Central Banks and Government Debt

Are central banks monetizing debt?

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Abstract

This paper aims to determine if central banks have been monetizing the government debt. That is the case if a higher government debt is associated with low short-term interest rate. The goal for central banks monetizing debt is to increase inflation, therefore decreasing the size of government debt. Three hypotheses are constructed. Firstly, higher government debt leads to lower short-term interest rates. Further developments are done with respect to the *euro zone* and the financial crisis. Fixed effects regressions are used to test the hypotheses. Results show no clear signs of central banks monetizing debt. The ECB had lower short-term interest rates when debt was over 90% of GDP after 2008, however it can be explained by a regime change in monetary policy and the increased hedge the euro zone has against consumption risk due to its' size. Specification of the non-linear relationship debt has with short-term interest rates makes results highly sensitive to specification of the regressions. More research is needed that tests more specifications and remove the effect monetary unions have on interest rates.

Keywords: government debt, short-term interest rate, monetary policy, monetizing debt.

Contents

1 Introduction

Central banks work independently towards the goal of stabilizing inflation and the real economy. They do this by adjusting the short-term interest rate, lowering it increases inflation, and increasing it decreases inflation. The other actor present in this essay is the government. Governments commonly have debt and it increases with deficits and decreases with surpluses. Managing government debt[1] can be done in three ways, taxes, austerity and inflation (Piketty, 2017, p. 701). Taxes and austerity are not of included in this essay, however inflation is.

Historically inflation has been used to decrease the real size of government debt. The hyperinflation in Germany after the First World War drastically decreased the size of debt (Dornbusch, 1996, p. 5). One has to ask if the inflation was created with the goal of decreasing the real size of debt, but it can possibly be seen as an attempt at monetizing the debt. Monetizing the debt can be defined as money growth exceeding the growth rate required to achieve policy objectives (Thornton, 1984, p. 41).

Turning to the modern development we can observe that government debt levels have increased whilst short-term interest rates have decreased[2] (Jordà, Schularick, & Taylor, 2017). Since central banks are assumed to independent of governments, this decrease of short-term interest rates should not be directly associated with the increasing size of government debt. However it causes the thought that this can be central banks' attempt at monetizing the debt and so forth decrease its' size. The former chairman of the ECB, Draghi, said in 2012 that the ECB was prepared to do *"Whatever it takes"* to save the euro zone from consequences of the financial crisis and the recession. This opened the possibility for quantitative easing, and with central banks being able to purchase of bonds and government bonds the opportunity to monetize debt became greater.

From this it can be asked if central banks are trying to monetize the debt. That is the question that I will be trying to answer in this thesis. The focus will be placed on the short-term interest rate and its' relationship with government debt. If high levels of debt

[1] Government and public debt are often refereed to as just debt in this thesis.
[2] As shown in Figure 1 and 2.

implies lower short-term interest rates it can be seen as an attempt at increasing inflation with the purpose of decreasing the size of debt, therefore monetizing the debt.

Three hypotheses are tested. Firstly, a wide approach will be taken when studying 18 advanced economies. Several regression are made to see if higher debt leads to lower short-term interest rates. Secondly, the fact that the data contains several countries part of the euro zone makes it possible to study the region more thoroughly. With the former chairman of the ECB, Draghi, opening up for greater flexibility for counteracting the recession it is possible that we can see some deviations from other economies included in the data. USA and Japan are also big economies in the data but they have no clear sign from their central banks that they will do *"Whatever it takes"*. Thus the use of euro is included in the regression models to see if there has been an attempt at monetizing debt in the euro zone.

One possible explanation on why the euro zone countries could be found having lower interest rates is that large economies have an increased hedge against consumption risk (Hassan, 2013). This makes large economies interest rates levels lower compared to smaller economies levels (Hassan, 2013). This effect is even more prominent for currency unions (Hassan, 2013). This could explain why the countries part of the euro zone have lower short-term interest rates. It can also be explained, and this is what is tested in the essay, if the debt is being monetized by the ECB in the euro zone countries.

Third and last, there has been a change in the development of government debt and short-term interest rates after the financial crisis in 2008[3]. After 2008 there seems to be shift in the monetary regime and in how central banks work. This can possibly explain the sharp decline in short-term interest rates and increase in government debt after 2008.

Inflation decreased after 2008 together with the recession and in accordance with the Taylor-rule the short-term interest rates are lowered in an attempt at increasing the price level (Taylor, 1993). With the recession the tax income for governments decreased with lower demand, and that caused a larger deficit. Another explanation for this decrease in short-term interest rates can be that it is an attempt at monetizing the debt. In-

[3]See Figure 1 and 2.

crease money growth, more than necessary for maintaining price stability, with the goal of causing inflation that decreases the size of government debt.

Government debt's relationship with macroeconomic indicators has been studied before. The relationship is often assumed to be non-linear. A study by Reinhart and Rogoff (2010a) studied debt and economic growth. They used a model where the debt did not have any effect on growth until it exceeded a certain threshold level of debt. Their threshold level was when debt exceeded 90% of GDP. The same approach was used when studying debt and short-term interest in Canada, and when debt exceed a threshold the changes in short-term interest rate from *Bank of Canada* in response to changes in inflation decreased (Mitra, 2007). The same threshold approach will be used in the model whilst testing the hypotheses, along side a quadratic approach of including government debt. This quadratic approach includes debt in such a way that when debt changes, the short-term interest rate changes directly. It is still a non-linear implementation and helps to show that the relationship between debt and short-term interest rates is non-linear.

The econometric approach chosen for testing for debt monetization are several regressions using fixed effects with dummy variables for government debt, use of euro and years after 2008. The data used is panel data from 1980 until 2020 from 18 advanced economies. The regression models with chosen variables suffer from heteroskedasticity and it has to be treated with robust standard errors.

Results from the regressions show results that is the opposite of what the two first hypothesis needed to be supported. Higher debt seems to lead to higher short-term interest rates. Including the euro gives no significant evidence of lower interest rates in the euro zone during the whole period. The third hypothesis is supported by the regression results. There is a significant decrease in short-term interest rates when debt exceeds 90% for countries part of the euro zone after 2008. If the reason for this decrease is caused by the high debt is not certain. One possible explanation is that the ECB has deviated towards fiscal policy instead of monetary policy. This transition is a risk taken by central banks when they are increasing their purchases of government bonds (Issing, 2012). The decrease in short-term interest rates can partly be motivated by the more

expansive monetary policy. There is a possibility that central banks are monetizing debt. To get better and more robust results more countries and currency unions are needed in the data used for the analysis.

The thesis is composed of different sections. In section 2 the different hypothesis and accompanying theories are presented. Section 3 contains a description of the different regressions models used for analysis. In the end if section 3 the data used is presented and discussed with descriptive statistics including graphs over development over time, and differences between included countries. The results are presented in section 4 together with a discussion concerning different problems with the results. Lastly, section 5 contains a short conclusion that summarizes results and present possible further developments of future research needed for more robust results.

2 Theory and hypotheses

The ECB and Swedish Riksbank have the same primary goal of maintaining price stability (Riksbanken, 2022; FEUF art. 127, 2012). Their goals are the same since Sweden is part of the EU, and that implies the following of the *Treat on European Union*. In article 105 it is said that central banks part of the *European System of Central Banks* should have the primary objective of maintaining price stability. The secondary goal for the Riksbank is the stabilization of production and unemployment at sustainable growth paths (Riksbanken, 2022). The inclusion of the secondary goal was done in November 2022 (SFS 2022:1568). Before the law change the goal was only to maintain a fixed monetary value (SFS 1988:1385), much like the single goal of the ECB. Other central banks are found to have similar goals to the ECB and the Riksbank. The Federal Reserve in the US has a dual mandate in which the two goals are maximum employment and stable prices (Federal Reserve Reform Act of 1977). Central banks often have the same main goal of maintaining price stability. Goals concerning areas of the real economy with unemployment and growth comes secondary to maintaining price stability (Piketty, 2017, p. 724).

Since central banks work with inflationary targeting, there are several ways to decide

the short-term interest rate that is the main instrument when working towards stabilizing inflation. One way of modelling an inflation target regime is to use the Taylor rule (Taylor, 1993). According to this rule the short-term interest rate is regulated with the following equation when having 2% as inflation target:

$$r = p + 0.5y + 0.5(p - 2) + 2 \tag{1}$$

where

$$r = federal\ funds\ rate$$
$$p = rate\ of\ inflation$$
$$y = percent\ deviation\ from\ trend\ GDP$$

The policy rule proposes an alternative to discretionary monetary policy, moving away from discussions over how to change the short-term interest rate to a concrete rule (Taylor, 1993). Taylor (1993) propose that a policy rule should not be followed mechanically, but that it could be a tool used by central banks.

Central banks operate in different ways, and those ways change. Maintaining price stability is the common goal, and the size of the government debt is not directly incorporated when central banks set the short-term interest rate.

However central banks are able to buy government bonds. The ECB are allowed to buy government debt even though it has to be bought indirectly through investors in the secondary market (FEUF art. 18.1). During the euro-crisis, the ECB did everything it could to save the euro as a currency. The previous president of the ECB, Draghi, said in 2012 that the central bank would do *"Whatever it takes"* to save the euro (Draghi, 2012). The financial crisis caused central banks to change in their way of achieving the goals. The ECB started buying government bonds, and so did the Swedish central bank too. Since 2015 the Riksbank have been buying an impactful amount of government bonds, with the goal of meeting the inflation goal of 2% (Riksbanken, 2020). The ability for central banks to buy government bonds gives them the ability to increase the monetary

supply and so forth increase inflationary pressure. What will be tested in this thesis is if price stability is the only goal or is it also an secondary goal where central banks attempt to monetize debt.

2.1 Hypothesis 1

Recently a development has been observed, increasing average size of government debt and a decreasing average short-term interest rate[4]. Reasons for this can be the that central banks are trying to monetize the debt through lowering short-term interest rates when debt levels are high with the goal of decreasing the size of debt through higher levels of inflation. This motivates the first hypothesis:

H1: larger government debt leads to lower short-term interest rates.

Reducing the size of government debt can be done in three ways, taxes, inflation and austerity (Piketty, 2017, p. 701). Taxes and austerity are not included in this essay, though inflation is. When inflation increases the real value of bonds, which have a nominal value, decreases (Piketty, 2017, p. 706). Piketty (2017) means that having an inflation level at 5%, not 2% as is the norm, the real public debt would be reduced by more than 15%, *ceteris paribus*. Germany financed the First World war with debt, however it disappeared when high inflation was present after the war (Dornbusch, 1996, p. 5). France also had high debts during the world wars, high inflation levels made the debt level low in the end of the period, making the burden of debt a small problem when reconstruction after the wars began (Piketty, 2017, p. 706).

Creating inflation with low short-term interest rates can be understood as the central banks are monetizing the debt. The definition of "monetizing the debt" is different depending on what literature is used. Andolfatto and Li (2013) explains it as permanent source of financing for government spending by money creation, in this case the purchases of government bonds. A wider definition is given by Thornton (1984, p. 41):

Specifically, it was pointed out that the phrase "monetizing the debt" means

[4]See Figure 2.

money growth excess of that required to achieve some policy objective that is induced by rapid growth in the federal debt.

With inflation and monetizing of the debt explained, not rejecting H1 would imply that a decrease in short-term interest rates when debt levels are high can be a sign of central banks monetizing government debt.

High and hyper-inflation are the not the only levels of inflation that can be used to decrease the public debt. Moderate inflation has been used in the US during the period 1948 to 1980. Interest rates on bond yields were kept low to increase debt liquidation (Dornbusch, 1996, p. 10). Dornbusch (1996) explains the methods as functioning whilst it was being done as sideshow. Effects of this monetary policy regime was a decrease in the debt to GDP ratio. The results from the policy stopped after public adapted to the current inflation regime in the end of 1970's (Dornbusch, 1996). The inflationary targeting regime that was adopted was caused by the stagflation in the 1970's. Central banks became independent, static, and with the main goal of maintaining price stability (Piketty, 2017, 723). This idea of moderate inflation to decrease the debt supports H1. If there would be a sideshow to decrease the size of debt present in modern monetary policy then we should see lower short-term interest rates when the debts are high.

Studies of monetary policy responses to changes in inflation, with respect taken to size of public debt have been done before. When the public debt was over a certain threshold of debt, in this case 50.2% relative to GDP, the short-term interest rate change as a response to inflation was 99% of the normal response (Mitra, 2007, p. 18). This threshold-effect was observed in Canada and it will be extended to a larger set of economies when testing H1.

2.2 Hypothesis 2

The wide approach in H1 is applied to all countries in the analysis. One special group of countries are of extra interest, countries using the euro as their currency. They have one common central bank, the ECB, and thus a common monetary policy. With this special group the second hypothesis is formulated:

H2: larger government debt leads to lower short-term interest rates in the euro zone.

Monetary unions, such as the EMU, have been found to lower real and nominal interest rates (Hassan, 2013). Hassan (2013) found that the size of the country, measured in real GDP, has a negative relationship with real and nominal interest rates. The negative relationship is motivated by size of the economy hedging against consumption risk, and consequently lowering the returns on assets (Hassan, 2013). He found this effect extra prominent when including the euro zone as one economy in his testing. This use of the euro zone will therefore be used in this hypotheses to test if there is any deviation in the euro zone from the other included economies.

If the hypothesis holds the ECB offers lower short-term interest rates when government debt levels are high. Possible explanations for this can be that the ECB has an increased hedge against different risks, making them able to offer lower short-term interest rates than smaller central banks. The euro zone then can be seen as a large economy and has the ability to offer lower interest rates as Hassan (2013) has found them to do. An alternative explanation is that the ECB is trying to monetize the debt.

Offering lower interest rates when the debt level are high will increase the inflationary pressure. If the ECB has a rate that is lower than is motivated to maintain price stability they can be assumed to be monetizing debt when following Thornton's (1984) definition of monetization of debt.

One could argue that the US could have been included in the same way as the euro zone has been in this hypothesis. It is a big economy and all states use the US dollar as their currency. The size of their public debt has also increased to higher levels after the financial crisis (Jordà, Schularick, & Taylor, 2017). However the analysis will be centered towards the euro zone and the ECB. In 2012 the chairman of the ECB, Draghi (2012), said that the ECB had to do *"Whatever it takes"* to counteract the consequences of the financial crisis. The financial crisis and its' effects are included in the next hypothesis. By studying the euro zone during the whole period we will later be able to conclude if the ECB has changed their approach after the financial crisis or not. Therefore we can

nuance the question whether the ECB has been monetizing the debt the whole period, or only after the financial crisis.

2.3 Hypothesis 3

The third and last hypothesis takes time in respect. Since the financial crisis in 2008 debt to GDP and short-term interest rates have deviated from their previous paths. This could be seen in Figure 2. Deficits have increased since the demand in the economy decreased and interest rates have been lowered in accordance with the Taylor rule to increase the inflation level. The ECB is also doing *"Whatever it takes"* and have started buying government bonds in an attempt at reaching its' inflation goals. The euro zone can be seen as a large economy and the ECB therefore has some influence over the interest rates provided in the area. However the US and Japan, also big economies, are also included in the data. The analysis will be narrowed down to the euro zone. Motivated by the ECB's statement that they will do *"Whatever it takes"*, therefore opening up to the possibility that they are monetizing the debt. Thus last hypotheses is:

> **H3:** larger government debt leads to lower short-term interest rates for countries using Euro after 2008.

If a decreased interest rate is found, one possible explanation is that rates are decreased with the purpose of decreasing the size of large government debts through monetization. An alternative explanation, together with the idea of lower interest rates in currency unions (Hassan, 2013), is that of a shift in the monetary policy regime for the ECB.

Historically, the role of central banks have been changing and monetary policy regimes have been replaced by different ones. Central banks have taken bigger and more active roles since World War 1 when the gold standard was still in use. After the Great Depression their role was extended to act as a "lender of last resort" with the goal of maintaining financial stability (Piketty, 2017, p. 711-712). Central bank independence and inflationary targeting was established in the end of the 1970's when stagflation was present (Piketty, 2017, p. 723). After the financial crisis in 2008 the idea of static central bank changed and the role of a central bank became more dynamic (Piketty, 2017, p. 723).

Independent central banks engage in monetary policy, but if they are monetizing the debt they have moved into fiscal policy and hence shares it with governments. After the financial crisis in 2008 central banks started buying large amounts of government bonds, going from a restrictive monetary policy to expansive (Goodfriend, 2012; Issing, 2012). These purchases are motivated by central banks by their deflationary hindering effects. When done in too great extent the central banks move from monetary to fiscal policy (Issing, 2012). If central banks are engaging in fiscal policy, they have entered politics, and their independence is at risk. Having entered into fiscal policy, might be an indicator of an attempt at monetizing debt since the possibility created with the increased instrumental freedom.

If the H3 is supported from the results, it could be evidence that there has been a shift in how the ECB engages in monetary policy. It might also be an indicator that the ECB has entered into fiscal policy. Their previous stance, keeping the inflation low being their main goal, might have been changed after 2008. This would support Piketty's idea that central banks roles changed after the financial crisis in 2008. But if that is the case it can only be said of the ECB and not role of central banks in general. If it is true for all central banks there should be no significant difference for the euro zone compared to other countries.

3 Empirics and method

The three hypotheses are tested with a two-way fixed effects panel data model. The data used contains annual observations covering 18 advanced economies between 1980 and 2020. The relationship between government debt and short-term interest rate is assumed to be non-linear. With the goal of trying to increase our understanding of this non-linearity two ways of modelling this relationship are tested.

Firstly, a quadratic model is specified. It implies that when the debt increases the short-term interest rate will be affected directly. If it increases or decreases depends on the level of debt. The second non-linear way of including debt is by using a threshold level. A threshold is a level of debt, that when exceeded debt is assumed to have an

impact on the short-term interest rate.

This approach is similar to the one used by Reinhart and Rogoff (2010a) who argued that when the debt exceeded a certain amount of debt, a threshold, the effect it had on growth jumped. The same threshold level used by Reinhart and Rogoff (2010a), debt exceeds 90% of GDP, will be used in the second model. An interpretation is that when the debt is below 90% of the size of GDP it has no effect on the short-term interest rate. But when it exceeds, the size of it is so large that the central banks in some way include it when setting the short-term interest rate.

3.1 Method

Four regression models are made for testing the three hypotheses. The dependent variable is short-term interest rate. Explanatory variables consist of a constant set of control variables, varying dummy variables including thresholds for government debt and one model containing quadratic and linear government debt. In equation (2) and (3) the specifications of the ordinary least squares regressions are found. The important difference between the models is the form of the non-linear relationship between debt and short-term interest rate. Firstly the quadratic model is presented:

Quadratic model

$$r_{it} = \alpha_i + \boldsymbol{\beta}_1 \boldsymbol{X}_{it} + \beta_2 debt_{it} + \beta_3 debt_{it}^2 + \delta_t + \epsilon_{it} \tag{2}$$

where

$$\boldsymbol{X}_{it} = \left\{ \begin{array}{c} x_{Inflation_{it}} \\ x_{GDP-gap_{it}} \\ x_{Logarithm\ of\ exchange\ rate_{it}} \\ x_{Lagged\ short-term\ interest\ rate_{it}} \\ x_{Unemployment_{it}} \end{array} \right\}$$

Short-term interest rate, r_{it}, is the dependent variable. The different control variables included are denoted by $\boldsymbol{X}_{it}$. The control variables are inflation, GDP-gap, natural logarithm of exchange rate (*local currency/USD*), one year lagged short-term interest rate and unemployment rate. The remaining explanatory variables are linear debt ,$debt_{it}$, and quadratic debt ,$debt_{it}^2$, these are of interest with respect to the hypothesis 1. Time and use of euro is not included in the quadratic model so we can not use results from this model with respect to hypothesis two and three.

H1 is supported when the marginal change in short-term interest rate is negative for higher levels of debt. When that is the case, an increase in government debt leads to lower short-term interest rates. The two-way fixed effects error terms are α_i for country specific effects, and δ_t for year specific effects.

Threshold model

$$r_{it} = \alpha_i + \boldsymbol{\beta X}_{it} + \boldsymbol{\theta Z}_{it} + \delta_t + \epsilon_{it} \tag{3}$$

where

$$\boldsymbol{Z}_{it} = \left\{ \begin{array}{c} z_{Debt\ over\ 90\%_{it}} \\ z_{Euro\ after\ 2008_{it}} \\ z_{Euro\ and\ debt\ over\ 90\%_{it}} \\ z_{Debt\ over\ 90\%\ after\ 2008_{it}} \\ z_{Debt\ over\ 90\%\ after\ 2008\ and\ euro_{it}} \end{array} \right\}$$

Similarly to the quadratic model in equation (2), the threshold model in equation (3) contains the same control variables, denoted by $\boldsymbol{X}_{it}$. It also shares the same dependent variable and error terms. It does not have the quadratic and linear implementation of debt which is the important difference. Instead several dummy variables are used. $\boldsymbol{Z}_{it}$ contains the five dummy variables. The dummy variables are the threshold with debt exceeding 90% of GPD, use of euro after 2008, use of euro and debt over 90% of GDP,

debt over 90% of GDP after 2008 and lastly use of euro after 2008 with a debt larger than 90% of GDP. The dummy variables either have the value 1 when conditions are fulfilled or 0 when they are not.

By using several control variables that are assumed to determine the interest rate, the model can be used to study inference by adding government debt in different ways. The control variables, $\boldsymbol{X}_{it}$, are used to explain the movement of the dependent variable as assumed from theory and goals from central banks and the Taylor-rule. The dummy variable for debt larger than 90% is the first variable of interest in equation (3). It is denoted by $\theta_{Debt\ over\ 90\%}$. If hypothesis 1 holds this coefficient should be negative, showing lower short-term interest rates when government debt exceeds 90% of GDP. Hypothesis 2 incorporates the euro. The variable of interest is the interaction term between dummy variables for debt over 90% and using euro, $\theta_{Euro\ and\ debt\ over\ 90\%}$. When hypothesis 2 holds this is negative. $\theta_{Debt\ over\ 90\%\ after\ 2008\ and\ euro}$ is the last coefficient of interest with regards to hypothesis 3. If the coefficient is significantly negative, then larger government debt leads to lower short-term interest rates for countries using Euro after 2008.

Choosing to include debt in the model with the threshold approach is motivated by previous research done by Reinhart and Rogoff (2010a). They argued that when debt exceed 90% of GDP, growth declines. Their approach was simple and easy to understand[5]. However, it was criticized for being too simple and they answered the critique themselves with a following study (Reinhart & Rogoff, 2010b). Égert (2014) was one who critiqued their approach. He argued the model was very sensitive to modeling choices, and tested it by trying different and more complex threshold models. Even with the critique, the threshold approach is still being used, and will be used to answer the different hypotheses. The level of 90% debt to GDP will be used as the threshold.

The observations are from the period 1980-2020. During this period modern inflationary targeting started becoming common and floating exchange rates have been used. Under these assumptions, a common macroeconomic idea is that short-term interest rates are an effective way to manage inflation.

[5]One part of their approach is replicated for debt and short-term interest rate in Figure 4.

The data used when working with these models is panel data. In this study the two way fixed effects model has been used. We cannot assume that the dependent variable is exogenous, and that makes the OLS estimator inconsistent and biased. Therefore a fixed effects estimator is used. A two way error term is used, both fixed effects for the individual countries and the individual years. The four models are tested for heteroskedasticity and serial correlation. If these problems exist, robust standard errors have to be used. The coefficients are still consistent if these problems are present but the standard errors will be biased (Baltagi, 2021b). Testing for heteroskedasticity is done with the Breusch-Pagan test, for serial correlation the Breusch-Godfrey test and for stationarity the augmented Dickey–Fuller test[6].

3.2 Data and descriptive statistics

Data is collected from the *Macrohistory Database* (Jordà, Schularick, & Taylor, 2017). It contains annual observations of several macroeconomic indicators for 18 advanced economies[7]. The data set is wast and only a small fraction of the variables will be used in the analysis. It contains the dependent and control variables that are included in the regressions. Calculating inflation was done with consumer price index, having $CPI = 100$ in 1990. Real GDP, also in 1990:s price level, was used to calculate the GDP-gap. The cyclical component of the real GDP was removed using the Hodrick-Prescott filter[8].

Between 1980-2020 some form of currency collaboration has been present in the European Union. First the *European Currency Union*, ECU, where the currencies were fixed against each other, and from 1991, the *European Monetary Union* (EMU) with the euro zone (Eurostat, 2016).

Another motivation for the chosen time frame is the shift towards independent central banks in the end of the seventies (Piketty, 2017, p. 723). Central banks were faced with stagflation and consequently their independence was increased to counteract this development (Piketty, 2017, p. 723). In Figure 1 and 2 development between years 1980-

[6] All tests and models are done in R version 4.2.2, mostly using the `plm` package

[7] Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK and USA.

[8] Excel add-in *=hp_filter()* was used (Annen, n.d.).

2020 of government debt, short-term interest rate and inflation can be found.

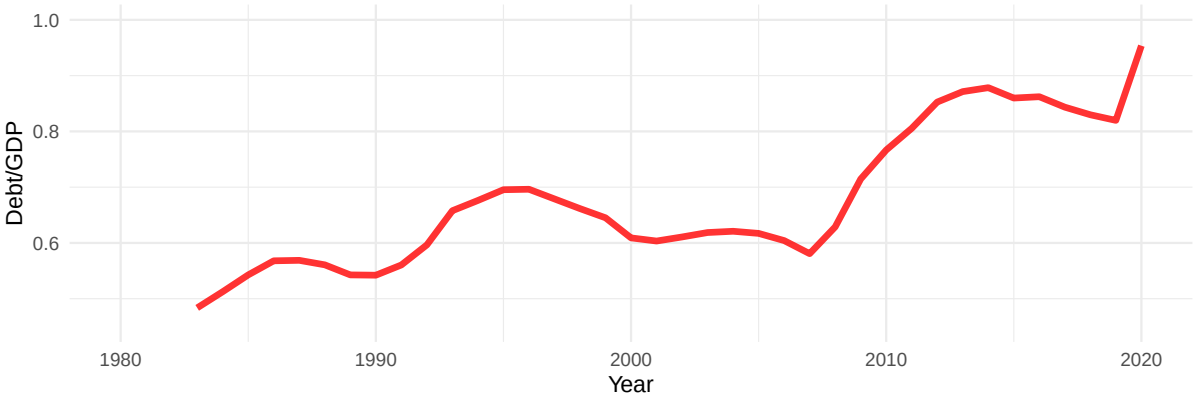

Figure 1: Yearly average of debt to GDP

Figure 1 contains the annual average of government debt to GDP. The average is calculated from all the 18 economies. Government debt has increased over the period as a whole, with exception for the decrease in the period between 1995-2007. It moves sharply together with economical crises and the two most prominent ones are the financial crisis in 2008 and the Covid-19 pandemic in 2019.

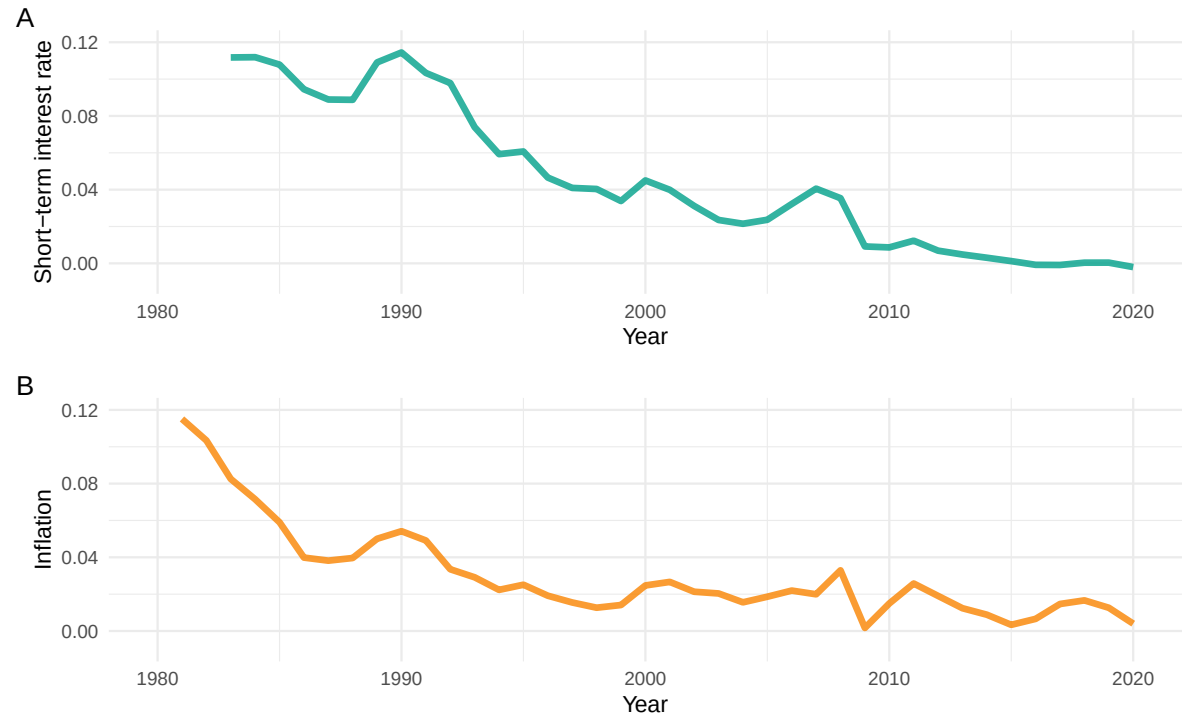

Figure 2: Annual average of A) short-term interest rate and B) inflation

The development of annual averages of short-term interest rates and inflation are illustrated in Figure 2. We have an increased average size of debt and decreased average short-term interest rates. This trend is in accordance with H1 and partly motivates the hypotheses. The low inflation rate in 2020 started to be maintained in the early nineties. The decreased inflation moves very similarly to the development of the short-term interest rate, which is to be expected from economic theory, since they are positively correlated.

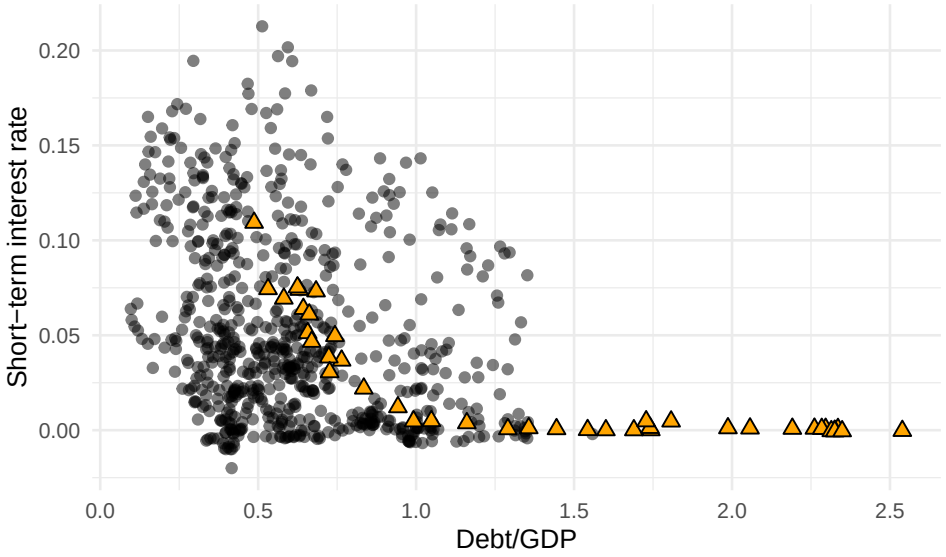

Figure 3: Short-term interest rate and debt to GDP with Japan marked with orange

Among the economies in the data there is an outlier. Japan has a higher debt level than all other economies and lower short-term interest rates. Japans development of these two variables are diverging from the other economies. In Figure 3 the debt to GDP level and short-term interest rates for the 18 nations are shown. It can be observed that Japan, marked with orange triangles, is far south-east in the figure, deviating from the other countries marked with black points.

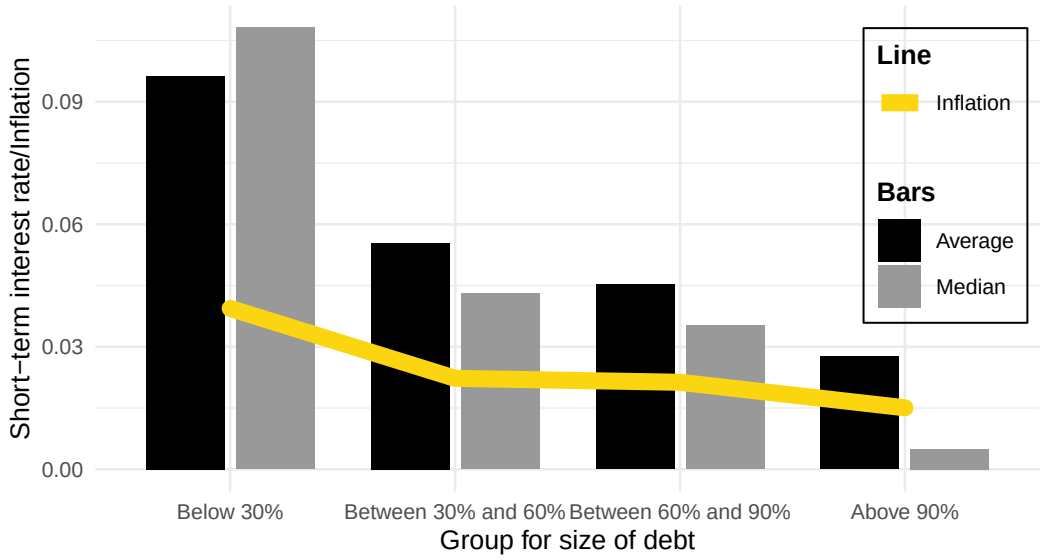

Figure 4: Short-term interest rate, debt to GDP and inflation

By grouping the observations by size of government debt, an analysis can be made similar to the one made by Reinhart and Rogoff (2010a, p. 8). Their analysis was criticized for being too simple. Figure 4 partly replicates their approach to seeing if government debt decreases growth. Figure 4 show the average and median short-term interest rate, and the median inflation for four different groups. The groupings are done based on the size of debt[9]. These are only descriptive statistics and econometric results of the analysis are presented in section 4. Regardless, in the figure a clear decrease in short-term interest rate is present when the size of government debt increases. Inflation decreases with increasing size of debt. There seems to be no increase in inflation that can be explained by lower short-term interest rates in the figure. The figure is to simple for advanced analysis, however it explains why the hypotheses are proposed, and that historically, when debt has been high the short-term interest rates have been low.

Table 1: Regressions

	Dependent variable:			
	Short-term interest rate			
	(1)	(2)	(3)	(4)
Inflation	0.265***	0.265***	0.263***	0.263***
	(0.025)	(0.024)	(0.023)	(0.023)
GDP-gap	0.799**	0.820**	0.824**	0.800**
	(0.361)	(0.363)	(0.371)	(0.376)
Log of exchange rate	−0.011*	−0.012**	−0.012*	−0.012*
	(0.007)	(0.006)	(0.006)	(0.006)
Lagged short-term interest rate	0.601***	0.611***	0.610***	0.602***
	(0.036)	(0.033)	(0.033)	(0.035)
Unemployment	−0.004	−0.003	−0.002	−0.002
	(0.026)	(0.024)	(0.024)	(0.025)
Debt/GDP	−0.002			
	(0.004)			
$(Debt/GDP)^2$	0.003**			
	(0.001)			
(D)Debt over 0.9		0.003***	0.004***	−0.00003
		(0.001)	(0.001)	(0.002)
(D)Euro (D)after 2008				−0.0002
				(0.002)
(D)Euro and (D)debt over 0.9			−0.002	0.003
			(0.001)	(0.002)
(D)Debt over 0.9 (D)after 2008				0.006
				(0.004)
(D)Debt over 0.9 (D)after 2008 (D)Euro				−0.007*
				(0.004)
Observations	718	718	718	718
R^2	0.683	0.681	0.681	0.682
Adjusted R^2	0.652	0.650	0.650	0.650

Note: *p<0.1; **p<0.05; ***p<0.01
White's robust standard errors
Table template from Hlavac (2022).

4 Results and discussion

4.1 Results

The results from the four regressions are presented in Table 1. Each regression has one column and the explanatory variables included in each regression are the ones which have regression coefficients and standard errors are available. Short-term interest rate is the dependent variable. Inflation, GDP-gap, natural logarithm of exchange rate, one year lagged short-term interest rate and unemployment are the control variables, they are used in all regressions. The variables that are dummy variables are denoted with *(D)* in the table.

The data is in decimal form for all control variables except the exchange rate. An interpretation of the decimal form coefficients is that when there is a percentage unit increase in an explanatory variable, the short-term interest rate changes with the coefficients value. For example, the inflation increases with one percentage unit, the short-term interest rate increases with 0.265 percentage units ($0.265 \cdot 1 = 0.265$).

Testing for heteroskedasticity was done with the Breusch-Pagan test and it was found in all models. Therefore White standard errors are used since they are heteroskedastic-consistent (Baltagi, 2021a). Serial correlation is not found and it has been controlled for with the Breusch–Godfrey test. All variables used are stationary, testing was done with an augmented Dickey–Fuller unit-root test.

Regression coefficients for control variables in regressions (1-4) are as expected from how short-term interest rates are used in macroeconomic theory and from central banks goals. For example, when the GDP-gap increases, the interest rate is increased to lower inflationary pressure. Similarly the inflation coefficient is positive, meaning increased interest rates when inflation increases. Significance levels are high, inflation and GDP-gap have p-values below 0.01. Exchange rate is significant at the 0.10 level and in regression (2) significant to the 0.05 degree. The only insignificant control variable is the unemployment rate. It does not seem to be taken into account when central banks change the short-term

[9]Government debt size below 30%, between 30% and 60%, between 60% and 90% and above 90%.

interest rate. This is expected since a large part of the observations are from countries part of the euro zone, and with a common monetary policy goal from ECB. Their goal of managing inflation was absolute above all other goals, such as working with employment levels. Adding last years short-terms interest rate as a lagged variable creates a model with a much higher R^2 value, and its coefficient is highly significant. It can be assumed that central banks start from the previous interest rate level when they decide on the new one.

First the quadratic model is tested. Debt and short-term interest rate are not assumed to have linear relationship, thus a quadratic regression model is specified along with regressions using thresholds to include government debt. In regression (1) the government debt is included with a linear debt to GDP variable and one that is quadratic. Coefficients for control variables are similar to the ones in the other regressions, no significant differences. The linear debt variables is not significantly different from zero, however the quadratic one is, at the 5% level. It is positive with a value of 0.003. The marginal increase in short-term interest rates is positive when the size of debt exceeds 1/3 of GDP. When the debt is smaller increasing it would lead to a lower interest rate, according to the coefficients for government debt in regression (1). The R^2 and adjusted R^2 values for regression (1) are marginally higher than the other regression, it has the best fit to the data.

The assumption of debt having a non-linear relation with short-term interest rate is not questioned, but the form of it can be. No support is found for the hypotheses since at high levels of debt the short-term interest rates decreases based on the results from regression (1).

Regression (2) contains control variables and one dummy variable for government debt over 90%. It tests hypothesis 1, larger government debt leads to lower short-term interest rate. The results are not supporting H1. The coefficient is significant and positive, with a p-value lower than 0.01. An interpretation of the coefficient is that when the debt exceeds 90% of GDP, the short-term interest rate is 0.3% higher than when debt is below 90%. This is the opposite of H1.

A possible explanation to the increase is that a larger amount of debt brings risk for default. A country with large debt can be assumed to be at a larger risk of defaulting on the debt. With the increased risk, the lender has to be compensated for this risk, thus a higher interest rate. One other reason can be that the high debt level is self-sustaining. A high interest rate level causes the debt to grow, and the debt is maintained at a high level caused by high interest rates. In this case the relation between debt and interest rate is reversed, interest rates cause an increase in debt. Regression (2) is the simplest regression and no respect to being part of the euro zone and time has been taken.

In regression (3) the setup is similar regression (2) but with one extra dummy variable, use of euro as currency. Coefficients change slightly from regression(2), and the added coefficient for debt and euro is not significantly different from zero. The debt over 90% coefficient increases to 0.004 and is still significant. The interaction term between debt over 90% and euro is negative, indicating that euro countries could have a lower interest rate when high debts are present but not at a significant level. Nothing can be concluded with regards to the second hypothesis from regression (3).

The monetary unions ability to offer lower interest rates presented by Hassan (2013) is not to be found in the results from the regression. One reason why a decrease is not observed is that the data used contains observations from only 18 countries, and nine of them are part of euro zone. If more countries not using the euro were included, the effect the currency union has on the short-term interest rate could possibly have been observed. Explanatory power is similar in regression (2) and (3), having the same R^2 and adjusted R^2 values, 0.681 and 0.650 respectively.

The fourth regression contains not only debt and euro, but also a dummy variable for time. As seen in Figure 2 there is a shift in policy action after the financial crisis in 2008. Central banks started buying government bonds and there was an overall shift in central bank policies (Goodfriend, 2012; Issing, 2012). Firstly, the control variables are marginally changed but no significance levels have changed with exception from the coefficient for exchange rate. It has dropped in significance in regression (3) and (4), compared to (2). Three more interaction terms are added in regression (4). Firstly one

for observations with euro after 2008. Secondly, observations with debt over 90% after 2008, and lastly use of euro with debt over 90% after 2008.

The inclusion of these variables creates a deviation from results previously found in regression (2) and (3). Having a government debt larger than 90% is not significant anymore, and there seems to be no explanatory power in studying the government debt alone when trying to determine short-term interest rate. No regression coefficients for dummy variables are significant, except for final coefficient. When the debt exceeds 90% of GDP, the year is after 2008 and the country is using euro, there is significance at the 10% level. The coefficient is negative with a value of -0.007. This means that when these criteria are observed for an observation in the data, the short-term interest rate is 0.7% lower. The result supports the third hypothesis, larger government debt leads to lower short-term interest rates for countries using Euro after 2008.

Hypothesis 3 holds, given presented results but it can also be explained by other causes. The idea from Hassan (2013) that monetary unions can offer lower interest rates due to increased hedge against consumption risk is one alternative reason. Another is the aftermath of the financial crisis. The euro zone was in a recession and the low interest rates were used, in accordance with the Taylor-rule, to increase the inflation. Governments had increased deficits caused by lower demand leading to lower tax-income. This finding is limited to the euro-countries and it shows that the ECB has a unified monetary policy in the euro zone.

4.2 Discussion

When summarizing the results it can be concluded that no support for the first two hypotheses is found. High debt levels do not decrease the short-term interest rates, it instead increase them.

This can be explained by looking at central banks goal, which is to achieve price stability. An increase of government debt is caused by a deficit from the government. This deficit can be caused by increased spending. When a government increases spending the money supply increases and inflationary pressure increases. Central banks therefore

have to counteract this by increasing the short-term interest rate in accordance with the Taylor-rule. This is later questioned with regards to hypothesis 3 and the euro after 2008.

Central banks have not lowered short-term interest rates in purpose of decreasing debt, or has at least not succeeded in decreasing debt by lowering short-term interest rates in the current time frame. Since there has been no increase in inflation that can lower the size of debt. Monetary policy has developed and the inflationary targeting regime is still in use. Central banks can be seen as transparent with their goals of managing inflation and are found to work towards achieving them. Comments about their performance are not included in this thesis.

From the quadratic regression (1) the same results in opposite of H1 are found again. When debt increases, the short-term interest rate increases. The quadratic model's increased quality of fit gives some idea on how future research should be done. The assumption of non-linearity is correct, but more forms of relationships need to be tested.

The results are more nuanced whilst testing the last two hypotheses. The theory of larger countries having lower interest rate levels and currency areas having even lower (Hassan, 2013) can be observed in regression (4). Countries in the euro zone having high debt are found having lower short-term interest rates after 2008 compared to other countries in the data. The currency unions effect on lowering interest rates is a possible explanation of the results. The idea that the lowering of interest rates, in this case is created with the goal of increasing inflation with the purpose of decreasing the size of debt, is not plausible since there has been no increase in inflation that decreases the size of debt.

The possibility that the decrease of short-term interest rate for euro-countries after 2008 is observed can be explained by the euro zone's increased ability hedge against consumption risk, thus having a lower interest rate level. To exclude this effect from the one debt has on short-term interest rate one would need data spanning more countries and regions, preferably several currency zones too. A development of this study would including the effect of currency zones decrease of interest rates, making it possible to determine the debts effect on short-term interest rate with the effect from currency unions

already included in the model.

A different explanation for the lower interest rates in the euro zone after 2008 when debt was high can be the change in the monetary policy regime. A change happened after the financial crisis and can have lead to the debt being included in the setting of the short-term interest rate. The lower interest rates can an attempt to increase the money supply, increasing inflation and decreasing the real size of debt. If the decrease of short-term interest rates are used with the goal of higher inflation, it has failed during the period between 2008 and 2020. Inflation rates have remained low for the whole period, as seen in Figure 2. No decrease in government debt in that period is caused by the ECB monetizing the debt.

The move from monetary policy to fiscal policy is supported by regression (4). These lower interest rates are part of expansive monetary policy and the ECB has also been buying government bonds. This is part of the regime change and a step towards fiscal policy. There is increased interaction between governments and the ECB and thus a decrease in independence.

Results from this expansive monetary policy during the period is in conflict with what would be seen if the ECB has been monetizing the debt. Then inflation should be higher, assuming central banks can achieve it with their policy instruments. The government debt should also have decreased. Thus, there are no clear signs that ECB has been monetizing the debt.

As summary we see that the two first hypotheses, H1 and H2, can not be confirmed. The third hypothesis, H3, is not rejected. Euro-countries have had a lower interest rate when debt exceeds 90%. Problems such as a narrow set of countries should be taken into account. A broader data set including more countries, not only advanced economies, and currency unions would increase the quality and robustness of the results. From this study one can conclude that there seems to be a relationship between debt level and short-term interest rate. It is most likely non-linear, since the non-linear models in regression (1) and (4) performs well.

5 Conclusion

An increase in government debt and a decrease of short-term interest rates has been observed. When the panel data covering 18 countries between 1980 and 2020 is grouped by the size of debt and means and medians are presented for each group there is a clear decease in short-term interest rates when the debt increases[10]. The question asked in this essay is if the increased government debt has caused, or is related with, the decrease of short-term interest rates. Central banks engaging in monetary policy action with the goal of creating inflation has been used to decrease the size of government debt before in Germany and the US for example (Dornbusch, 1996). Inflation is one of the possible ways to decrease the size of government debt (Piketty, 2017). If the increase in money supply is larger than money growth motivated by the goal is stabilizing price growth, it can be assumed that the debt is being monetized (Thornton, 1984).

Two-way fixed effects regression models are used to study the inference and see how government debt impacts short-term interest rates. A non-linear threshold method is used. It is a popular approach in macroeconomic research when working with government debt. A threshold level of 90% of GDP is used, similar to Reinhart and Rogoff's study of debt and growth (2010a). Thus debt is assumed to have no effect on shirt-term interest rate until it exceeds 90% of GDP. Results from the regressions show the opposite of hypotheses one and two. There is an increase in short-term interest rate when the size of government debt exceeds 90% of GDP. So far no conclusions can be made that a lower interest rate level is used with the purpose of decreasing size of government debt through monetization.

With the analysis using more developed regression models including dummy variables for time and use of euro support of hypothesis 3 is found. After 2008 countries using the euro are found to have lower short-term interest rates when the government debt exceeds 90% of GDP.

This decrease in short-term interest rate could be caused by high government debt but other explanations have to be taken into account. One alternative theory on why a lower interest rate is observed is that currency unions offer a lower interest rate level.

[10]See Figure 4.

This lower level is explained by their increased hedge against consumption risk (Hassan, 2013). The idea that lower interest rates are used with the aim of decreasing size of debt is not supported by the results from this analysis. There has not been a sideshow were interest rates are kept low in purpose of lowering size of the debt by causing inflation.

The ECB have deviated towards fiscal policy and the lower interest rate after 2008 from hypothesis 3 can be a sign of that. The debt has not been monetized, but there has been a change in how the ECB acts when trying to managed inflation. Their way is less restrictive and has moved towards a more expansive monetary policy after 2008, and the distinction between monetary and fiscal policy is decreasing.

There are problems in the analysis. Firstly, the data covers only 18 advanced economies. More countries and currency unions should be included for more variation in the data. If more currency unions are included, the negative effect the currency union has on interest rates can be separated from the debts effect on short-term interest rates. Different specifications of the non-linear modeling of government debt also have to be developed. The quadratic model, regression (4), has the best fit. One alternative to construct a better threshold-model is the technical method of testing for best threshold level, or levels, for each included country. This approach was tested Ègert (2014). He tested several different threshold models that had been used in studying debts impact on economic growth. He found that threshold models are highly sensitive to specification choices. More research is needed with bigger data sets and other non-linear modeling specifications. Another extension of research to find support for the hypotheses is to include quantitative easing in the models.

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