NATURAL RATE OF INTEREST IN THE EURO AREA

Abstract
We estimate the euro area natural rate of interest using a structural macro model with nominal, real and financial frictions. Our results indicate that during and after the Great Recession the euro area natural rate has been negative. We also find that the natural rate is a useful and relevant monetary policy indicator both from the descriptive and from the normative point of view. First, monetary policy rules which include the natural rate fit the euro area data well, compared to policy rules which do not include the natural rate. Second, a counterfactual exercise indicates that while a monetary policy tracking the natural rate could not attain macroeconomic stability - stable inflation and potential output - it could still help to stabilize the economy.

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1. Introduction

In this paper we analyze the use, and usefulness, of the natural rate of interest in euro area monetary policy. We estimate a macro (DSGE) model with nominal, real and financial frictions; the model also features unemployment. As a part of this exercise we obtain estimates of the euro area natural interest rate: in particular we find that during and after the Great Recession the euro area natural rate has (probably) been negative. We further establish that monetary policy rules which include the natural rate fit the euro area data well, compared to policy rules which do not include the natural rate. Finally, with counterfactual analysis, we illustrate that tracking the natural rate could make the economy more stable; in particular estimates of the natural rate could be used when the central bank decides on (potential) unconventional monetary policy measures.

The paper is structured as follows. In Section 2 we discuss, at a general level, the natural rate and its (potential) uses in monetary policy. In Section 3 we present the model framework, and in Section 4 we discuss the main estimation results. Section 5 presents the counterfactual simulation, and Section 6 concludes. A detailed description of the model framework can be found in the Appendix.

2. Natural rate of interest

2.1 What is the natural rate of interest?

Over a century ago the Swedish economist Knut Wicksell characterized the natural rate of interest as follows:

“There is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them. This is necessarily the same as the rate of interest which would be determined by supply and demand if no use were made of money and all lending were effected in the form of real capital goods” (Knut Wicksell, Interest and Prices, 1898, p. 102.)

The notion of the natural rate of interest often used in contemporary policy discussions comes close to this Wicksellian definition. The natural rate of interest is meant to be the real rate of return to safe (and liquid) assets that is consistent with price stability, or stable inflation. If the real interest rate is below (above) the natural rate, inflation tends to accelerate (decelerate). In recent policy debate, this notion of the natural interest rate has been used for example by Benoît Cœuré, Member of the Executive Board of the ECB, in a public lecture on the economic consequences of low interest rates (see Cœuré 2013).

Another, somewhat different but nevertheless closely related, notion used in contemporary policy debate pertains to real activity. According to this definition, the natural rate of interest is the level of real interest rates consistent with output being at its potential level – or alternatively the real rate of interest where investment and savings bring about full employment. This notion of the natural rate was used for example by (Harvard Professor, and former member of Clinton and Obama administrations) Larry Summers, in a speech on secular stagnation at the IMF in fall 2013. Summers argued that the combination of negative natural interest rates and the zero lower bound may prove a chronic inhibitor of economic activity, holding economies below their potential. (See also Summers 2014.)
In modern macroeconomics, the natural rate of interest is given a still somewhat more precise definition that essentially tries to formalize the older Wicksellian ideas\(^1\). The natural rate is the short term riskless real interest rate that would prevail in an idealized situation, where prices and wages were perfectly flexible. In this idealized set-up, all prices and wages would be set at their target levels\(^2\), and hence there would be no inflationary pressures (which arise from the need to change prices and wages)\(^3\). The equilibrium would also be consistent with output being at its potential level (as defined in modern macroeconomics). Hence the modern macroeconomic definition of the natural interest rate reconciles the notion related to price stability, and the notion pertaining to potential output.

The natural interest rate depends only on (so called) real economic factors (as opposed to nominal factors). In the parlance of economics, these ‘real factors’ include not only economic fundamentals, such as consumer preferences and firm technologies, but also expectations regarding the future, and perceptions of risk and uncertainty (regarding the ‘real side’ of the economy). Importantly, the natural interest rate does not depend on the nominal side of the economy; in particular, it is not affected by monetary policy. Indeed, in the idealized situation, or thought experiment, where all prices and wages are perfectly flexible, money is just a veil: real economic variables (including quantities such as GDP, consumption and investment, and relative prices, such as real wages and the real interest rate) are completely decoupled from nominal variables (essentially nominal prices, measured in monetary terms, and nominal interest rates).

\[2\] Two measures of the natural rate

The measure of the natural interest rate used in modern (New Keynesian DSGE) macro models reacts to shocks (from the real side of the economy): hence the natural rate may vary significantly over the business cycle. Recent structural, New Keynesian DSGE, model based estimates of the natural interest rate have been presented by Barsky et al. (2014), Curdia et al. (2015) and Del Negro et al. (2017) for the US, and by Hristov (2016) and Gerali and Neri (2017) for the euro area.

In this paper we also adopt the business cycle frequency measure of the natural rate: this measure is attractive from the monetary policy perspective, as an important objective of monetary policy is to stabilize the economy over the business cycle. In particular, like Curdia et al. (2015), we estimate our model with a large number of different monetary policy rules, both with and without a measure of the natural rate. This exercise allows us to ask a (predominantly) descriptive question: Have measures of the natural rate played a role in guiding euro monetary policy? (Curdia et al. ask a similar question in the context of US monetary policy). Furthermore, like Barsky et al. (2014) we conduct a counterfactual exercise, where monetary policy tracks the natural rate. This allows us to ask a (more) normative question: Is the natural rate a useful indicator, if the central bank wants to stabilize euro area macro economy, in particular inflation and real activity? (Barsky et al. conduct a similar analysis for the US.) Finally, like Hristov (2016) and Del Negro et al. (2017) we use a model which features financial frictions, on top of nominal and real frictions.

\(^1\) Indeed, Michael Woodford, one of the most vocal advocates of the modern macroeconomic concept of the natural rate, calls his style of macro modeling and monetary policy analysis not only New Keynesian but also neo-Wicksellian. Woodford forcefully puts forward the Wicksellian notion of the natural rate is his 2003 book *Interest and prices*, named after Wicksell’s work a century earlier.

\(^2\) That is, firms set prices at a level that maximizes their profits, and labor unions set wages at a level that maximizes the labor income of union members.
An alternative measure used in the literature is the (so called) long run natural rate. This long-run measure is driven by secular, slowly moving, processes (e.g. demographics), rather than by cyclical factors. Weber, Lemke and Worms (2008), and Hamilton et al. (2016) apply time series methods to extract the low-frequency component from market data on yields on index-linked bonds. A branch of literature starting with Laubach and Williams (2003) (see eg. Mésonnier and Renne (2007), Fries et al. (2016), Pescatori and Turunen (2016) and Holston et al. (2017)) uses a semi-structural model where the natural rate depends on the trend growth rate of the economy, and on a transitory component. Finally, there are natural rate measures based on overlapping generations (OLG) models, which emphasize the role of demographic factors (Gagnon et al. (2016) and Eggertsson et al. (2017)).

2.3 When is the natural rate of interest low?

There are two main macroeconomic factors affecting the (business cycle measure of) natural rate of interest: expected growth prospects, and perceptions of risk and uncertainty.

The natural rate of interest varies positively with expected growth. If people expect a better future they are relatively reluctant to sacrifice today’s consumption in order to get more tomorrow. In other words, their willingness to save tends to be low. On the other hand, bright future prospects encourage firms to invest. Hence, when the future looks good, a high real interest rate is needed to equilibrate the supply of savings and the demand for savings – or savings and investments. In sum, the natural rate of interest is high.

If the future looks bleak, we are in the opposite situation: consumers want to prepare for a rainy day by saving, but firms are unwilling to invest. Then a low real interest rate is required to reconcile savings and investments.

On the other hand, uncertainty about future growth lowers the real rate of return of riskless assets, or the natural rate. Uncertainty creates the need for precautionary saving, increasing people’s propensity to save. The demand for savings, however, tends to drop as firms put on hold investment projects. For demand and supply to match, the real rate of return to safe assets, or the natural interest rates, should be lower in uncertain times. (On the other hand, the real rate of return demanded from projects that are risky, or are perceived to be risky, is likely to rise.)

In addition to these macroeconomic factors, also financial frictions may affect, and lower, the natural interest rate. If for example a (larger than average) part of households and firms face borrowing constraints, this lowers the demand for savings, and puts downward pressure on the riskless real interest rate. Also problems and frictions in the banking sector, which hamper financial intermediations, may have similar effects. (Notice however, that at the same time the real interest rate faced by many borrowers may rise, as spreads widen.)

2.4 The role of the natural rate in monetary policy

What is the role of the natural rate of interest in monetary policy? Is it an indicator to be used in designing the policy stance, a benchmark against which to assess the performance of the monetary authority, or perhaps both?
2.4.1 Natural rate in the canonical New Keynesian macro model: sufficient statistic

We first address these questions in the simplest possible, or canonical New Keynesian macro model⁴ (see e.g. Galí 2008, Ch. 2.).

To do so, we need some simple definitions:

i) (Ex ante) real interest rate = nominal interest rate – expected inflation

ii) Natural interest rate = real interest rate in a hypothetical parallel economy, with no nominal frictions

iii) Interest rate gap = natural interest rate - (ex ante) real interest rate

Now, as explained for example by Barsky et al. (2014), the canonical New Keynesian macroeconomic framework tightly links the real interest rate gap to output and inflation dynamics.

A) The current output gap is the sum of current real interest rate gap and all expected future real interest rate gaps. (This is basically just the New Keynesian IS curve).

B) The current inflation depends on expected future inflation and the current output gap. (This is the New Keynesian Phillips curve.)

It is easy to see that in this framework the central bank should try to steer the real interest rate towards the natural level. First, by closing the interest rate gap (now and in the future), the central bank would also close the output gap (see item A above), meaning that realized output would equal potential output. Second, by closing the output gap, the central bank would establish price stability (B).

Hence, according to the canonical New Keynesian macroeconomic model, the natural rate of interest is a sufficient statistic for monetary policy. It is the key indicator of demand pressures, to be used in designing the policy stance. It is also the key benchmark, against which the performance of the monetary authority is to be assessed.

2.4.2 Natural rate in policy-relevant frameworks: a useful indicator

In the canonical New Keynesian framework discussed above, the natural rate of interest essentially summarizes all the economic information the central bank needs. Moreover, by tracking the natural interest rate, the central bank could (in principle) establish full macroeconomic stability, consisting of price stability and output reaching its potential level. When we move from the canonical model to more policy-relevant frameworks, like the ones used in modern central banks, these stark properties no longer hold.

Compared to the canonical model, the policy-oriented models include a number of additional features, frictions and market imperfections, which make them empirically more realistic and more relevant for policy analysis. These features include (among other things), imperfect competition in labor markets and sticky nominal wages, (inefficient) wage and price mark-up shocks which affect inflation dynamics, and several forms of real frictions (e.g. investment adjustment costs, and financial frictions in the recent generation of models).

⁴ The canonical New Keynesian model features imperfect competition and sticky prices in goods markets, but no other market imperfections. In particular labor markets are competitive and wages are flexible.
Then the statements A) and B) no longer hold (at least not exactly):

A’) The current output gap is not the sum of current real interest rate gap and all expected future real interest rate gaps.

B’) Current inflation depends on expected future inflation and the current output gap, and on other factors. These other factors include for example wage and price mark-up shocks.

Hence, even if monetary policy managed to exactly track the natural interest rate, making the interest rate gap zero in every period, this would not close the output gap (A’). And even if the output gap could be somehow closed, this would not guarantee price stability (B’).

One way of understanding these properties is to notice that the policy-oriented frameworks try to provide a (reasonably) realistic description of a modern economy, with its many different distortions and market imperfections. Then it is quite natural that a central bank, equipped with one policy instrument (the policy rate) cannot simultaneously address all the market imperfections. Hence, even if the central bank somehow knew the natural rate of interest, it could not hope to achieve the goal of price stability and potential output. (And if a further objective of addressing financial stability is added to the list, the task facing the central bank becomes even more formidable.)

However, while natural rate of interest is not a sufficient statistic, or a panacea, it can still be a useful indicator. First even if a monetary policy tracking the natural rate could not achieve price stability and potential output, it could still move the economy quite some way towards theses targets. (This will be illustrated in the counterfactual simulations we conduct in Section 5.) Hence, it can be beneficial to use estimates of the natural rate as one of the guidelines in the design of the policy stance.

Second, and perhaps still more importantly, according to macroeconomic thinking, a (sufficiently) negative natural rate of interest is a precondition for a liquidity trap to arise. And when an economy is in a liquidity trap, unconventional monetary policies may be needed. Hence under current circumstances, the natural rate of interest is perhaps above all a key indicator to be applied, when central banks assess the need for unconventional monetary policies.

3. Model framework and data

3.1 Model framework

In modern macroeconomics, the natural rate of interest is defined as the real riskless interest rate in a flexible price economy, with no (inefficient) wage and price markup shocks.

To estimate the natural rate of interest, we use a model framework that builds on the work by Smets and Wouters (2003, 2007), Gali, Smets and Wouters (2011) and Gertler and Karadi (2011). The starting point is the well-known Smets-Wouters (2003, 2007) model. This model features both sticky prices and sticky wages. These nominal rigidities are empirically realistic, and they are also important for the analysis of monetary policy. It also incorporates a number of other frictions and features, which improve its empirical fit, and hence make it more useful in policy analysis. These features include adjustment (or installation) costs in investments, variable capital utilization rate, habit persistence in consumption, and indexation of wages and prices to their previous values.

The Gali-Smets-Wouters (2011) models differs from the Smets-Wouters (2003, 2007) framework in that it involves an explicit treatment of unemployment. Including unemployment into the analysis is evidently important as such, but having the unemployment rate as an observed variable also allows
the Gali-Smets-Wouters model to distinguish between (efficient) labor supply shocks and (inefficient) wage mark-up shocks. This is useful, since labor supply shocks should affect the dynamics of the natural rate of interest, while wage mark-up shocks should not.

Finally, to address financial frictions, we augment the Gali-Smets-Wouters (2011) framework with an explicit treatment of financial intermediation, modeled as in Gertler and Karadi (2011). In particular, the Gertler-Karadi model includes two interest rates: an interest rate on riskless and liquid assets (in the model households’ deposits in banks) and an interest rate on assets which can be thought of as riskier and less liquid (in the model the yield on the funds the banks invest in non-financial firms); the spread between the interest rates is an observed variable in our framework.

See the Appendix for a more detailed description of the model framework.

3.2 Data

We estimate the model using the following euro area macro and labor market time series: real GDP, real private consumption, real investments, GDP deflator, nominal wage rate, unemployment rate, employment, the size of the labor force, and short nominal interest rate (3 month Euribor). In addition, we use a measure of euro area banks spreads, which we have adopted from the recent empirical work by Gilchrist and Mojon (2017). These are the average spreads on the yield of euro area banking sector bonds relative to the yield on German federal government securities of matched maturities. In particular, this measure of spreads aims at capturing credit risk and liquidity premia, and at disentangling these from term premia.

The model is estimated with Bayesian methods. The estimation sample is 1999Q1:2016Q4. We use the subsample 1999Q1:2014Q2 to estimate the model parameters, and the whole sample to estimate of the (time series of the) latent variables, including the natural rate of interest. The end of the parameter estimation subsample 2014Q2 is the time when the euro area hit the effective zero lower bound of interest rates. As a robustness check we have also estimated the model parameters using the subsample 1999Q1:2007Q3, predating the financial crisis.

3.3 Monetary policy rules

Following the work by Curdia et al. (2011, 2015) – who analyze US monetary policy – we estimate the model with a large number of different monetary policy rules. The key aim of this exercise is to examine the role the natural interest rate has played in euro area monetary policy. Do model variants where the monetary policy rule includes a measure of the natural rate fit the euro area data well (compared to model variants where the monetary policy rule does not include the natural rate)? A second motivation for studying a large number of model variants is to provide some robustness checks.

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5 We estimate a linearized model, but evidently the zero lower bound implies a non-linearity in the monetary policy rule. Then it is better to estimate the linear model using a subsample that excludes the zero lower bound period, and then let the ZLB deviations from the linear structure be captured shocks.

6 Curdia et al. (2011, p.1-2) motivate the focus on monetary policy rules as follows: “[E]mpirical dynamic stochastic general equilibrium (DSGE) models have incorporated ever more detailed and realistic descriptions of private sector behavior and of the monetary transmission mechanism, following the seminal work of Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2007). In terms of modeling the monetary...
We consider Taylor rules, where the current (period t) policy rate depends on
a) the past (period t-1) policy rate
b) a measure of inflation
c) a measure of real activity
d) and possibly on a measure of the natural rate of interest

We consider alternative inflation measures (current inflation vs. expected future inflation; quarterly inflation vs. annual inflation), alternative measures of real activity (model-based output gap, statistical output gaps based on the Hodrick-Prescott (HP) filter, GDP growth, no measure of real activity; measures of current real activity vs. expected future real activity). We consider rules both with and without the natural rate of interest.

The estimated monetary policy rules are of the general form:

\[ \text{interest rate}_t = \rho \ast (\text{interest rate}_{t-1}) + (1 - \rho) \ast [\beta_\pi \ast \text{inflation} + \beta_y \ast \text{real activity} \\
+ \beta_{ac} \ast D_1 \ast (\text{gap accelerator}) + D_2 \ast (\text{natural rate})] + \text{monetary policy shock} \]

where \( \rho, \beta_\pi, \beta_y, \) and \( \beta_{ac} \) are estimated coefficients, \( D_1 \) is a dummy variable which takes the value 1 if a gap accelerator (change in the output gap) is included in the monetary policy rule (and 0 otherwise), and \( D_2 \) is a dummy variable which takes the value 1 if the natural rate is included in the monetary policy rule (and 0 otherwise).\(^7\)

Altogether, we estimate 80 model variants, with 40 monetary policy rules including the natural rate, and 40 rules with no natural rate. See Table A1 in the Appendix for a complete list of the monetary policy rules.

4. Natural rate estimates for the euro area

4.1 Baseline estimate

As the ‘baseline model’, we choose the model variant with the best fit, or the highest marginal data density. The monetary policy rule with the best fit includes one-year-ahead expected future annual inflation, current model-based output gap, a gap accelerator and a (model-based) measure of the natural interest rate. Overall, monetary policy rules that include the natural rate appear to fit the euro area data reasonably well: of the 10 rules with the best fit, 7 include the natural rate (and 4 of the top 5 rules include the natural rate). A similar result is established by Curdia et al. (2015) for the US. More generally, the data seem to favor Taylor rules where monetary policy reacts to expected future inflation, and to a measure of current output gap. Table A1 in the Appendix reports the fit of model specifications with different policy rules. The Appendix also provides information on the prior and posterior distributions of estimated parameters in the baseline model.

\(^7\) Note that here all variables are deviations from their steady state values. Hence no intercept is needed in the monetary policy rules.
Figure 1 shows the euro area natural rate estimate from the baseline model specification. As a benchmark we also display the euro area (ex) ante real interest rate. The natural rate is volatile and pro-cyclical; i.e. the natural rate tends to be high during economic booms and low during recessions. Importantly, the Great Recession, and its aftermath, stands out, with (significantly) negative natural interest rates. These findings are quite well in line with the recent DSGE-model based estimates reported by Barsky et al. (2014), Curdia et al. (2015) and Del Negro et al. (2017) for the US, and by Hristov (2016) and Gerali and Neri (2017) for the euro area.

4.2 Robustness analysis

Figure 2 displays natural rate estimates from 78 model specifications, differing with respect to the monetary policy rule. (2 model specifications have a very poor fit, and they were discarded as outliers; see Table A1 in the Appendix.) While different model variants give different estimates, the collection of estimates forms a rather clear, pro-cyclical, pattern.

There is more disagreement between the model variants during and after the Great Recession, especially starting from the year 2012: while for example our baseline model variant indicates that that the natural rate has been clearly negative (close to -4%), there is a bunch of model variants which suggest that the natural rate has been less negative (hovering between 0% and -2%). However, all model variants by and large indicate that the euro area natural rate has been below zero during and after the Great Recession.
Figure 2. Euro area natural rate estimates: 78 model variants

Figure 3. Drivers of the natural interest rate. Note: headline is the deviation of the natural rate estimate from its steady state value.
4.3 What explains the negative euro area natural interest rate?

What explains the negative natural interest rate in the euro area during and after the Great Recession? According to our model framework, a key driver of negative natural interest rates is the so called risk shock (Figure 3). The risk shocks are literally shocks to households’ ‘risk appetite’, i.e. the households’ willingness to hold riskless (and/or liquid), as opposed to risky (and less liquid) assets. More broadly speaking, these shocks attempt to capture (in a largely reduced-form way) the effects of uncertainty and precautionary motives on saving and investment decisions. (See Barsky et al. (2014) or Del Negro et al. (2017) for more discussion on the interpretation of the ‘risk shock’.) Hence, our model indicates that the negative natural interest rates during and after the Great Recession are largely driven by heightened uncertainty, and/or the increased appetite for riskless assets. – An alternative interpretation might be that the de facto supply of safe, and liquid, assets shrank during the Financial crisis and the European debt crisis, when securities which were previously seen as safe, were reclassified as risky.

Also weakened growth prospects explain a part of the negative natural interest rates during the financial crisis—see the contribution of TFP shocks in Figure 3. However, growth prospects appear to be a secondary driver, compared to risk appetite and/or uncertainty. The overall picture of the drivers of the natural rate is similar to the DSGE model based results established by Gerali and Neri (2017) for the euro area, and by Del Negro et al. (2017) for the US.

5. Counterfactual simulation: tracking the natural rate

While our results suggest that information on the natural has been applied (alongside with estimates of expected future inflation, and the output gap) to guide euro area monetary policy, the euro area (ex ante) real interest rate has deviated from (our baseline estimate of) the natural interest rate (Figure 1). But what would have happened if the central bank had tracked the natural interest rate, and the interest rate gap (see Section 2.4.1) had been zero in every period? Would the euro area economy have been more stable, in particular during and after the financial crisis? To address these questions, we conduct a counterfactual analysis. We assume that the central bank (somehow) knows the ‘true’ natural rate of interest in the euro area (the baseline natural rate estimate from our model). We then simulate our baseline model (keeping the parameters estimates, and the estimated shock processes) under the counterfactual Taylor rule (cf. Barsky et al. 2014)

\[ \text{nominal interest rate} = \text{natural rate} + 1.01 \times \text{expected future inflation} \]

Since, by definition

\[ \text{(ex ante) real interest rate} = \text{nominal interest rate} - \text{expected future inflation} \]

we know that under this counterfactual Taylor rule, the (ex ante) real interest rate is very close to the natural rate. Notice that the counterfactual policy rule satisfies the Taylor principle, since the coefficient of inflation is larger than unity. Also notice that the counterfactual monetary policy rule differs from the estimated baseline rule in several respects: in particular, the baseline involves interest rate smoothing, policy reaction to the output gap, and a monetary policy shock. We then study what happens to some key macroeconomic variables (inflation, output, unemployment).
Figure 4. Counterfactual simulation: Tracking the natural rate. Baseline monetary policy rule: blue solid line; counterfactual: red dashed line. Note: Baseline (GDP deflator) inflation (b) and unemployment rate (d) are equal to the observed euro area time series, and baseline HP-filtered output gap (c) is computed from observed output.

The results from the counterfactual simulation illustrate both the potential usefulness, and the limitations, of the natural rate as a monetary policy indicator (Figure 4). – See also the discussion in Section 2.4.2.

a) Tracking the natural rate comes very near to closing the model-consistent output gap: even during the Great Recession (realized) output would have been close to its potential (flex-price) level. – By contrast under baseline monetary policy, the model-consistent output gap is clearly negative during the Great Recession.

b) However, tracking the natural rate would have boosted inflation only marginally, compared to baseline (i.e. realized inflation): during the Great Recession inflation would have remained well below 2%.

c) The central bank could not have prevented the drop in output during the financial crisis: the HP-filtered output gap is clearly negative even under the counterfactual policy. However, recovery from the financial crisis could have been stronger, and the double-dip recession could have been avoided.

d) Finally, the simulation exercise suggests that unemployment would have risen less during the Great Recession.
In sum, tracking the natural rate would have stabilized in particular the real side of the economy (items a, c and d). It may appear a bit surprising that counterfactual inflation differs so little from realized inflation (item b). However, this outcome essentially reflects the fact that the connection between output and inflation dynamics has been rather weak - In particular, during the Great Recession euro area output dropped drastically, but the drop in inflation was rather modest, in comparison. – Then in our estimated model, the euro area Phillips curve is rather flat: (nearly) closing the (model based) output gap under the counterfactual policy does not significantly change inflation dynamics, compared to the baseline.

A natural rate targeting central bank would have hit the effective zero lower bound of (short term riskless) nominal interest rates during the Great Recession (Figure 5). However, recent experience suggests that a more accommodative stance can be adopted with unconventional monetary policies (forward guidance and large-scale asset purchases). The combined effect of conventional monetary policies (at the ZLB) and unconventional monetary policies is measured for example by the (so called) shadow interest rates (see e.g. Wu and Xia (2016)), which have been clearly negative in the euro area after the launch of large scale asset purchase programs (the shadow rate estimate in Figure 5 is adopted from Kortela (2016)). Comparing the shadow rate and the counterfactual monetary policy trajectory essentially suggests that under natural rate targeting, unconventional monetary policy measures would have been introduced somewhat earlier than they were adopted in reality (Figure 5).

**Figure 5. Actual and counterfactual monetary policy. Note: Baseline nominal interest rate is the actual short term interest rate in the euro area.**

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8 A shadow rate is a summary measure of monetary policy stance, capturing unconventional as well as conventional policy measures. Estimates of the shadow rate use information provided by not only short term interest rates, but the whole yield curve. Differences between alternative shadow rates for the euro area based on different models are typically quite large. However, all measures indicate that the ECB’s monetary policy stance has recently been very accommodative. In Kortela (2016), shadow rate is based on a multifactor shadow rate term structure model (SRTSM) with time-varying effective lower bound of short term interest rate.
6. Concluding remarks

In sum, our analysis suggests that the natural rate of interest could be a useful and relevant monetary policy indicator both from the descriptive and from the normative point of view. First, our results indicate that estimates of the natural rate of interest have been applied (alongside with estimates of expected future inflation, and the output gap) to guide euro area monetary policy: monetary policy rules which include the natural rate fit the euro area data well, compared to policy rules which do not include the natural rate. Second, the counterfactual exercise we conducted illustrates that while the natural rate is not a perfect benchmark against which the performance of the monetary authority should be assessed (tracking the natural rate would not establish macroeconomic stability), it can still be a useful indicator in the design of monetary policy (tracking the natural rate could bring the economy closer to stability). In particular, the natural rate could be of use, when the central bank decides on (potential) unconventional monetary policy measures. Hence, the efforts to estimate the ‘true value’ of the natural rate appear to be worthwhile.

References:


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Appendix on monetary policy rules

Variables used in the monetary policy rules (Table A1)

a) Measures of inflation, real activity and the natural rate

Inflation

- pip = quarterly inflation
- pip4 = annual inflation

Real activity

- x = model based output gap
- xhp = HP-filtered output gap
- gy = quarterly output growth
- gy4 = annual output growth

Natural rate

- rf = natural rate (estimated within the model)

b) Timing: Current, past and expected future values

- +1 = expected value of the variable, one quarter ahead
- +4 = expected value of the variable, one year ahead
- -1 = past, previous quarter, value of the variable
- variables without a time index = current values
Table A1. List of monetary policy rules considered in the paper. Indicator: 1 (red background), if the measure of inflation, real activity or natural rate is included in the rule; blank, if the measure is not in the rule. The rules are ranked in terms of model fit (marginal posterior probability, modified harmonic mean).