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# "Finding the Tipping Point—When Sovereign Debt Turns Bad"

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## Abstract

Public debt has surged during the current global economic crisis and is expected to increase further. This development has raised concerns whether public debt is starting to hit levels where it might negatively affect economic growth. Does such a tipping point in public debt exist? How severe would the impact of public debt be on growth beyond this threshold? What happens if debt stays above this threshold for an extended period of time? The present study addresses these questions with the help of threshold estimations based on a yearly dataset of 101 developing and developed economies spanning a time period from 1980 to 2008. The estimations establish a threshold of 77 percent public debt-to-GDP ratio. If debt is above this threshold, each additional percentage point of debt costs 0.017 percentage points of annual real growth. The effect is even more pronounced in emerging markets where the threshold is 64 percent debt-to-GDP ratio. In these countries, the loss in annual real growth with each additional percentage point in public debt amounts to 0.02 percentage points. The cumulative effect on real GDP could be substantial. Importantly, the estimations control for other variables that might impact growth, such as the initial level of per-capita-GDP.


This paper—a product of the Economic Policy Sector, Poverty Reduction and Economic Management in Latin America adn the Carribbean Region—is part of a larger effort in the department to understand the impact of indebtedness on economic growth. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at fkoehler@worldbank.org.

# "Finding the Tipping Point - When Sovereign Debt Turns Bad"

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[1]Mehmet Caner and Thomas Grennes are from North Carolina State University, and Fritzi Koehler-Geib an Economist at the World Bank. The views expressed in this paper are those of the authors and do not necessarily represent the views of the World Bank Group, its Board of Executive Directors, or the countries they represent. The authors thank the anonymous reviewers for their insightful comments and suggestions on an earlier draft of this paper, as well as for comments received from participants at the World Bank-AfDB Debt Management Conference in Tunis in March 2010 where this paper was presented. We have tried to duly incorporate them in this version of the paper. This paper was prepared for the Debt Management Facility Stakeholders Forum in Tunis, March 29-30 2010, and is forthcoming in "Sovereign Debt and the Financial Crisis," eds. Carlos A. Primo Braga and Gallina A. Vincelette. World Bank. 2010. The authors would like to thank Rodrigo Chaves and Zafer Mustafaoglu for very helpful comments and support and Gallina Vincelette for very helpful suggestions.

# *I. Introduction*

Public debt has increased substantially for countries at all income levels as a result of the current global economic crisis. Historical evidence indicates that increases in debt persist for years following financial crises (Reinhart and Rogoff 2010; Scott 2010). In addition, projections of standard measures of public debt relative to GDP for the next 30 years indicate that debt levels are unsustainable for many countries (Cecchetti, Moharty, and Zampolli 2010). Taking account of the implicit public debt associated with social security, medical care, and contingent liabilities would reveal a substantially magnified debt problem (Cecchetti, Moharty, and Zampolli 2010).

The increase in public debt has raised concerns over whether it is starting to hit levels at which it might slow economic growth. Does such a "tipping point" exist? How strong would the growth impact be if debt surpassed the threshold? What would happen if debt stayed at elevated levels for an extended period of time?

According to Reinhart and Rogoff (2010), the answer to the first question is "yes." Using histograms summarizing evidence from 44 developed and developing economies, they find a threshold of 90 percent central government debt to GDP, after which the real growth rate declines. This threshold has received considerable attention in the press, which has referred to it as a "tipping point" (Pozen 2010). The threshold has practical significance, because the United States and many other countries have either reached this point or are projected to reach it soon and remain above it for years.

If debt thresholds exist, there are theoretical and empirical reasons why they might vary by country income. Debt may play out differently in low-income countries, because of less developed domestic financial markets; a different degree of openness (Frankel and Romer 1999; Levine and Renelt 1992); and different institutions (Acemoglu and others 2003; Alfaro and others 2008). Debt levels in low-income countries may also have different implications for growth through the inflation channel. Governments in countries without well-developed bond markets have resorted to monetizing government debt by selling bonds to their central banks. As a result, empirical studies have found a connection between fiscal deficits and inflation in low-income countries but no systematic connection in high- income countries (Catao and Terrones 2005; Pattillo, Poirson, and Ricci 2002).

This article analyzes thresholds in long-term average public debt to GDP ratios and the differential impact of debt on long-term GDP growth below and above such a threshold. It relies on estimates first introduced by Hansen (1996, 2000) and takes into account country characteristics such as initial GDP, inflation, and trade openness.

The analysis contributes to the literature by providing an econometrically rigorous analysis of the impact of long-run average public debt to GDP ratios on long-run average growth rates. It differs from the literature in three significant ways. First, the literature focuses primarily on the nexus between external debt and growth (see, for example, Cordella, Ricci, and Ruiz-Arranz 2010; Pattillo, Poirson, and Ricci 2002, 2004). In contrast, this chapter analyzes the nexus between total public debt and growth. Second, other studies (Cordella, Ricci, and Ruiz-Arranz 2010; Pattillo, Poirson, and Ricci 2002, 2004; and

Reinhart and Rogoff 2010) investigate the short-run effect of external debt on growth. In contrast, this analysis emphasizes the long-run relationship. Third, this analysis uses a different methodology to provide the core findings. In contrast to previous studies, which relied on spline functions (Cordella, Ricci, and Ruiz-Arranz 2010; Pattillo, Poirson, and Ricci 2002, 2004) or histograms (Reinhart and Rogoff 2010), this analysis relies on the threshold estimation techniques developed by Hansen (1996, 2000).[1]

The chapter is organized as follows. The next section, section II, describes the data. The third section describes the methodology. The fourth section presents the results. The last section provides some concluding remarks.

## *II. Data*

The analysis is based on a data set of 101 countries (75 developing and 26 developed), consisting of annual observations for the period 1980–2008 (countries are listed in the annex). By including a large group of both developing and developed countries, this data set improves on previous data sets.[2]
The main variables are gross public debt, GDP growth, and a set of control variables known to influence economic growth (table 1). Public debt is measured as the ratio of general government gross debt to GDP. When considering the debt-growth nexus, debt at all levels of government is relevant, because it influences the government's ability to engage in growth-enhancing potentially countercyclical policies. The average debt to GDP ratio was 67.1 percent for the entire sample (59.9 percent for high-income countries). Average GDP growth was 3.8 percent for the entire sample (2.6 percent for high-income countries).

**Table 1: Data Sources**

| *Variable* | *Time series* | *Data Source* |
|---|---|---|
| Real GDP growth | GDP (constant 2000 dollars) | World Development Indicators (World Bank) |
| Public debt | General government, gross debt, GDP (current dollars) | World Economic Outlook (IMF) |
| Openness | Imports of goods and services (current dollars)<br>Exports of goods and services (current dollars)<br>GDP (current dollars) | World Development Indicators (World Bank) |
| Inflation | Consumer price index | World Economic Outlook (IMF) |
| Initial GDP | GDP per capita in 1970 (constant 2000 dollars) | World Development Indicators (World Bank) |

*Source*: Authors.

## *III. Methodology*

The main results of the analysis draw on a threshold least squares regression model following Hansen (1996, 2000). We also use pooled least squares regressions, to relate our findings to those of Reinhart and Rogoff (2010). The description of the methodology here focuses on the threshold estimation technique (we do not account for potential endogeneity in the regressions).

Threshold estimation is used because it is superior to other techniques that have been used to estimate a nonlinear function. It allows one to identify the threshold level, its significance, the coefficients of the different regimes, and their significance simultaneously from the data based on a solid theory.

### III.1. Threshold Regression Model

The specification of the threshold LS regression model is as follows:

$$Y_i = \beta_{0,1} 1_{\{X_i \le \lambda\}} + \beta_{0,2} 1_{\{X_i > \lambda\}} + \beta_{1,1} X_i 1_{\{X_i \le \lambda\}} + \beta_{1,2} X_i 1_{\{X_i > \lambda\}} + \beta_{2,1} W_i 1_{\{X_i \le \lambda\}} + \beta_{2,2} W_i 1_{\{X_i > \lambda\}} + u_i \quad (1)$$

where 1 represents an indicator function that takes the value of one when the event inside happens, otherwise zero. Y represents the long run average real growth rate and X represents the long run average public debt-to-GDP ratio. W represents control variables. "i" is a country index. The unknown threshold value λ as well as the coefficients $\beta_{0,1}$ through $\beta_{2,2}$ are estimated with the threshold LS method of Hansen (2000). Note that equation (1) can be rewritten in two equations, where the first represents the regime below the threshold and the second the regime above the threshold:

$$Y_i = \beta_{0,1} + \beta_{1,1} X_i + \beta_{2,1} W_i + u_i, \quad if \quad X_i \le \lambda$$

$$Y_i = \beta_{0,2} + \beta_{1,2} X_i + \beta_{2,2} W_i + u_i, \quad if \quad X_i > \lambda$$

A more specific methodology would be to set thresholds on selected control variables. Here however, we start from a more general specification with two separate regimes, as described in equation (1).

### III.2 Test for Threshold

We test for a threshold in the relationship between the long-run average public debt to GDP ratio (1980–2008) and long-run average growth to verify the model in equation (1). The null hypothesis is that the

slope coefficients and intercepts are identical in the two regimes. In equation (1) this means that by using a heteroskedasticity-consistent Lagrange multiplier test (Hansen 1996), we test the following null hypothesis:

$$H_0 : \beta_{0,1} = \beta_{0,2}, \beta_{1,1} = \beta_{1,2}, \beta_{2,1} = \beta_{2,2} \qquad (2)$$

If there is no threshold, expression (2) will not be rejected, and a simple least squares model can be estimated. If there is a threshold effect, equation (1), including the unknown threshold value of $\lambda$, is estimated. Bootstrap *p*-values are used for this purpose, because they can replicate the asymptotic distribution, as Hansen (1996) shows.

## *IV. Results*

Overall, the results suggest that thresholds exist in the relationship between the long-run average public debt to GDP ratio and long-run GDP growth. They suggest that it is crucial to take into account initial GDP, that the threshold level differs for developing and developed economies, and that the cost of surpassing the debt threshold is high over time.

A note of caution on the results relates to potential endogeneity. Long-run average debt may be endogenous. The focus of the current study is to analyze the relation between long-run average debt and long-run GDP growth. Due to the interest in this long-run relation, we cannot use the instrumental variable threshold technique of Caner and Hansen (2004) which relies on short-run averages as instrument. The use of short-run average debt however, would imply a different research question. We will tackle the short-term question through panel data analysis in a future project.

However, the present study addresses potential endogeneity in the following way: Estimations are repeated adding initial debt/GDP (1980) to control for omitted variables bias and reverse causality. The results remain qualitatively the same with the same threshold values and small changes of the coefficients in the two regimes.

### IV.1 Debt Threshold – All Countries

The first main result is that the threshold level of the average long-run public debt to GDP ratio on GDP growth is 77.1 percent for the entire sample of 79 countries (initial GDP data were not available for 22 countries) (table 2). If debt surpasses this level, each additional percentage point in the ratio of public debt to GDP costs the economy 0.0174 percentage points in annual average real growth. This effect is highly significant and quantitatively important. Below this threshold, additional debt increases growth (the estimated coefficient is 0.065). This result is consistent with the idea that at moderate debt levels, a higher public debt to GDP ratio may actually imply that credit constraints are looser, and that the economy has more resources available for investment.

The results are derived from the model in equation (1), first developed by Hansen (1996), when equation (2) is rejected. We control for the (logarithm of) initial (1970) GDP per capita, inflation, and trade openness. The test statistic for the Lagrangean multiplier test is 14.21. Because the limit is nonstandard

but recoverable by a bootstrap procedure (Hansen 1996), the p-value from 1,000 bootstrap replications is 0.093, significant at the 10 percent level. The coefficients on inflation are insignificant. Trade has a positive effect on the growth under the high-debt regime, possibly because more credit is available for trade. Initial GDP per capita coefficients are significant and much higher in low-debt than high-debt regimes.

***Table 2: Threshold Regression, Two Regimes Based on Estimated Threshold Debt Level, Dependent Variable real average GDP growth***

| Variables | **Regime 1: Debt>=77%** | | **Regime 2: Debt <77%** | |
|---|---|---|---|---|
| | **Slope** | **Std Error** | **Slope** | **Std Error** |
| Log Initial GDP/capita(1970) | 0.00006* | 0.00001 | 0.0002* | 0.0001 |
| Trade Openness | 0.0454* | 0.0078 | -0.0007 | 0.0012 |
| Inflation | 0.0012 | 0.0007 | -0.0244 | 0.0164 |
| Debt/GDP | -0.0174* | 0.0010 | 0.0653* | 0.0128 |

*Source: Authors*

Note: Note: R^2 for the first regime is 0.985, and for the second regime is 0.987. There are 12 countries in the first regime, and 67 in the second regime. The 95% confidence interval for the Debt/GDP in Regime 1 is [-0.0195, -0.0154], for the second regime [0.0402, 0.0905]. These are based on Likelihood ratio test in Hansen (2000). The 95% Confidence Interval for Threshold estimate is [0.770574, 0.770574]. * represents significance at 5% level by using standard normal critical values as in Hansen (2000).

## IV.2 Debt Threshold Excluding Initial GDP

The second main result is that it is crucial to include initial GDP in the estimations. Repeating the estimations but omitting initial GDP significantly changes the threshold value. The estimated threshold for the debt to GDP ratio is 97.6 percent (table 3). The impact is small but highly significant and positive.

The results are derived from a Lagrangean multiplier test of equation (3.2). The test statistic for the Lagrangean multiplier test is 12.75, with a bootstrap *p*-value from 1,000 bootstrap replications of 0.097, significant at the 10 percent level. The country sample covers all 99 countries.

***Table 3: Threshold Regression, Two Regimes Based on Estimated Threshold Debt Level, excluding initial GDP, Dependent Variable real average GDP growth***

| Variables | **Regime 1 Debt>=97.6%** | | **Regime 2 Debt<97.6%** | |
|---|---|---|---|---|
| | **Slope** | **Std Error** | **Slope** | **Std Error** |
| Trade Openness | 0.00007* | 0.00001 | -0.0005* | 0.0001 |
| Inflation | 0.0027* | 0.0003 | -0.0091 | 0.0103 |
| Debt/GDP | -0.0147* | 0.0007 | 0.0805* | 0.0069 |

*Source: Authors*

Note: R^2 for the first regime is 0.976, and for the second regime is 0.969. There are 11 countries in the first regime, and 88 in the second regime. The 95% confidence interval for the Debt/GDP in Regime 1 is [-0.0173, -0.0130], for the second regime [0.0688, 0.0946]. These are based on Likelihood ratio test in Hansen (2000). The 95% Confidence Interval for Threshold estimate is [0.9074, 1.0441]. * represents significance at 5% level by using standard normal critical values as in Hansen (2000).

## IV.3 Differential Debt Threshold – Developing versus Developed Economies

The third main result is that the threshold differs substantially for developing and developed economies. Repeating the estimations for the subsample of developing countries yields a debt to GDP threshold of 64 percent. Moreover, the negative impact of debt exceeding this threshold is slightly greater than in the full set of countries (coefficient is –0.020 compared with –0.017 for the entire sample). We would have liked to repeat the exercise for the sample of developed countries only, but the small number (26) of countries made doing so impossible. The difference between the threshold for the full sample and the threshold for developing countries suggests that as a group, developing countries encounter growth rate problems at a lower debt to GDP levels.

The results, based on a Lagrangean multiplier test of equation (2), reveal the existence of a threshold (table 4). The coefficient for the Lagrangean multiplier test is 18.66; the bootstrap *p*-value is 0.002. The sample size of developing countries is 55 (reduced by lack of data on initial GDP for some countries). Coefficients on the control variables show the expected sign. Interestingly, the coefficient on trade openess is positive for high-debt regimes, which is understandable, but negative for low-debt regime, possibly because of trade barriers.

***Table 4: Threshold Regression, Two Regimes Based on Estimated Threshold Debt Level, Developing Countries Sample, Dependent Variable real average GDP growth***

| Variables | **Regime 1 Debt>=64%** | | **Regime 2 Debt<64%** | |
|---|---|---|---|---|
| | **Slope** | **Std Error** | **Slope** | **Std Error** |
| Log Initial GDP/capita(1970) | 0.0249* | 0.0015 | 0.0034 | 0.0024 |
| Trade Openness | 0.0002* | 0.0001 | -0.0015* | 0.0007 |
| Inflation | 0.0008* | 0.0004 | -0.0086 | 0.0311 |
| Debt/GDP | -0.0203* | 0.0039 | 0.0739* | 0.0093 |

Note: R^2 for the first regime is 0.98, and for the second regime is 0.98. There are 16 countries in the first regime, and 40 in the second regime. The 95% confidence interval for the Debt/GDP in Regime 1 is [-0.0312, -0.0088], for the second regime [0.0491, 0.0965]. These are based on Likelihood ratio test in Hansen (2000). The 95% Confidence Interval for Threshold estimate is [0.6335, 0.8524]. * represents significance at 5% level by using standard normal critical values as in Hansen (2000).

## IV.4 Growth Costs of Exceeding the Debt Threshold

What do these figures mean in terms of the quantitative impact of public debt on growth? How costly is it in terms of economic growth, when debt is above the threshold for an extended period of time? The fourth main result is that the impact of the public debt to GDP ratio exceeding the threshold level is costly in terms of GDP growth (table 5). The most extreme case is Nicaragua, where the average annual real growth rate could have been 4.7 percent higher had debt been at the 64 percent debt threshold for developing countries. High indebtedness was responsible for an annual loss of 4.7 percentage points of real GDP growth, equivalent to a 264 percentage point loss over the 28 years of the study. This example illustrates the high costs of persistent violations of debt threshold levels.

***Table 5: Estimated Forgone Growth as a Result of Exceeding the Debt Threshold, by Country***

| *Country* | *How high growth could have been if the debt-to-GDP ratio had been at the threshold level (percent real average growth rate)* | *Annual percentage point loss in real GDP growth* | *Cumulated loss over 28 years (percentage point loss in real GDP growth)* |
|---|---|---|---|
| Angola | 3.2 | 1.2 | 62.8 |
| Belgium | 2.7 | 0.6 | 18.4 |
| Bolivia | 2.4 | 0.1 | 1.6 |
| Bulgaria | 2.5 | 0.6 | 16.7 |
| Burundi | 2.6 | 0.8 | 24.3 |
| Canada | 3.1 | 0.4 | 11.6 |
| Congo, Rep. of | 5.0 | 1.0 | 32.7 |
| Côte d'Ivoire | 2.1 | 1.2 | 41.1 |
| Croatia | 1.5 | 0.2 | 6.0 |
| Ecuador | 3.0 | 0.1 | 1.5 |
| Greece | 2.2 | 0.0 | 0.5 |
| Guinea | 4.0 | 0.4 | 13.0 |
| Hungary | 1.8 | 0.1 | 3.2 |
| Indonesia | 6.8 | 1.3 | 45.2 |
| Italy | 2.1 | 0.4 | 10.9 |
| Jamaica | 2.0 | 0.2 | 5.1 |
| Japan | 2.9 | 0.6 | 18.6 |
| Jordan | 5.1 | 0.1 | 2.3 |
| Lao PDR | 6.8 | 0.8 | 33.0 |
| Latvia | 2.5 | 0.1 | 3.1 |
| Lebanon | 5.2 | 0.4 | 11.7 |
| Madagascar | 2.4 | 0.5 | 15.3 |
| Mali | 3.3 | 0.2 | 5.2 |
| Nicaragua | 6.6 | 4.7 | 264.6 |
| Nigeria | 3.4 | 0.2 | 4.7 |
| Philippines | 3.2 | 0.0 | 1.2 |
| Sierra Leone | 3.1 | 1.0 | 33.0 |
| Singapore | 7.3 | 0.4 | 13.0 |
| Tanzania | 5.0 | 0.2 | 6.3 |

*Source: Authors' calculations.*

Note: For developed economies a threshold of 77 percent public debt-to-GDP ratio is applied and for developing countries of 64 percent.

## IV.5 Comparing Our Results with Reinhart and Rogoff (2010)

We compare our findings with those of Reinhart and Rogoff (2010) by running simple pooled least squares regressions for subsamples below and above the threshold they suggest. In the pooled regressions we find a regime switch at the 90 percent debt to GDP ratio as indicated by Reinhart and Rogoff's analysis based on histograms. However, repeating the pooled regressions with a debt threshold of 60 percent, also shows a regime switch. These results illustrate that this methodology does not deliver clear threshold levels.

Additionally, given the demonstrated importance of controlling for initial GDP, the use of histograms or pooled regressions can only be indicative and must be interpreted with care. At least over longer periods of time, public debt can become detrimental to growth at lower levels of debt.[3]

We pool observations on GDP growth and government debt to GDP ratios for the same 20 industrial countries as Reinhart and Rogoff. We then run simple pooled least squares (with heteroskedasticity-corrected errors) for two sets of countries. The first set contains countries with debt levels of at least 90 percent (table 6). The second includes countries with debt ratios below 90 percent. We compare the slope coefficients for the government debt to GDP ratios for the two sets of regressions. The result allows a more precise comparison of countries above and below the threshold than Reinhart and Rogoff. As Reinhart and Rogoff (2010) suggest, there is a regime switch at the 90 percent debt to GDP ratio. [4]

We extend this simple exercise by also considering a 60 percent public debt to GDP ratio (table 7). The first set of observations corresponds to debt ratios above 60 percent, and the second group is for debt ratios below 60 percent. The difference between slope coefficients for the two groups is small compared with the 90 percent threshold. However, in these regressions there is a regime switch at the threshold level, with the impact of debt on GDP turning negative above.

**Table 6: GDP Growth and Debt Ratio: 90% Threshold Level**

| Debt | Slope | Std Error | t test | p-value |
|---|---|---|---|---|
| >=90% | -0.0137 | 0.0065 | -2.10 | 0.038 |
| <90% | 0.0012 | 0.0055 | 0.23 | 0.819 |

**Table 7: GDP Growth and Debt Ratio: 60% Threshold Level**

| Debt | Slope | Std Error | t test | p-value |
|---|---|---|---|---|
| >=60% | -0.0091 | 0.0037 | -2.43 | 0.016 |
| <60% | -0.0057 | 0.0089 | -0.03 | 0.519 |

## *V. Conclusion*

This analysis provides an analytical foundation for the debt-growth relationship by formally testing for the existence of a threshold and estimating the threshold value while controlling for other important variables that influence growth. The threshold value is sensitive to the inclusion of income per capita, and it decreases when high-income countries are excluded from the sample.

The main findings are that the threshold level of the average long-run public debt to GDP ratio on GDP growth is 77 percent for the full sample and 64 percent for the subsample of developing countries. Surpassing these thresholds is costly for countries, which forgo GDP growth if debt exceeds the threshold for an extended period.

The analysis of debt thresholds can be informative, but threshold levels should be interpreted with caution. Our analysis is based on long-term averages over nearly 30 years, so that temporary deviations from the average need not have important negative effects on growth. If a country's debt ratio exceeds the threshold for a year or two because of a recession, its long-term growth need not suffer (Scott 2010). The existence of debt thresholds need not preclude short-term fiscal stabilization policy. If debt explosions move debt ratios above the threshold and keep them there for decades, however, economic growth is likely to suffer.

## *VI. Appendix*

### Countries covered

| *Economy type* | *Countries* |
|---|---|
| Developing economy (75) | Algeria; Angola; Argentina; Bangladesh; Benin; Bolivia; Brazil; Bulgaria; Burkina Faso; Burundi; Cameroon; Chad; Chile; China; Colombia; Congo, Rep. of; Costa Rica; Côte d'Ivoire; Croatia; Dominican Republic; Ecuador; Egypt, Arab Rep. of; El Salvador; Estonia; Ethiopia; Ghana; Guatemala; Guinea; Haiti; Honduras; Hungary; India; Indonesia; Jamaica; Jordan; Kenya; Lao PDR; Latvia; Lebanon; Lithuania; Madagascar; Malaysia; Mali; Mexico; Morocco; Nicaragua; Niger; Nigeria; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; the Philippines; Poland; Romania; Russian Federation; Rwanda; Senegal; Sierra Leone; Singapore; the Slovak Republic; Slovenia; South Africa; Sri Lanka; Tanzania; Thailand; Togo; Tunisia; Turkey; Uganda; Ukraine; Uruguay; Venezuela, R. B. de; Vietnam |
| Developed economy (26) | Australia; Austria; Belgium; Canada; the Czech Republic; Denmark; Finland; France; Germany; Greece; Iceland; Ireland; Italy; Japan; Korea, Rep. of; Portugal; the Netherlands; New Zealand; Norway; the Slovak Republic; Slovenia; Spain; Sweden; Switzerland; the United Kingdom; the United States |

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[1]. Cordella, Ricci, and Ruiz-Arranz (2010) also estimate threshold regressions. These results are not used for the main message of their paper.

[2]. Reinhart and Rogoff (2010) analyze 20 developed countries; other studies focus exclusively on developing countries. See, for example Pattillo, Poirson, and Ricci (2002, 2004) and Cordella, Ricci, and Ruiz-Arranz (2010), each of which analyzes more than 60 countries.

[3]. We use a shorter period of time than Reinhart and Rogoff (2010) and general government debt rather than central government debt.

[4]. The simple pooled regression does not control for any other economic variables that affect growth or test for the existence of a threshold. Thus, the results should be interpreted with caution.