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Sovereign Debt Crises in Latin America: A Market Pressure Approach

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ABSTRACT: We construct a continuous sovereign debt crisis index for four large Latin American countries for the period 1870–2012. To obtain the optimal set of indicators and the optimal value of the threshold for dating crises we apply the receiver operating characteristic (ROC) curve. Our sovereign debt crisis index is a weighted average of three indicators: the debt-to-GDP ratio, the external interest rate spread, and the exports-to-imports ratio. The continuous index allows a more advanced analysis of sovereign debt crises as illustrated with an investigation of the relationship between sovereign debt crises and business cycles in Latin America.

KEY WORDS: debt crisis index, receiver operating characteristic (ROC) curve, sovereign debt crises

Introduction

The sovereign debt crisis in Europe has renewed interest in sovereign debt crises. Until now the analysis of sovereign debt crises has been limited by the crisis index that is traditionally used, which is a binary variable to distinguish debt default (crisis) periods from non-debt default (crisis) periods. To overcome this limitation, we construct a continuous index for sovereign debt crises. A continuous index has two advantages. First, a continuous index is more informative. It makes it possible to compare the relative sizes of different debt crises, to identify near-default periods, and to perform Granger causality tests with the business cycle or economic growth. Second, a sovereign debt crisis index reflects debt servicing difficulties, whether or not these end in default. We call this sovereign debt crises index a market pressure index. The construction of the debt market pressure index (DMPI) is our main contribution to the literature.

To construct a continuous index, we combine indicators that show different behavior in times of a debt crisis compared to normal times for the four largest Latin American countries—Argentina, Brazil, Chile, and Mexico—for the period 1870–2012. We have chosen these countries for their long history of sovereign debt crises.

Our crisis identification procedure is based on the idea underlying the Exchange Market Pressure Index (EMPI), which was introduced by Girton and Roper (1977) and used by Eichengreen, Rose, and Wyplosz (1995) to identify currency crises. The EMPI captures not only significant currency depreciations, but also periods when the exchange rate is under pressure and defended by depleting foreign reserves and/or increasing interest rates. Similarly, we extend the traditional focus on sovereign debt defaults to sovereign debt crises by including periods of debt-servicing difficulties that put pressure on the market for sovereign debt.

The indicators we select to construct the DMPI—the debt-to-GDP ratio, the external interest rate spread, and the exports-to-imports ratio—are based on stylized facts of sovereign debt crises in

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/MREE.

emerging economies and on the theoretical literature on sovereign debt crises, notably Arellano's (2008) incarnation of the sovereign default model of Eaton and Gersovitz (1981) and the sudden stop model of Calvo (1998, 2003).

Empirical research on sovereign debt suggests that the debt-to-GDP ratio is a strong indicator for sovereign defaults in emerging economies (Manasse and Roubini 2009; Furceri and Zdzienicki 2012; Catão and Milesi-Ferretti 2014). Reinhart and Rogoff (2010) observe that debts continue to rise after defaults as arrears accumulate and GDP contracts. This debt overhang will remain high until the debt is restructured, which is typically defined as the end of the debt default period. Borensztein and Panizza (2009) observe that credit ratings and external interest rate spreads surge in the first years of a debt default. The current account typically reverses in times of a debt crisis (Aguar and Gopinath 2006; Catão and Milesi-Ferretti 2014). In addition, a sudden stop in capital inflows can trigger a decrease of the current account deficit.

When the DMPI is used as a crisis index, it has to be combined with a decision rule—a crisis is signaled when the index exceeds a threshold—and compared to a benchmark crisis series. For the benchmark we follow the definition of Manasse, Roubini, and Schimmelpfennig (2003), who define sovereign debt crises as episodes of either an outright default or a near default. Near-default episodes are periods of large IMF assistance (access in excess of 100 percent of quota) to avoid a possible default. Debt defaults are thus a subset of debt crises.¹

The threshold is determined by the trade-off between missed crises and false alarms—each having its own cost. We apply the receiver operating characteristic (ROC) curve to find simultaneously the optimal set of indicators and the value of the threshold. Recently, the ROC methodology has been applied in different fields of economics. Berge and Jordà (2011) apply ROC curves to evaluate the performance of their business cycle index, Catão and Milesi-Ferretti (2014) to signal external debt crises, and Jordà, Schularick, and Taylor (2011) to signal banking crises. Catão and Milesi-Ferretti (2014) use a multivariate probit model to determine which index best signals sovereign debt defaults. Our work is fundamentally different since we construct a crisis index that reflects stress on the sovereign debt position, while they model an early warning system to determine which indicators have the highest predictive power for external debt crises. In addition, we take into account the entire sovereign debt crisis episode while they focus only on the first year of the external debt crisis. Furthermore, whereas Catão and Milesi-Ferretti (2014) implicitly assume that missed crises are as costly as false alarms, the utility function criterion we adopt allows us to choose the best possible index under different combinations of penalties for missed crises compared to false alarms.

Method

To build a debt market pressure index (DMPI) we need to select indicators, weights, and thresholds similarly to the construction of an exchange market pressure index for currency crises (cf. Eichengreen, Rose, and Wyplosz 1995) or a money market pressure index for banking crises (see von Hagen and Ho 2007).

Construction of the DMPI

We construct different debt crisis indexes with different combinations of indicators suggested by the literature. All indicators are transformed when required to avoid non-stationarity and are standardized per country.

Define $DMPI_t^i$ as a weighted average of, say, three variables $X_{1,t}^i$, $X_{2,t}^i$, and $X_{3,t}^i$, with standard deviations $\sigma_{X_1^i}$, $\sigma_{X_2^i}$, and $\sigma_{X_3^i}$, respectively. Index i refers to the country (1 = Argentina; 2 = Brazil; 3 = Chile; 4 = Mexico), and t refers to the observation ($t = 1, \dots, T$). For the weights, we follow Eichengreen, Rose, and Wyplosz (1995) by taking inverted standard deviations

$$DMPI_t^i \equiv \frac{X_{1,t}^i}{\sigma_{X_1^i}} + \frac{X_{2,t}^i}{\sigma_{X_2^i}} + \frac{X_{3,t}^i}{\sigma_{X_3^i}}. \quad (1)$$

The indexes are pooled and standardized, such that we obtain a vector of size $4T$ in case the series are of equal size.

DMPI as a Crisis Index

The DMPI identifies periods with increased pressure on debt servicing. However, we have no similar benchmark that captures debt-servicing difficulties, only a binary benchmark variable. Therefore, to evaluate the effectiveness of the continuous index as a crisis index, we convert the index into a binary variable such that we can compare our index with a benchmark. If the index exceeds a preestablished threshold, then a crisis is signaled and the value of 1 is assigned to the binary variable, and zero otherwise. The higher the threshold, the less exceedances are to be expected. This will result in fewer false alarms (type I error), but also in more missed crises (type II error). The optimal threshold depends on the relative costs of the two error types. To determine the optimal threshold, we do a grid search over the interval $[0; 2.5]$ in steps of 0.1 times the standard deviation of the DMPI and compare the crisis signals to a published benchmark crisis series. For each country and each period, the constructed crisis signal dummy is compared with the benchmark crisis dummy. For each threshold, we construct a contingency table as in Table 1.

The ROC Curve

In signal detection theory, a receiver operating characteristic (ROC) curve is a graphical illustration of the performance of a binary classifier system as its discrimination threshold is varied. The ROC curve was first developed by electrical engineers and radar engineers during World War II for detecting enemy objects in battlefields and was soon introduced to psychology to account for perceptual detection of stimuli. One application in economics is presented by Berge and Jordà (2011), who evaluate the performance of their business cycle index. They argue that “A major advantage of the ROC curve is that it is not tied to a specific loss function as it itself is a map of the entire space of trade-offs for a given classification problem. The ROC curve can be estimated non-parametrically and ROC-based summary statistics have large sample Gaussian distributions that make formal inference convenient . . .” (Berge and Jordà 2011, 249).

The total positive rate (TPR), or $R(c)$, is defined as $n_1/(n_1 + n_3)$; that is, the percentage of correct crisis signals relative to the total number of crises. The TPR depends on the threshold c . A

Table 1. Contingency table of crisis realizations and signals

Index	Realization	
	Crisis	No crisis
Crisis	n_1 (TP)	n_2 (FP)
No crisis	n_3 (FN)	n_4 (TN)

Notes: n_1 : number of observations in which the model signals a crisis that actually took place: correct crisis signals (TP: true positive); n_2 : number of observations in which the model signals a crisis that did not take place: false alarms (FP: false positive); n_3 : number of observations in which the model does not signal a crisis that actually took place: missed crises (FN: false negative); n_4 : number of observations in which the model does not signal a crisis that did not take place: correct noncrisis signals (TN: true negative).

Figure 1. The receiver operating characteristic (ROC) curve for the four largest Latin American countries.

high TPR means that the model signals the crises well, while a low TPR implies that the model misses crises. TPR is also known as the sensitivity or recall rate, the power of the test, or 1 minus the Type II error.

The other principal statistic is the false positive rate (FPR), or $r(c)$, which is defined as the percentage of false alarms relative to the total number of noncrisis years: $n_2/(n_2 + n_4)$. FPR equals 1 minus the specificity, or the Type I error, the size of the test. A high FPR means that the index signals crises that do not take place, and a low FPR implies that the index correctly does not signal a lot of crises. In the remainder of this article, we use R and r to indicate the total positive rate and the false positive rate, respectively.

Figure 1 displays a ROC curve for our index. A random guess gives a point along a diagonal line from the left bottom to the top right corner (the so-called line of no discrimination). Points above the diagonal represent good classification results (better than random); points below the line represent poor results (worse than random). The perfect classifier system has a TPR of 1 and an FPR of 0. This means that the model shows 100 percent sensitivity (no missed crises) and 100 percent specificity (no false alarms).

Utility

To determine the combination of indicators and the threshold that generate the best possible outcome, we turn to a utility function approach.² This method was first introduced by Charles Sanders Peirce in 1884 (Baker and Kramer 2007). After assigning utility values, we calculate the overall utility of the classification:

$$U(r) = U_{11}R\pi + U_{01}(1 - R)\pi + U_{10}r(1 - \pi) + U_{00}(1 - r)(1 - \pi), \quad (2)$$

where U_{ij} is the utility associated with signal i , given the true state j ; U_{11} is the utility of a correctly signaled crisis; U_{01} is the utility of a missed crisis; U_{10} is the utility of a false alarm; U_{00}

is the utility of a correctly signaled noncrisis episode; and π is the unconditional probability of observing a crisis.

The utility is maximized by taking the first derivative of the utility function with respect to r , the false positive rate. After rearranging, we obtain

$$s = \frac{dR}{dr} = \frac{U_{00} - U_{10}}{U_{11} - U_{01}} \frac{1 - \pi}{\pi}. \quad (3)$$

So, the optimum is the point where the slope of the ROC curve equals the expected marginal rate of substitution between the net utility of accurate noncrisis and crisis signals. If the ROC curve is continuous and concave, the optimum is the point where the slope of the ROC curve equals s (Baker and Kramer 2007).

If the loss-to-profit ratio $(U_{00} - U_{10})/(U_{11} - U_{01})$ is large or the outcome rare (π small), the slope will be steep, and the optimal operating point will occur at a small value of FPR. This is the case when false alarms are relatively “expensive” compared to missed crises. If the loss-to-profit ratio is smaller or the outcome is more common, the slope will be less steep and the optimal operating point will occur at a larger FPR value. This is the case when missed crises are relatively expensive compared to false alarms.

To determine the optimal set of indicators and the threshold, we assign values to the utilities U_{ij} of signal i given the true state j in Equation (2). We use $U_{11} = 1$, $U_{00} = 1$, $U_{10} = -1$, and apply a range of $-1, -2, -3, \dots, -10$ for U_{01} . The motivation behind this nonsymmetric treatment is that we assume that missed crises are more costly than false alarms. The more negative U_{01} , the more a missed crisis is penalized compared to false alarms.

Data

We use an unbalanced panel consisting of four large Latin American economies (Argentina, Brazil, Chile, and Mexico) for the period from 1879 (for Mexico the starting year is 1895) up to and including 2012.

Drawing on stylized facts, theoretical soundness, and data availability, we selected the following variables as potential crisis indicators: total central government debt as a percentage of GDP (from Reinhart and Rogoff 2010), external interest rate spread, inflation, changes in government expenditure, fiscal budget, domestic nominal interest rate, terms of trade, ratio of exports to imports (all from Aiolfi, Catão, and Timmermann (2011)), and polity2, a dummy variable that captures the political system on a scale of +10 (full democracy) to −10 (autocracy) drawn from Polity IV, Center for Systemic Peace. All series are standardized as mentioned above.

The external spread series is incomplete.³ We replace missing data with inflation as suggested by Manasse and Roubini (2009) and Reinhart and Rogoff (2009), especially for emerging markets. Visual inspection of the combined series (standardized external spread and standardized inflation) shows no signs of structural breaks. Correlation coefficients between inflation and external spread in years that both series are available are equal to 0.85 for Mexico (1996–2012), 0.65 for Argentina (1993–2012), and 0.33 for Chile (1870–1956). The debt-to-GDP ratio is based on total gross central government debt, which consists of both external and domestic debt. We use this series as a proxy for foreign currency sovereign debt. For further details on definitions and sources, see Appendix B.

To determine the accuracy of the DMPI, we compare the crisis signals with reported benchmark crisis dummies that consist of the debt defaults according to Standard and Poor’s (S&P), as reported in Borensztein and Panizza (2009), complemented with IMF large financial assistance packages (Manasse and Roubini 2009) (see column (3) in Table 2). Following Reinhart and Rogoff (2009), we use a two-year exclusion window, which implies that debt crises with two years intervals or shorter are considered the same crisis.

Table 2. Sovereign debt crisis episodes for the four largest Latin American countries, 1870–2012

	Standard and Poor's (Borensztein and Panizza 2009)	Manasse and Roubini (2009)	Combined
	Sovereign debt defaults	IMF financial assistance	Sovereign debt crises
Argentina	1890–93, 1982–93, 2001–05	1995	1890–93, 1982–95, 2001–05
Brazil	1898–01, 1902–10, 1914–19, 1931–33, 1937–43, 1983–94	1998–99, 2001–02	1898–10, 1914–19, 1931–33, 1937–43, 1983–94, 1998–02
Chile	1880–83, 1931–47, 1983–90	-	1880–83, 1931–47, 1983–90
Mexico	1866–85, 1914–22, 1928–42, 1982–90	1995	1914–22, 1928–42, 1982–90, 1995

Results

The utility function approach selects three indicators as optimal for the DMPI index: the external interest spread, the debt-to-GDP ratio, and the ratio of exports to imports.⁴ The selected indicators are in line with the sudden stop model: a high debt-to-GDP ratio makes a country vulnerable for debt crises, and the current account reverses when a crisis unfolds; a high debt level increases the probability of a debt crisis, which causes external spreads to increase, and when a crisis unfolds, the current account deficit reduces sharply, which is in accordance with Arellano (2008). Government expenditures, the fiscal budget, the terms of trade, and (changes in) the political system do not contribute to a higher utility. Figure 2 shows the DMPI and the benchmark crisis periods for the

Figure 2. DMPI and benchmark debt crisis periods (shaded areas).

Figure 3. DMPI: Utility (vertical axis) under different penalty values for missed crises, with the threshold on the horizontal axis.

four Latin American countries. A peak in the DMPI implies increased pressure on debt servicing. We can see that our debt crisis index shows peaks at the time of the debt crises, except for the Mexican debt crisis in the 1930s. We also observe that our index has peaks that are not associated with debt crises, such as for Argentina in the 1940s (revolutionary reforms during Peronist era: Gallo 2006) and for Chile in the 1970s (high inflation and political turmoil).

Figure 3 shows the utility values for different values of U_{01} . We apply two criteria to choose the penalty for a missed crisis: (1) The threshold is positive, and (2) the cost of a missed crisis is higher than the cost of a false alarm.

We report two optimal thresholds for different penalties for a missed crisis:

1. Mild penalty for missed crises ($U_{01} = -2$): The optimal threshold is 0.5 times the standard deviation. The results are shown in Table 3. The corresponding total positive rate R is 0.704, and the false positive rate r is 0.108.

Table 3. Contingency table for threshold 0.5

DMPI index (model)	Realization	
	Crisis	No crisis
Crisis	93 (17.0%)	45 (8.2%)
No crisis	39 (7.1%)	370 (67.6%)

Table 4. Contingency table for threshold 0.1

DMPI index (model)	Realization	
	Crisis	No crisis
Crisis	120 (21.9%)	107 (19.6%)
No crisis	12 (2.2%)	308 (56.3%)

2. Strong penalty for missed crises ($U_{01} = -4, -5$): The optimal threshold is 0.1 times the standard deviation. The results are shown in Table 4. The corresponding R is 0.909, and r is 0.258.

Comparison of the contingency tables shows that increasing the threshold decreases the number of false alarms, but at the cost of an increase in the number of missed crises. More precisely, when comparing the lower threshold (0.1) with the higher threshold (0.5), we observe that R (the true positive rate) increases by 0.205, and r (the false positive rate) increases by 0.150. By using a higher threshold, the performance in terms of missed crises improves relatively more than the performance in terms of false alarms deteriorates.

The performance of DMPI against the benchmark for debt crises is shown in Table 5. Column (3) lists the identified debt crises for a relatively high penalty for missed crises, and column (4) for a relatively mild penalty for missed crises. Which threshold to use depends on how strong the policy maker wants to penalize missed crises.

In our analysis of the results in the remainder of this section, we use a threshold of 0.5 (the last column of Table 5). The crisis signals are to a large extent similar to the published benchmark crisis dummies (the combination of S&P and IMF assistance). Our index does not miss any crisis period, although in some crises our DMPI does not identify the entire debt crisis period. Especially toward the end of the crisis period, our index often does not identify an increased pressure on the debt position. This can be explained by the renegotiations that are often more a political and legal issue and less an

Table 5. Benchmark debt crises and the constructed Debt Market Pressure Index for thresholds of 0.1 and 0.5 times the standard deviation respectively

Country Threshold	Benchmark	DMPI	
		0.1	0.5
Argentina	—	1876	—
Argentina	1890–93	1891–1903	1891–94, 1899–1902
Argentina	—	1915	—
Argentina	—	1932–37	—
Argentina	—	1941–46	1943–45
Argentina	—	1975–79	1976–78
Argentina	1982–95	1982–91, 1995	1982–91
Argentina	2001–05	2001–12	2001–12
Brazil	—	1889–90	1889–90
Brazil	1898–1910	1898–1909	1900–05, 1909
Brazil	1914–19	1914–16	1914–15
Brazil	—	1922–23	—
Brazil	1931–33, 1937–43	1930–45	1931–45
Brazil	1983–94, 1998–2002	1981–2006	1982–2005
Chile	1880–83	1878–82	1879–80
Chile	—	1898–99	1898
Chile	1931–47	1915–50	1915–17, 1931–46
Chile	—	1969–77	1973–76
Chile	1983–90	1983–91	1983–88
Mexico	—	1896–97	—
Mexico	1914–22	1909–27	1913–18, 1924
Mexico	1928–40	1931–43	1934–35, 1943
Mexico	1982–90	1982–90	1982–89
Mexico	1995	1995–99	1995–96

economical or financial issue. Our index picks up most crises in time; there are four crises that are picked up one year late, and one crisis (Mexico 1928–42) that is identified six years late.

The false alarms occur in periods with high volatility in the region or major political events. The sovereign debt crisis in Argentina in 1890 (Barings crisis) caused increased pressure from international investors on the entire region, in particular Brazil. In the late 1890s, Brazil experienced a debt crisis that affected Argentina and Chile. In Argentina, a period of frauds in the 1930s was followed by revolutionary reforms in the Peronist era starting in 1943. In the mid-1970s, both Argentina and Chile experienced military coups, started market reform experiments, and suffered from (very) high inflation (Ocampo and Ros 2011).

Application

An advantage of a continuous index as opposed to a binary variable is that the continuous index is more informative. This additional information can be used for more analysis, such as testing for endogeneity or causality between sovereign debt crises and economic growth and/or business cycles. Here we analyze the relation between business cycles and sovereign debt crises for four Latin American countries and show impulse-response functions based on a two-variable VAR system.

We perform an econometric analysis for the relation between debt crises and the short business cycle index of Aiolfi, Catão, and Timmermann (2011) shown in Figure 4. We did not update the index, so the comparison is for the period 1870–2004. We determine the DMPI for this shorter time horizon and find that the same combination of indicators performs best in mimicking its benchmark. The correlation coefficient between the business cycle index and the DMPI is -0.388 . The negative sign is expected since defaults typically take place in the recession phase of the business cycle.

Figure 4. Business cycle index for four Latin American countries, 1870–2004.

Figure 5. Impulse-response functions for DMPI and the business cycle index (BCS) with 90 percent confidence intervals. Cholesky ordering: BCS–DMPI.

To gain more insight into the relationship between the debt crisis index (DMPI) and the business cycle (BCS), we construct a VAR system and analyze the impulse-response functions (i.e., responses to one unit reduced form innovations) derived from the moving average or Wold representation of the reduced form model. The number of lags based on the likelihood ratio test is eight, which is about the average length of a sovereign debt crisis.⁵

The two-variable VAR with eight lags is stable, which implies that the impulse-response functions are valid. According to the block exogeneity Wald (chi-square) test, Granger causality is unidirectional at a level of significance of 5 percent. Accordingly, we assume that contemporaneous shocks to business cycles Granger-cause debt crises.

The graph in the lower-left panel of [Figure 5](#) shows that a one-standard-deviation shock to BCS lowers DMPI for two periods and increases DMPI in periods 4–7. Since the model is linear, for negative shocks the signs of the responses reverse. At continuation, we explain the graphs with reversed effect. Thus, a negative shock to economic activity increases the probability of a debt crisis for two years. In a recession, the probability of a default is higher, which explains the increased probability of a debt crisis. After four periods, the debt crisis index decreases while at the same time the business cycle starts an upturn (see top-left panel in [Figure 5](#)).

Our approach to construct a continuous DMPI variable can be easily applied to other countries. In Boonman, Jacobs, and Kuper (2013), we calculate the continuous sovereign debt crisis index for five European countries for the period 1992–2012. For these European countries, we use the same three indicators as for the Latin American countries. However, we cannot calibrate the continuous sovereign debt crisis indexes in terms of the selection of indicators and the threshold in the decision rule by maximizing utility as explained in this article because there are no benchmark crisis dummies for these countries.

Conclusion

We construct a continuous sovereign debt crisis index for four large Latin American countries for the period 1870–2012. Applying the receiver operating characteristic (ROC) curve, we determine the optimal sovereign debt crisis index and the threshold if we convert the index into a binary variable to compare it with a benchmark crisis index. For the definition of a debt crisis (DMPI), the optimal combination is debt-to-GDP ratio, external interest rate spread, and exports-to-imports ratio. The indicators are similar to the ones that feature in the models of Arellano (2008) and Calvo (2003). The probability of default is positively correlated with interest rates and, thus, the interest rate spread. In sudden stops, debt-to-GDP ratio tends to be high. This debt overhang will remain high until the debt is restructured, which typically takes a long time. Furthermore, in a sudden stop, capital inflows reverse, which is reflected by an increase in exports relative to imports.

The benchmark for this index consists of defaults according to Standard and Poor's, complemented by periods when IMF assistance was required. The optimal threshold is 0.5 times the standard deviation when missed crises have a relatively lower cost (two times the costs of a false alarm) or 0.1 when missed crises have a relatively high cost (four to five times the costs of a false alarm). Using 0.5 as the threshold, the DMPI index performs well in terms of missed crises: It does not miss any debt crisis period, although in various crises, our constructed crisis dummy does not identify the entire debt crisis period. Our index generates many false signals, yet all these periods can be traced to high volatility in the region (debt crises in neighboring countries), sharp drops in commodity prices, or major political events (military coups).

We illustrate the potential of our debt market pressure index in an analysis of the relationship between the business cycle index and the debt crises index in a two-variable VAR model. The impulse responses show that a negative shock to economic activity increases the probability of a debt crisis for two years. Four years after the shock, the probability of a debt crisis drops.

Notes

1. We refer to Appendix A for an overview of alternative definitions of sovereign debt defaults and sovereign debt crises.

2. Alternatives to evaluate the signals of binary variables are the area under the curve, and, as a special case, the Youden index. These methods do not make a distinction between false alarms and missed crises; these events have the same weight.

3. Missing observations for Argentina 1961–92, Chile 1957–99, Mexico 1895–1995.

4. A combination that yields similar results in performance consists of the debt-to-GDP ratio and the ratio of exports to imports.

5. Experimenting with different lags, or including exogenous variables like the US long-term interest rate and US real GDP growth yields similar impulse response functions.

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Appendix A

Debt Crisis Definitions

The following list of definitions is partially based on Pescatori and Sy (2007). We have ordered the definitions from narrow to broad.

- Moody's defines a default when the issuer has a missed or delayed disbursement of interest and/or principal, even if the delayed payment is made within the grace period or when the issuer offers a new security that leads to a diminished financial obligation (e.g., lower coupon or par value). This traditional definition of debt crises—focusing on defaults—does not capture all debt-servicing difficulties. For example, Moody's did not report the default of Greece before 2012, despite Greece having major debt-servicing problems since 2010.

- Standard and Poor's rates sovereign issuers in default if a government fails to meet principal or interest payment on external obligation on due date, or when a rescheduling of principal and/or interest is at less favorable terms than the original obligation.
- Detragiache and Spilimbergo (2001) define a debt crisis if (1) there are arrears of principal or interest on external obligations toward commercial creditors (banks or bondholders) of more than 5 percent of total commercial debt outstanding or (2) there is a rescheduling or debt restructuring agreement with commercial creditors as listed in the World Bank's Global Development Finance. They use a four-year exclusion window, which means that if a new crisis begins less than four years after completing the previous crisis, then this is not considered a new crisis but rather a continuation of the earlier crisis.
- Beim and Calomiris (2001) define a default when all or part of interest and/or principal payments due were reduced or rescheduled. They depart from the previous definitions because they consider not only bonds and bank loans to sovereign nations, but also supplier's credit. They exclude intergovernmental loans.
- A country may avoid a default through a large financial package from the IMF, as was the case in Mexico and Argentina in 1995 and in Brazil in 1998–99 and 2001–02. Therefore, Manasse, Roubini, and Schimmelpfennig (2003) extend the debt crisis definition. They consider not only outright default as a debt crisis, but also situations where default is avoided through the provision of large-scale official financing by the IMF. They define a debt crisis if (1) Standard and Poor's definition of a debt default applies, or (2) the country receives a large nonconcessional IMF loan, defined as access in excess of 100 percent of quota, which is partly used in the first year.
- Ciarlone and Trebeschi (2005) define a debt crisis if one of five conditions occur: (1) a country has officially declared a moratorium on public or external debt payments, (2) a country has incurred a missed payment of interest and/or principal on external obligations toward official and commercial creditors that adds up to more than 5 percent of the debt service ratio paid by year-end, (3) a country has accumulated arrears of interest and/or principal on external obligations toward official and commercial creditors that add up to more than 5 percent of the total external debt outstanding by year-end, (4) a country has signed a debt restructuring or rescheduling agreement with an official and/or commercial creditor, or (5) a country has received a large assistance package from the IMF, where large is defined as access in excess of 100 percent of quota.
- According to Pescatori and Sy (2007) and Sy (2003), the relatively low number of sovereign debt crises since the 1990s can partly be attributed to the definition of debt crises. Default on debt was common in the 1980s, but since bond markets developed strongly in the mid-1990s, the number of debt defaults has diminished, while numerous countries have faced difficulties in their debt servicing. For this reason, they propose an alternative definition of debt crisis: sovereign stress. There is sovereign stress when bond spreads are trading 1,000 basis points or more above U.S. Treasuries. The threshold is chosen as it is considered a psychological barrier for investors. The problem is that the data do not always fit this rigid definition: Some Asian countries did not even exceed the threshold in the Asia crisis, while various Latin American countries exceed the threshold also in tranquil times. As an alternative, they take the 90th percentile, based on extreme value theory and the kernel density estimation. Also under this definition, however it is possible that countries without debt problems will be included.

Appendix B: Data

Variable	Definition	Source
Exports	Exports, in millions of USD	1870–2003: ACT2011, 2004–12: IFS
Imports	Imports, in millions of USD	1870–2003: ACT2011, 2004–12: IFS (Brazil and Mexico: 1948–2012: IFS)
Export volume	Exports volume index, 2000 = 100	1870–2003: ACT2011, 2004–12: IFS (Argentina and Brazil), growth from WDI (Chile and Mexico)
Import volume	Imports volume index, 2000 = 100	1870–2003: ACT2011, 2004–12: IFS (Argentina and Brazil), growth from WDI (Chile and Mexico)
Terms of trade	Terms of trade, index: 2000 = 100	1870–2003: ACT2011, 2004–12: calculation: ToT = [exports / export volume] / [imports / import volume]
Inflation	Consumer price inflation (CPI), annual, geometric change	1870–2003: ACT2011, 2004–12: IFS
External spread	Interest difference between United States and domestic government on bonds denominated in USD. For Chile the reference country is the United Kingdom until 1956.	Brazil 1870–2004: ACT2011, Argentina 1870–1960 and 1993–2003: ACT2011, Chile 1870–1956 and 2000–03: ACT2011, Argentina, Brazil, and Chile 2004–12: Bloomberg; Mexico 1996–2012: Bloomberg
Government expenditure	Government expenses, in constant 1995 local currency; index: 1995 = 100	1870–2004: ACT2011, 2005–12: WEO (adjusted for structural break)
Government revenues	Government revenues, in constant 1995 local currency; index: 1995 = 100	1870–2004: ACT2011, 2005–12: WEO (adjusted for structural break)
Gross debt to GDP	Ratio of central government (external and domestic) debt to GDP	1870–2009: RR2011, 2010–12: Ministerio de Economia (Argentina), Tesouro Nacional (Brazil), Banco de Chile (Chile), Secretaria de Hacienda y Finanzas Publicas (Mexico)
Polity2	Polity2 index: -10 (autocracy) to +10 (democracy)	1870–2012: Polity IV project, Center for Systemic Peace
BC index	Business Cycle Index	1870–2004: ACT2011

Notes: ACT2011: Aiolfi, Catão, and Timmermann (2011); IFS: International Financial Statistics, from International Monetary Fund; RR2011: Reinhart and Rogoff (2011); WDI: World Development Indicators, from World Bank; WEO: World Economic Outlook, from International Monetary Fund.