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Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff

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We replicate Reinhart and Rogoff (2010A and 2010B) and find that selective exclusion of available data, coding errors and inappropriate weighting of summary statistics lead to serious miscalculations that inaccurately represent the relationship between public debt and GDP growth among 20 advanced economies. Over 1946–2009, countries with public debt/GDP ratios above 90% averaged 2.2% real annual GDP growth, not −0.1% as published. The published results for (i) median GDP growth rates for the 1946–2009 period and (ii) mean and median GDP growth figures over 1790–2009 are all distorted by similar methodological errors, although the magnitudes of the distortions are somewhat smaller than with the mean figures for 1946–2009. Contrary to Reinhart and Rogoff's broader contentions, both mean and median GDP growth when public debt levels exceed 90% of GDP are not dramatically different from when the public debt/GDP ratios are lower. The relationship between public debt and GDP growth varies significantly by period and country. Our overall evidence refutes RR's claim that public debt/GDP ratios above 90% consistently reduce a country's GDP growth.

Key words: Public debt, Austerity
JEL classifications: E60, E62, E65

1. Introduction

In 'Growth in Time of Debt', Reinhart and Rogoff (hereafter RR; 2010A for their working paper version and 2010B for their published paper) present a set of what they characterise as 'stylised facts' concerning the relationship between public debt and GDP growth. RR summarise the overarching results of these papers succinctly:

> . . . whereas the link between growth and debt seems relatively weak at 'normal' debt levels, median growth rates for countries with public debt over roughly 90 percent of GDP are about one percent lower than otherwise; average (mean) growth rates are several percent lower. (RR, 2010A, p. 573)

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To build the case that they had established a new set of stylised facts regarding public debt levels and GDP growth, RR stress the robustness of their overarching findings to a range of countries and time periods. They also stress the robustness of these findings to alternative measurement techniques and ways to categorise data.

This paper presents a critical analysis of 'Growth in a Time of Debt', both the working paper and the subsequent published version, in terms of the methods used by RR, the ways they executed their research approach and their research results. To be more specific, our paper is a narrowly gauged critical replication. As is standard for such critical replication exercises, we maintain our focus on their two versions of their 'Growth in a Time of Debt' paper. Aside from a few brief comments, we do not attempt to integrate our discussion on 'Growth in a Time of Debt' into a broader survey of the literature on public indebtedness and GDP growth or other related topics. We do briefly consider some policy implications that follow from the results of our critical replication, in particular regarding austerity policies as practised in our contemporary period in the USA and Europe. But again, given this paper's deliberately narrow focus as a critical replication exercise, we do not attempt an extended discussion on austerity policies or any other related policy issue.

The methods employed by RR in 'Growth in a Time of Debt' are non-parametric and appealingly straightforward. They organise data for a range of countries and different time periods based on the ratios of public debt relative to GDP in each country. They present four data categories in terms of public debt/GDP ratios: ≤30%, 30–60%, 60–90% and >90%. They then compare average real GDP growth rates across each of the public debt/GDP groupings. Organising data in this way, they identify a major non-linearity in the relationship between countries' public debt/GDP ratios and their corresponding rate of GDP growth. That is, they find that average GDP growth rates vary only to moderate degrees as long as the level of public debt remains <90% of its GDP for the countries in their sample. However, they find that these countries' average GDP growth performance falls off significantly when their public debt/GDP ratios exceed 90%.

In Table 1 we present RR's key results on mean real GDP growth in advanced economies between 1946 and 2009. As the table shows, real mean GDP growth ranges between about 3% and 4% as long as the ratio of public debt/GDP falls within either their 0–30%, 30–60% or 60–90% public debt/GDP category. However, mean GDP growth collapses to −0.1% for their sample of countries when the public debt/GDP ratio exceeds 90%.[1]

A necessary condition for establishing a stylised fact is that the calculations on which such facts are based are accurate and that the results of such calculations are robust across alternative reasonable methods of calculation. Through our replication exercise, we conclude that their findings are neither accurate nor robust. We rather show that (i) selective exclusion of available data, (ii) coding errors and (iii) inappropriate methods for the weighting of summary statistics have generated serious measurement problems that produce inaccurate figures on the relationship between public debt and growth among these 20 advanced economies, both over the period 1946–2009 as well as in

[1] The figures we present in Table 1 are taken from the first line of Appendix 1 in RR (2010A). We note that the data shown in the bar charts (Figure 2 in both RR, 2010A and 2010B) do not match up precisely with the data they present in Appendix 1 of the 2010A working paper version. Despite these differences in the figures they themselves present, the overall finding is still consistent across the two versions of the paper.

Table 1. *Duplication of RR (2010) findings: real average annual GDP growth at various public debt/GDP ratios for 20 advanced economies, 1946–2009*

Public debt/GDP ratios	GDP growth rates
≤30%	4.1%
30–60%	2.8%
60–90%	2.8%
>90%	−0.1%

Sources: RR (2010A, 2010B).

their long historical time period, 1790–2009. As one critical case in point, referring to the data from RR that we show in Table 1: when properly calculated, the average real GDP growth rate over 1946–2009 for countries carrying a public debt/GDP ratio greater than 90% is actually *positive* 2.2%, not *negative* 0.1% as RR claim.

More generally, contrary to RR, we find no evidence for a dramatic drop-off in average GDP growth when countries' public debt levels rise above 90% of their GDP. We correspondingly refute the claim by RR that there exists a 'historical boundary' that is robust across countries and time periods in which economic growth consistently falls off in a non-linear pattern when the public debt levels exceed 90% of GDP. In fact, as we show, there is a major non-linearity in the relationship between public debt and GDP growth, but that non-linearity is between the lowest two public debt/GDP categories, 0–30% and 30–60%, a range that is not relevant to current policy debate.

For the purposes of this replication, we follow RR in assuming that the direction of causation in the relationship between public debt levels is that high public debt levels produce declines in average GDP growth rates. In other work (see, e.g., RR, 2011; Reinhart *et al.*, 2012), RR acknowledge the potential for reverse causation. This would occur primarily as a result of recessions, which would raise public indebtedness by both reducing tax revenue and increasing public expenditures through countercyclical interventions. However, in the papers that we are replicating (RR, 2010A, 2010B), RR make clear that their analysis is organised around the premise that the primary direction of causation runs from high public debt to slower GDP growth.

We originally posted a preliminary working paper version of this study in April 2013 (to which we refer hereafter as HAP, 2013). Our working paper produced an intense global debate through much of the spring of 2013. This was an outgrowth of the major influence that had been exerted by the RR research in both academic and policy-making circles, in particular in providing an intellectual foundation in support of austerity policies in the aftermath of the 2007–09 financial crisis and subsequent Great Recession.[2] We refer briefly to this background in what follows. Of particular importance for this current paper is that RR twice responded formally to the HAP (2013) critique, in two lengthy *New York Times* articles and an Errata memorandum (RR, 2013A, 2013B, 2013C). These responses have enabled us to focus our present discussion more sharply than was possible in our original HAP working paper.

[2] As we discuss further below, it is an indisputable fact that 'Growth in a Time of Debt' has provided a critical intellectual underpinning on behalf of austerity policies. This is the case regardless of whether it was RR's intention to exert this type of influence. We do not attempt to discern RR's intentions on this matter.

Our discussion proceeds as follows. Section 2 describes the influence that the RR research has exercised since it was first published in 2010. Section 3, the main body of this paper, describes in detail the three problems we identify with RR's research in their 2010 papers: their selective data exclusions, coding errors and inappropriate weighting methodology. Focusing initially on RR's mean GDP growth calculations with their 1946–2009 data sample, we also show how these problems interact to magnify the effects on the calculation of real GDP growth relative to the impact of each separate factor acting alone. We then show how the problems with their data accounting and methodology generate similar distortions with their calculations of both the mean GDP growth figures for 1790–2009 and the median figures for 1946–2009.

Based on these findings, we offer new evidence on RR's claim to have identified a robust non-linearity in the pattern of GDP growth once public debt levels exceed 90% of GDP. We produce a range of evidence demonstrating that, in fact, there is no such non-linearity at the 90% public debt/GDP boundary. We also show that there is a non-linearity in the relationship between GDP growth and public debt/GDP ratios. But this non-linearity occurs when public debt levels range between 0% and 30% of GDP.

In Section 4 we conclude the paper by recognising first the issues we raised in HAP (2013) in which RR have subsequently acknowledged mistakes. We then summarise the major areas where they have not retracted their findings and show that these areas of ongoing dispute are all matters of considerable significance, about which this current paper seeks to provide greater clarity.

2. Public impact and policy relevance

As we noted above, the RR research has exerted a substantial influence throughout the globe in shaping macroeconomic policy debates since its publication in 2010. In particular, this work has provided a major empirical foundation in support of austerity policies aimed at reducing the high public debt levels that emerged in the aftermath of the 2007–09 global financial crisis and the subsequent Great Recession.

More specifically, according to RR's web site,[3] the findings reported in the two 2010 papers formed the basis for Reinhart's 10 March 2011 testimony before the US House of Representatives Budget Committee, 'Lifting the Crushing Burden of Debt',[4] and a *Financial Times* opinion piece, 'Why we should expect low growth amid debt' (RR, 28 January 2010). The key tables and figures have been reprinted in additional Reinhart and Rogoff publications and presentations at the Centre for Economic Policy Research and the Peter G. Peterson Institute for International Economics (RR 2011A, 2011B). A Google Scholar search for the publication, excluding pieces by the authors themselves, finds more than 500 results.[5]

Their main findings have also been widely cited in the popular media. RR's own web site lists 76 high-profile features, including *The Economist*, *Wall Street Journal*, *New York*

[3] http://www.reinhartandrogoff.com/related-research/growth-in-a-time-of-debt-featured-in [date last accessed: 7 April 2013].

[4] The testimony for the house committee hearing, chaired by Paul Ryan is not linked to on their web site, but can be found at http://budget.house.gov/uploadedfiles/reinharttestimony3102011.pdf [date last accessed: 8 October 2013]. Reinhart also testified before the US Senate Budget Committee on 9 February 2010.

[5] A search on [Reinhart Rogoff 'Growth in a Time of Debt'-author:rogoff -author:reinhart] yielded 538 Google Scholar results on 7 April 2013.

Times, *Washington Post*, Fox News, National Public Radio and MSNBC as well as many international publications and broadcasts.

Further, RR (2010B) was the only evidence cited on the consequences of high public debt on economic growth in the 2013 US Federal Budget plan proposed by Republican Paul Ryan, which was passed in the House of Representatives. Congressman Ryan's 'Path to Prosperity' proposal reports that RR's research 'found conclusive empirical evidence that gross debt (meaning all debt that a government owes, including debt held in government trust funds) exceeding 90 percent of the economy has a significant negative effect on economic growth' (Ryan, 2013, p. 78). George Osborne, the UK Chancellor of the Exchequer, and Olli Rehn, the leading economic official of the European Commission, are other leading policy makers who have frequently cited the RR work as significantly influencing their thinking. Indeed, Paul Krugman observed in June 2013 that 'Reinhart–Rogoff may have had more immediate influence on public debate than any previous paper in the history of economics' (Krugman, 2013).

Krugman wrote this comment as part of the intense global response that followed from the initial posting of our April 2013 working paper (HAP, 2013). The fact that our critique, even while still in the form of a preliminary draft, elicited such a high level of worldwide interest offers further evidence of the major influence exerted by the RR research. We provide, as relevant, some brief comments on our subsequent public debate with RR.[6]

3. Replication

RR examine three datasets: 20 advanced economies over 1946–2009; the same 20 economies over the long historical period 1790–2009; and 20 emerging market economies from 1970 to 2009. We replicate the results only from the first two samples. We focus primarily on the 1946–2009 time period for the advanced economies, since these figures are clearly the most relevant to ongoing US and European policy debates. The more recent data are also the most reliable, since they entailed much less splicing together of data by RR from multiple sources that frequently used different statistical methodologies. We examine the results reported by RR in terms of both mean and median figures.

On their web site, RR provide public access to country historical data for public debt and GDP growth in spreadsheets with complete source documentation.[7] However, these publicly available spreadsheets do not include information on the exact data series, years and methods used in their paper. As such, we were unable to replicate the RR results from the data they posted on their web site.

In response to our request of April 2013, RR did provide us with the working spreadsheet that they used in producing the RR papers. Through using their working spreadsheet, we were able to approximate closely the published RR results. This was how we were able to identify the selective exclusion of available data, coding errors and inappropriate methods for weighting summary statistics.

[6] Our contributions to the debate and rejoinders to RR include Ash and Pollin (2013), Pollin and Ash (2013A, 2013B) and Herndon (2013). See Harding (2013) for a summary of the debate as of May 2013.

[7] See http://www.reinhartandrogoff.com/data/browse-by-topic/topics/9/ and http://www.reinhartandrogoff.com/data/browse-by-topic/topics/16/ [date last accessed: 7 April 2013].

3.1 Data gaps and selective exclusion of available data

RR designate 1946–2009 as their period of analysis for the post-World War II advanced economies. Most differences between countries in their period of coverage are due to the starting year of each country's relevant dataset. For example, the US data series extends back to 1946. Outside the USA, the series for some countries do not begin until the 1950s and that for Greece is unavailable before 1970. Overall, nine countries are available from 1946 onward, 17 from 1951 and all countries but Greece enter the dataset by 1957.

There are some gaps and oddities in this 1946–2009 dataset. For example, the public debt/GDP ratio series is unavailable for France for 1973–77, real GDP growth is unavailable for Spain for 1959–80, Austria experienced 27.3% and 18.9% real GDP growth in 1948 and 1949 (with both years in lower public debt groups), respectively, and Portugal's debt/GDP jumps by 25 percentage points from 1999 to 2000 when the country's currency and the denomination of the series changed from the escudo to the euro.

The longer time series, 1790–2009, includes available years of data for the same 20 now advanced economies. There is substantial variation in the availability of data with this longer series. For example, complete public debt and GDP data begin for the USA in 1791, in 1831 for the UK, 1880 for France, Germany and several other countries, 1925 for Canada and 1932 for New Zealand.

There are also significant gaps within the available time series for many of the countries. In notes to their Table 1 of both 2010A and 2010B, RR report that 'There are missing observations, most notably during World War I and II years.' Some gaps in the data do correspond to the two World War periods. For example, Belgium lacks data for 1914–20 and 1940–46, but there are also other gaps that are longer and not explained by RR. Thus, Denmark lacks public debt/GDP data for 1914–49. The series for France is incomplete from 1932 to 1948. Nine countries, both neutral and non-neutral in World War I, include data for 1914–18. Only for the USA (1941–44) and the UK (1940–45) are data for World War II explicitly excluded from the spreadsheet calculations of mean and median growth by public debt/GDP category.

In our replication exercises, we do not pursue the implications of these data gaps described above. However, we do examine further RR's data exclusions concerning three countries, which significantly affect their overall conclusions. These are for Australia (1946–50), New Zealand (1946–49) and Canada (1946–50). At no point do RR either explicitly explain they why they chose to make these data exclusions or even indicate that they had done so. The closest they come to considering the issue in either the 2010A or 2010B versions of their paper is in the following passage:

> Of course, there is considerable variation across the countries, with some countries such as Australia and New Zealand experiencing no growth deterioration at very high debt levels. It is noteworthy, however, that those high-growth high-debt observations are clustered in the years following World War II. (RR, 2010A, p. 11)

In other words, RR appear to justify their selective data exclusions because, as quoted above, these data 'are clustered in the years following World War II' when economic growth was high. However, in contrast with this reasoning as applied to the cases of Australia, Canada and New Zealand, RR include all four of the immediate post-World War II observations in which the USA was in the >90% public debt/GDP category. In

three of these four years, the US economy was contracting at the same time as it was in the highest public debt/GDP category. RR do not provide an explanation of their reasoning behind the decision to exclude Australia, Canada and New Zealand in these years, while these economies were growing rapidly, but to include the USA, which was contracting in three of the four relevant years.[8]

In the case of Canada, all five omitted years were in the >90% public debt/GDP category. Those years were also the only ones in which Canada was in this highest public debt/GDP category. Mean GDP growth in Canada for the excluded years was 3.0%, while median Canadian GDP growth for these years was 2.2%. For Australia as well, all five excluded years were in the highest public debt/GDP category. They were also the only years in which Australia was in this highest public debt/GDP category. RR note that Australia experienced 'no growth deterioration' (RR, 2010A, p. 11) during these years that RR chose to exclude from their dataset.

The 1946–49 exclusions for New Zealand are of particular significance. This is because New Zealand was in the highest public debt/GDP category in all four of these excluded years. New Zealand's real GDP growth rates in those years was +7.7%, +11.9%, −9.9% and +10.8%. After RR chose to exclude the 1946–49 New Zealand data, New Zealand then contributes only one year, 1951, to the highest public debt/GDP category. RR report New Zealand's real GDP growth in 1951 as being −7.6%. As we discuss below, these data choices by RR regarding New Zealand have a substantial impact on their overall findings.

3.2 Spreadsheet coding error

In addition to these deliberate data exclusions by RR, a coding error in the RR working spreadsheet also unintentionally excludes five countries entirely (Australia, Austria, Belgium, Canada and Denmark) from all parts of the analysis.[9] The error appears in the calculations of both mean and median GDP growth with the 1946–2009 sample as well as with the mean and median GDP growth for the sample over the 220-year period 1790–2009. The omitted countries are selected alphabetically. It is clear from the spreadsheet itself that these are random exclusions. RR have since acknowledged this to be the case (RR, 2013A, 2013B, 2013C).

3.3 Summarising all RR data exclusions for highest public debt/GDP category

Table 2 lists all of the countries in RR's 1946–2009 data sample that are included at any time in the >90% public debt/GDP category. We also show the number of years

[8] The US series includes very large declines in GDP growth associated with post-World War II demobilisation while, over this same period, the US public debt/GDP ratio is in the >90% category due to the public debt build-up tied to the high levels of wartime borrowing and spending. Thus, in 1946, the US public debt/GDP ratio was 121.3% and GDP growth was *negative* 10.9%. More generally, over the full 1946–2009 time period, the USA experienced only four years (1946–49) during which its public debt/GDP ratio exceeded 90%. GDP growth in these years was −10.9%, −0.9%, 4.4% and −0.5%. See Irons and Bivens (2010) for a more detailed discussion.

[9] In their analysis with the 1946–2009 dataset, RR calculated both means and medians of cells in lines 30–44 instead of lines 30–49. In their analysis with the 1790–2009 dataset, RR calculated both means and medians for cells in lines 5–19 instead of lines 5–24. As such, Australia, Austria, Belgium, Canada and Denmark were excluded entirely from their calculations with both the 1946–2009 and 1790–2009 data samples.

Table 2. *Accounting for years in which countries' public debt/GDP ratio exceeds 90% for 1946–2009*

Countries in which public debt/GDP >90% over 1946–2009	Years in which public debt/GDP >90%	Total number of years with public debt/GDP >90%		
		Correct total	RR own count through chosen exclusions[a]	RR actual count through chosen exclusions plus spreadsheet errors[b]
Australia	1946–50	5	0	0
Belgium	1947, 1984–2005, 2008–09	25	25	0
Canada	1946–50	5	0	0
Greece	1991–2009	19	19	19
Ireland	1983–89	7	7	7
Italy	1993–2001, 2009	10	10	10
Japan	1999–2009	11	11	11
New Zealand	1946–49, 1951	5	1	1
UK	1946–64	19	19	19
USA	1946–49	4	4	4
Totals for all countries				
Country-years	–	110	96	71
Countries	–	10	8	7

Notes: [a]Exclusions for Australia, Canada and New Zealand.
[b]Additional exclusions for Australia, Austria, Belgium, Canada and Denmark.
Source: Authors' calculations from unpublished working spreadsheet provided by RR.

that each country is included in this highest public debt/GDP category.[10] We can sum up the RR data exclusions in two ways: summarising by 'country-years', in which each year of excluded data from any of the countries in the sample counts as one observation; or summarising by countries, in which any number of years of data (one or more) for any given country is counted as one country exclusion.

As we see from Table 2, the correct total in RR's 1946–2009 data sample in which a country is in the >90% public debt/GDP category is 110 country-years. With RR's chosen data exclusions, the total falls to 96 country-years. With both their chosen exclusions and their spreadsheet errors, the total number of country-years in the >90% public debt/GDP category falls to 71. The differences are due, again, to RR's deliberate exclusions of Australia, Canada and New Zealand and to the additional exclusions for Belgium.

RR made the same spreadsheet coding error in calculating mean and median GDP growth by public debt/GDP category for 20 advanced economies over the 220-year

[10] Table A1 in the Appendix presents a full listing of all 20 countries in the RR dataset. This table also shows the number of years in which the public debt/GDP ratio for each of the countries fell within one of the four public debt/GDP categories (i.e. ≤30%, 30–60%, 60–90% and >90%) and the average GDP growth rate experienced by each country within each of these public debt/GDP categories. As we report in Table A1, Austria and Denmark (i.e. two of the five countries RR excluded from their analysis due to their spreadsheet error) did not, in fact, experience any years over 1946–2009 in which their public debt exceeded 90% of their GDP. As such, RR's inadvertent exclusion of these two countries from their analysis did not affect their estimates of average GDP growth when public debt exceeded 90% of GDP.

period 1790–2009. By calculating the mean for cells in lines 5–19 instead of lines 5–24, the coding error entirely excludes the same five countries (Australia, Austria, Belgium, Canada and Denmark) from the analysis.

We examine the impact of all these data exclusions after we also consider, next, their inappropriate weighting methodology.

3.4 Inappropriate weighting in calculating summary statistics

Throughout their analysis, RR adopt a weighting methodology for measuring the central tendency of real GDP growth within each of their four public debt/GDP categories that, in our view, is inappropriate for understanding the issues at hand.

Their approach is as follows, focusing first on their calculations of mean GDP figures. After assigning each country-year to one of the four public debt/GDP categories, RR calculate the mean real GDP growth for each country within the category, i.e. a single average value for the country for all the years it appeared in the category. In other words, RR compute overall averages as means of country means. Thus, real GDP growth in the UK averaged 2.4% per year during the 19 years that the UK appeared in the >90% public debt/GDP category. This mean GDP growth figure for the UK's 19 years in this highest public debt/GDP category then counts as one country observation in generating the mean GDP growth figure for the category *for all countries*. By the same token, as we have discussed above, according to RR's (incorrect) accounting, New Zealand was in the >90% public debt/GDP category for one year only, 1951. In that one year, New Zealand's GDP growth was −7.6%. According to RR's methodology, this one year experience for New Zealand counts equally with the 19 years in which the UK was in the highest public debt/GDP category in calculating the mean GDP growth figure for all countries.

In other words, RR are generating mean values for GDP growth through averaging by country, with each country counting as a single observation, no matter how many years it appears in any given public debt/GDP category: 19 years for the UK or 1 year only for New Zealand. Clearly, the impact of RR's approach is to greatly amplify the effects of short-term episodes with high public debt levels in calculating the overall impact of high public debt on GDP growth. As we will show more systematically below, the impact of New Zealand's one-year episode would be far more modest if it were counted as only one country-year observation within, as we saw in Table 2, the total of 110 country-years in which any country's public debt/GDP ratio was above 90%.

New Zealand's one-year experience in 1951 is the most obvious case in point illustrating the problem with RR's weighting methodology. But there are also other important examples. Thus, with respect to RR's 1790–2009 data sample, Norway spent only one year (1946) in the 60–90% public debt/GDP category during the total 130 years (1880–2009) in which data for Norway are included in the sample. Norway's economic growth in this one year was 10.2% (due to rapid recovery after occupation during World War II). This one extraordinary growth experience contributes fully 5.3% (one of 19 countries) of the weight for the mean GDP growth in the 60–90% public debt category even though it constitutes only 0.2% (one of 455 country-years) of the country-years in this category. Indeed, Norway's one year in the 60–90% public debt category receives a weight equal to, for example, 23 years for Canada, 35 years for Austria, 42 years for Italy and 47 years for Spain.

Further, RR utilise this same methodology in calculating medians. The result is that what RR term 'median' GDP growth figures for each public debt/GDP category is, more precisely, the median of each country's median GDP growth figure, calculated over the total number of country-years in which each country is included in one of the four public debt/GDP categories. Clearly, this approach contrasts sharply with calculating central tendencies through taking the means or medians of all country-years, which can be calculated in straightforward ways. The RR approach requires two decisions: first, how to aggregate annual data for each country into a single country summary measure; and, second, how to aggregate country summary measures into a single summary measure of central tendency for the full data sample.

RR need to explain and justify in detail their weighting methodology for generating means and medians, yet at no point do they do so in either version of their 2010 paper.[11] As such, their methodology appears arbitrary and unsupportable. In fact, it is possible that within-country serially correlated relationships could support an argument that not every additional country-year observation contributes a proportional amount of additional useful information. Thus, the existence of serial correlation could suggest that, with the case of the UK, for example, 19 years of carrying a public debt/GDP load greater than 90% and averaging 2.4% GDP growth over those years does not warrant 19 times the weight of New Zealand's single year at −7.6% GDP growth. But RR do not themselves offer any argument as to why the one-year experience in New Zealand should have 19 times the influence as each year in which the UK economy operated with high public debt levels.

3.5 Impact of RR exclusions, errors and methodology

We can observe the impact of RR's selective data exclusions, spreadsheet errors and inappropriate weighting methodology from various perspectives. To begin with, in Table 3 we show how each country's experiences in the >90% public debt/GDP category are weighted using RR's data sample and one-number-per-country weighting methodology versus a country-year weighting approach along with the correct inclusion of all countries in the sample. As we see, Australia, Belgium and Canada are all dropped through RR's accounting and thus carry zero weight. In contrast, through correctly including the relevant data in the sample and weighting by country-years, Canada and Australia should be weighted at 4.5% each and Belgium should properly account for fully 22.7% of the total weight of country-years in the >90% public debt/GDP category.

Using RR's methodology, the remaining countries are all weighted equally, as one-seventh or 14.3%, of the total number of observations in the high public debt category, no matter how many years each country was carrying debt above 90% of its GDP. In contrast, with country-year weighting, the overall weight for each of the countries ranges widely, from 3.6% for the USA to the highest figure, for Belgium, of 22.7%.

In Table 4 we show the differences in the estimates of GDP growth for each country during the years in which the countries were in the >90% public debt/GDP category. The table shows clearly how we move from a mean GDP growth rate of *negative* 0.1%

[11] They also have not offered a substantive defence of their methodology in response to the criticism we presented in HAP (2013). The closest they have come to such a defence is their assertion that 'It is the accusation that our weighting procedure is unconventional that is itself unconventional' (RR, 2013B). But this assertion is not followed by any substantive discussion as to why their methodology should be preferred relative to, e.g., weighting observations by country-years, as we have done both here and in HAP (2013).

Table 3. *Alternative weighting of country observations for above 90% public debt/GDP category for the 1946–2009 time period*

Countries in which public debt/GDP >90% over 1946–2009 time period	RR country weighting	Country-year weighting
Australia 1946–50	0%	4.5%
Belgium 1947, 1984–2005, 2008–09	0%	22.7%
Canada 1946–50	0%	4.5%
Greece 1991–2009	14.3%	17.3%
Ireland 1983–89	14.3%	6.4%
Italy 1993–2001, 2009	14.3%	9.1%
Japan 1999–2009	14.3%	10.0%
New Zealand 1946–49, 1951	14.3%	4.5%
UK 1946–64	14.3%	17.3%
USA 1946–49	14.3%	3.6%

Source: Authors' calculations from working spreadsheet provided by RR.

through RR's accounting and weighting methodology as well as their errors to a *positive* 2.2% mean under accurate accounting and country-year weighting. There are three major factors at play, as we have discussed:

(i) The full exclusions of Australia, Belgium and Canada from the highest public debt category. The GDP growth rates for these three countries while in the highest public debt category averaged 3.8%, 2.6% and 3.0%, respectively.
(ii) The exclusions of 1946–49 data for New Zealand. This meant that RR included only the one year, 1951, in which New Zealand was counted as being in the >90% public debt/GDP category. Given their weighting methodology, this one year, with –7.6% growth, counted as 14.3% of the entire sample of observations for countries in the highest public debt category.
(iii) There are large differences in weights among the countries that are fully included in their data sample. In particular, the four years (1946–49) in which the USA is in the highest public debt category and averaged −2.0% GDP growth are weighted as 14.3% of all observations by RR, as opposed to 3.6% of all observations through proper accounting and country-year weighting.

In addition, a fourth, smaller factor affecting RR's average GDP estimate is that they made a transcription error in transferring the country average figure from the country-specific spreadsheets to the summary spreadsheet. This transcription error reduced New Zealand's average growth in the >90% public debt/GDP category from −7.6% to the figure they report, −7.9%. Because only seven countries appear in RR's >90% highest public debt category, with each country carrying a 14.3%

Table 4. *Combined impact of RR data exclusions, spreadsheet errors and weighting methodology on GDP growth for >90% public debt/GDP category for 1946–2009 time period*

Countries in which public debt/GDP >90% over 1946–2009 time period	RR estimate	Estimate with full data sample and country-year weighting
Australia 1946–50	No years in sample	3.8% (4.5% weight)
Belgium 1947, 1984–2005, 2008–09	No years in sample	2.6% (22.7% weight)
Canada 1946–50	No years in sample	3.0% (4.5% weight)
Greece 1991–2009	2.9% (14.3% weight)	2.9% (17.3% weight)
Ireland 1983–89	2.4% (14.3% weight)	2.4% (6.4% weight)
Italy 1993–2001, 2009	1.0% (14.3% weight)	1.0% (9.1% weight)
Japan 1999–2009	0.7% (14.3% weight)	0.7% (10% weight)
New Zealand 1946–49, 1951	−7.9% (14.3% weight)	2.6% (4.5% weight)
UK 1946–64	2.4% (14.3% weight)	2.4% (17.3% weight)
USA 1946–49	−2.0 (14.3% weight)	−2.0% (3.6% weight)
Average GDP growth for all countries in >90% public debt/ GDP category	**−0.1%**	**+2.2%**

Source: Authors' calculations from working spreadsheet provided by RR.

weight, this transcription error reduces RR's estimate of mean real GDP growth by 0.1 percentage point.

Table 5 provides a full accounting of the impact of the data exclusions, spreadsheet errors, inappropriate weighting methodology and transcription error as they impact, in combination, calculations of mean GDP growth for all countries in the RR 1946–2009 sample. These factors have strong interactive effects. We see in Table 5 the effect of each possible interaction between the data exclusions, spreadsheet errors, RR weighting methodology and transcription error.

As the table shows, the combined effects of RR's overall approach have relatively small effects on mean GDP growth in the lower three public debt/GDP categories. Thus, for the 0–30% public debt/GDP category average GDP growth remains consistently around 4% per year. For the 30–60% and 60–90% public debt/GDP categories, average GDP growth is consistently around 3% per year with or without adjusting for the RR errors and methodological choices. However, we see how, with the >90% category, we go from an appropriately calculated mean GDP growth figure of +2.2% to the RR estimate of −0.1%. In other words, with their estimate that average GDP growth in the >90% public debt/GDP category is −0.1%, RR overstate the growth gap between the highest and next highest public debt/GDP categories by a factor of nearly two-and-a-half.

We can see the relationship between public debt/GDP ratios and GDP growth more fully in Figure 1. This figure presents all of the country-year data as continuous

Table 5. *HAP recalculated GDP growth rates with RR calculated figures (percentages) for 1946–2009 time period*

	Public debt/GDP category			
	≤30%	30–60%	60–90%	>90%
Recalculated results				
All data with country-year weighting	4.2	3.1	3.2	2.2
Replication elements				
Separate effects of RR calculations				
Spreadsheet error only	4.2	3.0	3.2	1.9
Selective years exclusion only	4.2	3.1	3.2	1.9
Country weights only	4.0	3.0	3.0	1.9
Interactive effects of RR calculations				
Spreadsheet error + selective years exclusion	4.2	3.0	3.2	1.7
Spreadsheet error + country weights	4.1	2.9	3.4	1.4
Selective years exclusion + country weights	4.0	3.0	3.0	0.3
Spreadsheet error + selective years exclusion + country weights	4.1	2.9	3.4	0.0
Spreadsheet error + selective years exclusion + country weights + transcription error	4.1	2.9	3.4	−0.1
RR published results				
RR (2010A, 2010B, Figure 2) (approximated)	3.8	2.9	3.4	−0.1
RR (2010B, Appendix Table 1)	4.1	2.8	2.8	−0.1

Note: Values from bar chart in RR (2010A, Figure 2) are approximate.
Sources: Authors' calculations from working spreadsheet provided by RR (2010A, 2010B).

real GDP growth rates plotted against public debt/GDP categories. RR mean growth estimates are indicated by diamonds with the corrected growth estimates indicated by filled circles. The substantial disparity between the RR estimate and our corrected figure for the >90% public debt/GDP category is evident in the plot, as are the relatively inconsequential errors in the lower three categories. The plot also shows large variation in real GDP growth in each public debt/GDP category. Finally, the plot includes an empty square as the data point for New Zealand in 1951, which, as we have discussed, alone accounts for 14.3% of RR's result for the highest public debt/GDP category.

3.6 Reassessing RR's mean GDP calculations for 1790–2009

The three sets of problems (data exclusions, spreadsheet errors and inappropriate weighting methodology) that distorted RR's GDP growth estimates with the 1946–2009 data sample have a similar impact with their long time series. We can observe this by reviewing the data presented in Table 6. As the first row of the table shows, RR (i.e. incorporating the exclusions, spreadsheet errors and weighting methodology) find that mean GDP growth is at its peak with the ≤30% public debt/GDP category, at 3.7%. Mean growth then falls to 3.0% for the 30–60% category and rises to 3.4% for the

60–90% category. According to RR's calculations, mean GDP growth then falls in the >90% category to 1.7%, a steep drop-off of 1.7 percentage points in GDP growth.

But these differences in mean growth for the higher public debt categories diminish dramatically when correcting RR's data exclusions and errors and weighting by country-years rather than their one-number-per-country approach. As we see in the second row of Table 6, GDP growth falls off from 3.2% in the 30–60% category to 2.5% in the 60–90% category. The subsequent drop in mean GDP growth in the >90% category is to 2.1%. Two important points emerge here: (i) the growth decline in the >90% public debt/GDP category relative to the 60–90% category is a modest 0.4 percentage points; and (ii) this growth drop-off is *less* than the decline that occurs

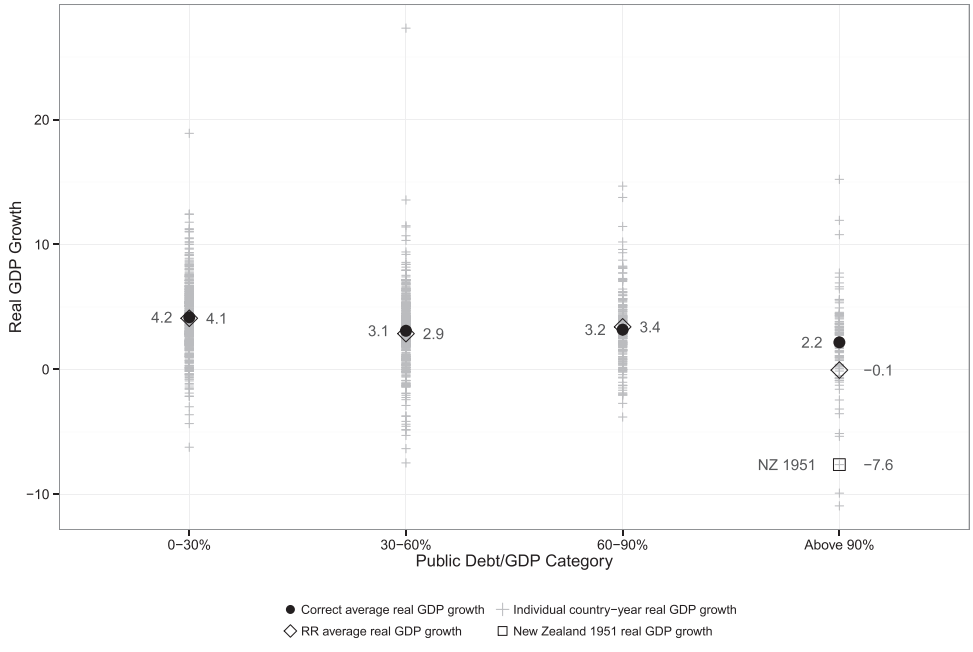

Fig. 1. *Real GDP growth by public debt/GDP categories (data are country-years, 1946–2009).*
Note: Our replication of RR published values for average real GDP growth within category are printed to the right. Corrected values for average real GDP growth within category are printed to the left.
Source: Authors' calculations from working spreadsheet provided by RR.

Table 6. *Recalculation of RR's mean GDP growth rates (percentages) with 1790–2009 data sample*

	Public debt/GDP categories			
	≤30%	30–60%	60–90%	>90%
RR means in 2010 papers	3.7	3.0	3.4	1.7
Recalculations, correcting for exclusions and errors; country-year weighting	3.7	3.2	2.5	2.1

Source: Underlying data from working spreadsheet for RR (2010A, 2010B).

between the 30–60% and 60–90% public debt/GDP categories, where the decline is 0.7 percentage points.

Briefly, after correcting for RR's data exclusions, errors and inappropriate weighting method with the 1790–2009 dataset, there is no longer evidence supporting RR's contention that, when countries reach a public debt level >90% of GDP, economic growth declines to a significant degree and in a pattern that does not occur with the lower public debt/GDP categories.

3.7 Reassessing RR median GDP growth calculations for 1946–2009

In their 25 April 2013 *New York Times* response to HAP (2013), RR emphasise that they had always accorded greater significance to their results based on calculating median GDP growth figures rather than means. Their response includes the following two representative passages:

> Our paper gave significant weight to the median estimates, precisely because they reduce the problem posed by data outliers, a constant source of concern when doing archival research that reaches far back into economic history spanning several periods of war and economic crises.

> We have never used anything but the conservative median estimate in our public discussions, where we stated that the difference between growth associated with debt under 90 percent of GDP and debt over 90 percent of GDP is about 1 percentage point.

In fact, as we noted above, in both versions of their 2010 paper, RR made the same mistakes with exclusions, spreadsheet errors and weighting method in generating their median GDP growth figures.[12] In Table 7 we show the impact of correcting for these problems. As we see in the first row of the table, according to their initial published figures, median GDP growth falls from about 3.0% for the 30–60% and 60–90% public debt/GDP categories to 1.6% in the >90% category. However, once we include the full data sample and calculate the median GDP growth based on country-years rather than one number per country, we see in the second row of Table 7 that the GDP growth decline is much smaller. That is, median GDP growth is at 2.9% for the 60–90% public debt/GDP category and 2.3% for the >90% category, a 0.6 percentage point drop-off.

Table 7. *Recalculation of RR's median GDP growth rates (percentages) with 1946–2009 data sample*

	Public debt/GDP categories			
	≤30%	30–60%	60–90%	>90%
RR 2010 medians	4.2	3.0	2.9	1.6
HAP recalculations, correcting for exclusions and errors; country-year weighting	4.1	3.1	2.9	2.3
RR recalculations, correcting for exclusions and errors; country weighting	4.2	3.0	2.9	2.5

Source: Underlying data from working spreadsheet for RR (2010A, 2010B) and from RR (2013C).

[12] They also clearly did not recognise this when they published their *New York Times* response (RR, 2013A, 2013B), but only after we published our *New York Times* rejoinder on 29 April 2013 (Pollin and Ash, 2013B). They posted online their Errata document with corrections for their median figures on 5 May 2013 (RR, 2013C).

What is equally notable in calculating median GDP growth figures is that in RR's own recalculation in their Errata (RR, 2013C), they themselves show a still smaller GDP growth decline in their >90% category. In this calculation, RR now properly include all the relevant figures from their spreadsheet while still calculating medians through their one-country/one-observation methodology. Through this method, as we see in the last row of Table 7, RR themselves find that GDP growth falls from 2.9% for the 60–90% category to only 2.5% for the >90% category. That is, using medians as their preferred measure of central tendency as well as their preferred one-observation-per-country weighting methodology, the GDP growth drop-off for the >90% public debt/GDP category is now only 0.4 percentage points.

3.8 Non-linearity at historical boundary?

Beyond the specifics of their estimates on the relationship between public debt/GDP ratios and GDP growth, RR also conclude, more generally, that they have identified a robust non-linear relationship between public debt levels and GDP growth, i.e. the significant fall-off in GDP growth after the 90% threshold in the public debt/GDP ratio is crossed. They hold that this robust relationship operates consistently across time periods and countries. However, our recalculation of both the mean and median values for GDP growth after adjusting for their data exclusions, spreadsheet errors and inappropriate weighting method casts doubt on these broader historical generalities as well. We now examine the evidence on the existence of any such non-linearity in several ways.

3.8.1 Adding an additional public debt/GDP category. Working with both the 1946–2009 and 1790–2009 data samples, we first add the category 90–120% public debt/GDP ratio, which then also establishes a >120% category as now being the highest public debt/GDP grouping. We show the results of adding this additional category in Figures 2 and 3, including each country-year data point from both datasets.

Starting with Figure 2 showing the 1946–2009 time period, mean GDP growth in the 90–120% category is 2.4%, which is reasonably close to the 3.2% GDP growth figure for the 60–90% category. Mean GDP growth in the new category (>120% public debt/GDP) is lower at 1.6% but does not fall off a non-linear cliff.

It is also evident from the individual observations in Figure 2, with each cross mark in the figure representing one observation, that variation in GDP growth within each of the public debt/GDP categories is large. This is an important observation in its own right for assessing the validity of generalities regarding the existence of robust non-linearities at historical boundaries. But RR do not examine this issue at all in their 2010 studies.

The absence of a non-linearity boundary at the 90% public debt/GDP threshold is even clearer with the long period (1790–2009) data sample, as we see in Figure 3. Thus, with this long time period data sample, mean real GDP growth in the 90–120% public debt/GDP category is 2.5%. This GDP growth rate is identical to the figure for the 60–90% category. Even with the new highest category of >120%, mean GDP growth is lower at 1.6%, but GDP growth does not decline in a sharp non-linear way even at this highest public debt/GDP level.

3.8.2 Scatter plots with regression line. In Figure 4 we present a scatter plot of the 1946–2009 data, showing all of the country-years, with continuous real GDP growth plotted against public debt/GDP ratios. The figure also includes a locally fitted

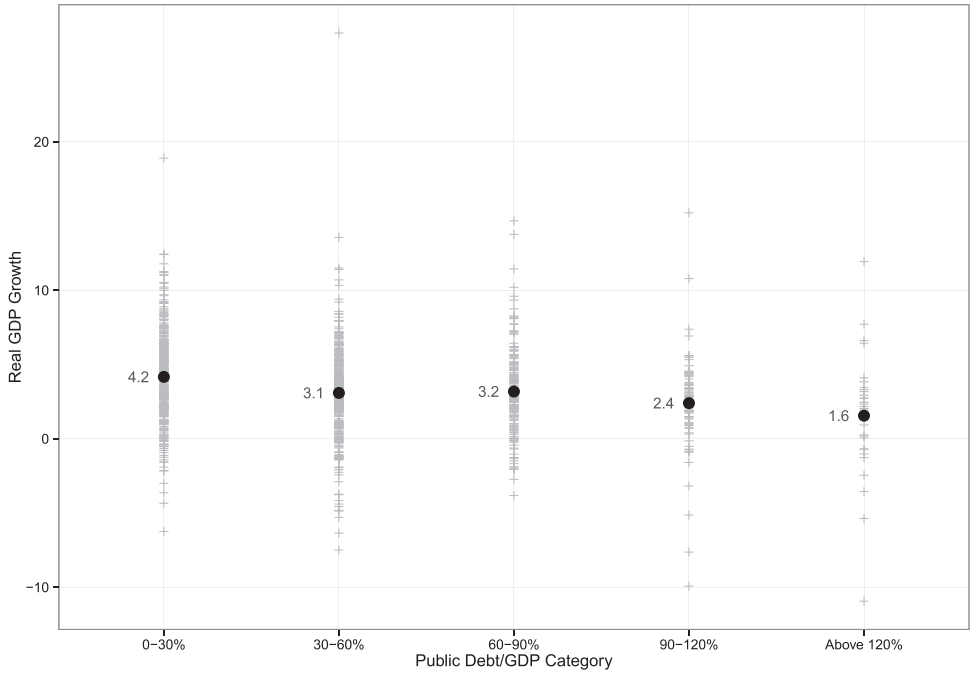

Fig. 2. *Real GDP growth with expanded public debt/GDP categories (data are country-years, 1946-2009).*
Note: Mean real GDP growth within each public debt/GDP category indicated with filled circles.
Source: Authors' calculations from RR working spreadsheet.

regression function.[13] As we see, no particular boundary or non-linearity is evident in either dimension around the 90% figure for the public debt/GDP ratio. The data thin out gradually between 70% and 120% public debt/GDP ratios, as is clear from both the points in the scatter plot and the widening of the 95% confidence interval for mean GDP growth. More generally, the wide range of GDP growth at various public debt levels is evident.

Figure 4 does suggest a non-linearity in the relationship between GDP growth and public debt/GDP ratios, but this occurs as the public debt/GDP ratio rises from 0% to around 30%. This pattern becomes more evident still in Figure 5, which is a close-up of Figure 4, focusing on the country-year observations in which GDP growth ranges between 0% and 7% and the public debt/GDP ratio ranges up to 150%. What we see clearly in Figure 5 is that at 0% public debt/GDP ratio, average GDP growth is almost 5%. But when the public debt/GDP ratio reaches 30%, average GDP growth is only slightly greater than 3%, i.e. average GDP growth drops off by nearly 2 percentage points as countries' public debt/GDP ratios rise from 0% to 30%. This pattern contradicts RR's claim that 'it is evident that there is no obvious link between debt and growth until public debt reaches a threshold of 90 percent' (RR, 2010B, p. 575). At the same time, as we can see in Figure 5, the relationship

[13] The locally smoothed regression is estimated with the general additive model with integrated smoothness estimation using the mgcv package in R. The smoothing parameter is selected with the default cross-validation method. Alternative methods, such as LOESS, and smoothing parameters produce similar results.

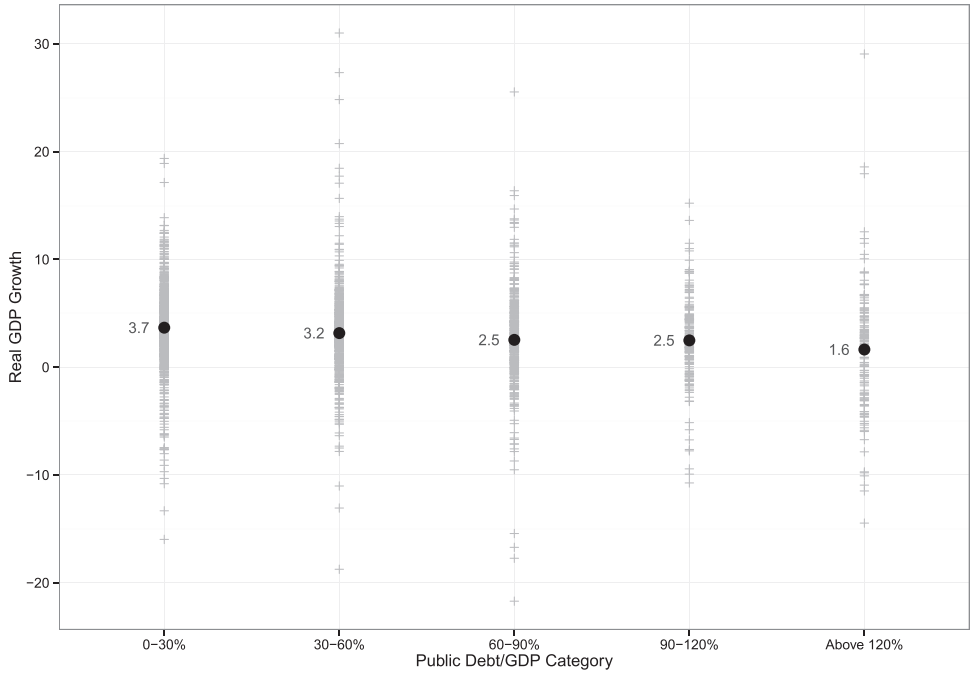

Fig. 3. *Real GDP growth with expanded public debt/GDP categories (data are country-years, 1790–2009).*
Note: Mean real GDP growth within each public debt/GDP category indicated with filled circles.
Source: Authors' calculations from RR working spreadsheet.

between average GDP growth and public debt levels is relatively flat over a wide domain of debt/GDP values. Specifically, between public debt/GDP ratios of 38–117%, we cannot reject a null hypothesis that average real GDP growth is 3%.

This pattern contradicts RR's claim that 'the nonlinear response of growth to debt as debt grows towards historical boundaries is reminiscent of the "debt intolerance" phenomenon developed in Reinhart, Rogoff, and Savastano (2003)' (RR, 2010B, p. 577). The concept of debt intolerance presented in the 2003 Reinhart, Rogoff and Savastano paper (Reinhart *et al.*, 2003) refers to the propensity with developing countries for debt crises and default to result when a country's external debt approaches a context-specific threshold. According to this 2003 paper (p. 1), 'debt intolerant' countries undergo 'extreme duress', i.e. debt crisis and serial default, when they approach the threshold. By suggesting a similarity to this 'debt intolerance' scenario in summarising the findings of their 2010 paper, RR make it clear that they envision a public debt/GDP threshold that leads to sharp reductions in GDP growth once a country crosses the historical threshold.

3.8.3 Varying results by post-war subperiods. We explore the historical specificity of the results by examining mean real GDP growth by public debt categories for subsample periods in the 1946–2009 data. Table 8 presents results for 1950–2009, 1960–2009, 1970–2009, 1980–2009 and 2000–09. We see in the table that the higher GDP growth rates for the 0–30% public debt/GDP category erodes substantially in the shorter and more recent time periods. Thus, GDP growth for the 0–30% category was 4.1% per

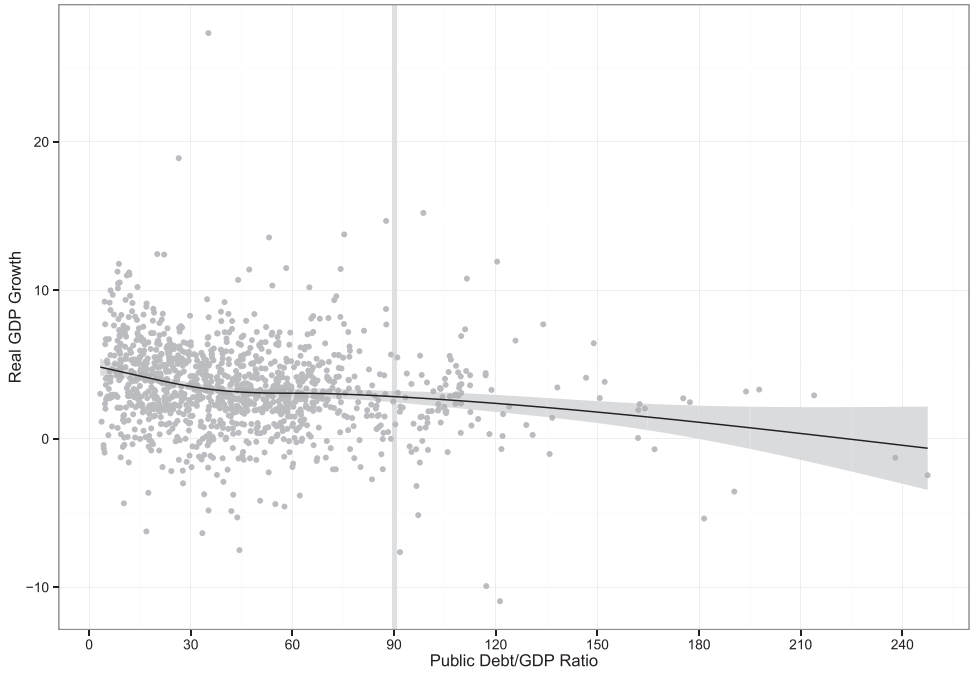

Fig. 4. *Real GDP growth and public debt/GDP ratios (all country-year observations, 1946-2009).*
Notes: See footnote 9 for details on regression line calculation.
Shaded region indicates 95% confidence interval for mean real GDP growth.
Source: Authors' calculations from RR working spreadsheet.

year in the 1950–2009 sample, but declines to only 2.5% in the 1980–2009 sample. Growth in the middle two public debt/GDP categories also declines noticeably, especially in the 2000–09 period, where average GDP growth was 1.9% for the 30–60% category and 1.3% for the 60–90% category, as opposed to the 3.0% and 3.1% averages, respectively, for the middle two public debt/GDP categories in the 1950–2009 sample. In contrast, average GDP growth in the highest public debt/GDP category remains stable across all samples of years, remaining within 0.3 percentage points of 2% per year throughout.

It will be useful to focus further on the results for 2000–09. Only four countries appear in the >90% public debt/GDP category over these years. They collectively contribute 31 country-years of data: Belgium, eight years; Greece, 10 years; Italy, three years; and Japan, 10 years. As we see in the last row of Table 8, with this data sample for 2000–09, average real GDP growth for these four countries in the >90% category is 1.7%. It is notable that between 2000 and 2009, the growth trajectory for the >90% category actually outperformed growth in the 60–90% category and is only 0.2 percentage points below the 1.9% growth rate for the 30–60% category.[14]

[14] Table 8 reports standard errors as well as mean values for GDP growth. We do this because we recognise that the number of observations for the 2000–09 years is significantly lower than for the various longer time periods presented in this table. As such, as is conveyed by the larger size of the standard errors as our sample size narrows, our estimates for GDP growth over 2000–09 are less reliable than the figures for the longer time periods.

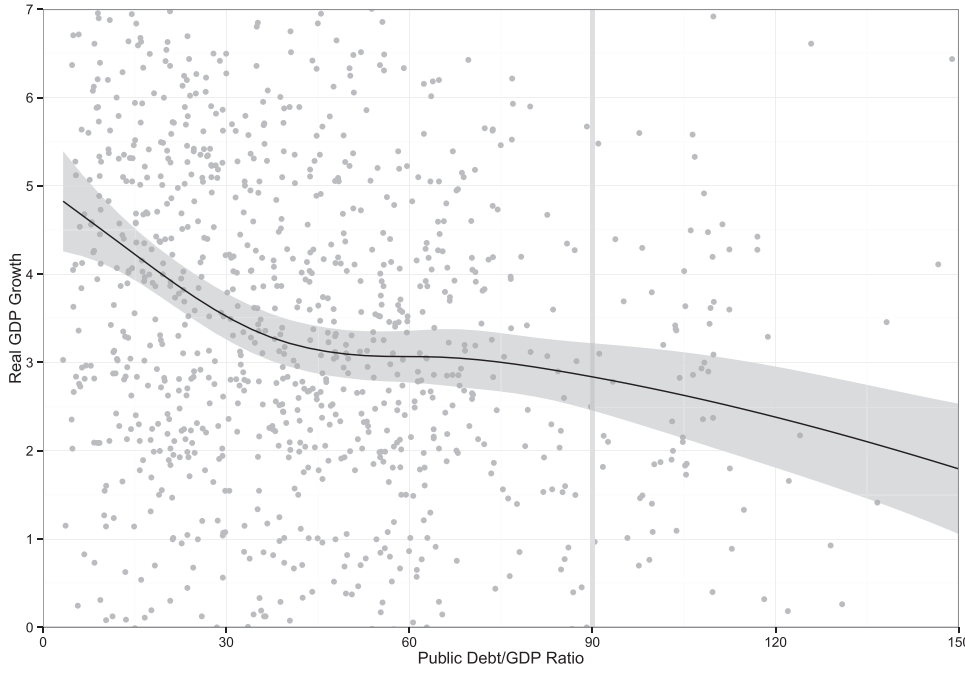

Fig. 5. *Close-up of real GDP growth and public debt/GDP ratios (showing only country-year observations between 0% and 7% GDP growth and 0–150% public debt/GDP, 1946–2009).*
Notes: See footnote 9 for details on regression line calculation.
Shaded region indicates 95% confidence interval for mean real GDP growth.
Source: Authors' calculations from RR working spreadsheet.

Table 8. *Alternative post-war subperiods for real average annual GDP growth (percent) by public debt/GDP categories*

	Public debt/GDP category			
	≤30%	30–60%	60–90%	>90%
Subperiod				
1950–2009	4.1	3.0	3.1	2.1
	(0.1)	(0.1)	(0.2)	(0.3)
1960–2009	3.9	2.9	2.8	2.1
	(0.1)	(0.1)	(0.2)	(0.2)
1970–2009	3.1	2.6	2.6	2.0
	(0.2)	(0.1)	(0.2)	(0.3)
1980–2009	2.5	2.5	2.4	2.0
	(0.2)	(0.1)	(0.2)	(0.3)
1990–2009	2.7	2.4	2.5	1.8
	(0.3)	(0.2)	(0.3)	(0.3)
2000–2009	2.7	1.9	1.3	1.7
	(0.3)	(0.3)	(0.4)	(0.5)

Note: Standard errors are in parentheses.
Source: Authors' calculations from working spreadsheet provided by RR.

These patterns suggest two important conclusions: (i) even the apparent non-linearity between the 0–30% public debt/GDP category and the higher categories is a historically specific pattern, not a robust result across the full 1946–2009 time period;

and (ii) the relationship between public debt and GDP growth is weaker in more recent years relative to the earlier years of the sample.

4. Conclusion

The influence of RR's research came from their straightforward, intuitive use of data to construct a set of stylised facts characterising the relationship between public debt levels and GDP growth for a range of national economies and a range of time periods. However, this laudable effort at clarity notwithstanding, RR made significant mistakes in reaching the conclusion that countries facing public debt levels in excess of 90% of GDP will experience a major decline in their GDP growth rate. The key problems we have identified with RR's work, including exclusion of available data, spreadsheet errors and an inappropriate weighting method, significantly reduced the measured average GDP growth rate for countries in the >90% public debt/GDP category. The full extent of their mistakes transforms the reality of modestly diminished average GDP growth rates for countries carrying high public debt levels into a false image that high public debt ratios inevitably entail sharp declines in GDP growth. Moreover, as we show, there is a wide range of GDP growth performances at every level of public debt among the 20 advanced economies that RR survey.

In the aftermath of the public debate generated by the posting of our April 2013 working paper, RR did acknowledge their spreadsheet errors. They also recognised that, in fact, there is no clear public debt threshold beyond which GDP growth will fall off sharply. At the same time, RR have not addressed other crucial problems that we identified with their papers. These include the following:

(i) RR have not addressed their decision to include data for the USA in the early post-World War II period while explicitly choosing to exclude data for Australia, Canada and New Zealand for the same years. The US figures for these years support their hypothesis while those from Australia, Canada and New Zealand weaken their hypothesis.

(ii) RR have not responded to our findings showing that the relationship between public debt levels and GDP growth varies substantially by country and over time. Especially significant here is the pattern for the most recent decade in their post-war dataset, i.e. 2000–09. As we have shown, there is no evidence in these most recent years for any drop-off at all in GDP growth when public debt exceeds 90% of GDP relative to when the public debt/GDP ratio ranges between 30% and 90%. Relative to experiences from 60 or 200 years ago, such recent patterns for GDP growth under high public debt levels are likely to be more informative for assessing present-day policy concerns.

(iii) Considering only median figures, the results that RR regard as more reliable, the GDP growth drop-off falls only 0.4 percentage points with the >90% public debt/GDP category for the 1946–2009 dataset, according to RR's own recalculations in their Errata document. The growth drop-off with the >90% category is only 0.3 percentage points for the 1790–2009 sample (Table 1, Panel 4, RR 2013C). Their recalculations corrected for data exclusions and coding errors, but still retained their preferred country weighting methodology. Briefly, RR themselves find no substantial GDP growth decline through their own recalculations, but they have not acknowledged this result.

(iv) Whatever happen to be RR's preferences with respect to data exclusions and weighting methodology, they do not acknowledge the need for their main findings to be

robust across reasonable alternative methodologies and data choices. The most obvious case in point is that their main finding on mean GDP growth for the >90% public debt/GDP category can swing by almost 2 percentage points of GDP growth based on the treatment of New Zealand's early postwar years alone. We strongly support what we take to be a consensus view of research standards: that any major empirical conclusions need to hold up consistently when one moves from using one method of calculation to another. RR's findings do not meet this standard test for robustness.

Beyond these strictly analytical considerations, we also believe that the debate generated by our critique of RR has produced some forward progress in the sphere of economic policy making. In particular, it has established that policy makers cannot defend austerity measures on the grounds that public debt levels greater than 90% of GDP will consistently produce sharp declines in economic growth.

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Appendix

Table A1. *Data on public debt/GDP ratios and GDP growth rates for all countries in RR 1946–2009 dataset*

Country		≤30%	30–60%	60–90%	>90%
Australia	Years in category	37	13	9	5
	GDP growth	3.2	4.9	4.0	3.8
Austria	Years in category	34	27	1	0
	GDP growth	5.2	3.4	−3.8	
Belgium	Years in category	0	17	21	25
	GDP growth	–	4.2	3.1	2.6
Canada	Years in category	3	42	14	5
	GDP growth	2.5	3.5	4.5	3.0
Denmark	Years in category	23	16	17	0
	GDP growth	3.5	1.7	2.4	–
Finland	Years in category	44	16	4	0
	GDP growth	3.8	2.4	5.5	–
France	Years in category	24	21	10	0
	GDP growth	5.1	2.7	3.0	–
Germany	Years in category	48	11	0	0
	GDP growth	3.9	0.9	–	–
Greece	Years in category	13	5	3	19
	GDP growth	4.0	0.3	2.7	3.1
Ireland	Years in category	10	14	32	7
	GDP growth	4.2	4.5	4.0	2.4
Italy	Years in category	26	6	17	10
	GDP growth	5.4	2.1	1.8	1.0
Japan	Years in category	22	17	4	11
	GDP growth	7.3	4.0	1.0	0.7
Netherlands	Years in category	17	34	2	0
	GDP growth	4.1	2.6	1.1	–
New Zealand	Years in category	9	33	17	5
	GDP growth	2.5	2.9	3.9	2.6
Norway	Years in category	51	12	1	0
	GDP growth	3.4	5.1	10.2	–
Portugal	Years in category	42	9	7	0
	GDP growth	4.5	3.5	1.9	–
Spain	Years in category	5	36	1	0
	GDP growth	1.5	3.4	4.2	
Sweden	Years in category	18	35	11	0
	GDP growth	3.6	2.9	2.7	–
UK	Years in category	0	39	6	19
	GDP growth	–	2.2	2.5	2.4
USA	Years in category	0	37	23	4
	GDP growth	–	3.4	3.3	−2.0
Total country-years		426	439	200	110
Total countries		17	20	19	10

Source: Authors' calculations from working spreadsheet provided by RR.