

**BI Norwegian Business School – Thesis**

**MSc in Business – major in Economics**

***LOW GLOBAL INTEREST RATES***

***AND***

***SECULAR STAGNATION***

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Submission date: 12.08.2016

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This thesis is a part of the MSc programme at BI Norwegian Business School.

The school takes no responsibility for the methods used, results found and conclusions drawn.

## **Preface**

This paper is compiled through the autumn of 2015 and the spring of 2016 as the final thesis for the master-programme MSc in Business with major in Economics at BI Norwegian Business School.

Being able to develop my own master thesis has been an enriching and exciting task at hand. After many hours of research, analysis and writing I can finally see myself pleased with the result.

I will give a big thank to my supervisor, Hilde C. Bjørnland, who has been helpful throughout the whole process. Without you it would not be possible.

Also I would like to thank the rest of the Economic Faculty at BI Norwegian Business School and lecturers throughout the master-programme. I have never learned as much in my whole life. Thank you.

Thanks to Norges Bank for useful comments and suggestions.

I hope you as a reader will find it interesting.

Marita Bråten

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BI Oslo, 12.08.2016

## Summary

Countries globally are currently facing low, or even negative, real interest rates. Even at this level economies are not able to reach satisfactory growth. Potential reasons are a changing savings-investment structure characterised by excess savings together with demographic factors that have led the economy into a period of persistent low values of the real interest rates, output growth and inflation. Also weak productivity growth is assumed to contribute, as it is experienced a diminishing effect of innovation compared to a few decades earlier.

This situation of low rates not being able to increase growth rates has put into light again the phenomenon of ‘secular stagnation’ – a situation where an economy re-equilibrates at a lower level of economic activity with lower demand and lower natural real interest rates. This paper draw linkages to Japan, which turns out to be far ahead compared to the rest of the world in exploring the area.

A model revealing an equilibrium of secular stagnation in A New Keynesian framework is presented. In this model, a situation of ongoing unemployment and economic stagnation seems feasible without any natural forces toward full employment.

This paper strives to determine the relationship between real interest rates and output growth in the long term. An asymmetric relationship is revealed in which a low-rate regime is characterised by a positive relation. Furthermore, in addition to depressing economic growth further, lower real interest rates are found to increase credit growth, an important determinant of financial instability.

The results are discussed in a financial setting focusing on the much debated phenomenon that low interest rates may lead to financial instability. Low interest rates drives up asset prices as investors seek yield and make rational bubbles feasible.

Policy implications are also discussed. Monetary policy turns out less effective as nominal interest rates moves toward values close to zero. The paper discusses policy implications both in regard to monetary and fiscal policy, where fiscal policy turns out as being a much more effective tool.

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## 1.0 Introduction

Although the recent financial crisis may be said to be over, economists are doubtful that we are facing a lighter future. ‘The Economist June 13<sup>th</sup>-19<sup>th</sup> 2015’ front-page illustrates a warrior celebrating the defeat of a dragon representing the financial crisis. However, as he looks back satisfied by the victory he is just about to walk into the next dragon’s mouth. Some economists talk about ‘the new normal’ or ‘new neutral’, a situation of sustained low real interest rates.<sup>1</sup>

With real interest rates at negative values, low inflation and output below potential the economy may be argued to be in a situation of ‘*secular stagnation*’ – the idea that an economy re-equilibrates at a lower level of economic activity with lower demand and lower natural real interest rates (Summers 2013b, 2014a). The term was first introduced by Alvin Hansen (1938, 1939) but was later reintroduced by Summers, whose resumption of the secular stagnation hypothesis caused huge interest in the past years’ literature. The topic has been discussed by well-known economists such as Bernanke (2015), Krugman (2013), Mankiw (2015), and more, and several estimation models have arisen such as papers by Hamilton et al. (2015), Clarida (2014), and Eggertson and Mehrota (2014).

A changing saving-investment structure towards excess savings together with demographic factors has led to such a situation which may persist on a sustained basis. Low rates have also been experienced before, like after WW2 and in the 1970s. However, these periods were characterized by high inflation reducing the real rates. Today inflation seems to be low, which is an unusual situation that will need a closer look.

In his 2013 IMF speech Summers (2013a) points to the fact that GDP in the U.S. has fallen further and further behind potential as defined in 2009, where it was said to be recovered from the financial crisis. He points to reasons such as reduced investment demand, higher risk aversion as a result of the financial crisis which increases savings, slower productivity growth and lower consumption due to income inequality (Summers 2013b). It is interesting to note the low investment level despite the low interest rates which would normally suggest the opposite. To cite Bernanke (2015): “At a negative interest rate, it would pay to level the Rocky

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<sup>1</sup> See Clarida (2014) and McCulley (2003)

Mountains to save even the small amount of fuel expended.” The same trends are seen also elsewhere in the world and Buiter (2013) argue that at least also Japan and EU are facing a situation of secular stagnation.

If the world economy is in fact facing secular stagnation, a huge debated phenomenon, it will result in important policy implications for future growth. The secular stagnation hypothesis suggests that the economy has experienced a structural shift where the same given level of real interest rate do not result in the same level of output as previously. This will result in considerably limits for the monetary policy as interest rates may possibly not be reduced enough to secure full employment due to the problem of the zero lower bound (Summers 2013a). It will also have implications for financial stability as lower interest rates raises the asset values and drive investors to take more risk, increasing the chances of bubbles (Summers 2013b).

The secular stagnation hypothesis, the discussion around the topic, and the huge implications it would have for future growth has motivated me to look more deeply into the topic. The fact that we are in a historical unique situation with low interest rates around the world without being able to maintain economic growth makes it an especially interesting topic to study. Below I will go more deeply into some of the recent trends that have led us into this situation of low rates, low growth, and excess savings relative to investment.

## **1.1 Current Situation**

### **Low interest rates globally**

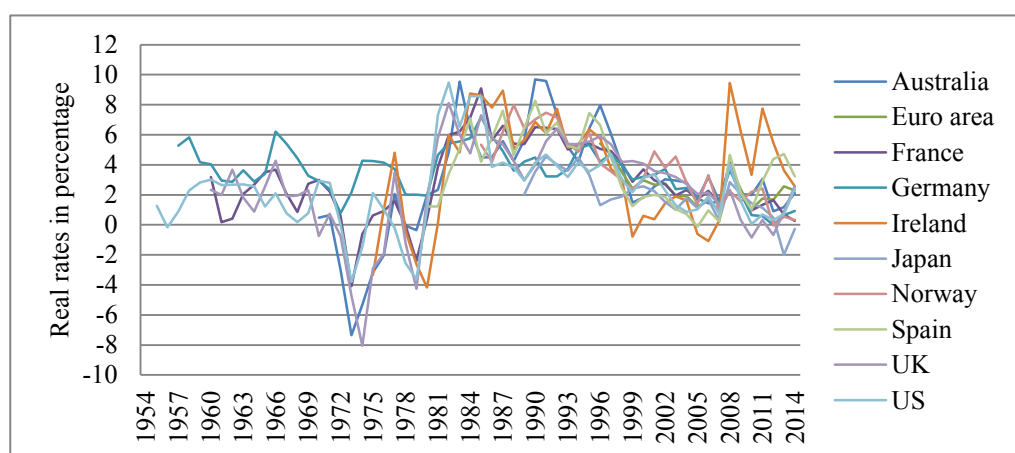
Low interest rates, both short- and long-term are seen most places around the world. Almost half of the world countries' nominal interest rates are now at historical low levels.<sup>2</sup> In a sample of countries accounting for 70 % of world GDP (see appendix 1), 50% of the countries have short-term interest rates below 1%, while more than one third do have rate at 0 or below (Trading Economies 2015). Even more surprising results are found for the most developed countries, measured by GDP per capita (see appendix 2). U.S. is no exception. With ten-year government bonds traded ( as of April 2015) at 1.9% and at 2.5 % for thirty-years, they are at historical low levels, predicted to be a long-term trend rather than a

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<sup>2</sup> 44 % out of the 150 countries listed do have a current interest rate at historic level (as of 2015)

temporary phenomenon (Bernanke 2015). With nominal rates around zero real rates are obviously at negative numbers. In the 1990s, world long-term real interest rates averaged around 4%, before the financial crisis it had dropped to 2%, and today world long-term real interest rate is at 0 % or even negative (King and Low 2014, Haldane 2015). Figure 1 illustrates the low long-term real interest rates for ten selected countries in the period 1954-2014.

Figure 1.1: Long-term real interest rates 1954-2014



Source: OECD and own calculations

### Low output growth

In addition to low interest rates there has also been a tendency for recent low output growth around the world. To cite Summers (2014a): “*The economy (read: US) is now 10 percent below what in 2007 we thought its potential would be in 2014*”. There has in other words been little or no progress in restoring GDP to its potential in the US in the aftermath of the recent financial crisis. Employment declined sharply during the crisis and only a small portion of that decrease has been recovered since. The economy is characterized by low consumption demand, affected by factors such as changed income distribution discussed later in this section (Lange, Pütz and Kopp 2016). Furthermore, average number of working hours per capita has declined and is predicted to continue to do so in the future (Lange, Pütz and Kopp 2016 and Johansson and Guillemette 2012). Also, return to human capital have declined over the past decades, a trend likely to continue (Lange, Pütz and Kopp 2016). The same situation has also been true for other economies. IMF’s Economic Outlook (2015) points to a declined potential output growth, both for advanced and emerging economies. IMF forecast the output growth to increase slightly in advanced economies (from 1.3 % to 1.6%) but to



remain below pre-crisis level in the medium term. In emerging economies output growth is expected to decline further (from 6.5% to 5.2%).

### **Excess saving relative to investment**

The decline in output growth described above is potentially due to declined growth in investment relative to saving (IMF 2015). During the financial crisis the level of private investment fell sharply and the economy has seen little recovery since. The contraction was found most notably in advanced economies, which experienced a fall of 25 % on average compared to pre-crisis forecasts. Lange, Pütz and Kopp (2016) point to insufficient investment due to several reasons such as insufficient investment made by the governments, particularly infrastructure (Eichengreen 2014) and less capital needed in production as production is relatively less capital intense than before (Summers 2013b, 2014). Not only have there been a decrease in the amount of capital bought but there has also been experienced a substantial shift in the relative price of capital towards lower commodity prices (Summers 2014a). With a declining price of capital investment goods may be achieved with less spending reducing investment in absolute terms. Additional recent trends leading to declined investments is policy uncertainty and financial constraints (IMF 2015), a trend towards a more non-competitive market structure (Lange, Pütz and Kopp 2016)<sup>3</sup> and demographic factors like declined population growth decreasing overall investments through less technological change (Hansen 1939, Krugman 2014). Also, since working aged people buy relatively more capital-intensive goods such as housing, demographic factors like less working aging people has decreased demand for such goods (Lange, Pütz and Kopp 2016). There are recently been experienced slower technological change and IMF (2015) report weaker productivity growth and decline in total factor productivity, at least for advanced economies. Information and communication technology (ICT) has experienced diminishing effects (IMF 2015) and the innovation rate has also gone down in general (Belke and Verheyen 2014).

### **Higher precautionary savings**

Evidence suggests a situation of higher precautionary savings recently. There may be many reasons such as demographic factors or changed income distribution,

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<sup>3</sup> Increased concentration of market power for profit-maximizing firms implies investment and production below the competitive level (Pepall et. al 2014)

however some argue it is also a result of increased uncertainty after the crisis (Summers 2013b, Teulings and Baldwin 2014).

The demography is characterized by ageing of population (OECD 2016a) caused by greater life expectancy (OECD 2016b) and the fact that the baby-boomers are now getting above the pensioner age. Greater life expectancy and falling fertility rates are most evidently in emerging market economies (IMF 2015). This results in a declined part of the population contributing to the working force and a reduced growth rate of the working-age population (IMF 2015). There is also experienced a declined rate of population growth in general (OECD 2016c, Summers 2014a) meaning that the above mentioned trend will not be offset by new people born (see appendix 3).

In the newspaper (VG 2014) you can read about how the worlds 85 richest people are richer than half of the world, and how the difference between the richest and poorest increases.<sup>4</sup> Change in the distribution of income towards increased income inequality is noted by Summers (2014a) and is also an important trend is determination of the natural real interest rate as it increases the propensity to save (Summers 2014a).

A global trend worth noting is the global excess of desired savings in emerging countries, such as China and other Asian emerging markets that are holding increasingly more reserves, often referred to as the global savings glut (Bernanke 2015). Capital flow from emerging markets into advanced economies leads to a trade deficit in advanced economies and a current account surplus in emerging economies. The huge capital inflows into advanced economies put a downward pressure on market rates and thus lower the rates. This is in fact shown for U.S. by a downward trend in indexed bond yields (Summers 2013b). It further pushes up the value of the dollar and causes a currency appreciation in the industrial world (Eggertson, Mehrota and Summers 2016).

An important point worth to stress is the long-run supply-side damage from the Great Recession or more simplistic said; the current recovery from great financial crisis (Leduc and Rudebusch 2014). Much of the low growth experienced are possibly a result of the financial crisis and may return to normal after a while. However, not all trends are a result of the financial crisis and a situation of further

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<sup>4</sup> Source: The World Wealth and Income Database

potential decline is far from irrelevant. The IMF World Economic Outlook (2015) forecasts a continuing decline in potential employment, below pre-crisis rates for capital growth and investment, and productivity growth that will most likely return to precrisis rates but not higher.

## **1.2 Method of Analysis and Main Results**

This paper strives to answer the following research question:

*“What is the relationship between real interest rates and output growth in the long-run, and does it support a situation of secular stagnation?”*

The research question will be analysed through correlation and regression analysis using data for ten countries retrieved from the OECD database. There will be a special focus on Norway using a longer dataset available from Norges Bank and a credit variable from a dataset by Schularick and Taylor (2012) will be included in a multivariate setting.

The analysis supports a possible positive relation between a country’s real interest rate and output growth as positive coefficients are found for eight of the ten countries, where four turns out significant. No support was found for a negative relation. Furthermore, the analysis for Norway reveals an asymmetric relationship where a low-rate regime is characterized by a clear positive relation having important implications for financial stability. A reduction in the real rate do not seem to have any positive effect on demand, rather it increases credit growth, an important determinant for financial instability.

## **1.3 Further Structure**

The further structure of this paper will be as follows. Section two presents the main literature and theory related to the topic focusing on the long term natural real interest rate and how it is determined. The analysis is conducted in section three, four and five with the results presented in section six. These sections strives to answer the above research question by own analysis performed in a cross-country setting. Section seven draws linkages to the situation in Japan that reminds much of the situation seen elsewhere in the world. Section eight discusses policy implications with focus on monetary and fiscal policy, and financial stability respectively. The last section concludes.

## **2.0 Literature Review and Theoretical Framework**

In the current chapter literature and theory related to the topic will be presented. The chapter is divided into three parts, being ‘theories of growth’, ‘the secular stagnation hypothesis’ and ‘theoretical framework’.

### **2.1 Theories of Growth**

Although no one can be sure how future growth will look like there has been put out many theories. As early as in 1972, The Limits to Growth (LTG) hypothesis was introduced by Meadows, Meadows, Randers and Behrens (1972), who concluded that a continuing of the growth rates experienced at that time would not be sustainable. In 2004 there was made a 30-year update (Meadows et al. 2004) for the LTG hypothesis. It mentions “overshooting”, the phenomenon of going beyond limits without intentions to do so, caused by the three factors growth, some sort of a limit/barrier, and a mistake in the responses that strive to keep the system within its limits. Lately, one of the authors came up with a new book: 2052 – A global forecast for the next forty years (Randers 2012), where he claims that the world has in fact overshoot it’s limits. Growth, one of the main drivers for overshooting, did continue; both in global population, world economy (measured by GDP) and in human footprint. Hence, we are in a situation (in 2012) that cannot be continued without major problems, he argues. He points to the main root cause being what he refers to as *short-termism*, the fact that capitalism and democracy focus excessively on the short term effects, rather than what benefits society in the long-run. His analysis points to slower GDP growth in the future caused by slowdown in population- and productivity growth.

#### **Technological slowdown hypothesis**

*“It is argued, that the technological progress in recent decades has increased labour productivity less than in the decades before and that it is the nature of the technological change that is the explanatory of less growth”*  
- Robert Gordon, 2012

The “nature of the technological change” that is mentioned refer to the fact that the effects of technological change and innovation has faded out. Mokyr (2015) asks the question how likely there is that technological advances will continue at the rate they did since the second industrial revolution in 1870, or even accelerate. Information and communication technology has reduced access costs to

information, making further scientific research and technological advances more accessible. Globalisation is another factor contributing to innovation through global openness and shared knowledge. Moreover, as was the case during the past industrial revolutions, we still face well-defined problems, like global warming and climate change, which will depend on innovation to be solved. Mokyr concludes that technological progress is far from an end, or even diminishing returns, and argues that secular stagnation seems unlikely to be the problem.

More pessimistic views are found by, among others, Gordon (2012) with his technological slowdown hypothesis suggesting slowdown in the rate of technological progress. He also argues that even if innovation were to continue at the same growth rate that has been experienced before the financial crisis in 2007, there are six 'headwinds' which will lead to a significantly lower growth rates in the long term compared to previously. He estimates the growth to be half or less than the annual rate of 1.9 % experienced in the period 1860-2007. These six headwinds regard demography, education, income inequality, globalization, energy/environment, and consumer and government debt.

In neoclassical models, first developed by Solow (1956), growth in income per capita depends on the rate of technological progress, and so technological advances are key to economic growth. Assuming constant technological progress, the model implies exponential growth in output (Lange, Pütz and Kopp 2016).

## **2.2 The Secular Stagnation Hypothesis**

A much discussed phenomenon, probably most known after Lawrence Summers re-introduced it in 2013 is 'secular stagnation' (Summers 2013b). Secular stagnation is an old phenomenon, introduced by Hansen (1938, 1939), but were put into light again by Summers at the IMF Fourteenth Annual Research Conference held in Washington 2013. It describes a situation where an economy re-equilibrates at a lower level of economic activity where the level of demand is no longer maintained, and hence, the world economy is characterized by low growth and low natural real interest rates on a permanent basis (Summers 2014a). As short term real interest rates are constrained by the zero lower bound, real rates may not be able to fall far enough to ensure full employment and adequate growth, referred to as a chronic insufficiency of demand. Achievement of the

three goals; adequate growth, capacity utilization, and financial stability simultaneously proves difficult.

In the fall of 2009, there was no more ‘panic in the air’ after the financial crisis as Summers states it (2013a). Yet, four years after the financial normalization (read 2013) when the economy should have normalized as well, the US economy was still facing a disappointing development, with GDP well below potential and almost no progress in employment (Summers 2013, 2014a). Summers points to the period of 2002-2007 which grew at a satisfactory growth rate however, a period he owes to a bubble with unsustainable increase in housing prices and debt-to-income ratio for households. He argues that during the financial crisis, “even a great bubble wasn’t enough to produce any excess aggregate demand”. Recovery had only kept up with population growth and normal productivity in the US and been worse elsewhere in the world, and unsustainable bubbles, as experienced in the past decade, were only sufficient to drive moderate growth. In fact, he argues that secular stagnation might have started as early as back to 1990s or before. He asks the question: “In the last 15 years: can we identify any sustained stretch during which the economy grew satisfactory with conditions that were financially sustainable?” (Summers 2014a).

In his IMF speech, Summers (2013b) raises the possibility of secular stagnation for US and other major global economies, and admits that he thinks the idea of secular stagnation fit the modern economy very well.

Furthermore he considers the possibility that the structure of the economy has gone through changes, leading to a significant shift in the natural balance between savings and investment. Excess savings relative to investment has caused a decline in the natural real rate of interest that is associated with full employment, he argues (Summers 2014). Summers (2015) emphasize the importance of the savings-investment relation in his definitions stating that: “*the essence of secular stagnation is a chronic problem of an excess of desired saving relative to investment*” and “*secular stagnation and excess foreign saving are best seen alternative ways of describing the same phenomenon*”.

Secular stagnation might be seen as a source of low interest rates. In his 2013 article; “Why stagnation might prove to be the new normal” Summers (2013b) asks the question: Is there a basis for believing that equilibrium real interest rates

have declined? In the case of a fall in the natural real interest rate we would have increasing difficulty of achieving full employment and strong growth and we would not experience any excess demand, which is just like the situation has been (Summers 2013a). The fact that natural real interest rates have declined, he argues, is therefore reasonable for six reasons (Summers 2014a).

On the savings side, greater concentration of income and wealth together with increased risk aversion raises the propensity to save, causing higher household savings and lowering the natural real rate. Furthermore, there is a global trend for emerging markets to hold increasingly more reserves, hence increasing demand of safe assets, depressing the yields in the US (Summers 2013b).

Also factors on the investment demand side, such as slower population and labour force growth, slower productivity growth and major structural changes in the economy, all factors mentioned earlier, reduces capital investment (Summers 2013b, 2014). A decline in population growth itself is often associated with lower real rates, illustrated later in this paper.

First, there has been reduction in demand for (debt-financed) investment as companies are typically becoming less capital-intensive (think WhatsApp vs Sony). Also, he mentions what he refer to as the reverse of Say's law, namely that lack of demand, creates its own lack of supply (Summers 2014a). Furthermore, a substantial shift in the relative price of capital goods, making capital goods cheaper, reduces investment in terms of amount spent. The demand for investment goods is not rising fast enough to keep up with the increase in supply, and hence the price of investment goods falls.

Falling wages and prices, or lower than expected, are likely to worsen performance as consumers and investors delay spending. Low inflation levels are encountered across the industrial world, with no sign of picking up, suggesting a chronic demand shortfall (Summers 2013b). Also lower inflation means any interest rate translates into higher after tax rate, meaning that pre-tax rate needs to be lower in order to achieve the same after-tax rate (Summers 2014).<sup>5</sup> After all, it is the after-tax real rates that matters for an economy, he argues.

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<sup>5</sup> Example/proof available in article

Therefore, Summers (2013a) suggests that the natural interest rates has fallen, and emphasize how then conventional macroeconomic thinking would leave us with a very serious problem because of the zero lower bound. Implications of secular stagnation and suggestive solutions and policies are given in section 8.

### **Criticism of Secular Stagnation Hypothesis**

Summers also points to reasons for optimism, which goes against his theory of secular stagnation. First of all, there has recently been observed strong stock markets which might indicate optimism for the future, taking into account the importance of finance and that financial stability is indeed a necessary condition for satisfactory economic performance (Summers 2013a). But he also stresses the point that even if the economy accelerates next year, this provides no assurance that it is capable of sustained growth at normal real interest rates (Summers 2013b). Also, one should not forget that there has been fears of secular stagnation also before (end of WW2) which was proved wrong (Summers 2013b).

The view of Lawrence Summers has been criticised by (among others) Ben Bernanke (2015), the former chairman of the Federal Reserve. First of all, Bernanke is sceptical that the US actually faces secular stagnation despite the slow economic growth, low inflation and low interest rates. He argues that negative or zero real interest rate are unlikely to last for long, and further that the current slow economic growth are just a result of the recent financial crisis. The greatest critics, however, regards the secular stagnation hypothesis' lack of global perspective. Summers' secular stagnation hypothesis fails, according to Bernanke, to take into account the international dimension and the fact that any open economy are free to borrow or lend money in the international market and thus eliminating the situation of secular stagnation. Disregarding the secular stagnation hypothesis, Bernanke's answer to the current low interest rates is what he calls "The Global Savings Glut" (Bernanke 2015).

Hamilton et. al (2015) are also sceptical to the secular stagnation hypothesis. There are several reasons for this, including weak evidence before 2008, and also after 2008 as the slow recovery may be better explained by other factors. Moreover, as of 2014 the U.S. growth was already well above potential, supporting their opinion that growth will continue to pick up and create a full recovery in the economy. They suggest that the economy will withstand higher



interest rates. They also point the hypothesis' ignorance of fiscal policy, which proves to be a lot more effective at the zero lower bound (Christiano, Eichenbaum, and Rebelo, 2011). This results from how the government spending is financed, which is more effectively financed by debt compared to financing by taxes, which results in a zero multiplier. They explain the recent slow economic growth by "severe medium-term headwinds" and place the current situation somewhere between the concepts of Great Moderation on the one hand, and Secular Stagnation on the other. By analysing the U.S. economy in the last three business cycles the paper concludes that the economy has not suffered from chronic under-employment as it has reached full or well above potential in all three cycles. They point to the fact that the rise in inflation has been smaller through the period, but explain it as simply improved monetary policy.

One of the central questions of Summers (2014a) in explaining secular stagnation is whether bubbles have been necessary in creating economic growth. However, also on this point, the paper's conclusion contradicts the secular stagnation hypothesis concluding that bubbles have not been necessary to achieve growth (however, it has been contributing).

Furthermore, based on their analysis, they conclude that persistent headwinds may have a persistent negative effect on the real rate, but the rates have always tended to rise back to their averages in the end. This is consistent with the criticism of the statement "this time is different" (Reinhardt and Rogoff 2009), which argues that no time is different, and an economy will always recover.

### **2.3 A Model of Secular Stagnation**

Eggertsson and Mehrota (2014) formalize the secular stagnation hypothesis in an overlapping generations New Keynesian model to test the secular stagnation hypothesis of ongoing unemployment and economic stagnation without any natural force towards full employment. They find support for a secular stagnation equilibrium by finding that unemployment is high for an indefinite amount of time due to a permanent drop in the natural rate of interest.

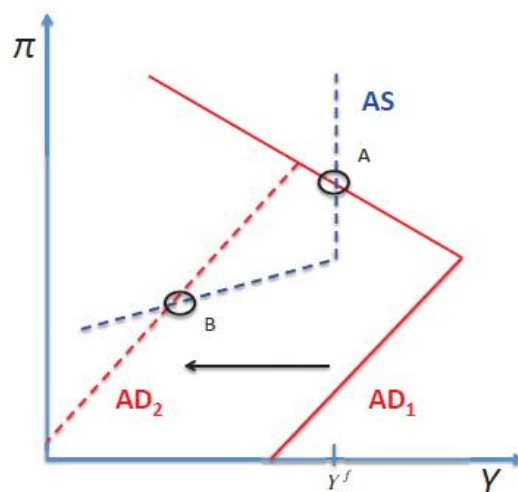
Eggertsson and Mehrota (2014) moves away from the typical framework where the natural rate is determined by the household's discount factor to one where the natural rate depends on the household's transition from borrowing to saving over

a lifecycle (relative supply of savings to demand for loans), and thus, opens the possibility for secular stagnation.

The model uses real shocks, rather than self-fulfilling expectations to illustrate their results. They consider a deleveraging shock (a sudden and permanent reduction in debt which reduces demand for loans), slowdown in population growth (increases supply of savings), increased income inequality (raises propensity to save), and fall in the relative price of capital - all factors causing a downward pressure on the real interest rate. This leads to reduced interest rates and a possible permanent drop in output by lowering the natural rate of interest below zero on a sustained basis. In such situations, the ZLB will bind, real wages will exceed market clearing rate and output will fall below full employment. The key result here, which differs from previous analyses, is that the economy settles down at this new steady state with a permanently lower real interest rate, possibly negative.

The equilibrium of secular stagnation is illustrated in the below graph together with a normal equilibrium, where AD and AS is aggregate demand and aggregate supply, respectively.

Figure 2.1: An equilibrium of secular stagnation



Source: Eggertson, Mehrota and Summers (2016, figure 4)

### ***Equilibrium under normal conditions***

The equilibrium under normal conditions is characterized by an intersection of the aggregate demand and supply curves at the solid demand line ( $AD_1$ ).

At sufficiently high inflation rates, the demand curve is downward sloping as the central bank will cut the nominal rate more than one to one in response to inflation below target, assuming positive interest rate, lowering real rates and increasing demand. However, at zero lower bound, cutting the interest rate is no longer possible, and declining inflation rates raises the real rate, hence reducing demand and result in the upward sloping demand curve.

Supply is determined by the interest rate set by the central banks in accordance to the Taylor rule in trying to stabilise inflation around a target. There is a trade-off between low inflation and output growth until full employment is reached and output equals its full employment level at which output will stay constant. When natural rate of interest is positive, the intersection will happen in the vertical segment of the supply curve and determined by the inflation target. In this scenario, the interest rate may be used, in both directions, to regulate output so as to ensure that full employment is always reached. Shocks to demand will not affect this equilibrium, as the shocks are perfectly offset by the central banks by using the nominal interest rate to obtain its inflation target.

### ***The secular stagnation equilibrium***

However, there is another equilibrium scenario drafted in the above graph (the intersection of the supply curve with the  $AD_2$  line). If the natural real interest rate is too low (sufficiently negative for the ZLB to bind), it is more likely that real rate is higher than the natural and this causes the aggregate demand curve shifting to the left. For any given inflation rate output is reduced. This would normally cause a drop in interest rate to give incentives to spending, but because of the zero lower bound this will not happen, a phenomenon also referred to as a short-run liquidity trap (Keynes 1936). Hence, the economy moves away from equilibrium and are no longer in the situation of full employment. The two curves (demand and supply) now intersects at an equilibrium of secular stagnation, characterized by a binding zero-lower-bound, inflation rate below target, and a persistent output gap (Eggertson, Mehrota and Summers 2016).

Eggertsson and Mehrota (2014) find that the inflation level consistent with equilibrium is bounded from below by the real rate, i.e. there exists a lower bound on steady state inflation, being equal to the negative of the natural rate of interest. This has particular significance. If real rate is permanently negative, steady state

inflation needs to be permanently above zero. Under rigid prices, if economy cannot reach this level of inflation due to low inflation targets by central banks, this will instead result in a drop in output, and output may fall permanently below the full-employment level. They show that if central banks are unwilling to tolerate high enough inflation, there will be a permanent decline in output, due to the increased interest rates set by the central banks in order to fight inflation. An inflation target that is too low will have no effect in an economy experiencing secular stagnation, referred to as the “timidity trap” (Krugman 2014).

In the case of secular stagnation, assuming negative natural rate of interest, for any given inflation rate output is reduced. However, with a high enough inflation target (credible commitment to future inflation), consistent with the negative natural interest rate, one may be able to move the economy out of secular stagnation, as the real rate is reduced enough to stimulate spending and output.

However, the situation will not eliminating the secular stagnation equilibrium and monetary policy is therefore of rather limited use as low rates over a longer period of time will not guarantee a recovery (Eggertson and Mehrota 2014). Fiscal policy seems, however, to be a much more effective tool in reaching for full employment as increase in government spending and/or redistribution of income from savers to borrowers turns out to be very effective in eliminating secular stagnation equilibrium. They show so by introducing taxes to their model where the real interest rate is affected by fiscal policy through taxes and government spending. The effects of fiscal policy (permanent increase in government debt) shift the entire aggregate demand curve, thus increasing the natural rate of interest and ruling out the secular stagnation equilibrium. Government spending increases demand and may hence avoid secular stagnation. At zero lower bound, fiscal policy has even more effect, consistent with the results for Christiano, Eichenbaum and Rebelo (2011).

In their model, a permanent fall in employment is possible without any self-correcting force back to full employment. They conclude their paper arguing that a permanent recession is possible, meaning a liquidity trap may last as long as the shock that gave rise to it (e.g. population growth slowdown, income inequality or deleveraging shock).

## **2.4 Theoretical Framework – the natural real interest rate**

Hamilton et al. (2015)'s paper "The equilibrium real funds rate: past, present and future" examines the behaviour, determinants, and implications of the natural real interest rate, defined as the rate consistent with full employment and stable inflation in the medium term. The purpose is to conclude whether the concept of secular stagnation turns out to be right, with especially focus on the U.S. The paper finds a positive long run relation between output growth and the average real rate, representing the natural rate. However, the sign of the correlation is very sensitive to sample and contradicting theoretical foundation they find a less clear relation to trend GDP growth than what is widely believed. This suggests that output growth do have some long run impact the natural real rates but does evidently not explain the real rate alone, and other factors may play a large role in determining the average real interest rates.

In further attempt of explaining the decline in real interest rate that has happened throughout their sample period (decline starting in the 1930s), they point to several factors. First, the financial markets tended to be much less regulated, implying a higher real interest rate. More regulations such as higher requirements for bank reserves, lower the cost of funding government debt, and hence allow the real rate to decline.

### **The natural real interest rate**

The natural real interest rate, the equilibrium real rate, the neutral rate, or the Wicksellian interest rate (after Knut Wicksell), all with the same meaning; they are the interest rate consistent with full employment. Meaning that if the actual real interest rate equals the natural rate, output will equal its potential and the so-called output gap will equal to zero. The real interest rate may also be defined as a measure of the reward for giving up a real unit of consumption for one period or, equivalently, it is the cost of borrowing one unit or real output for one period (Taylor 1999). Interest rates can also be viewed as the price that equilibrates investment demand and the desire to save (Belke and Verheyen 2014).

As has been emphasised up to now, the real interest rates globally are currently unusual low. Clarida (2014) talks about "the new neutral", where 'central banks have entered a new era for global monetary policy rates closer to 0 % in real terms rather than 2% as before the crisis'. King and Low (2014) estimates the long-term

real interest rate on global basis and finds a broad pattern of continuing decline for the period 1985-2013. The same do Laubach and Williams (2003), who's methodology for estimating the natural real rate has been extended to recently and reveals a substantial and continuing decline in the real interest rate all the way back to the early 1960s for the US. Indicators also suggest that they will stay low for an extended period in several countries in the future. The ECB President Mario Draghi expects low rates for the key ECB interest rate (Belke and Verheyen 2014) and so does Andrew G. Haldane, Chief Economist in the Bank of England, for the UK interest rate (Haldane 2015). Estimates for the natural real interest rate are also made by numerous papers. Hamilton et al. (2015) estimates the equilibrium rate to be in the range 1-2 % in the medium term. Rachel and Smith (2015) suggest a stagnation of the natural rate at 1 % or lower.

### **Determination of the real interest rate**

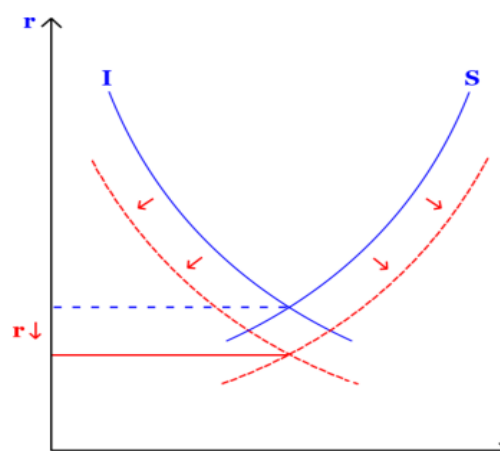
Evidence suggests that the natural real interest rate has experienced a decline recently. In attempt of answering Bernanke's question (2015): "Why are interest rates so low?" it is an interesting aspect to consider the drivers of the long-term real interest rate and link the determinants to reasons why the natural real interest rate has experienced a (secular) decline recently.

It is known from theory that the real rate equals the nominal interest rate adjusted for inflation (the Fisher equation), and so central banks play an important role in affecting the real interest rates. This is done through the monetary transmission mechanism which demonstrates how the interest rates, represented by the key rate determined by the central bank, affect output and inflation by affecting the market rates through three different channels; the demand channel, the exchange rate channel and the inflation expectation channel (Norges Bank 2004). A fall in the interest rate tends to increase consumption and investment, increasing output and inflation. Furthermore, lower rates also decreases the exchange rate and inflation will accelerate due to 'imported price inflation' (imported goods becomes more expensive). Also expectations about future inflation affect inflation as low rates may lead to expectations of higher inflation, which may in fact become true (self-fulfilling expectations). Confidence in monetary policy stabilises inflation expectations and thus help stabilise actual inflation.

Since the real rate by definition is the nominal interest rate minus inflation, the inflation rate obviously plays a significant role in determining the natural real interest rate. Failing to take variation in this variable into consideration may lead to poor estimates of the natural real rate (Hamilton et. al 2015). Furthermore, the nominal rate is determined such as to minimize the distance to the natural real interest rate, i.e. the real interest rate consistent with full employment of labour and capital resources (Bernanke 2015). Taking expectations of inflation into account the central banks can then set the nominal rate so as to minimize such distance.

Low natural real interest rates are argued to be caused by low growth in a short term perspective<sup>6</sup>, but by a changing saving-investment structure in the long term where the level of saving is too high compared to investment, probably causing a decline in the natural real interest rate (Rachel and Smith 2015). Summers (2014a) formulates it as: “*changes in the structure of the economy have led to a significant shift in the natural balance between savings and investment, causing a decline in the equilibrium or normal real rate of interest that is associated with full employment*”. The Metzler Diagram shows how the natural real interest rate is determined by the intersection between saving and investment in a simple two-region model (Obstfeld and Rogoff 1996). Higher supply of savings lowers the real interest rate while higher demand for investment increases the real interest rate.

Figure 2.2: The Metzler Diagram



<sup>6</sup> According to economic theory, lower growth will push down real rates however, various papers find no such linkage (Laubach and Williams 2003, Leduc and Rudebusch 2014)

Second, there is declining rate of population growth, which was also one of Alvin Hansen's (1939) main arguments when he argued for secular stagnation in the 1930s. Some studies also go as far as to argue that the natural rate of interest actually equals the rate of population growth, as in the 'Samuelson consumption-loan model' by Samuelson (1958). Without having to share this view it should be reasonable that the declining rate of population growth will have some effect on the natural real rate.

Also other demographic factors mentioned earlier in the paper such as greater life expectancy increase the supply of savings and contribute to a lowering of the natural real interest rate (Backhus et al. 2013, King and Low 2014, Hamilton et. al 2015). Higher life expectancy means lower time value of money and also lower risk related to debt, both factors in favour of a lower real interest rate (Hamilton et. al 2015). For instance does the neoclassical Ramsey-model of economic growth (Ramsey 1928) relate the safe real rate to a representative consumer's discount factor and expected consumption growth. The consumer's discount factor may be affected by variables such as expected lifetime, where a longer expected lifetime reduces the discount rates, as agents become less impatient.

Changes in the distribution of income in the direction of higher income inequality raise the propensity to save and increases savings by raising the share of income to those with lower propensity to spend (i.e. the rich) (Summers 2014a). Higher propensity to save lowers the natural real interest rate which equates demand of investment with supply of savings, just has been experienced in today's economy. In the Keynesian literature savings is assumed to hurt the economy as it reduces aggregate savings as a result, referred to as the "paradox of thrift" or "paradox of savings". "Saving hurts the economy – it even hurt investments, thanks to the paradox of thrift" (Krugman 2013, p. 1). The old Keynesian literature implies that if everyone saves more, aggregate savings will actually fall as a consequence. This is because aggregate demand falls and thus households earn less income to save. Hence, increased supply of savings may actually decrease aggregate saving as a consequence (Eggertsson and Mehrota 2014).

In addition to increased supply of savings, there are also forces working towards decreased demand for investment, such as a substantial shift in the relative price of capital goods. Capital has become less expensive which decreases the value of



capital. This is also pointed to by Mokyr (2015) who emphasise that excess supply of capital (and lack of demand), reduces the price contributing to a decline in the natural real rate. Summers (2013) suggestion of a decline in the cost of capital is captured in Eggertson and Mehrota's (2014) New Keynesian model. The decline in the relative price of investment goods results in a declined natural rate of interest. The reasoning behind this result is as relative cost of investment declines, more funds are left for the bond market through savings, increasing supply of funds/savings, thus decreases the natural rate of interest. Furthermore, a rise in the depreciation rate shifts the loan supply as capital is getting less attractive (making loans less attractive), thus reducing the natural rate of interest (Eggertson and Mehrota 2014).

As a fifth reason, Summers points to the 'after-tax effects' which turns out relevant at today's low inflation rates. The consequence of disinflation is that for any given after-tax real interest rate, the pre-tax real interest rate needs to be lower. Since it is the after-tax rate that turns out relevant in the economy, the pre-tax rates needs to be lower to achieve the same after-tax rate in the case of lower inflation compared to a situation with higher inflation. This also contributes to a lower natural real interest rate in today's economy. Finally, there are substantial global moves to accumulate central bank reserves and invest in safe assets.

Capital inflows (savings) from the emerging markets (such as China and the old Soviet Union) to the advanced economies creates a global capital market (King and Low 2014) also referred to as "the global savings glut" by Ben Bernanke (2015a). These capital inflows, reflecting differences between savings and investment across countries (Backhus et al. 2013), causes an oversupply of savings and lowers the natural real rate in the advanced economies. Too much capital flows to a country is argued to cause a situation of secular stagnation (Eggertson, Mehrota and Summers 2016). For a given level of output the natural real rate needs to be lower to accommodate the extra supply of savings and hence the interest rate lowers in attempt of maintain full employment. Backhus et. al. (2013) points to demographic trends as drivers to the international capital flows. At too low interest rates such capital flows will be subject to a risk of capital misallocation (Belke and Verheyen 2014).

According to Ben Bernanke (2015) the recent low long-term government bond yields can be explained by term premiums, the return on investments over the risk-free return, experiencing a downward trend recently. The downward trend in term premiums can mainly be explained by two things: risk and demand. Low inflation and accommodative monetary policy (low rates) together with higher demand, increases the price on bonds and hence reduces the yield. Interest rates tend to have an inverse relationship to the bond prices, defined as the discounted present value of the future paid dividends. A lower rate lowers the discount factor, increasing the asset value or price. This again, decreases the yield, defined by coupon amount divided by price, so that there is an inverse relation between yield and bond price. However, although the last years decline in term premium can be explained, the last years/recent further decline is still a puzzle.

### **Structural changes in the financial system – credit**

Several papers<sup>7</sup> have analysed the structural changes in the financial system in recent years and the related consequences for financial stability and monetary policy, and the ‘credit view’ has gradually attracted attention (Schularick and Taylor 2012). Schularick and Taylor (2012) argue that we live in “the age of credit”, where the role of credit plays a bigger part in the macroeconomy. Credit aggregates contain valuable information of financial crises, and recent episodes of financial instability have often been result of credit booms and failure of the financial system. These trends may have led to more uncertainty or caution in regards credit and may have increased savings relative to investment on a sustained basis in the economy. Also policy choices by central banks and additional regulations after the recent financial crisis may have had an impact (King and Low 2014).

### **Relationship between real interest rate and growth**

Different theories hypothesise about the relationship between the real interest rate and economic growth. For instance, higher interest rates are argued to raise the cost of capital and hence lowering the level of investment and thus output (Mallick and Agarwal 2007). Considering another perspective, a rise in interest rate raises financial savings making credit more easily available to investors,

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<sup>7</sup> See Adrian and Shin (2008, 2009), Mendoza and Terrones (2008), and Hume and Sentance (2009)

contributing to a rise in investment level and hence output (Mallick and Agarwal 2007).

Output is mainly assumed to grow at exponential rates implied by neoclassical and Keynesian growth models (Harrod 1939, Lange, Pütz and Kopp 2016). However, Lange, Pütz and Kopp (2016) cast doubts over this assumption in their analysis. Empirical evidence also suggests that there is a non-linear relation between real interest rates and growth, where the relation tend to be positive at lower values of the real interest rate, and negative at higher values (Fry 1997).

The Keynesian literature suggests that growth may be low since the long-run potential growth rate has fallen, suggested by Gordon (2012), and the fact that growth rates today are below this level (Teulings and Baldwin 2014). The New Keynesian Model links the real interest rate to consumption through a dynamic IS (Investment-Saving) equation that relates the intertemporal marginal rate of substitution in consumption to the real interest rate. The equation leads to an intertemporal condition with the result that higher expected consumption growth is associated with higher real rates (Romer 2012).

The real interest rate is as known, the relative price of current consumption in terms of future consumption (Taylor 1999). Assuming a non-zero interest rate and also a discount rate at which individuals discount future consumption, changes in consumption may be explained by the two variables' relation to each other (Romer 2012). If the interest rate exceeds the discount rate, consumption will be rising over time, while if the opposite is true, consumption will be declining over time. Higher discount rates (the more one discounts the future), makes the real rate higher and the model thus implies that greater life expectancy (lower discount rate) decreases the real interest rate. Furthermore, higher uncertainty about either inflation or consumption growth lowers the real interest rate, as experienced after the recent financial crisis.

Consumption may be shown to be dependent on two terms respectively, one financial part, the individuals' assets, and one human wealth component, the present value of the individual's future labour income:

$$C_t = r(1 + r)^{-1}A_t + r(r - g)^{-1}Y_t^\alpha$$

This relation assumes a constant consumption path, like the permanent income hypothesis would imply (Romer 2012)<sup>8</sup>, and that real labour income is expected to grow at rate  $g$ . A rise in the real interest rate will thus have two effects on consumption; a substitution effects and a wealth effect. The human wealth component implies that a rise in the real interest rate leads to a higher discounting of labour income and consumption will hence fall. This substitution effect will always be negative as a rise in the real interest rate increases the price of current consumption in terms of future consumption. The effect of a rise in the financial component (wealth effects), however, depends on whether the person is a net debtor or net creditor. For a net creditor (positive term), an interest rate increase will increase assets and consumption will hence increase. Therefore, the results of a change in the real interest rate on consumption are ambiguous. For developed countries, the stock of wealth is generally positive (meaning they are net-creditor), leading to a positive wealth effect. In that sense, a change in the real interest rate has two opposing effect on consumption and may be a reason why there is often found a weak empirical link between the real rate and consumption.

In the New Keynesian baseline model, consumption is set equal to output. By defining the output gap as the deviation from potential output, the natural rate of interest can be written as a function of growth in potential output directly. Output gap of zero on average implies that the average value of the real interest rate equals the natural real interest rate (Hamilton et al. 2015).

At the zero lower bound, shift in aggregate supply in the direction of households wishing to work more, triggers deflationary pressure, raising real interest rate and decreasing overall demand. This is a paradox in the Keynesian literature where more supply of labour actually decreases labour in equilibrium (Eggertsson and Mehrota 2014).

The basic Keynesian literature assumes flexible prices, however, wages are perceived to be subject to price rigidity (Keynes 1936). Eggertson and Mehrota find prices to be downwardly rigid, explaining persistent unemployment in the Great Depression (Eggertson and Mehrota 2014). Due to price rigidity, trading

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<sup>8</sup> Note that empirics also seem to support the Permanent-Income Hypothesis rather than for instance the random walk theory (See Campbell and Mankiw 1989)

between countries, fixed capital, and other departures from the baseline model, the assumption of output equal to consumption is not likely to hold in practice. This hypothesis is proved to be right, as the relationship does not seem to fit well with empirical data. This leads to the conclusion of the New Keynesian Model not giving a good reason for the interest rate being dependent on output growth in the short run (Hamilton et al. 2015). However, although the New Keynesian Model may not give a good reason for a short-run relationship between the real interest rate and output growth there are strong theoretical reasons to believe there is a long-run relation between the two (Hamilton et. al 2015).

Long-term interest rates are also important to investment as a real interest rate increase tends to depress stock market values through higher cost of capital (Romer 2012). There are different theories regarding investment, a key component of aggregate demand. Domar (1946) distinguishes between capacity effects (investment increases the capacity to produce) and demand effects (investment increase demand). The growth rate of investment equals the product of the savings rate and the potential productivity of investments. Also Kalecki et. al (1987, though Lange, Pütz and Kopp 2016) indicates savings and profitability of production as important determinants for investment. This is modelled in intertemporal optimizing models where firms use the ‘net present value rule of investment’ to make investment decisions. That is, firms looks at the expected present value of the expected future income stream which the new investment will generate and only if this amount is greater than the cost of the investment should a project be undertaken. The models are referred to as ‘q theory’ or ‘Tobin’s q model of investment’ due to the central role of the variable ‘q’, the ratio of the net present value of the marginal investment project to its cost. The model suggests lower investment at higher interest rates, as an increase in expected future short-term rates reduces investment. According to the theory, one would therefore predict a negative relation between real interest rates and investment. Also various long run changes in the economy may affect investment (Kalecki et. al 1987).

In neoclassical models, demand for investment is a function of relative rental prices; user cost of capital relative to the rental cost of factor of production, for instance cost of labour which would be the real wage rate. The marginal product of capital is set equal to the user cost of capital which results in an investment equation conditioned on output and the real user cost of capital. The model results

in a negative relation between the real interest rate and investment. These neoclassical models are argued to be a good framework for investment demand in the long run (Taylor 1995).

### **Low Interest Rates as a Source of Bubbles**

*“Low real rates can produce bubbles and foster financial instability”*

*- Teulings and Baldwin (2014)*

Bubbles, defined as an asset whose market price exceeds the expected present discounted value of its dividends, may start to explode in a rational way as long as the real rate falls to values close to, or below, the growth rate in the economy (Tirole 1985, Teulings and Baldwin 2014). An interest rate lower than the growth rate leads people to save in bubbly assets rather than to invest due to the low return on investments. The price of the asset will grow at the economy's growth rate as long as investors invest a fixed share of their income in the asset. This leads to the price increasing more than present value would imply, which is in fact the definition of a bubble. Bubbles may also be seen as an alternative way for society to deal with excess saving. Buying bubbly assets with the intention of selling them at a later stage is an alternative way of saving for future consumption, more likely to happen as long as the real rate is below the growth rate of the economy (Teulings and Baldwin 2014).

A bubble is often referred to as a rational Ponzi game, a situation when debt is being 'rolled over' and not being paid back over a lifetime. Ponzi financial structures become more attractive as interest rates are low relative to expected growth rates. A rational Ponzi game or a bubble may be feasible in an overlapping generations model, for instance that of Diamond (1965), assuming the economy can grow at a rate exceeding the return to capital, i.e. the interest rate, in the long run. When the real rate falls to values close to the economy's growth rates, no one will invest as the rate of return is too low, and asset prices start to explode in a 'rational' way making Ponzi games become feasible.

Under Diamond's (1965) model it is feasible for the government to issue debt to benefit one generation (the benefit), and then pay the interest (the cost) by issuing still more debt, whenever the growth rate is higher than the return to capital, as the benefit, is higher than the cost (Tirole 1985). Debt issue is welfare improving

because it reduces the overaccumulation of capital by instead increasing consumption. Whenever there is capital overaccumulation in the balanced growth equilibrium, rational Ponzi games are possible. Same results are revealed in the model of King and Ferguson (1993) which shows that Ponzi games may remove the problem of overaccumulation and by doing that, improve welfare. If the natural real interest rate is below zero, this model actually predicts that bubbles are necessary for the existence of an equilibrium.

According to Tirole (1985) there are three conditions necessary to create a bubble, namely durability, scarcity, and common beliefs. Therefore, the possibility of creating too much of an asset may prevent bubbles. Also, ageing societies might run a greater risk of bubbles, referred to as ‘the paradox of ageing societies’ (Koo 2014). Ageing societies leads to an increase in the required stock of savings and this greater supply of savings pushes the natural real interest rate down, increasing the likelihood of bubbles. Tirole (1985) also suggests that bubbles may arise when there is excess savings in an economy. People will buy an asset so that the price increases more than the present value would imply.

## **Conclusion**

The secular stagnation hypothesis of ongoing unemployment and economic stagnation without any natural force towards full employment has gained interest after low economic growth together with low interest rates has been experienced recently. An equilibrium of secular stagnation proves possible in the model of Eggertsson and Mehrota (2014) caused by factors such as limits to debt, slowdown in population growth, increased income inequality, and fall in the relative price of capital, factors leading to reduced real interest rate on a permanent basis. Reduced real interest rate may also be caused by a changed savings-investment structure, illustrated by the Metzler diagram. Empirically, the real interest rate and economic measures such as consumption, investment and output are found to be ambiguous; however, evidence suggests a non-linear relation between interest rates and growth suggesting a positive relation in a low-rate regime. Furthermore, theory suggests that a situation of secular stagnation may be destructive for an economy’s financial stability as low real interest rates are modelled as a source of bubbles.

### **3.0 Introduction to the Analysis**

The analysis strives to answer the following question:

*“What is the long-term relationship between the real interest rate and output growth?”*

The purpose is to determine whether the results support a situation of secular stagnation in today’s economy.

The analysis consists of four parts. The first part describes all data used in the subsequent analysis. The second part performs a basic analysis in a cross-country setting including data for ten countries in the period 1960-2015. The data is retrieved from the OECD database. The third part (section four) performs an analysis for Norway using a longer dataset from Norges Bank (NB) for the period 1830-2015. The analysis is focusing on an asymmetric relationship between the real interest rate and output growth. The last part (section five) of the analysis is performed for Norway, focusing on financial stability. A credit variable from a dataset by Schularick and Taylor (2012) is used to illustrate the results. Summary of the results are given at the end of the analysis.

#### **3.1 Data Description**

All variables used in the first part of the analysis are obtained from the OECD database. A more detailed description is given in appendix 4. An overview of the included countries with related available data-range for the main variables is given in the below table.



Table 3.1: Overview of the data-range for the real interest rate and growth in real GDP per capita for the included countries

Country	Nominal interest rates	Real interest rates	Real GDP per capita	Growth in real GDP per capita
Australia	1970-2015	1970-2014	1960-2015	1961-2015
Euro area	1970-2015	1996-2014	1996-2014	1997-2014
France	1960-2015	1960-2014	1960-2015	1961-2015
Germany	1957-2015	1957-2014	1970-2015	1971-2015
Ireland	1971-2015	1975-2014	1970-2015	1971-2015
Japan	1989-2015	1989-2014	1970-2015	1971-2015
Norway <sup>9</sup>	1985-2015	1985-2014	1970-2015	1971-2015
Spain	1980-2015	1980-2014	1970-2015	1971-2015
United Kingdom	1960-2015	1960-2014	1960-2015	1961-2015
United States	1954-2015	1954-2014	1970-2015	1971-2015

### **Growth in GDP per capita and the long-term real interest rate**

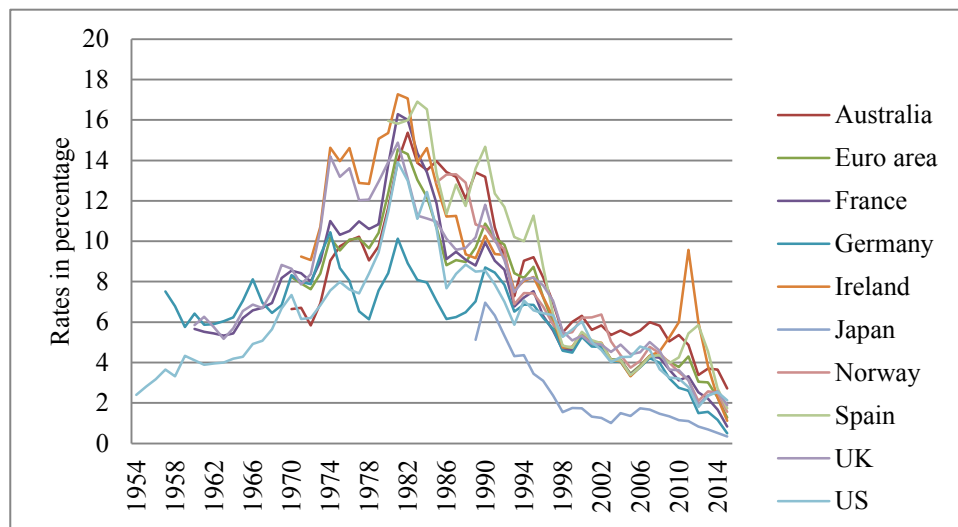
There is a clear downward trend for the long-term nominal interest rate from the 1970-1980s for all countries included, especially after the early 1980s, illustrated in figure 3.1 below. This is consistent with what Hamilton et.al (2015) describes in their paper with a broad tendency for the U.S nominal rate to decline through World War II (1939-1945) (although this period is not shown in the below graph), rise sharply until 1980, and then decline again since. One may also notice the common trend for the included countries indicating certain dependence between the countries.

The inflation rate, presented in figure 3.2, reflects the development of the interest rate, as high rates are experienced in advance of, and during, the periods of high interest rate. The period of high inflation starting from late 1972, is referred to as The Great Inflation of the 1970s, and lasted until the 80s (Collard and Dellas 2004). The reason was an oil price shock (The Oil Crisis Recession) increasing the oil price, which reduced growth in many OECD countries permanently (Barufaldi 2014). Easy-money designed to generate full employment in the US

<sup>9</sup> Note that a longer dataset is available from Norges Bank which will be used later in the analysis

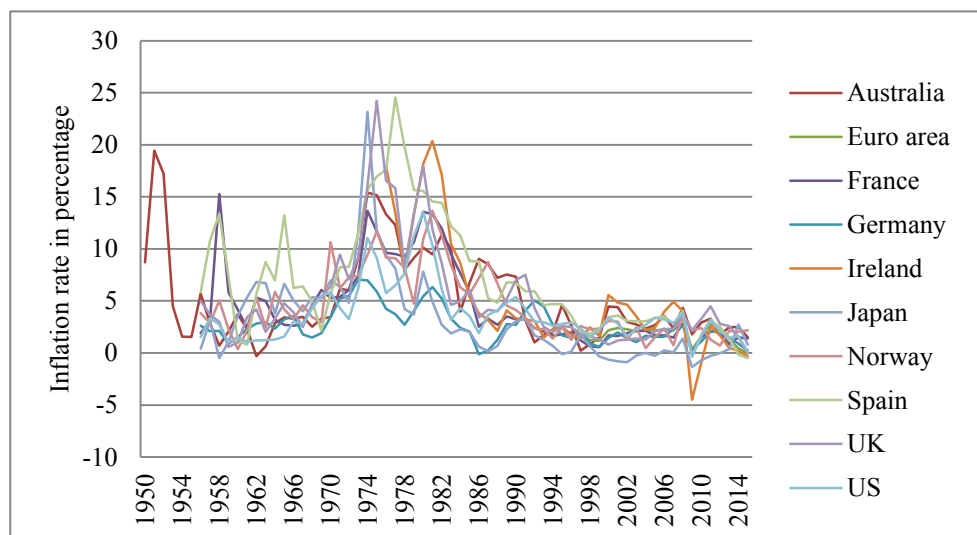
caused the high inflation rates (Bresiger 2016). The Oil Crisis Recession was characterized by so-called “stagflation”; low economic growth together with high inflation. In the past two decades one has experienced low levels of inflation and also more stable inflation rates, which may be seen in context with the low interest rates, but also the many countries that have implemented inflation-targeting around 2% or below, including Australia (1993), Norway (2001), and the UK (1997).<sup>10</sup>

Figure 3.1: Long-term nominal interest rates 1954-2015



Source: OECD

Figure 3.2: Inflation rate 1950-2015



Source: OECD

<sup>10</sup> Year of implementation in parentheses

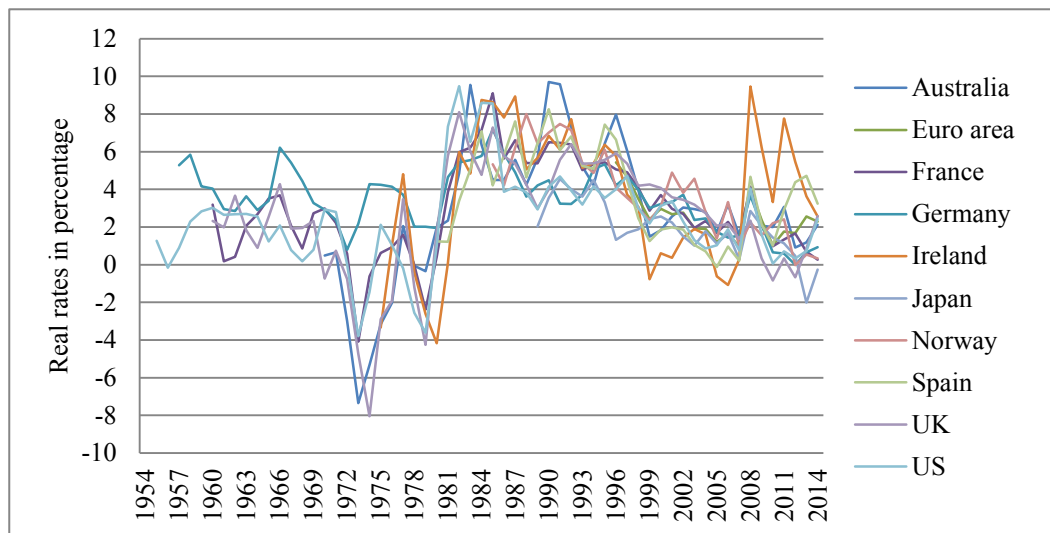
### The long-term real interest rate

The real interest rates, shown in figure 3.3, are obtained from the variables above, calculated as the nominal interest rate adjusted for inflation by the following relationship (Fisher equation):

$$1 + r_t = \frac{1 + i_t}{1 + \pi_{t+1}}$$

where  $r_t$  is the long-term real interest rate in period  $t$ ,  $i_t$  is the long-term nominal interest rate in period  $t$ , and  $\pi_{t+1}$  is the inflation rate one period forward (Fisher 1930).

Figure 3.3: Long-term real interest rates 1954-2014



Source: OECD and own calculations

Also the real rates have declined consistently since the 1980s, although low levels of the real rate has also been experienced before. However, as was seen in figure 3.2, these low rates were primarily due to high inflation rates as opposed to today when inflation rates seem to be at low levels around target.

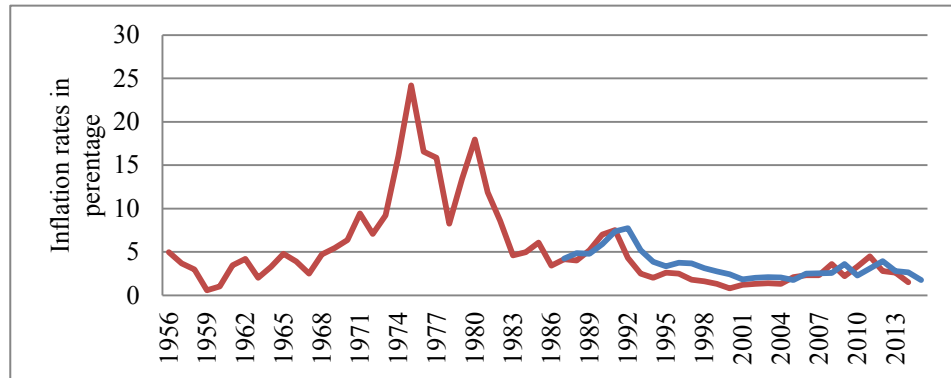
### Estimation of Inflation as Input to the Real Rate

Calculating the real interest rate based on nominal rates and inflation may also be done in alternative ways. In estimating the real interest rate, Hamilton et al. (2015) uses estimates of the inflation rate as a representation of the expected inflation one period forward rather than the actual rate as was used above. The regression coefficients are based on the 30 previous observations (30-year interval) and inflation is estimated using the autoregressive model:

$$\pi_t = c + \varphi\pi_{t-1} + \varepsilon_t$$

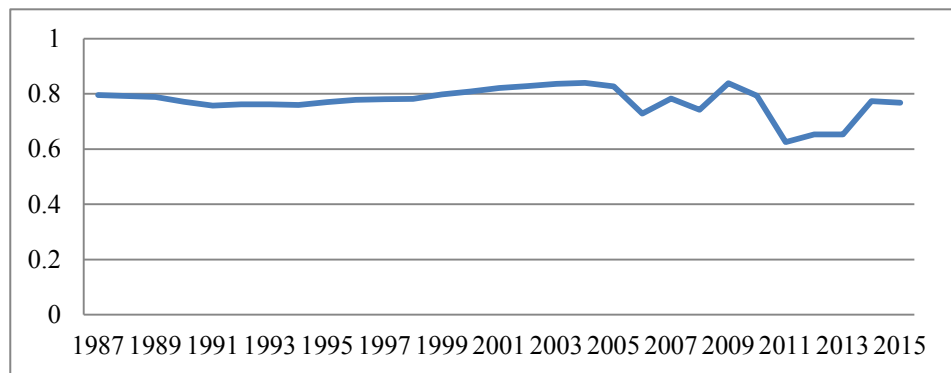
The resulting inflation rate for the UK is given below compared to the actual inflation rate. Also, the persistence level, the coefficient  $\varphi$ , is given.<sup>11</sup>

Figure 3.4: Estimated inflation rate vs actual inflation rate for UK



Source: OECD and own calculations

Figure 3.5: Persistence of the inflation rate (UK)



Source: OECD and own calculations

The real interest rate is then estimated using the following relation:

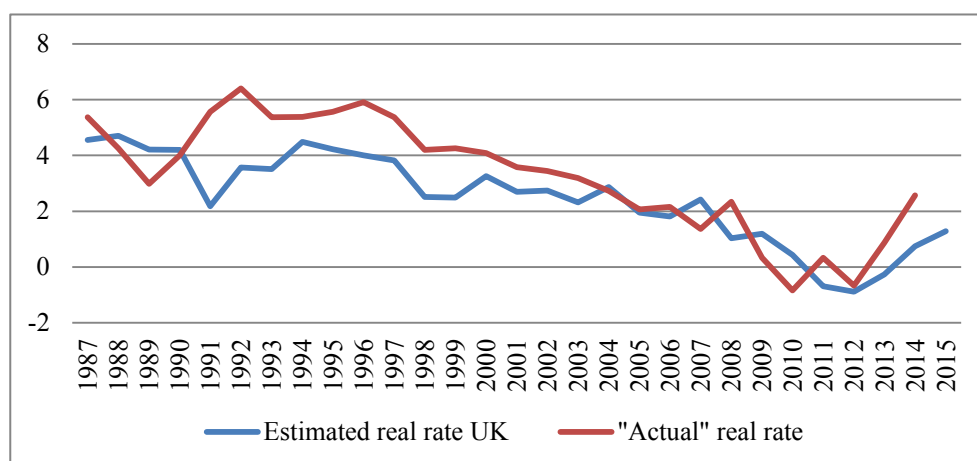
$$1 + r_t = \frac{(1 + i_t)}{(1 + (c_t + \varphi_t\pi_t))}$$

where  $c$  and  $\varphi$  are the estimated coefficients from the regression above. Figure 3.6 illustrates the two different methods for the UK where the red line represents the real rate based on estimated inflation, while the blue line represents the real rate based on actual inflation where the latter is calculates as:

$$r_t = \frac{(1 + i_t)}{(1 + \pi_{t+1})} - 1$$

<sup>11</sup> May be compared to Hamilton et al. (2015) Exhibit 2.2, Row 3

Figure 3.6: Estimated vs actual long-term real interest rate UK 1987-2015



Source: OECD and own calculation

For simplicity, I have chosen to make use of the actual inflation rate one period forward in estimating the real rate for all countries, UK included.

### Growth in Real GDP per Capita

Data for GDP per capita retrieved from OECD are given in current prices. The data are therefore adjusted for inflation in order to achieve data for *real* GDP per capita, i.e. in constant prices with base year chosen as 2015.

In order to convert the nominal measures to real values, discount factors are made for each year for each country as the product of the discount rates for each of the following years up to where  $t = 2015$ :

$$\delta_{i,t} = (1 + \pi_{i,t+1}) * (1 + \pi_{i,t+2}) * (1 + \pi_{i,t+3}) * \dots * (1 + \pi_{i,T})$$

where  $T = 2015$ .

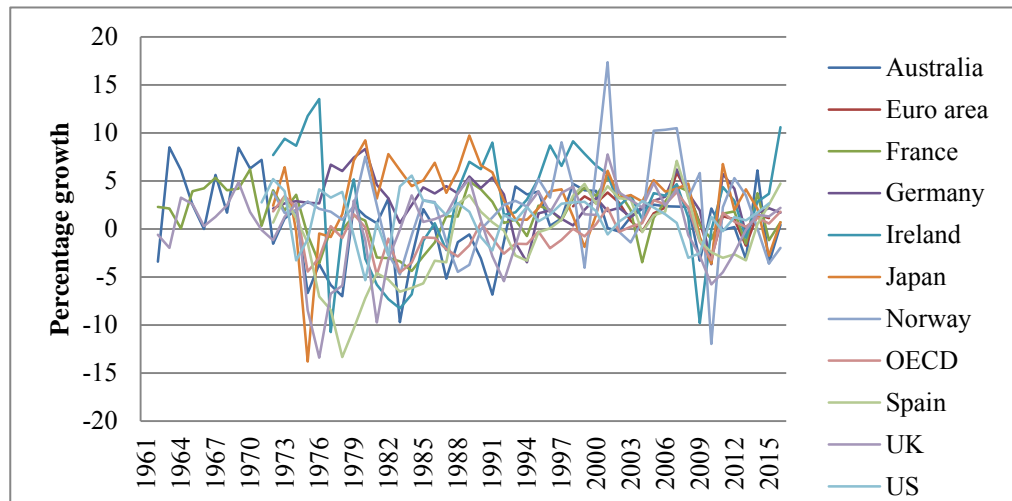
The discount factors are then multiplied with the corresponding year's value of GDP per capita in current prices to achieve that year's GDP per capita in constant prices, i.e. the real values.

Growth rates are simply calculated as following year's GDP divided by current year's GDP.

Table 3.7 illustrates growth in real GDP per capita for the period 1961-2015.<sup>12</sup>

<sup>12</sup> Raw data and additional figures are given in appendix 5

Figure 3.7: Growth in real GDP per capita 1961-2015

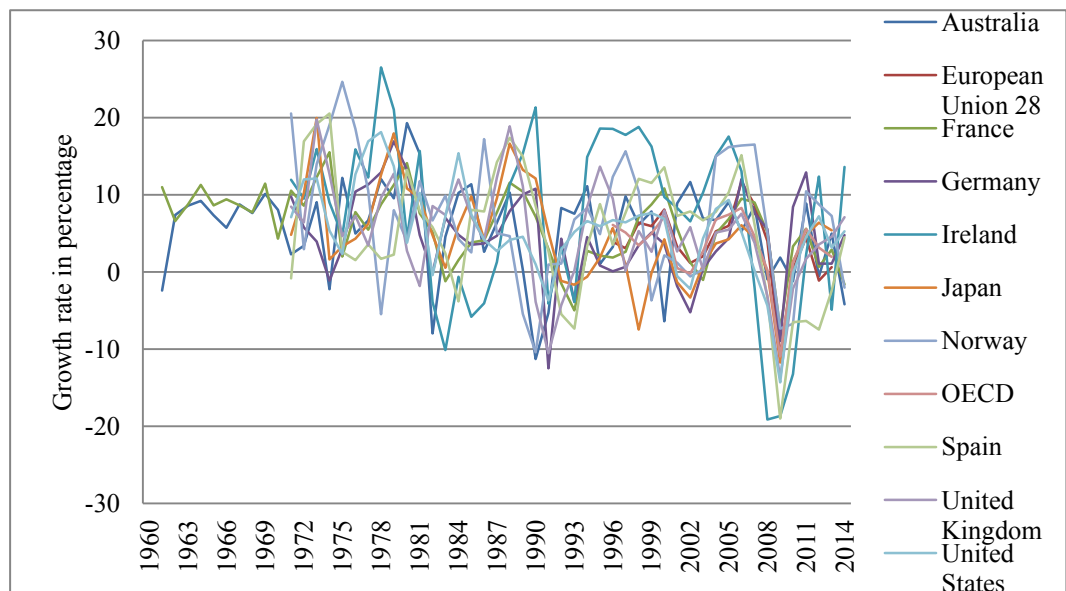


Source: OECD and own calculations

### Investment

Investment is represented by the growth in Investment GFCF (Gross Fixed Capital Formation) in nominal and per-capita values, given in figure 3.8. As shown, there was a drop in investments during the recent financial crisis, however, the economy seem to have recovered mostly since.

Figure 3.8: Growth in investment GFCF per capita 1961-2015



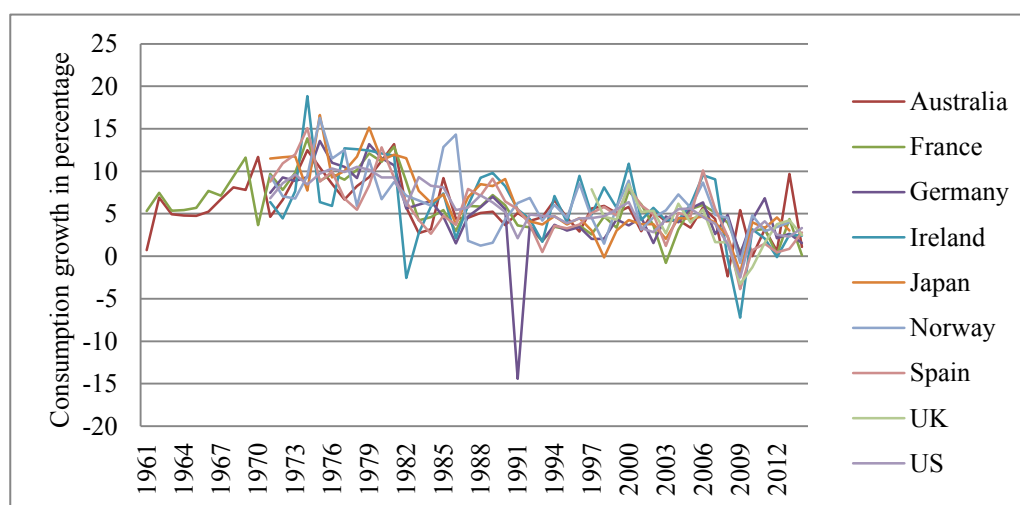
Source: OECD and own calculations

### Consumption

Consumption growth is given by growth in household spending per capita, also in nominal values, presented in figure 3.9. A sharp decline was experienced during

the recent financial crisis. Note the outlier for Germany due to the German reunification in 1990.

Figure 3.9: Growth in household spending per capita 1961-2015



Source: OECD

### Description of Dataset by Norges Bank

A longer dataset is available for Norway from Norges Bank and a more detailed analysis will therefore be performed for Norway later in this paper. Description of the dataset is given in the current section.

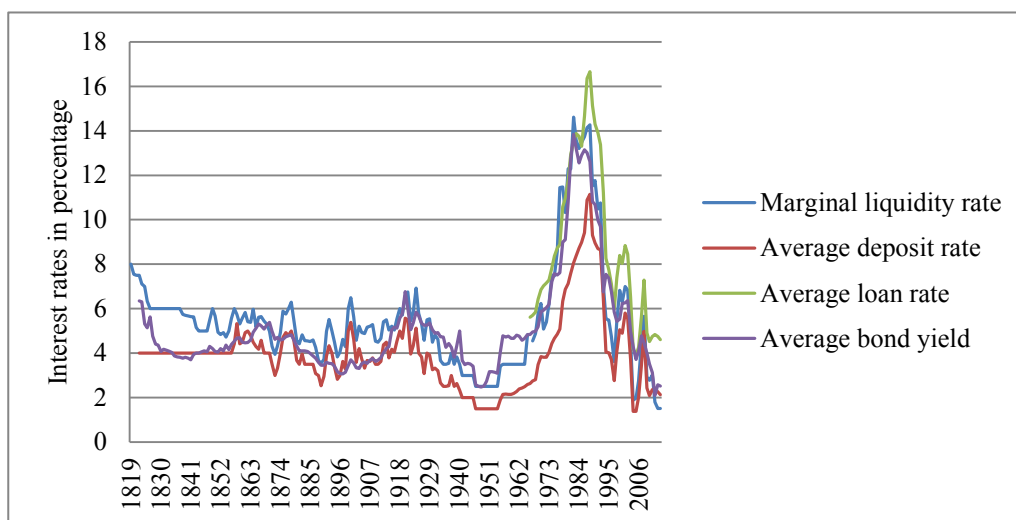
The relevant variables for the analysis are the long-term real interest rate, and investment, government consumption, private consumption, and GDP, all variables in per capita-values and growth rates. All data are retrieved from Norges Bank (2014) (norgesbank.no).

### Nominal interest rates

The nominal interest rates included in the dataset are the marginal liquidity rate, the average deposit rate, average loan rate and average bond yield. All rates are yearly rates. As figure 3.10 shows, the marginal liquidity rate is always higher than the deposit rate, which seems to follow the marginal liquidity rate quite closely. The marginal liquidity rate is also more volatile than the average bond yield rate, the long-term nominal yield on government bonds.

For a representation of the long-term nominal interest rate the average bond yield will be used.

Figure 3.10: Nominal interest rates Norway 1819-2014

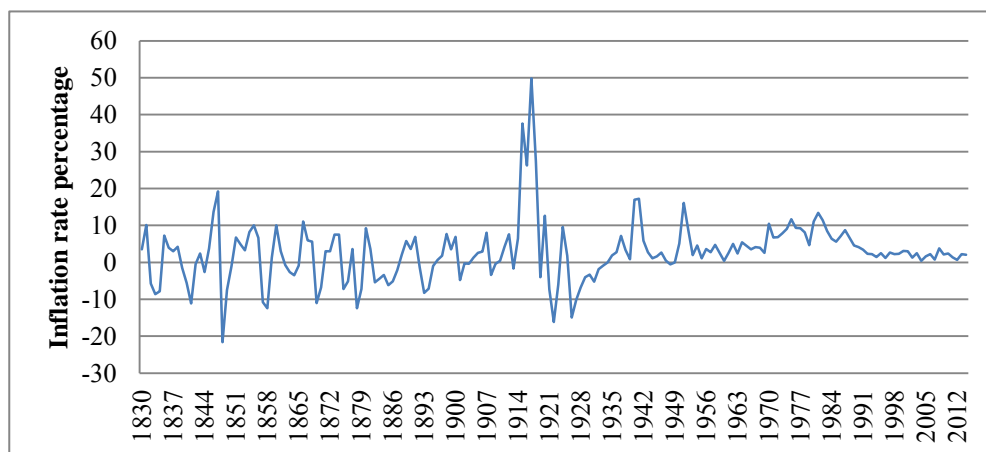


Source: Norges Bank

### Inflation

The inflation is measured as changes in the consumer price index, which ranges all the way back to 1516. However, the analysis will make use of data only from 1830, presented below.<sup>13</sup> As figure 3.11 illustrates, inflation has become more stable throughout the time and is currently fluctuating just above zero. The inflation rate is useful in attaining real interest rates from the nominal rates.

Figure 3.11: Inflation rate 1830-2014



Source: Norges Bank

### GDP, Consumption, and Investment

Other very useful variables for describing an economy is GDP, consumption; both private and governmental, and investment. The data are in constant prices (2005-

<sup>13</sup> See appendix 6 for graphical representation of raw data for consumer price index and inflation from 1516

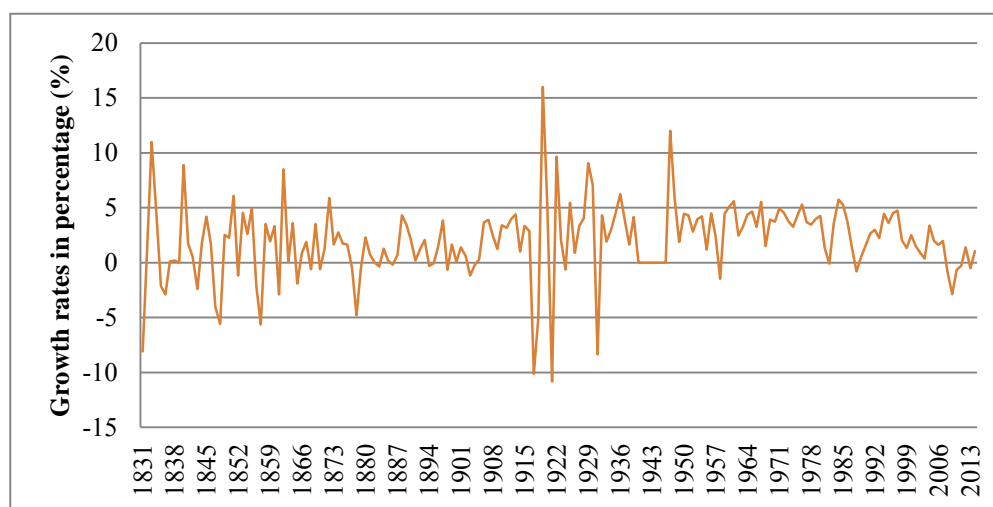


prices) and divided by the population in order to achieve per-capita values. Growth rates are presented below, while raw data are given in appendix 8.

The first graph (figure 3.12) shows growth in real GDP per capita, while figure 3.13 shows growth in consumption (private and governmental) and investment in the period 1831-2014. Investment growth in 1919 turned out to be very high and in order to give a better picture of the growth rates the rest of the period, this data-point is considered an outlier and excluded from the below graphs. Investment itself is quite volatile compared to the other variables, also confirmed by descriptive statistics displaying a significantly higher variance related to the mean value of growth in investment compared to the other variables.<sup>14</sup> This is consistent with other findings, for example that of investment being three times as volatile as output (Kydland and Prescott 1990).

As one may notice in the below graphs is that data is missing from during the war (1940-1946). A constant growth rate throughout the period of the missing data is assumed for all variables.

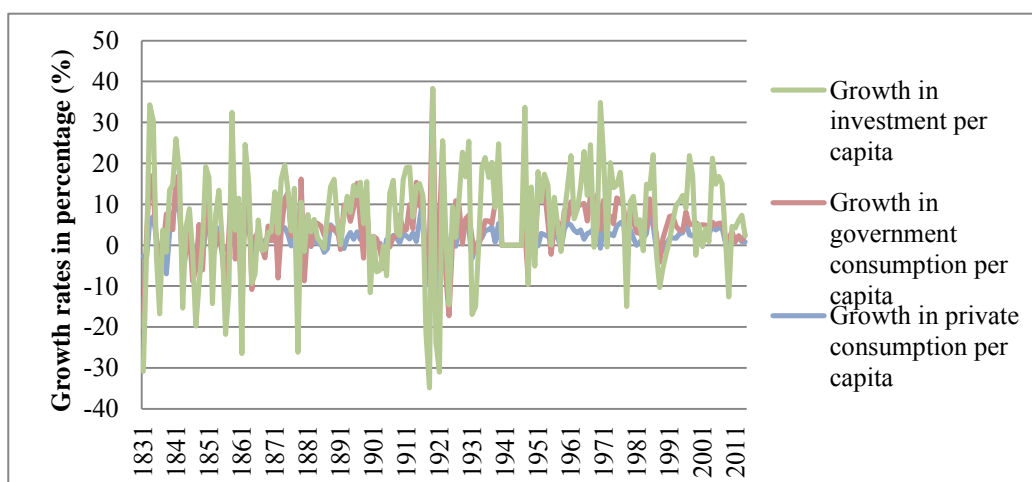
Figure 3.12: Growth in real GDP per capita 1831-2014



Source: Norges Bank

<sup>14</sup> Growth in investment per capita has a standard deviation of 0.1623, compared to GDP per capita (0.0344), Private consumption per capita (0.0376) and government consumption (0.0576). See appendix 7 for descriptive statistics.

Figure 3.13: Growth rates private- and government consumption, and investment  
1831-2014 (outlier excluded)



Source: Norges Bank

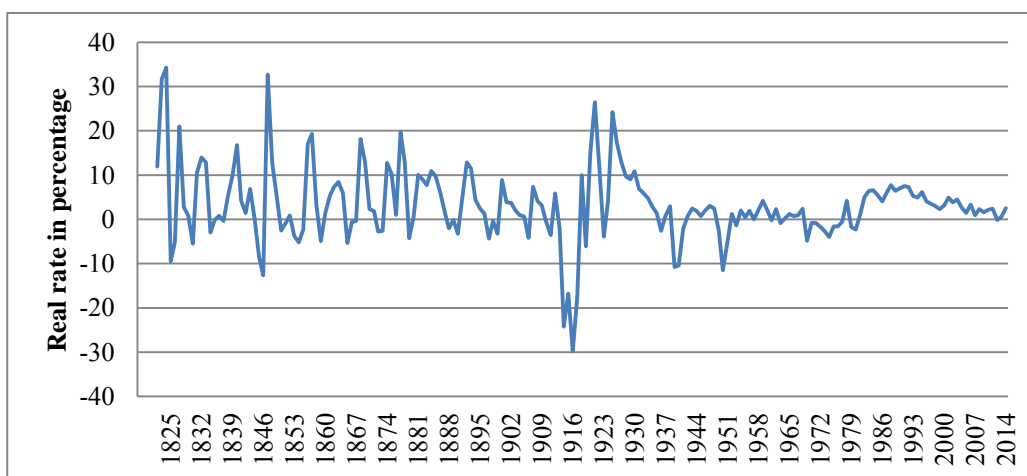
### The real interest rate

The real interest rates are obtained from the variables above, and calculated as the nominal interest rate adjusted for inflation by the following equation:

$$r_t = \frac{1 + i_t}{1 + \pi_{t+1}} - 1$$

A graphical illustration is given in figure 3.14 below.

Figure 3.14: Long term real interest rate



Source: Norges Bank and own calculations

One may recognize the high volatility in the real rate which is primarily due to high volatility in the inflation rate. The rate is more volatile in the first period of the dataset, before WW2, and significantly more stable in the last part of the dataset.

## Data from Schularick and Taylor (2012)

Data are also retrieved from the dataset of Schularick and Taylor (2012), an annual dataset consisting of 14 countries for the period 1870-2008 including several variables. The subsequent analysis will focus on the variable ‘total bank loans’ representing credit.

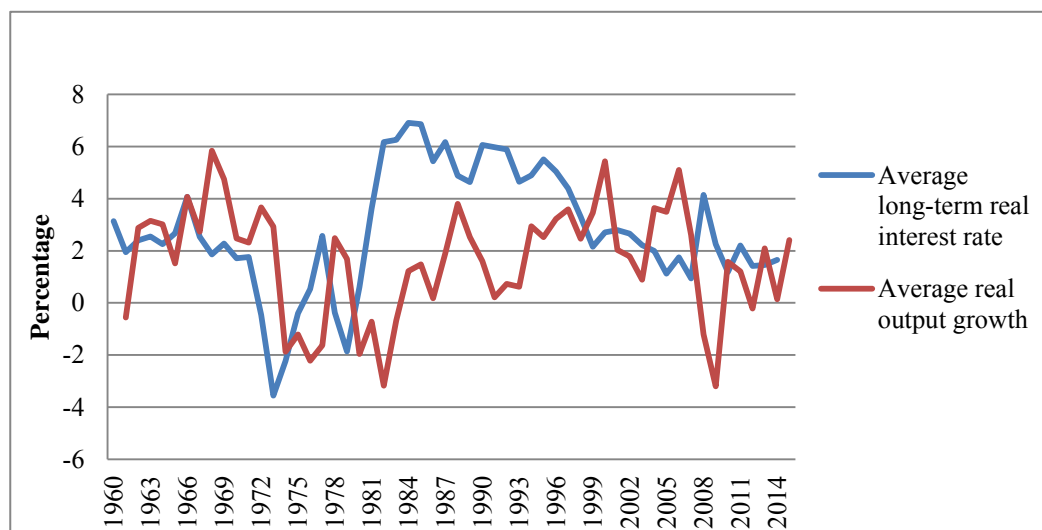
### 3.2 Analysis – some results

This section presents preliminary results for the 10 countries included in the OECD dataset described earlier. The analysis consists of correlation- and regression analysis to uncover part of the relationship between the long-term real interest rate and growth in real output. Support for a positive relation is found. A closer look at Norway reveals an asymmetric relationship between the long term real interest rate and growth in output where a low-rate regime seems to be characterized by a positive relation.

#### Correlation Analysis

The correlation analysis focuses on the relation between the long-term real interest rate and the real output growth represented by growth in real GDP per capita. The relationship is illustrated in the very simplified graph below, illustrating the average long-term real interest rate and average real output growth for the ten included countries for the available data-range in the period 1960-2015.<sup>15</sup>

Figure 3.15: Long-term real interest rate against real growth in output 1960-2015



Source: OECD and own calculations

<sup>15</sup> The included countries are: Australia, Euro area, France, Germany, Ireland, Japan, Norway, Spain, UK, US. Each country is included in the average for the specific country's data-range.

A first look at the above graph reveals a positive relationship in the first part of the dataset where the interest rate seem to be leading output growth, while there might be a tendency for a negative or ambiguous relation in the last part of the dataset.

The correlation table below (table 3.2) consists of three parts where the real interest rate and growth in real GDP per capita are analysed in relation to each other for three scenarios; real interest rate and GDP growth in same period, real rate leading GDP, and GDP leading the real interest rate. The results are not very robust as they vary significantly between the different scenarios. However, the strongest<sup>16</sup> correlations are found in the second scenario where the real rate is leading the real output growth. In this scenario, there is a positive relationship for 7 of the 10 countries (8 if the long dataset for Norway is used), where 4 of the countries shows relative strong correlations, all being above 37 %. It seems like these countries also tend to have a somewhat longer dataset, most likely leading to more significant results. Also note that using the longer dataset for Norway lead to a positive relation, as opposed to a negative relation using the short dataset from OECD. Using the averages illustrated in the figure above reveals a positive correlation between the long-term real interest rate and output growth of 0.1834, assuming the real rate is leading output growth by one period.

Different theories might support all three scenarios.<sup>17</sup> Considering a situation of slow economic growth, this often suggests that interest rates are reduced to stimulate growth, at least in the short term. Thinking in this manner, growth rates would lead the real interest rate. On the contrary, when interest rates are reduced, this would often cause economic growth to pick up, implying that the interest rate leads output growth. However, this may also be considered as a short-term perspective. In the long term, low rates may be argued to be a result of a changed savings-investment balance, causing an adjustment of the natural real interest rate, which may again affect growth. Also note that in this paper there is a focus on long-term real interest rate, which are often said to lead economic growth as they reflect future stock market prices etc. For a more detailed theoretical discussion, refer to section two of this paper.

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<sup>16</sup> Measured by the number of strong correlations (example above 37 %)

<sup>17</sup> See Leduc, Rudebusch (2014), Rachel, Smith (2015), Taylor (1999).

Table 3.2: Correlation table illustrating different scenarios

Country	Time frame	Corr	Corr	Corr
		$(r_t, \Delta y_t)$	$(r_{t-1}, \Delta y_t)$	$(r_t, \Delta y_{t-1})$
Australia	1970-2014	-0.0152	0.3775	-0.1701
Euro area	1996-2014	0.0195	-0.0691	0.2528
France	1961-2014	-0.0927	0.1066	-0.2042
Germany	1971-2014	-0.0365	0.0600	-0.0550
Ireland	1975-2014	-0.0840	0.4016	-0.2714
Japan	1989-2014	0.0271	0.2421	-0.0279
Norway (OECD)	1985-2014	-0.1261	-0.0283	-0.2156
Norway (NB)	1831-2014	-0.1962	0.0220	-0.1336
Spain	1980-2014	-0.2093	-0.0724	-0.2559
UK	1961-2014	0.3950	0.7087	0.1445
US	1971-2014	0.0127	0.3912	-0.2075

### Regression Analysis

A regression using ordinary least squares (OLS) has been conducted for the following relationship:

$$\Delta y_{i,t} = \alpha_i + \beta_i r_{i,t-1} + \gamma_{1,i} \Delta y_{i,t-1} + \gamma_{2,i} \Delta y_{i,t-2} + \gamma_{3,i} \Delta y_{i,t-3} + \gamma_{4,i} \Delta y_{i,t-4} + \varepsilon_t$$

where  $\Delta y_{i,t}$  is the growth in real GDP per capita for country  $i$  in period  $t$  (change from period  $t-1$  to period  $t$ ) and  $r_{i,t-1}$  is the real long-term interest rate in period  $t-1$ . The numbers of lags of the dependent variable that are included are based on a lag-reduction test (F-test) up to four lags.<sup>18</sup> The results from the regressions reveal a positive correlation for eight out of ten countries, where four are statistically significant. The four countries tend to have longer dataset than the countries with less significant results. For the “significant” countries, the real interest rate for the previous period seems to explain between 14-60 % of the variation in real GDP per capita (refer to appendix 10 for summary of regression output).

The question arises whether one period is enough for the real rate to lead or have any effect on the growth in GDP per capita. Based on a lag-reduction test

<sup>18</sup> See appendix 9 for zero and four lags

performed, the same number of lags of the dependant variable will be included, but now also with additional lags of the real rate.<sup>19</sup>

The regression performed is the one below, where two lags of the dependant variable and four lags of the real rate are included as example. Number of lags included of the real rate is based on a lag-reduction test (F-test). Regression output is summarized in table 3.3.

$$\Delta y_{i,t} = \alpha_i + \beta_{1,i}r_{i,t-1} + \beta_{2,i}r_{i,t-2} + \beta_{3,i}r_{i,t-3} + \beta_{4,i}r_{i,t-4} + \gamma_{1,i}\Delta y_{i,t-1} + \gamma_{2,i}\Delta y_{i,t-2} + \varepsilon_t$$

Table 3.3: Regression output including lags of the real rate

Country	$\hat{\alpha}$	Lags of real rate (j)	$\hat{\beta}_j$	$\hat{\beta}_j$ p-value	Adj. $R^2$
Australia	-1.2139	1	0.3813**	0.0093	0.1441
Euro area	0.9324	1	-1.0935*	0.0802	0.3288
		2	1.0570**	0.0385	
France	0.1353	1	0.1643	0.1846	0.2835
Germany	0.7609	1	-0.5519	0.1011	0.2541
		2	0.8364**	0.0173	
Ireland	-1.2642	1	0.6456**	0.0021	0.3214
Japan	1.7475	1	0.6896	0.2479	0.1261
		2	0.8600	0.1773	
		3	-1.6151*	0.0526	
		4	0.3053	0.6439	
Norway	0.1587	1	-1.3770	0.1378	0.1155
		2	1.1510	0.2652	
		3	-1.1524	0.2720	
		4	1.9926**	0.0474	
Spain	-0.2869	1	0.1366	0.4099	0.5863
UK	-1.6015	1	0.7271**	0.0000	0.6011
US	0.0329	1	0.3158**	0.0064	0.2184

\*Significant at 10% level

\*\*Significant at 5 % level

<sup>19</sup> Refer to table 5 in appendix 10 for additional information regarding time-period and included lags of the dependant variable for each specific country

When allowing for more than one lag of the real rate to be included, more coefficients turn out significant. This is true for Euro area (two lags included, both significant), Germany (two lags included, the second significant), and Japan and Norway (two lags included, one of them significant). The variation explained by the model, measured by the adjusted R-square, is also significantly improved from the previous regression (appendix 10).

Based on the analysis there is support for a positive relation between the long term real interest rate and output growth for the majority of the countries included in the dataset. Next section will look more deeply into Norway.

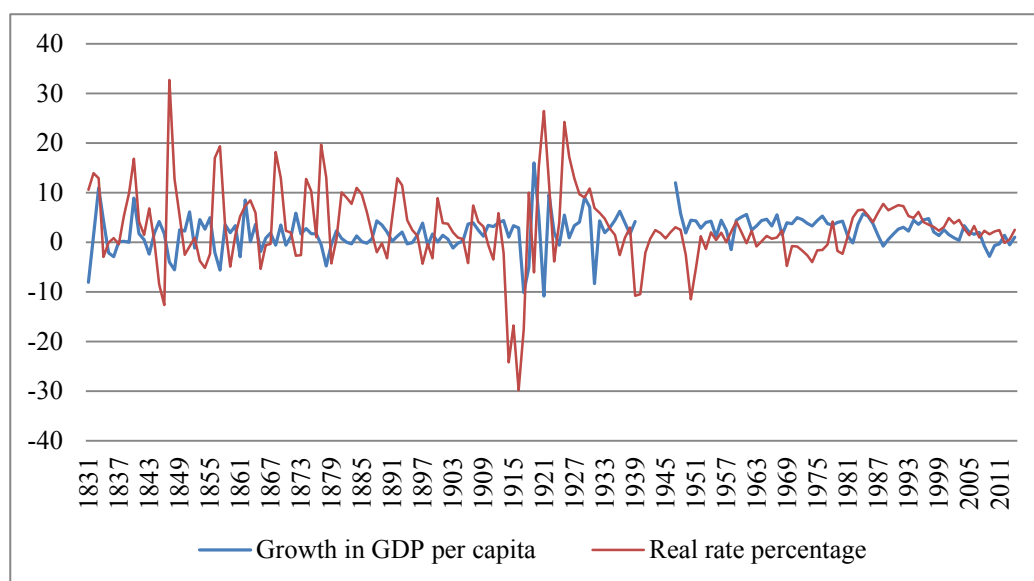
## 4.0 Analysis for Norway

This section performs a detailed analysis of Norway based on a longer dataset obtained from Norges Bank. The analysis reveals an asymmetric relationship where a low-rate regime is characterized by a significant positive relation between the long-term real interest rate and economic growth, measured by growth in GDP per capita.

### 4.1 Simple analysis: Norway

The analysis starts by simple correlation- and regression analysis where the relationship between growth in GDP per capita and the long-term real interest rate is investigated. The two variables are presented graphically in figure 4.1 below for the time period 1831-2014.

Figure 4.1: Percentage growth in real GDP per capita and the real rate for Norway  
1831-2014



*Source: Norges Bank and own calculations*

### 4.2 Correlation analysis

From the preliminary results including ten different countries from the OECD dataset there was a strong tendency for the middle column ( $r_{t-1}$ ,  $\Delta y_t$ ) to reveal a positive relationship between the long-term real interest rate and growth in real GDP per capita. However, Norway was one of the countries revealing an ambiguous relationship. Extending the dataset for Norway as well as dividing into three different periods of equal length, the correlation is analysed in more detail. The results are shown below in table 4.1. For when the real rate is either in the



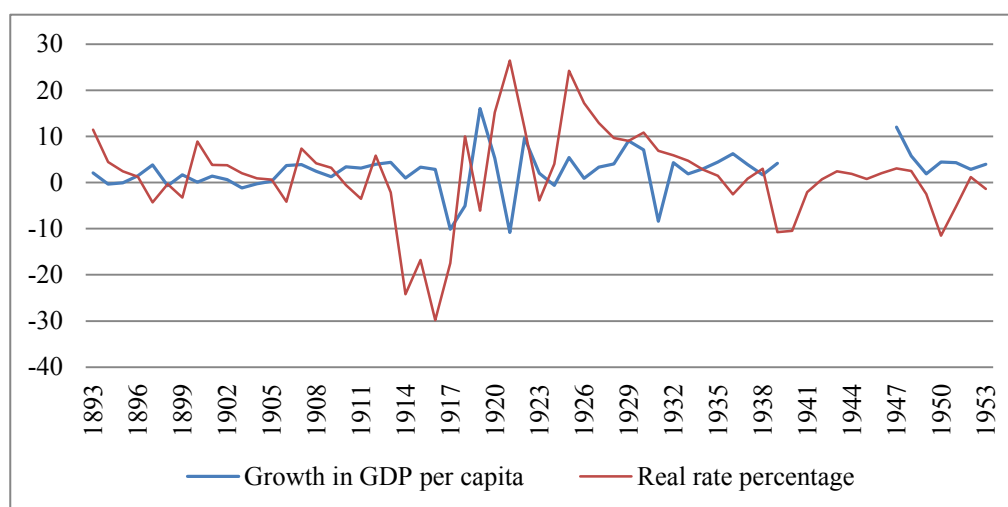
same period as, or lagging the economic growth variable, the relationship is negative in all periods. However, the relationship is more ambiguous when the real rate is leading economic growth.

Table 4.1: Correlation table for Norway (NB dataset)

Time-period (t)	Corr ( $r_t, \Delta y_t$ )	Corr ( $r_t, \Delta y_{t+1}$ )	Corr ( $r_{t+1}, \Delta y_t$ )
<b>1831-2014</b>	-0.1962	0.0220	-0.1336
<b>1831-1892</b>	-0.2890	-0.0896	-0.1965
<b>1893-1953</b>	-0.0660	0.1751	-0.0003
<b>1954-2014</b>	-0.2310	-0.0904	-0.2605

For the scenario when the real rate is leading output growth, the relation is positive for the full dataset, but the positive correlation is in fact entirely due to the middle period 1893-1953, as shown in the below graph (figure 4.2).

Figure 4.2: Real interest rate vs percentage growth in GDP per capita 1893-1953



Source: Norges Bank and own calculations

Before any conclusion is made about the relationship between the long-term real rate and output growth, a closer analysis is necessary. Most evidence point to a negative correlation, however, there may seem like there could be a positive link when the real rate is leading the growth rate in GDP per capita. This relation will be investigated closer using a regression analysis.

### 4.3 Regression analysis

Based on the results from the correlation analysis above, a simple regression is performed on the form:

$$\Delta y_{i,t} = \alpha_i + \beta_i r_{i,t-1} + \varepsilon_t$$

Where  $\Delta y_{i,t}$  is percentage growth in real GDP per capita in period t, while  $r_{i,t-1}$  is the long-term real interest rate the previous period. The results from the regression analysis are shown in table 4.2 below.

Table 4.2: Summary of regression output for Norway (short regression)

Time-period	No. of observations	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\beta}$ p-value	Adjusted $R^2$
1832-2014	183	2.3068	0.0101	0.7672	-0.0050

Using a longer dataset for Norway now reveals a positive relationship, although the relation is far from significant. Including more lags of the dependent variable (shown below), reveals an even greater positive effect on economic growth next period, however, still not significant although more significant than the first regression and the R-square suggesting more explanatory power. Number of lags of the dependant variable is based on a lag reduction test (F-rest) suggesting four lags. Summary of regression output is given in table 4.3.

Regression including more lags of the dependant variable:

$$\Delta y_{i,t} = \alpha_i + \beta_i r_{i,t-1} + \gamma_{1,i} \Delta y_{i,t-1} + \gamma_{2,i} \Delta y_{i,t-2} + \gamma_{3,i} \Delta y_{i,t-3} + \gamma_{4,i} \Delta y_{i,t-4} + \varepsilon_t$$

Table 4.3: Summary regression output, including lags of the dependant variable

Time period (obs.)	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\beta}$ p-value	$R^2$ (adjusted)
1831-2015 (180)	1.2978	0.0129	0.7035	0.1012 (0.0754)

The question arises whether *one* period is enough for the real rate to lead or have any effect on growth in GDP per capita. When including lags of the real rate two of the coefficients (the second and third lag) are significant but with opposing signs. However, the model explains little of the variation in output and so the real rate do not seem like a significant variable.

#### 4.4 Analysis for Norway – Asymmetry

One reason why there might not exist any clear relation between the real interest rate and output growth for the sample period analysed may be a change in the relationship over the period, that is; the relation is asymmetric. This section analyses the possibility further using the longer dataset from Norges Bank.

##### Low- vs high-rate regime

Literature discussed the different mechanisms of the real rate depending on the level of the real rate, or a so-called asymmetric relationship between the real interest rate and economic growth.<sup>20</sup> Table 4.4 below motivates this relation, where a high rate-regime seems to be characterised by a negative relation, whereas a low rate-regime seem to be characterised by a positive correlation. Note that the correlation coefficient is between the long-term real interest rate at time  $t$ , and growth in real GDP per capita the same period.

Table 4.4: Investigating low vs high-rate regime

Dataset	No. of observations	Corr ( $r_t, \Delta GDP_t$ )
Full dataset <sup>21</sup>	177	-0.19
Real rate above 5%	56	-0.24
Real rate below 5 %	121	-0.03
Real rate below 2 %	81	+0.04
Real rate below 1%	67	+0.09

##### Considering the effect of low real interest rates

The insignificance of the real rate's effect on output growth in the regression analysis performed earlier seems to be explained by an asymmetric relationship as shown above. The subsequent analysis will have a special focus on the effect a low real interest rate on output growth as this is the case of relevance in a situation

<sup>20</sup> Refer to section 2.0 "Literature review and theoretical framework". Same relation is found empirically by for example Fry (1997).

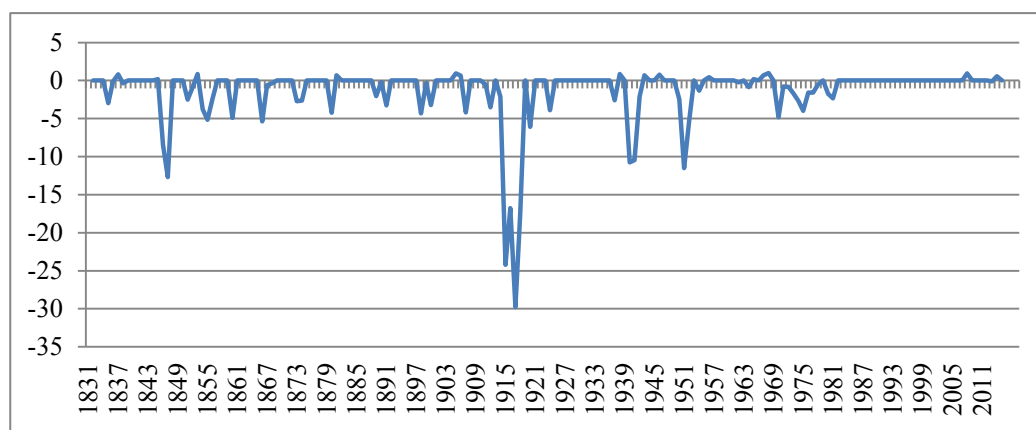
<sup>21</sup> Note that the missing data between 1940-1947 are excluded from the analysis

of secular stagnation. The method used in this paper includes the generation of a new data-series for the long-term real interest rate where

$$r_{new_{i,t-1}} = \begin{cases} r_{i,t-1} & \text{if } r_{i,t-1} < 1\% \\ 0 & \text{otherwise} \end{cases}$$

Similar approach is used in Bjørnland (2008) for different analysis.<sup>22</sup> The new series will only capture the real rate of low values below 1%, while values above the threshold are simply set equal to zero. The new series is illustrated in figure 4.3 below.

Figure 4.3: New series of the long term real interest rate



Source: Norges Bank and own calculations

The regression becomes

$$\Delta y_{i,t} = \alpha_i + \beta_{i,1} r_{new_{i,t-1}} + \gamma_{1,i} \Delta y_{i,t-1} + \gamma_{2,i} \Delta y_{i,t-2} + \gamma_{3,i} \Delta y_{i,t-3} + \gamma_{4,i} \Delta y_{i,t-4} + \varepsilon_t$$

Table 4.5: Summary of regression output using new series of the real rate

Variable	Coefficient	Standard error	P-value
$\alpha$	1.4494	0.3814	0.0002
$r_{new_{i,t-1}}$	0.1369	0.0628	0.0306
$\Delta y_{i,t-1}$	0.1851	0.0738	0.0131
$\Delta y_{i,t-2}$	-0.0799	0.0732	0.2762
$\Delta y_{i,t-3}$	0.1813	0.0728	0.0137
$\Delta y_{i,t-4}$	0.1582	0.0715	0.0282

<sup>22</sup> Note that for instance Kilian and Vigfusson (2009) have shown that using censored data when analysing the effect of asymmetric shocks (for the energy market) may give inconsistent parameter estimates. Hence, results should be interpreted carefully

The regression consists of 180 observations, dataset reduced because of the lagged values of the dependent variable. The regression explains 13.59% (or 11.11% according to adjusted R-squared) of the variation in the dependent variable.

As table 4.5 reveals, the real interest rate is now significant at 95 % confidence level and shows a positive coefficient. Low values of the real interest rate (below 1%) have a positive effect on output growth the following period, meaning higher values of the real rate (within the range given) leads to higher economic growth.

Including also the initial series of the real interest rate previous period in addition to the new series of the low rate, reveals results as shown in table 4.6.

Table 4.6: Summary regression output including new series of real rate and initial series

<b>Variable</b>	<b>Coefficient</b>	<b>Standard error</b>	<b>P-value</b>
Intercept	1.9776	0.4627	0.0000
$r_{i,t-1}$	-0.0934	0.0471	0.0490
$r_{new_{i,t-1}}$	0.2620	0.0887	0.0036
$\Delta y_{i,t-1}$	0.1476	0.0756	0.0525
$\Delta y_{i,t-2}$	-0.0912	0.0728	0.2122
$\Delta y_{i,t-3}$	0.1882	0.0723	0.0100
$\Delta y_{i,t-4}$	0.1544	0.0709	0.0308

Now, both the initial series of the long-term real rate and the new series for the low rate turn out significant. The new series of the low rate has a positive coefficient as expected, and the initial series of the real rate has a negative coefficient of -0.0934. The model explains 21.58 % (adjusted R-square) of the variation in output growth.

## 5.0 Analysis Norway: Financial Stability

Consequences of low real interest rate are of great concern mostly in regards to its effect on financial stability. This section will include a variable representing credit to analyse low real interest rate's impact on financial stability in a multivariate setting. The credit variable is retrieved from the dataset of Schularick and Taylor (2012) described earlier. The analysis starts with a regression analysis meant as a motivation for further analysis.

### 5.1 Regression – Motivation

The following regression is performed for Norway for the period 1878-2009 using OLS:

$$\Delta y_t = \alpha + \beta_1 r_{t-1} + \beta_2 \text{priv\_consump}_{t-1} + \beta_3 \text{gov\_consump}_{t-1} + \beta_4 \text{inv}_{t-1} + \beta_5 \text{credit}_{t-1} + \varepsilon_t$$

The dependant variable,  $\Delta y_t$ , refer to growth in GDP per capita while  $r_t$  is the real long term interest rate, both variables retrieved from Norges Bank, as well as private consumption, government consumption, and investment. 'Credit' is a measure of total bank loans or total lending obtained from Schularick and Taylor's (2012) dataset. All variables are in real values, and all variables (except the real rate) are log-transformed and defined in per capita-values. A selection of the regression output is given in table 5.1 below.

Table 5.1: Summary of regression output

Variable	Coefficient	Standard error	P-value
$\alpha$	-1.8751	0.2960	0.0000
$r_{t-1}$	0.0019	0.0008	0.0169
$\text{priv\_consump}_{t-1}$	1.2265	0.0653	0.0000
$\text{gov\_consump}_{t-1}$	0.1587	0.0365	0.0000
$\text{inv}_{t-1}$	-0.0481	0.0408	0.2408
$\text{credit}_{t-1}$	-0.0920	0.0166	0.0000

As presented in table 5.1, all variables are statistically significant except from the investment variable. The regression also explain almost all variation in the dependent variable, the adjusted R-square being 0.9963, explaining 99.63 % of the variation in output. What is of most interest is the effect of the real interest rate on output growth which here turns out to be positive and also statistically significant. The real interest rate has a positive effect on output growth meaning an increase in the real rate leads to an increase in output growth the next period controlling for other variables.

## **5.2 Performing a SVAR Using Credit Growth**

The relationship introduced above will be analysed further in a multivariate setting using a structural vector autoregressive model (SVAR). The reason is the multivariate setting and the ability of the model to analyse and predict many variables at the same time as well as the possible problem of simultaneity among the included variables. The optimal construction of the SVAR model in order to ensure that no valuable information is lost in the analysis, the SVAR should be performed with the variables at levels (but log-transformed).

A structural form of the VAR model, the structural autoregression model (SVAR), first introduced by Sims (1980), identifies structural shocks and causal relationships from the reduced form VAR by introducing various restrictions. In order to do structural analysis, the shocks (error terms) will need to be uncorrelated. In order to satisfy this requirement a Cholesky decomposition may be used, where the residuals are orthogonal, i.e. uncorrelated by construction. The Cholesky decomposition, being a short-run restriction, imply that the second shock does not affect the first variable contemporaneously (at time  $t$ ), while both shocks can affect the second variable contemporaneously. After one period, there are no more restrictions.

### **Identification of the Structural Model – Cholesky Decomposition**

The credit variable from Schularick and Taylor's dataset will be included in the SVAR analysis by the following Cholesky ordering:<sup>23</sup>

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<sup>23</sup> All variables are log-transformed. A constant growth rate through the period is assumed for missing data

$$\begin{bmatrix} r_t \\ credit_t \\ inv_t \\ priv\_consump_t \\ gov\_consump_t \\ \Delta y_t \end{bmatrix}$$

The ordering implies that the real rate has contemporaneous effect on all the other variables, that is, it affects the other variables on impact. Output growth is affected by all variables contemporaneously but only affects the other variables with a lag. The real rate responds with a lag to the other variables.

### Representation of the SVAR

The VAR model extends the univariate autoregression (AR) model to a vector of many variables (Bjørnland and Thorsrud 2015).

A VAR model of order  $p$  may be written

$$y_t = \mu + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t$$

where  $y_t$  is a  $(K \times 1)$  vector of random variables:

$$y_t = (r_t, credit_t, inv_t, priv\_consump_t, gov\_consump_t, GDP_t)'$$

$A$  is a  $(K \times K)$  coefficient matrix,  $\mu$  denotes a  $(K \times 1)$  vector of intercept terms, and  $e_t$  is a  $(K \times 1)$  vector of white noise error terms (uncorrelated error terms with expectations of zero).

The representations may be written:

$$\begin{bmatrix} r_t \\ credit_t \\ inv_t \\ priv\ consump_t \\ gov\ consump_t \\ GDP_t \end{bmatrix} = \begin{bmatrix} \theta_{11,0} & 0 & 0 & 0 & 0 & 0 \\ \theta_{21,0} & \theta_{22,0} & 0 & 0 & 0 & 0 \\ \theta_{31,0} & \theta_{32,0} & \theta_{33,0} & 0 & 0 & 0 \\ \theta_{41,0} & \theta_{42,0} & \theta_{43,0} & \theta_{44,0} & 0 & 0 \\ \theta_{51,0} & \theta_{52,0} & \theta_{53,0} & \theta_{54,0} & \theta_{65,0} & 0 \\ \theta_{61,0} & \theta_{62,0} & \theta_{63,0} & \theta_{64,0} & \theta_{65,0} & \theta_{66,0} \end{bmatrix} \begin{bmatrix} \varepsilon_{r,t} \\ \varepsilon_{credit,t} \\ \varepsilon_{inv,t} \\ \varepsilon_{priv\ consump,t} \\ \varepsilon_{gov\ consump,t} \\ \varepsilon_{GDP,t} \end{bmatrix} + \theta_1 \varepsilon_{t-1} + \dots$$



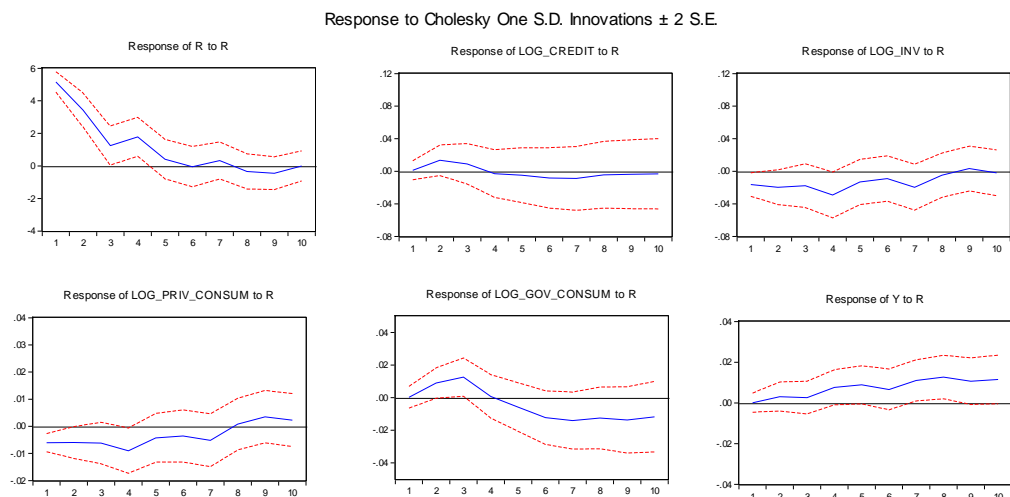
## Stability of the VAR

A requirement for the results to be valid is that the VAR model is stable. The VAR model presented above turns out to be stable as no root lies outside the unit circle. It is worth noting that this does not necessarily mean that the variables are stationary as the VAR model may be stable even with non-stationary variables included, due to cointegration of the variables. Cointegrated variables can be included in a VAR despite non-stationarity, and also should, in order to not lose relevant information (Brooks 2014).

## Impulse Responses: Results

The impulse responses show the percentage change as a result of a positive shock to the real interest rate. As the results are based on symmetry, results of a negative shock may be interpreted as the opposite.

Figure 5.1: Impulse responses from a positive shock to the real interest rate



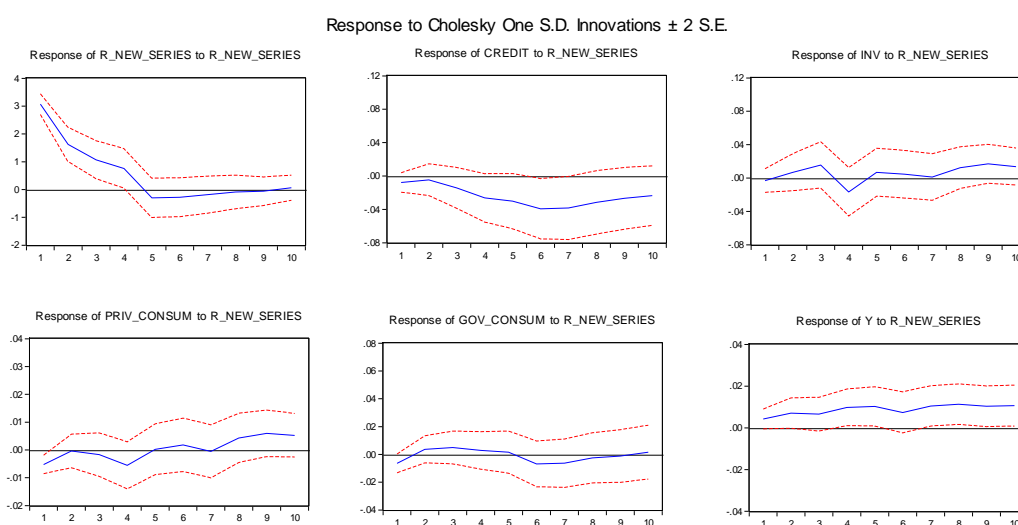
As the impulse responses in figure 5.1 shows, an increase in the long-term real interest rate leads to an increase in real output, illustrated in the graph in the bottom-right corner. The results are also robust as they are not affected by changing of the ordering of the SVAR (see appendix 11 for alternative ordering).

What is of special interest is the effect of the real rate on credit, meant as an indicator for financial stability. However, the impulse responses show no clear effect as also the uncertainty bands are very large.

## Include the New Series of the Real Rate

When the new series of the real rate (see section 4.4) is used instead of the raw data, the effect on credit is much higher. This result is illustrated in figure 5.2 below, in the top middle column. A higher real interest rate (given a low rate regime) leads to lower credit growth. This effect is much greater in a low rate regime compared to a high rate regime where credit growth instead increases as a response to an increase in the real interest rate.<sup>24</sup>

Figure 5.2: Impulse responses in a low-rate regime



The analysis performed for Norway reveals a positive change in economic growth when there is a positive shock to the real interest rate. Credit growth decreases as expected as higher real interest rates make loans and credit less attractive. Similarly, as the results are subject to symmetry, a decrease in the real interest rate leads to higher credit growth. However, growth rate turns out to decrease as a result of a fall in the interest rate, rather than increase as would be the preferable situation. The results are even stronger when using a series of the real rate representing only low values. Therefore, in a low-interest-rate environment a decrease in the real interest rate does not seem to improve demand, rather it will lead to a fall in output at the same time as credit responds with an increase, an increase that is greater in a low-rate environment than in general. In a situation of secular stagnation, with low interest rates and employment below potential, a decline in the real interest rate will have no positive effect on output; rather it will increase credit growth, an important determinant of financial instability.

<sup>24</sup> See appendix 12 for impulse responses in a high rate regime

## 6.0 Summary of Results

The analysis conducted was aimed at revealing a long-term relationship between the real interest rate and economic growth, as measured by growth in real GDP per capita.

A correlation- and regression-analysis performed in a cross-country setting including ten countries supported a positive relation between the two variables. The correlation coefficient turned out positive for eight (nine if a longer dataset for Norway was used) of the ten countries included. The coefficients were significant for the four countries; Australia, Ireland, the UK and the U.S. There was found a higher correlation in the case where the real rate was leading output growth compared to other scenarios.

There was found no support for a negative relation between the real interest rate and growth as none of the negative coefficients were significant.

The correlation analysis for Norway revealed an asymmetric relationship between the long-term real interest rate and output growth where a high rate-regime seemed to be characterised by a negative relation, whereas a low rate-regime was characterised by a positive relation.

Performing a regression using a new generated series of the real rate which equals 0 for interest rate-values above 1 % results in significant positive effect of the new real rate on real output growth. Hence, in a low rate-regime, the real rate seems to have a positive effect on economic growth, measured by real GDP per capita.

Performing a SVAR analysis for Norway including variables for investment and consumption and also credit growth from Schularick and Taylor's dataset reveals a positive, significant effect of the long-term real interest rate on output growth. Furthermore, an increase in the real interest rate decreases credit growth, more evidently in a low-interest-rate environment.

Thus, in a low-interest-rate environment, like that of secular stagnation, a decrease in the real interest rate does not seem to support demand, rather it decreases output growth further behind potential and also increases credit growth, an important determinant of financial instability.

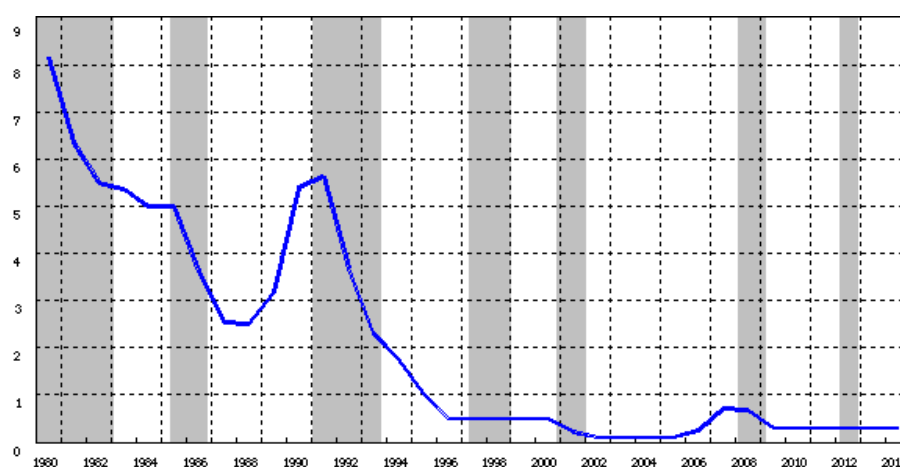
## 7.0 Linkages to Japan

Real rates globally are now below zero several places. Haldane (2015) points to the fact that Japan has been there for 20 years. Even with such low rates, Japan has not been able to foster satisfactory economic growth.

In his paper, Buiter (2013) believes Japan, together with the EU, is at risk of secular stagnation. He recognizes the need for a larger temporary fiscal stimulus, and more effort in increasing labour supply and boost productivity in order to achieve higher potential output.

In analysing a possible situation of secular stagnation in the rest of the world today it would be meaningless to not draw linkages to Japan. I will especially point out the development experienced in the Japanese economy in the 1990s. The below table shows interest rates (basic discount rate/basic loan rate) from 1980-2014 sourced from the Bank of Japan (BOJ 2015). Interest rates started to decline sharply in early 1990s and have done so ever since.

Table 7.1: Basic discount rate/basic loan rate Japan 1980-2014.



*Source: Bank of Japan*

Ever since the asset price bubble in the 1980s ended (around 1990), Japan has experienced declining rates of growth, inflation and real interest rates. The asset price bubble in the 1980s was characterized by excessively optimistic expectations about future economic performance, so-called ‘euphoria’, as opposed to a rational bubble (Shiratsuka 2003).

Since, 1993 (past 21 years) Japanese growth rates has barely been above 1 % (Summers 2014a). Gross domestic product today (2013) is less than two-thirds of

what was predicted a generation ago, even though interest rates have been zero for many years (Summers 2013b).

Also inflation has been low. Japan has experience 15 years of deflation and stagnation (Buiter 2013). In the 15-years period 1999-2013, eleven out of fifteen years was characterized by negative inflation, so-called deflation (OECD).

### **Causes of Japan's situation**

The main causes of the prolonged slowdown in Japanese growth despite the low interest rates are many of the same characteristics as are experienced in the rest of the world. A changed savings-investment balance causes a large negative output gap. Excess saving and declining rate of private investment give rise to a private saving surplus. The main reasons are structural factors such as slowdown in growth of the working age population due to aging of population and declining rate of total factor productivity which reduces investment growth (Fukao et al. 2015).

Japan has also experienced labour market problems such as too high job security which makes it hard for firms to cut jobs, a factor reducing training expenditure and hence human capital accumulation (Fukao et al. 2015).

### **Lessons to Learn from Japan's experience**

What lessons might be derived from Japan's experience? If the rest of the world were to be similar to Japan, we would know that low or even negative interest rates are not sufficient to drive sufficient economic growth and to resolve the underlying fundamental problems. If the real rates are kept low for a longer period, rate of returns on capital would eventually decline, only reinforcing the problem of low investment demand. Also, as emphasised before, low interest rates is always a risk for financial stability and may cause a situation of bubbles.

Japanese policy today, stimulates private investment by reducing the interest rates. As Summers (2014a) has pointed to it is difficult to simultaneously achieve full employment through low interest rates together with financial stability. For growth to be sustainable, it is necessary to raise the rate of return on capital through other means, for instance through productivity growth. Low productivity growth seems to be caused by structural factors such as the labour market

mentioned but also inefficient use of public investment. Therefore, Fukao et al. (2015) also suggests labour market reforms in the case of Japan.

Similarly, other countries are most likely also limited by fundamental obstacles that need to be resolved in an alternative manner rather than decreasing the interest rates more than already done. If this happens, it may compromise on the economy's financial stability.

Also, Fukao et al. (2015) emphasise the need for an international monetary system which mitigates the unbalanced capital flows, where some countries such as China and Germany enjoys huge current account surpluses, while others such as the US struggles with large deficits (Fukao et al. 2015).

## **8.0 Policy Implications**

If in fact the economy faces secular stagnation, Summers (2013b) argues that this will have profound policy implications. Secular stagnation means that economic and policy conditions will probably not return to normal, just like the situation turned out to be in Japan. Consequences of secular stagnation will be that monetary policy will not be able to normalize, there will be a continuing need for expanded public and private investment, and there will be a need for global coordination to assure an adequate level of demand and its appropriate distribution (Summers 2013b). He stresses the point of the importance of integrated capital markets where real rates will depend on global conditions. *“It is important to think of the saving-investment balance for the global economy and not just for countries individually. With a global perspective, encouraging countries with excess saving to invest more, would be a successful policy approach”*, he argues (Summers 2015).

Furthermore, he argues that simultaneous achievement of adequate growth, full employment and financial stability appears increasingly difficult. This situation, he argues, is likely to be related to a substantial decline in the natural real rate of interest (Summers 2014a). Therefore, there will be increased likelihood of bubbles at lower interest rates, which raises assets values and drive investors to take greater risk as they seek yield (Summers 2013b).

IMF (2015) suggests the use of fiscal and monetary policy in order to increase the level of demand and economic activity in a country. However, it is worth noting that the actual reasons behind the weak investment are important to determine in order to justify and implement the right policy decisions. This section presents important implications for monetary policy, fiscal policy, and financial stability, each in turn.

### **8.1 Implications for Monetary Policy**

It is argued that ‘when monetary policy and macroprudential policies act in a coordinated way it improves the stability in the system’ (Rubio and Carrasco-Gallego 2014). The subsequent chapter focuses on monetary policy-making; its objectives, challenges, and future considerations that should be taken into account given the low-interest-rate environment of today’s economy.

Although there are varying objective functions among central banks, a common aim of monetary policy is to keep the economy at full employment (Belke and Verheyen 2014). This is achieved by most central banks through price stability and inflation targeting, such as Norges Bank's operational target of 2.5% inflation over time (Norges Bank 2014). As ECB (2016) states it: "*The primary objective of the ECB's monetary policy is to maintain price stability. This is the best contribution monetary policy can make to economic growth and job creation.*"

### **The Problem of Zero Lower Bound**

In a situation of secular stagnation, there will be reduced efficacy of monetary policy given the zero lower bound (ZLB) on interest rates (Summers 2013b). It is often assumed that the central bank cannot set an interest rate of below zero and so the ZLB is seen as a major constraint for monetary policy (Belke and Verheyen 2014). The problem of ZLB refers to the situation when natural real interest rate is lower than the actual real rate, which forces the central banks to reduce the interest rate in order to ensure full employment. This may be done through two ways in which one is to raise inflation. However, as actual output falls below potential this might be difficult to achieve in such a situation as inflation is rather likely to slow down further rather than increase. The only possible option left is to reduce the nominal interest rate, as long as the rate is not already at its lower bound, zero, hence the problem of ZLB.

Hitting the ZLB is often associated with major risks, some which might be avoided if inflation is kept at a slightly positive value, the reason for the common practice of inflation targeting at positive values (Belke and Verheyen 2014). Also Eggertsson and Mehrota (2014) show how a too low inflation targeting may cause a situation of secular stagnation and imply that central banks would be better off by tolerating a higher inflation. However, studies reveal that an interest rate at the ZLB would make an inflation target less credible because the central bank would not be able to increase inflation just by the use of conventional monetary policy (Belke and Verheyen 2014). Thus, central banks are risking their independence in a low-rate-regime by losing credibility in reducing the real rate to a desirable level. The Bank for International Settlements (BIS) states that 'a vicious circle can develop, with a widening gap between what central banks are expected to deliver and what they can actually deliver. This would make the eventual exit from



monetary accommodation harder and may ultimately threaten central banks' credibility' (BIS 2012, p. 48).

### **Suggested Solutions and Corresponding Challenges**

Summers has the view that macroeconomists may contribute by moving beyond their traditional models of business cycles to contemplate the possibility of secular stagnation (Summers 2015). He suggests considering how one can manage an economy behind its potential with zero nominal interest rates, not just permanently, but 'chronic and systematic' (Summers 2013a). In his article, Summers (2014a) formulates three possible solutions or responses to the problem of secular stagnation, however, some significantly more desirable than others. Not in his favour, but still a possible response is what he calls "stay patient". For the first option he argues simply that there is not much we could do as the estimates are expected to be a sustained, long-term decline. This option therefore includes nothing to change or counteract the situation, the strategy Japan has pursued for many years.

The second option is to reduce the actual real rate of interest, in order to match the reduced natural real rate, so as to improve economic activity. To state his argument, this option is better than doing nothing but comes at significant costs, such as the possibility of creating financial bubbles and debt to be rolled over. Protracted low interest rates may contribute to a build-up of financial vulnerabilities by 'triggering a search for yield in unwelcome segments' (BIS 2012). The third option is to turn to fiscal policy presented in the next section.

To ignore the problem of ZLB and simply turn to unconventional monetary policy is another possibility, suggested by Haldane (2015), although he doubts the solution as a desirable steady-state. The zero lower bound is an increasing problem of today's central banks and Haldane (2015), chief economist at the Bank of England, believes that monetary institutions may require a fundamental rethink of a number of current central bank practices if the real rates are to stay low or even decline in the future. Since the financial crisis, numerous countries have reached the lower limit of the interest rate and the concept of quantitative easing (QE), categorized as 'unconventional' monetary policy, has been commonly used (Haldane 2015). However, it is argued that protracted monetary easing may lead

to significant asset price hikes and accelerating credit growth (Belke et al. 2010), a major predictor of future financial crises (Schularick and Taylor 2012).

Haldane (2015) even mentions a revision of the inflation target, as he points out that “*if equilibrium real rate shift, so too should the optimal inflation target*” (Reifschneider and Williams 2000), although higher inflation may possible induce costs. As he emphasise, in England’s case, the inflation target is a choice of the government rather than the Bank of England.

Hamilton et. al (2015), who estimates the value of the natural real interest rate and discusses implications that these results may have for monetary policy, suggest more inertia to be put into the policy reaction function. The reason is the high uncertainty around the natural real interest rate which suggests more weight to be put on past values of the real rate rather than the less reliable estimates.<sup>25</sup> In this manner they may be better off in reaching their objectives in terms of more robust economic outcomes, however, this comes at a cost of greater volatility in interest rates, as they refer to as overshooting.

“*Pre-crisis, central bankers were to set interest rates in response to inflation and the output gap, with no meaningful additional information coming from credit or monetary aggregates*” is argued by Schularick and Taylor (2012) who analyses credit growth in the modern macroeconomy. In their opinion, money and credit aggregates should be included in policymaking as they hold valuable information. The view that ‘asset price developments should only influence the formulation of monetary policy to the degree that they affect the central banks’ inflation forecast’ (Bernanke and Gertler 2001) is now being challenged. The monitoring of general financial conditions such as volumes and prices on specific asset markets is of overall importance as only considering the inflation rate and caring for the inflation target might miss out development in certain markets (Belke and Verheyen 2014). Also, having in mind the great impact that monetary policy may have on financial markets should be a reason itself to put more emphasis on the financial market.

Also, low interest rate works destructive for balance sheets repair (Belke and Verheyen 2014). As interest rate decrease, and thus also the financing costs,

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<sup>25</sup> In practice, more inertia in the policy function means adopting a later but steeper path for normalizing the funds rate, i.e. react later but more “dramatic”.

balance sheet problems are easier to ignore from a borrower's perspective. This causes still weak balance sheets and misallocation of credit. It is argued that in the case of over-indebted economic agents one needs an even higher degree of monetary accommodation than before in order to stimulate growth, only reinforcing the problem.

Furthermore, due to a more globalised world, and the fact that monetary policy spillovers are of increasing significance forces central banks to attach more importance to the global implications of their policies (Belke and Verheyen 2014). Policy reactions are increasingly affected by the international environment and monetary policy should therefore to a greater extent have a global perspective. Also, according to Eggertson, Mehorta and Summers (2016) expansionary monetary policy tend to generate negative externalities on trading partners, and hence they would rather turn to fiscal policy as a preferable solution.

The co-existence of low interest rates in major advanced economies and huge capital inflows from emerging markets is what Belke and Verheyen (2014) refer to as 'the monetary policy dilemma'. It refers to a situation where each country will have to choose between setting low rates and risking the financial stability to a greater extent, or whether to instead increase the rates aiming for a safe way to attract global financial or monetary liquidity. Low interest rates in advanced economies may also lead to spillover effects to emerging markets and risking global price and financial instability. Higher rates and capital inflows to emerging markets might put an upward pressure on emerging markets' exchange rates inflating prices and risking credit and asset price bubbles.

Lastly, there are risks stemming from the exit from unconventional monetary policies. There is no longer enough for central bankers to focus merely on national interests and there is need for international coordination of monetary policies (Taylor 2013). Any uncoordinated exit or exit at different pace may lead to tensions and risks in an international perspective including currency wars (competitive devaluation of currencies) and unnecessary capital flows.

## 8.2 Implications for Fiscal Policy

Summers (2014a) argues that simultaneous achievement of full employment, satisfactory growth and financial stability is impossible simply through the operation of conventional monetary policy and argues that more reliance on fiscal policy is necessary. He even argues that expansionary fiscal policy is in fact necessary. Also Eggertson, Mehrota and Summers (2016) states that “*recognizing open economy considerations reinforce the case for primary reliance on fiscal rather than monetary policies in combatting secular stagnation*”.

As the preferable strategy, Summers (2014a) suggests raising the level of demand at any given interest rate, rather than reducing the rate through monetary policy. That means raising the level of output consistent with an increased level of the natural rate and hence mitigating the risks associated with low interest rates. This, he argues, might be done through stimulating demand in various ways using fiscal policy. Public investment is proved to play a substantial role for a country’s economic growth. This may be done by, for instance, promote private investment through various tax reforms and/or promote exports through trade agreements, relaxed export controls, or through simple promotion of U.S. export. Government spending plays a significant role as this would raise the level of demand, as found for instance by Eggertson and Mehrota (2014) in a New Keynesian framework, and hence prevent the problem related to the ZLB. Also, he points to the possible large potential multiplier, making a long-run impact of the stimulus on GDP after it has been withdrawn.

The ‘fiscal multiplier’ or ‘government spending multiplier’, the effect of fiscal stimulus on growth in output, is often suggested to be in the range between zero and one,<sup>26</sup> although some studies find it to be larger than one as well (example Ramey 2011) (Christiano, Eichenbaum and Rebelo 2011). Christiano, Eichenbaum and Rebelo (2011) argue that the government-spending multiplier can be much larger than one when the nominal interest rate does not respond to an increase in government spending, a natural scenario when the ZLB on the nominal interest rate binds. The reason is simple. An increase in government spending raises the level of output and hence also expected inflation. The higher expected

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<sup>26</sup> See Barro (1981), Ramey (2011), Gali, Lopez-Salido, and Valles (2007), Monacelli and Perotti (2008), Less than one: Aiyagari, Christiano, and Eichenbaum (1992), Baxter and King (1993), Ramey and Shapiro (1998), Burnside, Eichenbaum, and Fisher (2004), Ramey (2011).

inflation rate reduces the real rate, further increasing output through increased private spending and again increasing inflation expectations. With this the economy has stepped into a good spiral where the net result of increased output may be very large. Also, the often associated problem of deflation with the ZLB is solved as inflation is raised (Christiano, Eichenbaum and Rebelo 2011).

Simulations studying a one percent increase in the budget deficit directed at government spending in the U.S. reveal that when fiscal stimulus is in place there is substantial response to real GDP (Summers and Reifschneider 2014).<sup>27</sup> They find a long-run impact of the stimulus on GDP also after withdrawal which makes the potential multiplier quite large. The same study finds that the fiscal stimulus reduces the long-run debt-to-GDP ratio, a desirable result having in mind the risk of financial instability.<sup>28</sup> As a result, Summers highlight the substantial emphasis that should be put on fiscal stimulus increasing demand as a means of achieving adequate growth and also adequate supply potential (Summers 2014a).

Also, in his respond to Bernanke, Summers (2015) turns to expansionary fiscal policy as a solution to promote growth, particularly through public investment. At negative or zero real interest rate, debt would be very cheap, and any investment would generate enough profit to cover such costs. Therefore, and due to multiplier effects, investment, particularly public investment should be initiated. The argument is supported by the 2014 IMF World Economic Outlook which suggests that public investments in countries where interest rates are near the zero lower bound are likely to significantly reduce debt-to-GDP ratio (Summers 2015). Even temporary fiscal expansions of sufficient magnitude will, under plausible assumptions, move economies in secular stagnation into normal conditions (Eggertson, Mehrota and Summers 2016, Delong and Summers 2012). Also important, is the The IMF Annual Report (2015) suggestions of policies such as to strengthen the labour force participation.

It is worth noting also the positive externalities that each country's policy choices may have for their trading partners including capital flows as a result of increased real interest rate and a possible appreciation of currency due to preferable fiscal stimulus (Eggertson, Mehrota and Summers 2016).

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<sup>27</sup> Ongoing analysis, referred through Summers (2014a)

<sup>28</sup> Supported also by other studies. See for example Delong and Summers (2012)

### **8.3 Implications for Financial Stability**

As Summers states it in his IMF Fourteenth Annual Research Conference speech (2013): “*finance is all too important to leave entirely to financiers or even to financial officials. Financial stability is indeed a necessary condition for satisfactory economic performance*”. However, in a situation of secular stagnation he argues that it is impossible for an economy to simultaneously achieve full employment, satisfactory growth and financial stability simply through the operation of conventional monetary policy. More simplistic said; if an economy aim for full employment and satisfactory growth through lowering the interest rate, this will compromise on financial stability and the economy will have to expect financial instability or even a bubble.

According to Summers, a situation of secular stagnation started a long time ago, and growth rates seen in recent years has only been due to financial bubbles. In the past 15 year, he argues that the economy has not grown satisfactory with conditions which have been financially sustainable (Summers 2014).

#### **Implications of Negative Interest Rates**

As previously mentioned, a bubble is likely to arise whenever the growth rate is higher than the real interest rate (Teulings and Baldwin 2014), increasing the chances for bubbles whenever the real rate is low. Financial instability as a consequence of low interest rates may be due to several reasons Firstly, assuming yield-seeking investors, low interest rates increases investors risk-taking as they reach for yield (Teulings and Baldwin 2014). The low rates drive investors to take more risk and increase the likelihood of bubbles (Summers 2013b), or ‘triggering a search for yield in unwelcome segments’ as BIS (2012) states it. Also, as coupon obligations become very low, it promotes irresponsible lending and hence increases the likelihood of bubbles.

The Bank for International Settlements (BIS) has several times warned central banks of negative interest rate in their reports. Firstly, there is a risk simply due to the unexploredness of the area. Also, the traditional problem of ZLB, presented earlier, suggests challenges. Especially, they note the low rates negative impact on bank’s balance sheets. They emphasise the crucial role of handling these problems to ensure global financial stability in the future.

## **Globalisation of Financial Markets and Spillover Effects**

Belke and Verheyen (2014) note the possible spillover effects in today's globalised world. Lagarde (2016) emphasise the increased interconnectedness of countries around the world. As countries are being more dependent on each other they affect each other to a much greater extent, a factor that needs to be taken into consideration. Capital flows and the challenges that come with it impose significant risk (IMF 2015). Too much capital inflows to a country may cause a situation of secular stagnation; for a given level of output, the real rate needs to be lower to accommodate the extra supply of savings, reinforcing the problem of secular stagnation (Eggertson, Mehrota and Summers 2016). This is for instance seen in the U.S. where capital inflows from China push down interest rates. These low interest rates in advanced economies may lead to spillover effects in emerging market economies, as low rates in advanced economies stimulate capital flows to emerging markets, as has been recently experienced (World Bank 2015). This puts an upward pressure on exchange rates in emerging markets, causing credit and asset bubbles such as the Chinese property bubble (Belke and Verheyen 2014). On the other hand, will higher interest rates in advanced economies trigger capital inflows to advanced economies and stimulate positive externalities for trading partners. This will lead to an appreciation of the currency in advanced economies, being beneficial to the world economy as a whole (Chinn 2013). The fact that these spillover effects become increasingly significant forces central banks to focus more on the importance of the global implications of their policies. Capital controls are also suggested as a solution (Eggertsson, Mehrota and Summers 2016)

## **May Financial Crises be predicted? – The Importance of Credit**

Financial crises may be defined as: “Events during which a country's banking sector experiences bank runs, sharp increases in default rates accompanied by large losses of capital that result in public intervention, bankruptcy, or forced merger of financial institutions” (Schularick and Taylor 2012). Financial crises are often associated with “credit booms gone wrong” (Minsky 1977, Kindleberger 1978), and causes are often too much lending or financial speculation, both linked to credit creation.

Schularick and Taylor (2012) stress the importance of credit growth as a powerful predictor of financial crises. They argue that important structural changes in the financial system have led to greater importance of credit in the macroeconomic environment, a period they refer to as the ‘age of credit’. They find credit growth to be a powerful predictor of financial crises, as high credit growth is often registered prior to periods of financial instability and crises. Credit aggregates contain valuable information about the likelihood of future financial crises. Also, financial instability has often been the result of failures in the operation or regulation of financial systems and the study of financial systems are therefore of importance. Adrian and Shin (2008) also finds financial markets including liquidity, borrowing conditions and market confidence, to matter more than even for credit and financial stability. This is of special interest as I find low interest rates to cause higher credit growth in my analysis, meaning that low interest rate may also be related to the likelihood of financial crises.

It is hard to state exactly what an economy needs at a specific point in time but it is obvious that the financial system is of importance for monetary policy and that the analysis of financial systems should be taken into consideration in a country’s policy decision-making.

### **“This Time Is Different”**

As a conclusion, I would like to stress the criticism of the quote “this time is different” especially emphasised by Reinhart and Rogoff (2009) in their book with the same name. They conclude that financial fallouts occur in clusters, with a surprisingly consistent frequency, duration and ferocity. The quote refers to the often perceived belief that a crisis will not happen today although economic factors would indicate so.

To site them correctly: *“The essence of the this-time-is-different syndrome is simple. It is rooted in the firmly held belief that financial crisis are things that happen to other people in other countries at other times; crisis do not happen to us, here and now. We are doing things better, we are smarter, we have learned from past mistakes. The old rules of valuation no longer apply. Unfortunately, a highly leverage economy can unwittingly be sitting with its back at the edge of a financial cliff for many years before chance and circumstances provoke a crisis of confidence that pushes it off”* (Reinhart and Rogoff 2009, pg. 15).



## 9.0 Conclusion

With real interest rates at negative values, low inflation and output below potential the economy may be argued to be in a situation of ‘*secular stagnation*’ – a situation where an economy re-equilibrates at a lower level of economic activity with lower demand and lower natural real interest rates. A changing saving-investment structure together with demographic factors has led to such situation which may persist on a sustained basis.

The secular stagnation hypothesis of ongoing unemployment and economic stagnation has gained interest after low economic growth together with low interest rates has been experienced recently. There is a huge ongoing discussion whether this is a situation of secular stagnation or just the aftermath of the financial crisis. Linkages are drawn to Japan which has been in the situation since the 1990s that other advanced economies are experiencing today. Demographic factors and structural changes in the economy supports the secular stagnation hypothesis, whereas criticism such as phrase “this time is different” points in the opposite direction. Whichever reason that turns out correct will have significant implications for future policy.

This paper has investigated the situation of low real interest rates, low inflation and output below potential through the research question:

*“What is the relationship between real interest rates and output growth in the long-run, and does it support a situation of secular stagnation?”*

The analysis conducted was aimed at revealing a long-term relationship between the real interest rate and economic growth, as measured by growth in real GDP per capita. The analysis was performed through correlation- and regression-analysis in a cross-country setting using data from OECD as well as a more detailed analysis of Norway using a longer dataset from Norges Bank and a credit variable from an additional dataset by Schularick and Taylor.

The analysis supported a possible positive relation between real interest rates and output growth in the long term, especially in a low-rate regime as we are in today. Positive coefficients was found for eight (nine if a longer dataset for Norway was used) of the ten countries included, where four turned out significant. There was found a higher correlation in the case where the real rate was leading output

growth compared to the other scenarios tested. Furthermore, the analysis for Norway revealed an asymmetric relationship where a low-rate regime was characterized by a clear positive relationship. A resulting implication is that with an increase in the real interest rate we would be able to stimulate growth. Furthermore, in a low-rate regime a decrease in the real interest rate was found to increase credit growth, a variable often explaining financial crises. Therefore, a low-interest-rate environment may impose risks for an economy's financial stability.

Thus, in a low-interest-rate environment, like that of secular stagnation, a decrease in the real interest rate does not seem to support demand, rather it decreases output growth further behind potential and also increases credit growth, an important determinant of financial instability.

If the world economy is in fact facing secular stagnation it will result in important policy implications for future growth. Summers argues that simultaneous achievement of full employment, satisfactory growth and financial stability is impossible simply through the operation of conventional monetary policy.

Consequences of secular stagnation will be that monetary policy will not be able to normalize, there will be a continuing need for expanded public and private investment, and there will be a need for global coordination to assure an adequate level of demand and its appropriate distribution.

It will also have implications for financial stability as lower interest rates raises the asset values and drive investors to take more risk, increasing the chances of bubbles. Due to the fact that a bubble is likely to arise whenever the growth rate is higher than the real interest rate, there is an increased chance for bubbles whenever the real rate is low. Theory suggests that a situation of secular stagnation may be destructive for an economy's financial stability as low real interest rates are modelled as a source of bubbles.

This paper's analysis has found support for the belief that low interest rates may foster financial instability and would therefore suggests that a reduction in interest rates as a solution to the secular stagnation hypothesis should be implemented with care.

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## Appendices

### Appendix 1: Countries ranked by GDP

Table 1: Countries ranked by GDP in billion USD

No.	Country	GDP billion USD	Percentage of	
			world GDP (accumulated)	Nominal interest rate
1	United States	17,419	0.16	0.50
2	Euro Area	13,410	0.28	0.00
3	China	10,355	0.37	4.35
4	Japan	4,601	0.42	-0.10
5	Germany	3,868	0.45	0.00
6	United Kingdom	2,989	0.48	0.50
7	France	2,829	0.50	0.00
8	Brazil	2,346	0.53	14.25
9	Italy	2,141	0.55	0.00
10	India	2,067	0.56	6.50
11	Russia	1,861	0.58	11.00
12	Canada	1,785	0.60	0.50
13	Australia	1,455	0.61	1.75
14	South Korea	1,410	0.62	1.50
15	Spain	1,381	0.64	0.00
16	Mexico	1,295	0.65	3.75
17	Indonesia	889	0.66	6.75
18	Netherlands	870	0.66	0.00
19	Turkey	798	0.67	7.50
20	Saudi Arabia	746	0.68	2.00
21	Switzerland	701	0.68	-0.75
22	Sweden	571	0.69	-0.50
23	Nigeria	569	0.69	12.00
24	Poland	545	0.70	1.50

## Appendix 2: Countries ranked by GDP per capita

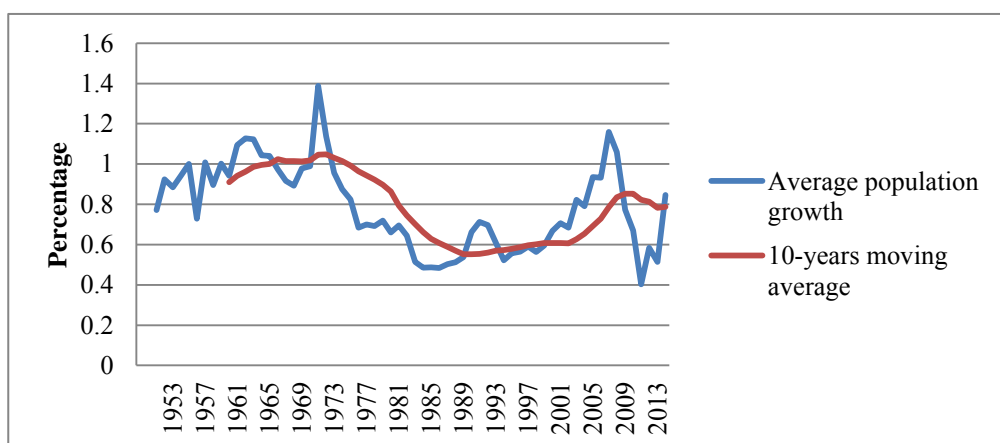
Table 2: Countries ranked by GDP per capita

No.	Country by GDP per capita	GDP per capita USD	Nominal interest rate
1	Luxembourg	79,511	0.00
2	Norway	67,246	0.50
3	Qatar	60,796	4.50
4	Iceland	59,693	5.75
5	Switzerland	58,997	-0.75
6	Macau	52,477	0.75
7	Ireland	49,361	0.00
8	Denmark	47,547	-0.65
9	United States	46,405	0.50
10	Sweden	46,061	-0.50
11	Netherlands	43,141	0.00
12	Austria	41,077	0.00
13	United Kingdom	40,968	0.50
14	Germany	39,718	0.00
15	New Caledonia	38,896	0.30
16	Finland	38,837	0.00
17	Canada	38,293	0.50
18	Singapore	38,088	0.23
19	Belgium	37,857	0.00
20	Australia	37,828	1.75
21	Japan	37,595	-0.10
22	France	35,670	0.00
23	Hong Kong	34,222	0.75
24	Euro Area	32,789	0.00
25	Kuwait	30,147	2.25

### Appendix 3: Population growth

The below figure shows the average population growth for 9 selected countries<sup>29</sup> in the period 1951-2014 as well as a 10-year moving average over the same period.<sup>30</sup> As one may see from the figure, the population growth tend to decline over a long-run perspective, where the first half of the dataset experiences an average of 0.9139 % whereas there is an average of 0.6607 % for the second half of the dataset.

Figure 1: Average population growth and the moving average 1950 – 2014



Source: OECD

### Appendix 4: Description of data (OECD data)

All data retrieved from OECD are yearly data.

Countries included in the dataset are: Australia, Euro area (18 countries), European Union (28 countries), France, Germany, Ireland, Japan, Norway, OECD<sup>31</sup> (total and Europe), Spain, United Kingdom, and the United States.

Below is given a description of all variables, mentioned in alphabetical order.

<sup>29</sup> Australia, France, Germany, Ireland, Japan, Norway, Spain, UK, and the US

<sup>30</sup> Note that the data for Germany are manipulated due to the German reunification in 1990

<sup>31</sup> OECD (34 countries): Australia, Austria, Belgium, Canada, Switzerland, Chile, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Hungary, Ireland, Iceland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, New Zealand, Poland, Portugal, Slovak Republic, Slovenia, Sweden, Turkey, United States.

### *Consumption*<sup>32</sup>

To measure the consumption level of households, OECD's data for 'household spending', defined as the amount of final consumption expenditure made by resident households to meet their everyday needs (OECD) are used.

The indicator is measured in million USD, in current prices and PPP's. Data are yearly and ranging from 1970-2014 (from 1960 for Australia, France, and the UK).

### *Gross Domestic Product (GDP)*<sup>33</sup>

Gross domestic product (GDP) is the standard measure of the value of final goods and services produced by a country during a period minus the value of imports (definition by OECD). GDP at market prices is the expenditure on final goods and services, such as final consumption expenditures, gross capital formation, and exports less imports (OECD).

The dataset measures GDP in USD per capita and in million USD at current prices and PPP's. The dataset is a measure of nominal GDP (current prices), which I later convert to real GDP (constant prices). The dataset runs from 1970 – 2014 (1995 – 2014 if European Union and Euro area are to be included).

### *Household savings*<sup>34</sup>

Net household savings is defined as the subtraction of household consumption expenditure from household disposable income, plus the change in net equity of households in pension funds (OECD).

The data are obtained by multiplying household's disposable income per capita with household savings as a percentage of disposable income, and are hence measured in household savings per capita. Data ranges from 1999-2014 (available for Australia and the US from 1970-2014).

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<sup>32</sup> OECD (2016), Household spending (indicator). doi: 10.1787/b5f46047-en (Accessed on 30 May 2016), URL: <https://data.oecd.org/hha/household-spending.htm>

<sup>33</sup> OECD (2016), Gross domestic product (GDP) (indicator). doi: 10.1787/dc2f7aec-en (Accessed on 30 May 2016), URL: <https://data.oecd.org/gdp/gross-domestic-product-gdp.htm>

<sup>34</sup> OECD (2016). Household savings. URL: <https://data.oecd.org/hha/household-savings.htm>  
OECD (2016). Household disposable income. URL: <https://data.oecd.org/hha/household-disposable-income.htm#indicator-chart>



### *Investment (GFCF)*<sup>35</sup>

Gross fixed capital formation (GFCF) is the acquisition (including purchases of new or second-hand assets) and creation of assets by producers for their own use, minus disposals of produced fixed assets (OECD).

The dataset is based on yearly data and ranges from 1970-2014, except from OECD total and European Union/Euro area (1995-2014).

The values are in million USD at current prices and PPP's (also available in annual growth rates).

### *Inflation (CPI)*<sup>36</sup>

Inflation measured by consumer price index (CPI) is defined as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households (OECD).

The dataset represents changes in price level including food and energy (this may be excluded). Inflation is measured in terms of the annual growth rate of prices (also available in 2010 base year). Data are yearly, ranging from 1971/6-2014 except EU/Euro area (1997-2014).

### *Long term interest rate*<sup>37</sup>

Long-term interest rates refer to government bonds maturing in ten years (10-year government bonds). Rates are mainly determined by the price charged by the lender, the risk from the borrower and the fall in the capital value. Long-term rates are generally averages of daily rates, measured as a percentage. These interest rates are implied by the prices at which the government bonds are traded on financial markets, not the interest rates at which the loans were issued. In all cases, they refer to bonds whose capital repayment is guaranteed by governments. Long-term interest rates are one of the determinants of business investment. Low long-term interest rates encourage investment in new equipment and high interest

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<sup>35</sup> OECD (2016), Investment (GFCF) (indicator). doi: 10.1787/b6793677-en (Accessed on 30 May 2016), URL: <https://data.oecd.org/gdp/investment-gfcf.htm>

<sup>36</sup> OECD (2016), Inflation (CPI) (indicator). doi: 10.1787/eee82e6e-en (Accessed on 30 May 2016), URL: <https://data.oecd.org/price/inflation-cpi.htm>

<sup>37</sup> OECD (2016), Long-term interest rates (indicator). doi: 10.1787/662d712c-en (Accessed on 30 May 2016), URL: <https://data.oecd.org/interest/long-term-interest-rates.htm>

rates discourage it. Investment is, in turn, a major source of economic growth (definition by OECD).

The dataset consists of yearly (1989-2014) data (available also monthly and quarterly).

### *Population*<sup>38</sup>

Population is measured in millions of people. Data are yearly and ranges from 1956-2014.

### *Productivity*<sup>39</sup>

Productivity is in the dataset measured by GDP per hour worked, which indicates the productivity of labour (labour-productivity). It measures how efficiently labour input, i.e. total hours worked of all persons engaged in production, is used in the production process.

The data is measured in USD (constant prices of 2005 and PPP's). Data are yearly and ranging from 1970-2014 (limited to 2000-2014 if EU/Euro area and OECD are to be included).

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<sup>38</sup> OECD (2016), Population (indicator). doi: 10.1787/d434f82b-en (Accessed on 30 May 2016), URL: <https://data.oecd.org/pop/population.htm>

<sup>39</sup> OECD (2016). GDP per hour worked. <https://data.oecd.org/lprdy/gdp-per-hour-worked.htm>

## Appendix 5: GDP per capita (additional figures)

Figure 2: GDP per capita, current prices 1960-2015

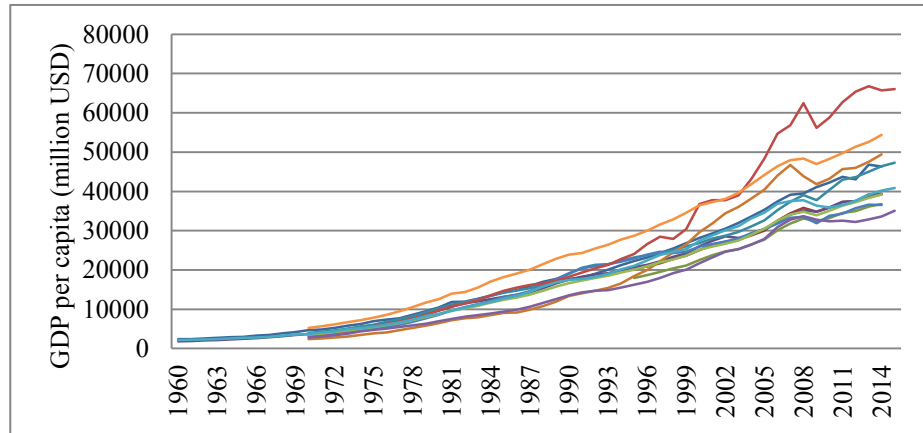


Figure 3: Growth in GDP per capita, current prices 1961-2014

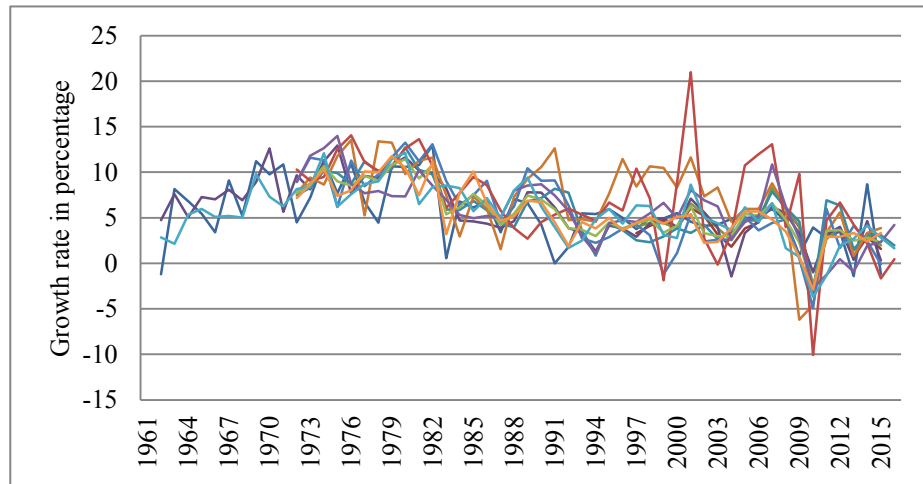


Figure 4: Real GDP per capita (constant prices, 2015 base year)

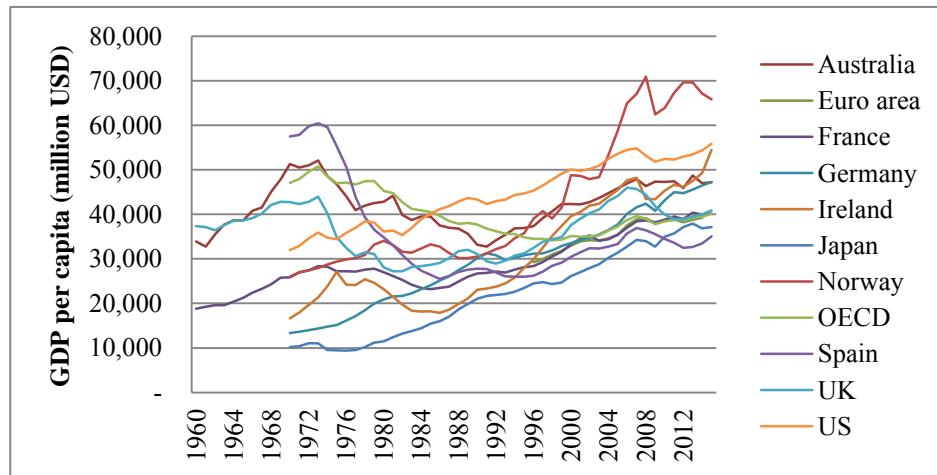
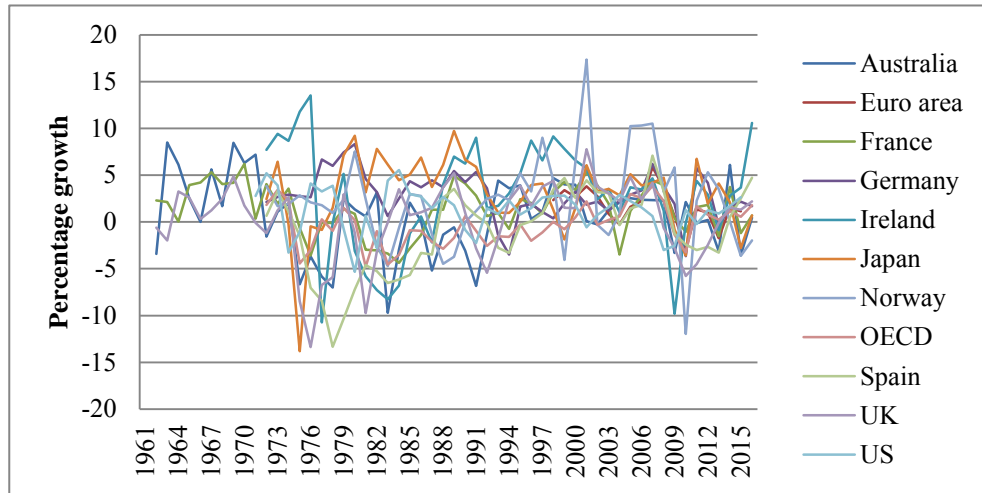


Figure 5: Growth in real GDP per capita (adjusted for inflation) 1961-2015



**Appendix 6: CPI and Inflation (additional figures)**

Figure 6: Consumer Price Index, 1998=100

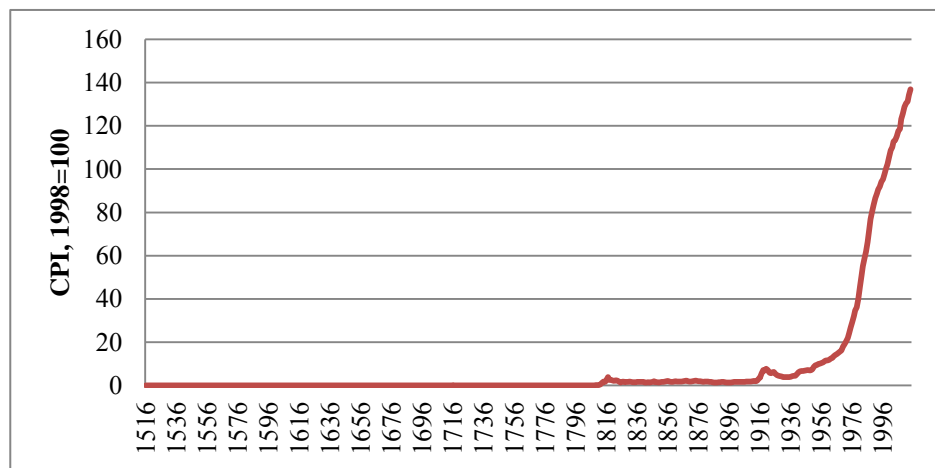
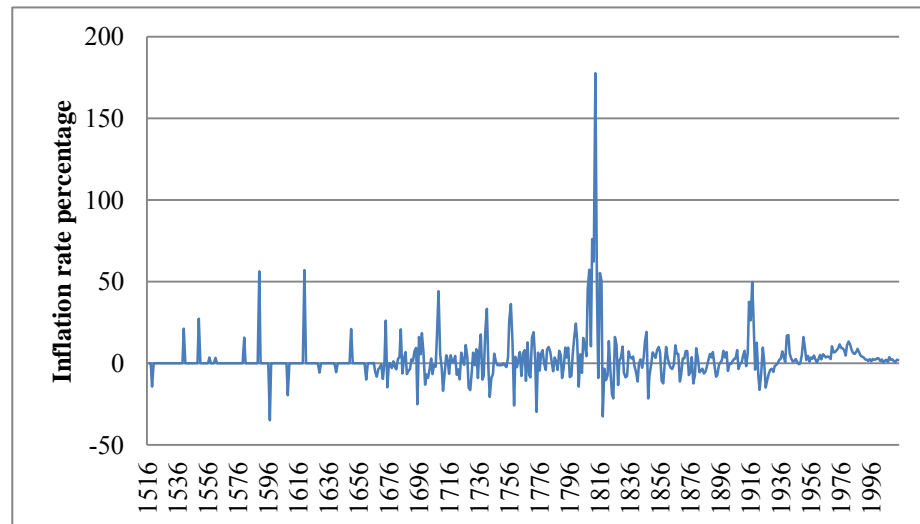


Figure 7: Inflation rate: changes in the CPI 1517-2014



## Appendix 7: Descriptive Statistics

	<b>GDP per capita</b>	<b>Private consumption per capita</b>	<b>Government consumption per capita</b>	<b>Investment per capita</b>
Average	110539.2458	52848.88629	20159.69763	25920.1259
Standard error	9944.707748	4061.651882	2071.381262	2411.20266
Median	37851	27092.56332	4965.45704	7645.65311
Mode	13246	#I/T	#I/T	#I/T
Standard-deviation	133051.1217	54341.19861	27713.19252	32259.693
Variance	17702600982	2952965866	768021039.7	1040687791
Kurtosis	0.550029059	1.054037418	0.55974204	0.6412711
Skewness	1.393163532	1.457946555	1.407649698	1.33461129
Range	435175	201113.5699	90729.29009	117640.723
Minimum	11840	8735.54065	1003.630039	1455.51652
Maximum	447015	209849.1106	91732.92013	119096.239
Sum	19786525	9459950.645	3608585.876	4639702.54
Count	179	179	179	179

	<b>Growth in GDP per capita</b>	<b>Growth in private consumption per capita</b>	<b>Growth in government consumption per capita</b>	<b>Growth in investment per capita</b>
Average	0.02079853	0.01860362	0.023999803	0.03255129
Standard error	0.002582079	0.002823397	0.004331566	0.0122027
Median	0.020617739	0.019604978	0.024729664	0.02638921
Mode	#I/T	#I/T	#I/T	#I/T
Standard- deviation	0.034352324	0.03756285	0.057627741	0.16234642
Variance	0.001180082	0.001410968	0.003320957	0.02635636
Kurtosis	3.548419007	7.626548864	1.608753568	74.1917485
Skewness	- 0.330557582	0.204525721	-0.200723	6.82792884
Range	0.268189522	0.384085306	0.376869126	2.12615527
Minimum	- 0.108183392	-0.157674123	-0.174282626	-0.35928818
Maximum	0.160006129	0.226411184	0.2025865	1.76686709
Sum	3.681339835	3.292840736	4.247965184	5.76157875
Count	177	177	177	177

## Appendix 8: GDP, Consumption and Investment

Figure 8: GDP by expenditure: GDP, private and government consumption and investment, million 2005-NOK

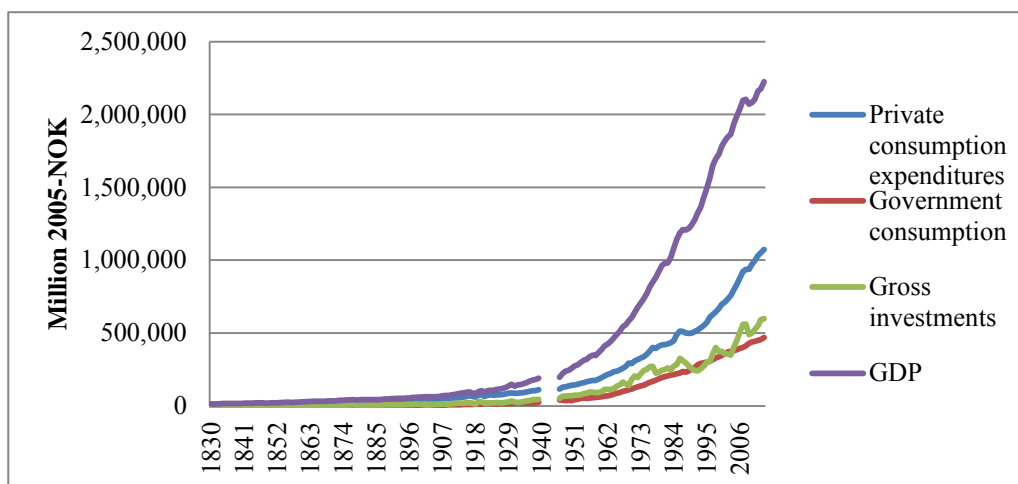


Figure 9: GDP, private and government consumption and investment per capita, million 2005-NOK

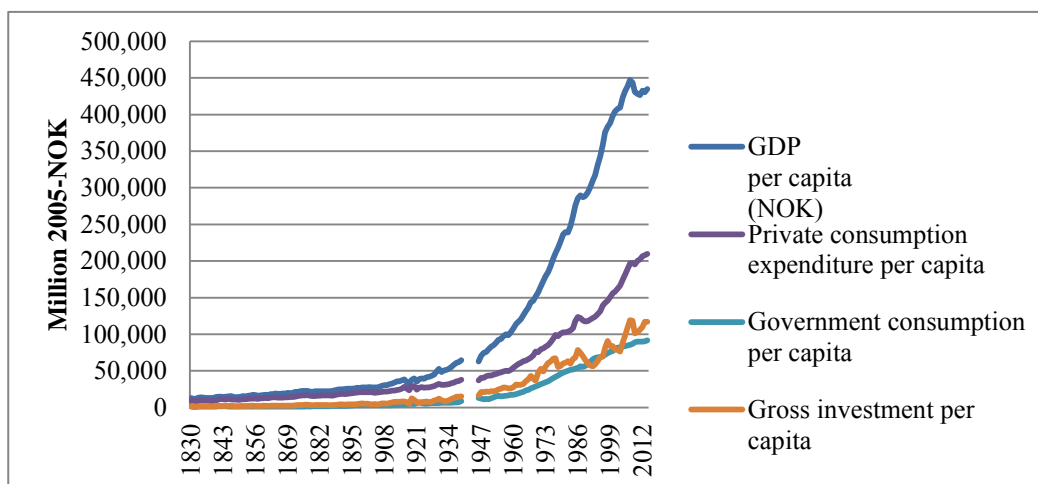


Figure 10: Growth rates GDP, private and government consumption and investment per capita 1831-2014

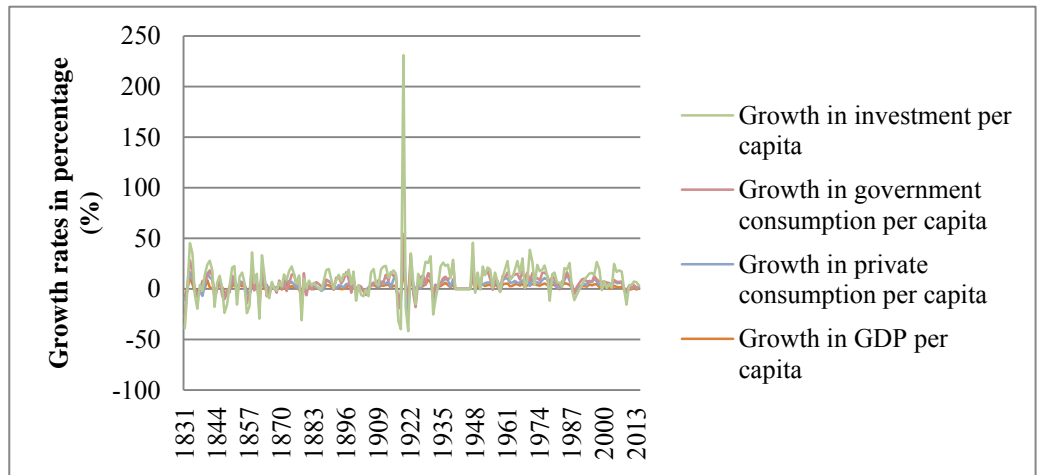


Figure 11: GDP, consumption and investment (growth rates) 1831-2014. Outlier excluded.

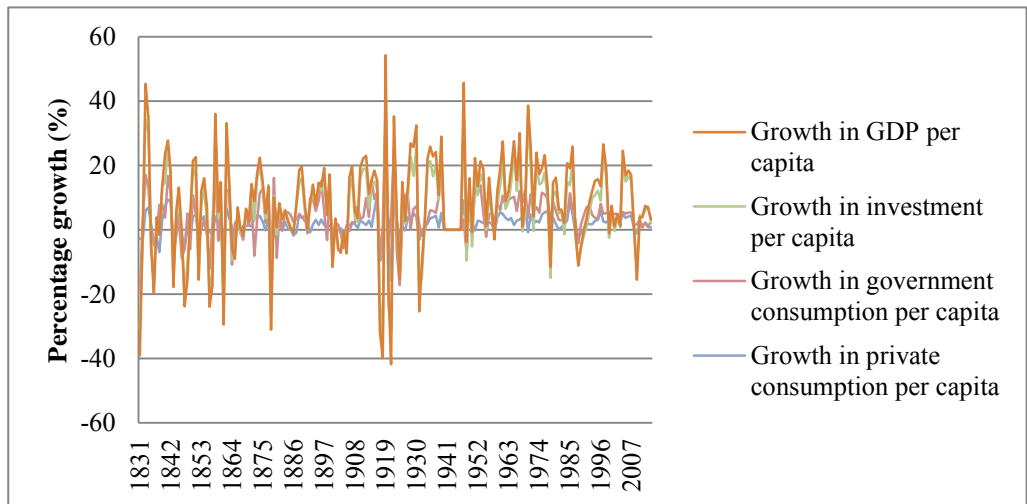
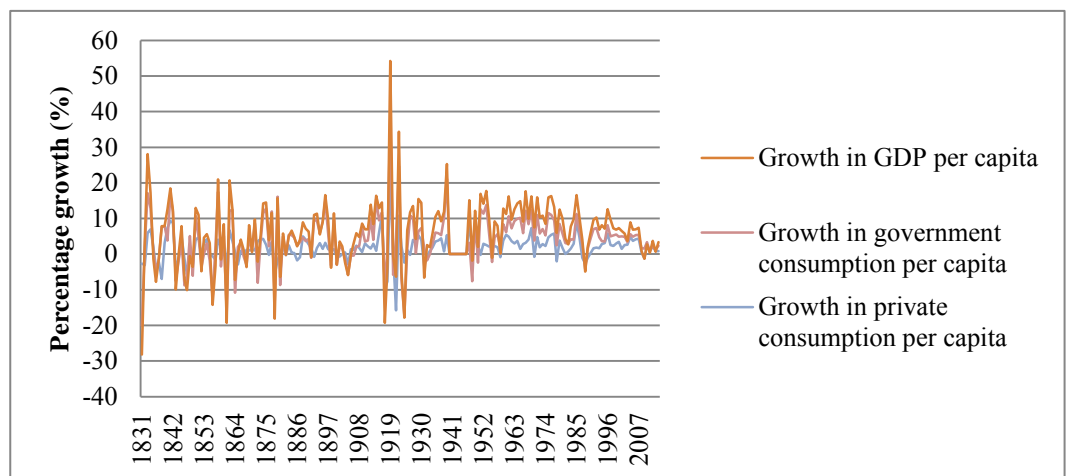


Figure 12: Growth rates 1831-2014 (investment excluded)





## Appendix 9: Regression analysis (OECD data)

Regression conducted:  $y_{i,t} = \alpha_i + \beta_i r_{i,t-1} + \varepsilon_t$

Table 3: Regression output - basic regression (no lag of dependant variable)

Country	Time period	Number of observations	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\beta}$ p-value (significance level)	Adjusted $R^2$
	1971-		-			
<b>Australia</b>	2015	45	1.1995	0.3782	0.0106	0.1226
	1997-					
<b>Euro area</b>	2014	18	1.9521	-0.1154	0.7852	-0.0574
	1961-					
<b>France</b>	2015	55	1.0972	0.1116	0.4388	-0.0073
	1971-					
<b>Germany</b>	2015	45	2.5956	0.0879	0.6956	-0.0196
	1976-		-			
<b>Ireland</b>	2015	40	0.2152	0.5909	0.0102	0.1392
	1990-					
<b>Japan</b>	2015	26	1.6196	0.4313	0.2334	0.0194
	1986-					
<b>Norway</b>	2015	30	2.7347	-0.0720	0.8820	-0.0349
<b>Norway (NB)<sup>40</sup></b>	1832-					
	2014	183	2.3068	0.0101	0.7672	-0.0050
	1981-					
<b>Spain</b>	2015	35	0.4722	-0.1049	0.6796	-0.0249
	1961-		-			
<b>UK</b>	2015	55	1.9971	0.9143	0.0000	0.4928
	1971-					
<b>US</b>	2015	45	0.4471	0.3205	0.0079	0.1334

<sup>40</sup> Data retrieved from Norges Bank. Note how the datapoints from the war (1940-1946) has been “manipulated”. A constant growth rate is assumed for the missing data.

Table 4: Regression including four lags of the dependant variable

<b>Country</b>	<b>Time period (obs.)</b>	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\beta}$ p-value (significance level)	$R^2$ (adjusted)
<b>Australia</b>	1971-2015 (45)	-1.3421	0.4083	0.0089	0.1985 (0.0958)
<b>Euro area</b>	1997-2015 (14)	3.8635	-1.4896	0.1576	0.3836 (-0.0016)
<b>France</b>	1961-2015 (51)	-0.0788	0.1862	0.1659	0.3567 (0.2852)
<b>Germany</b>	1971-2015 (41)	1.2132	0.1138	0.6221	0.2135 (0.1011)
<b>Ireland</b>	1976-2015 (40)	-2.0900	0.7391	0.0015	0.4032 (0.3154)
<b>Japan</b>	1990-2015 (26)	2.1574	0.5181	0.1848	0.1663 (-0.0421)
<b>Norway</b>	1986-2015 (30)	2.2061	-0.0435	0.9355	0.1269 (-0.0550)
<b>Norway (NB)</b>	1831-2015 (180)	1.2978	0.0129	0.7035	0.1012 (0.0754)
<b>Spain</b>	1981-2015 (35)	-0.3982	0.1668	0.3340	0.6452 (0.5840)
<b>UK</b>	1961-2015 (51)	-1.5600	0.6906	0.0000	0.6418 (0.6021)
<b>US</b>	1971-2015 (41)	0.7552	0.2238	0.0608	0.3129 (0.2147)

## Appendix 10: Regression analysis

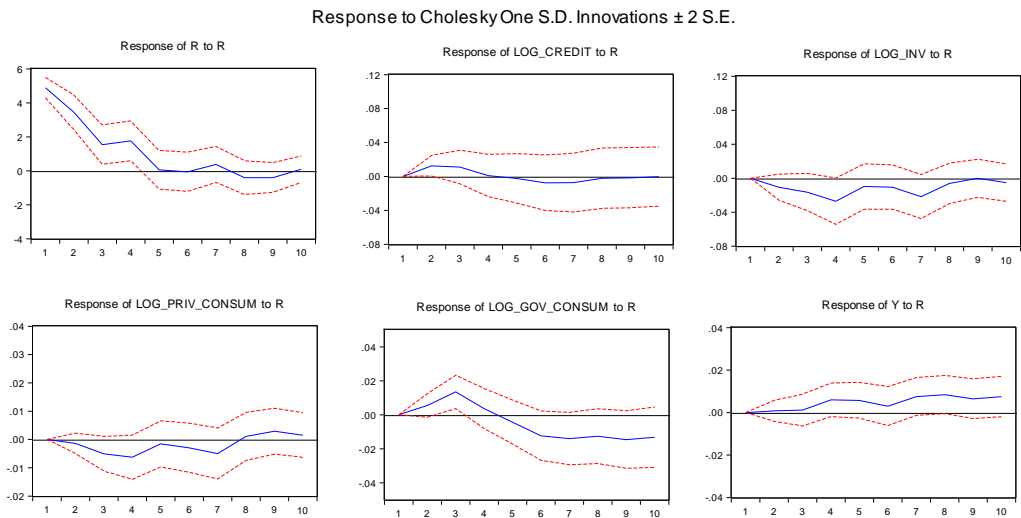
Table 5: Summary of regression output – included lags based on F-test

Country	Time period (obs.)	Included lags of the dependent variable (GDP) <sup>41</sup>	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\beta}$ p-value (significance level)	Adj. $R^2$
Australia	1971-2015 (45)	1	-1.2139	0.3813	0.0093	0.1441
Euro area	1997-2015 (16)	2	2.6844	-0.7126	0.2860	0.0758
France	1961-2015 (54)	1	0.1353	0.1643	0.1846	0.2835
Germany	1971-2015 (44)	1	1.2509	0.1095	0.5960	0.1600
Ireland	1976-2015 (40)	1	-1.2642	0.6456	0.0021	0.3214
Japan	1990-2015 (26)	1	1.1796	0.4228	0.2452	0.0104
Norway	1986-2015 (30)	2	2.7458	-0.1008	0.8379	-0.0088
Spain	1981-2015 (35)	1	-0.2869	0.1366	0.4099	0.5863
UK	1961-2015 (51)	1	-1.6015	0.7271	0.0000	0.6011
US	1971-2015 (44)	1	0.0329	0.3158	0.0064	0.2184

<sup>41</sup> Included lags based on a lag-reduction test (F-test) up to 4 lags included

## Appendix 11: Robustness of VAR (financial stability)

Figure 13: Impulse responses – testing for robustness



## Appendix 12: Impulse Responses in High-rate Regime

Figure 14: Impulse response in a high rate regime (rates above 4%)

