The Debt-to-GDP Threshold Effect On Output: A Country-Specific Analysis

by Luke Lechtenberg

Abstract: The recent economics literature has focused on establishing a general debt-to-GDP threshold across countries where output growth becomes negatively affected. This paper, conversely, attempts to establish debt-to-GDP thresholds for individual countries, the purpose of which is to show that a country's fiscal policy decisions should be based on data specific to that country, which should foster more informed and prudent policy making.

Introduction

In the aftermath of the 2008 financial crisis, economists began conducting a postmortem, asking questions such as: how did this happen, how could it have been prevented, and how can we recover from it as quickly as possible? This paper is concerned with the lattermost question, but even more specifically, the question of what effect the level of public debt has on GDP growth. Reinhart and Rogoff (2010), in their paper "Growth in a Time of Debt," were the first to broach this question following 2008. They asserted that when a country's public debt reaches a 90 percent debt-to-GDP threshold, GDP growth slows. Their findings had far reaching consequences and prompted many Eurozone governments, such as France, Austria, Germany, Italy, Greece, and the United Kingdom, to enact budget austerity measures in an effort to avoid the 90 percent threshold.

This paper reviews some of the theoretical and empirical economics literature on this topic, and unlike Reinhart and Rogoff (2010), who establish a general debt threshold for all countries, this paper establishes debt thresholds for *individual* countries through threshold regression analysis and supports the theory proposed by Chudik et al. (2015) that debt trajectory, not the level of debt, is what affects GDP growth. Ultimately, the threshold found by Reinhart and Rogoff will be rejected as a basis for government fiscal policy decisions, as it is based on general data when country-specific data is needed.

Review of the Literature

During recessions, governments go into debt to finance spending that boosts aggregate demand and output in the short run, averting the disasters of a potentially deeper and longer recession (Mankiw & Elmendorf, 1999). In the short run, wages and prices are sticky so increases in aggregate demand—achieved through increases in government expenditure—boost national income. The downside of public debt is manifest in the long run where classical economic assumptions hold and wages and prices are no longer sticky. A decrease in government savings (i.e., an increase in government debt) is assumed to not be matched by an equal increase in private savings, which in turn drives up demand for money in the loanable funds market, thereby raising the interest rate (Mankiw & Elmendorf, 1999; Gale & Orszag, 2003). A higher interest rate ultimately results in a decrease in investment and a subsequent decrease in capital stock, which lowers the marginal product of labor and thereby lowers wages and income (Mankiw & Elmendorf, 1999).

"Growth in a Time of Debt" by Reinhart and Rogoff (hereinafter R & R) addresses the negative impacts of government debt that are evident in the long run (R & R, 2010). R & R (2010) believe that there is a debt-to-GDP threshold where GDP growth is sharply and negatively affected, and they purport that threshold to be 90 percent. To find this threshold, R & R (2010) studied twenty advanced economies over the period 1946-2009 and exogenously imposed

four levels of thresholds in order to group countries according to their levels of debt. The four thresholds were 1) below 30 percent, 2) between 30 and 60 percent, 3) between 60 and 90 percent, and 4) above 90 percent. The countries with debt-to-GDP levels in excess of 90 percent had median growth rates about 1 percent lower than countries at the other threshold levels. This simple statistical analysis led R & R (2010) to believe that once countries reach a 90 percent debt-to-GDP ratio, their economic growth is severely impacted. Their paper provided the rationale for subsequent austerity measures initiated throughout the Eurozone, as countries such as Great Britain and Greece made drastic cuts in government expenditures to avoid the 90 percent threshold.

Many papers were published in response to R & R's, either supporting, questioning, or rejecting their conclusions. Fortunately, Panizza and Presbitero published a survey of the "recent literature on the links between public debt and economic growth in advanced economies" (i.e., papers that addressed R & R's findings, either directly or indirectly) (Panizza & Presbitero, 2012, p. 1). The main conclusion that Panizza and Presbitero found throughout the literature is embodied in this statement by the International Monetary Fund: "There is no simple relationship between debt and growth . . . There are many factors that matter for a country's growth and debt performance. Moreover, there is no single threshold for debt ratios that can delineate the 'bad' from the 'good'" (Panizza & Presbitero, 2012, p. 1). In other words, R & R oversimplified the relationship between debt and GDP growth, and it is not possible to apply a single, general threshold to individual countries. The critical problem in R & R's oversimplification is their exogenously imposed thresholds. An ideal model would establish thresholds endogenously, which would provide a more accurate measure of how public debt affects GDP growth.

Minea and Parent (2012) delve deeper into R & R's contention that a universally applicable 90 percent debt-to-GDP threshold exists across developed countries, and argue that, in fact, no such universally applicable threshold exists. Minea and Parent (2012) use cutting edge econometrics, a Panel Smooth Threshold Regression model, and find that, on average, countries with debt levels between 90 and 115 percent grow slower than those with lower debt levels. However, countries with debt levels in excess of 115 percent actually exhibit a positive relationship between debt and growth (Minea & Parent, 2012). The authors emphasize that this is not an excuse for countries to run profligate fiscal policies; rather, it simply illustrates that the relationship between debt and growth is subject to complex nonlinearities, and therefore making policy decisions according to a universal threshold is unwarranted. Indeed, Panizza and Presbitero agree, saying that "the conventional interpretation of the presence of a debt threshold, which is generally used to argue that if a country raises its public debt-to-GDP ratio above 90 percent, GDP growth will decline" is a "fallacy" (Panizza & Presbitero, 2012, p. 18).

Égert (2015) critiques Reinhart and Rogoff by using their data to replicate their study, and then proceeds to point out the weaknesses and underlying assumptions in the conclusions they draw. At first, Égert (2015) conducts a simple comparison by graphing debt and GDP on a scatter plot. The plots do not reveal any relationship between debt and growth, even when GDP is lagged and non-overlapping averages of growth and debt in 10 year intervals are used (Égert, 2015). Égert then moves to an econometric test of R & R's results, imposing the same thresholds that R & R used in their study (<30%, 30%–60%, 60%–90%, and >90%) (Égert, 2015). But, just like Panizza and Presbitero (2012), he finds these imposed thresholds to be very arbitrary, unreliable, and undesirable, which leads him to construct a threshold regression model that determines thresholds endogenously (Égert, 2015). His model finds relatively weak connections between debt and growth, and in fact the relationship becomes weaker as debt levels rise. In addition, his model finds thresholds that are much lower than 90 percent—60 percentage points lower in fact, with a negative relationship evident at the 30 percent debt-to-GDP level in advanced economies (Égert, 2015). In all, the fact that this study found a much weaker relationship between debt and growth casts significant doubts on the existence of a universal 90 percent threshold as purported by R & R.

Chudik et al. (2015) advance the most compelling hypothesis about the effects of debt levels on GDP growth. They argue that the complexity of the

relationship between debt and growth makes any attempt to establish a one-way, causal, non-linear effect between the two difficult, and any claim that does attempt to establish such a relationship is unconvincing. Instead, the authors contend that the *trajectory* of public debt is what has significant negative long-run effects on growth. Foundational to their argument is the observation that "cross-country experience shows that some economies have run into debt difficulties and experienced subdued growth at relatively low debt levels, while others have been able to sustain high levels of indebtedness for prolonged periods and grow strongly without experiencing debt distress," which leads us to conclude that the effect of debt on growth varies from country to country (Chudik et al., 2015, p. 4). While not criticizing R & R directly, Chudik et al. point out problems with their study, namely that their results are based on "strong homogeneity assumptions" and have also ignored reverse causal effects from GDP growth to debt (Chudik et al., 2015, p. 4).

One of the more pertinent findings by Chudik et al. (2015) is that short-run deficits are acceptable, and in the long run market and consumer expectations are what matter. This parallels the conventional wisdom that a temporary increase in government expenditures during recessions is necessary to avoid hysteresis, or the "echo" of the recession into the future, which negatively impacts growth even after the recession is over. Indeed, if the debt-to-GDP ratio is raised temporarily to "help smooth out business cycle fluctuations," Chudik et al. find no long-run negative impact on growth (Chudik et al., 2015, p. 6).

Method

I perform a threshold regression according to the following equation, for each country individually:

$$\Delta y = (\alpha_0 + \alpha_1 n + \alpha_2 \pi + \alpha_3 y_{t-1})\, i(d \geq \gamma) + (\beta_0 + \beta_1 n + \beta_2 \pi + \beta_3 y_{t-1})\, i(d < \gamma) + e_t$$

The threshold variable, d, is debt-to-GDP ratio, the dependent variable, Δy, is annual real GDP growth per capita, and gamma, γ, is the endogenous threshold parameter. The independent variables are population (n), inflation (π) based on CPI, and GDP growth lagged one period (y_{t-1}). The annual data is from Reinhart and Rogoff's (2010) data set used in their paper "Growth in a Time of Debt." Observations for each variable extend as far back as 1861, resulting in more than one hundred observations for each country, even when gaps in the data are accounted for. The countries analyzed are Australia (annual observations from 1862-2008), Canada (1871-2008), Chile (1862-2008), France (1862-2008), Germany (1862-2008), Greece (1914-2008), Italy (1862-2008), New Zealand (1871-2008), the United Kingdom (1862-2008), and the United States (1871-2008). These countries were used because many of them enacted budget austerity measures, as mentioned in the introduction, and because they are the world's leading economies, so enough data is available on each country to populate the model.

Preview of Results

Within the sample, statistically significant thresholds were found for France, Greece, Italy, the United Kingdom, and the United States. The regression results for these countries are included below, as well as two graphs of each country's debt levels over time; one graphs debt over the past century and a half, while the other graphs debt over the past three decades. The purpose of including the graphs is to investigate Chudik et al.'s (2015) claim that debt trajectory matters when establishing a statistically significant debt threshold.

Statistically significant thresholds were not found for Australia, Canada, Chile, Germany, and New Zealand. Therefore, their regression results are not included. Graphs of debt over time, exactly like the ones listed in the preceding paragraph, are included to support the other side of Chudik et al.'s claim. To explain, if Chudik et al.'s findings hold, then countries without significant debt thresholds should have debt levels that are either falling or low. For clarity, the results are broken up into two sections, Results A and Results B. The countries with significant debt thresholds are in Results A, while the others are in Results B. A discussion of the results follows each section, which is then followed by a discussion of both sections together along with a brief policy discussion.

Results A

France

Dependent Variable: GDP_GROWTH
Method: Threshold Regression
Date: 11/17/16 Time: 21:58
Sample (adjusted): 1880 2008
Included observations: 106 after adjustments
Threshold type: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Threshold variable: DEBT
Threshold selection: Trimming 0.15, Max. thresholds 5, Sig. level 0.05
Threshold value used: 79.57662

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEBT < 79.57662 -- 64 obs				
C	0.147933	0.034045	4.345190	0.0000
GDP_GROWTH(-1)	0.043328	0.148949	0.290893	0.7718
DEBT	-0.000104	0.000217	-0.481304	0.6314
INFLATION	-0.000370	0.000876	-0.422493	0.6736
POPULATION	-2.04E-06	5.72E-07	-3.565847	0.0006
79.57662 <= DEBT -- 42 obs				
C	1.066937	0.251549	4.241471	0.0001
GDP_GROWTH(-1)	-0.350835	0.098570	-3.559247	0.0006
DEBT	0.000312	0.000103	3.022824	0.0032
INFLATION	0.002816	0.000529	5.323966	0.0000
POPULATION	-2.68E-05	6.18E-06	-4.331559	0.0000

R-squared	0.477227	Mean dependent var	0.030144
Adjusted R-squared	0.428217	S.D. dependent var	0.035779

Figure 1.1. France.

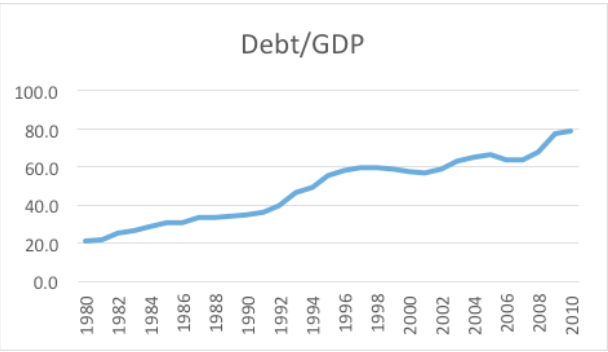

Figure 1.2. Debt/GDP of France, 1980-2010.

Figure 1.3. Debt/GDP of France, 1880-2006.

Greece

Dependent Variable: GDP_GROWTH
Method: Threshold Regression
Date: 11/17/16 Time: 22:06
Sample (adjusted): 1919 2008
Included observations: 80 after adjustments
Threshold type: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Threshold variable: __DEBT
Threshold selection: Trimming 0.15, Max. thresholds 5, Sig. level 0.05
Threshold values used: 65.27505, 103.19699

Variable	Coefficient	Std. Error	t-Statistic	Prob.
__DEBT < 65.27505 -- 46 obs				
C	0.140568	0.041891	3.355545	0.0013
GDP_GROWTH(-1)	-0.281431	0.069062	-4.075025	0.0001
__DEBT	-0.000744	0.000402	-1.849778	0.0689
__INFLATION	-0.000747	0.000456	-1.636901	0.1065
POPULAITON	-6.32E-06	4.53E-06	-1.395037	0.1678
65.27505 <= __DEBT < 103.19699 -- 13 obs				
C	0.798787	0.117592	6.792867	0.0000
GDP_GROWTH(-1)	-0.967773	0.250343	-3.865790	0.0003
__DEBT	-0.004738	0.001057	-4.481403	0.0000
__INFLATION	0.002640	0.001388	1.901869	0.0616
POPULAITON	-3.85E-05	8.21E-06	-4.695141	0.0000
103.19699 <= __DEBT -- 21 obs				
C	0.168537	0.232813	0.723914	0.4717

Figure 2.1. Greece.

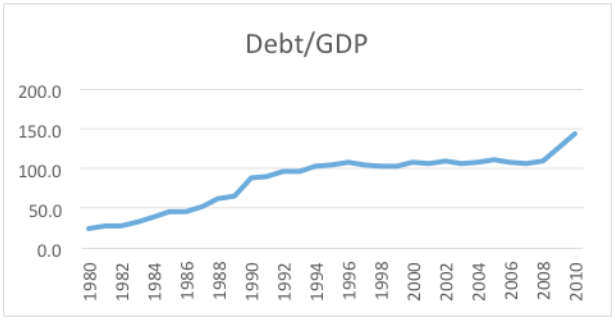

Figure 2.2. Debt/GDP of Greece, 1980-2010.

Figure 2.3. Debt/GDP of Greece, 1861-2008.

Italy

Dependent Variable: GDP_GROWTH
Method: Threshold Regression
Date: 11/17/16 Time: 23:25
Sample (adjusted): 1863 2008
Included observations: 146 after adjustments
Threshold type: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Threshold variable: DEBT
Threshold selection: Trimming 0.15, Max. thresholds 5, Sig. level 0.05
Threshold value used: 47.44524

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEBT < 47.44524 -- 29 obs				
C	0.436049	0.178434	2.443757	0.0158
GDP_GROWTH(-1)	0.093713	0.189599	0.494269	0.6219
DEBT	-0.001375	0.002677	-0.513531	0.6084
INFLATION	0.003588	0.001097	3.269774	0.0014
POPULATION	-6.98E-06	3.09E-06	-2.260828	0.0254
47.44524 <= DEBT -- 117 obs				
C	0.039014	0.024401	1.598918	0.1122
GDP_GROWTH(-1)	0.282316	0.091459	3.086804	0.0025
DEBT	-0.000361	0.000201	-1.798709	0.0743
INFLATION	-0.000364	0.000124	-2.930913	0.0040
POPULATION	1.44E-07	3.81E-07	0.378306	0.7058

R-squared	0.392249	Mean dependent var	0.023198
Adjusted R-squared	0.352030	S.D. dependent var	0.055865
S.E. of regression	0.044969	Akaike info criterion	-3.299642

Figure 3.1. Italy.

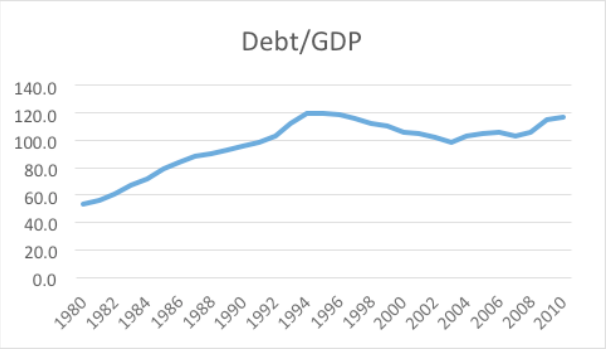

Figure 3.2. Debt/GDP of Italy, 1980-2010.

Figure 3.3. Debt/GDP of Italy, 1861-2008.

United Kingdom

Included observations: 146 after adjustments
Threshold type: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Threshold variable: DEBT
Threshold selection: Trimming 0.15, Max. thresholds 5, Sig. level 0.05
Threshold values used: 91.149999, 156.07999

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEBT < 91.149999 -- 98 obs				
C	-0.000557	0.017802	-0.031286	0.9751
GDP_GROWTH(-1)	0.195570	0.119747	1.633195	0.1048
DEBT	8.44E-05	0.000169	0.499062	0.6186
INFLATION	-0.000608	0.000480	-1.267274	0.2073
POPULATION	3.39E-07	2.86E-07	1.186264	0.2377
91.149999 <= DEBT < 156.07999 -- 23 obs				
C	-0.504190	0.156619	-3.219207	0.0016
GDP_GROWTH(-1)	0.413091	0.130780	3.158678	0.0020
DEBT	0.000481	0.000364	1.319862	0.1892
INFLATION	0.002106	0.000548	3.845966	0.0002
POPULATION	8.90E-06	2.50E-06	3.566434	0.0005
156.07999 <= DEBT -- 25 obs				
C	0.650161	0.162896	3.991273	0.0001
GDP_GROWTH(-1)	-0.323497	0.151724	-2.132143	0.0349
DEBT	-0.000867	0.000284	-3.050334	0.0028
INFLATION	0.003347	0.000929	3.604493	0.0004

Figure 4.1. United Kingdom.

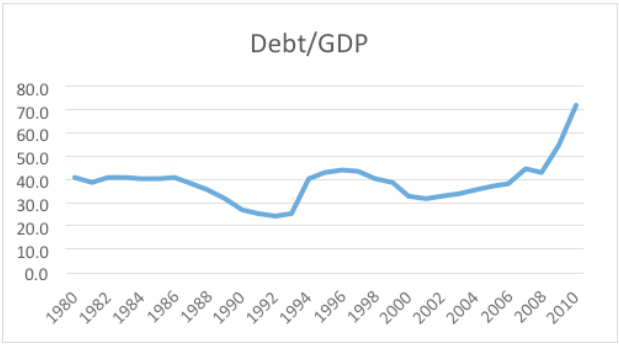

Figure 4.2. Debt/GDP of the United Kingdom, 1980-2010.

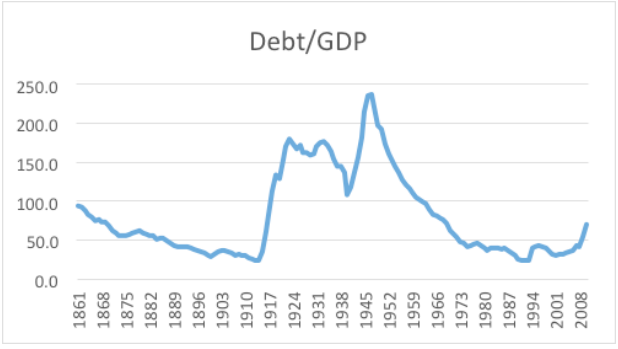

Figure 4.3. Debt/GDP of the United Kingdom, 1861-2008.

United States

Sample (adjusted): 1872 2008
Included observations: 137 after adjustments
Threshold type: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Threshold variable: DEBT
Threshold selection: Trimming 0.15, Max. thresholds 5, Sig. level 0.05
Threshold values used: 11.57626, 62.84406

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEBT < 11.57626 -- 27 obs				
C	0.630494	0.208309	3.026720	0.0030
GDP_GROWTH(-1)	-0.803624	0.193045	-4.162885	0.0001
DEBT	-0.022889	0.011231	-2.038028	0.0437
INFLATION	0.009821	0.003541	2.773646	0.0064
POPULATION	-4.45E-06	1.45E-06	-3.070083	0.0026
11.57626 <= DEBT < 62.84406 -- 87 obs				
C	0.022945	0.013200	1.738253	0.0847
GDP_GROWTH(-1)	0.336509	0.114546	2.937752	0.0040
DEBT	0.000898	0.000519	1.730728	0.0860
INFLATION	0.002749	0.001132	2.428738	0.0166
POPULATION	-2.42E-07	1.09E-07	-2.216760	0.0285
62.84406 <= DEBT -- 23 obs				
C	0.416441	0.094356	4.413514	0.0000
GDP_GROWTH(-1)	0.254673	0.147733	1.723875	0.0873
DEBT	-0.003801	0.000781	-4.868371	0.0000

Figure 5.1. United States.

Figure 5.2. Debt/GDP of the United States, 1980-2010.

Figure 5.3. Debt/GDP of the United States, 1861-2005.

Discussion of Results A

For France, the model found a threshold at a debt-to-GDP ratio of 80 percent (Figure 1.1). The coefficient for debt is significant at the 99 percent confidence interval. What is interesting, however, is that debt is actually positively associated with growth. France is the only country in this sample that the model assigns a positive debt coefficient. This is certainly unexpected, but should be interpreted as Minea & Parent (2012) interpreted their unexpected results: countries should not take what the model returns as infallible, and therefore France should not run profligate fiscal policies.

For Greece, the United Kingdom, and the United Sates, the model found debt thresholds significant at 99 percent confidence, but unlike France, debt was negatively associated with GDP growth. The highest thresholds for the three countries were 103, 156, and 63 percent for Greece, the U.K., and the U.S., respectively (Figure 2.1, 4.1, and 5.1). The model returned three threshold levels for each country, and for Greece and the United States, the second threshold level was also statistically significant, but only Greece's second threshold was negatively associated with GDP growth; this means that debt becomes negatively associated with GDP growth for Greece at a threshold of 65 percent. Additionally, Italy's debt-to-GDP threshold was established at 47 percent at 90 percent confidence (Figure 3.1).

These results closely mirror the hypothesis of Chudik et al. Reviewing the graphs of debt for all five countries, their debt levels consistently and steadily increase for at least several decades prior to 2010, with the United Kingdom being the only exception (Figure 1.2, 1.3, 2.2, 2.3, 3.2, 3.3, 5.2 and 5.3). That said, the United Kingdom's debt does increase steadily all throughout the previous decade, with a dramatic spike occurring in 2008 (Figure 4.2 and 4.3). These results give strong credence to the hypothesis advanced by Chudik et al. (2015) that debt trajectory matters in establishing a statistically significant debt threshold.

Results B

Australia

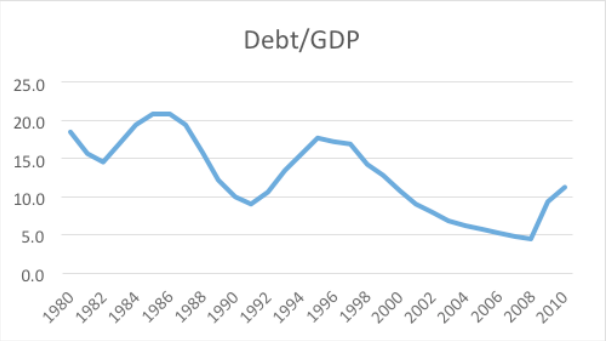

Figure 6.1. Debt/GDP of Australia, 1980-2010.

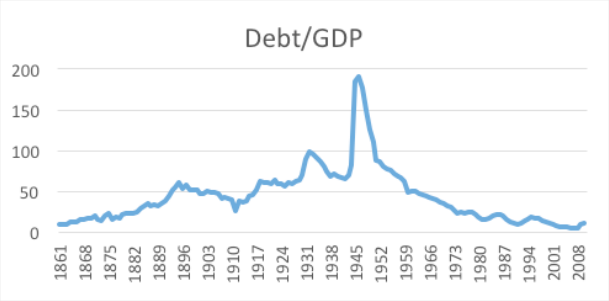

Figure 6.2. Debt/GDP of Australia, 1861-2008.

Canada

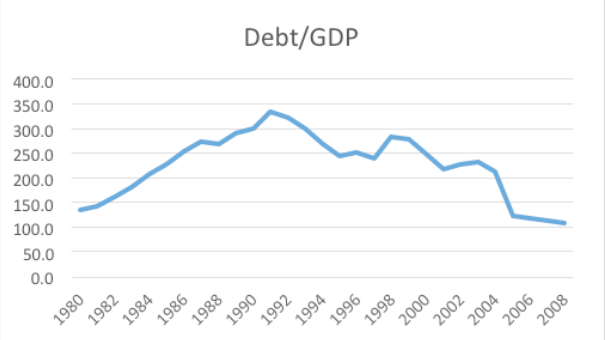

Figure 7.1. Debt/GDP of Canada, 1980-2008.

Figure 7.2. Debt/GDP of Canada, 1867-2007.

Chile

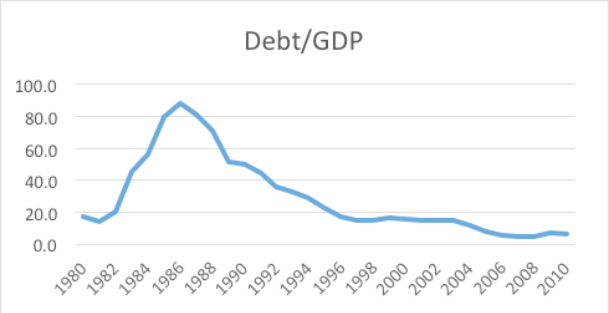

Figure 8.1. Debt/GDP of Chile, 1980-2010.

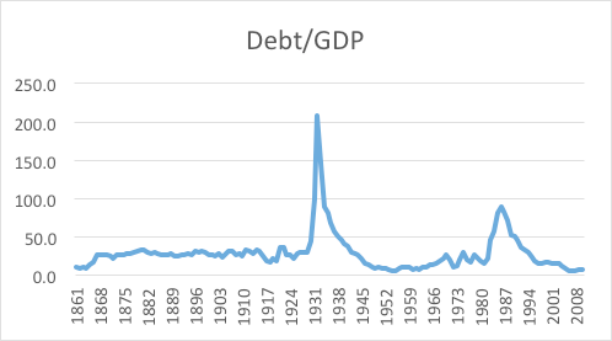

Figure 8.2. Debt/GDP of Chile, 1861-2008.

Germany

Figure 9.1. Debt/GDP of Germany, 1980-2010.

Figure 9.2. Debt/GDP of Germany, 1880-2006.

New Zealand

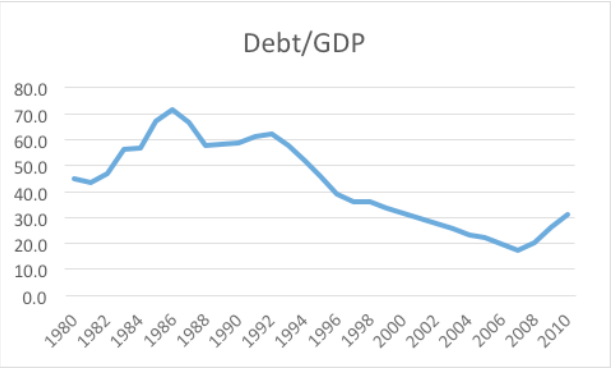

Figure 10.1. Debt/GDP of New Zealand, 1980-2010.

Figure 10.2. Debt/GDP of New Zealand, 1861-2005.

Discussion of Results B

Because no statistically significant debt thresholds were found for these countries, their regression results were not included. However, the graphs that track debt levels are pertinent to addressing Chudik et al.'s (2015) findings and therefore were included. Australia, Canada, Chile and New Zealand all have either falling levels of debt or have maintained low levels of debt for the past century and a half (Figure 6.1, 6.2, 7.1, 7.2, 8.1, 8.2, 10.1, and 10.2). The only exception is Germany, as debt levels for Germany are steadily increasing over time (Figure 9.1 and 9.2). There are several reasons why this could be: first, the data on Germany's public debt levels is very sparse, and there are several large gaps within the last one hundred and fifty years where no debt-to-GDP ratio is given. The model probably did not have enough observations to establish a significant threshold. Second, while Germany's debt level is increasing, it is still relatively low compared to the other countries in this sample. Indeed, countries in Section A had to reach a debt-to-GDP ratio of at least 60 percent before a significant threshold was determined, and Germany has yet to reach a 50 percent debt-to-GDP threshold.

In contrast to the countries in section A, the countries in section B did not have statistically significant debt thresholds. However, these results still strongly support the findings of Chudik et al. Indeed, according to Chudik et al. (2015), we would expect that debt in countries with low or falling levels of debt would not affect GDP growth negatively, and this is exactly what the model finds to be the case for Australia, Canada, Chile, New Zealand, and Germany.

Discussion of Results A and B and Policy Implications

These results differ from most of the current literature because they are generated for individual countries, based on data specific to that country. This is critical because the austerity measures adopted by Eurozone countries in response to the 2008 crisis and R & R's paper did not consider country-specific data, and as a result, budget cuts were implemented in haste which probably had negative economic effects. That is, conventional economic theory as outlined by Douglas and Mankiw (1999) says that increases in government expenditures can help mitigate the damages of a recession. The exact opposite of this, budget cuts, has contractionary effects, which is highly counterproductive during a recession.

No statistically significant thresholds were found for countries with low levels of debt or falling levels of debt, which is in lockstep with Chudik et al.'s (2015) findings. Furthermore, countries with rising levels of debt for at least the previous decade had statistically significant debt-to-GDP thresholds, where GDP growth becomes adversely affected. It is therefore very important for future governments, when contemplating whether to implement austerity measures, to consider whether their debt is on a downward trajectory or has yet to reach detrimental levels. If either of these conditions hold, then austerity measures are unwarranted. If debt is on an upward trajectory or has reached a high debt-to-GDP level, panic is ill-advised and the most prudent course of action is to lower debt levels gradually, restoring the confidence of markets, consumers, and foreign governments in the country's central government.

Governments must consider the monetary environment when borrowing to pay for government expenditures. The 2008 financial crisis presented an economic situation that we had never seen before: the Federal Reserve made prolonged efforts to remain at the zero lower bound (ZLB), keeping interest rates at zero from 2009 to the end of 2015. At the ZLB, government spending multipliers are greater than in "normal" times (Delong & Summers, 2012). This is because demand in the loanable funds market is very slack, so an increase in government spending does not cause a rise in interest rates and therefore the crowding out effect is avoided. Therefore, if there ever is a time to borrow and increase government spending, it is at the zero lower bound, where government expenditures have the greatest potential to affect economic output positively.

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