, this could be one of the reasons why 12-month changes perform quite well in the Kaminsky-Reinhart model since we would expect that level variables show slower speed of recovery than the year-to-year changes (level variables do not "jump" as much as changes). This implies that in the recovery phase level variables will stay "low" for a longer period. If no distinction is made, the result is a lot of false signals or noise during the crisis period and the recovery phase, affecting the performance of level variables.

In order to address this issue, I will distinguish three periods: pre-crisis period (signal horizon or 24 months ahead of crisis), a crisis/recovery period, and a tranquil period. To do this we need a measure of duration of a crisis. Once we have this measure, we can compare the pre-crisis regime with a more accurate tranquil period.

III. Alternative Indicators of Currency Crisis

Considering the problems just described, I will explore some additional indicators of currency crises. In the first part of this section I will explain how I make the distinction between tranquil periods and recovery/crisis periods. In the second part, I describe the data and individual indicators that I will analyze in this paper. The third part of this section presents the performance of the proposed indicators and compares them against the best indicators proposed by Kaminsky and Reinhart.

1. Dealing with post-crisis bias: crisis/recovery and tranquil periods

As a starting point, I consider the same set of countries and currency crisis episodes proposed by Kaminsky and Reinhart. Using annual real GDP data, I establish crisis/recovery periods. The beginning of each crisis/recovery period is determined by the currency market pressure index and the end of it is when real GDP is greater than or equal to the real GDP of the previous peak. Remaining periods are considered "normal" or "tranquil".

2. Data and Indicators

This paper explores 11 indicators that are not considered in Kaminsky and Reinhart's paper, and it uses monthly data from January 1970 to June 1998. The analysis includes 20 developed and developing countries (Argentina, Bolivia, Brazil, Chile, Colombia, Denmark, Finland, Indonesia, Israel, Malaysia, Mexico, Norway, Peru, Philippines, Spain, Sweden, Thailand, Turkey, Uruguay and Venezuela) and the indicators can be classified in five groups: (1) Adequacy of International Reserves; (2) External Sector and International Competitiveness; (3) Domestic Financial Sector; and (4) Domestic Real Sector.

2.1 Adequacy of International Reserves

In this category I consider indicators that can be good proxies of what happens to the level of international reserves (measured in US dollars) ahead of a currency crisis. Economic theory suggests that we should expect a reduction in the level of reserves ahead of a crisis, so this indicator should be a good candidate for leading indicator of a currency crisis. However, it is misleading to use the level itself as an indicator of crisis because it does not take into account differences of size and international exposure across countries. In order to correct for this scale effect, I include in the analysis the ratio of Net International Reserves (NIR) to GDP and the ratio of NIR to Imports.

Another measure that is also included in this category is the ratio of NIR to M2. The motivation for using this indicator is that it is a measure of the fraction of money holdings that are covered by international reserves. If M2 is relatively high compared to NIR then a shift in demand for money could cause a significant change in the stock of international reserves.

Also, in order to compare the actual level of international reserves with some measure of the optimal level for international reserves, I estimate an optimal demand for international reserves and consider as an indicator of crisis the percentage difference between the actual level of international reserves and the estimated level. This estimation is based on a panel regression with fixed effects; the results are presented in the following table.

TABLE 4: Estimation of Optimal Stock of International Reserves (1)
(all variables in logs)

	Coef.	Std. Err.	t	P>|t|
GDP US$	1.250	0.009	133.1	0.000
Imports/GDP	0.642	0.020	31.4	0.000
Std dev NIR (last 24 months)	0.091	0.005	17.1	0.000
$R^2 = 0.806$ N=6728				

(1) Panel regression with fixed effects (constant term is country specific). Regression estimated in tranquil times.

2.2 External Sector and International Competitiveness

As indicator of the performance of the external sector of the economy I use the percentage difference between exports (measured in US dollars) and the average of the last 24 months. Another indicator that has been widely used in early warning models is a measure of overvaluation of the real exchange rate. In this line, I use a measure of the deviation of the real exchange rate from its recent trend. As a measure of recent trend of the real exchange rate I use a moving average of the last 4 years. This indicator considers only past information.

2.3. Domestic Financial Sector

Currency crises have been linked to rapid growth (boom-bust) in credit and the monetary aggregates. For this reason I include measures like the M2 multiplier (ratio M2/M0) and domestic credit to M2 (% deviation from average of last 24 months). Also, as a measure of the possible evolution and collapse of asset price bubbles, I include in the analysis the percentage deviation of stock prices from their average of last 24 months.

2.4. Domestic Real Sector

As an indicator of output, I include in this category the percentage deviation of the industrial production index from the average of last 24 months.

3. Performance of Indicators

Based on the comparison of the behavior of each indicator during tranquil and pre-crisis periods (24 months window), this section presents the performance of each individual indicator, including in this analysis the best six indicators of Kaminsky and Reinhart's paper, according to each indicator's noise-to-signal ratio and presence in crises episodes[2].

Table 5 presents the performance of each of these variables. Column (3) shows the difference between the average value of the indicator during tranquil periods and the average value of the indicator during the 24 months ahead of the crisis (pre-crisis window). This difference is divided by the standard deviation, in order to get a comparable measure across indicators. In this aspect, what is desirable is to have and indicator with a large difference and low standard deviation. Therefore, the higher is the absolute value for this indicator, the better is the indicator. Column (4) presents the noise-to-signal ratio. This is computed by the same method used by Kaminsky and Reinhart, but correcting for the post-crisis bias.

[2] Among the indicators considered by the authors we selected those that have the lowest noise-to-signal ratio and issue a signal in at least half of the crises episodes. We compute overvaluation of the real exchange rate (RER) as the deviation of the actual RER from its average of last 48 months, instead of computing the deviation from a deterministic trend as Kaminsky and Reinhart do.

TABLE 5: Indicators Performance – Crisis window vs. Tranquil period

	Average of each period			
	Tranquil Period	Pre-crisis Window	(2) – (1) / Std Dev	Noise-to-signal ratio
	(1)	(2)	(3)	(4)
International Reserves (NIR)				
NIR – NIR estimated (%)	5.4	-17.6	-0.46	0.48
NIR/M2 (%)	24.0	18.6	-0.30	0.51
NIR/GDP (%)	7.7	6.5	-0.21	0.59
NIR/IMP ratio	4.8	4.2	-0.20	0.51
NIR (12-month change %) – KR	**26.8**	**19.4**	**-0.11**	**0.59**
NIR/M2 (12-month change %) – KR	**8.9**	**-1.9**	**-0.06**	**0.52**
External Sector and Real Exchange Rate				
RER – RER avg 48m (%) – KR	**-1.1**	**-8.8**	**-0.37**	**0.60**
Exports (12-month change %) – KR	**17.3**	**9.2**	**-0.27**	**0.65**
Exports – Exports avg 24m (%)	12.2	6.7	-0.28	0.76
Domestic Financial Sector				
M2 multiplier (M2/M0 ratio)	4.6	5.1	0.16	0.47
Dom. Credit/M2 (actual – avg 24m, %)	0.6	2.3	0.14	0.86
Stock prices – stock prices avg 24m (%)	13.5	11.2 (*)	-0.04	0.46
Stock prices (12-month change %) – KR	**50.5**	**58.5 (*)**	**0.01**	**0.55**
Domestic Real Sector				
Ind Prod – Ind Prod avg 24m (%)	3.3	1.1	-0.26	0.54
Ind Prod (12-month change %) – KR	**3.8**	**1.5**	**-0.25**	**0.56**

(*) For most indicators average of crisis window is significantly different than average of tranquil period at levels below 1%. The exceptions are stock prices.

Table 6 ranks all the indicators according to columns (3) and (4), separately, and presents the average ranking for each individual indicator. In terms of results, the table shows that the indicators that perform best are the percentage difference of the stock international reserves from its estimated level and the ratio of international reserves to M2. Also, it is clear that the Kaminsky and Reinhart's indicators do not perform as well as the proposed indicators. Evidence of this is that only one of their indicators is in the top half of the table.

TABLE 6: Ranking of Individual Indicators

	Ranking according to		
	avg precrisis – avg tranquil / Std Dev	NTS ratio	AVERAGE RANKING
NIR – NIR_hat (%)	1	3	2.0
NIR/M2 (%)	3	5	4.0
M2 multiplier (M2/M0 ratio)	11	2	6.5
NIR/IMP ratio	9	4	6.5
Ind Prod – Ind Prod avg 24m (%)	6	7	6.5
RER – RER avg 48m (%) - KR	**2**	**12**	7.0
Stock prices - stock prices avg 24m (%)	14	1	7.5
Ind Prod (12-month change %) - KR	**7**	**9**	**8.0**
NIR/GDP (%)	8	10	9.0
Exports (12-month change %) - KR	**5**	**13**	**9.0**
Exports - Exports avg 24m (%)	4	14	9.0
NIR/M2 (12-month change %) - KR	**13**	**6**	**9.5**
NIR (12-month change %) – KR	**10**	**11**	**10.5**
Stock prices (12-month change %) - KR	**15**	**8**	**11.5**
Domestic Credit/M2 (actual - avg 24m, %)	12	15	13.5

IV. Multivariate Indicators of Currency Crises

This section departs from individual indicators and proposes two bivariate indicators. The idea is to propose indicators that not only perform well in practice, but also have a solid economic justification. The first indicator is based on the conventional approach, which emphasizes the role of inconsistent macro policies in explaining currency crisis and considers government decisions as state-invariant; the second is based on the non-conventional approach that considers that government decisions as state-dependent. Section V considers these two indicators and combines them into an aggregate index of currency crisis.

1. Conventional approach: role of inconsistent macro policies

This approach emphasizes the role of inconsistencies between fiscal, monetary and exchange-rate policies in explaining currency crisis. The idea is that a fixed exchange rate regime is unsustainable if the government allows domestic credit to grow more than the growth of the demand for money for a time long enough such that the resulting decline in international reserves pushes the stock of international reserves to a level so low that the economic authority cannot defend the prevailing exchange rate regime. Given this, the precise timing of the crisis will depend on how big the increase in domestic credit is compared to the increase of the demand for money, and also on the actual level of international reserves. Obviously, the probability of having a crisis in the coming months will be higher if the stock of reserves is low and it is declining at a high

rate (i.e. large difference between the growth of domestic credit and the growth of the money demand.)

Let me introduce the following two equations to explain the situation just described. Equation (1) represents the consolidated balance sheet of the financial system. In this equation the stock of money (M) is backed up by domestic credit (D) and international reserves (R). All variables are expressed in local currency. The equilibrium in the money market is given by equation (2). The real demand for money (m_d) depends on output and on the domestic real interest rate. Interest rate parity holds so the domestic interest rate is equal to the foreign interest rate (i^*) plus the expected depreciation of the local currency (ε). Also, it is assumed that power purchasing parity holds and the foreign price level is equal to one, then the domestic price level is equal to the exchange rate (e).

$$M = D + R \tag{1}$$

$$\frac{M}{e} = m_d(y, r) \quad , \quad r = (i^* + \varepsilon) - \pi^e \tag{2}$$

What is the effect of a change in domestic credit? The answer will depend on the exchange-rate regime. If the prevailing regime is a fixed exchange rate, and we assume for simplicity that output does not change, then the stock of money will stay the same since the demand for money is not affected. The initial increase (decrease) of the stock of money, resulting from the increase (decrease) in domestic credit, is unwanted so it will result in more (less) spending to adjust the actual money holdings to the desired level. This adjustment process produces a decrease (increase) of the stock of international reserves in an amount equal to the increase (decrease) of the domestic credit ($\Delta R = -\Delta D$). Therefore, in the case of a fixed exchange rate regime, the only effect of a change in domestic credit is a change in the composition of the consolidated balance sheet.

On the other hand, if the exchange rate regime is flexible, and the government does not intervene in the exchange rate market, the supply of money will in the end be the numeraire of the economy. Thus, an increase (decrease) in domestic credit will produce an increase (decrease) in the money supply and will generate a depreciation (appreciation) of the local currency and, hence, an increase (decrease) in the price level. As a result, the international reserves are unchanged and both money stock and domestic credit increase (decline) at the same rate.

Given the previous analysis, it is clear that among the variables that should be considered when assessing the probability of currency crisis, are the level of international reserves and the growth of domestic credit relative to the growth of money holdings. Considering this, we propose as a leading indicator of crisis a measure of inconsistent macroeconomic

policies that combines (i) the level of international reserves, represented by the deviation of the actual stock from its estimated level; (ii) the growth of domestic credit, represented by the monthly real growth of domestic credit; and (iii) the growth of domestic credit relative to the growth of money holding, represented by the deviation of the ratio of domestic credit to M2 from its average of last 24 months.

Table 7 shows how both level of international reserves and the behavior of domestic credit (actual growth and growth relative to money holding) affect the probability of having a currency crisis within the next 24 months. Consistent with the above explanation, the probability of crisis increases significantly when the level of international reserves is low and both real growth of domestic credit and percentage deviation of domestic credit/M2 from its average of the last 24 months are greater or equal to 2%. If this is the case, our data set indicates that the probability of a crisis within the next 24 months is 33%. Otherwise, the probability is only 14%[3].

Given the situation just described, the first indicator of crisis that I propose is one that issues a signal, or crisis alarm, when both the level of international reserves and domestic credit are in the critical region. The indicator is in the critical region when we achieve all the following conditions: (1) the actual stock of international reserves is more than 14% below its estimated optimal level; (2) monthly real growth of domestic credit is greater than or equal to 2%; and (3) the percentage difference of actual ratio of domestic credit to M2 from its average of last 24 months is greater than or equal to 2%. If these conditions are not met, then the indicator does not issue any signal or alarm.

TABLE 7: Probability of Crisis: Int. Reserves and Domestic Credit/M2

	Level of International Reserves (1)	
	Low (lower third)	**Normal/High** (middle and upper thirds)
Domestic Credit/M2 and real Domestic Credit (DC)		
Actual DC/M2 minus avg last 24m and DC real growth ≥ 2%	**33%**	14%
Actual DC/M2 minus avg last 24m and DC real growth < 2%	14%	14%

(1) The level is classified according to the percentage difference between the actual level and an estimation of the optimal level of international reserves. Level is considered low when actual int. reserves are below estimated level by more than 14%.

[3] Thresholds are picked to minimize noise-to-signal ratio of multivariate indicator, subject to issuing signals in at least half of crises episodes.

2. Non-Conventional approach: unemployment-inflation tradeoff

One of the limitations of the conventional approach is that it suggests that crises will occur only if macroeconomic policies are not consistent with a fixed exchange rate regime. Therefore, if we consider the conventional approach as the only explanation of currency crises, we may conclude that if a country has a significant amount of international reserves, and domestic credit is not growing, there is no chance of having a currency crisis. However, the evidence on currency crisis confirms that this has not been the case; even countries that have consistent policies have at times suffered from currency crises.

What is wrong in the conventional analysis of crises? A key assumption of this approach is that government decisions are state-invariant. This means that, no matter how bad is the economic situation, the government will maintain the fixed-exchange-rate regime while it is sustainable. This assumption is unrealistic, considering that governments face tradeoffs when deciding to maintain or abandon a fixed exchange rate regime. In this aspect, non-conventional models try to consider in the analysis that governments need not always obey strictly by the "rules of the game" of an exchange rate regime. Policymakers thus have the option of letting the exchange rate float, and if the opportunity cost of having a fixed regime is significantly high, the government may well at some point decide to abandon the fixed rate. This can occur even when it might have been possible (at some cost) to maintain the fixed-rate regime.

What are the costs and benefits of a fixed exchange rate regime? When a country commits to a fixed exchange rate regime, policymakers limit their possibilities of using fiscal and monetary policy to influence economic output. However, on the other hand, the country typically gets the benefits of more stable expectations, reduced costs of foreign trade and currency transactions, and (very likely) a lower rate of inflation. Therefore, if a country has decided to implement a fixed exchange rate regime, the decision of abandoning this regime or not will depend on the result of this cost-benefit analysis. In this aspect, suppose that changes have occurred that leave the country's real exchange rate out of equilibrium so that a real devaluation is called for. With a fixed exchange rate, this means that the new equilibrium will require a fall in prices and wages. If market rigidities tend to frustrate this necessary adjustment, the result will be declining output and increased unemployment. The "true" new equilibrium probably could be reached by a prolonged recession, but governments have often in such circumstances chosen to change the nominal exchange rate instead, either by devaluation to a new parity or by the decision to float.

As mentioned above, the output-inflation tradeoff faced by policymakers is a key factor in assessing how vulnerable a country is to a currency crisis. Also, among the variables that influence the output-inflation tradeoff, the overvaluation of the real exchange rate is very important. As mentioned before, this misalignment or overvaluation of the real exchange rate will result in unemployment and a deterioration of the economic situation.

If these are the underlying conditions, the output-inflation tradeoff faced by the government is almost inexistent and, therefore, the government has significant incentives to abandon the fixed exchange rate regime in order to correct the misalignment and reduce unemployment. If, on the other hand, there is no misalignment of the real exchange rate, the government will face a higher cost of abandoning the fixed regime since the depreciation of the exchange rate will only be reflected in higher domestic prices and a limited effect on output and employment.

The previous analysis suggests that a good leading indicator of currency crises is the overvaluation of the real exchange rate. Ceteris paribus, the more overvalued the real exchange rate is, the bigger are the incentives for the government to abandon the fixed regime and, therefore, the higher is the probability of having a currency crisis in the coming months. However, in practice, how can we assess if the real exchange rate is overvalued or not? Looking only at the behavior of the real exchange rate does not give us enough information to answer this question. Having an appreciating trend is not conclusive, since this behavior may be consistent with a change in the equilibrium real exchange rate. In order to get a better measure of overvaluation, and the incentives faced by policymakers, we propose an indicator that considers the behavior of both the real exchange rate and industrial production. The idea is that if we have a real exchange rate that is appreciating while at the same time economic activity is slowing down, it is more likely that this behavior is not due to a change in the equilibrium and, therefore, policymakers have more incentive to abandon the fixed exchange rate regime, compared to a situation where there is a depreciating trend of the real exchange rate and industrial production is increasing. Consequently, we should expect to see in practice that there is higher probability of a currency crisis if the economy is in the first situation rather than the second.

Table 8 presents evidence that supports the distinction just described. It shows the probability of having a currency crisis in the next 24 months, conditional on the behavior of both the real exchange rate and industrial production. In order to capture the recent trend of the real exchange rate and industrial production, we use the deviation of the actual value from a moving average that considers past months. For the real exchange rate the moving average considers the past 48 months and for industrial production it considers the past 24 months. Four possible combinations are considered: (1) both variables fall below their recent average, (2) real exchange rate is below its recent average but industrial production not, (3) real exchange rate is above its recent average but industrial production not, and (4) both real exchange rate and industrial production are above their recent average. Our data set confirms that the probability of crisis is higher when the real exchange rate is appreciating, compared to a situation where it is depreciating with respect to its moving average. However, in line with the reasons presented in the previous paragraph, the probability of crisis is the highest when both the real exchange and industrial production fall below their corresponding moving average. If the latter is the case, the conditional probability of having a crisis within the next 24 months is 38%. This compares to a probability of 22% when the real exchange rate is

below its average but industrial production not. On the other hand, the probability of a crisis when the real exchange rate is depreciating with respect to its recent average is 11%, when industrial production is below its average, and only 3% when neither of these two individual indicators falls below its recent average.

TABLE 8: Probability of Crisis: Overvaluation of RER

	Current RER - RER avg last 4 years (1)		
	< 0 Appreciating		≥ 0 Depreciating
Ind. Production (1)			
Below its last 2 year avg.	38%	>	11%
Above its last 2 year avg.	22%	>	3%

(1) The percentage difference between the value of the actual month and the average of last 24 months (48 months for RER).

Given these results, the second crisis indicator that we propose is a measure of overvaluation of the real exchange rate that issues a signal or crisis alarm when: (1) the actual real exchange rate has appreciated beyond its average of last 48 months; and (2) actual industrial production is below its average of last 24 months[4]. If this is not the case, then the indicator does not issue any signal or alarm.

V. Aggregate Indicator of Currency Crisis

This section recommends an aggregate indicator of currency crisis, based on the previous two indicators. The motivation for combining these two indicators is that even though each of them gives a different explanation for the cause of currency crisis, they complement each other. After getting a composite index of crisis, we compare its performance with a composite index that includes the best 6 indicators of Kaminsky and Reinhart's paper.

What does the evidence tell us about the effect of the indicators analyzed in the previous section on the probability of having a currency crisis? Table 9 shows the combined effect of these two indicators on the probability of having a currency crisis within the next 24 months. It is clear from the table that both indicators contribute in an important way to explaining the probability of a currency crisis. Having both indicators issue a signal increases the probability of a crisis to 50%, compared to 13% when neither indicator issues a signal. Also, having just one of these two indicators issue a signal has an important effect on the probability of crisis. If one indicator issues a signal while the

[4] 12, 24, 36 and 48 months were considered. The combination that minimizes the noise-to-signal ratio of this multivariate indicator is 24 months for industrial production and 48 month for RER. Main results are robust to other combinations.

other does not, the probability of a crisis is 28% and 35%, depending on the indicator that issues the signal. These probabilities are more than double the probability of crisis in the case where no indicator issue signals (13%) and they are also significantly bigger than the unconditional probability of crisis (15%).

TABLE 9: Probability of Crisis: Policy Consistency and Fundamentals

	Overvaluation RER Signal (1)	
	Yes	No
Inconsistent Policy Signal (2)		
Yes	50%	28%
No	35%	13%

(1) Considers months where RER is below avg. of last 48 months and Ind. Prod. Is below average of last 24 months.
(2) Considers months where actual international reserves are below optimal level by more than 14%, real growth of Domestic Credit is more than 2% and Domestic Credit to M2 ratio deviates more than 2% above its avg. of last 24 months.

The previous results are evidence of the importance of considering both indicators when assessing the probability of a currency crisis. The next question concerns how to combine them in order to get an aggregate indicator of crisis? We suggest computing a simple composite index that gives equal weight to each individual indicator:

$$I = \frac{1}{n}\sum_{i=1}^{n} I_i \ ,$$

where n is the number of indicators included in the index, and I_i is equal to 1 (if indicator i is in critical region) or equal to 0 (if indicator i is not in critical region.) The value of this index is limited between 0 and 1, where a higher number implies a higher probability of crisis. In the case of the proposed index, we have two individual indicators, inconsistent policy indicator and real exchange rate overvaluation indicator, so the composite index can have three values: 1 if both indicators issue a signal, 0.5 if one of the indicators issues a signal but the other not, and 0 if none of the indicators issues a signal.

The performance of the previous composite index is compared to a composite index, called KR-6, which includes the best six indicators proposed by Kaminsky and Reinhart's paper. This composite index is computed in the same way as the proposed index, but now instead of two individual indicators we have six.

Which composite index performs better? In order to compare both aggregate indicators, first we need to establish what a good indicator is. In this aspect, what we want is an indicator that has low noise-to-signal (signal is accurate) and, at the same time, issues a significant amount of signals so it predicts a considerable share of currency crises. Also,

we need to set a critical region for the index, so that whenever it is in this region, we get a crisis signal. In this aspect, the critical region will be such that, considering the actual value of the index, the conditional probability of crisis is greater than 25%.

Table 10 presents the performance of each composite index. In terms of accuracy, the proposed composite index performs better than the KR-6. The noise-to-signal ratio is the same, but the signal of the proposed indicator is more informative in the sense that the effect on the probability of a crisis of having a signal, compared to not having it, is bigger. In terms of the predictive capacity of the indexes, the proposed index performs unambiguously better than KR-6. The former issues more signals ahead of a crisis, issuing signals in 47% of the 24 months ahead of a crisis, while KR-6 only issues signals in 25% of those months. Also, the proposed indicator issues at least one signal in all analyzed crisis, while KR-6 misses 7 percent of them. If we set a more restrictive condition and consider a crisis to be predicted only if we get at least 3 consecutive signals within the 24 months ahead of a crisis, then the proposed index predicts 68% of the crises and KR-6 only 47%.

TABLE 10: Performance of Aggregate Crisis Indicators
(Cutoff: conditional probability of crisis > 25%)

	Proposed Crisis Index		KR-6 Index
Accuracy of Signal			
P(crisis/signal) / P(crisis/no signal) ratio	3	>	2
Noise-to-signal ratio	0.43	=	0.43
Presence during crisis			
% pre-crisis months correctly called (1)	47%	>	25%
% crisis predicted:			
at least 1 signal during pre-crisis (2)	100%	>	93%
at least 3 consecutive signals during pre-crisis (3)	68%	>	47%

(1) This is the total number of pre-crisis months correctly called as a share of total pre-crisis months.
(2) This is the number of crisis for which the indicator issues at least 1 signal during pre-crisis period as a share of all crises for which data is available for all months of the pre-crisis period.
(3) This is the number of crisis for which the indicator issues at least 3 consecutive signals during the pre-crisis period as a share of all crisis for which data is available for all months of the pre-crisis period.

In terms of robustness of the results, we find that the proposed crisis index still performs better than the KR-6 index when we don't take into account the post-crisis bias and, therefore, we consider all 76 crisis episodes in the analysis (no crisis duration consideration). For details see Appendix 2.

VI. Conclusions

This paper provides a critical analysis of Kaminsky and Reinhart (1999) and, after dealing with problems present in this paper, proposes an alternative aggregate crisis index. This index is better than the KR-6 in the following aspects: (1) even though it includes less individual indicators, it performs better than KR-6 both in terms of accuracy and predictive capacity; and (2) it is clearly motivated by economic theory and represents a unified versions of the currency crises approach that emphasizes the role of inconsistent macroeconomic policies as an explanation of currency crises, and the approach that emphasizes the role of tradeoffs among policymakers decisions as the main cause of this type of crises.

REFERENCES

Beck, T., Demirguc-Kunt, A., R. Levine, 1999, "A New Database on Financial Development and Structure", The World Bank.

Berg, A. and C. Patillo, 1999, "Are currency crisis predictable? A test". IMF Staff papers 46, 107-138.

Berg, A. Borensztein, E. and C. Patillo, 2004, "Assessing Early Warning Systems: How have they worked in practice?." IMF Working Paper 52. March.

Blanco, H. and P. Garber, 1986, "Recurrent Devaluations and Speculative Attacks on the Mexican Peso", Journal of Political Economy, February 1986, pp. 148-166.

Eichengreen, B. Rose, and A. Wyplosz, 1995, "Exchange rate market mayhem: the antecedents and aftermath of speculative attacks". Economic Policy .21:249-312

Flood, R. and P. Garber, 1984, "Collapsing Exchange-Rate Regimes". Journal of International Economics 17: 1-13.

Frankel, J. y A. Rose, 1996, "Currency crashes in emerging markets: an empirical investigation". Journal of International Economics 41 (3-4):351-366

International Financial Statistics, International Monetary Fund.

Kaminsky, G., S. Lizondo and C. Reinhart 1998, "Leading Indicators of Currency Crises", IMF Staff Papers, Vol. 45, No. 1. March.

Kaminsky, G., and C. Reinhart, 1999, "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems", The American Economic Review, Vol. 89, No. 3, June 1999, pp. 473-500.

Kaminsky, G.. and C. Reinhart, 2000, “On Crises, Contagion, and Confusion.” Journal of International Economics 51: 145-168.

Kaminsky, G., 2003, “Varieties of Currency Crises” NBER Working Paper No. w10193

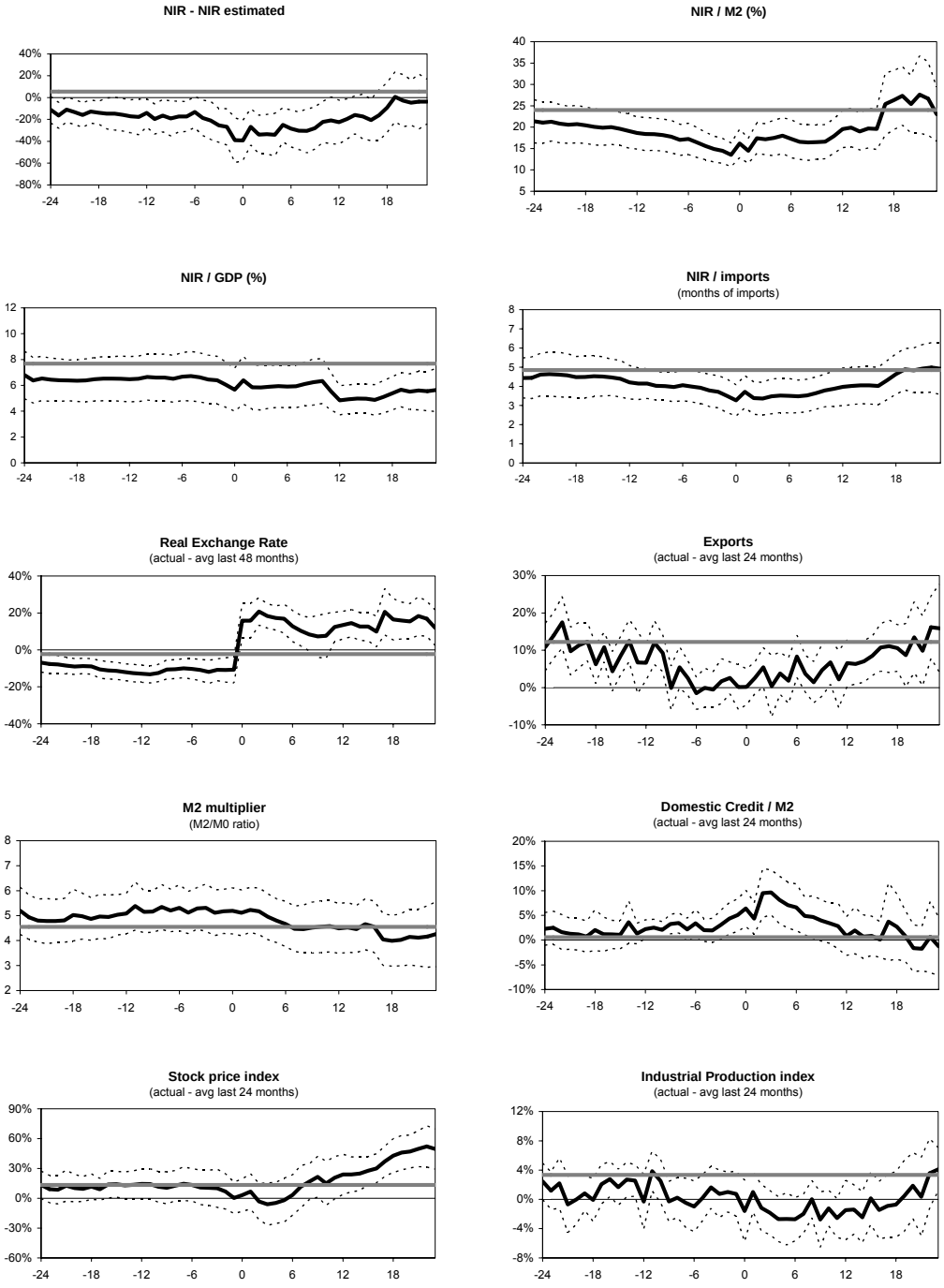
Krugman, P., 1979, “A Model of Balance-of-Payment Crises”, Journal of Money, Credit and Banking, August 1979, pp. 311-325.

Sachs, J. Tornell, A. and A. Velasco, 1996, “Financial Crises in Emerging Markets: the Lessons from 1995”. Brooking Papers on Economic Activity 1, 147-215.

Obstfeld, M., 1996, “Models of Currency Crises with Self-fulfilling Features”, European Economic Review, April 1996, pp. 1037-1047.

APPENDIX 1

Behavior of Alternative Indicators: before and after the crisis[5]



[5] Solid black line is the average for all crisis for which data is available. Solid gray line is the average of tranquil periods. Dotted lines correspond to +/- 2 standard deviations around the mean.

APPENDIX 2
Performance of Aggregate Crisis Indicators
(No duration of crisis considerations)

Crisis Index and KR-6 index
(Cutoff: conditional probability of crisis > 25%)

	Proposed Crisis Index		KR-6 Index
Accuracy of Signal			
P(crisis/signal) / P(crisis/no signal) ratio	2	>	1.8
1 / Noise-to-signal ratio	1.7	<	2.9
Presence during crisis			
% pre-crisis months correctly called (1)	33%	>	20%
% crisis predicted:			
at least 1 signal during pre-crisis (2)	76%	>	70%
at least 3 consecutive signals during pre-crisis (3)	50%	>	45%

(1) This is the total number of pre-crisis months correctly called as a share of total pre-crisis months.
(2) This is the number of crisis for which the indicator issues at least 1 signal during pre-crisis period as a share of all crises for which data is available for all months of the pre-crisis period.
(3) This is the number of crisis for which the indicator issues at least 3 consecutive signals during the pre-crisis period as a share of all crisis for which data is available for all months of the pre-crisis period.

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