Jonathan Leistner & Janko Zimmermann, 22.12.2021

Assignment 5: Reinhart-Rogoff (2010)

Contents

1. Introduction

In their paper "Growth in a Time of Debt", Reinhart & Rogoff (2010) analyse a historical cross-country dataset of 20 advanced economies (RR) on public debt/GDP ratio, real GDP growth and inflation to find correlations between the variables. Using dummy variables, they assign each annual observation to one of four boundaries describing the debt-to-GDP ratio: 30% or less, 30-60%, 60-90% and 90% or above. The authors then calculate the mean and median real GDP growth and inflation for each boundary and country. Finally, the cross-country means and medians of each boundary are calculated.

Reinhart & Rogoff conclude that countries experience significantly lower real GDP growth across all countries. A rise of inflation rates when public debt is high can only be observed in emerging markets. The publication was criticised by Herndon, Ash and Pollin (2013), who pointed out both arithmetical and systematic errors.

In the main part, in section 2.1, we will first discuss how the calculation revision affects the results from Reinhart and Rogoff. We then discuss how their mean calibration approach is flawed (2.2), replicate the data and address the errors and criticisms raised by Herndon and co-authors. In section 2.3, we compare the results with another dataset from Jordà, Schularick and Taylor (2017), the "Macrohistory database'' (JST), and finally examine the correlation of other variables with real GDP growth across public debt ratio boundaries in section 2.4. Section three summarizes the results

2. Main Part

2.1 Calculation Revisions

In this section we take the criticism of Herndon et al. into consideration and discuss how their points affect previous results. They first point out an arithmetical mistake. In their paper from 2010, Reinhart and Rogoff made a coding error which disregarded data of five out of 20 countries in the cross-country mean values. Country data of Denmark, Canada, Belgium, Austria and Australia were omitted with Belgium being the country with the most observations in the group of a public debt/GDP (debt ratio) of more than 90 percent. Belgium is also the only country affected by this error with data available in the >90% boundary. In total, 299 observations were disregarded. This led to strong differences in the results. The average real GDP growth in the four boundaries was quantified as 4.13 (<30%), 2.79 (30-

60%), 2.75 (60-90%) and -0.022 (>90%). A strong downward trend is clearly visible. The trend is also visible (3.89, 2.98, 2.53, 0.30) after the revision, even if not quite as strong. Most notably the formerly slightly negative growth rate in the >90% boundary had to be corrected to a slightly positive number. As can be expected, the differences in the corrected median values are not as drastic because individual omitted values are of less significance. The mean inflation values are lower after the correction, too (6.50, 6.32, 6.45, 5.15 versus 6.11, 5.88, 5.56, 4.82) but both results show a comparable downward trend when public debt is higher. In contrast, the median values show an increase in inflation in the >90% boundary compared to the 30-60% and 60-90% boundaries. This effect is more visible after the correction (5.19, 3.68, 3.47, 3.92 versus 4.87, 3.45, 2.70, 3.77).

Another point of critique by Herndon et al. is unexplained gaps in the dataset. The starting year of the post-war period was chosen differently for each country for no explained or plausible reason, ranging from 1946 for many countries to 1956 (Netherlands, Japan) and even 1970 for Greece. Furthermore, a gap appears in the Spanish data set in the years 1959-1980. While Reinhart & Rogoff justify the latter error with missing data and correct it in a revision, they do not address the criticism of the different starting years. The correction of the Spanish data led to a higher mean cross-country growth rate in the <30% boundary (3.98 to 4.20) and a similar change in the median values.

The last revisions by Reinhart & Rogoff concern data of New Zealand. In the original calculations, contrary to the statement on the starting year, the data for the years 1948 and 1949 were omitted and have now been added. This changed the New Zealand GDP growth rate in the >90% debt boundary drastically from -7.64 (previously a lot higher in absolute terms than other values) to -2.26. The cross-country average increased accordingly from 0.30 to 0.97. The median value remained unaffected. A final revision was issued by Reinhart & Rogoff when the New Zealand Statistical office was used as data source for the country, which registers a much higher GDP growth rate in the post-war period. Thus, in this revision the values for the 60-90% and >90% boundaries change from 3.88 and -2.26 to 2.30 and 6.05 respectively, which is now the highest value in the >90% boundary by far. This, in turn, results in a doubling of the mean cross-country growth rate (>90% boundary) from 0.97 to 2.01. The median values change from 1.87 to 2.51. Reinhart & Rogoff do not comment about which of the two data sets is more plausible.

The authors' claim that a debt-to-GDP ratio of over 90% is accompanied by very low average GDP growth rates close to zero does not hold up after several revisions. Inflation rates, however, still show a downward trend in correlation with higher public debt. A small upward trend in the high debt boundary can only be seen in the median values. Changes in the data set of single countries or even single observations can influence the outcome significantly which raises the question of how robust the results and correlations are. This leads to the next chapter where we investigate how a different calculation method for the country values gives insight into the robustness of the results.

2.2 Weighted Averages

The second critique by Herndon et al. (2013), in essence, suggests an alternative approach for summarizing all countries' average growth rate in the respective debt ratio group. Instead of the "Means of means" (MoM) approach by Reinhart and Rogoff, Herndon and co-authors urge to whey each country-specific value according to their relative appearance of each debt group (WA). This implies that countries with only a few years of a specific public debt ratio will have a smaller impact on the average real GDP growth rate or inflation and vice versa. We will now compare how the results are affected through this robustness check. The top and bottom left graphs of Figure 1 compare the two weighing approaches for real GDP growth and inflation rates in percent, respectively. Each column pair reflects one of the four debt ratios as suggested by Reinhart and Rogoff with the red column depicting an equal weighting of each observation and the turquoise column relative weighting approach. For the GDP

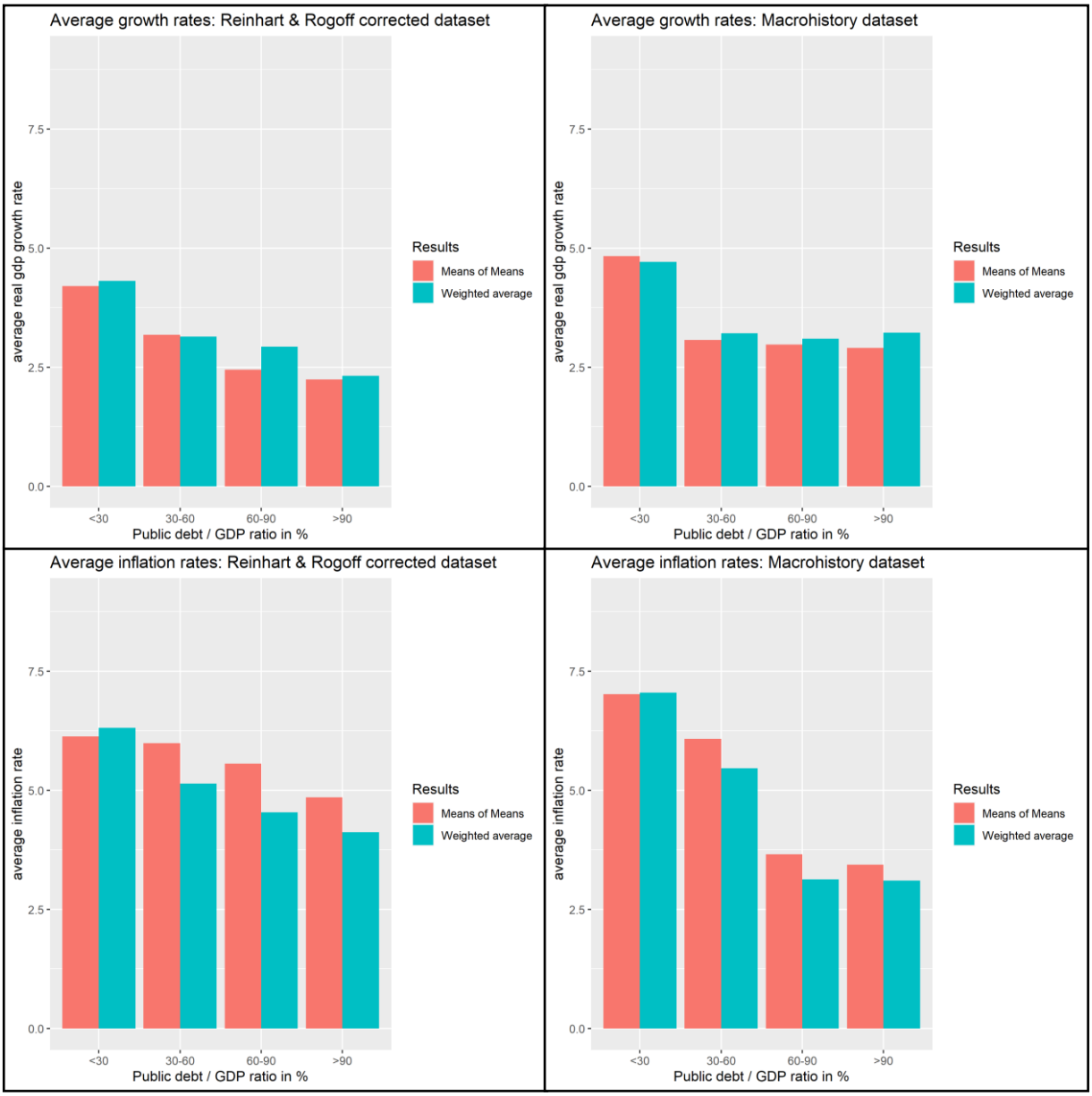

Figure 1: Comparison of RR and JST dataset results: for inflation and GDP growth rates according to debt ratio groups using two different weighing methods for the mean

growth rates, we can see that the different measurements do not result in much difference except for the 60-90 percent debt ratio group (2.93 weighted average versus 2.44 MoM). Overall, the WA values seem to be slightly higher than with the MoM-approach. The difference for inflation rates for the WA, being between 0.7-1.1 percentage points higher than the MoM above the 30% debt ratio, is more pronounced. It seems that a classic means approach tends to overestimate true inflation rate values. However, the declining trend of inflation given higher debt ratios seems to still be confirmed.

Note that our results are slightly different from the RR calculations (means of means approach). This relates to the above-mentioned discussion of missing data points. Within the relevant period (1946 - 2009), there are some countries where data is available, but RR exclude some post-war time windows and only start from later time periods. For the >90% debt ratio, this adds up to twelve additional data points (NZ 2, CAN 5, AUS 5) that we decided to include into the calculation to reflect a 'proper' post-war period. Additionally, in Greece, for 2008 and 2009 no debt ratios are documented but RR consider these years as "very high debt" regardless. This adds up a total difference of ten datapoints in the >90percent section (98 versus 108). See Table 1 for an overview of the differences. Using the full range

of datapoints results in higher growth rates for >90% debt ratio group than what RR predict (2.2 versus 2.0). As for inflation, for the very high debt ratio, RR's MoM inflation rate of 4.3 is 0.5 percentage points lower than the 'proper' post-war dataset (4.8).

Table 1: Growth rates comparison across debt ratios between the RR selection of post-war datapoints and the complete dataset.

	<30%	30-60%	60-90%	>90%
Number of observations: RR post-war	*446*	*442*	*199*	*98*
MoM Growth rate: RR post-war	*4.2*	*3.0*	*2.4*	*2.0*
Number of observations: 'proper' post-war	*445*	*443*	*199*	*108*
MoM Growth rate: 'proper' post-war	*4.2*	*3.2*	*2.4*	*2.2*

Because the topic of robustness seems to be an important issue in the analysis of these numbers, we have furthermore calculated the medians for our 'proper' dataset and with it the weighted averages of the median values. The top left and bottom left graphs of Figure 2 show the results. We can see that the difference in relative weighting versus equal weighting is not that big compared to the mean values (Figure 1). The results from RR show that median values are 0.5 percentage points higher than those of means (2.5 versus 2.0). A similar observation can be made using our 'proper' post-war period (median 2.7, mean 2.2).

To summarize, on the one hand, the weighted average approach has stronger impacts on the inflation results than on real GDP growth rates. The exclusion of some data points in the post-war period, on the other hand, does have a significant effect on the growth rates in the very high public debt ratio group. Using the full data range indicates that the reduction of real GDP growth is not as pronounced as RR predict. Using median values instead of means leads to even higher absolute real GDP growth values in the very high debt ratio group. Therefore, we will now consider an alternative dataset to further investigate the relation of public debt and real GDP growth across developed countries.

2.3 Database Comparison

To verify the insights that the dataset from Reinhart and Rogoff allows for, it makes sense to compare the results to a different dataset. We have already pointed out that we focus our analysis on the period ranging from the end of the second world war until the beginning of the financial crisis, 1946 – 2009. To use a comparable advanced economies dataset, the 'Macrohistory Database' from Jordà, Schularick and Taylor (2017) is used. As for the country sample, 17 countries are the same in both datasets, with the JST data furthermore including Switzerland. The data from RR exclusively includes Austria, Greece, and New Zealand. The top right and bottom right graphs from Figure 1 show the results for mean and weighted mean results of the JST dataset as well as the median results in Figure 2, accordingly.

The most important observation with regards to the very high debt ratio group is the remarkable difference in the median and mean results. While the RR-means (top-left graph in Figure 1) decline the higher the debt ratio is, the JST-means (top-right graph, Fig. 2) remain relatively constant with the weighted mean even increasing above >90percent (compared to the 60-90% group). Looking at the median comparison (top graphs of Figure 2), the jump from the high to the very high debt category is associated with relatively comparable real GDP growth rates in the RR data but a significant decline in the JST data. Reasons could be a combination of more datapoints and the more robust handling of the median as the proper 'middle value'. Therefore, the JST median values seem to support the original

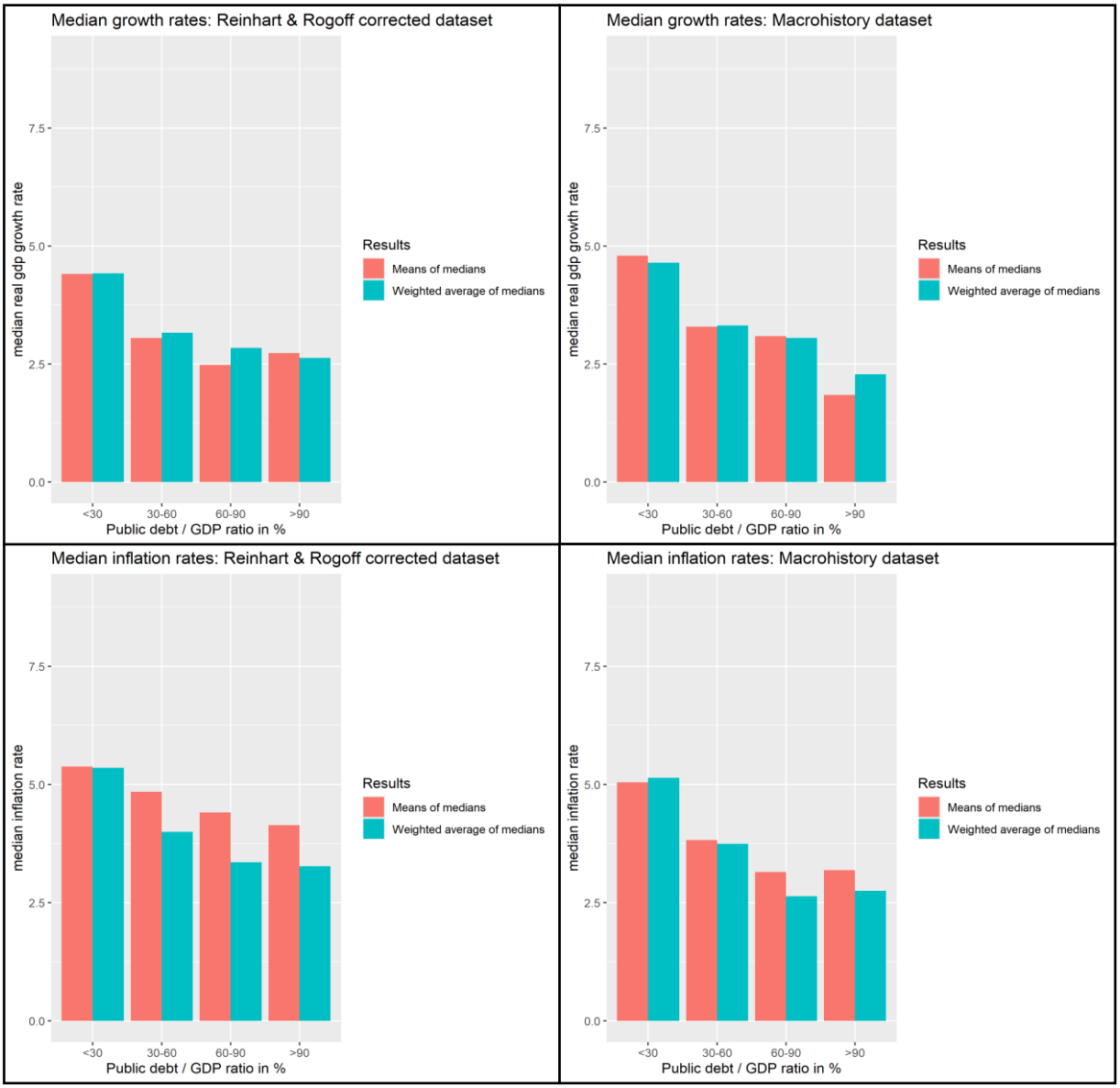

Figure 2: Comparison RR and JST dataset results: for inflation and GDP growth rates according to debt ratio groups using two different weighing methods for the median.

thesis of Reinhart and Rogoff that very high debt levels have a declining effect on real GDP growth. We think that the unclear results might have to do with the fact that growth rates indicate the direction of the economy. To understand the actual impact of public debt, it might, in addition, be important to consider the years following a high debt period where longer term economic effects take place. The considerations of growth rates during high debt periods only account for contemporaneous effects.

Looking at the inflation figures, it is notable that all results with weighted averages are lower than those of balanced weighting (bottom graphs of Fig. 1 and 2). We suspect that countries with only a few years of a particular debt ratio have too much of a weight in the MoM-calculations. Furthermore, these images seem to show a stronger link between inflation and public debt at least until debt ratios reach 90percent and more. The hypothesis that countries might be inclined to accept higher inflation rates with the goal to control influence their public debt ratios seems not to be confirmed with the datasets at hand.

Table 2 shows the number of datapoints for each debt ratio category. It gets clear that even though less countries are considered, the JST database has a higher number of observations for years with a debt ratio of more than 30 percent. One could suggest that the reason for the different completeness

of both datasets has to do with interpolation. According to the Macrohistory database documentation, the variables used (real GDP per capita, population, consumer price index and the debt ratio) were not subject to interpolation which means that indeed there are more data points available for the post-war period.

Table 2: Number of observations comparison JST and RR dataset for the period 1946-2009.	**<30%**	**30-60%**	**60-90%**	**>90%**
No. of observations: RR 'proper' post-war	*445*	*443*	*199*	*108*
No. of observations: JST post-war	*327*	*481*	*204*	*120*

2.4 Other Real GDP Growth Factors

To investigate relationships of the public debt/GDP ratio with variables other than inflation, we abuse the fact that the JST dataset has many more additional variables that we can analyse depending on the debt ratio of countries. Specifically, we analyse the behaviour of government expenditure, real interest rate, house prices growth rate, real consumption growth rate and an investment return growth rate in a similar fashion as Reinhart and Rogoff (2010) did. All data are taken from the Macrohistory Dataset and transformed into rates where necessary except for government expenditure which is shown as a share of GDP. Of all the values used, the weighted mean of the median was taken and plotted in Figure 3.

We have estimated the real interest rate by subtracting inflation from the long-term nominal interest rate. The government expenditure (nominal, local currency) is divided by nominal GDP to obtain the public expenditure share. Real per capita consumption and house prices are both transformed into annual growth rates. The investment return growth rate reflects the total returns on wealth (nominal weighted average of housing, equity, bonds and bills), risky assets (nominal weighted average of housing and equity) and safe assets (nominal weighted average of bonds and bills), all three entering with equal shares. The results can be seen in Figure 3, note that the data points for each debt ratio are connected with each other for illustrative purposes.

As already discussed, the weighted median of inflation rates does relate to the public debt/GDP ratio to a certain degree. As to be expected, government expenditure is higher in times of high public debt, showing a clear inverse relation to GDP growth rates.

The real interest rate takes on higher values the higher the debt ratio is, but prominently decreases in the highest debt boundary. This is inversely correlated to the inflation rate and a well-known correlation in advanced economies where central banks behave according to a Taylor rule.

In the investment return growth rate variable, the market reaction is observed, which also considers the non-government bond returns. Market returns should, in normal times, be higher than the nominal interest rate (sum of real interest rate and inflation rate) for investments to be more attractive than safe bonds. The values in the case of low debt ratios are in line with this. In the very high debt group, however, the investment return growth rate only matches the nominal interest rate. Because the way we measure investment return as a balanced combination of safe, risky and capital assets, it is implied that the capital and risky assets are less profitable in times with very high public debt. The values support the claim that private markets suffer in times of crisis (high debt ratio).

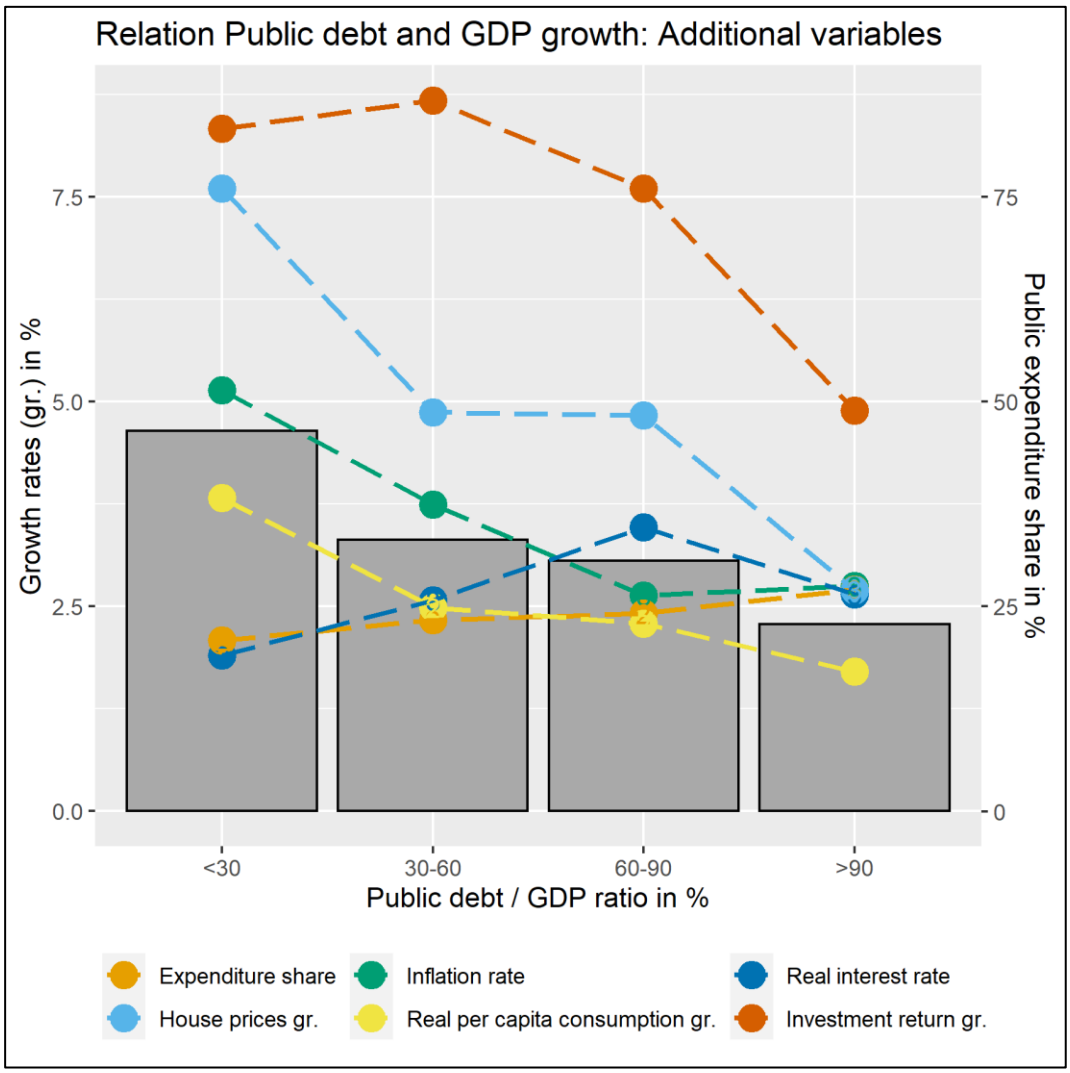

Figure 3: Comparison of additional variables. The grey bars depict the weighted average of countries' median real GDP growth rates (in percent) for respective public debt to GDP ratios. Data source: Jorà et al. (2017).

A high correlation can be seen in the real per capita consumption growth rate. In this non-aggregated variable, the reaction at the household level can be observed. Private consumption is higher in times with a lower public debt/GDP share. Since the data resemble a parallel shift of GDP growth rates, it could be assumed that they correlate only with GDP growth rates and not with the public debt ratio. The house prices growth rate follows a similar course, possibly for the same reasons.

3. Summary

To summarize, we have replicated the mistakes that Herndon et al. (2013) pointed out which led to revisions of both arithmetic and methodological nature. In addition, we have used a more consistent set of post-war data and found that difference matters for the real GDP growth response. Reinhart and Rogoff. We calculated inflation and real GDP growth rates as median and mean values in both equally and relatively weighted ways and found that the overall results do not speak a compelling language in either supporting or rejecting the original claims from Reinhart and Rogoff (2010). It is also unclear whether there is a specific public debt ratio that is associated with significant real GDP growth cuts, as the comparison between the two datasets from RR and Jordà et al. (2017) shows. When considering additional variables to investigate the interdependence of real GDP growth and public debt, market returns, house prices and real per capita consumption seem to be negatively affected by high debt

ratios and low GDP growth rates, while public expenditure share increases consequently with higher public debt shares. The inverse V-shaped real interest rate movement seems to indicate monetary policy behaviour by advanced economies central banks.

References

Herndon, Thomas, Michael Ash, and Robert Pollin. "Does High Public Debt Consistently Stifle Economic Growth? A Critique of Reinhart and Rogoff." *Political Economy Research Institute* Working Paper No." (2013).

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor. "Macrofinancial history and the new business cycle facts." *NBER macroeconomics annual* 31.1 (2017): 213-263.

Reinhart, Carmen M., and Kenneth S. Rogoff. "Growth in a Time of Debt." *American economic review* 100.2 (2010): 573-78.