MAKING EXPLOSIVE COCKTAILS: RECIPES AND COSTS FOR 26 CRISES FROM 1823 TO 2003

Néstor Adrián Amado[*], Ana María Cerro[**], and Osvaldo Meloni[***]

Resumen

La crisis, como los "cócteles explosivos" se producen mezclando poderosos ingredientes. Y la Argentina, desde 1823, ha hecho 26 "mezclas" que terminaron "explotando" ¿Cuántos ingredientes se necesitan para hacer un "cóctel explosivo"? ¿Cuáles son esos ingredientes? ¿Cuál es la mezcla más cara? Este trabajo busca identificar, mediante el método de *regression tree análisis*, las distintas "recetas" que generaron crisis económicas en Argentina a través de su historia. El trabajo también mide los costos de las crisis argentinas en términos de pérdidas de producto: Para ello, utilizamos la metodología sugerida por el FMI (1998)

Encontramos que hay cuatro mezclas explosivas, siendo ingredientes claves el Déficit Fiscal, la sobrevaluación del Tipo de Cambio Real, la tasa de crecimiento de los depósitos reales y el ratio de Deuda Externa a Exportaciones. Las crisis más frecuentes son aquellas que tienen al elevado déficit fiscal como ingrediente excluyente, aunque el costo medio de las crisis es mayor cuando se mezclan déficit fiscales moderados con fuertes caídas en la tasa de cambio de los depósitos reales, presumiblemente porque generan además una crisis bancaria.

Abstract

Crises, like "explosive cocktails" are made by mixing powerful ingredients. Argentina has made 26 "explosive cocktails" since 1823. How many ingredients are needed to make an "explosive cocktail"? Which are these ingredients? Which is the most expensive mix? This paper attempts to identify the different recipes that ended up in economic crisis throughout argentine economic history by means of the regression tree analysis technique. The paper also measures Argentina's crises costs in terms output losses. We follow the methodology used by the IMF (1998), that is, computing cumulative output lost relative to trend.

It is found that there are four explosive mixes, having Fiscal Deficit, Real Exchange Rate Overvaluation, Bank Deposit growth rate decline and the ratio of External Debt to Exports as the key ingredients. The most frequent crises are those having high fiscal deficit; though average cost is higher for crises mixing moderate fiscal with strong decline in Real Bank Deposits, presumably entailing banking crises.

Key Words: Currency Crises, Regression Tree Analysis, Crises costs

JEL Classification Codes: E32, N26

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Hundred of millions of people who expected rapidly rising standards of living have seen their living standards fall, hundreds of thousands if not millions of children have been forced to drop out of school and go to work, hundreds of billions of dollars of apparent wealth has been lost, the stability of large nations has been called into question, and the United States has made its largest nonmilitary foreign policy related financial commitments since the Marshall Plan.

Lawrence Summers,

International Financial Crises: Causes, Prevention and Cures
American Economic Review (2000)

Currency crises are quite expensive; a history of recurrent crises even more so. The costs arise in three ways: a substantial increase in public debt associated with a crisis, a disruption and loss of output, and the possibility of a socially controversial redistribution of income and wealth

Rudi Dornbusch
A Primer on Emerging Market Crises
NBER Working Paper 8376 (2001) "

I. INTRODUCTION

The flavor is bitter. Consequences are deleterious: output drops, reserves drain, domestic money depreciation, income distribution worsening. Depending on the ingredients, it can also provoke political order disruption, and institutional changes. The name of the drink is ***crisis*** and Argentina has become addicted to it.

Since Independence Argentina experienced 26 economic crises. That is, one crisis every 6 and a half years, more than any other country in the world. The record includes different varieties and mixes: currency crises, banking crises and twin crises. What are the ingredients of such explosive cocktails? Are they made with import components, such as increases in

* This paper builds on Cerro and Meloni (2003) and Amado, Cerro and Meloni (2004). We are grateful to the participants of the AAEP 2004 and LACEA 2004 Meetings for comments and suggestions to earlier versions of this paper. Naturally, all errors are ours. We gratefully acknowledge the support of the Consejo de Investigaciones de la Universidad Nacional de Tucumán (CIUNT) Grants F 303 and F 308. The views expressed herein are those of the authors and not necessarily those of the CIUNT.

international interest rates, changes in the international capital market conditions, and declining price of exports? Or they are also obtained with national condiments such as fiscal deficit, high indebtness and real exchange rate overvaluation?

How many ingredients are needed to make an explosive cocktail? Which is the most expensive mix? The objective of this paper is twofold. Firstly, we identify the different recipes that ended up in economic crisis throughout argentine economic history by performing regression tree analysis. We use fifteen financial and macroeconomic variables suggested by the theoretical and empirical literature.

Secondly, we attempt to list all costs provoked by crisis and measure Argentina's crises costs in terms of output losses. We follow the methodology used by the IMF (1998), that is, computing cumulative output lost relative to trend.

This paper is organized in five sections. In the following section we summarize the methodology carried out to date crises in Argentina, as performed by Cerro and Meloni (2003), and highlights some historical events that were key to understand those crises. In section III we identify the ingredients of "explosive cocktails" by means of the Regression Tree Method. Section IV evaluates the costs of currency crisis in terms of output losses and recovery time and discusses some other costs caused by crises. Finally, section V is reserved for concluding remarks.

II. CRISES IDENTIFICATION

Currency crises[1] are generally defined as situations in which speculative attacks on the exchange value of the currency result in devaluation (or sharp depreciation) of the currency[2]. The extended empirical literature proposes two alternative methods to identify currency crisis. The simplest one, searches for substantial nominal currency devaluations as performed by Frankel and Rose (1996). A more laborious approach, though still simple, is to construct a market pressure index that takes into account not only exchange rate changes but also movements in international reserves and interest rates. This is the approach followed by Cerro and Meloni (2003) to identify crises in Argentina from 1823 to 2003[3] [4].

The so-called Market Turbulent Index (MTI) is the sum of three rates of change: international reserves, exchange rate and interest rate weighted by the inverse of the respective standard deviation to avoid the most variable component dominates the index movements. Algebraically,

$$MTI = \frac{\hat{e}}{\sigma_e} - \frac{\hat{R}}{\sigma_R} + \frac{\hat{i}}{\sigma_i}$$

Where the symbol ^ represents the rate of growth of the variable; ***e*** is the exchange rate, ***R*** stands for international reserves, ***i*** is the domestic interest rate and σ_e, σ_R, σ_I are the standard deviations of the growth rate of the exchange rate, international reserves and domestic interest rate, respectively.

The Market Turbulence Index (MTI) stems from the idea that market pressure increases when exchange rate devaluates (rises), when interest rates increase and when international reserves fall. Under a floating exchange rate regime, we expect abrupt increases in the

[1] The literature on financial crises usually distinguishes four broad types of financial or economic crises. (a) Currency crises (b) Banking Crises (c) Systemic financial crises (d) Foreign debt crisis

[2] See IMF (1998)

3 Eichengreen, Rose and Wyploz (1994) pioneered this approach.

[4] Sansón (2004) constructs different market pressure indexes to study Argentine crises.

exchange rate as crisis develops, while under a fixed exchange rate, prior to devaluation, interest rates increase and international reserves diminish[5].

Depending on the deviation from the MTI, crises were classified as very deep (or crashes), deep and mild[6]. Table 1, Panels A and B, shows the behavior of the MTI and its components for the period 1823-1913, computed from annual data (Panel A), and 1914 –2002, calculated from monthly data, (Panel B). Computations from annual data might result in underestimation of the number of crises, since episodes occurred within a given year cannot be detected by the index. Likewise, due to data availability, from 1823 to 1874 the index includes only the exchange rate.

Table 1. Panel A. **Crises in Argentina: 1823- 1913. Annual data**

Crisis/year	Depreciation/ Devaluation (%)	International Reserves (%)	Crisis Type
1826/27	**253.0**	**na**	**Very Deep**
1829/30	127.8	na	Mild
1839/40	153.9	na	Deep
1846	45.7	na	Mild
1876	5.8	-67.4	Mild
1885	37.0	113.8	Deep
1889/91	**177.0**	**-28.6**	**Very Deep**

Source: Cerro and Meloni (2003)

Note: See Appendix for details.

Before the national organization period (starting in 1862) crises were associated with international conflicts that resulted in blockades to the port of Buenos Aires and hence in dramatic falls in the revenues from import tariffs, the main source of financing the public budget, which in turn was high and growing due to military spending. The country suffered three blockades. The first one, in 1826, during the war against Brazil (1825 – 1827) and two more in 1838 – 1840, performed by the French, and in 1845 – 1848 carried out by the combined French and British forces.

On the other hand, the three episodes dated in the last quarter of the century, the crises of 1876, 1885 and 1889/91, were good examples of inconsistency between monetary and fiscal policy. During the Sarmiento administration (1868-74) expenditures had grown considerably not only because the war with Paraguay and various conflicts in the provinces demanded military outlays but also due to the ambitious public investments plan[7]. The country had a convertibility regime and the adverse international conditions[8] that started in 1873 that led to the contraction in the gold-backed money supply, obliged the government to sell the stock of metallic notes and to reduce public sector expenditures. But the attempts to sterilize the negative effects of gold outflows failed and finally convertibility was abandoned in May 1876.

The crisis of 1885 had similar features. By July 1883 the paper-peso exchanged at par with the gold-peso[9]. The period of convertibility lasted only seventeen months. By the end of

[5] Typically, governments spend international reserves or increase interest rates to defend the currency or moderate exchange rates changes.
[6] See Appendix I for details.
[7] Cortés Conde (1989) -pages 87 and 113- describes the huge increment in expenditures during Sarmiento years and the austerity measures taken by Avellaneda.
[8] Delargy and Goodhart (1999) consider the 1873 crises as the first truly international one. The epicenter of the crisis was the Austrian Bourse, which received the impact of an investment boom triggered by a huge indemnity paid to Germany after the Franco –Prussian war.
[9] In 1881 the Congress voted a currency reform law that introduced a bimetallic standard system.

December 1884, the banks of issue did not stand ready to sell gold at par to all who offered the metallic note. Hence, in March 1885 the federal government decreed the inconvertibility of paper money.

The 1889/91 crisis was one of the deepest in Argentine history. The root of the crisis can be found in the poor administration of President Juárez Celman, characterized by the outrageous increased in public expenditure and the high level of indebtedness, both external and domestic. In this period, the government created the National Guarantee Banks (Bancos Nacionales Garantidos) that is, banks entitled to print their own money, which lead to huge increments in the monetary base. High levels of public indebtedness coupled with easy monetary policy brought about devaluation expectations, with the consequently fall in specie reserves. In 1890 most private and public banks broke and, given the impossibility of facing their obligations, a generalized default was declared.

Panel B shows the behavior of the MTI and its components during the 19 crises ocurred from the beginning of the WWI to the present. There were 4 crises episodes rated as very deep, 7 as deep and 8 as mild.

Table 1. Panel B. **Crises in Argentina: 1914- 2003. Monthly data**

Crisis	Rate of Change (%)			Market Turbulence Index				Crisis Amplitude (1)	Crisis Type
	Exchange Rate	International Reserves	Interest Rate	MTI > 3 σ	MTI > 2 σ	MTI > σ	MTI > ½ σ		
1914	0.7	-15.4	16.7		2		1	3	Deep
1918/19	0.1	1.1	27.6		1	2	1	10	Mild
1920/21	48.2	0.0	10.2			2	5	11	Mild
1929/31	79.4	-48.9	28.4	3	6	7	4	22	Very Deep
1937/38	18.6	-28.0	11.9			4	5	14	Mild
1948/49	247.4	-44.7		1	1	4	2	16	Deep
1950/51	114.7	-30.6			1	2	1	8	Mild
1955	66.7	-40.7				1	3	4	Mild
1958	97.6	-78.0		1	1	2	2	10	Deep
1962	76.3	-75.7		1	1		5	10	Deep
1964/65	103.5	-63.5			1	2	5	13	Mild
1971	134.1	-73.9					3	14	Deep
1975/76	2282.1	-80.9		2	4	7	2	21	Very Deep
1981/82	2999.3	-67.0	151.0	1	2	7	1	24	Deep
1983/84 /85	9958.6	-70.0	214.0			8	6	22	Mild
1986/87 /88	1498.7	-74.2	359.5		3	3	5	23	Deep
1989/90 /91	68935.6	-66.1	896.4	11	1	2	1	26	Very Deep
1995	0.0	-40.2	150.0		2	2	0	4	Mild
2001/02	268.5	-67.2	737.9	9	1	3	4	25	Very Deep

Source: Cerro and Meloni (2003)

Notes: See Appendix for details.

(1) Crises amplitude results from computing the numbers of months from the beginning to the end of the crisis.

The behavior of the variables deserves some comments. First, devaluations/ depreciations during crises increased over time, but clearly the 1948/49 crisis stands out for the magnitude of the devaluation, 247%, unusual for those years. It can also be observed that the 1975/76 crash constitutes a hinge. Before that crisis, devaluations ranged between two-digits and the lower three-digits and from 1975/76 climbed to the four-digits, reaching a peak in the 1989/91 crash. The smallest devaluations were those corresponding to the 1914 and 1918/19 crises with percentages lower than 1%. It is worthwhile to remark that the 1914 crisis had a peak in August 1914, when WWI forced President Victorino de la Plaza[10] to suspend the full convertibility of the peso after 13 years of gold standard regime.

Second, international reserves drainage also shows a growing trend, with percentages below the 50% until the 1955 mild crisis and almost doubling for the following crises. To illustrate the magnitudes involved in each period, notice that the 1929/31 crash implied a 49% fall in international reserves, the largest in the first half of the century, but modest if compared to most of the mild and deep crises in the lasts 50 years.

Third, the interest rates also exhibits two periods clearly distinguishable. For those crises before 1940, the growth rate never surpassed 30% while for the crises in the last quarter of the XX century the three-digit rate of change was the norm.

Forth, except for the 1929/31 crash, that lasts 22 months, the amplitude of crises before 1975/76 crash only occasionally reached the year, while for the rest of the century the amplitude was in the neighborhood of two years, with the sole exception of the so called Tequilla crisis in 1994 with four months duration.

It can also be observed that, based on the MTI components, the 1918/19 crisis was the mildest, with modest increases in the interest rates and almost no changes in exchange rates and international reserves. The deepest was the 1989/91 with uncontrolled increases in exchange rates and interest rates and huge reserve losses.

III. SEARCHING FOR COCKTAIL INGREDIENTS: AN APPLICATION OF THE REGRESSION TREE APPROACH

As we see from the previous section the magnitude of the fluctuations involved during crises in Argentina lead us to ask which are the factors involved in such performances, or to follow the analogy of the title of the paper, which are the ingredients of the “explosive cocktails” made in Argentina?[11]

In order to answer the question we will carry out regression tree classification analysis.

Regression Tree Analysis

The regression tree analysis is a non-parametric, data classification technique, aimed at identifying the variables involved in each crisis separately. The output of regression tree method is a set of terminal nodes, called tree. Each terminal node characterizes a crisis or a group of crises. The method considers an initial split of the data into two subgroups, favoring homogeneity within each group and heterogeneity between the groups. This split is repeated in sequential form until each subset terminates either when there is no impurity reduction from splitting or when the number of observations in the cell is less than a specified number of rows (or observations). Many different criteria can be defined for selecting the best split at each node. However, the properties of the final tree selected are insensitive to the choice of the splitting rule. Variable misclassification costs and prior distributions can be incorporated into the splitting structure in a natural way.

[10] President Roque Sáenz Peña died in 1914 and was succeeded by Vice- President Victorino de la Plaza.
[11] The searching for bartenders is left to the reader

Before applying the regression tree technique to the data set we choose the following parameters to build the decision tree:

1. *Predictor variable*: years of crises (plus the year preceding the crisis year) and non-crises, according to the MTI. Thus, in the sample, there are 65 *crises years* and 115 *non-crisis years*.
2. *Default method used to split nodes in the tree*: Gini splitting.
3. *Minimum size node to split*: 40 observations (or rows). This constraint results in a smaller tree (fewer nodes), which gives greater predictive accuracy than larger trees. There is a trade–off between the size of the tree and the misclassification rate (Bayes probability error). As the tree grows (more nodes) the method gets a better description of each crises but prediction is poorer.
4. *Probability of crisis*: 0.3. From the MTI classification we have 65 *crises years* (including the year preceding each crisis), which means that probability of crisis is 36%. A sensitivity analysis was carried out and the best fit was achieved with 0.3.
5. *Misclassification costs*: 1. This means that the cost of misclassify a *crisis year* as a *non-crisis year* is the same as committing the mistake of classifying a *non-crisis year* as a *crisis year*.
6. *Cross-validation*: 10 fold. V-fold cross validation is a technique to determine the optimal tree size. V-fold cross validation performs independent tree size test without requiring separate test datasets and without reducing the data used to build the tree to determine the optimal tree size. The learning dataset is partitioned into some number of groups called "folds". For instance, assume 10 partitions (the default number) are created. In each case, 90% of the data is used to build a test tree and 10% is held back for independent testing, that is, the classification error for this 10% is computed. This process is repeated 10 times, building 10 separate test tree. Then, their classification error rate as a function of tree size is averaged. This averaged error rate for a particular tree size is the cross validation cost. The tree size that produces the minimum cross validation cost is the optimal tree size.

The regression tree method applied to currency crises has a couple of advantages when compared to other traditional methods. First, it does not impose the same functional form to all crises such as logit and probit models. Second, the probability of crisis augments as the number of variables indicating vulnerability increases. For example, an expanding domestic credit may be explosive with a convertible fixed exchange rate and with capital inflow reversal.

The classification also identifies which subset of early warnings is most important to classify and predict crises. Interestingly, decision tree also handle missing data values in the sample using surrogate splitters, which are back-up rules that closely mimic the action of primary splitting rules. For example, the GDP growth is the predictor variable whose splits most closely mimic the split of the primary splitter: bank deposit growth. The construction of a regression tree is described in Amado, Cerro and Meloni (2004)

Empirical Results: recipes for crises

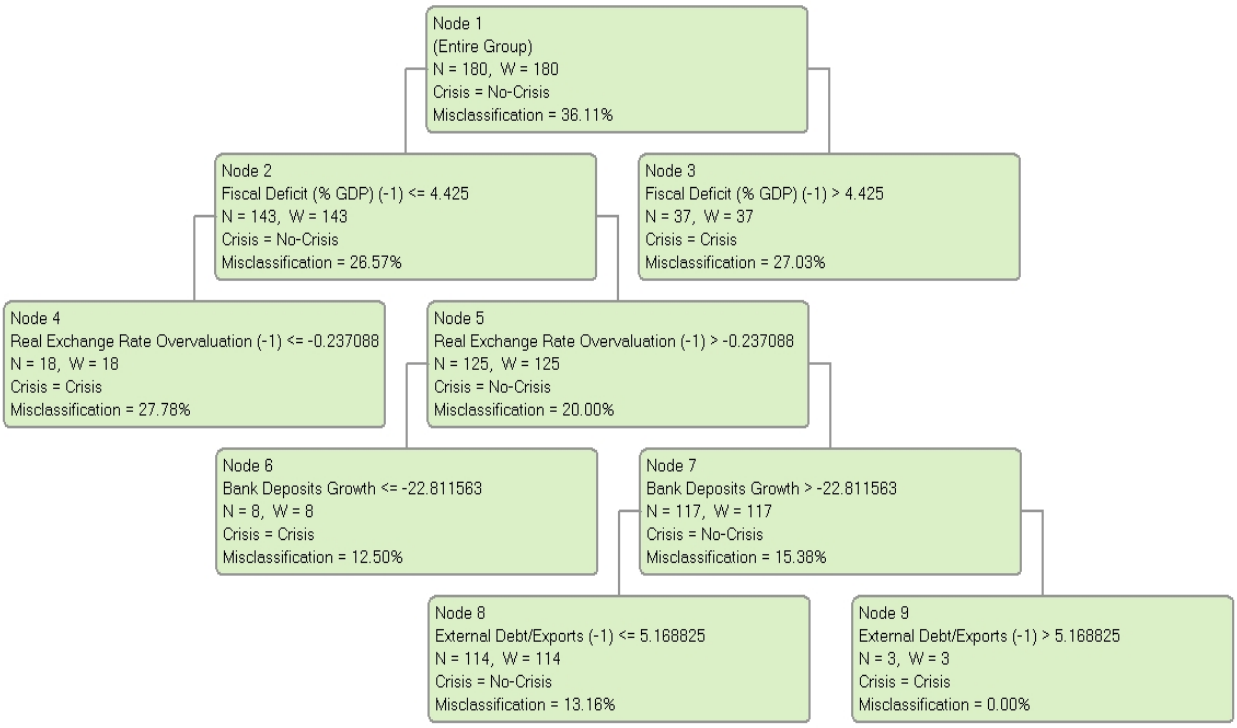
Previous to run the *Regression Tree* method, we classified each year as *crises* and *non-crises years* according to the MTI. The dependent variable is a dummy that takes the value 1 if the MTI identifies the event as crisis and 0 otherwise. We did not distinguish among crises intensity, i.e. very deep, deep, and mild. Independent variables were chosen from the prescription of the first, second, third generation models and the so-called sudden stops theory[12]. A total of fifteen indicators were used. The variables emphasized by the first-

[12] The theoretical models on the causes of financial crises are catalogued into three generations: first, second and third. Recently, sudden stops models have surged as another source of currency crises explanation. See Cerro and Meloni (2003)

generation model are Fiscal Deficit (% GDP), Public Expenditure Growth, Excess Real M1 Balances/GDP. Likewise, Second Generation Models stress Exports Growth, GDP Growth, Real Exchange Rate Overvaluation, Current Account Deficit. Third Generation Models consider the following as key variable: M2/Reserves Growth, M2 Multiplier Growth, M2/Reserves, M2 Multiplier, Bank Deposits Growth, External Debt/Exports. While, for Sudden Stop models variables are Nominal LIBOR, Nominal LIBOR Growth. This list of variables only pretends to show where the focus of the main theories at stake is. More than testing the relevance of particular models, we look for the recipe of crises in Argentina throughout history[13]. We do not make a tournament among rival theories; we are interesting in the ingredients of crises.

The results of regression tree classification are reported in Figure 1. It is found that observations are assigned to four terminal nodes[14].

Figure 1. **Regression Tree Analysis: Argentina 1823- 2003.**



The final classification rule identified four variables with overall importance greater than 50%: Fiscal Deficit (-1), Real Exchange Rate Overvaluation (-1), Bank Deposit Growth and the ratio of External Debt to Exports (-1). Notice that all four can be considered as *domestic condiments* contributing to crises[15]. In the fifth place comes the Nominal LIBOR (39% of importance) the only variable that can be mentioned as the *imported ingredient* of some "explosive cocktails".

Notice also the ability of the indicators lagged, compared to those contemporaneous, to predict crises one year in advance. This tree predicts better than the one found in a previous

[13] See Appendix for crises grouping according to different varieties as proposed by Kaminsky (2003).
[14] Actually, there are five terminal nodes; four nodes characterizing crises observations and one featuring non-crises.
[15] Of course, external factors, such as impairing in the terms of trade, may have influenced the behavior of exports and the fiscal deficit.

paper (see Amado, Cerro and Meloni, 2004) with contemporaneous variables as indicators, for the period 1885-2002. Nonetheless, both results are pretty much alike, since Fiscal Deficit is the variable that gets the first split of the data and Bank Deposit Growth and Real Exchange Rate Overvaluation are also splitters.

The overall importance of variables, based on the contribution that predictors make to the construction of the tree, is presented in table 2.

Table 2. **Overall Importance of Variables**.

Variable	Importance
Fiscal Deficit (% GDP) (-1)	100.00%
Real Exchange Rate Overvaluation (-1)	80,95%
Bank Deposits Growth	71,15%
External Debt/Exports (-1)	54,90%
Nominal LIBOR	39,28%
GDP Growth	19,41%
Excess Real M1 Balances (% GDP)	10,03%
Exports Growth	0,53%
Domestic Credit (% GDP)	0,41%

Finding cocktails ingredients

As already mentioned, the Regression Tree Classification Technique found four recipes for explosive cocktails. Notice that the results are *crisis years* and ***not*** crises. That is, a given crisis episode lasting two or three-year may have one recipe for one year and a different mix of variables for the others. The resulting cocktail formulas are the following:

First Split: High Fiscal Deficit

The first split of the data is carried out on the fiscal deficit as percentage of GDP (lagged once). If this variable exceeds 4.4% (observations with fiscal deficit higher than the 79.3 percentile), then that year should be considered as *crisis year*. We identify 27 *crisis years* that fulfill that condition: 1826, 1827, 1828, 1829, 1875, 1876, 1884, 1885, 1931, 1947, 1950, 1957, 1963, 1964, 1965, 1974, 1975, 1976, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1988 and 1989. Notice that high fiscal deficit was the only ingredient to make an "explosive cocktail" in those years. No other condiment was needed to generate a crisis, neither "*domestic"* nor *"imported"*. This variety of crises is consistent with first generation models and the probability of crisis in this final node is 54%.

Second Split: mixing moderate Fiscal Deficit with Real Exchange Rate Overvaluation

For those cases with moderate Fiscal Deficit to GDP ratio (less than 4.4%), there is a new split in the subgroup, performed by Real Exchange Rate Overvaluation lagged one period. If the real exchange rate overvaluation (-1) is in the 15.7 percentile or lower, we have another final node with 13 crises year: 1919, 1930, 1938, 1948, 1949, 1961, 1962, 1970, 1971, 1991, 2000, 2001 and 2002. That is, mixing moderate fiscal deficit/GDP with RER Overvaluation results in a new explosive cocktail. The probability of crisis of this node is 53%.

Third Split: moderate Fiscal Deficit, no RER Overvaluation plus strong decline in Real Bank Deposits

For those observations with no problems of real appreciation (observations with real exchange rate overvaluation lagged once, higher than the 15.7 percentile), the new split comes from Bank Deposits Growth. If real deposits fall more than 22.8% we have

another final node with 7 year crises: 1838, 1840, 1846, 1890, 1891, 1914 and 1990. Thus, another explosive mix is made with moderate fiscal deficit/GDP plus huge decline in real deposits. The probability of crisis in this node is 75%.

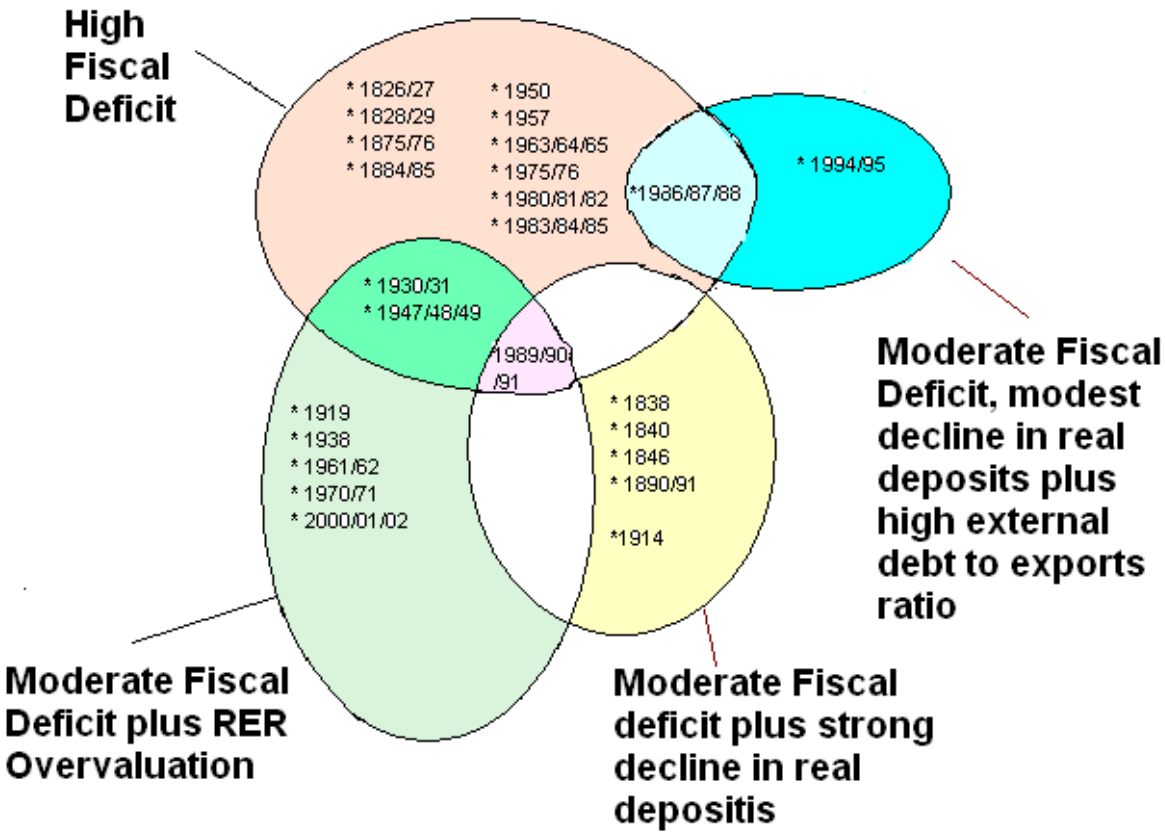
Fourth Split: moderate Fiscal Deficit, no RER Overvaluation, mild Real Deposits decline and high External Debt to Export ratio

Finally, if real deposit decline less than 22.8%, the sample is split again by the ratio of external debt to exports (lagged once), with a threshold of 5.2. For values greater than 5.2 (external debt in the 90-percentile or higher), we identify 3 crisis years: 1987, 1994 and 1995. That is, the last cocktail formula combines moderate fiscal deficit/GDP, mild (for Argentina) fall in real deposits and high external debt to exports ratio. The probability of crisis is 100%.

In the following diagram we have assign each *crisis year* to the four explosive cocktails and consider consecutive *crises years* as belonging to the same crisis episode. We have 10 crises in the first split (High Fiscal deficit), 4 of them corresponding to the XIX century crises. In the second split (Moderate Fiscal Deficit plus RER Overvaluation) we have 5 crises as well as in the third split (Moderate Fiscal deficit, plus Strong Decline in Real Deposits) and only one in the forth split (Moderate Fiscal deficit, Modest Decline in Real Deposits plus High External Debt to Exports ratio)

The intersections of splits stem from episodes with two or three *crisis year* belonging to different splits. For example, the 1930/31 crisis episode, worldwide known as the great depression, has one *crisis year* (1930) identified as coming from the second split and the other (1931) from the first split.

Figure 2. **Crises and Recipes**



Regression Tree and the MTI

The resulting rate of misclassification for the entire group of observations is relatively low, 25%. Moreover, as soon as we analyze each case separately, we found that there is only a small discrepancy between regression tree classification and MTI identification.

Misclassified data comes from three sources: (a) some *crisis years* were identified as non-crisis for the MTI presumably because some component of the MTI was lacking and avoided a correct classification, like the international reserves and the interest rates for 1823-1875 and the interest rate for 1940-1980; (b) for some other cases, the explanatory variables included in the Regression Tree indicate the existence of a crisis the year before the MTI components start to move (i.e. devaluation, reserves drainage, or scaling interest rates). It can be said that MTI is a good technique to identify crisis but fails as an early warning indicator. (c) There are also a few cases where the MTI signals a crisis but the Regression Tree technique denies it, but those are mostly the years included as "preceding years" and not properly *crises years* identified for the MTI.

Robustness.

In designing a classification tree, the ultimate goal is to produce a tree whose probability of error be, as close as possible, to the Bayes probability error. Table 3 shows the misclassification for the training dataset and the misclassification for the trees built for cross-validation. There are 31 misclassified *crisis years* for training data and 45 misclassified *crisis years* for cross-validation. The sensitivity analysis performed suggests a misclassification rate that stabilizes around 25%[16].

Since the definition of *crises years* is exogenous (taken from the MTI) and there are missing values in the sample, we check for robustness of the results. As a robustness check, we have varied the predictor variable using only the *crises years* suggested by the MTI and the *crises years* plus the two years preceding the *crisis year*. We have also conducted similar regression tree analysis for the period from 1885 to 2002 and for different percentages of the original sample (1823-2002) selected randomly[17]. The qualitative results are broadly similar, that is, none of the important results (fiscal deficit and real exchange rate overvaluation) are affected.

Table 3. Misclassification for Training Data and Cross-Validation. Summary Table.

	Misclassification for Training data			**Misclassification for Cross-Validation**		
	Crisis	***No-Crisis***	***Total***	***Crisis***	***No-Crisis***	***Total***
Predicted Crisis	50	16	66	41	21	62
Predicted No-Crisis	15	99	114	24	94	118
Total	65	115	180	65	115	180

IV. EVALUATING CRISES COSTS

The most common and obvious consequences of crises are short-run output drops. But there are also other effects on the country's production function inputs and on the total factor productivity that may have longer run impacts, such as diminishes in the human capital stock, institutional changes and income distribution worsening. By hurting some key inputs, crises might have delay effects or sequels that increase the probability of having a new and more severe crisis in the near future. The Dornbusch quotation, at the beginning of the paper, is very illustrative on this point.

16 See figure 1A in the Appendix.

17 We thank Andrew Nobel, Phillip Sherrod and Richard Olshen for comments and suggestions on this issue.

A complete evaluation of the cost of crises requires a careful examination of the impacts to avoid double counting[18].

The influence of crises on the income distribution has received a great deal of attention. Recently, Halac and Schmuckler (2004) describes five channels through which currency crises impact on income distribution[19].

The Output channel. The contraction of the economic activity causes a reduction in labor demand, particularly in the demand of unskilled workers. Moreover, the situation aggravates since the poor (mostly unskilled) generally have limited or no access to credit markets and lack assets to hedge against employment shocks. The recent 2001/02 crisis brought about a 15% decrease in real GDP and pushed vast sectors of the population below the poverty line.

The Inflation Channel. A high inflation is usually present in both, the process that ends up in a crisis and in the resolution of the crisis. The inflation tax deteriorates mainly the wealth and income of the poor. For example, the 1989/91 crash, that features hyperinflation, resulted in unprecedented poverty record in Argentina.

The Relative Prices channel. Currency depreciation, intrinsically associated with crises, increases the price of tradable relative to non-tradable goods. These changes in relative prices hurt the poor via fall in real wages. As currency depreciates, the prices of export goods and import goods go up with the consequent impact on wages.

The Public Spending channel. Once the crisis is in progress, the government usually cuts spending to close the fiscal gap that frequently characterizes crises episodes. Public spending cuts affect the provision of social services such as education, health and social programs aimed at the poor. As the public expenditure diminishes, the demand for labor gets affected both, directly through cuts in government temporary labor contracts, and indirectly via layoffs in firms suppliers of goods and services for the public sector.

The Financial channel. The resolution of crises usually entails huge bailouts from non-participants to participants of the financial sector. The devaluation of the peso announced in January 2002 would have meant the bankruptcy for many debtors, since 70% of the banking system's loan were denominated in dollars, the authorities decreed the conversion of the dollar debts to peso debts at the rate exchange rate that prevailed before the devaluation (one dollar equal to one peso) implying a 32 billons dollars transfer to borrowers.

There are some other variables affected by economic crises that have received considerably less attention, like migration and institutions, that might be very important in the case of Argentina:

The Migration channel. Crashes and the astonishing series of crises, change relative wages (domestic versus international) provoking "tradable human capital" to emigrate. The migration of skilled labor decreases human capital stock and affects the production function of the country.

The institutional channel. We can also conjecture that institutions, *the humanly devised constrained that structure political and economic interaction*, as defined by North (1991), affect and are affected by crises. Simple inspection of the historical data shows that cornerstones institutions, like democracy, the constitution of the country, and the independence of the judiciary resulted hurt, sometimes severely, few months after the beginning of most of very deep crises (or crashes). Table 4 seems to confirm the conjecture although linking these variables needs more theoretical and empirical work.

18 Schady (2002) analyzing the effects of the profound macroeconomic crisis in Peru in 1988–92 on the schooling and employment decisions made by urban school-age children founds that mean educational attainment was significantly higher for children who were exposed to the crisis than for those who were not.
19 We borrowed freely from Halac and Schmukler.

Interestingly, the six *Very Deep Crises* identified through the MTI were followed either by coup d'état (1930; 1976) or resignation before the president's term expires (Rivadavia in 1827; Juárez Celman in 1890; Alfonsín in 1989 and De la Rúa in 2001).

Again, following North (1991), if institutions were "devised to create order and reduce uncertainty", then we can conjecture that the interruption or *de facto* modification of rules generates disorder and uncertainty, which may weaken the economy and make the country prone to further crisis. Although we do not establish a formal and precise link between crises and institutional deterioration, it is also difficult to disregard a causal relationship between one crisis and the following, and the institutional channel arise as a good candidate to explain that apparent relationship.

Table 4**. Crisis and Political events**

Crisis		Political Events			MTI Classification
Crisis Years	**Beginning (month)**	**Changes in the Executive**	**Months between changes in Executive and Crisis beginning**	**Supreme Court Substitution**	
1826-27	na	President Rivadavia resigned July 7, 1827	*		Very Deep
1890-91	na	President Juárez Celman resigned Aug 6, 1990	**	No	Very Deep
1929-31	March 1929	Coup d'état (Yrigoyen) Sep 6, 1930	19	No	Very Deep
1955	Oct 1955	Coup d'état (Perón) Sep 16, 1955	-1	Yes	Mild
1962	Jan 1962	Coup d'état (Frondizi) March 28, 1962	3	Yes	Mild
1971	June 1971	Lanusse substitutes Levingston March 22, 1971	-3	****	Mild
1975-76	July 1974	Coup d'état (Martínez) March 24, 1976	21	Yes	Very Deep
1981-82	Dec 1980	Galtieri substitutes Viola Dec 11, 1981	12	****	Mild
1989-90-91	Jan 1989	President Alfonsín resigned July 8, 1989	6	No *****	Very Deep
2001-2002	Oct 2000	President De la Rúa resigned Dec 20, 2001	15	No******	Very Deep

Notes: * Rivadavia resigned after the 1826/27 crisis began, but we cannot establish the number of months between the two events since the crisis was identified with annual data.
** Juárez Celman resigned after the 1899/91 crisis began, but we cannot establish the number of months between the two events since the crisis was identified with annual data
*** Removed by another *de facto* government.
**** *De Facto* government
***** President Menen did not change the members of the Supreme Court, but increases the number of them from 5 to 9, which implicitly conditioned the Court.
****** President Kirchner (elected in 2003) removed various members of the Court appealing to constitutional mechanisms.

Computing Output loss

A rough assessment of the costs of the argentine crises in terms of lost output can be easily calculated by following three steps:

(a) Compute the *trend of the GDP growth*

(b) Compare GDP growth after a crisis with GDP growth trend.

(c) The cost in lost output is then estimated by adding up the difference between trend growth and actual growth in the years following the crisis until the time when annual output growth returned to its trend.

Likewise, we can also compute the recovery time from any given crisis, that is, how long it takes to the GDP growth to return to the *trend GDP growth*.

Table 5 Panels A and B exhibits the results for the periods 1823-1913 (crises computed from annual data) and 1914-2003 (crises computed from monthly data) respectively. It must be remarked that crises costs for 1823-1884 were estimated from fiscal revenues since GDP is not available for that period. Panel B features besides the duration of currency crises as obtained from the MTI fluctuations.

It must also be underlined that Argentina's GDP growth record changes dramatically through time so we compute *trend GDP growth* for various sub periods. Whereas this procedure is correct to avoid omitting mild crises, it obliges us to be cautious when comparing crises costs from different sub periods.

Table 5. Panel A. **Cumulative Output Loss and Recovery Time: 1823- 1913**

Crisis	Crises Classification according to MTI	Cumulative output loss (%)	Recovery Time (Years)
1826/27	**Very Deep**	**8.3**	**3**
1829/30	Mild	No cost	-
1839/40	Deep	4.7	1
1846	Mild	2.2	1
1876	Mild	No cost	-
1885	Deep	5.8	1
1889/91	**Very Deep**	**28.1**	**2**

Source: Cerro and Meloni (2003) and own calculations.
Note: From 1823 to 1884, cumulative output loss were estimated by computing cumulative fiscal revenue losses.

Despite the previous caveat about comparisons it seems reasonable to sustain that the 1890-91 crisis was the most important during the XIX century. During the 1887-1889 Argentina was speeding up at outrageous rates, what explains the magnitude of the crash.

The first crisis of the XX century, occurred in 1914, associated to the end of almost 14 years of convertibility under the gold standard regime, and preceded by the "golden years" of the centenary was very expensive too (15.8%). But, the dearest crisis in the first half of the century was the one related to the great depression, from 1929 to 1931, not only due to the enormous cumulative output loss (almost 24%) but also because recovery time was three years.

As the country's trend of the GDP growth diminished, and crises repeated with certain regularity, costs became relatively low. That is why, crises classified as *very deep* by the MTI, like the 1974/76 and 1989/91, cost "only" 6.5% and 7% respectively. At the beginning of the XX century the country fell from high levels of *GDP growth trend*, while at the end of the century it fell from very modest *GDP growth trend*. For example, the 1989/91 crisis was the culmination of a decade characterized by continuous crises and consequently poor performance measured by output growth. Hence, recovering the GDP growth to the levels prevailing previous to the crash demanded a relatively small increase in output.

Table 5. Panel B. **Cumulative Output Loss and Recovery Time: 1914- 2002**

Crisis		Crises Classification according to MTI	Cumulative output loss (%)	Recovery Time (Years)
Years	Duration (months)			
1914	3	Deep	15.8	1
1918/19	10	Mild	No cost	-
1920/21	11	Mild	No cost	-
1929/31	**22**	**Very Deep**	**23.7**	**3**
1937/38	14	Mild	2.8	1
1948/49	16	Deep	5.1	1
1951	8	Mild	8.8	1
1955/56	4	Mild	1.0	1
1958	10	Deep	10.3	1
1962	10	Deep	9.6	2
1964/65	13	Mild	No cost	-
1971/72	14	Deep	1.1	1
1974/76	**21**	**Very Deep**	**6.5**	**2**
1980/82	24	Deep	9.7	2
1983/85	22	Mild	7.0	1
1986/88	23	Deep	2.3	1
1989/91	**26**	**Very Deep**	**7.0**	**2**
1994/95	4	Mild	5.1	1
2000/2002	**25**	**Very Deep**	**23.0**	**3**

Source: Cerro and Meloni (2003) and own calculations.

We also conduct a comparison among the costs involved in each of the four nodes of the regression tree. That is, we want to know which is the cost of each type of crisis and, of course, which is the most expensive mix. Table 7 exhibits the cumulative output loss of each "explosive cocktail". Due to data availability, we computed the costs of crises from 1875 to 2002. When episodes involve more than one crisis year belonging to different mixes we compute the average cost.

Table 7. **Cumulative Output Loss. Classified by Node. 1875- 2002**

Variable	Node 3 **High Fiscal Deficit**	Node 4 **Moderate Fiscal Deficit + RER Overvaluation**	Node 6 **Moderate Fiscal Deficit + strong decline in Real Bank Deposits**	Node 9 **Moderate Fiscal Deficit + mild Real Deposits decline + high External Debt to Export ratio**
Number of Crises years	22	13	4	3
Total cost	63.8	53.5	35.5	5.9
Average cost	2.9	4.1	8.9	2.0

Crises in Node 3 (the high fiscal deficit type) are the most frequent, with total costs close to 64%, but its average cost is "only" 2.9%.

The dearest crises, with 8.9% cumulative output loss are Node 6 crises, which combines Moderate Fiscal Deficit plus strong decline in Real Bank Deposits, presumably entailing banking crises. On the other hand, the average cost of crises that mix moderate fiscal deficit with RER overvaluation is 4.1%, while Node 9 combining moderate fiscal deficit, mild real deposits decline and high external debt to exports ratio is 2%, perhaps due to the small numbers of cases.

V. CONCLUDING REMARKS

High Fiscal Deficit, Real Exchange Rate Overvaluation, Bank Deposit Growth Rate decline and high ratio of External Debt to Exports are the key ingredients of the 26 explosive cocktails that poisoned Argentina from independence days to the present. A touch of import condiment like an increasing LIBOR is also needed.

We found four crisis recipes, having fiscal deficit as the common factor in all mixes. The first one includes only extremely high fiscal deficits which predict a crisis with 54% of probability. This is the most frequent type of crisis in Argentina and its average cost, measure as the cumulative output lost per crisis year, is relatively moderate (2.9%)

When combining moderate fiscal deficits with real exchange rate overvaluation the probability of crisis remains around 53% and the average cost climbs to 4.1%. On the other hand, mixing moderate fiscal deficit with huge declines in the rate of growth of real deposits produces the dearest crises (average cost is 8.9%) and the probability of crisis increases to 75%. Finally, there a few cases of low-cost cocktails (average cost is 2%) having moderate fiscal deficits and high external debt to ratio exports as the main ingredients but the probability of crisis when this combination is present is 100%.

Results are very robust and reinforce the ones obtained by Cerro and Meloni (2003), that relied on a set of non-parametric tests and macroeconomic variables analysis in the neighborhood of the crises to conclude on the characteristics of argentine crises, and by Amado, Cerro and Meloni, (2004) that performed graphical analysis, probit regressions and regression tree analysis to determine the factors explaining currency crisis.

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Appendix

Market Turbulence Index

The index was computed with monthly data from 1914 to 2002. We imposed different criteria to sort crises, but whenever the MTI is greater than the mean (μ) plus ***k*** standard deviations (STD) we identify a "signal" or "turbulent episode". We require at least two "close" months with ***MTI*** greater than the mean value plus three STD to consider that episode as deep crisis or "crash". If the ***MTI*** is greater than μ plus two STD but less than μ plus three STD, we call it "mild crisis". If ***MTI*** exceeds its mean value in a half STD at least twice the episode is considered "minor turbulence". The remaining episodes, i.e. when the index departs less than one half standard deviation from the average are termed as "non- crisis" or tranquility times. In high inflation episodes (1976 and 1989), we excluded the data for the estimation of the moments, to preclude these data distort the "signals". In order to determine the boundaries of a given crisis and so avoiding dating twice the same crisis, we require at least six months with no signals between each other.

With annual data, we arbitrarily classified an episode as "mild crisis" when the market turbulence index exceeds one and a half standard deviations from the mean value in a given year. If MTI is greater than two STD we say that the crisis is "deep" and if MTI only exceeds its mean value in one STD, we term that episode as "minor turbulence". It is worth remarking that the terms "tranquility", "mild", "deep" and "very deep" are referred to the sub period considered and does not intent to be an absolute qualification for the whole period.

Table 1A. Panel A. ***Criteria to sort Crises. Monthly Data***

Criteria		Classification
Index	**# of Signals**	
MTI < 0.5 σ_{MTI}		Non- crisis
0.5 σ_{MTI}<MTI< 2 σ_{MTI}	Two close months	Mild
2 σ_{MTI} <MTI < 3 σ_{MTI}	Two close months	deep
MTI > 3 σ_{MTI}	Two close months	Very Deep

Table 1A. Panel B. ***Criteria to sort Crises. Annual Data***

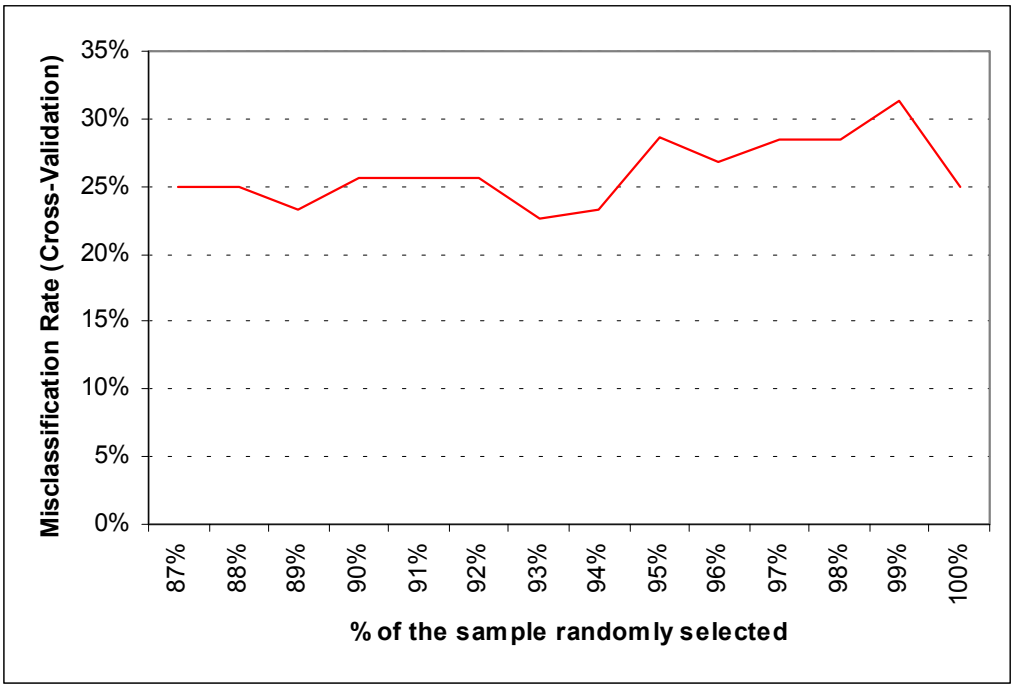
Criteria	Classification
MTI < σ_{MTI}	Non- crisis
σ_{MTI} <MTI < 1.5 σ_{MTI}	Mild
1.5 σ_{MTI} <MTI < 2 σ_{MTI}	Deep
MTI > 2 σ_{MTI}	Very Deep

The ***MTI*** was computed for six sub periods in order to keep its variance relatively homogeneous. Sub periods were chosen by political, economical and historical events.

(a) From the Independence to the National Organization: 1823 - 1861
(b) From the National Organization to the First World War: 1862- 1913
(c) The Interwar Period: 1914- 1945
(d) From Perón to Perón: 1946- 1976
(e) From Hyper to Hyper Inflation: 1976- 1991
(f) Convertibility: from boom to burst: 1992 – 2002

Sensitivity Analysis for The Bayes Probability of Error

Figure 1A. **Sensitivity Analysis for The Bayes Probability of Error**.



Varieties of Currency Crises

Following Kaminsky (2003) we classify each node in different varieties:

Table 2A. Varieties of Currency Crises.

Node	Characteristics	Fiscal Deficit	Current Account	Banking Crises	External Debt	Self-Fulfilling	Probability of Crises	Prediction
3	Fiscal Deficit (% GDP) (-1) > 4.425%	*					54%	Crisis
4	Fiscal Deficit (% GDP) (-1) < 4.425% RER Overvaluation (-1) < -0.237		*				53%	Crisis
6	Fiscal Deficit (% GDP) (-1) < 4.425% RER Overvaluation (-1) > -0.237 Bank Deposits Growth < -22.81%			*			75%	Crisis
8	Fiscal Deficit (% GDP) (-1) < 4.425% RER Overvaluation (-1) > -0.237 Bank Deposits Growth > -22.81% External Debt/Exports (-1) < 5.17					*	6%	No-Crisis
9	Fiscal Deficit (% GDP) (-1) < 4.425% RER Overvaluation (-1) > -0.237 Bank Deposits Growth > -22.81% External Debt/Exports (-1) > 5.17				*		100%	Crisis

Note: The * indicates to which variety of crises each group belongs

International Comparisons

In a recent study that covers the 1975-1997 period, the IMF (1998) accounts for 158 financial crises from 53 countries (22 industrial countries and 31 developing countries). Crises were classified in three categories, currency crashes, Banking crises, and Currency and banking crises (usually called twin crises). It is worth noting that IMF estimations may be biased downward because instances where output growth did not return to trend over the sample period were excluded from the calculations.

Table 4A. **Costs of Crisis 1970-1998**

Type of Crisis/ Countries	Number of Crisis	Average Recovery time (in years) 1	Cumulative output loss 2	Number of Crises with output losses 3	Cumulative output losses per crisis (in percentage points) 4
Currency Crises	158	1.6	4.3	61	7.1
Industrial	42	1.9	3.1	55	5.6
Emerging	116	1.5	4.8	64	7.6
Currency Crashes	55	2.0	7.1	71	10.1
Industrial	13	2.1	5.0	62	8.0
Emerging	42	1.9	7.9	74	10.7
Banking Crises	54	3.1	11.6	82	14.2
Industrial	12	4.1	10.2	67	15.2
Emerging	42	2.8	12.1	86	14.0
Twin Crises[6]	32	3.2	14.4	78	18.5
Industrial	6	5.8	17.6	100	17.6
Emerging	26	2.6	13.6	73	18.8

Source: World Economic Outlook, IMF (1998) and own calculations

Notes: (1) Average amount of time until GDP growth returned to trend. Because GDP growth data are available for all countries only on annual basis, by construction the minimum recovery time was one year
(2) Calculated by summing the differences between trend growth and output growth after the crises began until the time when annual output returned to its trend and by averaging over all crises
(3) Percent of crises
(4) Calculated by summing the difference between trend growth after the crises began until the time when annual output growth returned to its trend and by averaging over all crises that had output losses.
(5) Currency crashes are identified by crises where the currency component of the exchange market pressure index accounts for 75% or more of the index when the index signals a crisis.
(6) Identified when banking crises occurred within a year of currency crisis.