Rising Interest Rates and Government Debt Dynamics in the United States

by

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Abstract

The public debt to GDP ratio of the federal government of the United States is at a level not seen since the end of the Second World War. After a significant improvement in the government's fiscal balances following the Great Recession, the fiscal position started to deteriorate again, even as the economic output is above its potential level, and major social programs of the federal government are running towards insolvency. Interest rates have also started to rise increasing financing cost of government debt in the future. The goal of this paper to analyze how different fiscal policy decisions and interest rate trajectories effect public debt outcomes in the time period of the next 14 years. We also explore how a possible recession would impact the debt level. For these calculations we use a model which decomposes changes in the public debt to GDP ratio into four factors: real GDP growth, inflation, nominal interest rate, primary balance, and captures their interactions. In our analysis we confirm the findings of the Congressional Budget Office that US federal government debt is on an unsustainable path. We also concluded that contrary to our expectations changes in the average real short-term equilibrium interest rate in the time horizon of our analysis has no major impact on government debt. Furthermore, we find that a recession can lead to a larger public debt overhang for a longer period despite the government best efforts to reduce it. In our key fiscal policy recommendation suggest the federal government to start a fiscal consolidation program as soon as possible, reversing the effect of previous pro-cyclical measures to gain fiscal space preparing for a possible economic downturn.

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List of Abbreviations

CBO – Congressional Budget Office

CRFB – Committee for a Responsible Federal Budget

Fed – Federal Reserve

GFSM2001 – Government Finance Statistics Manual 2001

OMB – Office of Management and Budget

Introduction

Ten years past since the outbreak of the economic crisis in 2008 and the United States is currently in the second longest economic expansion period of its history. Despite the favorable economic environment, the debt to GDP ratio of the US federal government is at a level not seen since the end of the Second World War. Although there was a significant improvement of primary fiscal balances following the Great Recession government debt to GDP ratio did not decrease. In recent years fiscal policy started to take a worrying turn: fiscal stance loosened, even as several major trust funds of federal programs are heading towards insolvency. At the same time, interest rates have started to rise. Although it has been most pronounced in the US with the base rate hikes of a Federal Reserve, this phenomenon has factors which go beyond the United States and have their roots in global socio-economic trends. The goal of this paper is to analyze potential public debt outcomes in case of different policy decisions and interest rate trajectories in a period until the year 2032. We also examine how public debt would change in case of a recession.

Considering the significance of the problem – unsustainable fiscal policy in the largest economy of the world – there are no shortage of papers and reports which have public debt sustainability in the United States as their focus. One major source of these studies is the Congressional Budget Office. It is a US federal agency within the legislative branch of the government to provide lawmakers with information about the budget and fiscal issues. The CBO regularly produces reports about budget proposals as well as long term sustainability. In their paper titled "The Budget and Economic Outlook: 2018 to 2028", they concluded that under the current law, the federal budget is on an unsustainable path. Fiscal deficits will increase in the coming decade as revenues will not be able to keep up with rising expenditures, predicting a near 100% debt to GDP ratio by the end of the period. Another relevant paper was published by the CBO in 2018, which looked at alternative fiscal scenarios and their impact on public debt. They made projections until 2038, and concluded that if revenues are not increased as percentage of GDP, public debt can reach as high as 165% of the GDP by that year. Elmendorf-Sheiner also published a paper in 2017 about possible public debt trajectories. They focused on the implications of aging population and interest rates. In their calculations they assumed budget expenses on social security and Medicare would increase significantly as the share of Americans over 65 increases. They also assumed interest rates would remain well below their historical average. Their paper concludes: despite low interest rate costs, public debt will continue to rise unsustainably in the coming decades.

Despite the large volume of literature all pointing towards the same direction: the unsustainability of fiscal policy and rising government debt, we still believe we make a real contribution to the discussion. Unlike many other papers, we introduce different scenarios not only for fiscal policy decisions but also for interest rate trajectories. We also consider the possibility of a recession, and analyze how it would effect a potential fiscal consolidation program.

The structure of this paper is the following. In Chapter 1 we will explore interest rate dynamics. We establish some key, stylized facts about interest rate dynamics in the past, then look at what factors might have contributed to these interest rate changes. We also consider how the impact of some of these factors might change in the future leading to a rise in interest rates. In Chapter 2 we show how budgetary trends changed in the United States in the past and also look at public debt dynamics. As part of this chapter we also look at recent changes in fiscal policy and take a brief look at potential fiscal trends in the future. Chapter 3 describes our model. It is built around the decomposition of public debt changes to four components: real GDP growth, inflation, nominal interest rate, and primary deficit. The model further explains the dynamics behind each of these factors and captures their interactions. In Chapter 4, we explain the results of our analysis. We set up different scenarios an analyze the resulting differences in public debt to GDP trajectories, as well as interesting dynamics revealed by other key variables. Finally, we end the paper with our concluding remarks, and policy recommendations.

Chapter 1 – Is the End of Low Interest Rates Coming?

In this chapter we take an in-depth look at interest rate dynamics in past, untangling effect of the different factors which led to record-low interest rates during the crisis. We also make a projection on how these factors would change in the future and what that implies for interest rates trajectories. This chapter contains our key assumptions about the potential behavior of the equilibrium interest rate in the coming years. We find that there will likely be a modest but significant increase in the equilibrium real interest rate, although it will still remain below the historical average.

First, we describe some stylized facts about interest rate dynamics in the past, then identify the key factors why interest rates have fallen, and finally we explore how underlying change in these factors will likely affect interest rates in the future.

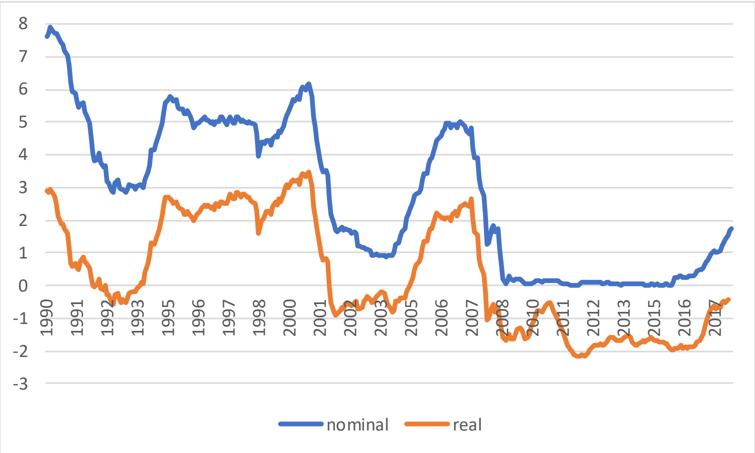
1.1 Stylized Facts About Interest Rate Dynamics in the Past

In the aftermath of the 2008 crisis interest rates have fallen to record-low levels worldwide and remained there as recovery appeared to be sluggish. Major central banks cut interest rates to keep inflation in the positive territory, and they quickly reached the zero-lower-bound: the limit of effective conventional monetary policy, the zero base rate. But with the specter of deflation still looming on the horizon, monetary authorities decided to engage in quantitative easing programs; buying government (and also private) securities to push inflation higher, while allowing real interest rates to fall even further.

Figure 1 illustrates the real[1] and nominal annual interest rate on 3-month Treasury Bills. As we can see, following the decline in interest rates in the early 1990s, there were three spikes in both

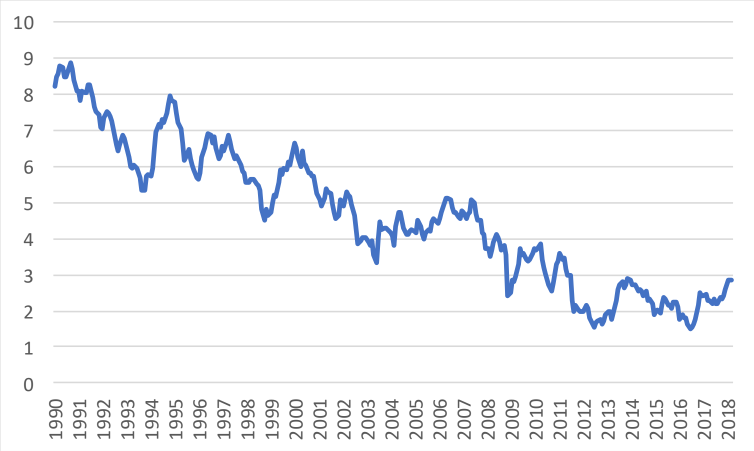
[1] to calculate the 3-month real interest rate we used the 3-month rolling core inflation rate three months ahead, in other words: the average inflation rate until the bond matures

nominal and real rates. The first one (1994-1995) corresponds a gradual 300 basis point of increase in the base rate by the Fed, the second (1999-2000) is the dotcom-bubble, while the third (2004-2006) is the period prior to the financial crisis of 2008. Note how nominal rates reached the zero lower bound by 2009 but in 2011-2012 there was an additional drop in the real rate, due to the quantitative easing program of the Federal Reserve. We can also see how there was an increase in the real and nominal rates just recently.



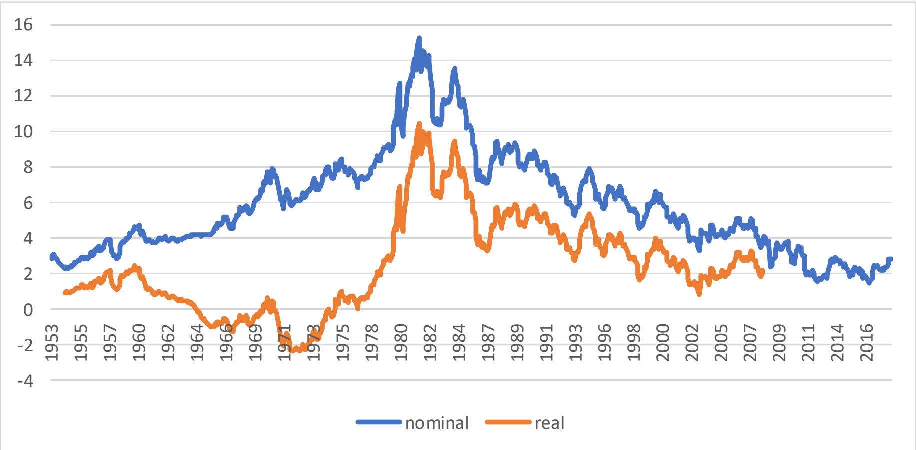
1. Figure: Nominal and real interest rate on 3-month Treasury Bill
(Source: Federal Reserve Bank of St. Louis)

However – as illustrated by Figure 2 – if we look at long yields we can see a clear downward trend all throughout the period and the effect of the Great Recession appears to be a relatively small downward shift. It is clear, there were other factors at play causing interest rates to fall, which are not related to the crisis.



2. Figure: 10-year US government bond yield
(Source: Federal Reserve Bank of St. Louis)

Looking at longer historical data reveals more. As Figure 3 shows, both nominal and real[2] long-term interest rates started to decline from the 1980s, and the persistently low yields in the aftermath of the crisis are unprecedented. (Real yields are calculated using the average inflation rate of the next 10 years, this is why the real yield series ends in 2008)



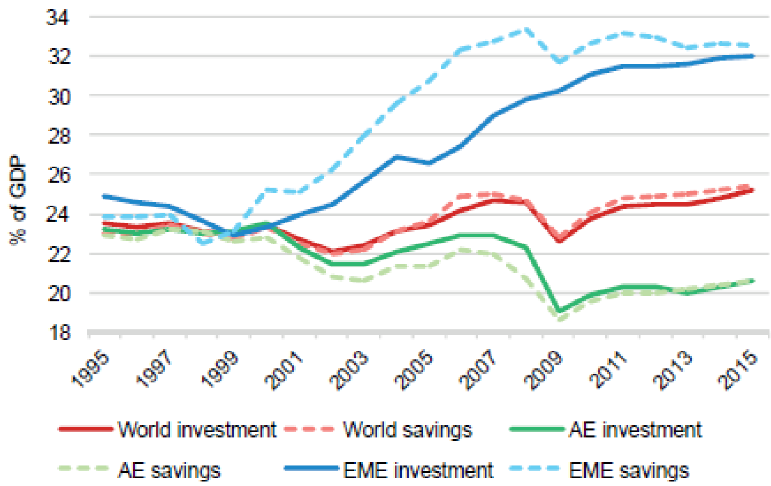
3. Figure: Nominal and real 10-year US government bond yields
(Source: Federal Reserve Bank of St. Louis)

We can also decompose movements in long-term interest rates to the effect of changing inflation expectations and the changes in the real long-term natural interest rate (Bean et al.

[2] to calculate the 10-year real interest rate we used the 10-year rolling headline inflation rate 10 years ahead, in other words: the average inflation rate until the bond matures. This also assumes perfectly accurate inflation expectations.

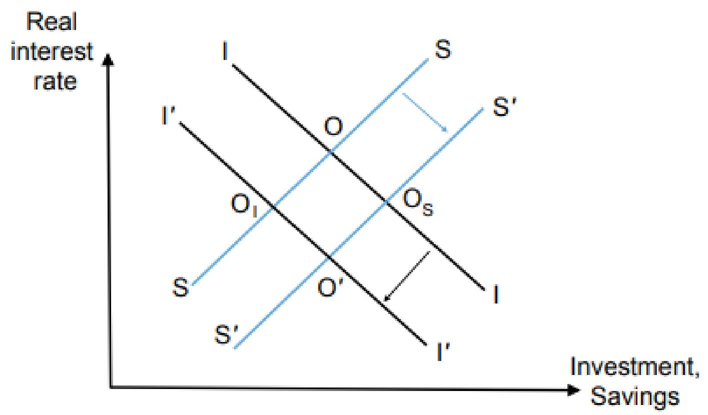
2015). The concept of natural interest rate was established by Swedish economist Knut Wicksell. He states that in case inflation expectations are anchored and in the absence of cost shocks, the natural rate of interest is the sum of the natural real interest rate and the inflation target. The natural real interest rate is the real interest rate corresponding to the potential level of output. Therefore, in order to understand interest rate changes on the medium term and beyond, we have to focus on the underlying factors which drive changes in the natural real rate of interest (Bean et al. 2015).

As the interest rate is technically the price of capital it would seem reasonable to examine changes in the relative supply and demand of capital, which corresponds to: savings and investment. However, this direct route is not feasible, as savings and investment have to equal each other by definition (in a closed economy): someone's debt is someone else's saving. As Figure 4 shows global investments and savings are equal consistently, only their relative values within different country groups change. As we can see, the surplus savings in emerging economies decreased in the aftermath of the crisis, but at the same time, the "excess" investment in advanced economies also disappeared, leaving the overall equilibrium unchanged.



4. Figure: Savings and investment in % of GDP
(Source: Bean et al. 2015, IMF WEO Database)

Therefore, if we would like to explain which factors drove the decline in the natural real rate of interest, we have to look at changes in the propensity to save and the propensity to invest on a global scale. In a simple loanable funds framework (as described in Bean et al. 2015), if the propensity to save increases or the propensity to invest decreases, the equilibrium interest rate will decline (see Figure 5)



5. Figure: Global market for loanable funds
(Source: Bean et al. 2015)

Although the interest rate data presented before focused on the US; due to the interconnectedness of the world economy and financial integration, global trends also influence interest rates in individual countries. In the next section we will discuss these trends.

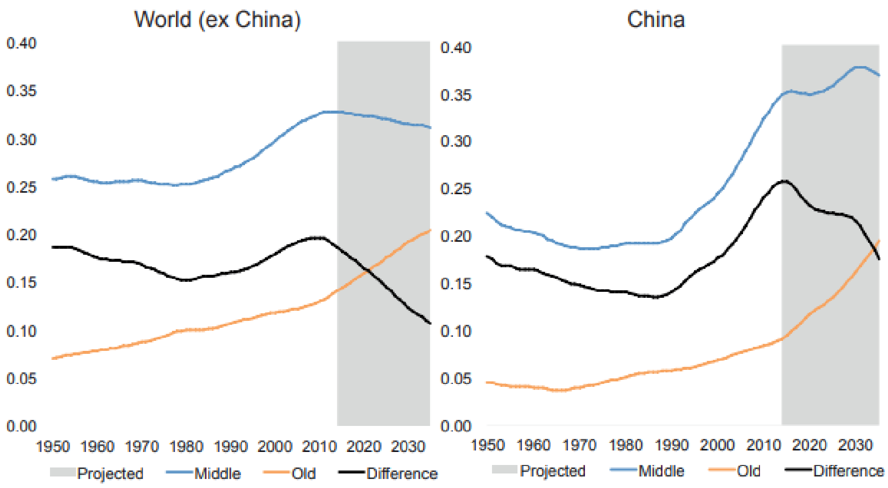
1.2 Propensity to Save

We first look at the savings side, to explore what factors might have influenced the natural real interest rate in the past decades. Our analysis follows that of Bean et al. 2015, in the remaining part of this chapter.

1.2.1 Demography

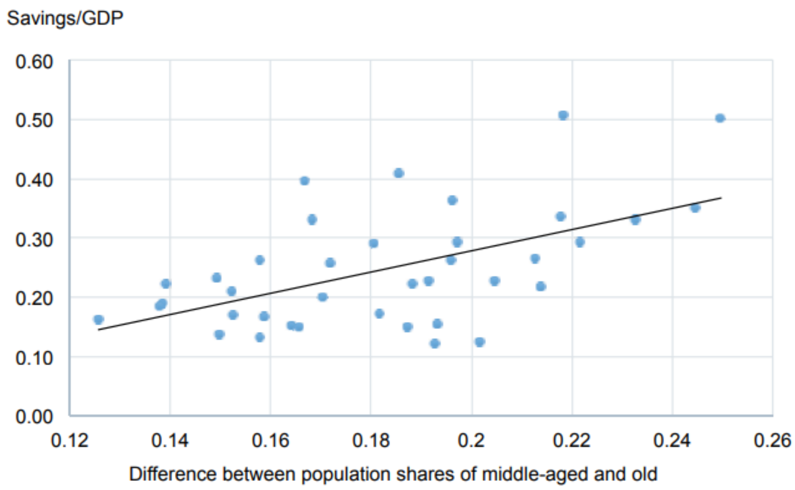
Most studies discussing interest rate dynamics point to demography as one of the potential principal causes for their decline. In advanced economies populations have been aging, but while the longevity of life increased significantly in the past decades the average age of retirement barely moved, which meant that life expectancy after retirement got longer. This in turn increases the stock of savings people would need to accumulate for retirement in order to maintain a given standard of living for their remaining life-years, which translates into an increase in the propensity to save.

Furthermore, after the baby-boom following the Second World War, there was a continuous decline in fertility. Its potential impact on the propensity to save can be understood if we divide adult life into three phases: young, middle-period and retired. We also assume that young adults consume their income which makes them neutral from the perspective of the loanable funds model, middle-aged individuals have higher salary and they are net savers as they accumulate funds for their retirement, while the retired deplete their assets. Therefore, what determines the propensity to save is the relative share of the “middle” and “old” cohorts of society. Figure 6 shows the share of these two groups and their difference. We can see how the relative share of the middle-aged has been increasing since the 1990s, and is expected to decline rapidly in the coming decades.



6. Figure: Share of age cohorts in China and the rest of the World
(Source: Bean et al. 2015, United Nations)

We can also see it on Figure 7 that there is a positive correlation between the difference in the population shares of the middle-aged and old and the savings per GDP ratio.

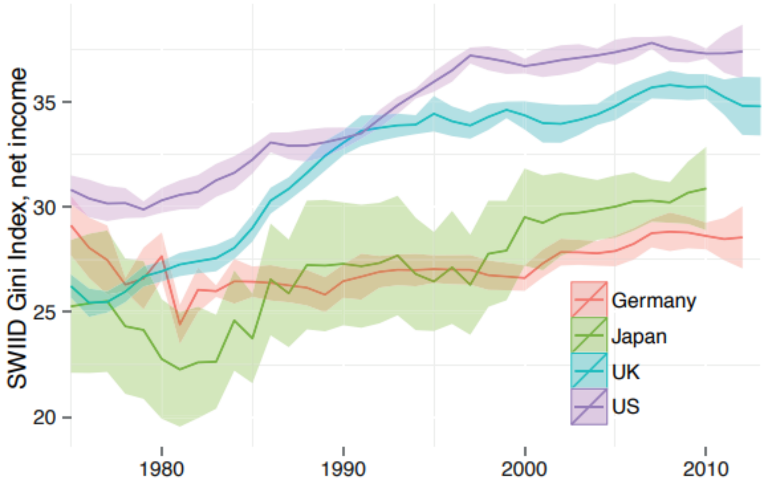


7. Figure: Demographic pressures and saving propensities
(Source: Bean et al. 2015, United Nations)

Considering also that the difference between the share of middle-aged and old population stated to increase as interest rates begin to decline, there is convincing evidence for the shifting demographic structure to be an important driver of interest rate dynamics.

1.2.2 Income Distribution

Another potential factor which may increase the propensity to save in income inequality. In many advanced economies the distribution of income became more unequal in the past decades indicated by rising GINI coefficients (Figure 8). This may have been related to increasing competition from developing countries with low labor costs, but technological advances are probably responsible for the larger portion of this change, as jobs filled by low-skilled workers are being automated.



8. Figure: Inequality in a few key economies[3]
(Source: Bean et al. 2015)

The key assumption here, is that if high-earners have a higher propensity to save than low-income individuals, than increased inequality will lead to a higher propensity to save on the aggregate level. However, income inequality started to increase a decade before interest rates began to fall, therefore it may not have been a major driver of the changes interest rates.

1.2.3 The Financial Integration of China

In the past decades, starting with the reforms of Deng Xiaoping in the 1980s, China started to open up and integrate to the world economy. This integration not only meant increasing trade with the outside world, but also financial integration. Chinese people are well known for their thrifty behavior, and indeed, China has a very high propensity to save. These savings have been incrementally "added" to the global pool of savings as capital restrictions were lifted gradually. In fact, this process is still going on. On the other hand, the opening of the Chinese economy created new investment opportunities for western companies potentially increasing the global propensity to invest. The question is: which of these forces have been stronger?

[3] Note: Solid lines indicate mean estimates; shaded areas give 95% confidence bands.

If we look at indicators reflecting the external position of the Chinese economy, we can find the answer. In 1990 the Chinese economy was only the 10th largest in the world, but by 2014 China became second only to the US. In terms of FDI inflow however: in 1990 China was not even among the top ten, and by 2014, it had only risen to the fifth place. At the same time China had high current account surpluses and accumulated a large stock a reserve, which means the country have been a net creditor of the world adding to the global pool of savings.

1.2.4 Hangover from The Crisis

All the factors and effects discussed above relate to longer trends which are not directly connected to, financial and economic crisis starting from 2008. As Figure 2 showed and was mentioned before long-term interest rates have been on a declining trend for decades before the Great Recession, however it can be argued that the crisis itself also had an impact on the propensity to save and therefore on the interest rates.

In the aftermath of the financial crisis of 2008, many developed countries sunk into, what described by Richard Koo a balance sheet recession (Koo. 2011). The bursting of the housing bubble and the ensuing carnage in the financial markets led to a sudden revaluation of a risks associated with leverage and increasing costs of debt financing for businesses and households alike. This triggered massive deleveraging in many developed nations. However, as companies and private individuals started to repair their balance sheets – paying down debt by cutting back spending – they worsened the financial situation of other economic agents. Since someone’s expenditure is someone else’s income, they too were in turn forced to start deleveraging. This led to a fall in aggregate demand and therefore a recession. The result of this change in the perception of risk associated with leverage and the ensuing debt reduction increased net savings in advanced economies (see Figure 4).

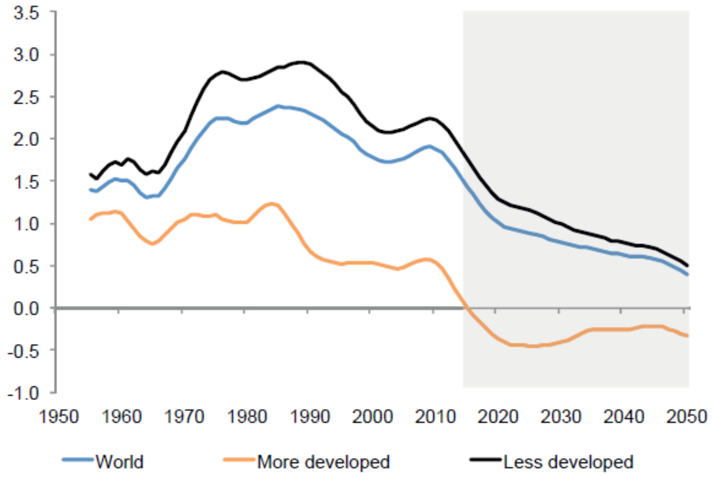
This effected not only households but companies as well. Even before the crisis in the US and other developed economies as well, the net financial asset position of the corporate sector has been rising, and the experience of the financial crash amplified that trend with firms accumulating liquid assets even faster (Bean et al. 2015). In the years after the recession, fiscal consolidation in many advanced economies gave yet another boost to global savings.

1.3 Propensity to Invest

Now we are going to look at the demand side of savings: how the propensity to save changed and influenced the global capital markets. We continue to follow the corresponding section of the paper by Bean et al. 2015.

1.3.1 Demography

One theory suggest that demographic trends not only contributed to the increase in savings, but also impacted investment. As a result of people living longer and having fewer children, working age population started to decline from the mid-1980s. We could assume that for a given capital-labor ratio, a slower growth in labor force as a result of aging population would require a slower growth in capital stock. On the other hand it can also be argued for that a slower growth in the labor force would actually encourage investment as companies would substitute capital for labor. However, we can see on Figure 9 that the slowdown in working age population growth started more than a decade before the decline of interest rates begun. Therefore, a clear connection between demography and investment cannot be established.



9. Figure: Working age (20-64 years) population growth (five year averages)
(Source: Bean et al. 2015)

1.3.2 Decline in the rate of innovation

Another theory which seeks to explain why there might be lower demand for capital and therefor a downward pressure on interest rates suggest that innovation is simply slowed down. Robert Gordon suggested in his 2012 paper this is the reason why potential growth slowed down in recent years: after the three set of key innovations: the steam engine and railroads, the internal combustion engine and electricity, and the digital revolution. In the future, without new innovations to sustain it productivity growth will slow down, which will also weigh down on the propensity to invest.

It is true, productivity growth slowed down after the crisis compared to previous decades, but it is unclear how much of this is the after-effect of the recession. It is also difficult, if at all possible, to estimate the speed of innovation in the future and its impact on productivity growth. We have probably not seen the full impact of the digital revolution yet, not to mention the potential productivity gains from automation and robotics. Therefore, it is not possible to say categorically that innovation has slowed down or it will slow down in the future.

1.3.3 Change in the nature of growth

This view suggests, that due to technological change, and the innovations of the digital era, economic activity itself was transformed. This led in certain industries – like software development – to a lower physical capital to output ratio, which lowers the demand for investment. Although this explanation can be a plausible explanation for low interest rates it is not possible to calculate its aggregate macroeconomic effect.

1.3.4 After-effects of the financial crisis

After the crisis, investment fell sharply, but it did not recover just as swiftly, indicating a rise of uncertainty in the economic environment end worsening prospects for profitability. Studies show, how it can take a long time for investor confidence to return. After the initial financial crisis, uncertainty rose again in Europe as the result of the sovereign debt crisis in the countries of the southern periphery – especially in Greece. This problem is far from being solved, which is obvious if we consider the rising political tensions between Italy's newly elected euroskeptic government and the European Commission over Italy's 2019 budget.

All these uncertainties lead to a depressed growth of investment, which lowers demand on the capital market, and therefore causes the interest rates to fall.

1.4 Portfolio shifts between risky and safe assets

Following the structure from Bean et al. 2015 we also look at how the preferences of investors and savers might have affected interest rates. In particular we explore how the effect of the increasing demand for safe assets and the changes in their supply influenced interest rates in the years following the crisis.

1.4.1 Demand for safe assets

In the aftermath of the crisis in the world of heightened uncertainty, the demand for assets deemed safe have increased. One indicator of this is how an increase in the probability of catastrophic events can lead to low risk-free rates and high equity premiums.

As a response to the crisis from policymakers, the requirements on capital buffers were also increased: banks were obliged to hold more liquid assets which can easily be turned into cash, in case of financial distress. These new regulations also added to the demand for safe assets.

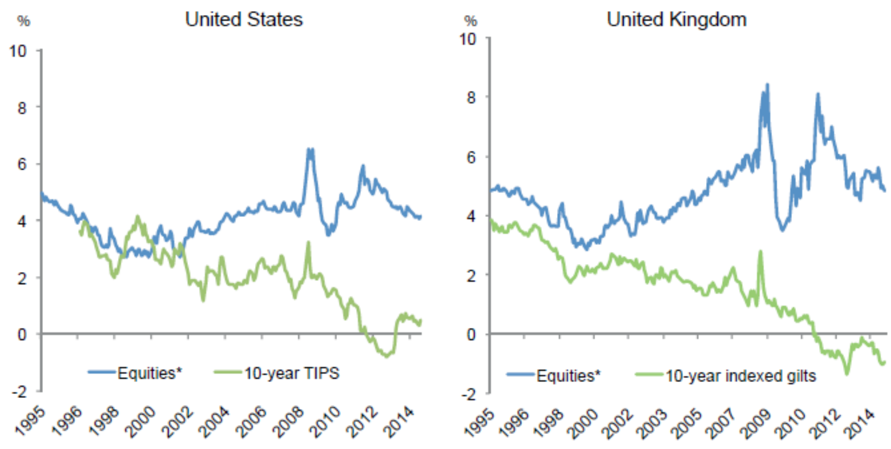
And last, but not least the quantitative easing programs of central banks have also been a source of additional demand. The whole purpose of the asset-purchase of central banks was to keep interest rates low, and by doing so boost aggregate demand in the economy and prevent deflation. These programs not only effected the price of assets which were directly purchased by central banks, but also the price of other assets as investors changed their portfolios' seeking higher yields.

1.4.2 Supply of safe assets

Even before the crisis there was an increasing demand for safe assets, the financial industry sought ways to fulfill this demand. The most notable way they accomplished this is by redistributing risks within the financial system through the repackaging mortgage-backed securities. These were then often rated "AAA" by the rating agencies and could be purchased by pension funds and other participants of the financial markets seeking safe assets. However the crisis revealed the faults of this process and led to a revaluation of risk throughout the financial sector: this meant that the volume of instruments considered "safe" by investors shrank significantly.

Another category of assets considered safe are government bonds, but the European sovereign debt crisis also caused a reassessment of risk, after which the bonds of several countries involved were no longer deemed safe.

One way to confirm the relative increase in the demand or relative decrease in the supply of safe assets is to compare how the spread between the yields on safe and risky assets changed over time before and after the crisis.



10. Figure: Safe interest rates and yield on equity in the United States and the United Kingdom
(Source: Bean et al. 2015)

As Figure 10 shows, the yield 10-year government bonds in both the US and in the UK have been on a downward track, even before the crisis. At the same time the yields on equity increased moderately from the early 2000s. Note that during the financial crash yields on both instrument categories in both countries spiked, indicating heightened uncertainty. However, since 2009, government bond yields declined significantly, widening the spread between yields of safe and risky assets. Although Figure 10 only illustrate yield changes for one class of safe assets and one interpretation of risky assets, the trends are in line with the theory which suggest an increase in the demand and a decline supply of safe assets.

1.5 Interest Rate Dynamics – Prospects for The Future

So far, we have described how interest rates moved in the previous decades and during the crisis. We showed how short-term interest rates followed business cycle fluctuations, and short-term real rates sunk deep into negative territory in the aftermath of the crisis as the quantitative easing program of the Federal Reserve begun. We also established that the decline of real and nominal long-term interest rates did not start with the crisis, but in fact it has been an ongoing trend since the 1980s.

Then – based on the paper by Bean et al. (2015) – we also explored the possible reasons behind the declining interest rates. In this next section, continuing on the analysis of Bean et al, we will discuss how these factors may change in the future and what would be their effect on interest rate dynamics.

1.5.1 Propensity to save

On the saving side one of the factors which is expected to change dramatically is demography. In the past decades demographic dynamics around the world likely exerted a downward pressure on interest rate, the increase of middle-aged old cohorts of society relative to old (see Figure 6) – as described earlier – meant a relative increase in the propensity to save. In the next few decades, as the aging of populations around the world reaches its next stage, this trend will turn around. The relative share of "old" cohorts are expected to increase, while the share of middle-age decrease. As middle-aged people tend to be net savers while old people tend to dissave, this situation will lead to lower propensity to save at the aggregate level, lowering the supply of savings and putting upward pressure on the equilibrium rate of interest.

The possible impact of Chinese financial integration is more difficult to forecast. Ultimately, it depends on the savings-investment balance of the Chinese economy, as well as the relative pace of financial integration on the savings and on the investment side. The declining current account surplus of the world's second largest economy suggest, that at the very least this will have at least a less pronounced effect in the future.

1.5.2 Propensity to invest

We explored various theories explaining why the propensity to invest declined in the years before and after the crisis. These pointed to demographic changes, decline in the rate of innovation, changing nature of growth, but we saw a lack of evidence for a connection between these trends and interest rates. The only the explanation which suggest that the lower propensity to invest was an after-effect of the crisis seemed to be credible. This also suggest that in time investor confidence will recover and businesses will become more willing to make the long-term commitment required for investment projects. In fact, considering economic activity in the United States, this is already happening.

1.5.3 Supply and demand of risky and safe assets

One major source of demand for safe assets in the aftermath of the crisis were the asset-purchase programs of central banks. The Federal Reserve has already closed its quantitative easing program and the European Central Bank is expected to follow suit in December 2018. This significantly reduces the global demand for safe assets. Naturally, central banks can also have a more direct impact on the interest rate, by changing the base rate. The Fed has already started raising interest rates, and the European Central Bank can have its first hike in the late summer of 2019. On the supply side of safe assets, it could be argued that the large deficits of the United States' Federal Government are contributing to their increase, however it is difficult the gauge their impact.

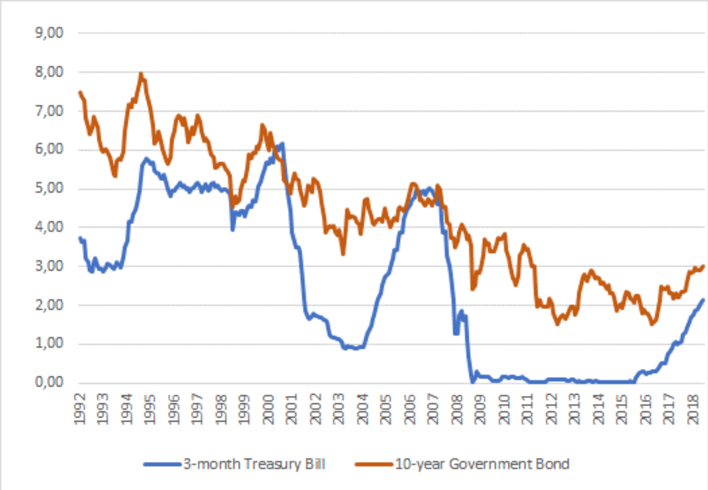
The following table summarizes impact key factors on the supply and demand side of the market of loanable funds. Only those are listed here which were previously found to have a potentially significant impact on interest rate dynamics.

1. Table: Key drivers of interest rate dynamics

	Key drivers of interest rate	Impact in the past	Expected change in their behavior in the future
Supply side	Demography:	Increasing share of middle-aged cohorts relative to old leads to an increase in net savings.	As populations age, the middle-aged to old cohorts ratio starts to decline which leads to a decline in net savings.
	Income distribution	Increasing income inequality leads to higher propensity to save, because high income individuals save a larger share of their income.	-
	The financial integration of China	China has a high propensity to save; the integration of these savings to the global financial financial markets increased the supply of capital	The declining Chinese current account surplus indicate, a weakening impact from Chinese financial integration.
	After-effects of the crisis	Fiscal consolidation in advanced economies further decreased the pool safe assets.	As fiscal consolidation in advanced economies stopped and particularly in the US, fiscal policy became looser, the downward pressure on the supply of safe assets from fiscal policy diminished.
	Supply of safe assets	Revaluation of the risk associated with mortgage-backed securities shrunk the pool of safe assets	-
Demand side	Change in the nature of growth	Due to technological innovations in digital technology, the nature of growth changed, requiring a lower physical capital to output ratio, which lowers the demand for investment.	-
	After-effects of the crisis	Rising uncertainty in the aftermath of the crisis and worsening prospects for profitability lowered investment.	As the effects of the crisis fade away, investment sentiment is recovering.
	Demand for safe assets	In the uncertainty after the crisis demand for assets considered safe increased. Asset purchase programs of central banks created additional demand for safe assets.	As the after-effects of the crisis fade away and the risk aversion of investors decreases, the demand for safe assets expected the decline too. Central banks are closing their asset-purchase programs which will significantly reduce the aggregate demand for safe assets.

As Table 1 shows several important factors influencing the supply and demand of capital are expected to change in the future, lowering the downward pressure on interest rates, while other expected to have the same impact. While it is difficult – if at all possible – to accurately measure the effect of these factors, the fact that some of them are expected to persist while others are likely fade away or even change their effect, we can conclude: there will likely be an increase in the equilibrium real interest rate, but it is still expected to remain below its historical average.

In fact, as Figure 11 shows the “normalization” of interest rates in the United States has already begun.



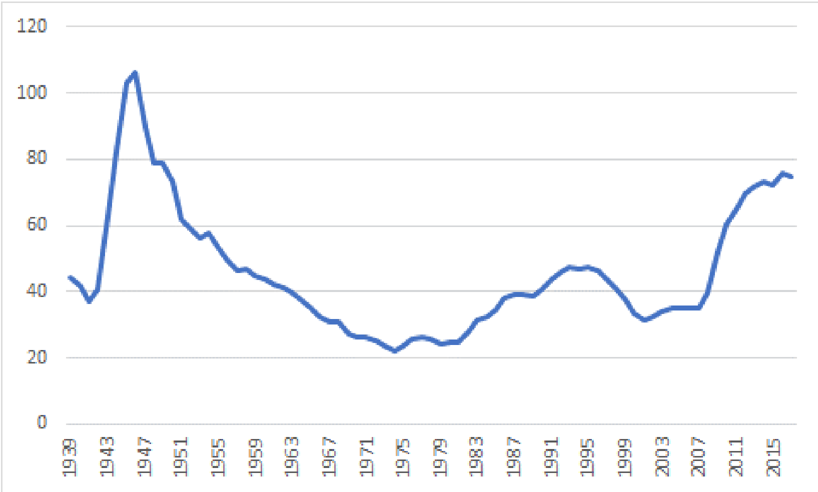
11. Figure: US Treasury Bill and Government Bond Yields
(Source: Saint Louis Fed)

Chapter 2 – Deficits and Debt in the United States

2.1 Deficit and debt dynamics in the past

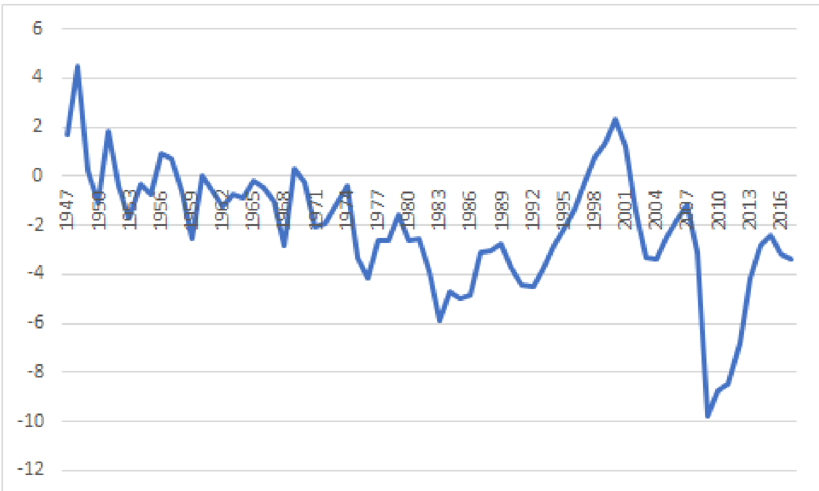
Government debt in the United States was 105.2% of the GDP in 2017 and according to the IMF it is expected to be around 106.1% in 2018, which is the highest level since World War II. Before go any further however, it is important to clarify what government debt actually includes and what measure we would like to use during our analysis. The data, which was referenced from the IMF includes all liabilities of the **general** government following the GFSM2001 methodology. This is an important distinction, especially in the case of the United States because it also includes the liabilities of States, not only the Federal Government. If we only look at the debt which was accumulated by the Federal Government (Federal debt held by the public) the relevant number for 2017 is 74.7% of the GDP. Going forward with our analysis, we chose to focus on the Federal Government. We see this as a justified simplification as the Federal Government is barred from bailing out the governments of states. The problems associated with state-debt could be a topic for another paper.

As Figure 12 shows, debt of the federal government has also reached has increased drastically in the aftermath of the financial crisis, to levels which have not been seen since the 1950s.



12. Figure: Federal debt held by the public (in % of GDP)
(Source: Saint Louis Fed)

The budget balance of the federal government is illustrated by Figure 13. It shows how deficits increased in the 1980s, during the last phase of the Cold War, then how the decreasing government debt during the 1990s was achieved by a massive 6% improvement in the fiscal balance. Deficits skyrocketed again during the crisis to around 10% of the GDP, then greatly reduced to only around 3% of the GDP. Recently however they started to increase once again.



13. Figure: Federal government balance (in % of GDP)
(Source: Saint Louis Fed)

It is also important to consider the one seemingly obvious question: why is high government debt a problem in the first place? Related literature has provided various reasons why governments should prevent the accumulation of high government debt. One explanation, that it has adverse effects on growth. A study by Reinhart and Rogoff in 2012 concluded that if government debt exceeds 90% of the GDP it can have a significant negative effect on GDP growth. Although later on a critique of this study was published by Herndon et. al (2013), rejecting the idea of having a simple threshold above which debt is considered "too high". Presbitero and Panizza (2013) surveyed the relevant literature on the connection between public debt and growth. They also came to the conclusion that there is no clear universal threshold above which government debt has a negative effect on growth and. Eberhardt and Presbitero (2013) in their paper stressed the importance of heterogeneity in the connection between debt and growth across countries, although they did find some evidence for a negative relationship between debt and growth.

Another possible downside of high public debt is higher yields on government bonds. Ardagna et. al showed in their 2004 paper, there is a nonlinear connection between government bond yields and government debt: countries with above-average debt to GDP ratios experience higher yields on government bonds (Ardagna et. al, 2004). Considering the unique role the United States plays in the world policymakers also have to consider, that a highly indebted US might see its international leadership position weakened (CRFB 2018). The Committee for a Responsible Federal Budget in their 2018 long term budget outlook also cite the increased likelihood of a financial crisis as one of the adverse effects of high public debt.

One important role fiscal policy can play is the counteract business cycle fluctuations, by allowing budget deficits to rise during recessions softening the impact of economic downturns. Empirical evidence showed that countries which enter recessions with lower public that can recover more quickly than countries with higher public debt because there is more fiscal space available to counteract the decline in economic activity (Jorda et. al, 2013). Before the financial crisis of 2008 – as Figure 12 and Figure 13 illustrates – the US federal government had a public debt of 35% and a budget deficit of 1.1% of the GDP. For 2018 the Congressional Budget Office expects the deficit to be 3.9% of the GDP, while debt held by the public will be 78%. Considering the aforementioned problems associated with high public debt, this is a serious fall in available fiscal space in case of a recession. While according to The Saint Lois Fed US potential GDP growth is around 1.8-2.1%, the IMF forecasts a 2.9% actual GDP growth for 2018, which is well above the potential rate. This, coupled with the tight labor market conditions – 3.8% unemployment rate in 2018 (IMF estimate) – means that the cyclically adjusted deficit of the federal government could be even higher. The United States is also currently in the second longest economic expansion period of its history, which coupled with high deficits means, that US fiscal policy became dangerously pro-cyclical. This leaves fiscal policy little room to maneuver when the next recession occurs, at least not without potentially undermining the credibility in the US government (by another expansion of debt) or damaging the institutional framework (increasing pressure on the Fed to accommodate a looser fiscal stance with less tight monetary policy).

2.2 Recent Developments and Future Prospects

As we have shown before an alarming trend have started towards fiscal irresponsibility in the United States. The deficit of the federal budget was only 2.4% of the GDP in 2015 but it has been increasing since: 3.2% in 2016, 3.4% in 2017 and is expected to be 3.9% this year. The following table summarizes the main items in the US federal budget:

2. Table: Federal Budget item in % of GDP
(Source: Monhly Budget Reviews, Congressional Budget Office)

	2015	2016	2017	2018
Receipts	**17,83**	**17,46**	**17,01**	**16,22**
Individual Income Taxes	8,46	8,26	8,14	8,20
Payroll Taxes	5,85	5,96	5,96	5,70
Corporate Income Taxes	1,89	1,60	1,52	1,00
Other Receipts	1,64	1,64	1,38	1,31
Outlays	**20,24**	**20,60**	**20,43**	**20,04**
Social Security Benefits	4,81	4,84	4,79	4,76
Medicare	2,93	3,16	3,05	2,85
Medicaid	1,92	1,97	1,92	1,90
Military	3,09	3,02	2,92	2,92
Net Interest on Public Debt	1,43	1,52	1,59	1,81
Other	6,06	6,09	6,15	5,80
Balance	**-2,41**	**-3,14**	**-3,42**	**-3,82**

We can see how both receipts and outlays have decreased in % of GDP since 2015-2016, but outlays increased less so. It is important to discuss a few important data points, which very well illustrate the underlying changes in US federal budgeting. The Tay Cut and Jobs Act of 2017 went into effect in 2018, which introduced some major changes in the revenue side of the budget. The most significant of these was lowering the corporate tax rate from 35% to 21%. As a result corporate income taxes dropped from 1.5% of the GDP in 2017 to 1% 2018. On the expenditure side, net interest rates on debt held by the public increased significantly from 1.6% of the GDP in 2017 to 1.6% in 2018. This shows that the monetary tightening of the Fed starts to have an effect on the financing cost of public debt.

The Congressional Budget Office estimates that even with no policy change, budget deficits would continue to increase over the coming decades (CBO, 2018). They expect non-interest spending to increase from 19% of the GDP in 2018 to 23% in 2048, while revenues would stay mostly flat in the period relative to the GDP. The CBO estimates an average 4.9% deficit for the 2019-2028 period, and an average 6.1% deficit for 2029-2038. This would mean that debt held by the public would rise to 96% of the GDP by 2019-2028 and 118% by 2029-2038.

Revenues while projected to remain unchanged for most of the period, CBO expects sharp increase in 2026. This is the year when provisions of the Tax Cuts and Jobs Act of 2017 expire and income taxes increase. The growth of expenditures is expected to be driven mainly by rising cost for Medicare, Medicaid, Social Security, as well as increasing interest expenditure. The main driver behind increasing social security and healthcare expenses is demography. The US population is aging, the share of 65 or older will increase from 16% of the population in 2018 to 22% by 2048. The reason why this change in demography will result in higher spending as a percentage of GDP on social security and healthcare, is because a larger share of elderly people are social security recipients than other age groups, and most beneficiaries qualify for Medicare at the age of 65 (CBO, 2018). These federal programs are financed through trust funds and rising expenses also threaten the solvency of these. According to the Committee for a Responsible Federal Budget the fund for Medicare Hospital Insurance will become insolvent in 2026, while the Social Security Old Age & Survivors Insurance will be exhausted by 2032. It does not mean that these programs will become completely defunct: in the case of Medicare the necessary cut would be 14% and for Social Security this number is 27% (CRFB, 2018). These programs are very popular however, and it is unlikely that the federal government would let them go insolvent or reduce benefits from one year to the next. What is more likely is that these programs will continue, putting an extra burden on the federal budget.

To summarize: the debt of the US federal government is on an unsustainable path. With no policy change, the increase in revenues will not keep up with rising expenditures which will lead to wider deficits, and in turn higher public debt. Chapter 4 will explore in detail the components of rising debt and analyze how the debt trajectory would change in case of different fiscal policy decisions, and potential negative shocks to economic growth.

Chapter 3 – The Model

In this chapter we will describe the general form of the model used for scenario analysis. The most important requirements for the model is to be able to capture the relationship between fiscal policy and economic growth (fiscal multiplier effect), and simulate the maturity of government bonds and the refinancing of government debt. Additionally, the model has to have a long-term equilibrium state with regards to growth and unemployment rate, irrespective of short-term fiscal policy changes. The time horizon of the analysis is 14 years.

Box 1 – Notation Glossary

γ_t = nominal GDP growth rate from period t-1 to t
g_t = real GDP growth rate from period t-1 to t
g_t^* = potential growth rate
Y_t = real GDP
Y_t^* = potential real GDP
Y_t^N = nominal GDP
h = output gap
b_t = "drift" of the economy towards equilibrium level output
s = smoother parameter with base value of 2.5
i_t = nominal interest rate in period t on outstanding debt at the end of period t-1
i_t^s = short term interest rate
r_t = real interest rate in period t
r_t^{s*} = real short term equilibrium interest rate in period t
π_t = change in GDP deflator from period t-1 to t
π^* = inflation target
p_t = primary balance in period t in percentage of GDP
Δp_t^G = net change in "intended" primary balance in % of GDP from period t-1 to t
p_t^* = cyclically adjusted primary balance in period t in percentage of GDP
τ = marginal tax and transfer rate
μ_t = fiscal multiplier
μ^H = highest possible fiscal multiplier
μ^L = lowest possible fiscal multiplier
μ_t^b = interest rate-based multiplier component in period t
μ_t^h = output gap-based multiplier component in period t
d_t = debt at the end of period t in percentage of GDP
o_t = labor productivity growth
u_t = unemployment rate
u_t^* = non-accelerating inflation rate of unemployment
a_t = activity rate
m_t = employment rate
P_t = working age population
L_t = number of employed
i_t^{3m}= 3-month bond yield
i_t^{1y}= 1-year bond yield
i_t^{5y}= 5-year bond yield
i_t^{10y}= 10-year bond yield
i_t^{20y}= 20-year bond yield
c^{10y} = coefficient capturing the relationship between changes in 3-month and 1-year yields
c^p = coefficient explaining the correlation between changes in the primary balance and the 10-year yield
c^u = coefficient capturing the relationship between inflation and unemployment
D_t = outstanding government debt in period t in national currency unit
F_t = total financing needs in period t
$D_t^{\#k}$ = amount of government debt in period t which is expiring in k years
$w_t^{\#k}$ = share of new debt issued in period t with a k years expiry
$i_t^{\#k}$ = average interest rate payed on debt expiring within k years in period t

As a starting point, the model uses the formula of the decomposition of changes in government debt from Escolano's paper on debt dynamics (Escolano, 2010). They derive the formula in question in the following way:

For easier notations we define:

$$\lambda_t = \frac{i_t - \gamma_t}{1 + \gamma_t} \tag{1}$$

We also assume for that the constituent factors are constant over time, therefore:

$$\lambda = \frac{i - \gamma}{1 + \gamma} \tag{2}$$

Notice that:

$$1 + \lambda = \frac{1 + \gamma}{1 + \gamma} + \frac{i - \gamma}{1 + \gamma} = \frac{1 + i}{1 + \gamma} = \frac{(1 + r)(1 + \pi)}{(1 + g)(1 + \pi)} = \frac{1 + r}{1 + g} \tag{3}$$

Also:

$$1 + \lambda = \frac{1 + i}{1 + \gamma} = \frac{1 + r}{1 + g} \tag{4}$$

Therefore:

$$\lambda = \frac{i - \gamma}{1 + \gamma} = \frac{r - g}{1 + g} \tag{5}$$

We establish that the main equation governing the dynamics of debt ratio is:

$$d_t = (1 + \lambda_t)d_{t-1} - p_t \tag{6}$$

From equations (1) and (6) we can derive the following formula:

$$d_t - d_{t-1} = \frac{i_t}{1 + \gamma_t} d_{t-1} - \frac{\gamma_t}{1 + \gamma_t} d_{t-1} - p_t \tag{7}$$

So the change in government debt depends on the nominal growth, nominal interest rate and the primary balance. But based on the established connection between nominal and real interest rate and growth in equations (3) to (5) we can also notice that:

$$\frac{\gamma}{1+\gamma}=\frac{(1+\gamma)-1}{1+\gamma}=\frac{(1+g)(1+\pi)-1}{1+\gamma}=\frac{\pi+g+g\pi}{1+\gamma}=$$
$$\frac{\pi+g(1+\pi)}{1+\gamma}=\frac{\pi}{1+\gamma}+\frac{g}{1+g}=\frac{\pi}{(1+\pi)(1+g)}+\frac{g}{1+g} \tag{8}$$

So from (7) and (8) we can derive the following equation:

$$d_t-d_{t-1}=\frac{i_t}{(1+\pi_t)(1+g_t)}d_{t-1}-\frac{\pi_t}{(1+\pi_t)(1+g_t)}d_{t-1}-\frac{g_t}{1+g_t}d_{t-1}-p_t \tag{9}$$

This equation – a slightly modified version of Escolano's formula – gives the basis for our model. It brakes down the change in government debt into four components – four key determinants: nominal interest rate, inflation, and real GDP growth. Although π is the GDP deflator in the original equation, in our calculations, we assume inflation (consumer price index) equals the GDP deflator. We see this justified by the long-term nature of our analysis.

In the following, we describe our model. It effectively takes Escolano's formula one step further: simulating interactions between the four key components of change in government debt, as well as modeling the change of those four factors by their own explanatory variables.

3.1 Growth and the Labor Market

In our model real GDP growth is described as:

$$g_t=\mu_{t-1}\Delta p_t^G+g_t^*+b_t\left(\frac{Y_{t-1}}{Y_{t-1}^*}-1\right) \tag{10}$$

where μ_{t-1} is the fiscal multiplier in period t-1, Δp_t^G is the net change in "intended" primary balance (it does not include second order effects from changing taxes) from period t to period t-1, g_t^* is the potential growth rate in period t and b_t is the term which captures the economy's tendency to "drift" towards the equilibrium level of output (zero output gap). The b_t term is defined as:

$$if\ |h_t| \geq s;\ b_t = -\frac{h_t}{|h_t|}s; if\ |h_t| < s;\ b_t = -h_t \tag{11}$$

where s is a parameter determining the regular pace at which economy converges towards the equilibrium level of output and h_t is the output gap. Therefore, in the model the economy converges to the equilibrium level of output at a constant rate, until the output gap becomes smaller than this constant rate, at which point the remaining output gap closes.

Potential growth rate is also broken down to its components:

$$g_t^* = o_t + \frac{(a_t - u_t^*)P_t}{(a_{t-1} - u_{t-1}^*)P_{t-1}} - 1 \tag{12}$$

There o is the rate of productivity growth, a is the activity rate, u* is the non-accelerating inflation rate of unemployment (NAIRU) and P is the working age population. Unemployment rate is also calculated in the model in a residual basis:

$$u_t = a_t - m_t = a_t - \frac{L_t}{P_t} = a_t - \frac{L_{t-1}\frac{1 + g_t}{1 + o_t}}{P_t} \tag{13}$$

Where L is the number of employed, e is the employment rate. The number of employed, which is required to calculate the unemployment rate is derived based on the assumption that the part is total GDP growth which is above the labor productivity growth necessitates a proportional increase in the number of employed.

The output gap is calculated in the following way:

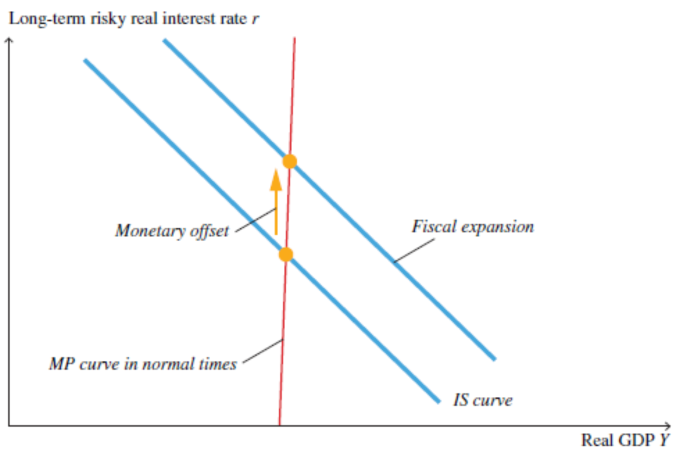
$$h_t = \frac{Y_t}{Y_t^*} - 1 = \frac{(1 + g_t)Y_{t-1}}{(1 + g_t^*)Y_{t-1}^*} - 1 \tag{14}$$

The reference year for real GDP and real potential GDP is 2017, and both are calculated on a basis of cumulative growth for the period of the analysis. From equation (12) and (13) we can also note that the difference between actual and potential output is entirely captured by the difference between the actual unemployment rate and the NAIRU.

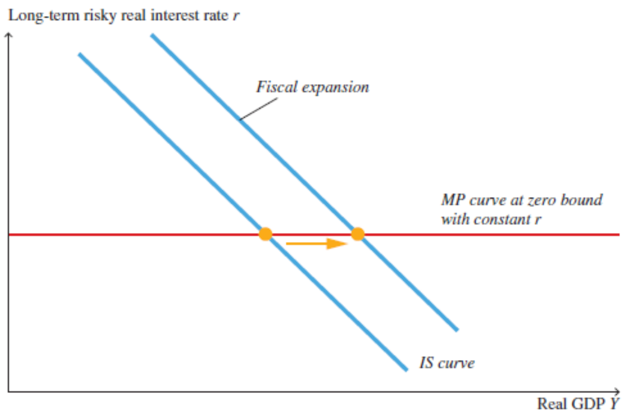
3.2 Fiscal Policy

As we can see from equation (10), aside from potential growth, the other key component of actual growth is fiscal policy. In the model, changes in fiscal policy has a direct effect on the primary balance and on economic growth. The key parameter to be considered for simulating changes in fiscal policy is the fiscal multiplier.

There is an abundance of literature discussing values of fiscal multipliers for different types of budget items (e.g.: taxes, transfers, public investment), and for different periods of the business cycle. Despite the large number of papers written on the issue, the reality is that estimating multipliers is difficult. Barro in his paper in 1981 concluded that the value of multipliers are around 0.8. Ramey in a more recent paper from 2011 estimated multiplier values ranging from 0.6 to 1.2 using VAR modeling techniques. Interestingly, according Ramey's estimations, the fiscal multiplier is not significantly higher when the sample is limited to periods when interest rates are near zero. This is important because much of the multiplier-literature burgeoning in the wake of the Great Recession were arguing that government spending multipliers are significantly higher at time of a recession, especially when interest rates are at the zero lower bound. Blanchard (2013) takes an indirect route to investigate whether multipliers are higher during an economic downturn. In his paper he examines the forecasting errors of economic growth for several countries in the aftermath of the financial crisis, when these countries were implementing fiscal consolidation programs. He found that there is a correlation between forecasting errors and the magnitude of fiscal consolidation: the larger the fiscal consolidation, the more forecasters overestimated economic growth. Blanchard sees this as evidence that fiscal multipliers were higher than what was in the specifications of forecasting models, and the reason for this difference between actual multiplier values and model parameters is that multipliers increased due to the recession. Blanchard also finds that the absolute value of the multiplier for government spending is higher (1.244) than for revenues (-0.86). Similar arguments were made by DeLong-Summers (2012). They point out that the reason why multipliers are higher during the condition of zero lower bound is because the crowding-out effect of government spending does not apply in such a situation. During "normal times", if the government increases demand, it will also increase inflationary pressure, which will prompt the central bank to raise interest rate, therefore reducing private investment. However, in case of a severe economic downturn when the zero lower bound holds, the increase in government consumption will not increase inflationary pressures enough to trigger an interest rate hike from the central bank. Therefore, there is no crowding-out of private investment which increases the efficiency of fiscal stimulus, which practically results in a higher multiplier value (DeLong-Summers, 2012).



14. Figure: IS-MP Analysis of a Fiscal Expansion in Normal Times
(Source: DeLong-Summers, 2012)



15. Figure: Fiscal Expansion at the Zero Lower Bound with Constant Real Interest Rate
(Source: DeLong-Summers, 2012)

Other studies used DSGE simulations to estimate the fiscal multiplier. In their paper focusing on the euro area, Furcieri-Mourougane (2010) estimated that the initial impact of a 1% increase in government spending can be as high as a 1.3% increase in total output (in the quarter it is implemented), however after a year the effect drops to 0.6% and to 0.2% after just two years. They also make a distinction between different fiscal policy measures. In line with other literature they conclude that government investment has the strongest, longest lasting effect on overall output, while capital tax cuts have the weakest. Christiano et al. (2011) also came to the conclusion using a new-Keynesian model that the fiscal multiplier is higher when the zero lower bound binds. They also suggest that multiplier values can be as high as 1.2, but are unlikely to be above that.

We will discuss the actual values for multipliers more in debt in Chapter 4, here we would like to introduce the methodology for multiplier calculations. The goal was to model the fiscal multiplier in a way that allows the for multiplier to be different in different stages of the business cycle. We aimed to find relatively simple equations which results impulse response functions that are similar to those found in the literature above, without the need to model the underlying structure of the economy. Therefore, the multiplier for period t is calculated in the following way:

$$\mu_t = \frac{\mu_t^i + \mu_t^h}{2} \tag{15}$$

Where μ_t^i is the interest rate based component of the multiplier in period t and μ_t^h is the output gap-based component of the multiplier. The μ_t multiplier is the simple average of the two "component" multiplier values. This multiplier captures the effect of public investment. The idea behind the formula is that – as described in the literature – the multiplier is higher when the zero lower bound holds (when interest rates are near zero), or when there are unutilized capacities in the economy (the output gap is negative). Normally these two conditions closely correlate with each other, but here can be some divergence, which is why we decided to include both approaches.

We derive the interest rate-based multiplier as:

$$if\ i_t^s > 0;\ \mu_t^i = \frac{1}{e^{150 i_t^s}}\mu^H + \left(1 - \frac{1}{e^{150 i_t^s}}\right)\mu^L;\ if\ i_t^s \leq 0;\ \mu_t^i = \mu^H \tag{16}$$

Where i_t^s is the short-term nominal interest rate in period t, μ^H is the highest possible fiscal multiplier for the country in case of a recession, and μ^L is the lowest possible fiscal multiplier during "normal times". The formula states, that if the short-term interest rate is equal or below zero (the zero lower bound holds) than the "interest rate-based multiplier" is equal to the highest possible value of the multiplier, and if the short-term interest rate is higher than zero, then a smoothing function will calculate the interest rate-based component of the multiplier based on μ^H and μ^L.

The output gap-based multiplier follows a similar logic:

$$if\ h_t < 0;\ \mu_t^h = \frac{1}{e^{-50 h_t}}\mu^L + \left(1 - \frac{1}{e^{-50 h_t}}\right)\mu^H; if\ h_t \geq 0;\ \mu_t^h = \mu^L \tag{17}$$

If the output gap is positive or zero the output gap-based component of the fiscal multiplier takes the lowest value possible, if the output gap is negative a smoothing function will calculate the output gap-based component of the multiplier based on μ^H and μ^L.

The literature on fiscal multipliers (such as - DeLong-Summers, 2012) suggest that multipliers on taxes and transfers are lower than on government investment. To capture this effect we introduce another multiplier(μ_t^T) specifically for taxes and transfers:

$$\mu_t^T = c^{\mu T} \mu_t \tag{18}$$

where $c^{\mu T}$ is a coefficient determining the connection between the fiscal multiplier on public investment and taxes and transfers.

As it was established in equation (10) "intended" change in primary balance – which can also be described as the change in the cyclically adjusted primary balance – has in impact on growth through the fiscal multiplier, and naturally it is a key component of the primary balance. The connection described in the following two equations:

$$p_t^* = p_{t-1}^* + \Delta p_t^G \tag{19}$$

$$p_t = p_t^* + h_t \tau \tag{20}$$

Where τ is the marginal tax and transfer rate, which is technically the elasticity of primary balance to changes in GDP, and p_t^* is the cyclically adjusted primary balance. Changes in the output gap has an impact on the primary balance. Higher (more positive) output gap means more revenues and less claims on social security and other benefits, therefore improved primary balance and vice versa. The term τ is originated from a 2012 paper by DeLong-Summers, in which they pointed out that the increase in debt caused by a fiscal stimulus is mitigated by the fact that the higher growth as a consequence of the increase in government spending will result in higher taxes.

3.3 Monetary Policy and Inflation

Monetary policy is not modelled in itself, as much as its results simulated. The core assumption is that the central bank will act to ensure its primary goal of price stability is met, not relenting to potential political pressure to keep interest rates low. In the model monetary policy follows a simple Taylor-rule to set the short-term nominal interest rate i_t^s which we assume equals to 3 month yields on government bonds.

$$i_t^s = MAX(0; r_t^{s*} + \pi_t + 0.5(\pi_t - \pi^*) + 0.5h_t) \quad (21)$$

Where r_t^{s*} is the equilibrium real short-term interest rate in period t and π^* is inflation target of the central bank. Note that the "MAX" function means the model does not allow for negative nominal interest rates. The r_t^{s*} is one of the most important exogenous variable of the whole model, as the key assumption is that this will gradually increase in the coming years, which will push interest rates higher. In the next chapter, as part of the scenario analysis, we will explore the consequences of potential equilibrium interest rate-paths.

The yield curve is also modeled with 3-month and 1-, 5-, 10- and 20-year yields. We assume that 3-month yields are equal with the short-term nominal interest rate set by the Taylor-rule as described above. The rest of the yield curve is calculated in reference to this baseline. Only the 10-year yields are modeled in more detail, for the rest of the yield is created by simple interpolation, using the 3-month and 10-year yields as anchors. The following equations describe how the yield curve is generated.

$$i_t^{3m} = i_t^s \quad (22)$$

$$i_t^{1y} = i_{t-1}^{1y} + c^{1y}(i_t^{3m} - i_{t-1}^{3m}) \quad (23)$$

$$i_t^{5y} = \frac{i_t^{1y} + i_t^{10y}}{2} \quad (24)$$

$$i_t^{10y} = \frac{\left(i_{t-1}^{10y} + c^{10y}(i_t^{3m} - i_{t-1}^{3m})\right) + (b^{10y} + b^{10y2} i_t^{3m})}{2} - c^p(p_t - p_{t-1}) \quad (25)$$

$$i_t^{20y} = i_{t-1}^{20y} + \left(i_t^{10y} - i_{t-1}^{10y}\right) \quad (26)$$

Where c^{1y} is the coefficient capturing the relationship between changes in 3-month and 1-year yields and c^p is the coefficient explaining the correlation between changes in the primary balance and the 10-year yield. The coefficient c^{1y} is calculated by regression using historical data, while c^p is originated from a study by Baldacci and Kumar (2010). They used panel data about the G20 countries from the period of 1980-2008 to analyze the connection between fiscal deficits and sovereign bond yields. The coefficients c^{10y}, b^{10y} and b^{10y2} are estimated based on historical yield data

Inflation is derived from a Philips-curve-like formula, the monetary transmission is not modeled explicitly.

$$\pi_t = \pi^* - c^u(u_t - u_t^*) \quad (27)$$

Where c^u is the coefficient capturing the relationship between inflation and unemployment. As equation (27) shows inflation define by a simple "Philips-curve like formula", where inflation is the function of the difference between the actual unemployment rate and the NAIRU. For the coffcient c^u we adopted the estimates from Ball-Mazumder 2015. In their paper they estimated different Phillips-curve specifications for the Unites States. For a similar specification we use in our model, the results for c^u, for the period of 2000Q1-2014Q4 was 0.981.

3.4 Debt Management

Debt management is extensively modeled in our calculations, because it is a crucial part of debt dynamics. On the top of the variables we have already discussed, expiry and interest rate structure are key factors in determining the financing cost of government debt. More precisely: they determine how quickly will an increase in the equilibrium level of interest rate will translate into higher interest payable on public debt. For these regarding debt financing we need the nominal GDP:

$$Y_t^N = (1+g_t)(1+\pi_t)Y_{t-1}^N \tag{28}$$

Where Y_t^N is the nominal GDP in the period t. The outstanding level of debt for period t can be given as follows:

$$D_t = D_{t-1} - p_t Y_t^N + i_{t-1} D_{t-1} \tag{29}$$

Where D_t is the outstanding level of government debt in period t, and i_{t-1} is the average rate of interest on outstanding government debt in period t-1. The debt to GDP ratio is naturally:

$$d_t = \frac{D_t}{Y_t^N} \tag{30}$$

The total financing needs in period t is derived as:

$$F_t = D_{t-1}^{\#1} - p_t Y_t^N + i_{t-1} D_{t-1} \tag{31}$$

Where F_t is the total financing need in period t and $D_{t-1}^{\#1}$ is the amount of government debt expiring within one year in period t-1. In other words F_t is how much new debt has to be issued in period t. New debt is financed at interest rates in the corresponding period (see yield curve calculations above). But debt which will expire in 2 years in period t-1 will become debt which expires within in year in period t. Therefore:

$$D_t^{\#1} = D_{t-1}^{\#2} + w_t^{\#1} F_t \tag{32}$$

Where $w_t^{\#1}$ is the share of new debt issued in period t with a 1 year expiry. We can calculate the interest rates following a similar logic:

$$i_t^{\#1} = \frac{D_{t-1}^{\#2} i_{t-1}^{\#2} + (D_t^{\#1} - D_{t-1}^{\#2}) i_t^{1y}}{D_t^{\#1}} \tag{33}$$

We can also give a general formula for calculating the outstanding debt of all expiry dates in period t:

$$k \ni [1,14] \ and \ t \ni [1,15], D_t^{\#k} = D_{t-1}^{\#k+1} + w_t^{\#k} F_t \quad (34)$$

And also for interest rates:

$$k \ni [1,14] \ and \ t \ni [1,15], i_t^{\#k} = \frac{D_{t-1}^{\#k+1} i_{t-1}^{\#k+1} + \left(D_t^{\#1} - D_{t-1}^{\#k+1}\right) i_t^{ky}}{D_t^{\#k}} \quad (35)$$

Where i_t^{ky} in the interest rate on new debt issued in period t with a maturity of k years. I equals to corresponding interest rates as calculated in the yield curve section, or an interpolation from them, using simple averages.

Notice that there is a 15[th] period in the period of the analysis, but there we are only dealing with debt up to 14 years of maturity. This is because in in order to make calculations more simple, we decided to create 16 categories for maturity. One category for each year for debt maturing within 1-15 years, and an extra category for debt with longer maturity. This simplification however required some "workaround" for the 15 and 15+ year maturity categories. Therefore:

$$D_t^{\#15} = \left(F_t - \sum_{k=1}^{14} D_t^{\#k}\right) \frac{w_t^{\#15}}{w_t^{\#15} + w_t^{\#15+}} \quad (36)$$

$$D_t^{\#15+} = F_t - \sum_{k=1}^{15} D_t^{\#k} \quad (37)$$

Also, for interest rates:

$$i_t^{\#15} = \frac{w_t^{\#15} F_t i_{t-1}^{\#15+} + \left(D_t^{\#15} - w_t^{\#15} F_t\right) i_t^{15y}}{D_t^{\#15}} \quad (38)$$

$$i_t^{\#15+} = \frac{w_t^{\#15+} F_t i_{t-1}^{\#15+} + \left(D_t^{\#15+} - w_t^{\#15+} F_t\right) i_t^{15+y}}{D_t^{\#15+}} \quad (39)$$

Chapter 4 – Scenario Analysis

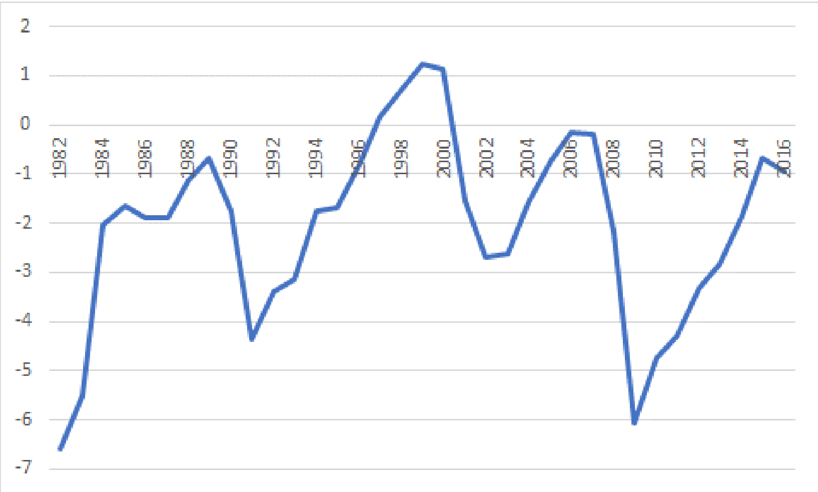
In this chapter we are going to analyze how government debt in the United States is expected to change in the next decades using the model that was described in the previous Chapter. As it was illustrated earlier, there are numerous forecasts and predictions for the trajectory of government debt in the United States. These are however – like the ones made by the CBO – are usually focusing on long term projections, assuming different fiscal policy scenarios. This paper takes a different approach: our forecast is shorter: "only" 15 years into the future – and while it does feature debt projections in case of different fiscal policy options – its main focus is to analyze debt outcomes in case of different equilibrium interest rate trajectories, as well as to show the potential impact of a recession on public debt. This chapter has two parts. First, we show how key parameters of the model were calibrated, then we are going to illustrate our findings about debt dynamics.

4.1 Calibrating the Model

The model – as shown in the previous chapter – can be divided into four sections: labor market and growth, inflation and monetary policy, fiscal policy and debt management. Each section has its own input and output variables and key parameters to be defined.

The labor market section is where the potential growth and output are calculated, and key exogeneous variables are: productivity growth, working age population, activity rate and the NAIRU. The CBO estimates that labor force productivity would increase 1.4% on average during the 2018-2028 period and 1.6% 2029-2038 (CBO 2018). We used these estimates in our calculations. For working age population we refer to the 15-64 age bracket and, our data comes from the 2017 estimates of the United States Census Bureau. The activity rate is projection is calculated indirectly. I was given so that potential growth would follow the forecast of the Saint

Louis Fed until 2025, then stay at around 1.8% which is the CBO's long term estimate. Changes in activity rate were calculated so that potential growth would follow this trajectory given the projection of working age population. For NAIRU data we also used the projections of the Saint Louis Fed. The calculation of the actual growth rate it is also required to set the smoothing parameter "s" which determines the pace at which the government returns to the equilibrium level of output, where actual and potential output are equal. To define the parameter, we used potential and actual output data from Saint Louis Fed. Figure 16 illustrates the output gap we calculated from the data:



16. Figure: Output gap in the United States (%)
(Source: Saint Louis Fed, own calculations)

The parameter s is defined by calculating the average pace at which the output gap was closing in the periods of recovery and boom during 1982-1989, 1991-1991, 2003-2007, 2009-2015. The average of several recovery periods also helps to filter out idiosyncrasies in fiscal policy: recovery in one period might have been higher because of expansive discretionally policy decisions unique to that period. Taking the average does not really excludes the effects of fiscal stance, but it implicitly accounts for similarities in fiscal policy decisions across recovery periods. Furthermore, we decided to consider these periods to limit distortions resulting from an ever-changing economic structure and political-economic framework. Following this methodology, we calculated s to be 0.8.

The second block of the model is inflation and monetary policy. The inflation equation requires the inflation target as an input which in our case is 2%, matching the Federal Reserve's long-term inflation target. The other important parameter is c^u the coefficient on the difference between the actual unemployment rate and the NAIRU. As we have explained before, we set this parameter to 0.98 based on Ball-Mazumder 2015.

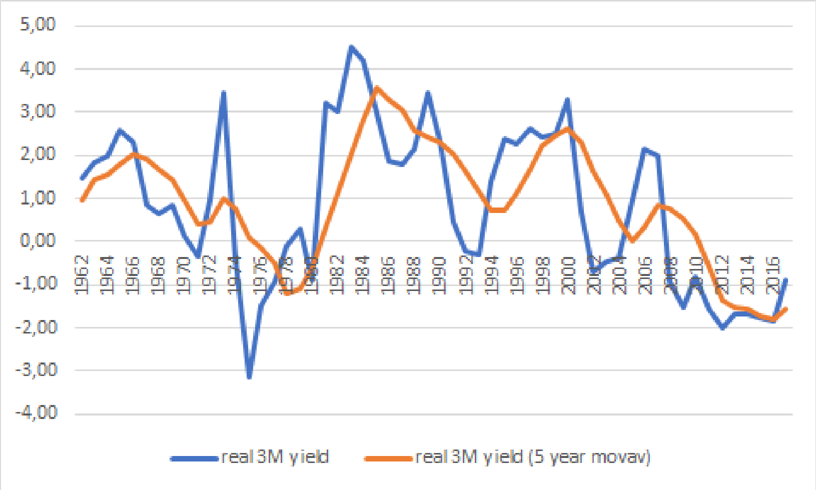
To calculate the short-term nominal interest rate the model requires as an input the short term real equilibrium interest rate rts*. One of the main purpose of this paper is to assess the impact different equilibrium real interest rate trajectories have on government debt. We will discuss in detail these interest rate trajectories in relation to different scenarios in the next section of this chapter. The yield curve is generated based on the short-term nominal interest rate, and requires two key parameters: the coefficients on 1-year and 10-year yields (c^{1y} and c^{10y}) which describe the connection between the first difference of these yields and the first difference of the 3-month yields. We estimated these parameters using historical data on government bonds and treasury bills from 1954. The resulting coefficients: c^{1y}=0,95; c^{10y}=0,45 (for details see the Appendix). Estimating 10-year yields requires other parameters as well. b^{10y} and b^{10y2} are the coefficients of the equation describing the connection between the 3-month yields and 10-year government bond yields our estimates of them are 0.02 and 0.87 respectively (for details see the Appendix). 10-year yields also require one more parameter (c^p) which captures the connection between yields and primary balance. We decided to calibrate this parameter based on Baldacci-Kummar's 2010 paper. They used a panel of 31 countries in the period of 1980-2008 to identify key determinants of long-term sovereign bond yields. They have concluded that the primary fiscal balance is indeed an important determinant of interest rates, and their paper suggest that a 1% of a GDP higher primary balance deficit corresponds to a 13.26 basis points higher 10-year government bond yields. We adopted this number in our model.

The fiscal policy block is the part of the model where the primary balance and the growth impact of a change in fiscal policy stance is calculated. Key inputs are changes in fiscal policy; these will be discussed later in their relation to the scenarios we analyze. In this section the fiscal policy multipliers are also calculated, and they require three parameters: the highest possible fiscal multiplier (μ^H) in case of a recession and zero lower bound, the lowest possible fiscal multiplier (μ^L) when the economy is at the equilibrium level of output, and the coefficient for tax multiplier ($c^{\mu T}$) which captures how much lower the multiplier is for taxes and transfers than from public investment. Based on the literature set $\mu^H = 1.5$, $\mu^L = 0.6$ and $c^{\mu T} = 0.8$. In practical terms this means that according to the model, the multiplier of taxes and transfers in 2017 was 0.56 and on public investment was 0.7. In case of an economic slowdown to near-stagnating GDP they would increase to 1 and 1.3 respectively. Changes in economic growth also affects the primary balance of the budget, as overall economic activity has an impact on government revenues and expenditures. This parameter (τ) is taken from Delong-Summers' 2012 paper. They estimate teta to be 0.333, and we adopt this number in our model.

4.2 Defining Scenarios

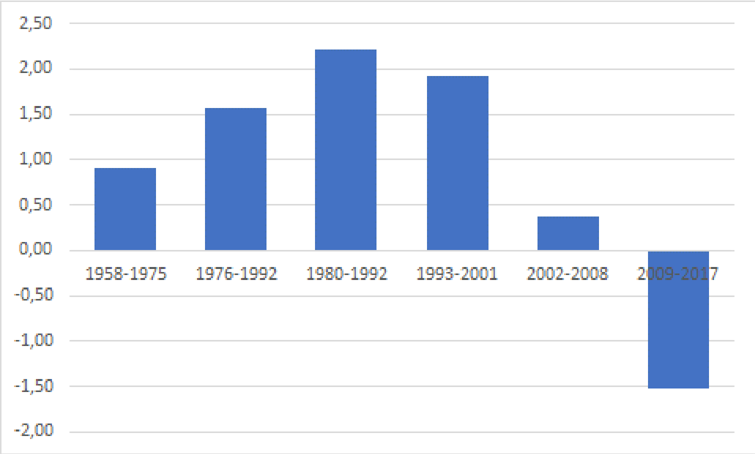
The scenarios which constitute the basis for our analysis reflect different possible combinations of exogeneous economic trends and policy decisions. Therefore, the goal of our analysis is not to create a forecast of government debt, but the make projections conditional on changes in fiscal stance and the economic environment for the purpose of comparing them. These scenarios therefore provide a more in-depth picture of public debt dynamics and can be used to assess the robustness of certain policy decisions.

One of the important variables scenario analysis is the short-term equilibrium real interest rate. As it was pointed out earlier, interest rates have been on the decline for decades, well before the crisis. It was also established that interest rates are recovering the question is, how long and how high are they going to rise.



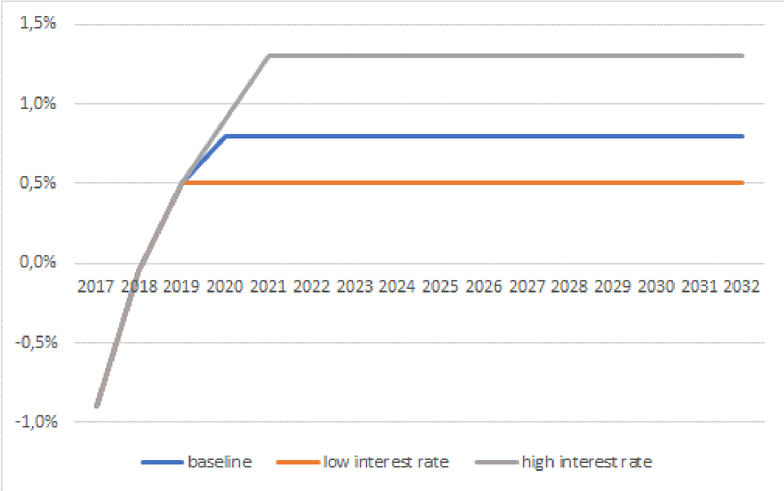
17. Figure: Real 3-Month Treasury Bill Yields (%)
(Source: Saint Louis Fed, own calculations)

Figure 18 shows the real 3-month Treasury Bill yields from 1962 onwards. It is apparent – even with the large fluctuations following business cycles that the average real rate has been on the decline. Figure 19 shows it even more clearly – how the average real yield changed from one cycle to the next. Note that the last period (2009-2017) is not a full cycle, we added it for reference.



18. Figure: Average Real 3-Month Treasury Bill Yields (%)
(Source: Saint Louis Fed, own calculations)

The historical average for real 3-month treasury bill yield, which we use as reference for the real short-term equilibrium interest rate is 1.3%. For the year of 2018 we expect this real rate to be around 0%. As we have explained in Chapter 1, it is unlikely that the real equilibrium interest rate rebounds to its historical average, but we can expect that the real rate will continue to increase to a certain extent. In or analysis we establish three scenarios for the equilibrium real short-term interest rate. In the baseline scenario we assume a rebound to 0.8%, in the low interest rate scenario the long-term average is 0.5%, while in the high interest rate scenario we assume that the real equilibrium rate returns to is historical average of 1.3%. The interest rate trajectories of these scenarios are illustrated by Figure 20.

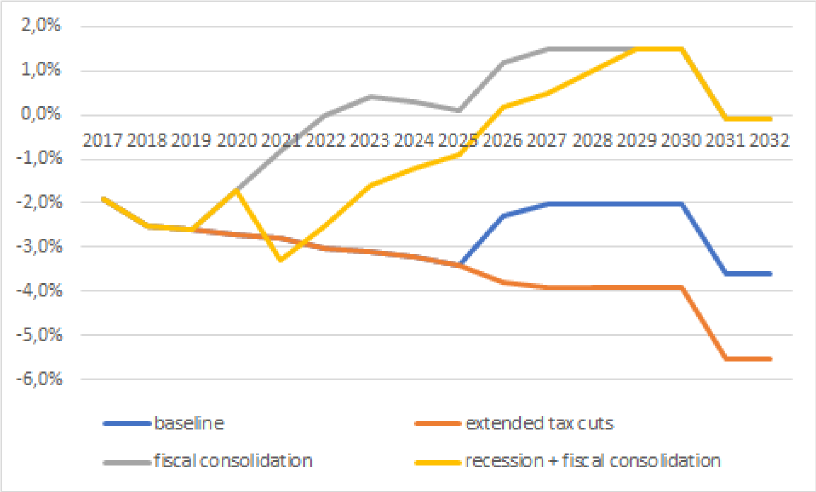


19. Figure: Equilibrium Real Short-term Interest Rate Trajectories in Different Scenarios

We also consider different fiscal policy scenarios in our analysis. As a baseline we follow the "2018 Long-Term Budget Outlook" and "The Budget and Economic Outlook: 2018 to 2028" by the Congressional Budget Office. We assume that budget revenues will stay largely flat in the period of our analysis until 2032, except for a 1.5% of the GDP rise in 2026 and 0.4% rise in 2027 when several provisions of the Tax Cuts and Jobs Act of 2017 expires. On the expenditure side, we assume a significant increase during the period of our analysis. Part of this is coming from the exhaustion of major trust funds of the budget. Many of these funds are financing popular government programs therefore in our baseline scenario we follow the assumption of the CBO, that these programs would continue, financed by the central budget. In terms of their technical implementation in our model: when a trust fund is exhausted its deficit reduces the primary balance of the government, but it has no impact on growth since the total benefits payed does not change. The funds in question and their exhaustion dates along with their deficits are: Highway Trust Fund (2022, 0.1% of GDP), Social Security Disability Insurance (2025, 0.1% of GDP), Medicare Hospital Insurance (Part A) (2026, 0.3% of GDP), Social Security Trust Funds (2031, 1.6% of GDP). The CBO project an increase in expenditures as a share of GDP from 19% in 2018 to 20.5% in 2028, however the exhaustion of the above-mentioned trust funds in this period does not explain this increase completely. In our calculations, the difference between the two is added as a gradual increase in long term budget commitments which also have an impact – albeit small – on growth.

We also establish to other scenarios. One where we assume that the provisions of the 2017 Tax Cut and Jobs Act are extended, therefore there is no increase in revenues in 2026-2027. In another scenario our assumption is that a fiscal consolidation program will start from 2020 which will improve the primary budget balance by 3.5% of the GDP over the course of four years. According the our calculations, in the baseline scenario, this is the smallest fiscal adjustment necessary to stabilize the public debt just below 70% of the GDP by 2032. The cyclically adjusted primary balances of these three scenarios are illustrated by Figure 21.

Last, but not least we also examine the possibility of a recession. For this scenario we use the baseline interest rate trajectory as the reference trajectory. We assume an exogenous 3.5% negative shock to GDP in 2021. As a response to this, the government will increase public investment by 1.5% of the GDP which will be phased out through the next two years (-0.5% public investment in 2022 and -1.0% in 2023). This according to our model result in a 0.9% recession for the year 2021. We also analyzed an alternative version of this scenario, when we assume that the government starts its fiscal consolidation program in 2020 which is interrupted by the recession in 2021, after which the fiscal consolidation continues, aiming at the 0.1% cyclically adjusted deficit by 2032, the end of the period of our analysis. The reason for this target is because this was the fiscal position necessary for deficit to stabilize in the "normal" fiscal adjustment scenario (see the details later). The cyclically adjusted primary balance for the major scenarios are illustrated by Figure 20.



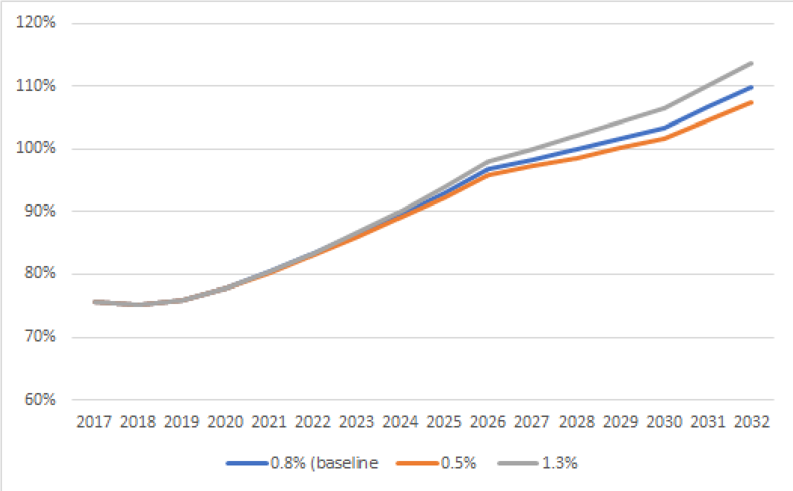
20. Figure: Cyclically Adjusted Primary Balance in % of GDP for Key Scenarios

All in all, we run no less than ten scenarios combining the aforementioned parameters. The following table summarizes these scenarios, where "X" marks an existing scenario for any given interest rate trajectory – fiscal policy combination.

Policy decisions end economic events	Description	Interest rate trajectory		
		0.5%	0.8%	1.3%
Baseline fiscal policy	follows the CBO's no policy change scenario with expiring provisions from the Tax Cut and Jobs Act of 2017.	**x**	**x**	**x**
Continued tax breaks	same as the baseline fiscal policy scenario, but the tax cuts of 2017 are extended	**x**	**x**	**x**
Fiscal consolidation	a fiscal consolidation program starts from 2020 which improves the cyclically adjusted primary balance by 3.5% in 2020-2023, in order to stabilize the debt level even if major federal programs continued after trust funds exhausted	**x**	**x**	
Fiscal consolidation 2	fiscal consolidation program starts from 2020 which improves the cyclically adjusted primary balance by 4.5% in 2020-2023, in order to set public debt on a downward path, even if major federal programs continued after trust funds exhausted	**x**	**x**	
Recession	A recession hits the economy in 2021 which is counteracted by a public investment increase of 1.5% of GDP which is phased out in the following two years.		**x**	
Recession with fiscal consolidation	A recession hits the economy in in 2021 in the midst of a fiscal consolidation program which is consequently interrupted, but resumed after the recession, aiming to reach a 0.1% primary deficit.		**x**	

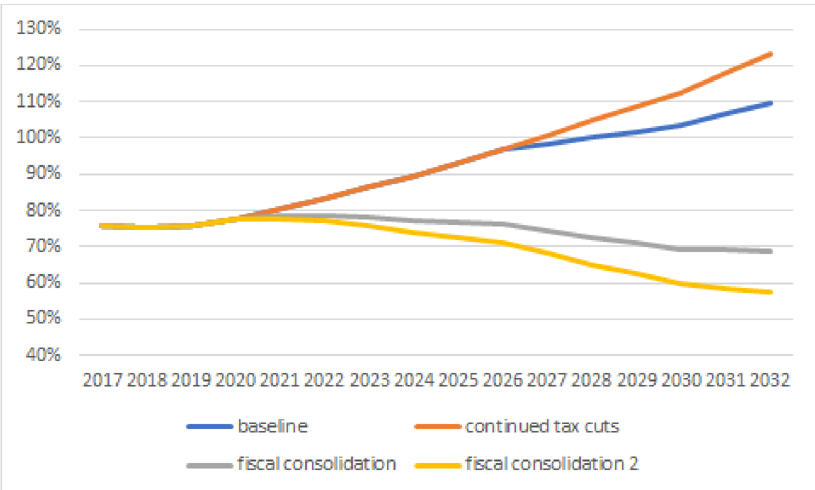
4.3 Results

First, we examined how the baseline fiscal policy scenario is affected by different real short-term equilibrium interest rate trajectories. As Figure 21 shows, there is only small difference in the public debt to GDP ratio at the end of the forecasting period, therefore we can conclude that different real short-term equilibrium interest rates (at least in the range of possibilities we explored) does not have a major impact on the public debt trajectory.



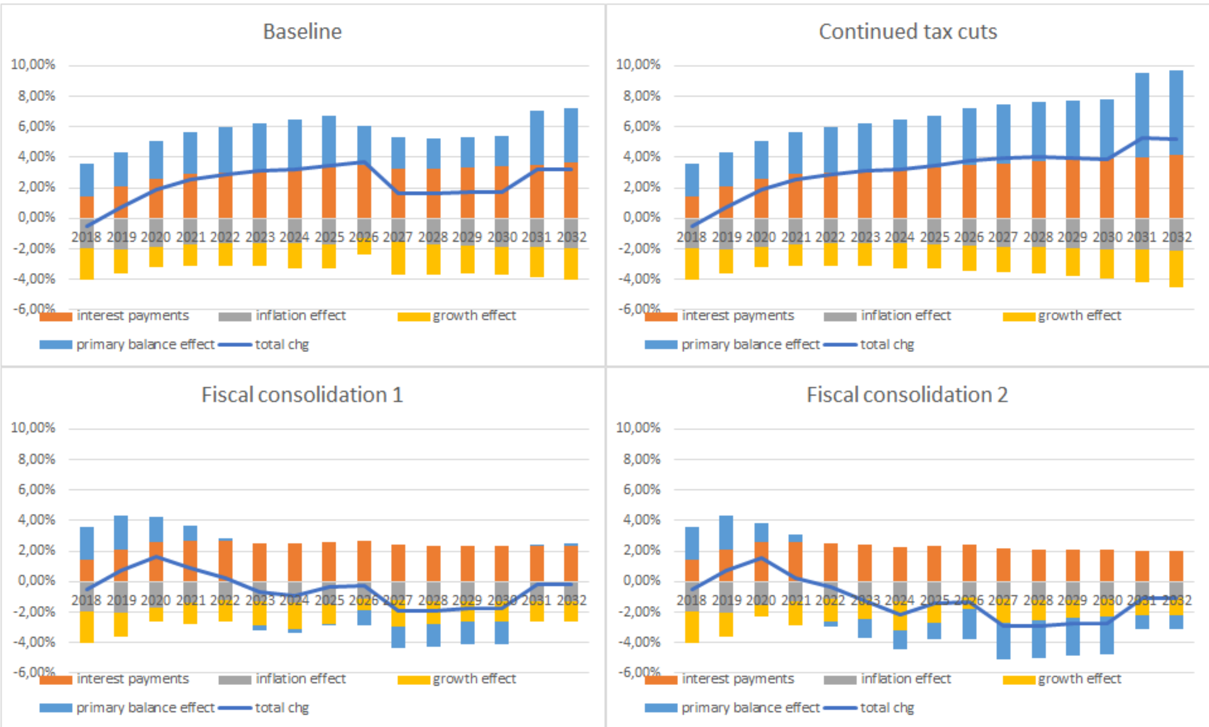
21. Figure: Public Debt to GDP Ratio (%) in Case of Different Real Short-term Equilibrium Interest Rates

Firgure 22 illustrates the public debt to GDP trajectories in case of different fiscal policy scenarios. As we can see, in case provisions of the 2017 Tax Cut and Jobs Act is extended public debt increases exponentially, due to increasing interest rate costs and the exhaustion of major trust funds of the budget. In the fiscal consolidation scenario, when the government successfully completes a fiscal consolidation program, improving the cyclically adjusted primary balance by 3.5% of the GDP, public debt stabilizes just below 70% of the GDP after major trust funds are exhausted. To keep government debt on a decreasing trajectory requires an even larger, 4.5% improvement in the primary balance (fiscal consolidation 2).



22. Figure: Public Debt to GDP Ratio (%) in Case of Different Fiscal Policy Scenarios

The next set of charts shows the decomposition of public debt changes in these four scenarios during the forecasting period. Notice how without fiscal consolidation interest rate payments continue to increase throughout the period. Also note that in the "fiscal consolidation scenario 1", there is a period between the expiry of tax cuts and the exhaustion of social security trust funds when public debt is on decline. This allows public debt to GDP ratio to stabilize at a lower level with lower interest payments.



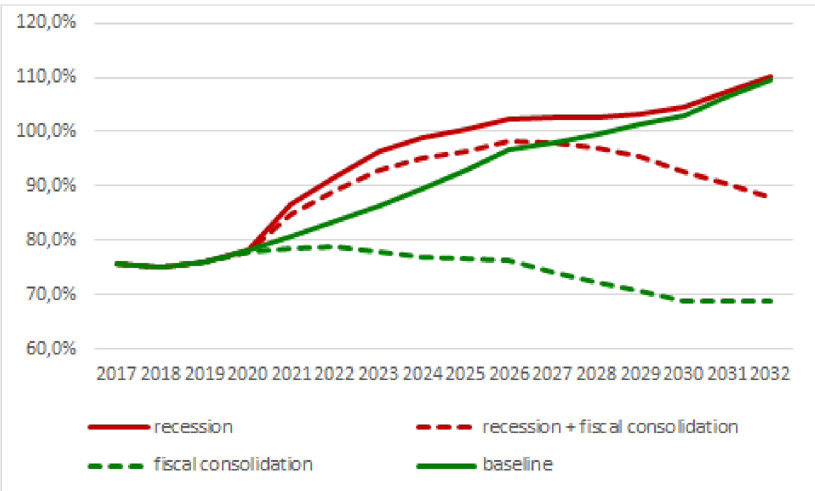
23. Figure: Decomposition of Public Debt Changes in Different Fiscal Policy Scenarios (in % of GDP)

Finally, we examine the case of a recession, and its impact on debt trajectories. As it was described before, we look at the case of a 3.5% negative shock to the total output which is partially counteracted by an increase of 1% of the GDP in public investment. This results in a 0.9% recession in out model. The following figure shows the GDP growth in the "baseline" and "recession" scenarios.

24. Figure: GDP growth (%) in the "baseline" and "recession" scenarios

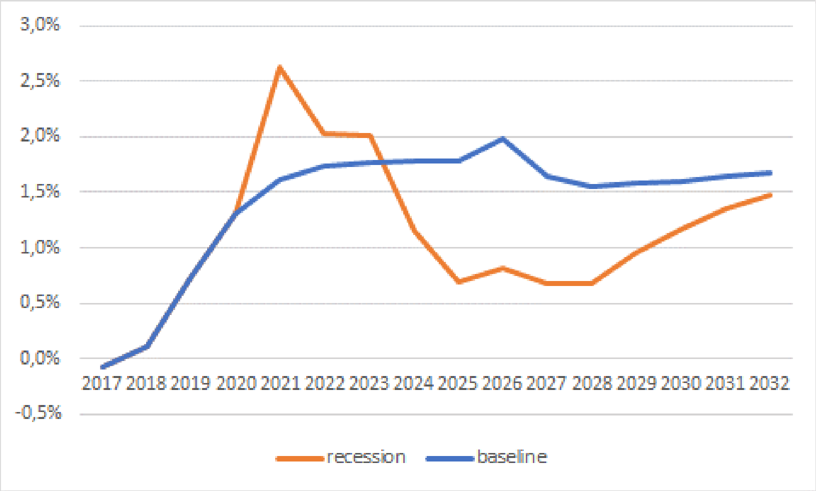
Notice, how after the recession GDP growth is higher than in the baseline scenario. This is because as a result of the recession the output gap becomes negative, and in the model the economy always converges towards the equilibrium level of output, hence the higher growth after the recession. Also note, that by the end of the forecasting period, the two growth rates are once again identical.

Figure 26 illustrates the public debt trajectories in the case of a recession, with and without fiscal consolidation, and compares them to "baseline" and fiscal consolidation scenarios.



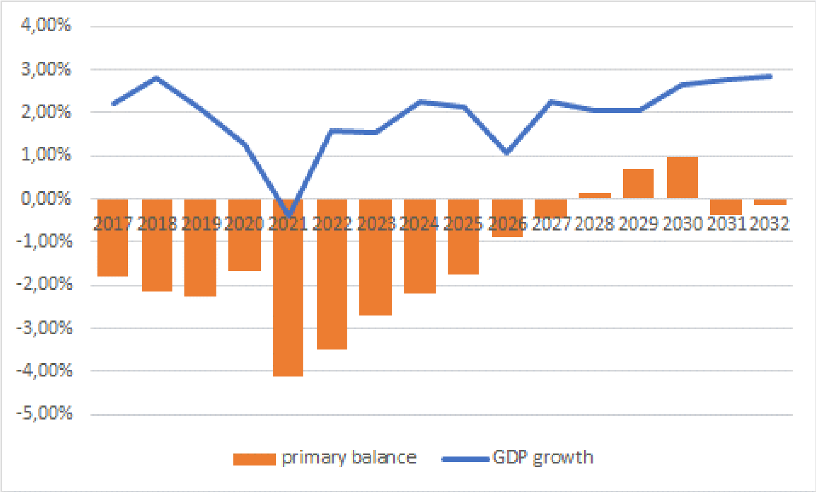
25. Figure: Public Debt to GDP Ratio (%) in Case of Different Scenarios

This chart reveals a few interesting findings. It may look surprising that comparing the "recession" scenario to the baseline, public debt to GDP first increases a lot more quickly, but by the end of the period they are approximately at the same level. It is because in our model, case of a recession interest rates decline, which lowers debt financing cost. But this takes effect with some delay after the actual recession with the refinancing of loans. Figure 27 illustrates this effect.

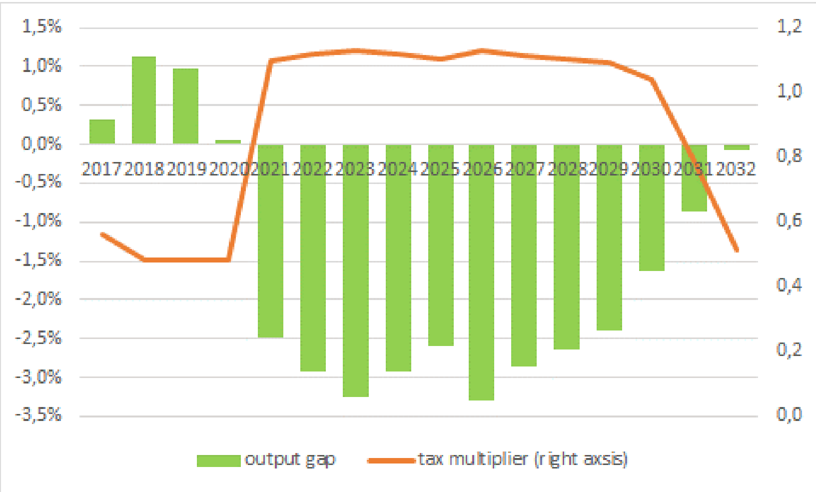


26. Figure: Average Real Interest Rate on Government Debt in „Baseline" and „Recession" Scenarios

Another interesting finding our calculations suggest is that it would be difficult to set public debt in a sustainable path in case of a recession. In the "recession + fiscal consolidation" scenario, we assume that after the recession, the government resumes its fiscal consolidation program to achieve a primary deficit of 0.1% of the GDP, the fiscal position necessary for stabilizing debt in the "normal" fiscal consolidation scenario. As Figure 26 suggests, according to our model, public debt would continue to rise after the recession for 8 years despite the ongoing fiscal consolidation. The following two figures reveal main reason behind this phenomenon.



27. Figure: GDP Growth and Primary Balance in % of the GDP in the „Recession + Fiscal Consolidation" Scenario



28. Figure: Output Gap and Tax-Transfer Multiplier GDP in the „Recession + Fiscal Consolidation" Scenario

As figure 28 and 29 reveal, that while the government have been continuously improving its primary balances after the recession, it was doing so at a time when fiscal multipliers are higher, which contributed to a depressed economic output (negative output gap) throughout the period. This suggest the possible danger, that in case of an economic downturn public debt may stay at persistently high levels.

4.4 Limitations of the Analysis

Before the final, concluding remarks, it is important to point out a few limitations of our analysis, which should be considered when interpreting the results. First – as it was highlighted before – the purpose of these work is not forecasting. Different scenarios were created to illustrate how the public debt to GDP trajectory would respond to different fiscal policy decisions and changes in the external environment. The auxiliary variables – such as GDP growth, or unemployment – calculated by the model cannot be considered forecasts either. Our model is designed to always return to a long-term equilibrium state which is generated from the exogeneous variables (productivity growth, working age population, real short-term equilibrium interest rate etc.), while allowing for external shocks to be introduced to the system.

One specific limitation of the model which should be highlighted is monetary policy. In the "real world" monetary policy reacts to the changes in inflation relative the long-term target and sets the interest rate accordingly, which has an impact on economic growth: higher interest rates discourage investment end encourage savings, leading to a cooldown of the economy, lower demand, hence lower inflation. In our model the economy returns to its equilibrium state independently of the interest rate equation, but since interest rates and inflation both depend on output gap, it allows all these variables to move together with internal consistency. This was a simplification we introduced, because monetary policy is, by design, a partially external factor in our model. The real-short term interest rate is an exogeneous variable, which is one of the main component of the equation defining the short-term nominal interest rate. The model still allows the real short-term interest rate to change in response to movements in inflation and output gap, but they fluctuate around the real short-term equilibrium interest rate, which describes our long-term view on the equilibrium interest rate.

Despite these constraints we argue that for most scenarios our model estimates monetary policy responses adequately. This however may not be fully the case in the recession with fiscal consolidation scenario. The potential caveat is that the real short-term equilibrium interest rate is not a fully exogenous variable in this context. As we explored the Chapter 1 monetary policy of central bank had an impact on the equilibrium interest rate in the past, when they started asset-purchase programs to combat deflationary pressures. In this specific scenario, when economic output stays below its potential for years we could see the Federal Reserve engaging in a similar program, which pushes real equilibrium interest rates down. This would result in a lower debt to GDP trajectory than our estimates.

We also decided not to put a premium on interest rates based on the debt to GDP ratio. This is justified by the fact that the United States government is in a unique position when it comes to financing its debt. Because of the dollars dominant position in international transactions, the US can more easily draw financing from external markets. However, if debt continues on its unsustainable upward path, this may change, as it undermines confidence in the US governments ability to meet its obligations. If this was the case, then our estimates for higher debt trajectories are lower their real values would be.

Conclusion

In this paper we explored how the government debt sustainability of the United States There is no shortage of literature on this subject, including the official reports US government instructions connected to the budgeting process (like the CBO) and analyses of independent think-thanks (like the CRFB), but we still believe our paper can make a meaningful contribution. In creating our projections we now only consider different fiscal policy decisions, but also looking at alternative scenarios for the short-term equilibrium real interest rate, and consider the potential effects of a recession.

From our calculations we can conclude that different real equilibrium interest rate paths have little effect on the debt to GDP ratio in the time-horizon of our analysis: even is interest rates stay below their historical average, public debt is still on an unsustainable path.

By examining various potential fiscal policy decisions, we conclude, that in case major federal programs are continued, even after their respective trust funds are exhausted, the federal government would need to improve its primary balance by 3.5% in order for public debt to GDP ratio to stabilize just below 70%. To achieve a long-term downward debt to GDP trajectory, the fiscal adjustment should be 4.5%.

As we analyzed recession-scenarios, we concluded, that a recession would significantly alter the long-term debt trajectory, due to the subsequent fall in interest rates leads to lower financing costs. Nonetheless this small difference is measured compared to an already unsustainable path. When considering fiscal consolidation after the recession we find that it could take several years for the government to set public debt to GDP on a downward path because fiscal multipliers are higher when economic output is below its potential. This makes fiscal adjustment more costly in terms of its impact on GDP growth.

To summarize: or calculations confirm the that the US public debt is on an unsustainable path. Although the debt trajectory appears to be robust to changes in the short term equilibrium real interest rate, a recession can significantly worsen the situation.

Policy Recommendations

Based on our findings the United States government should start improving its primary balances as soon as possible. Our model confirmed the CBO's statement according to which the later the adjustment starts, the more "expensive" it gets due to escalating interest rate expenditures. It is also important to note that the US is currently in its second longest expansion period (when GDP grew in each consecutive year without recessions). Although it cannot be forecasted how long it will last exactly, but it is possible that the US only have a few years before the next economic downturn comes. Even if it will not be as severe as the recession in our calculations, an economic slowdown could push government debt off from a sustainable path. This is especially true considering that political commitment may be lacking to resume fiscal consolidation immediately after the recession, due to the unpopularity of such measures.

The president's 2019 budget plan propose a fiscal path to put debt on a sustainable trajectory. Although the initial estimates of the OMB (Office and Management of Budget) were overly optimistic, the CBO confirmed that the numbers proposed can at least prevent debt to GDP ratio to rise above 90% by 2028 (CBO, 2018). This however hardly offers any reassurance, considering that according to the proposal, the budget balance improvements come largely from unspecified cuts on the expenditure side. In other words, there is no meaningful political commitment behind the document.

One the most significant negative factors on government debt sustainability are the exhaustion of trust funds, especially the ones related to social programs (Social Security, Medicare, Medicaid). This is especially true when considering the political cost of simply cutting these programs upon their insolvency. However, if they are continued, they will become a major drain on the federal budget. Finding long term solutions to make these programs sustainable should be a priority.

Finally, it is not the subject of these papers to discuss the merits and downsides of the 2017 Tax Cut and Jobs Act in terms of economic incentives and income inequality, but from budgeting perspective they definitely came at a wrong time. They were a procyclical measure adopted when actual GDP output is estimated to be above the potential level, which likely dampened their effect on economic growth. On the other hand, they further widened budget deficits exacerbating the US’s debt-problem. The provisions of this Act should not be extended past 2026-2027. A failure to allow to them to expire combined with the exhaustion of major trust funds could put public debt to GDP ratio on an exponentially increasing trajectory.

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Appendices

Appendix A: Output Tables for Scenarios

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect		GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%							2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%		2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%		2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	78,10%	2,02%	2,49%	-1,71%	-1,29%	2,53%		1,73%	2,34%	-2,53%	3,68%	-5,40%	1,3%
2021	4	80,66%	2,56%	2,76%	-1,56%	-1,39%	2,75%		1,82%	2,08%	-2,75%	3,73%	-5,76%	1,6%
2022	5	83,47%	2,81%	2,89%	-1,55%	-1,52%	2,99%		1,92%	2,00%	-2,99%	3,77%	-6,14%	1,7%
2023	6	86,46%	2,99%	3,03%	-1,60%	-1,53%	3,09%		1,87%	1,99%	-3,09%	3,79%	-6,37%	1,8%
2024	7	89,54%	3,08%	3,16%	-1,66%	-1,61%	3,19%		1,90%	1,99%	-3,19%	3,80%	-6,60%	1,8%
2025	8	92,93%	3,39%	3,28%	-1,71%	-1,57%	3,39%		1,78%	1,99%	-3,39%	3,81%	-6,93%	1,8%
2026	9	96,57%	3,64%	3,45%	-1,34%	-1,00%	2,53%		1,08%	1,48%	-2,53%	3,49%	-5,90%	2,0%
2027	10	98,04%	1,47%	3,24%	-1,68%	-2,16%	2,07%		2,29%	1,81%	-2,07%	3,48%	-5,48%	1,6%
2028	11	99,58%	1,54%	3,28%	-1,83%	-1,92%	2,01%		2,00%	1,94%	-2,01%	3,52%	-5,52%	1,6%
2029	12	101,32%	1,75%	3,38%	-1,86%	-1,78%	2,01%		1,82%	1,94%	-2,01%	3,55%	-5,60%	1,6%
2030	13	103,08%	1,75%	3,47%	-1,89%	-1,83%	2,01%		1,84%	1,94%	-2,01%	3,57%	-5,69%	1,6%
2031	14	106,34%	3,27%	3,54%	-1,92%	-1,97%	3,61%		1,95%	1,93%	-3,61%	3,61%	-7,45%	1,6%
2032	15	109,56%	3,22%	3,69%	-1,97%	-2,11%	3,61%		2,03%	1,93%	-3,61%	3,63%	-7,58%	1,7%

29. Figure: Output Table: real short term equilibrium interest rate (rse) = 0.8%; baseline fiscal policy

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect		GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%							2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%		2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%		2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	78,10%	2,02%	2,49%	-1,71%	-1,29%	2,53%		1,73%	2,34%	-2,53%	3,59%	-5,34%	1,2%
2021	4	80,60%	2,50%	2,70%	-1,56%	-1,39%	2,75%		1,82%	2,08%	-2,75%	3,59%	-5,65%	1,5%
2022	5	83,29%	2,70%	2,78%	-1,55%	-1,52%	2,99%		1,92%	2,00%	-2,99%	3,59%	-5,98%	1,6%
2023	6	86,14%	2,85%	2,88%	-1,60%	-1,53%	3,09%		1,87%	1,99%	-3,09%	3,59%	-6,18%	1,6%
2024	7	89,05%	2,91%	2,97%	-1,65%	-1,60%	3,19%		1,90%	1,99%	-3,19%	3,58%	-6,37%	1,6%
2025	8	92,25%	3,20%	3,07%	-1,70%	-1,56%	3,39%		1,78%	1,99%	-3,39%	3,56%	-6,68%	1,5%
2026	9	95,67%	3,42%	3,21%	-1,33%	-0,98%	2,53%		1,08%	1,47%	-2,53%	3,24%	-5,63%	1,7%
2027	10	96,92%	1,25%	2,98%	-1,66%	-2,14%	2,07%		2,29%	1,80%	-2,07%	3,22%	-5,19%	1,4%
2028	11	98,21%	1,29%	3,00%	-1,81%	-1,91%	2,01%		2,01%	1,94%	-2,01%	3,26%	-5,21%	1,3%
2029	12	99,71%	1,50%	3,08%	-1,83%	-1,76%	2,01%		1,82%	1,94%	-2,01%	3,28%	-5,28%	1,3%
2030	13	101,21%	1,50%	3,15%	-1,86%	-1,80%	2,01%		1,84%	1,94%	-2,01%	3,30%	-5,35%	1,3%
2031	14	104,22%	3,01%	3,22%	-1,88%	-1,93%	3,61%		1,95%	1,93%	-3,61%	3,34%	-7,09%	1,4%
2032	15	107,17%	2,95%	3,35%	-1,93%	-2,07%	3,61%		2,03%	1,93%	-3,61%	3,36%	-7,21%	1,4%

30. Figure: Output Table: rse = 0.5%; baseline fiscal policy

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect	GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%						2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%	2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%	2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	78,10%	2,02%	2,49%	-1,71%	-1,29%	2,53%	1,73%	2,34%	-2,53%	3,70%	-5,42%	1,3%
2021	4	80,68%	2,58%	2,78%	-1,56%	-1,39%	2,75%	1,82%	2,08%	-2,75%	3,89%	-5,89%	1,8%
2022	5	83,61%	2,93%	3,02%	-1,55%	-1,52%	2,99%	1,92%	2,00%	-2,99%	4,02%	-6,35%	2,0%
2023	6	86,80%	3,19%	3,24%	-1,61%	-1,53%	3,09%	1,87%	1,99%	-3,09%	4,10%	-6,65%	2,1%
2024	7	90,15%	3,34%	3,43%	-1,66%	-1,61%	3,19%	1,90%	1,99%	-3,19%	4,16%	-6,94%	2,1%
2025	8	93,85%	3,70%	3,61%	-1,72%	-1,58%	3,39%	1,78%	1,99%	-3,39%	4,19%	-7,33%	2,2%
2026	9	97,84%	4,00%	3,84%	-1,35%	-1,01%	2,52%	1,09%	1,48%	-2,52%	3,90%	-6,34%	2,4%
2027	10	99,69%	1,84%	3,66%	-1,70%	-2,19%	2,07%	2,29%	1,81%	-2,07%	3,91%	-5,96%	2,1%
2028	11	101,63%	1,94%	3,75%	-1,86%	-1,95%	2,01%	2,00%	1,94%	-2,01%	3,96%	-6,03%	2,0%
2029	12	103,80%	2,17%	3,88%	-1,90%	-1,82%	2,01%	1,82%	1,94%	-2,01%	3,99%	-6,15%	2,0%
2030	13	105,99%	2,19%	3,99%	-1,94%	-1,88%	2,01%	1,84%	1,94%	-2,01%	4,02%	-6,27%	2,0%
2031	14	109,70%	3,71%	4,10%	-1,97%	-2,02%	3,61%	1,95%	1,93%	-3,61%	4,06%	-8,06%	2,1%
2032	15	113,38%	3,68%	4,28%	-2,03%	-2,18%	3,61%	2,03%	1,93%	-3,61%	4,08%	-8,23%	2,1%

31. Figure: Output Table: rse = 1.3%; baseline fiscal policy

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect	GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%						2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%	2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%	2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	78,10%	2,02%	2,49%	-1,71%	-1,29%	2,53%	1,73%	2,34%	-2,53%	3,68%	-5,40%	1,3%
2021	4	80,66%	2,56%	2,76%	-1,56%	-1,39%	2,75%	1,82%	2,08%	-2,75%	3,73%	-5,76%	1,6%
2022	5	83,47%	2,81%	2,89%	-1,55%	-1,52%	2,99%	1,92%	2,00%	-2,99%	3,77%	-6,14%	1,7%
2023	6	86,46%	2,99%	3,03%	-1,60%	-1,53%	3,09%	1,87%	1,99%	-3,09%	3,79%	-6,37%	1,8%
2024	7	89,54%	3,08%	3,16%	-1,66%	-1,61%	3,19%	1,90%	1,99%	-3,19%	3,80%	-6,60%	1,8%
2025	8	92,93%	3,39%	3,28%	-1,71%	-1,57%	3,39%	1,78%	1,99%	-3,39%	3,81%	-6,93%	1,8%
2026	9	96,70%	3,77%	3,41%	-1,77%	-1,65%	3,79%	1,81%	1,98%	-3,79%	3,82%	-7,48%	1,8%
2027	10	100,59%	3,89%	3,55%	-1,84%	-1,71%	3,89%	1,80%	1,98%	-3,89%	3,81%	-7,73%	1,8%
2028	11	104,57%	3,98%	3,70%	-1,88%	-1,74%	3,91%	1,76%	1,94%	-3,91%	3,77%	-7,85%	1,8%
2029	12	108,46%	3,89%	3,80%	-1,95%	-1,86%	3,91%	1,82%	1,94%	-3,91%	3,74%	-7,96%	1,8%
2030	13	112,29%	3,83%	3,91%	-2,02%	-1,96%	3,91%	1,84%	1,94%	-3,91%	3,72%	-8,08%	1,7%
2031	14	117,58%	5,29%	4,01%	-2,09%	-2,14%	5,51%	1,95%	1,93%	-5,51%	3,71%	-9,87%	1,7%
2032	15	122,77%	5,19%	4,20%	-2,18%	-2,33%	5,51%	2,03%	1,93%	-5,51%	3,70%	-10,05%	1,7%

32. Figure: Output Table: rse =0.8%; provisions of 2017 tax cuts extended

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect	GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%						2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%	2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%	2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	77,86%	1,78%	2,51%	-1,48%	-0,94%	1,69%	1,25%	2,01%	-1,69%	3,45%	-4,37%	1,4%
2021	4	78,67%	0,81%	2,59%	-1,31%	-1,38%	0,91%	1,81%	1,74%	-0,91%	3,35%	-3,55%	1,6%
2022	5	78,71%	0,04%	2,55%	-1,24%	-1,44%	0,17%	1,86%	1,63%	-0,17%	3,27%	-2,74%	1,6%
2023	6	77,87%	-0,84%	2,47%	-1,36%	-1,64%	-0,32%	2,13%	1,80%	0,32%	3,31%	-2,26%	1,5%
2024	7	76,88%	-0,99%	2,47%	-1,49%	-1,66%	-0,31%	2,18%	1,99%	0,31%	3,46%	-2,35%	1,4%
2025	8	76,52%	-0,36%	2,56%	-1,47%	-1,35%	-0,11%	1,78%	1,99%	0,11%	3,56%	-2,62%	1,5%
2026	9	76,28%	-0,24%	2,66%	-1,10%	-0,82%	-0,97%	1,08%	1,48%	0,97%	3,33%	-1,57%	1,8%
2027	10	74,26%	-2,02%	2,44%	-1,32%	-1,71%	-1,43%	2,29%	1,81%	1,43%	3,39%	-1,09%	1,6%
2028	11	72,35%	-1,92%	2,42%	-1,38%	-1,46%	-1,49%	2,00%	1,94%	1,49%	3,48%	-1,02%	1,5%
2029	12	70,63%	-1,72%	2,42%	-1,35%	-1,29%	-1,49%	1,82%	1,94%	1,49%	3,54%	-1,00%	1,6%
2030	13	68,95%	-1,68%	2,41%	-1,32%	-1,28%	-1,49%	1,84%	1,94%	1,49%	3,59%	-0,98%	1,6%
2031	14	68,83%	-0,11%	2,38%	-1,28%	-1,32%	0,11%	1,95%	1,93%	-0,11%	3,65%	-2,62%	1,7%
2032	15	68,71%	-0,12%	2,41%	-1,28%	-1,37%	0,11%	2,03%	1,93%	-0,11%	3,68%	-2,63%	1,7%

33. Figure: Output Table: rse =0.8%; fiscal consolidation 1

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect		GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%							2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%		2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%		2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	77,74%	1,66%	2,52%	-1,37%	-0,76%	1,27%		1,01%	1,85%	-1,27%	3,34%	-3,86%	1,5%
2021	4	77,85%	0,11%	2,50%	-1,29%	-1,53%	0,43%		2,01%	1,72%	-0,43%	3,26%	-2,97%	1,5%
2022	5	77,30%	-0,54%	2,45%	-1,22%	-1,45%	-0,33%		1,89%	1,62%	0,33%	3,20%	-2,15%	1,6%
2023	6	75,88%	-1,42%	2,39%	-1,19%	-1,40%	-1,22%		1,84%	1,60%	1,22%	3,14%	-1,16%	1,5%
2024	7	73,58%	-2,30%	2,28%	-1,44%	-1,83%	-1,31%		2,47%	1,99%	1,31%	3,34%	-1,15%	1,3%
2025	8	72,14%	-1,44%	2,37%	-1,41%	-1,29%	-1,11%		1,78%	1,99%	1,11%	3,48%	-1,40%	1,5%
2026	9	70,80%	-1,34%	2,45%	-1,04%	-0,77%	-1,97%		1,08%	1,48%	1,97%	3,28%	-0,35%	1,8%
2027	10	67,79%	-3,01%	2,23%	-1,23%	-1,58%	-2,43%		2,29%	1,81%	2,43%	3,35%	0,16%	1,5%
2028	11	64,89%	-2,90%	2,19%	-1,26%	-1,33%	-2,49%		2,00%	1,94%	2,49%	3,46%	0,25%	1,5%
2029	12	62,19%	-2,70%	2,16%	-1,21%	-1,16%	-2,49%		1,82%	1,94%	2,49%	3,53%	0,30%	1,6%
2030	13	59,52%	-2,66%	2,12%	-1,16%	-1,12%	-2,49%		1,84%	1,94%	2,49%	3,59%	0,36%	1,6%
2031	14	58,44%	-1,08%	2,06%	-1,11%	-1,14%	-0,89%		1,95%	1,93%	0,89%	3,67%	-1,25%	1,7%
2032	15	57,37%	-1,08%	2,06%	-1,08%	-1,16%	-0,89%		2,03%	1,93%	0,89%	3,70%	-1,23%	1,7%

34. Figure: Output Table: rse =0.8%; fiscal consolidation 2

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect		GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%							2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%		2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%		2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	77,86%	1,78%	2,51%	-1,48%	-0,94%	1,69%		1,25%	2,01%	-1,69%	3,36%	-4,31%	1,3%
2021	4	78,61%	0,75%	2,53%	-1,31%	-1,38%	0,92%		1,80%	1,74%	-0,92%	3,21%	-3,44%	1,4%
2022	5	78,56%	-0,06%	2,44%	-1,23%	-1,44%	0,17%		1,86%	1,62%	-0,17%	3,09%	-2,60%	1,4%
2023	6	77,59%	-0,97%	2,34%	-1,35%	-1,64%	-0,31%		2,13%	1,79%	0,31%	3,11%	-2,10%	1,3%
2024	7	76,45%	-1,14%	2,31%	-1,48%	-1,66%	-0,31%		2,19%	1,99%	0,31%	3,24%	-2,16%	1,2%
2025	8	75,92%	-0,53%	2,38%	-1,46%	-1,34%	-0,11%		1,78%	1,99%	0,11%	3,33%	-2,41%	1,3%
2026	9	75,50%	-0,41%	2,46%	-1,09%	-0,81%	-0,97%		1,08%	1,47%	0,97%	3,09%	-1,36%	1,6%
2027	10	73,32%	-2,19%	2,24%	-1,31%	-1,69%	-1,43%		2,29%	1,80%	1,43%	3,13%	-0,86%	1,3%
2028	11	71,22%	-2,10%	2,20%	-1,37%	-1,44%	-1,49%		2,01%	1,94%	1,49%	3,21%	-0,80%	1,2%
2029	12	69,33%	-1,89%	2,20%	-1,33%	-1,27%	-1,49%		1,82%	1,94%	1,49%	3,27%	-0,77%	1,3%
2030	13	67,47%	-1,86%	2,18%	-1,29%	-1,25%	-1,49%		1,84%	1,94%	1,49%	3,32%	-0,74%	1,4%
2031	14	67,19%	-0,28%	2,15%	-1,25%	-1,29%	0,11%		1,95%	1,93%	-0,11%	3,38%	-2,38%	1,4%
2032	15	66,90%	-0,29%	2,18%	-1,25%	-1,33%	0,11%		2,03%	1,93%	-0,11%	3,41%	-2,39%	1,5%

35. Figure: Output Table: rse =0.5%; fiscal consolidation 1

year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect		GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%							2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%		2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%		2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	77,74%	1,66%	2,52%	-1,37%	-0,76%	1,27%		1,01%	1,85%	-1,27%	3,25%	-3,80%	1,4%
2021	4	77,79%	0,05%	2,44%	-1,29%	-1,53%	0,43%		2,01%	1,72%	-0,43%	3,13%	-2,86%	1,4%
2022	5	77,15%	-0,64%	2,35%	-1,21%	-1,44%	-0,33%		1,89%	1,62%	0,33%	3,03%	-2,01%	1,4%
2023	6	75,61%	-1,54%	2,26%	-1,19%	-1,39%	-1,22%		1,84%	1,59%	1,22%	2,94%	-1,00%	1,3%
2024	7	73,16%	-2,45%	2,13%	-1,44%	-1,83%	-1,31%		2,48%	1,99%	1,31%	3,12%	-0,97%	1,1%
2025	8	71,57%	-1,59%	2,20%	-1,40%	-1,28%	-1,11%		1,78%	1,99%	1,11%	3,24%	-1,21%	1,2%
2026	9	70,06%	-1,50%	2,26%	-1,03%	-0,76%	-1,97%		1,08%	1,47%	1,97%	3,03%	-0,15%	1,5%
2027	10	66,89%	-3,17%	2,04%	-1,21%	-1,57%	-2,43%		2,29%	1,80%	2,43%	3,10%	0,36%	1,3%
2028	11	63,83%	-3,06%	1,99%	-1,25%	-1,32%	-2,49%		2,01%	1,94%	2,49%	3,20%	0,45%	1,2%
2029	12	60,97%	-2,86%	1,97%	-1,19%	-1,14%	-2,49%		1,82%	1,94%	2,49%	3,27%	0,50%	1,3%
2030	13	58,15%	-2,81%	1,92%	-1,14%	-1,10%	-2,49%		1,84%	1,94%	2,49%	3,33%	0,56%	1,4%
2031	14	56,93%	-1,22%	1,86%	-1,08%	-1,11%	-0,89%		1,95%	1,93%	0,89%	3,40%	-1,04%	1,4%
2032	15	55,71%	-1,22%	1,86%	-1,06%	-1,13%	-0,89%		2,03%	1,93%	0,89%	3,43%	-1,02%	1,5%

36. Figure: Output Table: rse =0.5%; fiscal consolidation 2

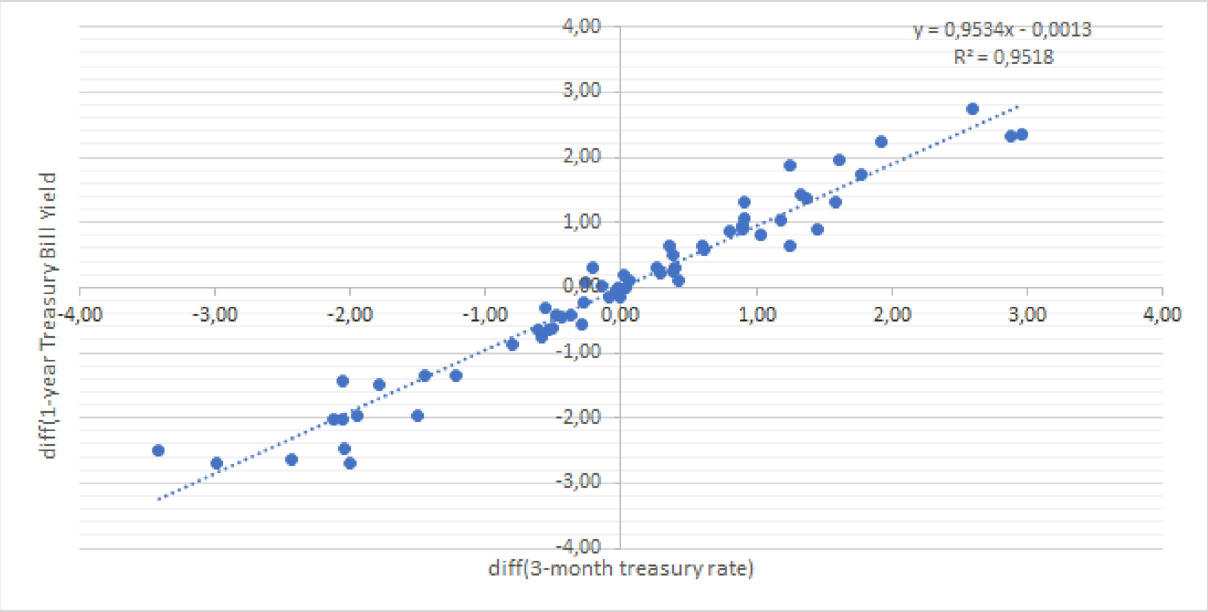
year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect		GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%							2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%		2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%		2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	78,10%	2,02%	2,49%	-1,71%	-1,29%	2,53%		1,73%	2,34%	-2,53%	3,68%	-5,40%	1,3%
2021	4	86,62%	8,53%	2,89%	-0,19%	0,69%	5,13%		-0,88%	0,24%	-5,13%	2,88%	-7,62%	2,6%
2022	5	91,59%	4,96%	2,43%	-0,32%	-1,91%	4,76%		2,25%	0,37%	-4,76%	2,41%	-6,97%	2,0%
2023	6	96,43%	4,84%	2,18%	-0,06%	-1,28%	4,00%		1,42%	0,07%	-4,00%	2,07%	-6,00%	2,0%
2024	7	98,92%	2,50%	1,93%	-0,62%	-2,63%	3,81%		2,81%	0,66%	-3,81%	1,82%	-5,62%	1,2%
2025	8	100,59%	1,66%	1,73%	-1,21%	-2,59%	3,73%		2,69%	1,27%	-3,73%	1,98%	-5,71%	0,7%
2026	9	102,41%	1,82%	1,93%	-1,14%	-1,65%	2,67%		1,66%	1,16%	-2,67%	1,99%	-4,72%	0,8%
2027	10	102,63%	0,23%	1,96%	-1,54%	-2,39%	2,19%		2,39%	1,56%	-2,19%	2,24%	-4,49%	0,7%
2028	11	102,59%	-0,04%	2,21%	-1,90%	-2,36%	2,01%		2,35%	1,93%	-2,01%	2,63%	-4,71%	0,7%
2029	12	103,44%	0,84%	2,60%	-1,92%	-1,84%	2,01%		1,83%	1,94%	-2,01%	2,91%	-5,02%	1,0%
2030	13	104,54%	1,11%	2,90%	-1,93%	-1,87%	2,01%		1,84%	1,94%	-2,01%	3,12%	-5,27%	1,2%
2031	14	107,35%	2,81%	3,14%	-1,94%	-2,00%	3,61%		1,95%	1,93%	-3,61%	3,31%	-7,16%	1,4%
2032	15	110,25%	2,90%	3,42%	-1,99%	-2,13%	3,61%		2,03%	1,93%	-3,61%	3,44%	-7,40%	1,5%

37. Figure: Output Table: rse =0.8%; recession

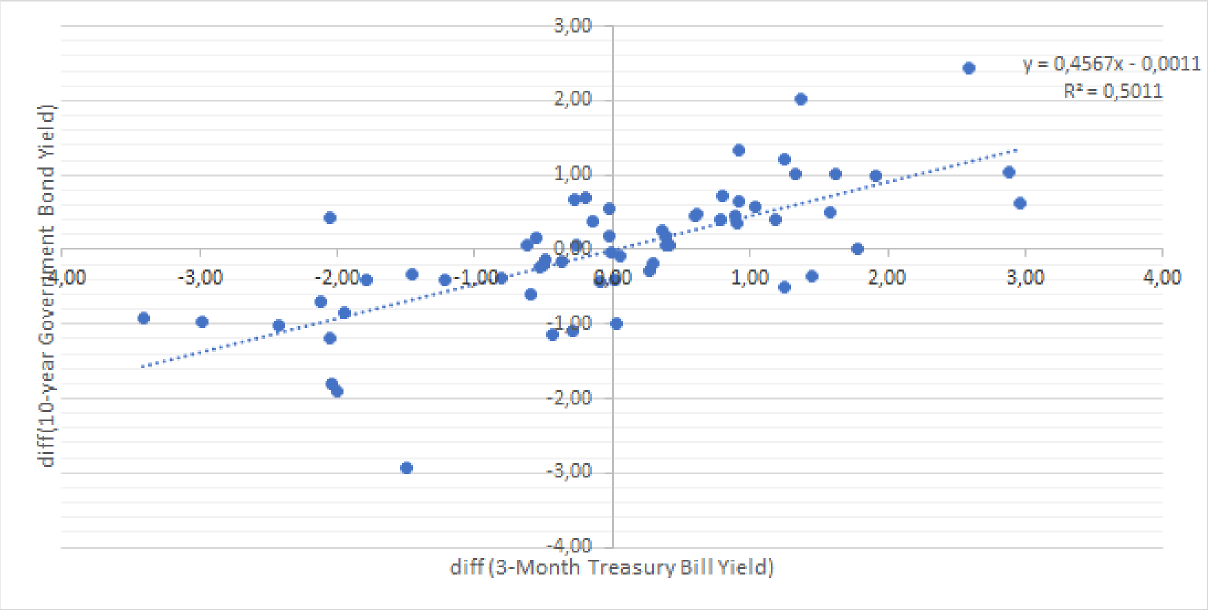
year	t	government debt (in% of GDP)	total chg	interest payments	inflation effect	growth effect	primary balance effect		GDP growth	inflation	primary balance	Average interest rate	Budget deficit	Average real interest rate
2017	0	75,63%							2,20%	2,10%	-1,80%	2,02%	-3,33%	-0,1%
2018	1	75,18%	-0,45%	1,44%	-1,98%	-2,06%	2,14%		2,80%	2,76%	-2,14%	2,87%	-4,30%	0,1%
2019	2	76,08%	0,90%	2,06%	-1,90%	-1,54%	2,28%		2,09%	2,65%	-2,28%	3,41%	-4,88%	0,7%
2020	3	77,86%	1,78%	2,51%	-1,48%	-0,94%	1,69%		1,25%	2,01%	-1,69%	3,45%	-4,37%	1,4%
2021	4	84,79%	6,94%	2,69%	-0,19%	0,31%	4,13%		-0,40%	0,25%	-4,13%	2,74%	-6,45%	2,5%
2022	5	89,31%	4,52%	2,29%	0,06%	-1,31%	3,47%		1,57%	-0,07%	-3,47%	2,32%	-5,55%	2,4%
2023	6	92,98%	3,67%	2,05%	0,28%	-1,34%	2,68%		1,52%	-0,31%	-2,68%	2,01%	-4,55%	2,3%
2024	7	95,03%	2,05%	1,83%	0,09%	-2,04%	2,17%		2,24%	-0,09%	-2,17%	1,78%	-3,87%	1,9%
2025	8	96,34%	1,31%	1,66%	-0,12%	-1,98%	1,76%		2,13%	0,13%	-1,76%	1,62%	-3,32%	1,5%
2026	9	98,13%	1,79%	1,55%	0,36%	-1,02%	0,89%		1,07%	-0,38%	-0,89%	1,50%	-2,37%	1,9%
2027	10	97,92%	-0,21%	1,44%	0,07%	-2,17%	0,45%		2,26%	-0,07%	-0,45%	1,40%	-1,82%	1,5%
2028	11	97,09%	-0,83%	1,35%	-0,08%	-1,97%	-0,13%		2,05%	0,08%	0,13%	1,34%	-1,17%	1,3%
2029	12	95,46%	-1,64%	1,27%	-0,24%	-1,96%	-0,70%		2,06%	0,25%	0,70%	1,28%	-0,52%	1,0%
2030	13	92,50%	-2,95%	1,19%	-0,73%	-2,46%	-0,96%		2,64%	0,79%	0,96%	1,30%	-0,24%	0,5%
2031	14	90,39%	-2,11%	1,16%	-1,18%	-2,47%	0,39%		2,75%	1,33%	-0,39%	1,64%	-1,87%	0,3%
2032	15	87,84%	-2,55%	1,42%	-1,62%	-2,48%	0,13%		2,83%	1,87%	-0,13%	2,18%	-2,05%	0,3%

38. Figure: Output Table: rse =0.8%; recession with fiscal consolidation

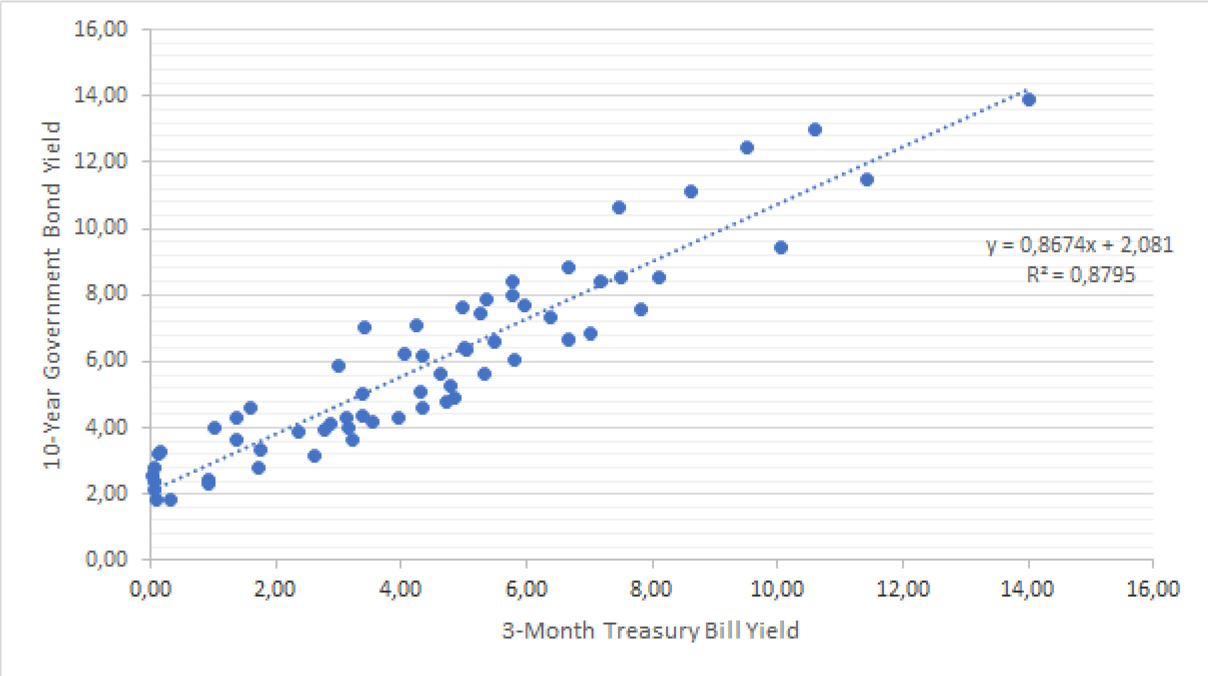
Appedix B: Estimating Parameters



39. Figure: Connection between the first difference of US 3-month Treasury Bill Yield and 1-year Treasury Bill Yield (sample: 1955-2017)



40. Figure: Connection between the first difference of US 3-month Treasury Bill Yield and 10-year Government Bond Yield (sample: 1955-2017)



41. Figure: Connection between the US 3-month Treasury Bill Yield and 10-year Government Bond Yield (sample: 1954-2017)