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Two Tales of the Natural Rate of Interest

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Abstract

We estimate the long-term natural rate of interest for the euro area with two specifications of a simple semi-structural macroeconomic model. The estimates provide competing interpretations for the euro area's current economic environment of weak growth, subdued inflation and exceptionally low nominal interest rates. In our first estimation, the current state of economy is attributed to persistent, recurring negative shocks to the output gap that restrain growth even when expansionary monetary policies are applied. The second estimation suggests that a large drop in the natural rate of interest is the problem, because, even with interest rates held close to zero, policy actions have not been able to revive the economy after major shocks in 2008, 2012 and 2016. As both views may explain some of the observed trends, the task of teasing out the drivers of current conditions and future trends is non-trivial. Nevertheless, policymakers should pay attention to both stories as they have quite different endings.

JEL codes: C32, E43, E52, O40
Keywords: euro area monetary policy, natural rate of interest

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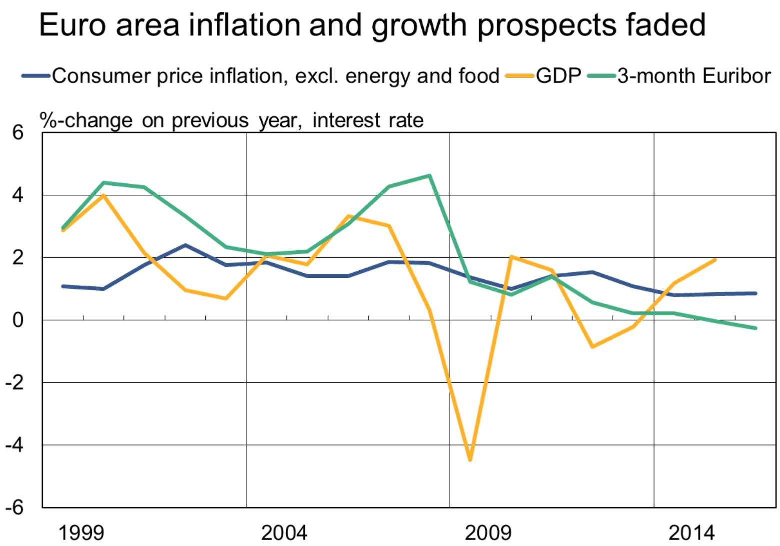
1. Old idea, new relevance

As in most advanced economies, interest rates have been exceptionally low in the euro area for years. Yet even with a prolonged period of low interest rates, inflation pressures remain subdued, economic growth in the euro area remains sluggish and the output gap has remained negative (Chart 1). One explanation why monetary policy has not been able to stimulate the economy as expected is that the equilibrium real interest rate, i.e. the natural rate of interest has fallen. The concept of a natural rate of interest was introduced in 1898 by the Swedish economist Knut Wicksell, who defined it as the neutral interest rate that has no impact on price levels. Nowadays, the natural rate of interest is usually interpreted as the real interest rate that brings the economy into equilibrium where the economy is at its full employment equilibrium, the output is at its potential level and the inflation is stable. Analyses of the natural rate of interest typically focus on the level of, and changes in, the risk-free short-term, e.g. 3-month, real interest rate.

Chart 1. Euro area inflation and growth prospects have faded



Source: Macrobond, Eurostat and EBF.
32403@Chart9

In this article, we estimate a long-term natural rate of interest for the euro area with two slightly differing sets of assumptions related to the model specifications. Previously Holston, Laubach and Williams (2016) have estimated the long-term natural rate of interest for the euro area. They find that the rate has fallen into negative territory. We study how sensitive the estimates of the natural rate of interest are to modelling and estimation assumptions. Particularly, we allow persistent, autoregressive shocks to output gap and set lower volatility in the Bayesian prior distribution for shocks to the natural rate of interest.

We find that these small modelling differences change the results significantly. They turn the estimates of current level of the natural rate of interest to positive territory and according to these results the rate would have fallen only by around one percentage point since the beginning of the financial crisis. Instead, the assumptions closer to Holston, Laubach and Williams (2016) lead to negative natural rate estimates, and indicate above 2 percentage points fall in the natural rate of interest. Thus, our estimation results suggest that even small differences in the assumptions can lead to contradictory explanations for the current gradually narrowing output gaps, subdued inflation and low interest rates. One interpretation attributes them to cyclical but still persistent and recurring negative shocks to the output gap. The other suggests that the structural changes in the economy have reduced the natural rate of interest, and are largely explaining current economic conditions.

Other estimation methods for the natural rate of interest point also to low (even negative) levels for the natural rate of interest. ECB vice president Vitor Constâncio, reviewing various estimates of the natural rate of interest, recently suggested that the natural interest rate level in the euro area has declined from a pre-crisis level of 1–2 % to somewhere between -2 % and 0 %, depending on the method applied.[1]

Several interpretations of the natural rate of interest have been suggested. Therefore, different estimation results should be compared with caution. We follow the definition of Laubach and Williams (2003) who define it as the interest rate that would prevail in the economy in the absence of shocks. Under this view, the economy ultimately stabilises at the level of the natural rate of interest, even if it may take up to a decade to do so. This definition of the natural rate of interest can, in fact, be regarded as a long-run approach. In contrast, general equilibrium models define the natural rate of interest as the interest rate needed to close the output gap in the absence of nominal rigidities in the economy.[2] Under this definition, the natural rate of interest is in constant flux as it reacts to the business cycle and other factors.

Even if the natural rate of interest leads to the closing of the output gap and stable inflation over the long term, it is not, however, the interest rate level consistent with the objective of monetary policy over the short term. This is because the link between the output gap and inflation may change over time, for example as a result of cost shocks impacting price setting, prices responding slowly to changes or several different rigidities in the real economy (such as those relating to the labour market or investments). The closing of the output gap would then be insufficient to restore desired rates of inflation, and the interest rate set for monetary policy purposes must be different from the both short- and long-term natural rate of interest.

Rest of the paper is organized as follows. The Chapter 2 describes the estimation method and presents the results. The Chapter 3 discusses the model of the natural rate of interest in a more structural setting and Chapter 4 reviews the economic factors that may explain the estimation results and that may be responsible for the current economic state of negative output gaps, subdued inflation and very low interest rates. Finally, Chapter 5 concludes.

2. A lower natural rate of interest for the euro area

Since there is no standardised way of estimating the natural rate of interest, analysis of the natural rate of interest and its deployment as a measure of the state of monetary policy incorporate a considerable degree of uncertainty. With the interest rate prevailing at its natural level, however, the output gap should close over time. It is therefore possible to measure the level of the natural rate of interest if the output gap and the impact of an interest rate change thereon are known.[3] Our approach follows Laubach and Williams (2003) who seek to gauge the long-term natural rate of interest by making use of the Kalman filter in the context of a simple macroeconomic model estimation.

2.1. Model description

We estimate the euro area natural rate of interest for two versions of the Laubach and Williams model. Each specification provides a snapshot of the current level of the natural rate and the monetary stance.[4]

The backbone of the model is a reduced-form IS equation, where the output gap, $\hat{y}_t$, is determined by its own lags, a moving average of the lagged real funds rate gap $\hat{\imath}_{t-1} - \bar{\imath}_{t-1}$ (difference between short-term EONIA rate and the natural interest rate, $\bar{\imath}_t$, minus expected inflation), and an error term:

$$\hat{y}_t = \beta_1 \hat{y}_{t-1} - \beta_2(\hat{\imath}_{t-1} + \hat{\imath}_{t-2} - \bar{\imath}_{t-1} - \bar{\imath}_{t-2}) + e_t. \quad (1)$$

[1] *Constâncio (2016).*

[2] *See e.g. Curdia (2015), Justiniano & Primiceri (2010) or Woodford (2003).*

[3] *There are significant challenges, on the other hand, associated with estimating the output gap (see e.g. ECB (2005).[4]The estimated assessment of the natural rate of interest is conditional on the estimated assessment of the output gap.*

[4] *The estimated assessment of the natural rate of interest is conditional on the estimated assessment of the output gap.*

Unlike the original Laubach and Williams model, we allow the error term to follow a moving average process with a serially uncorrelated shock, $e_t = \beta_3 e_{t-1} + \epsilon_t^{\hat{y}}$. This is motivated by the fact that certain types of shocks can have considerable persistence. Smets and Wouters (2003), for example, estimate the autoregressive parameter of productivity and preference shocks in the euro area to be 0.81 and 0.84, respectively.

Inflation, π_t, in the model is determined with a backward-looking Phillips curve, where the lags of inflation and output gap determine current inflation:

$$\pi_t = (1 - \alpha_1)\gamma_1 + \gamma_2 \pi_{t-1} + \gamma_3 \hat{y}_{t-1} + \epsilon_t^{\pi}. \qquad (2)$$

Based on the standard consumption Euler equation from the household intertemporal utility maximization natural rate of interest can be written as

$$\bar{\iota}_t = z_t + \gamma_4 4(\bar{y}_t - \bar{y}_{t-1}) + \epsilon_t^{\bar{\iota}}, \qquad (3)$$

where the growth rate of potential output and other elements (a "z-factor") determine the rate. The z-factor is assumed to follow an autoregressive process $z_t = \alpha_1 z_{t-1} + \epsilon_t^{z}$. Following Laubach and Williams (2003), we set the coefficient γ_4 to unity. In a more structural setting, γ_4 can be interpreted as an inverse of the intertemporal elasticity of substitution and is often set to unity in standard models (see e.g. Christiano, Eichenbaum and Evans (2005)). Both the actual ex-ante real interest rate and the growth rate of potential output are subject to serially uncorrelated errors:

$$i_t = i_{t-1} + \epsilon_t^{i} \text{ and} \qquad (4)$$

$$\bar{y}_t = 2\bar{y}_{t-1} - \bar{y}_{t-2} + \epsilon_t^{\bar{y}}. \qquad (5)$$

Finally, GDP is the sum of its potential level and the output gap, i.e. $y_t = \hat{y}_t + \bar{y}_t$. All error terms ϵ_t are serially uncorrelated with variance σ.

The model is estimated with Bayesian methods. The use of priors mitigates the pile-up problem that prevents the efficient estimation of some parameters. As Stock (1994) explains the estimated variances of the standard deviation of the shocks to unobserved variances are biased to be estimated to precisely zero. The priors for $\sigma^{\epsilon^{\bar{y}}}$ and $\sigma^{\epsilon^{\hat{y}}}$ are set such that posterior relative variance of output gap and potential growth (i.e. $\frac{Variance(\hat{y}_t)}{Variance(\bar{y}_t - \bar{y}_{t-1})}$ is close to the corresponding value of a standard Hodrick-Prescott filtering of quarterly business cycle models.

2.2. The Data

We use seasonally adjusted quarterly euro area data from 1999Q1 to 2016 Q4. Inflation is the annualised first difference of the seasonally adjusted log CPI (excludes food and energy prices), while inflation expectations for the calculation of real interest rates are the one-year-forward inflation expectation reported in the ECB's SPF survey (ECB (2016)). The measure of inflation expectation differs from the measures used by Laubach and Williams (2003) or Holston, Laubach and Williams (2016), who assume an autoregressive process for expectations. Our short-term interest rate is the 3-month EONIA rate. The GDP data are seasonally adjusted real GDP in logs.

2.3. Estimation results

We estimate the model with two slightly different assumptions to expand the discussion of the drivers of current economic situation of low growth, high unemployment and weak inflation rates. This slight modification highlights the extreme sensitivity of estimates of the natural rate of interest, producing two distinct narratives on the state of euro area economy and natural rate of interest. The priors for the estimation procedure are listed in Table 1.

Specification 1 allows shocks to output gap be very persistent. In Specification 2, the persistency parameter β_3 is set equal to zero following Laubach and Williams (2003) and Holston, Laubach and Williams (2016). Shocks to the natural rate of interest via the z-factor are assumed to be minor in Specification 1, i.e. σ^z is set to a small number in the prior distribution. The standard deviation of the shocks to the z-factor in the priors of Specification 2 is set three times larger than in Specification 1.

The posterior parameter estimates are relatively similar for both specifications. They are also economically reasonable, although parameter estimates of β_2 and γ_3 are somewhat larger than the corresponding estimates of Holston, Laubach and Williams (2016) for the euro area. Lower interest rates have expansionary impacts on output with some lag, and lagged positive output gap adds to inflationary pressure.

Table 1. Parameter estimates

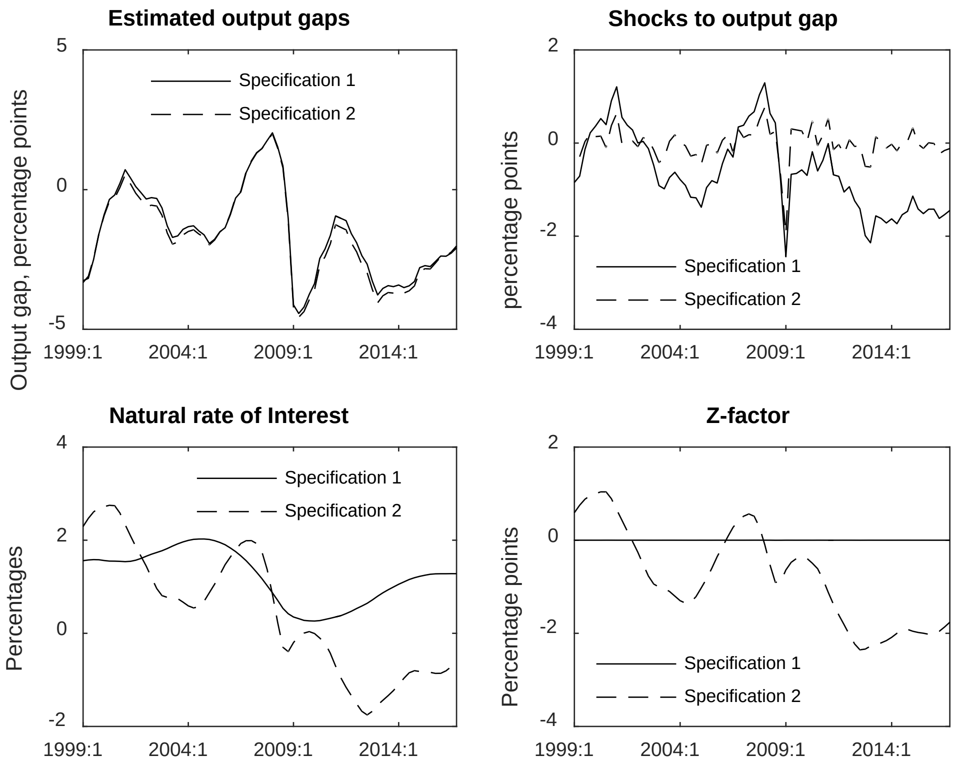
	Specification 1					Specification 2				
	Prior distribution			Posterior distribution		Prior distribution			Posterior distribution	
	Type	Mean	Sd	Mean	10% / 90%	Type	Mean	Sd	Mean	10 % / 90%
β_1	Gamma	0.8	0.1	0.80	0.70 / 0.91	Gamma	0.8	0.1	0.97	0.90 / 0.98
β_2	Gamma	0.3	0.1	0.22	0.14 / 0.30	Gamma	0.3	0.1	0.22	0.09 / 0.29
β_3	Gamma	0.95	0.2	0.91	0.80 / 0.96					
γ_1	Gamma	2	0.2	1.94	1.70 / 2.20	Gamma	2	0.2	1.97	1.70 / 2.21
γ_2	Gamma	0.5	0.2	0.25	0.17 / 0.37	Gamma	0.5	0.2	0.27	0.18 / 0.40
γ_3	Gamma	0.8	0.1	0.27	0.23 / 0.31	Gamma	0.8	0.1	0.25	0.23 / 0.31
α_1	Gamma	0.6	0.2	0.53	0.36 / 0.82	Gamma	0.6	0.2	0.94	0.61 / 0.98
σ^π	Inv. Gamma	1	0.1	1.06	0.98 / 1.23	Inv. Gamma	1	0.1	1.14	0.98 / 1.25
$\sigma^{\bar{\imath}}$	Inv. Gamma	0.4	0.5	0.18	0.13 / 0.76	Inv. Gamma	0.4	0.5	0.19	0.13 / 0.62
σ^i	Inv. Gamma	0.9	0.5	1.04	0.91 / 1.21	Inv. Gamma	0.9	0.5	1.12	0.88 / 1.25
σ^z	Inv. Gamma	0.2	0.5	0.07	0.06 / 0.33	Inv. Gamma	0.6	0.5	1.44	0.47 / 1.86

There are two major differences in the estimation results of two specifications. In Specification 1, persistent shocks to output gap (or the IS curve) lessen the persistence of the autoregressive (AR) process of the output gap. In Specification 2, where shocks are transient, the output gap is estimated to be close to a unit root process. This comports with the findings of Holston, Laubach and Williams (2016), who estimate the persistence of AR process at around 0.95. Specification 2 also points to highly volatile shocks to the z-factor that are estimated to be close to the unit root process (i.e. α_1 is close to unity). The unit root process of the z-factor is assumed in both Laubach and Williams (2003) and Holston, Laubach and Williams (2016). Instead, the results of Specification 1 tell a story of lower persistence of shocks to the natural rate of interest (α_1=0.53) and less volatile shocks to the z-factor (i.e. a lower σ^z).

The estimated output gaps are quite similar for both specifications (see Chart 3). The gap drops deep into negative territory in late 2008 and remains negative for the rest of the observation period. As the observation period comes to an end, we see the estimated gaps close very gradually, reaching around -2 % by the end of 2016. Our estimated gaps are roughly in line with estimates produced by other methods. For example, the European Commission, IMF and OECD estimate euro area output gaps for 2016 at -1.0, -1.2 and -1.5 %, respectively.

The two specifications yield radically different explanations for the observed persistent negative output gaps. Specification 1 attributes the negative output gaps to large and persistent shocks to output gap that only gradually die out. The shocks are cyclical and could represent for example financial market or demand shocks. In contrast, these cyclical shocks in Specification 2 are smaller and more transient. Under the Specification 2 story, the euro area faces a large temporary shock in late 2008, and smaller shocks at the end of 2012 and in early 2016, but the economic slack is explained by large, near-permanent changes in the long-term natural rate of interest, which, according to our estimates, falls to around -1.0 %. These changes could be caused by the structural, permanent changes in the economy, such as near-permanent slowdown of (expected) productivity growth. As in Specification 1, around one percentage point of the fall is driven by the drop in the growth rate of potential output, while shocks to the z-factor may explain as much as two percentage points of the fall.

Chart 2. Estimation results



Source: Calculations by the author.

Thus, in Specification 2 the expansionary impact of strong cuts in policy rates (as well as short-term interest rates such as the 3-month EONIA rate) are mitigated by the fall in the natural rate of interest. Combined with persistent output gaps, this would explain the exceptionally sluggish economic recovery after shocks to the real economy. In contrast, in Specification 1 the fall in the natural rate of interest is more limited as in that case the changes in the z-factor are negligible.

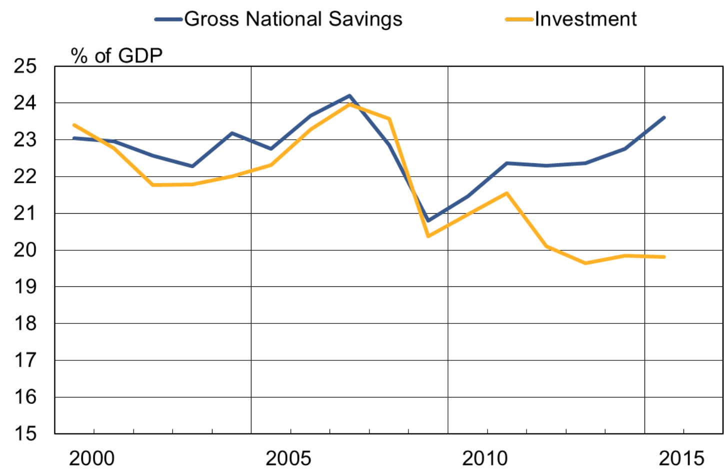
Holston, Laubach and Williams (2016) also estimate an equivalent model for the euro area. Unlike our estimations, they use data over longer periods. As in our Specification 2 story, they find shocks play a bigger role in affecting z-factor. Their results also suggest the natural rate of interest for the euro area has remained negative since 2011. This is more like the path of Specification 2, and quite unlike the path of Specification 1. In any case, our estimations show that the method applied in the calculation of the natural rate of interest incorporates a considerable degree of uncertainty with respect to both the model employed and statistical method used.[5]

3. Interpretation of empirical results

In equilibrium, a low natural rate of interest is reflected as a higher savings rate, a lower investment rate or both. The euro area savings rate has increased only modestly in recent years. The larger change has occurred in the investment rate, which has dropped around four percentage points since the onset of the 2008 crisis, and today only amount to around 20 % of GDP (Chart 4).

[5] *Laubach and Williams (2003) note a similar lack of precision.*

Chart 3. Euro area savings and investment rates



Source: Bloomberg, IMF WEO.

To understand the drivers of these trends, it is useful to analyse interest rates in a more structural framework rather than in the semi-structural model presented above. We do this with a more structural version of Equation 3. In a standard structural macroeconomic model (*see e.g. Galí (2008))* with a utility function of the constant relative risk aversion, the household's utility maximisation yields the following first-order condition with respect to savings

$$C_t^{-\delta} = \beta E_t[C_{t+1}^{-\delta} \frac{(1+r_t^N)}{(1+\pi_{t+1})}] \, , \qquad (6)$$

where $\frac{1}{\delta}$ denotes the intertemporal elasticity of substitution, C_t consumption and $E_t \frac{(1+r_t^N)}{(1+\pi_{t+1})}$ the expected real interest rate. Assuming the uncertainty related to the expected future inflation and covariance between inflation and consumption are small, the second-order approximation of the real interest rate can be written as

$$r_t = \left(\frac{1}{\beta} - 1\right) + \delta E_t(c_{t+1} - c_t) - \frac{\delta(\delta+1)}{2} \sigma_{C,t+1}^2) + \epsilon_t^{EULER}, \qquad (7)$$

where the lower case letters denote the log of the respective variable and $\sigma_{C,t+1}^{'2}$ denotes the variance of consumption.

Finally, change in output in a closed economy equals the weighted average of the change in consumption and investment: $c_t = \frac{y_0}{y_0 - i_0} y_t - \frac{i_0}{y_0 - i_0} i_t$, where y_0 and i_0 denote initial output and investment. Plugging this into Equation 7, we obtain:

$$r_t = \frac{1-\beta}{\beta} + \delta E_t(y_{t+1} - y_t) + \frac{\delta i_0}{y_0 - i_0} E_t(y_{t+1} - i_{t+1} - y_t + i_t) - \frac{\delta(\delta+1)}{2} \sigma_{C,t+1}^2 + \epsilon_t^{EULER} . (8)$$

When applied to a long-term equilibrium where the impact of all shocks have vanished, equation 8 shows that the real interest rate (i.e. the natural rate of interest) is affected by the discount factor, potential growth, the change in the share of investments in the economy, the uncertainty of future consumption and an error term.

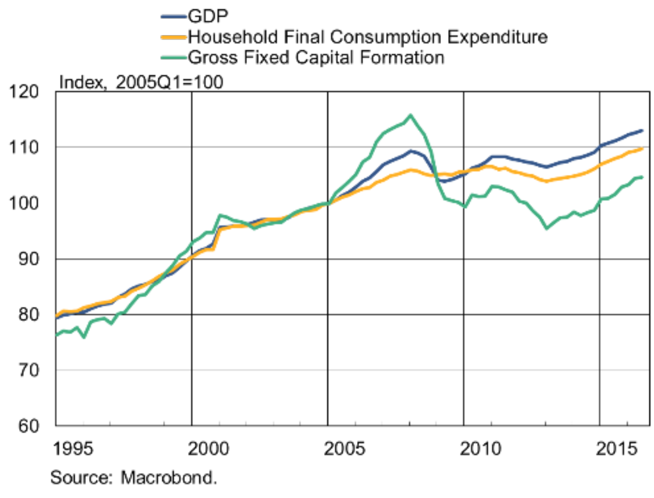
The first term on the right hand side is the rate of time preference. It measures the preference of households to defer consumption to the next period. Traditionally, this preference is thought to be a constant parameter, and set to around 1 % in most quarterly models, implying that $\beta = 0.99$. Of course, it is possible that households become more patient over time, increasing the discount factor β and causing the natural rate of interest to decline. Even so, it is reasonable to assume that the discount factor has an upper limit of 1. Values above unity imply households are willing to pay for delaying consumption rather than get paid for it. Therefore, it would be unrealistic to assume that this would alone turn natural rates into negative territory.

The second term, expected output growth, equals in the long-term equilibrium (i.e. in balanced growth path) potential growth. It impacts consumption and savings behaviour. A weak growth outlook encourages savings and causes households to defer consumption in anticipation of the bad times ahead. In the two estimates presented above, the slowdown of growth in potential output of recent years lowered the level of the natural rate of interest by around one percentage point. There is no indication that growth prospects weakened so much as to justify negative real rates, however. This would need negative potential growth, which is not the case. The European Commission's Autumn 2016 Forecast, for example, suggests that the euro area potential growth has slowed from around 2 % in the pre-crisis period to around 1 % in recent years. Other international institutions generally have also seen potential growth as remaining weak, but positive, in the post-crisis years.

Subdued growth after the financial crisis does reflect weak performance of total factor productivity.[6] The waning of the growth rate accounts for about one percentage point of the decline in the natural rate of interest since the financial crisis. Holston, Laubach and Williams (2016) estimate the slowdown of potential output explains the bulk of the decline in the natural rate of interest in the United Kingdom, Canada and the United States.

Our third term, share of investments, emerge as the estimated model use a very simple macroeconomic model without investments in which consumption equals output. However, in a more structural setting, a persistent expected fall in investment could in principle lead to a weak development of total output but decent consumption path. This would cause a downward bias in estimates of the natural rate of interest. For example, a structural change towards less capital-intensive production could have a negative impact on investments while promoting resilient consumption. However, the differences in the dynamics of output and consumption are relatively small, and thus unlikely to explain the negative natural rate of interest estimated in Specification 2 (Chart 4). [7]

Chart 4. Euro area GDP, consumption and capital formation



The fourth factor in Equation 8 represents the role of uncertainty over future economic developments and consumption. When uncertainty is high, risk-averse households are

[6] *See Anttila, J. (2016).*

[7] *Here, we consider euro area as a closed economy. In addition we ignore the role of public consumption. However, as consumption follows relatively closely output this should not have a large impact on our results.*

motivated to save as a precaution. Here, too, the natural rate of interest would decrease as the uncertainty about future rises.

The final term, ϵ_t^{EULER}, captures deviations from the derived Euler equation. Public policy or credit constraints might cause household behaviour to deviate from the modelled Euler equation. For example, Guerrieri and Lorenzoni (2015) find that credit constraints depress interest rates and cause an output drop.

The above analysis considers the savings side of the natural rate of interest. In equilibrium, the interest rate can also be explained from the investment side, i.e. demand for capital. Recalling the definition of Wicksell (1898) as “the current value of the natural rate of interest on capital,” the standard macroeconomic model results in the firm’s profit maximisation condition where the real rate equal the marginal product of capital (MPK) deducted by the rate of capital depreciation. Lower productivity growth after the financial crisis likely has had a negative impact on the long-term marginal productivity of capital, and thus the natural rate of interest.

A negative MPK –and thereby negative interest rates – seems implausible. With a negative MPK, investments would be unprofitable at equilibrium. In principle, a large structural change towards less capital incentive production in a new type of economy could lead to a negative MPK during the transition period. In fact, the income share of capital has in recent decades increased rather than declined (see OECD, 2015). However, it is possible that there are frictions that prevent optimal allocation of investments or lead to a spread between the short-term risk-free rate used in estimation and the actual interest rate used for financing the interest rate. The friction could be persistent as anticipated in Specification 2 or caused by an exceptionally persistent recession as in Specification 1.

4. Possible explanations for high savings and low investment rates

The imbalance between the propensity to save and propensity to invest have stimulated an ardent discussion about the potential drivers of this phenomenon.

Summers (2014) suggests the causes are demand-side factors such as declining rates of population growth, cheaper capital goods and changes in the distribution of income.

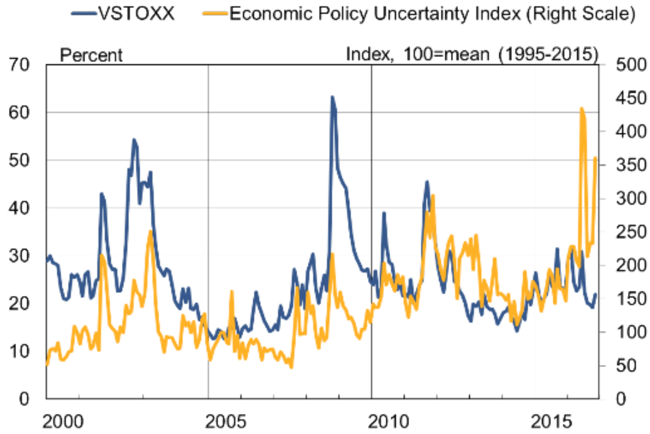
Alternatively, structural change and the reduction in the natural rate of interest could originate from secular stagnation on the supply side. For example, Gordon (2015) argues that sluggish trends in labour productivity caused by diminishing returns from the digital revolution contribute to this secular stagnation. In addition, Rogoff (2016) suggests that debt overhang has at least partly contributed to higher savings and weaker investment.

Next, we discuss several factors influencing the current state of economy. Particularly we analyse their potential impact on the estimates of the natural rate of interest in the context of more structural framework presented in the previous chapter.

Increased uncertainty

With the onset of the 2008 crisis, uncertainty soared. The VSTOXX Index, the most-used euro area stock market volatility measure, peaked in late 2008 (Chart 6). Stock market volatility declined quickly after its peak, but uncertainty has remained at levels above those observed before 2008. In the late 2015 and the first half of 2016, uncertainty levels surged. Notably, the political uncertainty measure proposed by Baker, Bloom and Davis (2016) also shows elevated uncertainty since the onset of the 2008 crisis. Unlike stock market volatility, this measure of uncertainty has increased steadily in recent years, peaking in July 2016 just after the UK’s Brexit referendum.

Chart 5. Stock market volatility vs. uncertainty in the euro area



Source: Macrobond.

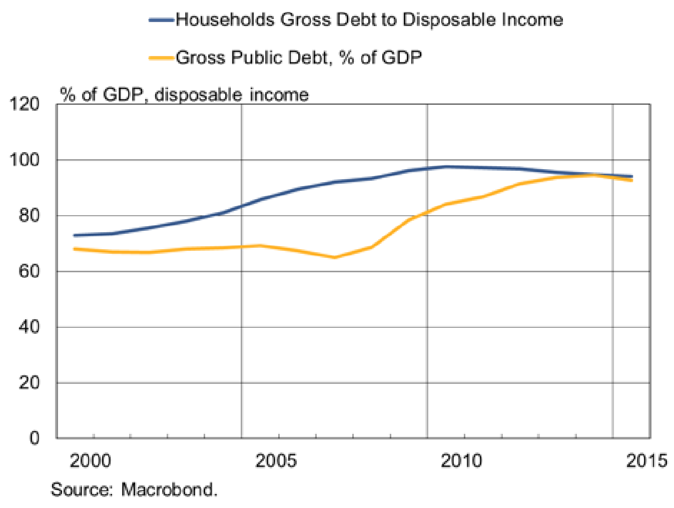
The observed increase in uncertainty could have induced more savings as shown in Equation 8. Uncertainty could also inhibit investment, which would explain the possible disconnect between expected MPK and risk-free interest rate. Heightened perceived uncertainty over profitability (or MPK) could put otherwise viable investment projects on ice. Higher uncertainty probably has a partially cyclical nature. For example, uncertainty about unemployment and the balance sheets of financial and nonfinancial firms typically fade as the economy recovers. In this sense, higher uncertainty as a driver of high savings and low investment rates better supports the narrative of Specification 1 for the current state of economy. However, if elevated uncertainty is the outcome of a structural reason such as permanently higher political uncertainty, it may well depress the natural rate of interest and thereby be reflected in Specification 2.

Private and public sector deleveraging

Private and public sector debt levels increased during the 2000s. Private sector indebtedness rose before the 2008 crisis in many euro area countries, including Greece and Spain, which later suffered heavily from the financial crisis. Public debt levels, in contrast, skyrocketed after the 2008 crisis in many countries (Chart 7).

It typically takes several years to clear up balance sheets and resolve a debt crisis (which shares certain elements with the current euro area depression) before recovery gets underway. Reinhart and Rogoff (2014) find that it has taken on average around eight years to reach the pre-crisis level of per capita income after a major financial crisis. Therefore, high savings and weak investment rates due to debt consolidation may partly explain the observed negative output gaps in Specification 1. However, debt consolidation, which is expected to be more cyclical in nature, should eventually end. For example, private debt levels in the United States declined by around 30 percentage points before stabilising in 2012 at a level above 100 % of disposable income. Thus, debt consolidation is an unlikely candidate for explaining the negative natural rates of interest observed in Specification 2.

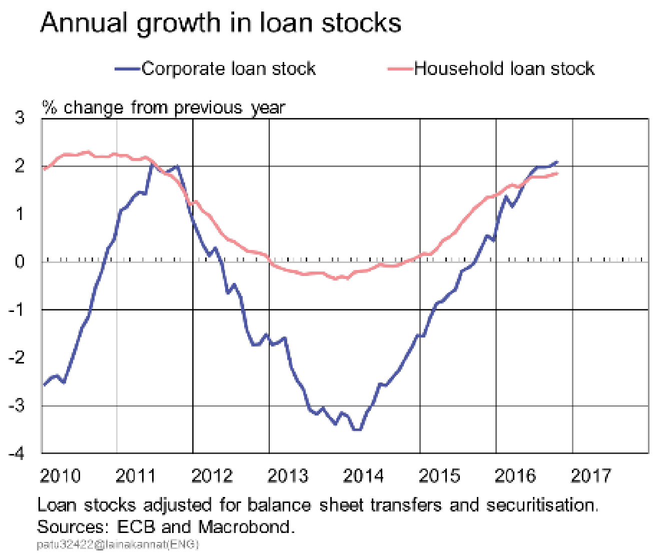
Chart 6. Euro area debt levels



Financial market friction

A closely related explanation for high debt levels is possible financial friction preventing efficient allocation of finance into households or viable investment. Financially constrained households lacking access to credit markets under reasonable conditions are forced to save more than they would if they had a choice (i.e. negative ϵ_t^{EULER} in Equation 8). In many euro area member states, high debt levels and weak economic conditions have induced a surge in non-performing loans. This has had a negative impact on bank balance sheets. As a result, the financial sector is unable to allocate resources into new projects efficiently, leading to a friction between risk-free rates and market rates, as well as a slowdown in lending volumes (Chart 8). Moreover, we see the recovery in loan stocks only begins around 2014. In principle, financial friction should have a cyclical nature, and be reflected in persistently negative output gaps as in Specification 1. However, if balance sheets are not restructured efficiently, particularly in the financial sector, friction persists and begins to be a structural feature. This factor could offer sufficient explanatory power not only for the decline in the natural rate of interest, but even its descent into negative territory as estimated in Specification 2.

Chart 7. Growth of loan stocks in the euro area

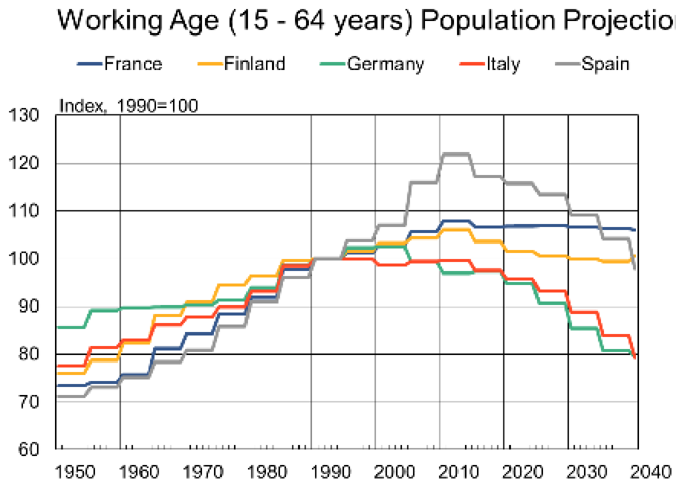


Ageing Population

The euro area population is ageing fast. Baby boomers are beginning to retire, while fertility rates generally remained well below the replacement rate. The growth rate of labour force has already stalled and is expected to decline in the near future (Chart 9).[8] In some member states such as in Finland, the labour force has already been declining for several years.

An ageing population affects savings and investment rates in several ways.[9] First, retiring baby boomers and lower fertility rates lead to a declining labour force and an abundance of capital relative to labour. Return on capital is depressed, so the investment rate remains low. Second, higher life expectancy adds willingness to save, particularly in years approaching retirement. However, once most baby boomers have retired, the savings rate should fall as retired people draw down their capital.

Chart 8. UN working-age population projections, medium fertility scenario



Source: Macrobond, United Nations.

Overall, an ageing population affects the natural rate of interest by lowering potential growth. However, other impacts may emerge via other channels (i.e. the z-factor in Equation 3 or the ϵ_t^{EULER} term in Equation 8) as explained above. Cagnon, Johannsen and Lopez-Salido (2016) analyse the size of the ageing impact on the natural rate of interest in the United States. They find that ageing has probably suppressed natural rate of interest by over one percentage point since the beginning of the 1980s and that the effect is permanent.

Both of our specifications find a decline in the natural rate of interest from lower potential growth to be around one percentage point. This may at least partly be explained by ageing. However, it is also possible that ageing has had additional suppressing impacts on the natural rate of interest that could partly explain the decline of the z-factor observed in Specification 2.

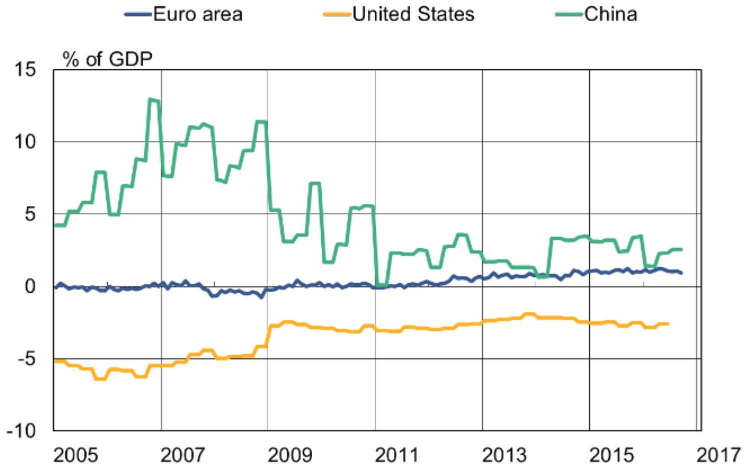
Global savings glut

A decade ago, Ben Bernanke (2005) asserted that the low global interest rates reflected the high savings rates of developing countries, particularly China, as well as other Asian emerging economies and oil-producing states. This "global savings glut" led to an inflow of capital into the developed economies, particularly the United States, causing pressure to hold down long-term interest rates in the mid-2000s. As a result, current account deficits in the United States remained large, while developing economies faced large surpluses. In contrast to the US, the euro area has not seen large current account deficits over the past ten years, but rather rising surpluses (Chart 10). The euro area has been a net saver with respect to

[8] *Projections of the size of the population ageing may vary significantly depending on assumptions about fertility rates and net migration.*
[9] *See the discussion in Carvalho, Ferrero and Nechio (2016).*

global capital markets. Thus, there are no large inflows of capital into the euro area that might explain low interest rates. However, globally low rates may have prevented larger outflows of capital from the euro area and helped maintain lower estimated natural rates of interest.

Chart 9. Current accounts



Source: Macrobond.

To summarise, several factors seem to have contributed to the downward pressure on the natural rate of interest. A lower natural rate of interest explains, at least partly, why economic stimulus and efforts to attain price stability have required more robust post-crisis monetary policy measures than in previous decades. These measures have triggered considerable cuts in both short- and long-term interest rates.

Even so, driving the natural rate of interest into negative territory in the euro area also requires substantial and protracted changes in savings behaviour. Even assuming the existence of such motivation, it is dubious, as discussed above, that it could be strong enough to explain the rate fall as in the model Specification 2.[10] By contrast, the short-run natural rate of interest according to the general equilibrium model could temporarily move into negative territory, driven e.g. by business cycles or other temporary shocks. Indeed, several factors point to the temporary, but persistent, shocks to the output gap like those observed in Specification 1.

Moreover, the level of the natural rate of interest appears to have declined in all advanced economies, not just the euro area. Holston, Laubach and Williams (2016) estimate that the interest rate since the financial crisis has dropped to 1.5% in the United Kingdom and Canada and to around 0.5% in the United States. They also find that natural rates of interest move globally to the same direction. This is explained in part by the interdependencies of economies with respect to e.g. financial markets and external trade, as well as by lower expectations of global growth since the financial crisis.

5. Conclusions

Estimates of the long-term natural rate of interest proved sensitive to our model assumptions. Using two slightly differing specifications, we produced two competing estimates for the current level of the natural rate of interest. Both grant that the rate has fallen since the onset of crisis, but the magnitude of the fall differs significantly. In both cases, the output gap has also remained persistently negative, despite strong monetary policy responses from the ECB. There are several possible explanations for the current slow recovery, subdued inflation and exceptionally low interest rates.

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[10] *Summers (2014) reviews several factors that might potentially affect the natural rate of interest in the US.*

Our two specifications of conditions determining the long-term natural rate of interest hold diverging implications for monetary policy. It is also easy to find credible potential explanations for both tales. If the current economic state is mainly the result of large shocks to the output gap, as Specification 1 suggests, current strong policy measures should gradually close the output gap and return inflation closer to its long-term average. However, if the long-term natural rate of interest has dropped significantly (and possibly even into a negative territory) as Specification 2 suggests, the expansionary impacts of current policy measures are significantly reduced. In this case, achieving price stability would require low interest rates going forward that are well below pre-crisis levels. Also non-standard monetary policy measures would have to be employed more frequently also in future to achieve price stability. Accordingly, discussions at the 2016 Jackson Hole Symposium focused on the potential challenges posed by low interest rates for the conduct of monetary policy.[11]

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[11] *See e.g. Yellen (2016) and Williams (2016).*

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