A GRAPHICAL ANALYSIS OF CAUSALITY IN THE REINHART-ROGOFF DATASET

Gray Calhoun*

Iowa State University

2015-06-23

Abstract

We reexamine the Reinhart and Rogoff (2010, *AER*) government debt dataset and present graphical evidence that supports the hypothesis that periods of slow economic growth cause debt levels to rise. In particular, low growth periods are clustered temporally, suggesting a common cause; low growth rates predict an increase in debt, even after conditioning on the debt level; and countries with high debt levels grow at roughly the same rate as those with low debt levels when we compare countries at similar points in time.

Keywords: Public debt, economic growth

JEL Classification Numbers: E6, F4

*Economics Department; Iowa State University; Ames, IA 50011. Telephone: (515) 294-6271. Email: «gcalhoun@iastate.edu», web: «http://gray.clhn.org». I'd like to thank (without implicating) Matt Simpson for initially prompting me to look at this issue and Otávio Bartalotti, Joydeep Bhattacharya, and Helle Bunzel for helpful comments on earlier drafts of this paper.

I. INTRODUCTION

The relationship between debt and GDP has received much recent scrutiny, largely because of new datasets collected and made available by Carmen Reinhart and Kenneth Rogoff. (See Reinhart and Rogoff, 2009, in particular, but their research agenda spans several other papers, including Reinhart and Rogoff, 2010a, Reinhart and Rogoff, 2011, and Reinhart et al., 2012.) This research suggests that high levels of government debt precede and may cause lower GDP growth,[1] but their research emphasizes the empirical regularities in the data and does not try to pin down causality. A critical analysis by Herndon et al. (2014) has discovered errors in some of the specific estimates presented in Reinhart and Rogoff (2010a,b), but it remains difficult to determine whether low growth causes a country's debt burden to rise, or whether high debt burdens cause low growth rates — this issue is complicated by the fact that economic agents are forward-looking, so one variable could change in response to an anticipated change in the other; i.e. causes can happen after their effects. In this paper, we present a short analysis of the advanced countries dataset provided by Reinhart and Rogoff (2010b,a) and Herndon et al. (2014) and derive some new stylized facts about the debt-GDP relationship. Specifically,

1. Low growth periods happen at roughly the same time in different countries, suggesting that a common element is at least partially responsible. The debt/GDP ratio has common patterns across countries, but at very long horizons, so it is unlikely to be that common element.

2. In aggregate, high debt/GDP predicts lower real GDP growth, but this pattern is much less pronounced when considering individual years.

3. Low growth rates tend to be followed by an increase in a country's debt burden, regardless of the country's initial level of indebtedness.

Taken together, these results suggest that low growth rates cause debt levels to increase, but that high debt has not caused low growth rates.

[1] Reinhart and Rogoff find that this relationship holds for total public debt as well as externally held debt alone.

II. DATA AND RESULTS

The dataset we use was initially studied by Reinhart and Rogoff (2010a) and Herndon et al. (2014) and covers 20 advanced countries from 1946 to 2009.[2] For each country, we have data on real GDP, which we convert to growth rates, and on real public debt, which we express as a percentage of GDP.[3] The data are annual observations and several observations are missing. In all, there are 1,275 observations, 90 missing values for the debt/GDP ratio, 63 missing values for GDP growth, and 126 observations where at least one of the values is missing. Although it features prominently in some of the debate surrounding Reinhart and Rogoff (2010a) and Herndon et al. (2014), an analysis of this missingness is beyond the scope of our paper and we simply drop years missing values of either series.

Figures 1 and 2 plot the debt burden for each country in the sample;[4] Figure 2 plots the countries individually for reference, and Figure 1 plots all of the series in the same panel to make common patterns more noticeable. The dark black lines and points indicate years where the country's GDP growth was negative. Several features of the data are apparent:

1. Aggregating over the full dataset is likely to be highly misleading; even if the relationship between debt and GDP is stable, the early values of the series are unusual and will strongly influence any of our estimates.

2. The low growth periods are clustered in time, which suggests that there is a common cause for low output growth in different countries. Countries with higher debt do not seem to be more likely to have low growth in a given period than countries with lower debt.

3. The debt burden tends to rise after output falls, although there are exceptions.

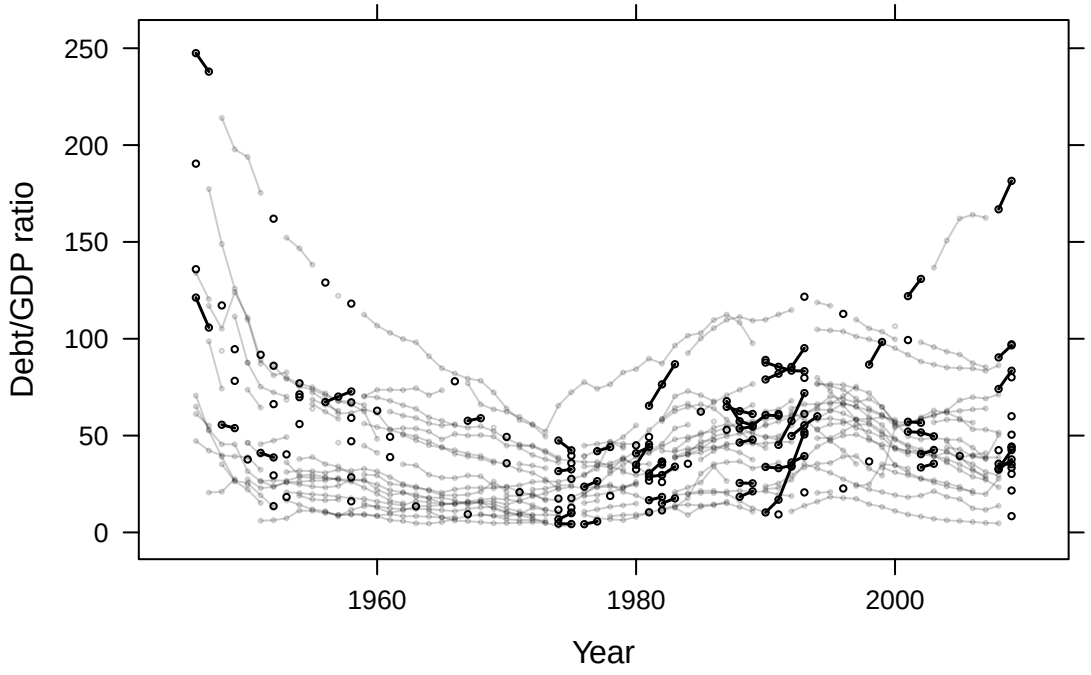
[2] The complete list of countries is: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States.

[3] Specifically, we analyze log(public debt/GDP), but this will often be implemented by presenting axes in log scales.

[4] All of our data analysis is conducted in R (R Core Team, 2014) and uses the plyr (Wickham, 2011) and Lattice (Sarkar, 2008) packages.

FIGURE 1

Annual debt/GDP ratio, all countries.



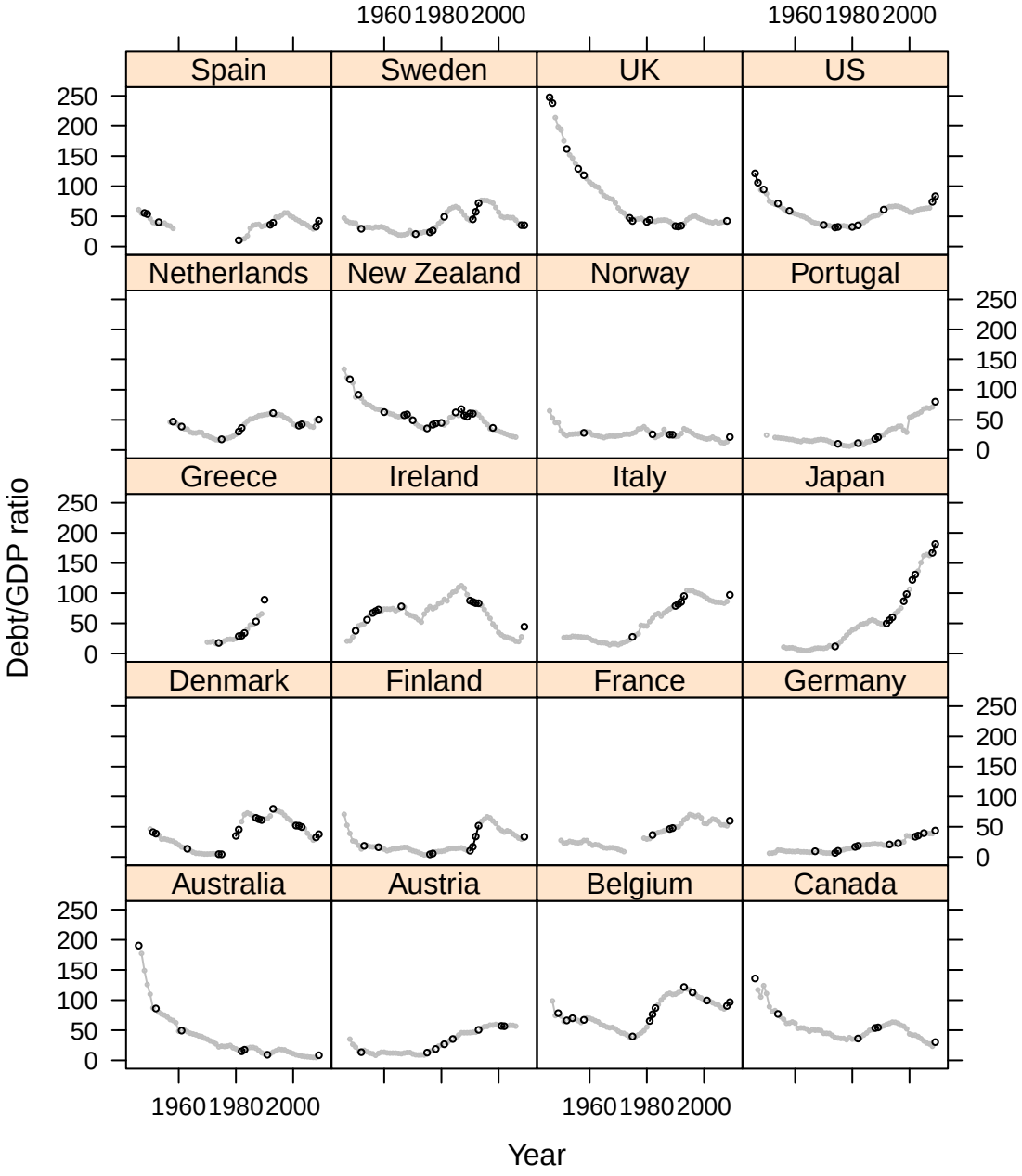
Annual Debt/GDP ratio, all 20 countries in dataset, 1946 to 2009. Country-year pairs where the GDP growth rate is negative are emphasized with black lines.

We can explore these points further by plotting GDP growth rates against the debt/GDP ratio, conditional on a given time period. These graphs are shown in Figure 3. The bottom left panel is a scatterplot for the years 1946 through 1953, the next panel to the right covers the years 1953 through 1960, etc., and the red curve is a fitted LOESS smoother (Cleveland et al., 1992). Each point represents GDP growth and log debt/GDP ratio for a given year. It is apparent from these graphs that there is a prominent negative relationship between GDP growth and debt burden at the beginning of the dataset, but the relationship is nearly flat for the rest. Moreover, there is little evidence of a sharp "threshold" at any level of debt/GDP ratio.

Our next set of graphs explores the opposite relationship: whether low GDP growth causes

FIGURE 2

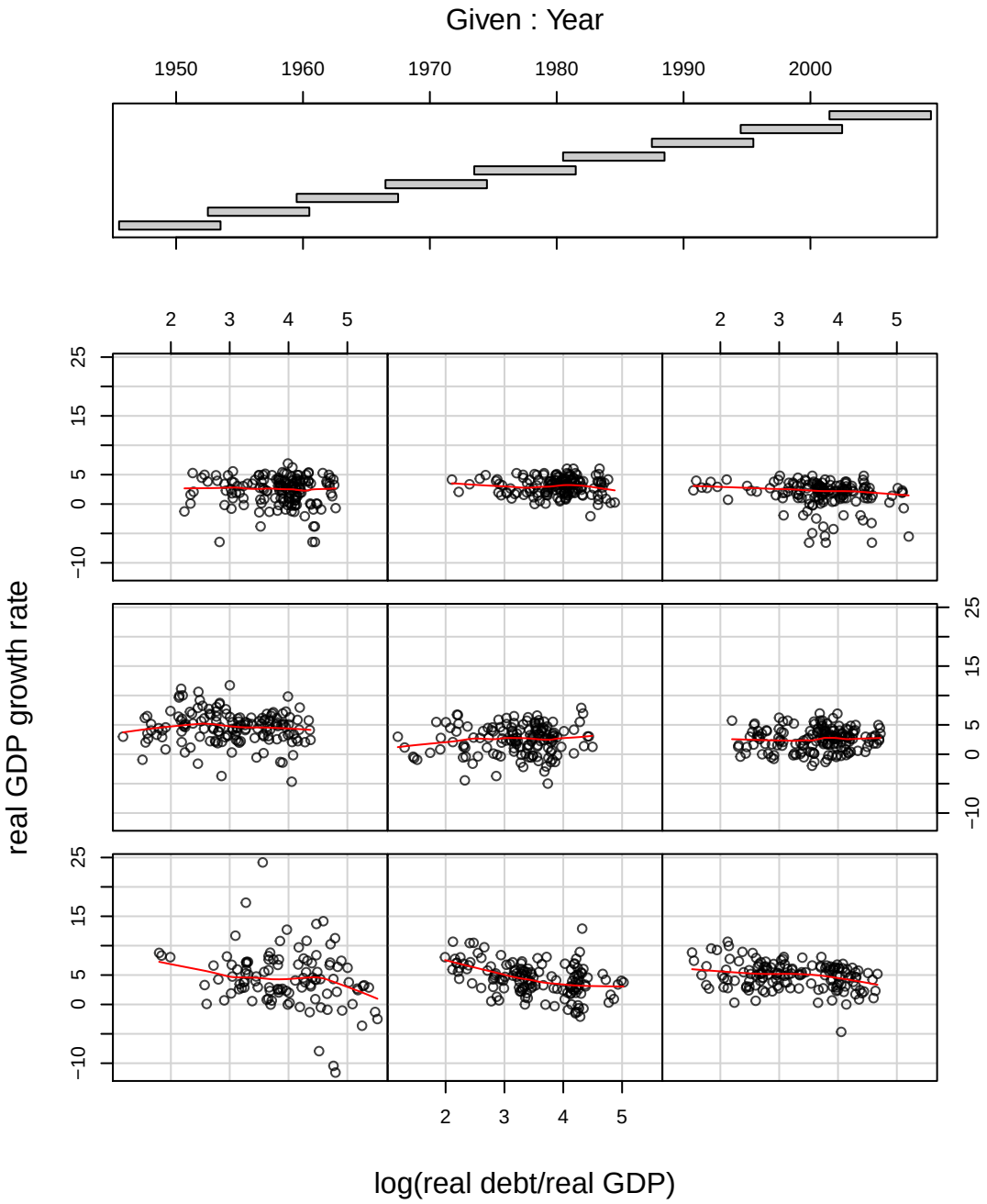
Annual debt/GDP ratio, individual countries.



Annual Debt/GDP ratio, all 20 countries in dataset, 1946 to 2009. Periods with negative GDP growth are emphasized with black lines and points.

FIGURE 3

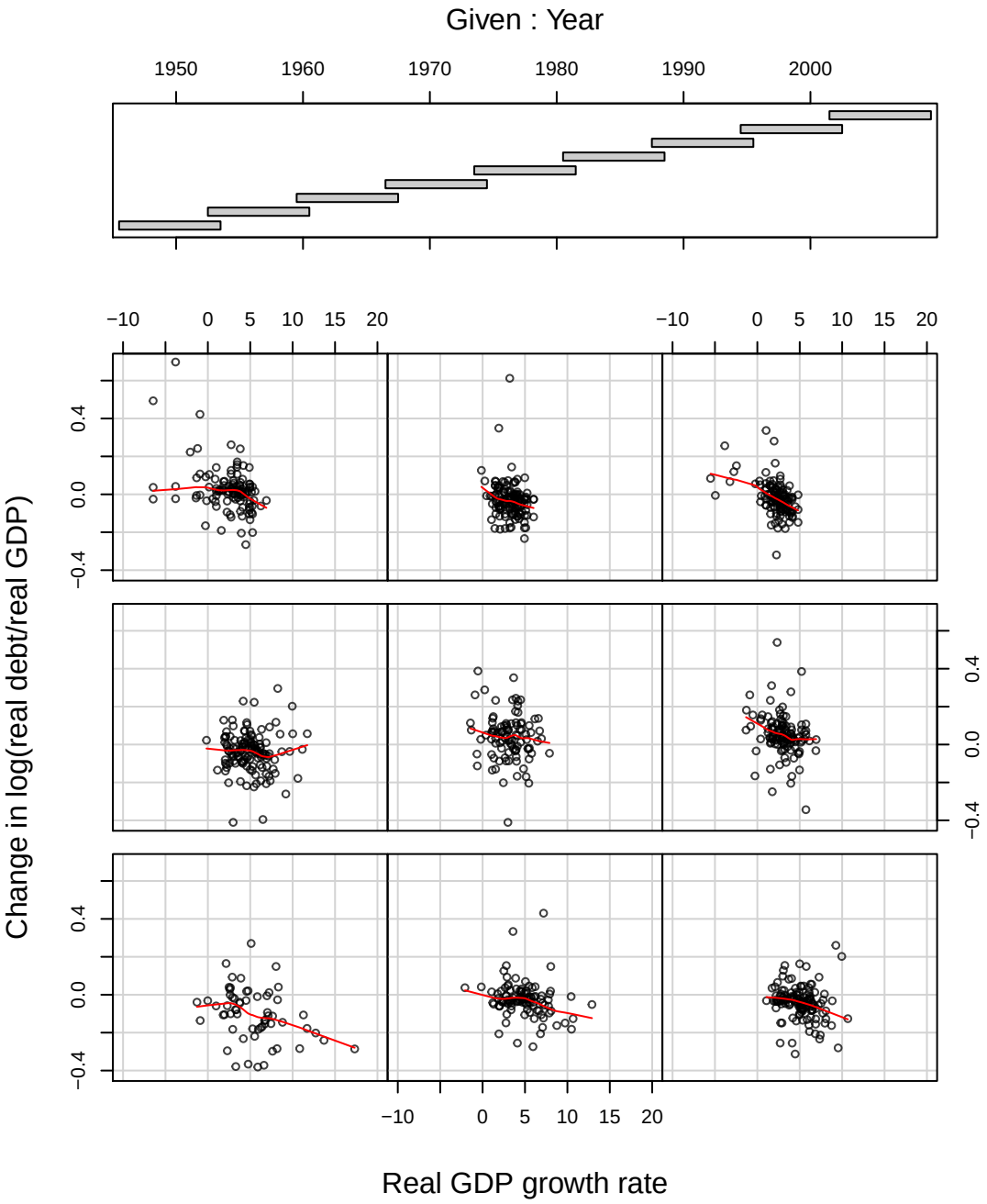
Growth rate predicted by debt ratio, grouped by subperiod.



Annual GDP growth rate plotted against annual log Debt/GDP ratio for all countries and years in dataset. Each panel plots a subset of the data, and the subsets encompass different time periods: for example, the bottom left panel corresponds contains observations between 1946 and 1953. The red regression curve is estimated with a LOESS smoother.

FIGURE 4

Debt ratios as predicted by GDP growth rate, grouped by subperiod.



Change in log Debt/GDP ratio plotted against GDP growth rate for all countries and years in dataset. Each panel plots a subset of the data, and the subsets encompass different time periods: for example, the bottom left panel corresponds contains observations between 1946 and 1953. The red curve is estimated with a LOESS smoother.

the debt burden to rise. Here we calculate the next period's change in the debt/GDP ratio,

$$\log(\text{debt}_{i,t+1}/\text{GDP}_{i,t+1}) - \log(\text{debt}_{i,t}/\text{GDP}_{i,t})$$

and plot these values against $\log(\text{GDP}_{i,t}) - \log(\text{GDP}_{i,t-1})$, where t denotes the year and i denotes the country; again, conditioning on the time periods as in the previous graphs. These graphs are shown in Figure 4. Here there is a much more pronounced negative relationship, low growth rates predict that the debt burden will increase next period, and this pattern is present in most of the subperiods studied.

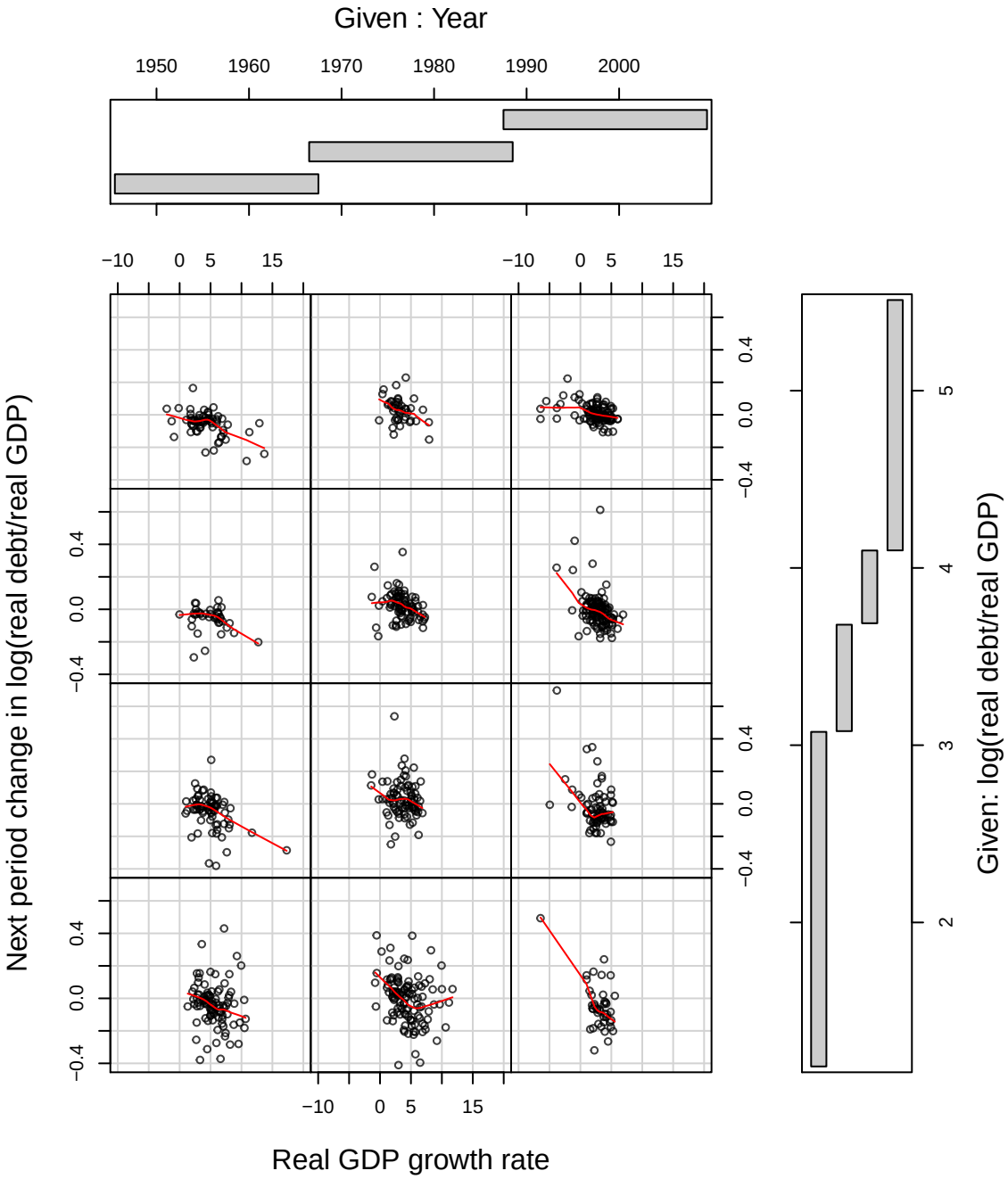
As a final check, we extend this last graph by conditioning on both the year and the debt burden, which is shown in Figure 5. Figure 5 demonstrates that the previous claims continue to hold even after controlling for level of debt burden. Note that some of the regression lines are distorted by heavily influential values of GDP growth rate, but that the prominent negative relationship holds even ignoring those values.

III. CONCLUSION

In summary, there are two possible causal relationships between public debt and GDP growth. Low GDP growth could cause the debt burden to rise, or high debt levels could lower GDP growth. The empirical patterns we present in this paper are consistent with the first relationship but are less supportive of the second: low periods of GDP growth tend to be followed by increases in debt burden (and high growth is followed by decreases in debt), regardless of a country's level of indebtedness, but (after the first decade or so following WWII), high levels of debt are not highly correlated with low levels of growth. Moreover, as we can see in Figure 1, low growth periods are clustered together, even for countries with very different levels of indebtedness.

FIGURE 5

Change in debt ratio, conditioning on subperiod and previous debt level.



Change in log Debt/GDP ratio plotted against GDP growth rate for all countries and years in dataset. Each panel plots a different subset of the data, representing a particular combination of years and values of debt burden. For example, all of the panels in the left column correspond to the years 1946 through 1968 and all of the panels in the bottom row correspond to debt/GDP ratios between 3 and 22 percent. The red curve is estimated with a LOESS smoother.

REFERENCES

Cleveland, W. S., E. Grosse, and W. M. Shyu (1992). Local regression models. In J. M. Chambers and T. J. Hastie (Eds.), *Statistical models in S*, Chapter 8, pp. 309–376. Chapman and Hall.

Herndon, T., M. Ash, and R. Pollin (2014). Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff. *Cambridge Journal of Economics 38*(2), 257–279.

R Core Team (2014). *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing.

Reinhart, C. M., V. R. Reinhart, and K. S. Rogoff (2012). Public debt overhangs: Advanced-economy episodes since 1800. *Journal of Economic Perspectives 26*(3), 69–86.

Reinhart, C. M. and K. Rogoff (2009). *This time is different: eight centuries of financial folly*. Princeton University Press.

Reinhart, C. M. and K. S. Rogoff (2010a, May). Growth in a time of debt. *American Economic Review, Papers and Proceedings 100*(2), 573–78.

Reinhart, C. M. and K. S. Rogoff (2010b). Growth in a time of debt. Technical report, National Bureau of Economic Research.

Reinhart, C. M. and K. S. Rogoff (2011). From financial crash to debt crisis. *American Economic Review 101*, 1676–1706.

Sarkar, D. (2008). *Lattice: Multivariate Data Visualization with R*. New York: Springer. ISBN 978-0-387-75968-5.

Wickham, H. (2011). The split-apply-combine strategy for data analysis. *Journal of Statistical Software 40*(1), 1–29.