Measuring the Natural Rate of Interest in the Eurozone: A DSGE Perspective

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Short-term and long-term interest rates are very low by historical standards both in the Eurozone and in other advanced economies. Low interest rates are not a temporary phenomenon, but part of a longer-term tendency – a declining trend that started to take shape prior to the recent global financial crisis and the worldwide recession that followed. Figure 1 shows that ten-year aggregated government bond yields in the Eurozone reached a peak in the early 1980s that was unmatched in the preceding decade, and have been declining with some interruptions ever since. Fluctuations in inflation, as shown in Figure 1, only partly explain this pattern. Since mid-2014, in view of the far more moderate than expected economic dynamic and decreasing inflation expectations, several central banks, including the European Central Bank (ECB) and the Bank of Japan, have implemented negative interest rates. Questions of whether central banks have excessively lowered the target for their benchmark short-term interest rates, whether they need to cut them any further, or, in the case of the Federal Reserve, how to increase the federal funds rate swiftly are top priorities for policymakers and academicians.

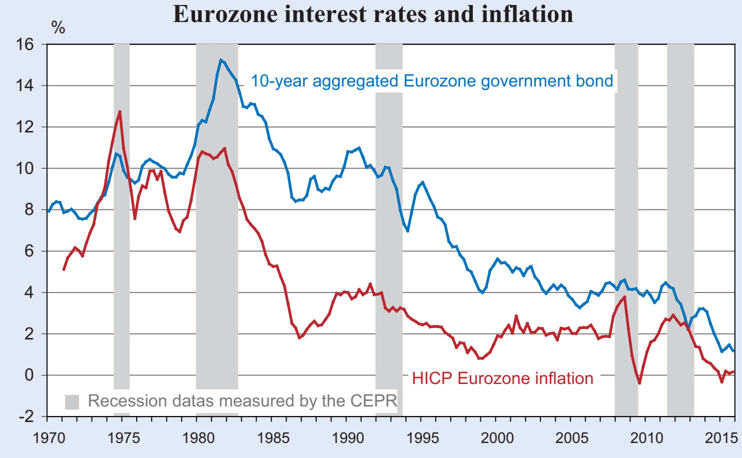
While central banks steer the short-term nominal interest rates, as many economists point out, in the long run rates are beyond the control of monetary policy (Bernanke 2015). All other things being equal, a monetary policy of lowering short-term rates tends to boost economic activity and, in turn, lift inflation and inflation expectations; and *vice versa.* The level at which rates must settle in due course to keep inflation stable over an extended period of time is determined by the economy's underlying characteristics. More specifically, a long list of factors, including households' preferences for present as opposed to future consumption and the economy's potential for growth, establish the real (that is, inflation-adjusted) interest rate. According to a concept introduced in 1898 by Knut Wicksell and fully integrated in modern macroeconomic theory by Michael Woodford (Woodford 2003), this long-term rate is where the real interest rate settles if inflation were at target and the economy were at maximum employment. This concept is known as the *natural, equilibrium, or Wicksellian* rate of interest.

The natural rate of interest is one of the central concepts to understanding the effects of monetary policy and macroeconomic relationships. It presents an important benchmark, consistent with the concept of potential output, as to whether policy is too tight or too loose: interest rates above the natural rate tend to lower inflation, and vice versa. For central bankers the goal is to direct interest rates so that they match up with the natural rate.

This article asks where the real natural rate of interest in the Eurozone currently lies? In its bid to answer this

Figure 1

Eurozone interest rates and inflation



Sources: Eurostat; Area Wide Model dataset for the euro area; Center for Economic Policy Research (CEPR).

* Ifo Institute. I am grateful to Tim Oliver Berg and Timo Wollmershäuser for their helpful discussions and comments.

question, the article builds on the well-known empirical framework by Smets and Wouters (2003 and 2007). Its results suggest that the natural real rate of interest in the Eurozone has gradually declined over the past 35 years and is currently very low by historical comparison. This provides some indications that, despite the fact that the ECB steered short-term rates into negative territory in mid-2014, the stance of monetary policy has remained tight since then. This, among other confounding factors, may be the reason why employment has chronically failed to reach full employment and inflation is stuck at levels far below the two percent target. Model projections for the natural rate are consistent with the expectations of many observers that key ECB interest rates will remain at their present or lower levels for an extended period of time, and well past the year 2017. However, given the model uncertainty involved in the analysis, it is unclear exactly how long the return to positive territory will take.

Estimation of the real natural rate of interest

Despite the importance of the natural rate of interest, using it to guide monetary policy decisions is highly problematic due to the fact that the natural rate is an unobservable variable, which limits its practicality as a gauge for measuring and tuning the stance of monetary policy. To overcome this difficulty, economists have developed various empirical methods that attempt to derive the natural rate from actual data, starting from different premises.

An important contribution to the literature on measuring the natural rate is an approach proposed by Laubach and Williams (2003; henceforth LW) applied to data for the United States. The authors estimate the natural real interest rate and potential output growth simultaneously, using a small-scale macroeconomic model linking real GDP, inflation and a short-term interest rate. In this model, by construction, the gap between real and potential GDP is a function of past gaps between the real interest rate and the real natural rate. The method makes it possible to separate fluctuations in the natural rate driven by long-run developments in the economy's underlying characteristics from those caused by cyclical factors. Thus, as discussed in a recent article by the two authors (Laubach and Williams 2015), the proposed measure is best-suited to gauge the level of the natural rate *in the long run.*

More recently, a new approach to estimating the natural rate has emerged, which is based on New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) models. This approach makes it possible to estimate alternative model-based notions of the natural rate by introducing relationships among the economic variables informed by some of the latest advances in economic theory. This article builds on such an approach. As with all empirical work based on structural models, the results may be sensitive to some features of the model framework. To illustrate this point, the results across two models that differ in the specification of the financial sector are compared. The first model employed is an extension of the framework proposed by Smets and Wouters (2007; henceforth SW) for the Eurozone. The present work differs from the original Smets-Wouters model in that it introduces some important departures from the original specification, which are briefly described below.[1] The second model is obtained by introducing credit frictions in the first framework (henceforth SW-fa), using the financial accelerator mechanism proposed by Bernanke, Gertler and Gilchrist (1999). The actual implementation of the financial accelerator follows Del Negro, Giannoni and Schorfheide (2015). The latter article shows that the marriage of the New-Keynesian model with the financial accelerator provides a reasonable explanation for the evolution of inflation in the wake of the recent global financial crisis and the subsequent tightening of financing conditions.

In contrast to the LW approach, the DSGE method tends to focus *on the short-run* fluctuations in the natural rate, taking the long-run value as constant. In the latter approach, the real natural rate is the inflation-adjusted rate of interest that would prevail after wages and prices adjust to drive economic activity to its most efficient level, making full use of all available resources. In other words, the natural rate is the rate that would prevail in the real-business cycle model that lies behind the sticky-wage-price model, and if there were no shocks to the mark-up on goods and labour markets, and no financial frictions. Barsky, Justiniano and Melosi (2014); Cúrdia (2015); and Del Negro, Giannoni, Cocci, Shahanaghi and Smith (2015) have used a similar definition to estimate the natural rate of interest. This short-run natural rate can fluctuate substantially over time, due to changes in its determinants – the potential growth rate of the economy, demographic characteristics of the population, consumers' impatience, etc. Notably, however, by construction the stance of monetary policy does not af-

[1] More details about the model structure, prior and posterior moments of the model parameters are available upon request.

fect the natural rate: once wages and prices have adjusted, the central bank has no meaningful role in steering economic activity to its potential.

Coming back to the two models used in this article, let us begin by introducing a slow moving inflation drift in the monetary policy rule, as compared to the original Smets-Wouters specification, whereby the central bank targets a constant inflation rate in all periods. This primarily accounts for the stability of long-run expected inflation since 2000. Secondly, due to a lack of consistent Eurozone data available on aggregate hours worked, employment data is used in the estimation instead. As a result, following Smets and Wouters (2003), an additional equation is introduced into the model, which defines how volatile fluctuations in total hours worked translate into more persistent changes in employment. Thirdly, the model substitutes the transitory technology shocks in the original Smets-Wouters framework with permanent shocks in technology. The permanent technology then follows an AR(1) in growth rates in technology. This makes it possible to capture secular stagnation, as discussed in Summers (2014). According to the supply-side secular stagnation hypothesis (Gordon 2015), following the recent financial crisis the failure of output and employment to return to their trend levels relatively quickly may relate to a fundamental decline in the rate of productivity growth.

Both models are estimated with Bayesian techniques. The first framework, SW, uses data on real GDP, consumption, investment, employment, real wages, inflation as measured by the consumer expenditure price index, and the three-month interbank interest rate. In the estimation of the second model, SW-fa, one key additional variable is used, the spread between IBoxx's BBB corporate non-financial bond yield and the ten-year German government bond yield. The parameters of the SW model are estimated twice; firstly, using data over the period 1980:2– 2015:4 and, secondly, over the period 1999:4–2015:4, with very similar results. Due to data limitations with the credit spread, the SW-fa model is estimated over the period 1999:4–2015:4. To preserve comparability between the results from the two frameworks, the estimates obtained over the shorter sample are presented. Using this sample period has an additional advantage in that it minimises the impact of various structural breaks that may have occurred following the introduction of the euro.[2]

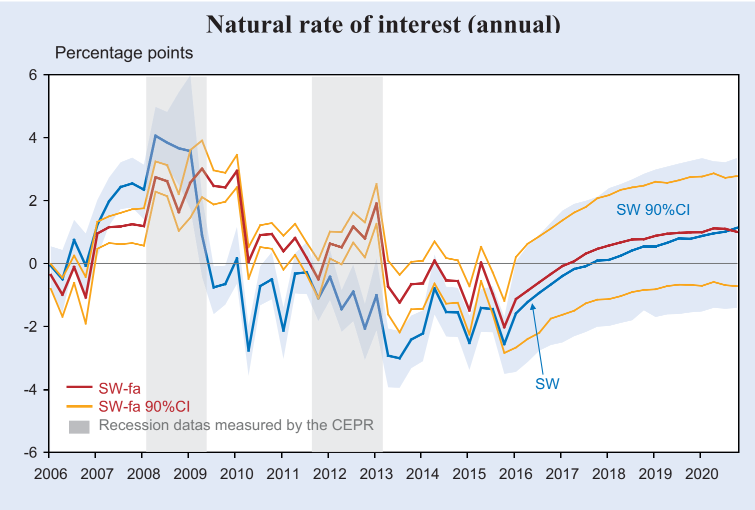
The real natural rate of interest is volatile and hard to pin down

Figure 2 presents the smoothed median measures of the natural rate of interest (on an annual basis) from the two DSGE models since 2006, along with their forecasts. The light-blue shaded areas represent the 90%-probability ranges of possible estimates from the SW model, while the area between the orange lines show the respective estimates from the SW-fa framework. Gray vertical shaded areas indicate recession dates as measured by the Center for Economic Policy Research (CEPR).

Fluctuations in the median natural rate of interest implied by the two models are of a similar order of magnitude as the volatility of the real interest rate over the estimation period. Their respective standard devia-

[2] The constraint of the zero lower bound on the policy rates has not been considered in the current estimation and will be properly dealt with in future work.

Figure 2



Notes: The solid blue line shows the median estimates of the real natural rate of interest in the extended Smets-Wouters (SW) model. The light-blue shaded region is the corresponding 90-percent confidence interval. The red solid line shows the median estimates of the real natural rate of interest in the extended Smets-Wouters model with a financial accelerator (SW-fa). The orange line represents the corresponding 90-percent confidence interval and the gray shaded areas indicate recession dates as measured by the CEPR.

Sources: Eurostat; Area Wide Model dataset for the euro area; author's calculations; Center for Economic Policy Research (CEPR).

tions are 187 and 128 basis points, compared to a standard deviation of the actual real rate of 162 basis points. The estimates, however, are surrounded by a great deal of uncertainty. The width of the 90-percent probability interval for the natural rate is about 1.5 percentage points on average and widens to 4.2 percentage points in 2009:1. The probability intervals for the forecasts are even wider, ranging from 3.8 percentage points in 2015 to 4.8 percentage points in 2020. From a practical point of view, while some policymakers are likely to consider such measures implausible, what they might find even more unpalatable is the difference between the median estimates of the natural rate from the two frameworks. Although this difference is not ‘sizeable’ over the estimation period (1.0 percentage points on average), the distance between the two measures widened to about 3.0 percentage points in 2009 and 2013, rendering estimates of the natural rates a poor guide to monetary policy.

The natural rate fell more sharply following the financial crisis according to the SW model as compared to the SW-fa model, from close to 4 percent in early 2008 to below – 2 percent in early 2010. However, both measures have remained negative since early 2013, fluctuating recently at around – 2 percent. What factors caused this sizeable fall in the natural rate?

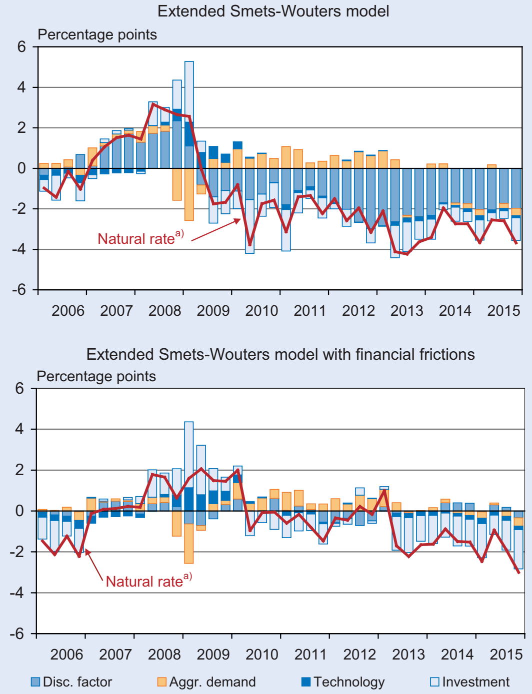
Figure 3 shows the historical contribution of each of four types of shocks (discount factor, investment-specific, aggregate demand, and technology shocks) to the evolution of the natural rate obtained by the SW and SW-fa models over the sample period in deviations from its average. The dominant source of the secular drop in the natural rate according to the SW model is driven by negative stochastic discount factor shocks (shown in blue), which capture exogenous fluctuations in consumer preferences to save and invest, as well as other not explicitly specified distortions in consumption decisions. This factor pushed up the natural rate above its sample period average by 2 percentage points in 2007/08, while it decreased the rate by over 1 percentage points in any single year since 2009. The factor’s depressive effect was felt most strongly in 2012, when it was responsible for the rate remaining below its average by 3 percentage points. By contrast, the presence of the financial accelerator mechanism in the SW-fa model reduces the importance of the discount factor shocks to the evolution of the natural rate. In the latter model, the significance of a second disturbance increases in both relative and absolute terms. This is a shock to the rate of return on capital (shown in light blue), which might be caused for example by changes in the efficiency of the investment technology. This disturbance has continuously depressed firms’ eagerness to invest since early 2010. According to the SW-fa model, this factor was solely responsible for the rate remaining below its average by 2 percentage points in 2013–2015. Other aggregate demand factors (shown in orange), such as government expenditure, lifted the natural rate by about 0.5 percentage points in 2008–2014. Since 2006, permanent changes in total factor productivity (shown in dark blue) have played a minor role in the variation in the natural rate.

The stance of monetary policy and economic activity

The *interest rate gap* is a notion closely related to the output gap: both concepts are central to the conduct of monetary (and fiscal) policy. It can be shown that deviations of the inflation-adjusted interest rate from the real natural rate – that is, the interest rate gap – are associated with deviations in output from its potential level (Justiniano, Primiceri and Tambalotti 2013). A positive interest rate gap indicates a restrictive monetary policy

Figure 3

Factors contributing to changes in the natural rate



a) The deviations of the real naturale rate of interest from its long-term average. Bars: the contribution of particular shocks to the evolution of the natural rate. The real natural rate over the sample period is estimated at 1.0 percent in both models.

Source: Eurostat; Area Wide Model dataset for the euro area; author's calculations.

stance and is associated with moderating inflationary pressures and a negative output gap. Theoretically, if policymakers manage to track the natural rate, the economy will produce at its maximum level of output without straining or idling resources – in other words, policymakers will close the output gap.

In practice, however, minimising the interest rate gap is difficult. The interest rate gap is a noisy signal of the economy's underlying characteristics: firstly, it depends on accurately gauging the natural rate, which is a latent variable, and secondly it depends on estimates of aggregate variables such as GDP that are subject to multiple revisions. To make things worse, monetary policy ability to efficiently stabilise economic activity might be considerably constrained with short-term rates being close or below the lower bound of zero percent.

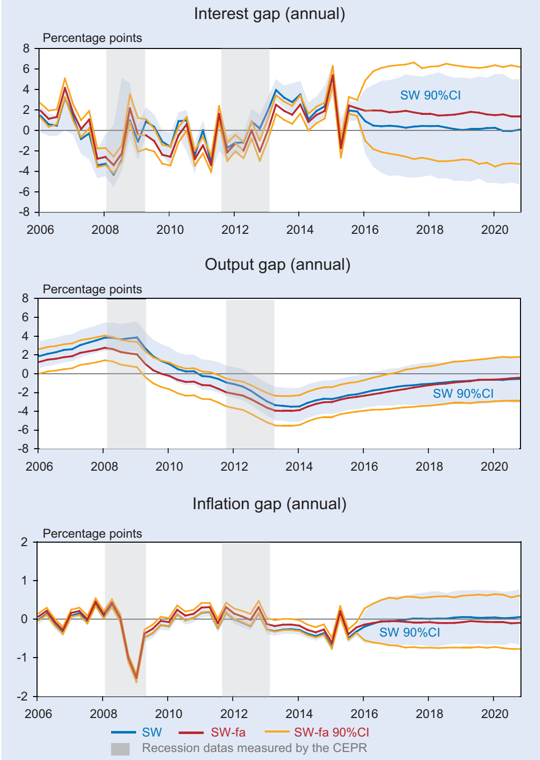
Figure 4 plots the interest rate, output, and inflation gaps obtained by the SW and SW-fa models, along with the forecasts of the gaps. Here, the inflation gap is defined as the percentage deviation of actual inflation from the estimated inflation target. Firstly it is worth noting that, like the natural rate, the interest rate gap has also fluctuated considerably over the sample period, with an average of 1.5 percentage points and a standard deviation of 190 basis points. The figure shows that the moderation in inflationary pressures in the summer of 2008, as well as the intensification of the financial crisis following the bankruptcy of Lehman Brothers, may explain why the ECB cut its policy rates so strongly in the fourth quarter of 2008, even before the output gap turned negative.[3]

Fluctuations in the interest rate gap around the zero line in 2009–2012, based on the two models, indicate that the ECB's swift and decisive reaction to deteriorating economic circumstances may have been accommodative enough to guarantee price stability over the medium term. However, the spreading of the European sovereign debt crisis beyond the periphery of the Eurozone in the second half of 2011, when yields on government bonds from Spain and Italy sharply rose, tipped the euro area back into another recession. The debt crisis had significant adverse economic and labour market effects. While the ECB managed to calm financial markets by cutting policy rates and offering unlimited support for all Eurozone countries involved in the sovereign state bailout programs in September 2012, the results suggest

[3] In fact, the output gap has an apparent tendency to significantly lag behind recessions. In other words, economic activity can often be seen to be expanding rapidly while the gap continues to be negative and sizable, and *vice versa*.

Figure 4

Interest rate, output and inflation gaps



Notes: The solid blue lines show the median estimates of the interest, output and inflation gaps in the SW model. The light-blue shaded regions are the corresponding 90-percent confidence intervals. The solid red lines show the median estimates of the interest, output and inflation gaps in the SW-fa model; The orange lines are the corresponding 90-percent confidence intervals and the gray shaded areas indicate recession dates as measured by the Center for Economic Policy Research (CEPR).

Sources: Eurostat; Area Wide Model dataset for the euro area; author's calculations; Center for Economic Policy Research (CEPR).

that the monetary stimuli were not supportive enough to prevent the interest gap from increasing. Since 2013, the recovery has been fairly slow, with output remaining below its potential and inflation falling below its target.

Both models predict a very gradual closing of the interest rate and output gaps. The gaps will close due to a slow abatement of the headwinds depressing growth, as shown in Figure 3, and the natural rate will return to pre-crisis levels in early 2018. As discussed by Cúrdia (2015), however, a DSGE model for the United States has repeatedly and incorrectly forecast the 'normalisation' of the natural rate for the past seven years. In reality, the forecasts have not materialised and the prevailing natural rate remains negative even in the fourth quarter 2015, similar to the Eurozone estimates shown here, despite the significant improvements in labour market conditions in the United States. Such an analysis presents a cautionary tale for the Eurozone prospects as well. This is also reflected in the low German harmonised 10-year bond yields – presumably an indicator of the Eurozone safe rates, which were only 0.17 basis points in March 2016. It is also consistent with the expectations of many observers that the Eurozone economy will remain depressed for many years to come.

Beyer and Wieland (2016) document that estimates of the natural rate of interest in the Eurozone obtained by the LW method dropped markedly following the global financial crisis, but never turned negative. Their results suggest that the ECB's response to the sovereign debt crisis may have been expansionary because the central bank steered the policy rates below their long-run natural levels. As pointed out by Krugman (2015), however, if monetary policy is constrained, by the lower bound on the policy rates, for instance, and given that the constraint is binding for several years, the interest rate gap may remain open for an extended period of time. In other words, in this case the long-run natural rate may be a misleading measure of the prevailing monetary policy conditions. The negative output gap in the last five years provides some support for this hypothesis.

Conclusion

This article studies the evolution of the natural rate, using two versions of Smets-Wouters model, with and without credit frictions. The estimates highlight a substantial degree of time variation in the natural rate, as well as variation between the measures from the two frameworks. The sharp fall in the natural rate provides support for the enactment of conventional and non-conventional measures to ease monetary policy. The lower bound on the policy rates may partly explain the persistently negative output gap in the last five years. Model projections for the natural rate indicate that key ECB interest rates will remain at their present or lower levels for an extended period of time, and well past the year 2017. Given the model uncertainty involved in the analysis, however, it remains unclear exactly how long the return to positive territory will take.

Many explanations for the low natural rate and the anemic recovery in many advanced economies following the Great Recession have been put forward. The trend towards a decline in the natural rate can partly be blamed on global factors, such as fewer investment opportunities in advanced economies as well as a higher propensity to save in emerging markets (Bernanke 2007). These factors are not explicitly modelled in the current analysis. It could also reflect secular stagnation, as argued by Summers (2014), whereby deleveraging by households and contractionary fiscal policy have helped to significantly weaken global demand. On the other hand, it could also reflect permanently lower growth rates in productivity (Gordon 2015). Such long-run effects are also hard to analyse using the current methodology. Some of these issues will be dealt with in future work.

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