

IN-DEPTH ANALYSIS

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# Growth prospects, the natural interest rate, and monetary policy

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Monetary Dialogue November 2018



Policy Department for Economic, Scientific and Quality of Life Policies  
Directorate-General for Internal Policies  
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## **Abstract**

The recovery from the Global Financial Crisis was characterized by sluggish output growth and by inflation remaining persistently below the inflation targets of central banks in many advanced economies despite an unprecedented monetary expansion. Ten years after the Global Financial Crisis, GDP remains below its pre-crisis trend in many economies and interest rates continue to be very low worldwide. This raises the question of whether low GDP growth and low interest rates are a temporary phenomenon or are due to a decline in long-run growth prospects (potential output growth) and equilibrium real interest rates (natural interest rate). In this paper, we address this for central banks very important question and discuss implications for monetary policy.

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This document was requested by the European Parliament's Committee on Economic and Monetary Affairs.

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## LIST OF ABBREVIATIONS

<b>CEA</b>	Council of Economic Advisors
<b>DE</b>	Germany
<b>DSGE</b>	Dynamic Stochastic General Equilibrium
<b>EA</b>	Euro Area
<b>ECB</b>	European Central Bank
<b>ELB</b>	Effective Lower Bound
<b>FR</b>	France
<b>GDP</b>	Gross Domestic Product
<b>IMF</b>	International Monetary Fund
<b>IS equation</b>	Investment-Saving Equation
<b>JP</b>	Japan
<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>UK</b>	United Kingdom
<b>US</b>	United States
<b>VAR</b>	Vector Autoregression
<b>WTO</b>	World Trade Organisation

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## EXECUTIVE SUMMARY

### Background

- Potential output and the natural interest rate are both important concepts for monetary policy. The natural interest rate helps to assess whether monetary policy is expansionary or contractionary. Potential output determines the long-run sustainable level of output that can be achieved without creating inflationary pressure and its growth rate is widely regarded as one determinant of the natural rate. The measurement of both variables is challenging as they are theoretic constructs that are not directly observable. A number of recent studies argue that the natural interest rate and potential output growth have decreased over the last two decades.

### Aim

- We analyse recent trends in potential output and in the natural rate and discuss factors behind these trends. Based on our results, we discuss implications for monetary policy.

### Findings

- The empirical evidence suggests that the Global Financial Crisis, in line with historical experiences, was associated with a permanent decline in GDP, but did not have large effects on long-run potential growth. However, potential output estimates are subject to high uncertainty. Unrelated to the Global Financial Crisis, there is a secular decline of potential output growth that started already in the late 1970s and that is related to declining productivity growth. Going forward, there are indications that the downward trend in potential growth is about to reverse, but there is no strong reason to expect sudden improvement.
- The natural interest rate has most likely declined over the last decades. Potential factors behind this are lower potential growth, increasing savings due to demographic change, and an increase in the demand for safe assets.
- Estimates of the natural interest rate are, however, particularly uncertain, sensitive to the methodology and econometric model specification, and subject to large revisions. Uncertainty is so large that pinning down a precise value is not possible.

### Implications

- The higher the uncertainty with regard to potential output or natural interest rates, the lower weight central banks should put on these estimates. They should allow for more inertia in adjusting their monetary policy and put a stronger focus on incoming inflation data.
- There is also increasing evidence that the relationship between the output gap and inflation has weakened and that it therefore has become more difficult for monetary policy to control inflation. Moreover, there is evidence that monetary policy is less effective in the aftermath of financial crises compared to non-crisis times. Against this backdrop, it is not obvious whether not sufficiently expansionary monetary policy, or related a low natural interest rate, was an important factor behind the sluggish recovery following the Global Financial Crisis.
- To the extent that the natural rate has declined, monetary policy will more frequently hit the Zero Lower Bound in the future. There are concerns that unconventional monetary policy is less effective and has negative side effects, especially if it is in place for long periods of time. This implies that central banks may have to accept deviations from their inflation targets for longer periods than in the past.



## 1. INTRODUCTION<sup>1</sup>

The recovery from the Global Financial Crisis was characterized by sluggish output growth and by inflation remaining persistently below the inflation targets of central banks in many advanced economies despite an unprecedented monetary expansion. Ten years after the Global Financial Crisis, GDP remains below its pre-crisis trend in many economies and interest rates continue to be very low worldwide. This raises the question of whether low GDP growth and low interest rates are a temporary phenomenon or are due to a decline in long-run growth prospects (potential output growth) and equilibrium real interest rates (natural interest rate). This question is very important for central banks. If sluggish output growth was mainly due to temporary factors and GDP is still far below potential output, central banks would strive to more expansionary monetary policy to close this gap, which in turn would lead to higher inflation rates according to the Phillips curve relationship. Moreover, if the natural interest rate has fallen to levels close to currently observed interest rates, then the current stance of monetary policy (measured via the distance between current rates and the natural rate) might be less expansionary than intended and one reason behind sluggish output growth and low inflation. Addressing this issue is crucial for central banks in assessing whether they can soon go back to standard monetary policy tools or whether keeping interest rates low and using unconventional measures is the new normal for monetary policy. However, potential output and the natural interest rate are not observable and estimates are subject to large uncertainty.

From a theoretical perspective, there could be several factors behind fluctuations in potential output or the natural interest rate. Moreover, there could be interdependencies between both variables. For example, low potential output growth is typically seen as one potential factor behind a low natural interest rate. There are also underlying factors that may affect potential output and the natural interest rate jointly, such as demographic change or productivity growth. In this regard, it has been argued that the world economy may have drifted into a 'secular stagnation' characterized by low natural interest rates reflecting a high propensity to save and low potential growth (Summers 2014). In this paper, we analyse recent developments in potential growth and the natural real interest rate and discuss the most important factors behind these based on the relevant literature. Based on our analysis, we derive implications for monetary policy.

We start by analysing whether sluggish GDP growth is mainly due to temporary factors or due to lower potential growth (Section 2). In doing so, we first discuss the impact of the Global Financial Crisis on GDP and potential output (2.1). Second, we focus on long-run developments in potential growth (Section 2.2). We proceed by analysing trends in the natural interest rate (Section 3). We start by describing the results of the recent empirical literature on natural interest rates and discuss problems and uncertainties with regard to estimation methods (Section 3.1). We then discuss potential drivers of the natural interest rate (Section 3.2). Section 4 summarizes our results and discusses implications for monetary policy, Section 5 concludes.

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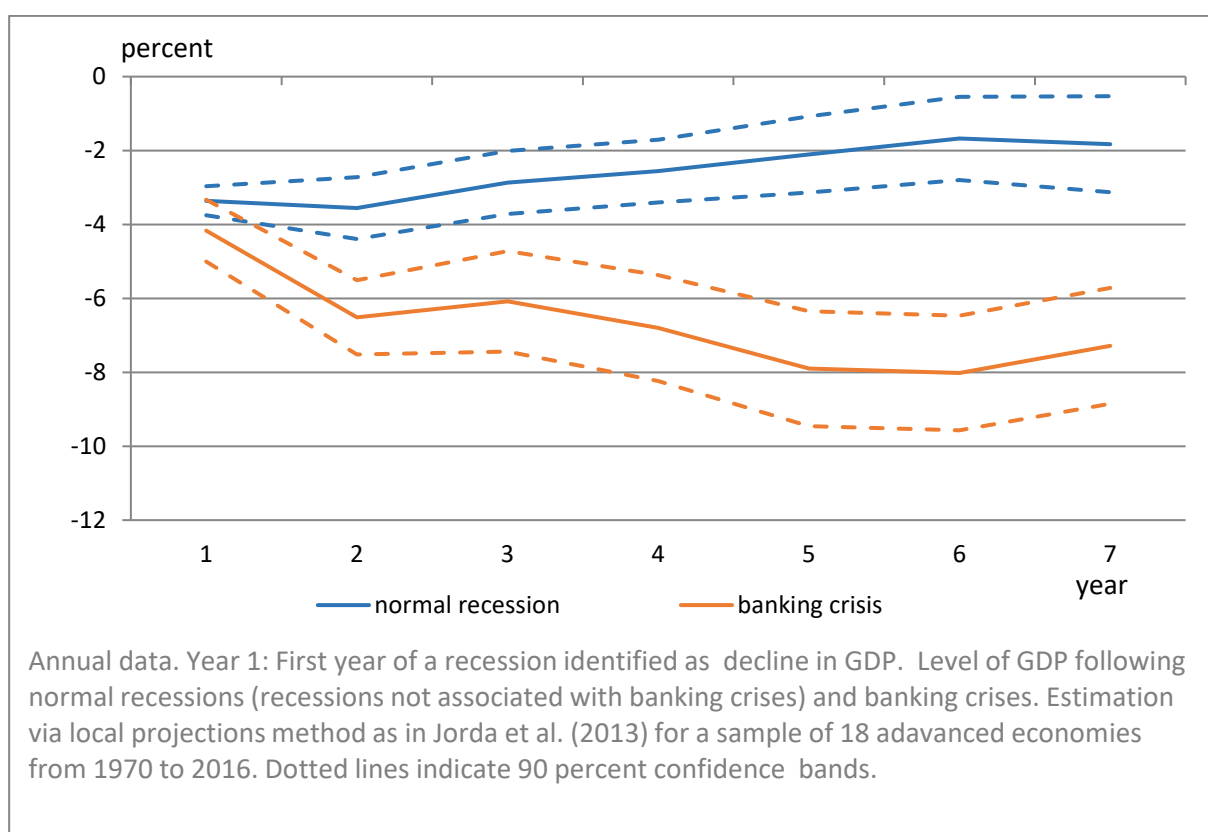
<sup>1</sup> The authors thank Stefan Kooths and Mewael F. Tesfaselassie for very useful comments and suggestions.

## 2. LONG-RUN TRENDS IN POTENTIAL OUTPUT

### 2.1. Growth prospects after the Global Financial Crisis

The Global Financial Crisis was associated with deep recessions and sluggish recoveries in many advanced economies raising the question of whether GDP was dampened temporarily or whether the crisis has led to a permanent decline in the level of potential output or even to a decline in potential growth. Financial crises can have permanent effects on potential output, e.g., if they are associated with financial constraints that hinder firms from making productive investments or with hysteresis effects due to long-lasting unemployment. However, financial crises do not hit countries arbitrarily but are usually linked to unsustainable pre-crisis developments. For example, the build-up of imbalances in credit or housing markets could be driving factors behind financial crises and are in fact reliable predictors, for banking crises in particular (Borio and Drehmann 2009; Jorda et al. 2015; Schularick and Taylor 2012). To the extent that the build-up of these imbalances is associated with higher GDP growth, a permanent decline in GDP following a financial crisis is not merely a consequence of the crisis but rather a consequence of such unsustainable pre-crisis developments.

Figure 1: GDP following normal recessions and banking crises



Source: OECD Main Economic Indicators; Laeven and Valencia (2013); own calculations.

The effects of financial crises on GDP and potential output have been analysed in several studies. These studies usually find that financial crises lead to a permanent decline in the level of GDP in advanced economies (Cerra and Saxena 2008; Jorda et al. 2013; Reinhart and Rogoff 2009). One reason for the permanent decline in GDP is that recoveries following financial crises are much weaker than those following normal recessions (Boysen-Hogrefe et al. 2016). Figure 1 summarizes the general

pattern of the results of these studies based on a sample of 18 advanced economies from 1970 to 2016 using the methodology of Jorda et al. (2013).<sup>2</sup> Following a financial crisis, GDP remains permanently below the path of GDP that would have been reached without a financial crisis (indicated by the zero-line), while following a normal recession GDP is recovering to levels close to its former path. In line with these results, studies that analyse the development of potential output find that the level of potential output is permanently lower following financial crises (Furceri and Mouroungane 2012; Ollivaud and Turner 2014).

While financial crises lead to a permanent decrease in the level of output and potential output, most studies find that negative effects on output growth are temporary and potential output growth remains largely unaffected by crises. For example, the results in Figure 1 shows that after about five years the level of GDP does not decline further compared to a scenario in which a country was not hit by a financial crisis, indicating that GDP growth is not permanently reduced. This result is in line with the studies focusing on potential output (Furceri and Mouroungane 2012; IMF 2009; Ollivaud and Turner 2014).<sup>3</sup> Moreover, studies that analyse the role of pre-crisis developments for the decline in GDP or potential output find that these developments are systematically related to the magnitude of the decline. For example, stronger credit growth (Jorda et al. 2013; Ollivaud and Turner 2014), a housing boom (Boysen-Hogrefe et al. 2016; Jorda et al. 2015), or a high investment share (IMF 2009) before a crisis lead to a stronger decline in GDP and potential output. To the extent that these pre-crisis developments have increased GDP growth before a crisis, post-crisis weaknesses in GDP and potential output are rather normalizations than consequences of the crisis itself that would permanently lower potential growth. Behind this backdrop, the sluggish recovery after the Global Financial Crisis was in line with historical experiences.

However, potential output cannot be observed and therefore has to be estimated. International organizations, such as the European Commission, the International Monetary Fund, or the OECD, use a production function approach to estimate potential output. This approach relies on filtering methods using past as well as future information to estimate potential output in a given year. Even though usually additional information, such as survey-based capacity utilization of firms, GDP growth forecasts or inflation, are taken into account to improve estimates, using filtering approaches implies that real-time estimates of potential output and in turn of the output gap are subject to high uncertainty and large revisions. Given that recessions can hardly be predicted (Dovern and Janssen 2017), this uncertainty may amplify during recessions and financial crises. For example, Dovern and Zuber (2017) show for a sample of advanced economies that OECD estimates of potential output for the fifth year after the beginning of a recession are revised downwards by about 5 percent on average compared to estimates that were made before the beginning of a recession. Following financial crises, potential GDP is revised downwards by up to 10 percentage points. Moreover, the downward revisions take place gradually and can differ substantially across recessions, indicating how problematic it is for central banks to rely on potential output and output gap estimates in times of recessions and financial crises.

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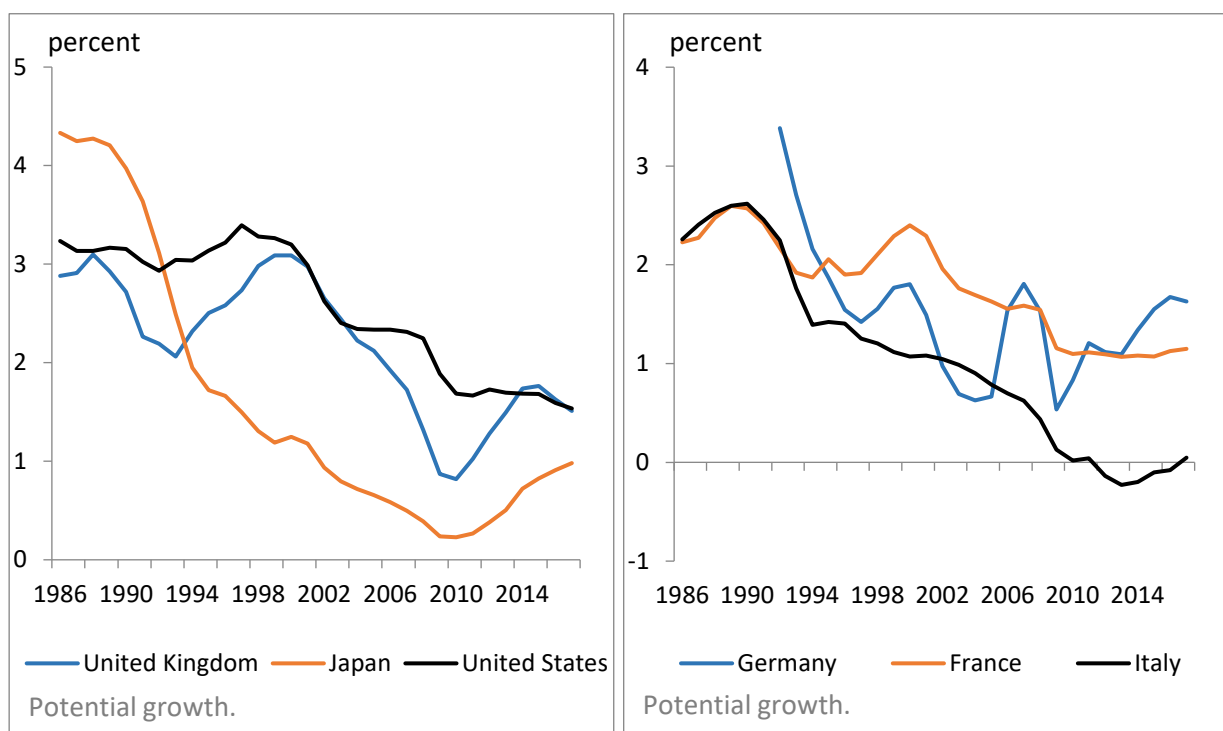
<sup>2</sup> The sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Recessions are identified as years with negative GDP growth rate. Banking crises are identified according to Laeven and Valencia (2013). Estimation based on local projections method according to Jorda et al. (2013).

<sup>3</sup> Furceri and Mouroungane (2012) find that potential growth is on average somewhat lower following financial crises, however, this decline is not statistically different from zero.

## 2.2. Long-run trends in potential growth and productivity

Potential output growth has been on a declining trend in advanced economies for many years, although with some fluctuations and significant differences across countries (Figure 2). In the US, potential growth was relatively stable at 3–3 ½ percent in the latter half of the 1980s and the 1990s according to OECD estimates, but started declining around the turn of the century towards a level of below 2 percent in recent years. The growth rate of the Japanese potential growth experienced a steep decline from around 4 percent at the beginning of the 1990s to close to zero around 2010, but has recovered somewhat since then to approximately 1 percent recently. Potential growth in the major European economies has been clearly trending downwards since the mid-eighties until around 2010 (from around 2 ½ percent to close to 1 percent in the UK and Germany, slightly more in France, and even zero percent growth in Italy). In recent years, potential output growth has stabilized or partially recovered (especially in the UK and Germany), according to the estimates of the OECD.

Figure 2: Potential output growth in advanced economies



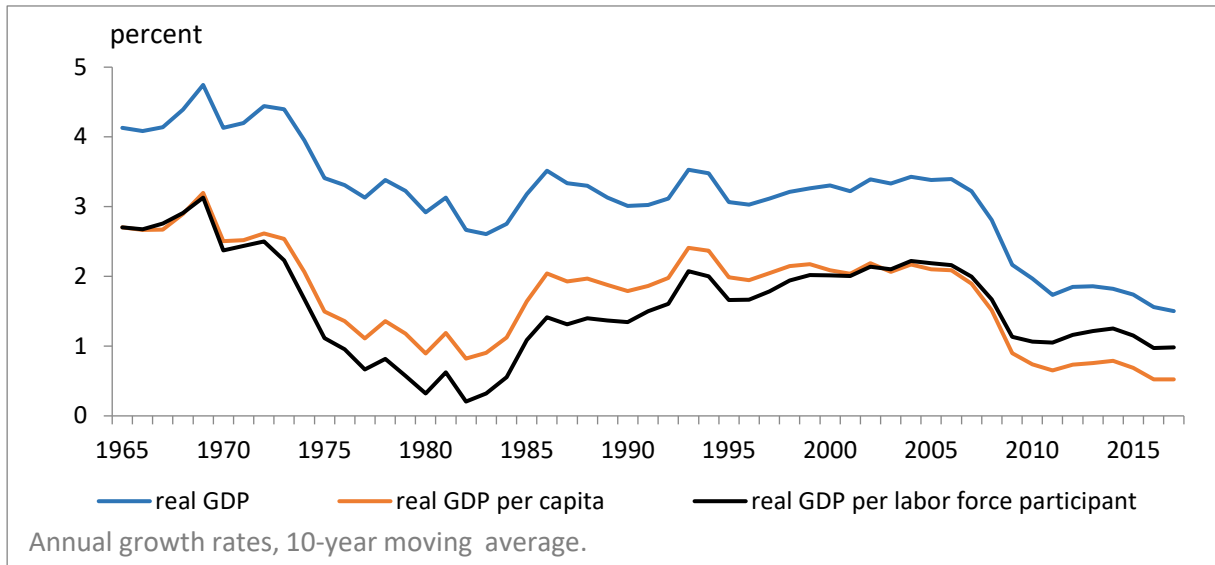
Source: OECD Economic Outlook.

### 2.2.1. Drivers of potential output growth

The growth rate of potential output is affected by growth in labour input, capital input, and the efficiency with which the factors of production are combined – Total Factor Productivity, which is generally associated with technological progress. In the advanced economies, demographics and their impact on labour force growth are partly responsible for the decline of trend growth. Especially in the case of the US, slower labour force growth dampened the growth rate of potential output. Therefore, the slowdown in economic growth is much less dramatic with respect to GDP per labour force participant (Martin 2017). While a slowdown in trend growth is still apparent in recent years by this yardstick, too, the level of growth is not exceptionally low (Figure 3). In Japan, the working age population has already been in decline for quite some time, and the labour force started to shrink in

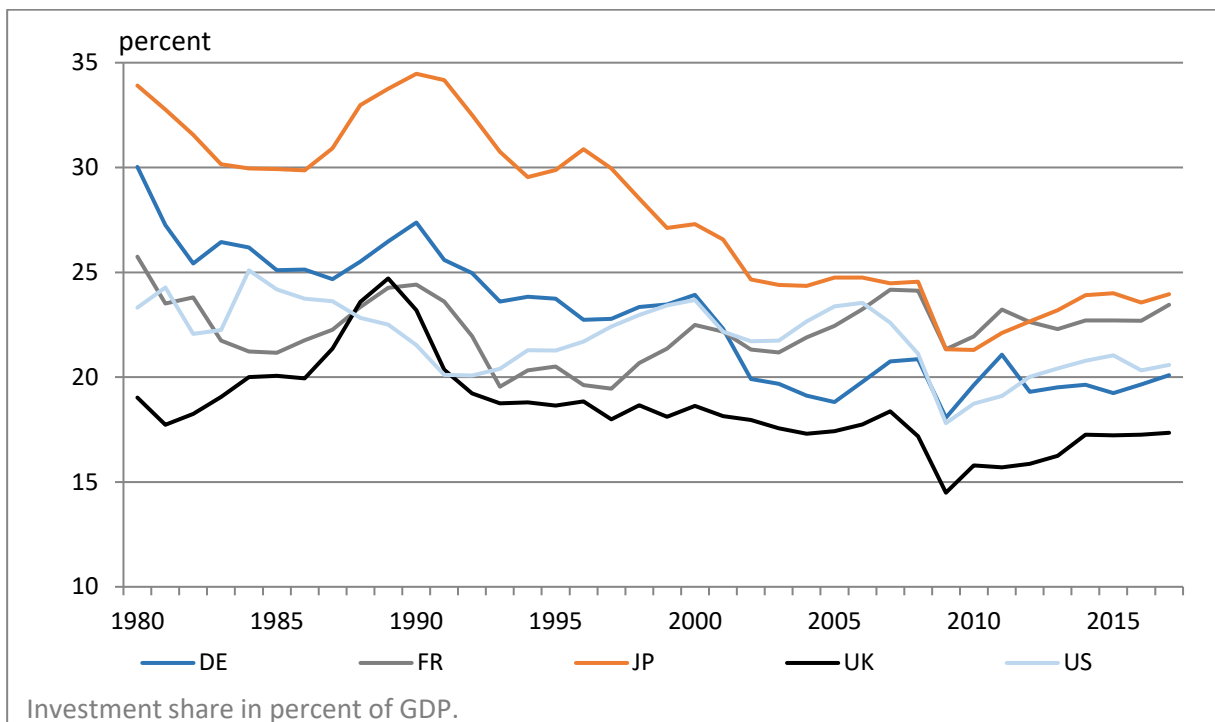
the late 1990s. In recent years however, the negative impact of population aging on the labour force growth has been offset by an increase in the participation rate, particularly of women and the elderly. In Europe, labour force growth has shown no clear trend since the 1970s.

Figure 3: US trend GDP growth 1965-2017



Source: Bureau of Economic Analysis, Bureau of Labor Statistics.

Figure 4: Investment shares in selected OECD countries 1980-2017

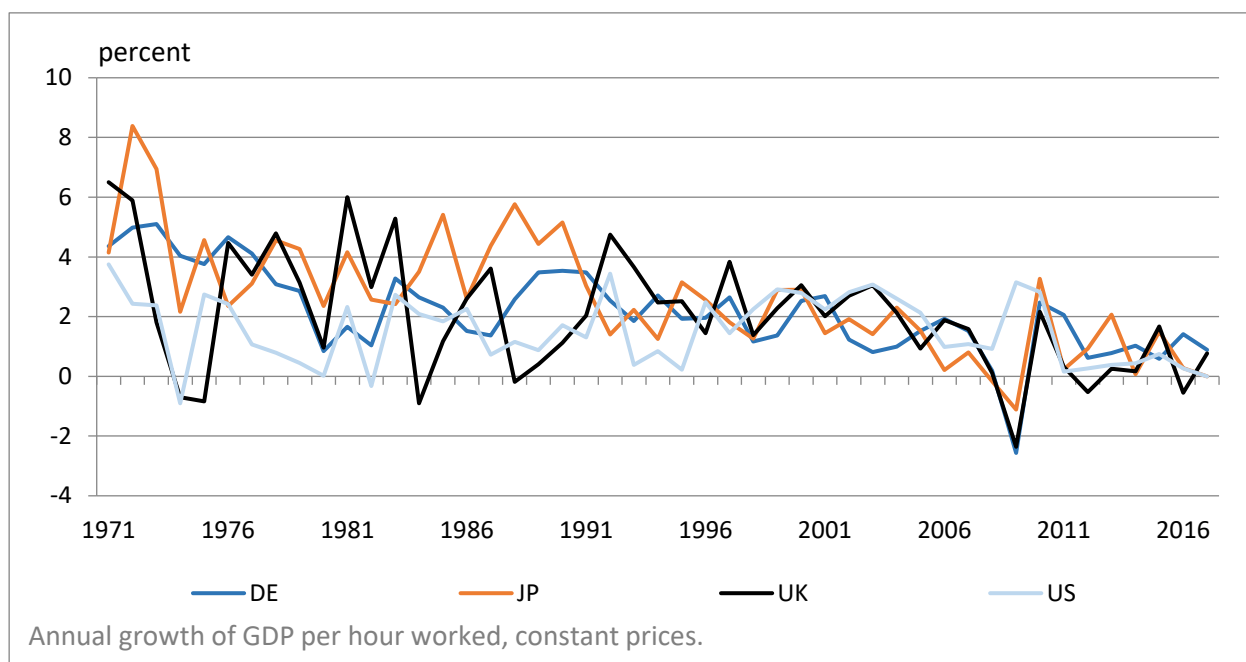


Source: IMF World Economic Outlook Database.

Declining levels of capital formation are another part of the explanation of declining trend growth in advanced economies, although to a differing degree. While the share of investment in GDP has been falling significantly over the past 35 years in a number of countries, including Japan, Germany, and the UK, the investment ratio has remained almost constant in other countries, such as the US and France (Figure 4).

The third driver of potential output growth is productivity. Productivity developments differed across the advanced economies in the 1990s and early 2000s, with a steady decline in trend productivity growth (measured as output per hour worked) in Germany, Italy, and Japan, relatively stable productivity growth in France and the UK, and even accelerating productivity growth in the US. More recently, productivity patterns have become more uniform, with growth slowing down to exceptionally low levels almost across the board (Figure 5).<sup>4</sup>

Figure 5: Labour productivity



Source: OECD.

### 2.2.2. Is there a productivity puzzle?

While the slowdown of productivity growth has been accentuated by the recent financial crises and their repercussions, econometric evidence suggests that the slowdown started already well before the Great Recession and the sovereign debt crisis in the euro area (Cette et al. 2016). The weakness of productivity came as a surprise to many observers who had expected more dynamic productivity growth as a result of the sweeping improvements in technology, including digitization, artificial intelligence, and robotics. The coincidence of the productivity slowdown and the availability of new

<sup>4</sup> The major exception is Spain where during the boom years in the late 1990s and early 2000s growth was strongly biased towards the construction sector and thus extremely labour intensive. This process reversed in the years following the financial crisis, leading to a strong recovery of productivity during the recession and in the beginning of the upturn.

technologies is labelled “productivity paradox” or “productivity puzzle”.<sup>5</sup> A number of explanations have been suggested to reconcile technological innovations with poor productivity performance.<sup>6</sup>

Some observers have argued that problems with accurately measuring new technology output would help solving the productivity puzzle. It is true that serious challenges in estimating GDP exist, including collecting data on the sharing economy, taking account of digital services that are not priced directly, and adjusting for the quality improvements associated with technological advances and new goods and services entering the market.<sup>7</sup> However, these problems should primarily affect the *level* of productivity growth, while in order to explain *changes* in productivity growth they need to have become significantly more important over time. This is according to a number of recent studies, however, is not the case. Thus, mismeasurement can at most account for only a modest share of the observed slowdown in labour productivity in advanced economies.<sup>8</sup>

Another strand of literature argues that the impact of the recent wave of innovations on productivity is likely to be lower than expected by technology optimists, or that the positive effect on productivity will materialize only with a long lag. According to Robert Gordon (2014), digitization does not have the potential to raise productivity in the same way that the industrial revolution did in the first half of the 20<sup>th</sup> century. A more optimistic explanation of the productivity paradox argues that the productivity enhancing impact of the new digital technologies needs more time to be realized (Brynjolfsson et al 2017). Investment in new equipment and necessary complementary tangible and intangible capital to reap the full benefits of digitization will need considerable time as will the associated restructuring of production processes and value chains. The introduction of new technology also contains an element of trial and error that may contribute to a long lag between the introduction of technology and measured productivity increases on the macro level. The implications of the two technology explanations of the productivity paradox for future productivity growth are substantially different. While productivity growth would remain sluggish according to the pessimistic view, the optimists rather expect a recovery.

Other explanations of the productivity slowdown are not directly related to new technologies. The role of structural change may be important as productivity growth on the macro level is not only affected by the development of productivity in each sector but also by the fact that the relative size of the sectors in the economy changes over time due to differences of productivity growth across sectors and reallocation of factors within the economy. According to Baumol (1967), productivity growth differs between sectors (say high in manufacturing, low in services), but wages tend to grow at a similar rate due to market competition and labour mobility. As a result, the share of resources allocated to the sector with lower productivity growth may rise over time, leading to a slowdown of productivity growth in the total economy (even if productivity growth in each sector remains unchanged). The effect of structural change on productivity growth can empirically be analysed using a growth accounting approach that divides total productivity growth into the contribution from within sector productivity growth, the productivity effect due to shifts of workers between sectors with different productivity *levels* (static reallocation effect), and the productivity effect that stems

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<sup>5</sup> The term productivity paradox goes back to Robert Solow’s 1987 notion that “you can see the computer age everywhere, but in the productivity statistics” (see also Brynjolfsson 1993 for a discussion of the productivity paradox of the 1980s). The term “productivity puzzle” has been coined in the discussion about surprisingly weak productivity growth in Britain (see e.g. Office for Budget Responsibility 2012).

<sup>6</sup> See Crafts (2018) and Freund (2018) for brief reviews.

<sup>7</sup> See IMF (2018) for a discussion of the argument.

<sup>8</sup> IMF (2018) estimates that for the US only 10-20 percent of the shortfall in labour productivity may be attributable to under-measurement of the digital sector. Barnett et al. (2016) suggest that up to 25 percent of the productivity gap in the UK could be due to measurement issues. IfW (2017) concludes that measurement problems do not significantly contribute to explaining the productivity slowdown in Germany.



from shifting workers between sectors with different productivity *growth rates* (dynamic productivity effect). Freund (2018) reports evidence for the US that the dynamic reallocation effect has been consistently negative over the past decades (i.e. labour has been shifted into sectors with relatively low productivity growth), but also relatively small and stable over time. Hence, it cannot explain the productivity slowdown. The static reallocation effect by contrast has contributed to the productivity slowdown, as it has turned from significantly positive to slightly negative over the past decades although the magnitude of the shift (around 1 percentage points over the past 30 years and less than ½ percentage points over the past 10 years) is moderate. IfW (2017) finds for a number of European countries that the contribution of structural change to changes in productivity growth is generally small and not consistent over time, although there have been notable effects from reallocation across sectors in some years in some countries.<sup>9</sup>

Another factor arguably contributing to the pronounced slowdown in productivity growth recorded in most recent years may be that the process of globalization of production apparently has lost momentum (Tenreyro 2018). The productivity enhancing effects of globalization (offshoring, build-up of global value chains, increased foreign direct investment), thus, are lacking today, and the current trend towards more protectionist policies with respect to international trade and investment do not bode well for future productivity.

In addition to secular developments affecting all (or most) countries, country-specific explanations are important in explaining productivity. The UK is a case in point, where productivity developments in the financial sector (which has a disproportionately large share in the economy by international comparison) are an important part of the explanation to the productivity puzzle. In Germany, normalization of productivity growth from the elevated levels of the reunification boom in the early 1990s and labour market reforms in the early 2000s, which have changed workers' attitudes and wage setting behaviour, are prominent examples of idiosyncratic explanations for the productivity slowdown. Especially the German "employment miracle" is a major factor behind German productivity in recent years (IfW 2017). Since the mid-2000s, a large number of workers with relatively low qualifications have found jobs as a result of wage moderation and enhanced work incentives. Therefore, the average endowment of German workers with both human capital and physical capital was reduced, leading to downward pressure on productivity.

### 2.2.3. Outlook for potential output growth

Projections for potential output growth come with large uncertainty, especially since the factors behind the recent slowdown in productivity are not fully understood. Arguments presented above support the view that the recent productivity slump may not be permanent, but there is also no strong argument to expect sudden improvement. There are indications that the downward trend in potential growth is about to reverse, partly due to the fact that the negative effects from the financial crisis are of temporary nature, partly due to policy initiatives strengthening the supply side of the economy. However, risks with regard to the global outlook (not only for the short term) abound, including increasing protectionism and interventionism (partly as a result of populist policy approaches), which have the potential to damage global growth in the longer term.

Trends of economic growth on the global level depend on the metrics used (Figure 6). Using market exchange rates for aggregation of national outputs (which gives relatively high weights to advanced economies) yields a picture of a gentle downward trend since the mid-1980s from slightly above 3

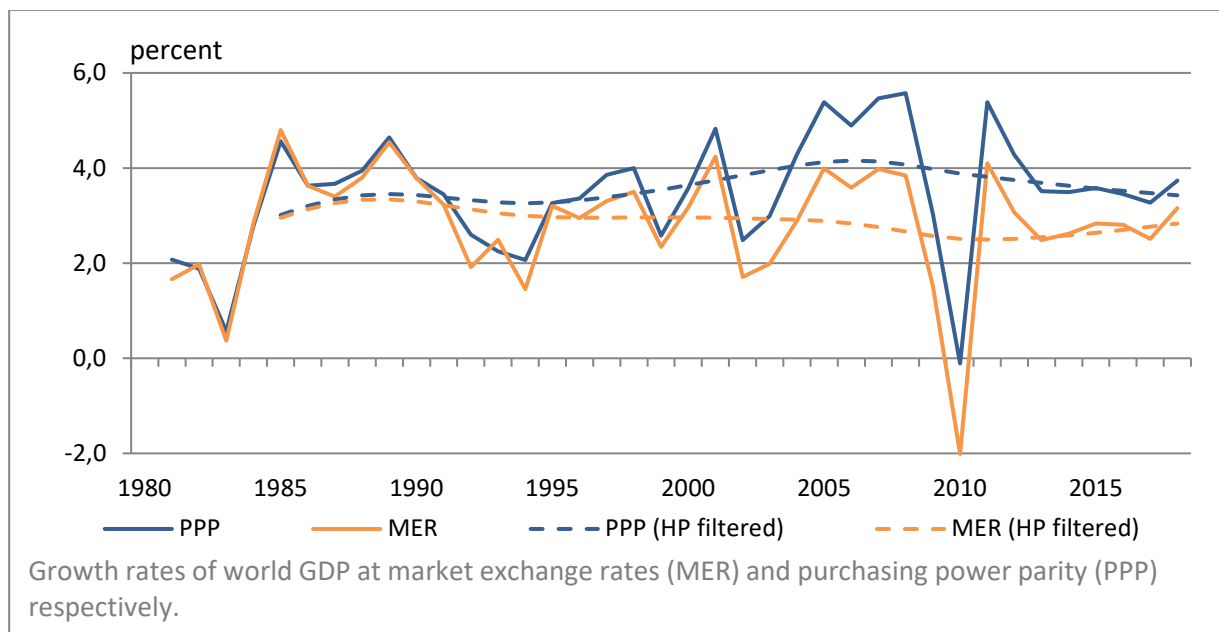
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<sup>9</sup> E.g. in Germany about one third of the significant slowdown of productivity growth in the period from 2005 to 2010 can be explained by changes in the reallocation effects. Fluctuations of productivity growth in the UK by contrast were dampened by the effects of structural change.



percent to 2 ½ percent around 2010 and a gradual acceleration in recent years. Based on the IMF's Purchasing Power Parity metrics, which gives a higher weight to emerging economies, the level of growth is higher and slower growth a relatively recent phenomenon: Before the Great Recession the world economy rather experienced a period of enhanced output growth, mainly due to higher growth in emerging economies. Chinese growth was particularly important given that country's rapidly rising share in global production. The integration of the Chinese economy into the world economy, which accelerated after China entered the WTO in 2001, was a major stimulus to global economic activity. However, with this process having largely run its course, potential for catch-up growth diminishing, and increasing concerns about financial, ecological, and social sustainability of economic growth in China, growth rates of GDP slowed down from more than 10 percent per year in the years from 2000 to 2011 to around 7 percent in more recent years. At the same time, commodity prices adjusted downwards as growth of demand from China moderated at the same time as new supply capacities were created, leading to adjustment pressures and lower growth in commodity producing countries. As Chinese growth is expected to gradually decline further over the coming years and a lower level of commodity prices is expected to prevail for some time to come, a return of growth rates in emerging economies to the high rates seen in the 2000s is not likely to materialize any time soon.

Figure 6: Global output growth 1980-2018



Source: IMF World Economic Outlook, own calculations.

### 3. THE NATURAL INTEREST RATE

Knut Wicksell originated the concept of a natural interest rate in 1898 as “a certain rate of interest on loans which is neutral in respect to commodity prices and tends neither to raise nor to lower them”. In terms of today’s economic concepts, this means the equilibrium real interest rate that prevails if GDP equals potential GDP and the inflation rate equals the inflation target.

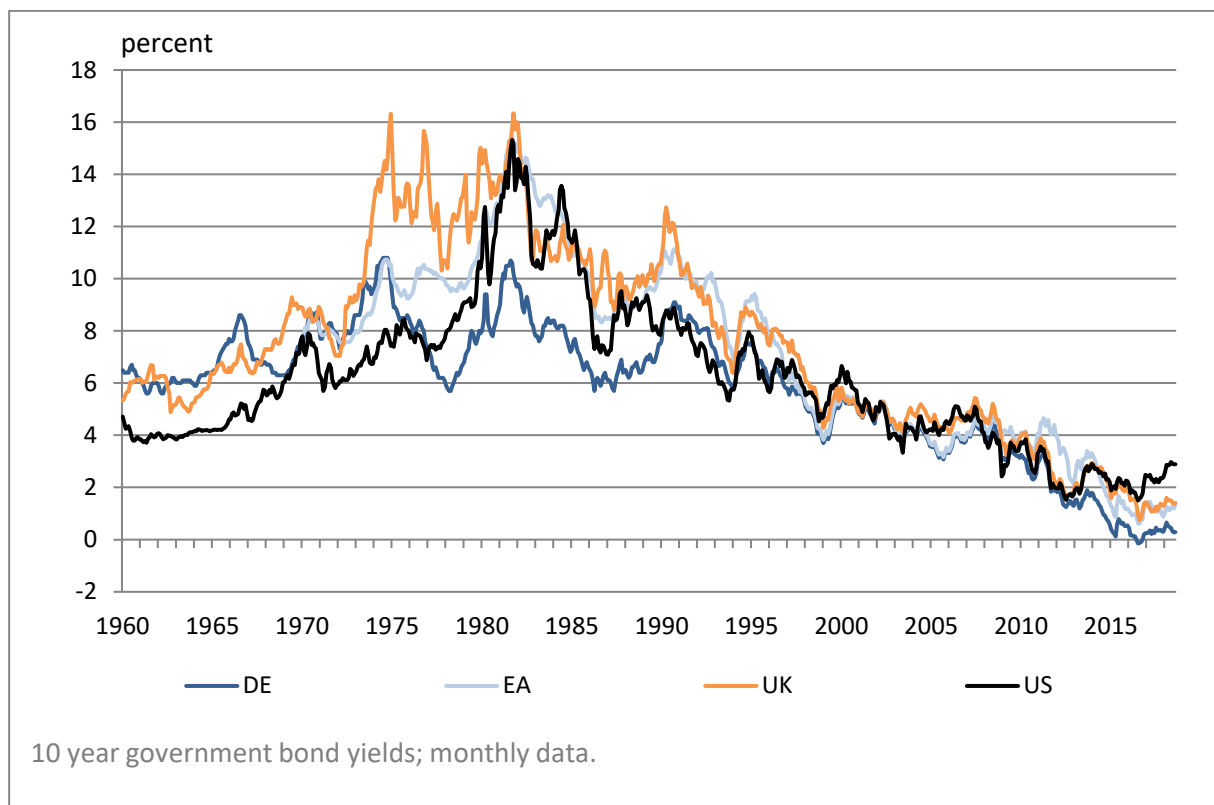
Accordingly, the measurement of the natural interest rate is important and has strong implications as it determines the neutral stance of monetary policy. For example, in the monetary policy rule by Taylor (1993) – known as the Taylor rule – the nominal interest rate equals the natural interest rate  $r^*$  plus inflation if inflation is at target and the output gap is closed:

$$i_t = r^* + \pi_t + 0.5 (\pi_t - \pi^*) + 0.5(y_t - y^*) + \varepsilon_t, \quad (1)$$

where  $i_t$  denotes the nominal policy rate,  $\pi_t$  the inflation rate,  $\pi^*$  the inflation target,  $y_t - y^*$  deviations of actual from potential output, i.e. the output gap, and  $\varepsilon_t$  a monetary policy shock. If central banks set the interest rate below the natural rate, monetary policy is expected to stimulate the output gap and inflation.

A decrease in the natural interest rate  $r^*$  implies that on average the policy rate  $i_t$  also needs to be set lower. A large decrease in the natural interest rate therefore could lead to a frequently binding Zero Lower Bound on the policy rate and the need to engage in unconventional policy measures on a regular basis. Precise estimates of the natural interest rate would allow distinguishing low interest rate periods that are caused by a decrease of the natural interest rate from those that are caused by persistently expansionary monetary policy.

Figure 7: Nominal interest rates



Source: OECD Main Economic Indicators.

Nominal interest rates have persistently declined since the beginning of the 1980s (Figure 7). While this decline coincided at the beginning with large declines in inflation, more recently nominal interest rates approached very low levels close to zero without substantial changes in trend inflation. This development gave rise to the hypothesis that the natural rate has approached very low levels as well.

### 3.1. Estimating the natural interest rate

The concept of the natural interest rate comes with two challenges for estimation. First, the natural rate is an economic concept for which different definitions exist. Second, the natural interest rate is not directly observable and therefore needs to be extracted from other data series. To do so, an econometric model needs to be specified that links observable data series to the unobservable natural interest rate. The exact definition of the natural interest rate is determined by how other data series are linked to the natural interest rate in such models. Hence, estimates of the natural interest rate might be only partially comparable across different models as they rely on different definitions and theories.

Beyer and Wieland (2017) propose distinguishing models that aim at the estimation of long-, medium- or short-term concepts of the natural interest rate. The long-run concept refers to an equilibrium rate that prevails after all cyclical and temporary factors have faded out, i.e. a steady state real interest rate. In the neoclassical model such an equilibrium rate is determined by the consumption Euler-equation. It depends on the long-run output growth rate, fiscal policy, and preference parameters like the time preference and the intertemporal rate of substitution, which influence the savings propensity. The medium-term concept is tied less stringently to structural models than the long-run concept, and semi-structural approaches that account for different determinants of the natural rate are used for estimation. The short-term concept is based on New Keynesian models and is defined as the rate that would prevail if prices and wages were flexible. It fluctuates a lot over the business cycle and does not correspond to the long-run equilibrium rate that is the reference point in the Taylor rule. While this concept is important in the academic literature on optimal monetary policy (Barsky et al. 2014, Curdia et al. 2014) it is less relevant for debates regarding structural changes in the economy leading to persistently low interest rates. Hence, in the following we discuss the long- and the medium-term concepts only.

#### 3.1.1. Medium-term natural rate estimates by Laubach and Williams

The most influential model in recent years for the estimation of the natural rate was developed by Laubach and Williams (2003), for which updated estimates have been published by Laubach and Williams (2016). It is the most prominent example of the medium-term definition of the natural interest rate and central banks are frequently referring to these estimates to explain their interest rate policy (Yellen 2015, 2017). Laubach and Williams estimate that the US natural interest rate has fallen from 3 percent around the year 2000 to about 0 percent in 2011 and has remained there ever since. They use a semi-structural model in which they assume that the natural interest rate depends linearly on the trend growth rate of output and an unobserved component that captures all other determinants like, for example, changes in the propensity to save. Thus, the equation for the natural interest rate includes three unobservable variables: the natural rate itself, the trend growth rate, and a variable capturing all unspecified determinants. To identify these variables from the data an IS-equation and a Phillips curve-equation are added to the model. The IS-equation links the output gap (the deviation of actual GDP from trend GDP) to deviations of the real interest rate from the natural interest rate and the Phillips curve links inflation to the output gap. Hence, the model consists of equations that link observable variables like GDP, inflation, and the real interest rate to unobservable variables like the natural interest rate, the trend growth rate, and other unspecified factors influencing the natural interest rate. The parameters of such a state space model and the

unobservable variables can be jointly estimated via applying the Kalman Filter and Maximum Likelihood estimation. The Kalman filter works on the principle that the estimates of unobservable variables are adjusted if the model's implied values for GDP, inflation, and the real interest rate deviate from the observed data. For example, the natural interest rate is adjusted if it is not in line with the relation between the output gap and the interest rate gap (defined as the deviation of the real interest rate from the natural rate) in the IS-equation. Of course, the output gap is an unobservable variable itself, but it is informed by the Phillips curve which links it to observable inflation data.

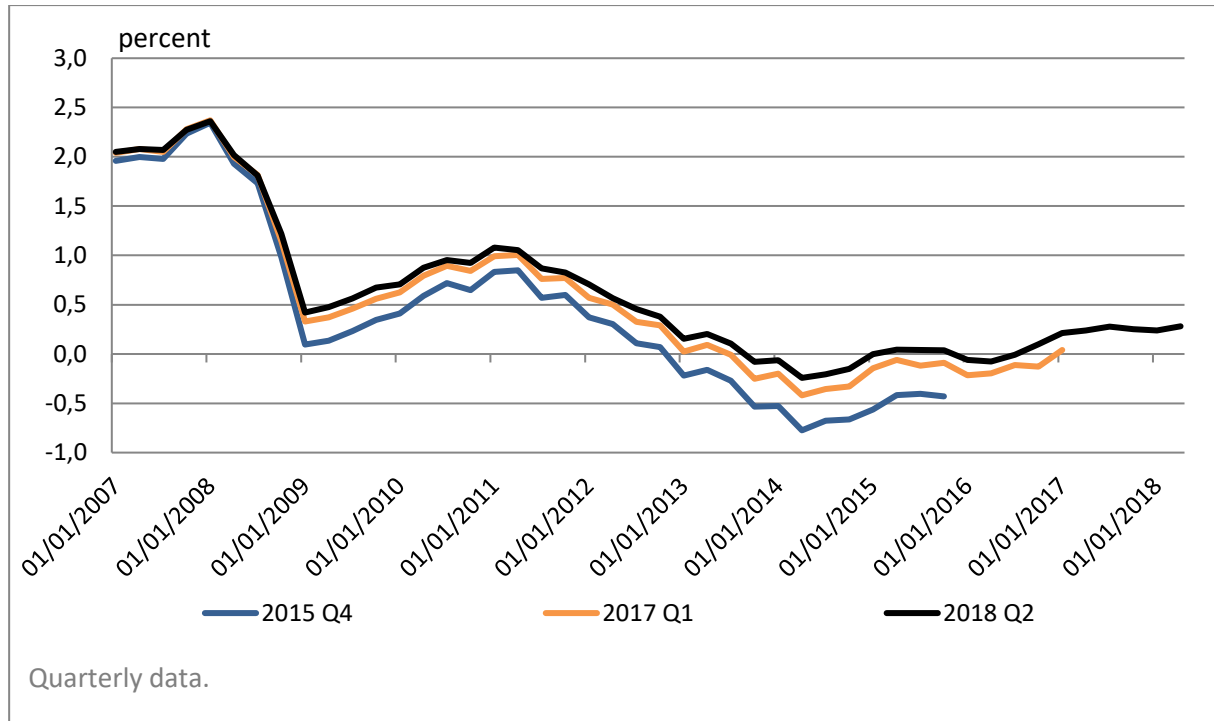
During the Great Recession output dropped a lot, but core inflation remained relatively stable, such that according to Laubach and Williams' model the drop in output led to a negative output gap, but also to a decline in potential output and its trend growth rate, reducing the natural rate estimates. Further, the very low observed real interest rates together with the natural interest rates estimates before the Great Recession would have implied a much quicker recovery of output to trend. Therefore, according to the IS-equation not only trend output but also the natural interest rate estimates need to be corrected downwards. According to Laubach and Williams, about half of the natural rate decrease since the onset of the Global Financial Crisis is explained by a decline in trend growth, while the catch-all other factors variable captures the other half. Holston et al. (2017) estimate a slightly modified model for the US, the euro area, Canada, and the UK and find a decrease in the natural interest rate in all four economies since the year 2007, for which the estimates range between 2 percent and 2.5 percent. According to these estimates, the decline in the natural rate was most pronounced in the euro area with a value of 0.3 percent in the second quarter of 2018. In the United States, the natural interest rate is estimated to be somewhat higher at 0.6 percent. In Canada and in the UK it is estimated to be about 1.5 percent. In all four economies the estimated trend growth rate has declined by 0.8 to 1 percentage points since 2007. This explains about half of the decline of the natural rates in the US and the euro area and 75 percent of the decline in Canada and the UK. The rest of the decline is attributed to unspecified factors.

### 3.1.2. Problems of the approach and alternative estimates

While most studies find a decrease in the natural interest rate since the late 1990s, the estimates of Laubach and Williams for the US are the lowest in the literature. Several papers propose possibilities to improve on their estimation approach. Taylor and Wieland (2016) argue that omitted variables in the IS-equation linking the output gap and the deviation of the real interest rate from the natural interest rate distort natural rate estimates. Examples of such omitted variables are regulatory and tax policy changes. Moreover, the model misses a monetary policy rule equation that determines the short-term interest rate. Including a monetary policy rule in the model is important as otherwise it is not possible to distinguish whether short-term interest rates are currently low due to the stance of monetary policy or due to a lower natural interest rate. Without modeling monetary policy, estimates of the natural rate will automatically adjust downwards if interest rates are low for an extended period. Taylor and Wieland (2016) analyse the period before and after the Great Recession and argue that expansionary monetary policy – and not a decrease in the natural interest rate – is the key reason for low real interest rates. Borio (2017) argues that the model of Laubach and Williams (2016) is not correctly specified as it assumes a stable Phillips curve relationship, while many contributions to the literature show that the Phillips curve relationship is not stable. Beyer and Wieland (2017) show that the results crucially depend on how the unobserved component of the natural interest rate is specified. If it is specified as a stationary process (rather than a random walk), as proposed by Garnier and Wilhelmsen (2009), point estimates of the natural interest rate are close to 2 percent rather than the 0 percent in Laubach and Williams (2016). Finally, real-time estimates of the natural interest rate can be subject to large revisions when additional and revised data become available (Clark and

Kozicki 2005). For example, estimates for the euro area based on the approach of Holston et al. (2017) were revised upwards by about 0.5 percentage points for several years between the end of 2015 and mid-2018 (Figure 8). The magnitude and the sign of revisions, of course, varies over time, countries, and estimation methodologies used.

Figure 8: Estimates of the natural interest rate in euro area from different vintages



Source: Federal Reserve Bank of New York (update on Holston, Laubach, and Williams, (2017)).

Furthermore, the estimation uncertainty within a given model is very high. Beyer and Wieland (2017) show that a 95 percent confidence band for the Laubach and Williams estimates ranges from -5 to +5 percent. Kiley (2015) tries to reduce these large confidence bands by including prior information in a Bayesian estimation framework and by including additional control variables in the IS-equation like asset prices, fiscal policy measures, and credit spreads. He finds that the data provides relatively little information on the natural rate, because the co-movement of output, inflation, unemployment, and the real interest rate is too weak to yield precise natural rate estimates. Hence, the posterior estimates are very close to the prior assumption regarding the time series process for the natural interest rate. Accounting for additional control variables, in particular credit spreads, leads to a point estimate of the natural interest rate of 1.25 percent. Using a ten year forecast from a simple time series model, Hamilton et al. (2016) find a natural interest rate of 0.4 percent for the US and the world (based on 17 advanced economies) with a 90 percent confidence band ranging from about -1 to +2 percent. Further, they find that in episodes, in which the real interest rate was much lower than the post-war average of about 2 percent, it remained low only temporarily. They conclude that it is not possible to seriously pin down a point estimate of the natural interest rate, that there is no evidence for permanently lower real rates, and that plausible ranges of values for the natural interest rate range from a little above zero up to 2 percent.

The approach by Laubach and Williams relies on a semi-structural model that links unobservable trends and cycles to the data. The discussion above shows that the results are highly uncertain and depend crucially on the model assumptions. Lubik and Matthes (2015) use an alternative approach based on a Vector Autoregression (VAR) that captures dynamic correlations among all considered variables (output growth, inflation, and the real interest rate) without imposing coefficient restrictions from theory. To account for secular changes over time, Lubik and Matthes allow for time-variation in the parameters of the model. To obtain an estimate for the natural interest rate, Lubik and Matthes use the estimated VAR and compute a five-year forecast for the real interest rate. This forecast is interpreted as a measure of the natural interest rate. The rationale is that the natural interest rate reflects a stable price equilibrium towards which the real interest rate eventually moves after cyclical factors have faded out. They assume that over a five-year horizon the real interest rate converges to its natural counterpart. Similar to Laubach and Williams, they find a secular decline in the natural rate over the last decades. However, their point estimate is 0.5 percent in 2015, so about 50 basis points higher than the one by Laubach and Williams. The uncertainty around the point estimate is similarly high as in the model by Laubach and Williams. A 90 percent confidence band ranges from about -2 to about +3 percent.

### 3.1.3. Estimates of long-run equilibrium rates

Del Negro et al. (2017) and Wieland and Wolters (2018) use fully theory-based macroeconomic models to estimate the long-run equilibrium rate. In contrast to the medium-term horizon of the semi-structural approaches discussed above, their natural rate estimates refer to a long-run concept of 20 to 30 years. The models used are Dynamic Stochastic General Equilibrium (DSGE) models as used by central banks for policy simulations and forecasting. The equations are derived from microeconomic optimization problems of households and firms, so that all variables and parameters have a clear structural meaning. The models are estimated using Bayesian estimation methods.

Both studies find a decline in the natural interest rate since the early 1990s. However, the size of the decline is larger in the Del Negro et al. study leading to current estimates of the natural interest rate for the US between 1 and 1.5 percent, while the ones of Wieland and Wolters are currently about 2 percent. The difference between the two studies can be traced back to differences in the definition of the natural interest rate and related methodological differences regarding its measurement. Wieland and Wolters estimate the model-implied steady state real interest rate. In order to account for slow-moving structural changes, they estimate the model based on a rolling window of 80 quarterly observations, i.e. of 20 years of data. Hence, their steady state concept refers to a situation in which all shocks including those that have highly persistent effects have faded out. Del Negro et al. compute at each point in time 20- and 30-year forecasts of the real interest rate, which they use as a measure of the long-run natural interest rate. Due to highly persistent shock processes that have not faded out after 20 or 30 years, they find time-variation in the natural interest rate. The natural rate estimates 0.5-1 percentage points lower than in Wieland and Wolters can be explained by an increased preference of investors for safe and liquid short-term assets, called the convenience yield by Del Negro et al. This shift in preferences is so persistent that it lowers the forecast-based natural rate estimates in the Del Negro et al. study. Wieland and Wolters focus instead on steady state measures, i.e. they measure the natural interest rate after all shocks have faded out including the highly persistent convenience yield shocks.

### 3.1.4. Using natural rates for policy discussions

Overall, it turns out that it is not possible to pin down the natural interest rate with a sufficiently high degree of precision. All studies find that the natural rate has decreased over the last two decades, but the size of the decline differs widely across studies (Table 1). Recent estimates for the US vary

between 0 and 2 percent with the influential Laubach and Williams estimates marking the lower bound. However, uncertainty bands are very large and estimates vary depending on the precise concept of the natural interest rate used, being lower for medium-term and somewhat higher for long-term concepts. Further, data revisions and data becoming available in the future might lead to substantial revisions of current estimates of the natural interest rate. Such uncertainty is particularly high at the sample end where it is difficult to distinguish cyclical dynamics and trend changes in real-time. Hence, it is uncertain whether the natural interest rate has declined substantially or whether recent low estimates will be revised upwards in the future (see, Hamilton et al., 2016, for a discussion that periods of real interest rates being below 2 percent have turned out to be temporary in the past). Finally, most of the literature focusses on natural rate measures related to short-term safe US assets. For these, specific aspects like a global increase in the demand for safe and liquid short-term assets since the Great Recession might be relevant leading to particularly low natural rate estimates.

Overall, natural rate estimates are of limited use in policy discussions (Clark and Kozicki 2005). Rather than relying on point estimates, policy should take into account imprecision in estimates (Orphanides and Williams 2007).

Table 1: Ranges of U.S. natural rate estimates

Study	Latest estimates	Uncertainty	Drop since late 1990s
Laubach and Williams (2016)	0.14% (2018, Q1)	-5%,+5% (95% band, Beyer and Wieland, 2017)	3%
Lubik and Matthes (2015)	0.5% (2015, Q2)	-1.5%,1.5% (90% band)	1.5%
Kiley (2015)	1.25% (2014, Q4)	0.4%,2.1% (68% band)	0.6%
Del Negro et al. (2017)	1-1.5% (2016, Q3)	0.6%,1.8% (68% band)	0.7%-1.2%
Wieland and Wolters (2018)	1.2-2.2% (2017, Q1)	0.9%,4% (95% band)	1%-2%

### 3.2. Factors behind the natural interest rate

Several factors that are associated with desired savings and desired investment can influence the level of the natural interest rate. Most frequently, the natural rate is related to potential output growth or productivity growth. Lower potential output growth (or expected consumption growth) is associated with a lower natural interest rate as investment tends to become less attractive due to lower returns on investment and as private households according to the Euler-equation tend to increase their savings to smooth consumption. The more economies are financially integrated the more global factors can have an effect on the natural interest rate. For example, Bernanke (2005) and Greenspan (2005) argue that with increasing financial integration a savings glut due to high desired savings in emerging economies has contributed to the decline in real interest rates in advanced economies. However, with increasing international financial integration international investment opportunities are increasing as well so that the impact on the natural interest rate is ambiguous. International financial integration has also led to an increase in the effective demand for safe assets, which are typically supplied by advanced economies (e.g. US government bonds), and thereby may have reduced risk-free rates (Caballero et al. 2017). Furthermore, demographic factors can influence



the natural interest rate. For example, a decline in the old-age dependency ratio could increase the propensity to save and thereby lower the natural interest rate. However, if a decline in the old-age dependency ratio is associated with an increase in population growth returns on investment (or the marginal product of capital) may also increase, leading to higher desired investment and thus putting upward pressure on the natural rate (Carvalho et al. 2016). Another factor that has been discussed in the literature is the downward trending relative price of investment goods implying that a declining investment share in GDP is sufficient to reach the same production path (IMF 2014). Other factors that have been discussed include a lack of investment opportunities (Gordon 2012), shifts in inequality that impact desired savings (Eggertsson et al. 2017), or shifts in risk premia that influence desired investment (CEA 2015). Recently, it has been argued that monetary policy could also be a factor influencing the natural rate, as the monetary regime may have an impact on natural interest rates (Borio et al. 2017).

The question to what extent these factors have contributed to fluctuations in the natural interest rate is very difficult to address. First, many of the potential factors are interdependent, making it difficult to identify their individual impact. Second, estimates of the natural interest rate are subject to high uncertainty indicating that the data are not very informative for identifying natural rates and suggesting that they will not be very informative as well for identifying the contributions of different factors. Third, the impact of these factors may vary over time and could be non-linear. Many studies that evaluate the impact of these factors are based on narrative approaches or calibrated theoretical models. Empirical studies are usually focussing only on one single factor. One exception is Borio et al. (2017) who analyse the impact of several factors at the same time (GDP growth, demographic factors, relative price of capital goods, inequality).

The results in the literature are mixed. The CEA (2015) concludes that lower potential output growth, demographic factors, and the global saving glut have contributed to a decline in the natural interest rate in addition to transitory factors. The IMF (2014) stresses the importance of the global savings glut, higher demand for safe assets, and the decline in relative prices of investment goods as well as a decline in investment profitability. However, Gomme et al. (2015) find that both returns on investment as well as investment volumes are not particularly low in the US. Also in other countries, such as Germany, equity and other investment returns have not strongly declined (Deutsche Bundesbank 2017). The fact that expected equity returns did not follow the decline of "safe" asset returns indicates that it is not a lack of investment opportunities, as suggested, e.g., by the secular stagnation hypothesis, that is behind the decline in natural interest rate but rather increased risk-premia due to a shift of demand towards safe assets. In this regard, Del Negro et al. (2018) find that the higher demand for safe assets in addition to lower productivity growth is an important factor behind the decline in their natural interest rate estimates. However, it is very difficult to establish a robust long-run link between one of these factors and the natural interest rate (Borio et al. 2017). Overall, the decline in potential growth and a stronger demand for safe assets related to a savings glut and demographic change seem to be important driver behind the decline in the natural interest rate in the last decades. While some of these factors are more likely to stay in place (lower potential output growth) others are more transitory or could reverse and put upward pressure on the natural rate (e.g., higher savings due to demographic change) in the future, even though it is difficult to anticipate when these effects will set in.



## 4. IMPLICATIONS FOR MONETARY POLICY

Potential growth and the natural interest rate have declined over the past decades. At the same time, there is a high uncertainty about the level of potential output and the natural interest rate. While recently potential growth and the natural interest rate have recovered somewhat according to most estimates, it is questionable whether they will reach levels perceived some decades ago. All of this has important implications for monetary policy.

A lower natural interest rate makes the conduct of monetary policy more difficult because it increases the likelihood that the Zero or Effective Lower Bound (ELB) will become binding more often in the future. Because there is always the alternative of holding zero-yielding cash, the central bank cannot reduce nominal interest rates far below zero. The ELB can therefore restrict conventional interest rate policy so that the central bank may undershoot its inflation target. In such a situation, a central bank may turn to unconventional measures such as forward guidance (in particular the promise to keep interest rates lower than otherwise expected for an extended period of time) and outright asset purchases.<sup>10</sup> However, there is a debate in the literature on how effective unconventional monetary policy is. Wu and Xia (2016) as well as Debortoli et al. (2018), using VAR models, find that there was no structural change in the Federal Reserve's ability to affect economic activity between the period before and after the Lower Bound became binding. However, Hamilton and Wu (2012) conclude that very large asset purchases may be necessary to achieve modest effects. Overall, estimates of the impact of an asset purchase programme (scaled to one trillion dollars) on inflation in the US range from zero to four percentage points across studies. On average, the peak effect (excluding one outlier) is estimated to be 0.5 percentage points. There are fewer studies for the euro area, but they also exhibit a sizeable range of estimates (cf. Fiedler et al. 2016 for an overview). Thus, very large asset purchase programmes may be required to reach a particular increase in inflation, which may not always be feasible. For example, the Eurosystem already holds close to 25 percent of all euro area government bonds making it, thus, increasingly difficult to further expand the balance sheet, especially if the balance sheet has not been reduced before the next period, in which the ECB would like to conduct expansionary monetary policy. Moreover, the impact might vary over time – unconventional measures could be effective in times of acute financial stress but less so otherwise (Borio and Hofmann 2017). There is evidence that unconventional monetary policy can be particularly effective during acute crisis phases where uncertainty, financial stress, and credit constraints are elevated, but that afterwards financial imbalances built up before the crisis impairs important transmission channels of monetary policy (Hesse et al. 2018). At the same time, unconventional monetary policy can have considerable side effects, such as distributional effects, creating financial imbalances, triggering non-productive investment, or the so-called zombification of firms (continuing provision of credit to non-creditworthy firms). Against this backdrop, it has become more likely that central banks will undershoot their inflation targets for extended periods of time and that attempts to fine-tune inflation can be associated with considerable costs (Eichenbaum 2017).

Propositions to deal with these challenges include adjusting or changing the flexible inflation-targeting framework of monetary policy within which many central banks operate. One prominent proposition is to increase inflation targets (Blanchard et al. 2010; Ball 2014). The idea behind is that higher inflation will increase the spread between nominal and real interest rates, allowing the central bank to push real rates further below zero to provide more stimulus to the economy. However, a higher inflation rate would also increase the costs of inflation (including relative price distortions,

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<sup>10</sup> In practise, it is sometimes difficult to neatly distinguish different types of unconventional policies. For example, large-scale asset purchase programmes could be seen as a form of forward guidance because they provide a commitment for the central bank to keep interest rates low for an extended period of time.

menu and shoe leather costs, the distortions due to taxation of nominal returns, etc.). Moreover, raising the inflation target could be ineffective or lead to a loss of central bank credibility and de-anchoring of expectations (Laubach and Williams 2015). This may be of particular concern as central banks have undershoot their inflation targets for a longer period in many advanced economies after the Global Financial Crisis and it is not obvious that they could reach a higher inflation target in a reasonable amount of time.

In addition, the high uncertainty surrounding estimates of potential output and the natural interest rate makes it more difficult for central banks to reach their targets. This suggests that central banks should put less weight on estimates of potential output (Ehrmann and Smets 2003, Smets 2002) and the natural interest rate (Hamilton et al. 2016) and more weight on incoming data on inflation or other business cycle indicators. More generally, policy rules more robust to measurement errors regarding potential output or the natural interest rate are preferable when estimation uncertainty is high (Laubach and Williams 2015). In this regard, it is also important that there is some uncertainty whether standard estimates of the natural interest rate capture all relevant information. For example, estimates which take the financial cycle into account result in substantially higher estimates of the natural rate (Juselius et al. 2017).

Beyond uncertainty about potential output and the natural interest rate, central banks are facing several additional challenges that make it more difficult for monetary policy to reach its targets. First, the Philips curve relationship, which describes how inflation reacts to changes in the output gap, has apparently weakened (BIS 2017, IMF 2013, Blanchard et al. 2015, Lodge and Mikolajun 2016). As monetary policy usually tries to influence inflation via engineering changes in the output gap, this weaker relationship makes it more difficult for central banks to reach their inflation targets within the same time-frame as in the past. One reason for this weaker relationship might be that inflation expectations are better anchored due to a high credibility of central banks so that inflation reacts less sensitive to changes in the output gap (Bernanke 2010, IMF 2013).<sup>11</sup> If this were the main driver of the weaker Phillips curve relationship it would not be a major concern of central banks. However, following the Global Financial Crisis, central banks in many advanced economies apparently had problems to hold inflation close to their targets indicating that well-anchored inflation expectations and a high credibility of central banks are not sufficient conditions to keep inflation close to target.

Second, the impact of monetary policy on the output gap seems to be state-dependent and to vary over time making it more difficult for central banks to conduct a monetary policy that stabilizes the output gap and in turn inflation. There is increasing evidence that expansionary monetary policy was particularly effective during the acute phase of the Global Financial Crisis (Ciccarelli et al. 2013, Dahlhaus 2017, Janssen et al. 2018) but less effective subsequently in the recovery phase (Bech et al. 2014, Borio and Zbair 2016, Janssen et al. 2018). Reasons for this could be that expansionary monetary policy helped to mitigate the high uncertainty during the acute phase of the Global Financial Crisis while afterwards the high indebtedness of private households and the boom in the housing markets preceding the crisis made monetary transmission via the credit channel and the housing market less effective.

Third, there is increasing evidence that monetary policy can have negative side-effects that harm the economy. Expansionary monetary policy leads to increasing risk-taking and thereby may lead to financial imbalances that undermine financial stability (Drehmann et al. 2012, Rajan 2005, Maddaloni and Peydro 2011). Moreover, expansionary monetary policy can contribute to the misallocation of resources. Cetto et al. (2016) show empirically that a decline in the real interest rate is associated with

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<sup>11</sup> Other factors behind the weaker Phillips curve relationship that have been discussed in the literature are globalization and digitalization. For a discussion, see e.g. Fiedler et al. (2018).

a significant decline in productivity. Furthermore, expansionary monetary policy can contribute to the so-called “Zombification” of firms and banks, a process where firms which are not creditworthy receive further funding because banks want to avoid writing down existing loans to these firms. This phenomenon has been observed in Japan (Caballero et al. 2008, Hoshi and Kashyap 2004). In the euro area, the windfall profits for banks in the peripheral countries due to the OMT announcement have mainly led to an increase of loans to firms with below than average credit servicing ability (Acharya et al. 2015). These firms did not use the additional funding for investment or job creation so that even in the short-run no stimulating effects for the economy have taken place. Finally, expansionary monetary policy, in particular in the euro area, may provide disincentives for structural reforms or financial consolidation of governments’ budget balances, e.g. because it lowers government bond yields. While these risks may be limited if monetary policy is expansionary only for some years, these risks could increase when monetary policy is expansionary for extended periods of time.

## 5. CONCLUSIONS

Overall, central banks are facing several challenges at the current juncture. Given that estimates of potential output and the natural interest rate are subject to high uncertainty and large revisions, central banks should put less weight on these estimates and put a higher weight on incoming data on inflation as well as other business cycle indicators and allow for more inertia in adjusting their monetary policy. There is also increasing evidence that the relationship between the output gap and inflation has weakened and that it therefore has become more difficult for monetary policy to control inflation. Moreover, there is evidence that monetary policy is less effective in the aftermath of financial crises compared to non-crisis times. As additionally, the sluggish recovery following the Global Financial Crisis was in line with historical experiences of other financial crises, it is not obvious whether a low natural interest rate (or not sufficiently expansionary monetary policy) was an important factor behind this sluggish recovery. To the extent that the natural rate has declined, monetary policy will more frequently hit the Effective Lower Bound in the future. There are concerns that unconventional monetary policy is less effective and has negative side effects, especially if it is in place for long periods of time. This implies that central banks may have to accept deviations from their inflation targets for longer periods than in the past.

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The recovery from the Global Financial Crisis was characterized by sluggish output growth and by inflation remaining persistently below the inflation targets of central banks in many advanced economies despite an unprecedented monetary expansion. Ten years after the Global Financial Crisis, GDP remains below its pre-crisis trend in many economies and interest rates continue to be very low worldwide. This raises the question of whether low GDP growth and low interest rates are a temporary phenomenon or are due to a decline in long-run growth prospects (potential output growth) and equilibrium real interest rates (natural interest rate). In this paper, we address this for central banks very important question and discuss implications for monetary policy.

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