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Estimating the Natural Interest Rate for Italy and the Netherlands

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ABSTRACT

Estimating the natural interest rate is fundamental for the proper definition of the stance of monetary policy. This research applies the Kalman filter to jointly estimate the natural interest rate, potential output and its growth rate for Italy and the Netherlands. The results indicate a decreasing trend in the natural interest rates and point out that a single monetary policy may not optimally suit both countries. There is a link between the real interest rate gap and the output gap, and the estimates of the natural interest rate are subject to a high degree of uncertainty.

Keywords: Kalman filter, Natural Interest Rate, Monetary Policy, Euro Area.

1. INTRODUCTION

Mainstream economic theories assume the existence of a long run equilibrium of the economy where economic fundamentals such as the inflation rate or the output level reach a level at which resources in the economy are optimally employed. Following the same line of reasoning, the nominal interest rate is also assumed to converge to a natural level in the long-run and this ‘equilibrium’ rate can be seen as a benchmark for monetary policy. The natural interest rate (NIR) was first mentioned by Wicksell (1936) who described it as “a rate which is neutral in respect to commodity prices, and tends neither to raise nor to lower them.” Its revival was driven by the works of Woodford (2003), who claimed that the equilibrium or ‘neutral’ rate addressed in the Taylor Rule varies continuously in response to real disturbances. Therefore, the real interest rate gap, defined as the difference between the actual interest rate and its natural counterpart, was seen as a good indicator for evaluating the current stance of monetary policy, as opposed to measures that deal with monetary aggregates or exchange rates.

Given its importance on the evaluation of the stance of monetary policy, the NIR has been on the centre of the latest macroeconomic discussions (ECB, 2004). In fact, when the short-term

nominal interest rate lies above the NIR, the policy is said to be contractionary and, by the same reasoning, when the opposite happens, the policy is said to be expansionary. This link is clearly illustrated by the Taylor Rule (Taylor, 1993), that makes recommendations for the nominal monetary policy interest rate, based on current economic conditions, namely the inflation gap and output gap, but also on the real interest rate. This type of monetary policy rule provides an anchor for the behaviour of interest rates.

Long-term interest rates in most advanced economies have been particularly low since the global financial crisis, something that has been linked with the current low short-term interest rates (Rachel and Smith, 2015). By the line of reasoning previously mentioned, this would mean that monetary policy was too expansionary. If this were the case, policy makers would only need to adopt a more contractionary monetary policy, thus increasing the interest rates. However, as mentioned by Blanchard, Furceri and Pescatori (2014) the problem is that this 'looser monetary policy' has not been accompanied by an increase in inflation and aggregate demand, as predicted by economic theory, meaning that, despite being countercyclical, this policy is not producing the desired outcome. Observable interest rates seem to be affected by their equilibrium equivalents. Therefore, to understand what drives the current stance of monetary policy, it is essential to comprehend the dynamics of its equilibrium aspects.

The subject of this research is to study the movements of the NIR for Italy and the Netherlands, using the Kalman filter. The choice of these countries is related to the fact that Italy is a large European country, usually considered a peripheral economy, and the Netherlands is a strong economy of central Europe. These countries have different economic indicators but belong to the same monetary union. Given the current context of low nominal interest rates in the Euro Area and the ever-growing discussion regarding the future of the single currency, it is fundamental to understand whether it makes sense for different economies to share the same interest rate. Besides this, the current debate on the Secular

Stagnation hypothesis (Summers, 2014) increases the relevance of this type of discussion. This analysis can be performed by a careful study of their equilibrium indicators.

The results seem to suggest that the Euro Area may not be such an optimal currency area, given the differences in the estimates of the NIR. Secondly, this rate seems to be declining in both economies, in accordance with the Secular Stagnation hypothesis. Finally, the estimates of the NIR are subject to a high degree of uncertainty, in line with Laubach and Williams (2003).

The remainder of this research is structured as follows: section 2 briefly discusses the relevant literature on the topic; section 3 presents the model and the data; section 4 provides a discussion of the results and compares with Holston, Laubach and Williams' (2016) Euro Area estimations; and the final section concludes.

2. LITERATURE REVIEW

Given the current goals of the central banks to achieve price stability and potential output, the NIR is one of the key indicators of the stance of monetary policy (Amato, 2005). However, there is no consensus regarding its measurement. This is mostly because this indicator “must be inferred from the data, rather than directly observed” (Holston, Laubach and Williams, 2016). Several variables have been related to its measurement such as the time preference of consumers, productivity and population growth, fiscal policy and risk-premia, and the institutional structure of financial markets (ECB, 2004).

This concept is differentiated according to its time horizon. A strand of the literature claims that the long-term NIR is the most stable, given the fact that in the long-run all markets have cleared and, provided there are no new economic disturbances, all the growth rates in the economy are constant, (Archibald and Hunter, 2001). Other authors prefer to study the concept of the short-term interest rate, given the difficulty in measuring an equilibrium state

in all markets. Laubach and Williams (2003) refer to the short-term real interest rate as the rate consistent with stable inflation and output at its potential level.

Neiss and Nelson (2001) were pioneers on the measurement of the NIR and its importance for monetary policy decisions. In their perspective, the NIR is the real rate of return in an economy with fully flexible prices. Using quarterly data for the United Kingdom for the period between 1980 and 1999, they develop a Dynamic General Stochastic Equilibrium (DSGE) with sticky prices and compute the ‘higher frequency component’ of the NIR, while tracking its period-by-period movements, which are required to keep inflation constant. Giammarioli and Valla (2003) apply a similar procedure to the Euro area, defining the NIR as the rate that achieves period-by-period price stability. Both papers conclude that the real interest rate gap can be quite helpful in predicting future inflation, in accordance with Woodford (2003). As Larsen and Mckeown (2004) put it, a DSGE approach is preferable to a Hodrick-Prescott (HP) approach or a Band-Pass (BP) approach in the sense that it allows for a structural interpretation of the real interest rate gap and its variations. Nonetheless, this approach relies on several arbitrary assumptions and its actual advantage over others is not clear.

Brzoza-Brzenina (2003) argues that the NIR is a quite reliable indicator of monetary policy, especially in an inflation-targeting regime. Through a Structural Vector Autoregressive (SVAR) approach, the author estimates the NIR for the U.S. for the period between 1960 and 2001. He shows that this rate varies over time, being a procyclical variable, in the sense that it increases during an economic expansion and decreases during recessions.

Orphanides and Williams (2002) try to study the impact of mismeasurements of the NIR in monetary policy. Their study covers quarterly data for the U.S. for the period between 1969 and 2002, and assumes that the NIR follows a random walk. They estimate the NIR using univariate filters such as the HP and the BP filters to obtain both one-sided estimates (which

only account for the information available at time t to compute estimates of unobservable variables) and two-sided estimates (which account for all the information available in the sample, both past and future, to compute estimates of a variable at time t), and multivariate filters, such as the Kalman filter (which produces optimal linear future forecasts based on information up to time t). They conclude that underestimating the volatility of real-time estimates of the NIR may be quite costly in terms of economic stabilization. On top of this, they claim that the costs of underestimating mismeasurements of this rate are higher than the costs of overestimating them.

In a 2003 paper, Laubach and Williams applied a State-Space approach to jointly estimate highly persistent components of the NIR, potential output and its trend growth rate in the U.S. for the period between 1961 and 2002. From their point of view, the NIR is the real short-term interest rate consistent with output at its potential level and stable inflation in the medium-term, i.e. once the effects of demand shocks on the output gap and supply shocks on inflation have completely vanished. Their approach builds on the works of Watson (1986), Clark (1987) and Kuttner (1994), with a key difference in that these authors do not account for an explicit relationship between the NIR and the growth rate of potential output. Their work resembles a New Keynesian framework (Galí, 2008), in the sense that they use a Phillips curve and an intertemporal IS curve to describe the dynamics of both the output gap and the inflation rate as a function of the real interest rate gap. However, the authors depart from the conceptual DSGE approach given that they do not treat the growth rate of technology and the rate of time preference as fixed. Laubach and Williams allow the NIR to be affected by low-frequency nonstationary processes that are highly persistent but difficult to detect. The authors estimate several variants of the IS and Phillips curve by maximum likelihood using the Kalman filter and conclude that the NIR shows significant variation over time. They also conclude that this variation is very much determined by the growth rate of

potential output. Once again, they state that it is important to account for mismeasurements in computing natural rates when making monetary policy decisions. In 2016, the authors updated the previous analysis, using data from the U.S., Canada, the Euro Area and the United Kingdom. Even though the conclusions are the same as in the 2003 paper, the authors emphasize the decline observed in the NIRs over the past quarter century, reaching a historically low point, and corroborating the Secular Stagnation hypothesis.

The issue of the reliability of the estimates of the NIR is also addressed by Clark and Kozicki (2004), who claim that these estimates are easily distorted by different data sources, successive data revisions and the usage of one-sided filters. Using the same approach as Laubach and Williams (2003), they conclude that the NIR is closely linked with the growth rate of potential output. On top of this, they also model the NIR as a random walk, as in Orphanides and Williams (2002), compare both models and reinforce the fact that these estimates should be carefully dealt with.

Garnier and Wilhelmsen (2005) use the same procedure as Laubach and Williams (2003), thus applying the Kalman filter to a small-scale macroeconomic model, which encompasses an IS and a Phillips curve, in order to estimate the NIR for Germany, the U.S. and the Euro Area. To do so, they use quarterly data for the period between 1961 and 2004 and conclude that the real interest rate gap is negatively correlated with the output gap and inflation. Besides pointing out the fact that one must be careful with the uncertainty regarding these estimations, the authors also conclude that the real interest rate gap may contain important information regarding future inflation in the Euro area.

Mésonnier and Renne (2007) depart from the same model as Laubach and Williams (2003) but instead assume that the unobservable process that drives the low frequency common fluctuations of the NIR and the growth of potential output is a stationary autoregressive process (as opposed to being nonstationary). They also assume that there are no co-

movements between the NIR and the growth rate of potential output. Furthermore, they compute an ex-ante real interest rate, opting for the usage of the inflation expectations provided by the model instead of deriving them from an autoregressive process. Applying this methodology to the Euro area for the period between 1979 and 2002, they estimate a time-varying NIR and conclude that monetary policy has been adequate for stabilising European inflation.

Benati and Vitale (2007) use the Kalman filter to jointly estimate the NIR, the natural rate of unemployment, expected inflation and potential output in the Euro Area, the U.S., Australia, Sweden and the United Kingdom. The authors generate the expectation of inflation endogenously within the model and exploit the information contained in the unemployment gap, to better filter out the cyclical component of economic activity. Apart from this, their approach is quite similar to the one performed by Laubach and Williams (2003). They conclude that the time-variation in the NIR is estimated to be quite large for the U.S., the Euro Area and Sweden, and smaller for Australia and the United Kingdom. Moreover, the authors also strengthen the idea that estimations of the NIR are subject to a high degree of uncertainty.

Lubik and Matthes (2015) make a comparison between the Laubach and Williams approach and a Time-Varying Parameters VAR (TVP-VAR) approach. The latter allows the lag coefficients (the parameters of the model) to vary over time. Applying both models to the same US quarterly data for the period between 1961 and 2015, the authors claim that the Laubach and Williams' estimates vary considerably and have high standard errors. They claim that these effects could be softened by increasing the theoretical rigor of the model or, on the other hand, reducing its structural aspects. According to the authors, besides the sustained decrease observed in the real rate as well as in its natural counterpart, the real rate's volatility seems to change over time. Given this, they argue that the TVP-VAR approach

could be more adequate for the study of the NIR since it imposes a less strict economic structure, meaning that it just captures the co-movement between the variables in a flexible manner. Nonetheless, the authors conclude that both models yield similar estimates since the 1980s and the uncertainty regarding these estimates makes the models practically indifferent over the past 30 years. However, they note that the natural counterpart has been above the real rate over an extended period, something that has been proven by both models.

This research contributes to the existing literature by applying the same procedure as Laubach and Williams (2003) to data for Italy and the Netherlands in order to jointly estimate the output gap, the growth rate of potential output and the NIR.

3. DISCUSSION OF THE TOPIC

3.1. Model

The approach adopted in this research follows Laubach and Williams (2003) (LW). The NIR is the real rate consistent with stable inflation and output at its potential level, as in Wicksell (1936). This research builds on a New Keynesian framework in the sense that an intertemporal IS curve and a Phillips curve are used to study the dynamics of the output gap and inflation as a function of the real interest rate gap, following the DSGE literature. As previously mentioned, the LW approach differs from the standard DSGE models since it allows for parameters that are usually treated as fixed in the literature (such as the households' rate of time preference or the productivity growth) to be affected by highly persistent and difficult-to-detect fluctuations (Stock and Watson, 1998). Therefore, the model allows the NIR to be affected by low-frequency nonstationary processes (i.e. shocks that affect the output gap and inflation but not the NIR).

To reduce the risks associated with misspecifications in the output gap and inflation dynamics, the estimations are performed using reduced-form equations. Given this, the following equations are estimated:

$$(1) y_t = y_t^T + \alpha_1(y_{t-1} - y_{t-1}^T) + \alpha_2(y_{t-2} - y_{t-2}^T) + \frac{\alpha_r}{200}[(r_{t-1} - r_{t-1}^*) + (r_{t-2} - r_{t-2}^*)] + \varepsilon_t^y$$

$$(2) \pi_t = \beta_\pi \pi_{t-1} + \frac{(1 - \beta_\pi)}{3} \pi_{t-2} + \frac{(1 - \beta_\pi)}{3} \pi_{t-3} + \frac{(1 - \beta_\pi)}{3} \pi_{t-4} + 100\beta_y(y_{t-1} - y_{t-1}^T) + \varepsilon_t^\pi$$

$$(3) r_t^* = g_t + z_t$$

$$(4) z_t = z_{t-1} + \varepsilon_t^z$$

$$(5) y_t^T = y_{t-1}^T + g_{t-1} + \varepsilon_t^T$$

$$(6) g_t = g_{t-1} + \varepsilon_t^g$$

Equations (1) and (2) are the measurement equations of the State-Space model, linking the observed variables (y_t and π_t) to the unobserved variables (y_t^T and r_t^*). Equation (1), the intertemporal IS curve, relates the output gap, $100(y_t - y_t^T)$, i.e. the log deviation of GDP (y_t) from its potential level (y_t^T), to its own lags and to the lags of the real interest rate gap (the difference between the real interest rate, r_t , and its natural counterpart, r_t^*). The sum of the coefficients α_1 and α_2 reflects the persistence of the output gap, meaning that the higher their sum, the greater will be the intertemporal dependence of current output gap. The coefficient α_r is the slope of the IS curve and it is expected to be negative, given that economic theory predicts that a positive real interest rate gap is associated with a negative output gap¹. In case the former gap is equal to zero and there are no demand shocks ($\varepsilon_t^y = 0$), the output gap converges to zero, meaning that output will be equal to its equilibrium level in the long-run. Equation (2) is the backward-looking Phillips curve and it explains inflation, π_t , as a function of its own lags (the first lag and an average of the second to fourth lags) and the lagged output gap. As in LW, the restriction that the coefficients of all the terms of lagged inflation sum to 1 is imposed². The coefficient β_y is the slope of the Phillips curve and it is

¹ The choice of two lags of the output gap and two gaps of the real interest rate gap is in line with LW. The restriction that the two lags of the real interest rate gap have the same coefficient is not rejected by a Wald test.

² The choice of four lags of inflation is justified by the Akaike selection criterion. The restriction of the sum of their coefficients being equal to 1 is not rejected by a Wald test. The choice of only one lag of output gap in equation (2) is in line with LW.

expected to be positive since a positive output gap creates inflationary pressures on the economy.

Equations (3) to (6) are the transition equations of the State-Space model. Equation (3) is the law of motion of the NIR, modelling the NIR as a linear combination of the growth rate of potential output, g_t , and all the other determinants of r_t^* , such as changes in the population growth rate or the discount rate (Guarda, Rouabah and Wintr, 2005), captured by the term z_t . As in LW, this research assumes a one-for-one relationship between the NIR and the growth rate of potential output. For simplicity, z_t is assumed to follow a random walk process, described by equation (4).

Potential output, y_t^T , is assumed to follow a random walk process with a stochastic drift, g_t i.e. the growth rate of potential output (equation (5)), which itself follows a random walk, displayed in equation (6). This implies that an innovation ε_t^T has a permanent effect on the level of potential output but only a one-period effect on its growth rate, whereas an innovation ε_t^g has a permanent effect on the growth rate of potential output, implying that potential output is integrated of order 2, as in Holston, Laubach and Williams (2016).

ε_t^T , ε_t^g and ε_t^z are assumed to be normally independently distributed shocks with standard deviations σ_T , σ_g and σ_z respectively and are serially and contemporaneously uncorrelated.

3.2. Data

The computation of the NIR requires data for real GDP, inflation, a procedure to calculate inflation expectations and the short-term nominal interest rate, in order to obtain the ex-ante real short-term interest rate.

The real GDP measure chosen is the *Index of Real Gross Domestic Product, Seasonally Adjusted* from the IMF International Financial Statistics. The measure of inflation is constructed using the consumer price index excluding food and energy, also known as core CPI. The series was retrieved from the OECD database.

In their 2003 paper, Laubach and Williams computed inflation expectations through a univariate AR(3) process of inflation estimated over the past 40 quarters to generate a forecast of four-quarter-ahead inflation. However, for reasons of consistency, the proxy chosen for inflation expectations is a four-quarter moving average of past inflation, as in Holston, Laubach and Williams (2016).

Both Italy and the Netherlands are on a monetary union since 1999 and, as consequence, there is no long series for the short-term nominal monetary policy interest rate. Therefore, this rate was proxied by the 3-month interbank rate as in Manrique and Marqués (2004). The authors argue that this rate, despite “being closely linked to the monetary policy interest rate, has a greater variability than the latter, which makes for readier estimation”. This series was retrieved from the OECD. The ex-ante real short-term interest rate is the difference between the short-term nominal interest rate and the inflation expectations.

Given data availability of the 3-month interbank rate, data for Italy is composed by 143 quarters ranging from 1980:Q1 to 2016:Q3, whereas for the Netherlands, the sample is composed by 119 quarters ranging from 1986:Q1 to 2016:Q3. The series were seasonally adjusted using the R-packages ‘seasonal’ and ‘x13binary’. The results of the Augmented-Dickey Fuller test can be found in Table 1 in Appendix 2.

3.3. Empirical Implementation

As it was previously mentioned, this research applies the Kalman filter to jointly estimate the level of potential output, its growth rate, and the NIR. This is done by rewriting equations (1) to (6) in the State-Space form and estimating them by maximum likelihood³.

A widely discussed issue in the literature related to this type of maximum likelihood estimations is the ‘pile-up problem’ (Stock, 1994). As clarified by Roberts (2001), 20th century U.S. data suggests that the growth rate of potential output may vary over time but

³ Please refer to Appendix 1 for a detailed description of the State-Space form matrices and the Kalman filter initial conditions.

these variations are likely to be small relative to the overall variation in the series, meaning that it may be difficult to detect them in the data. The problem comes from the fact that if a variable has large shocks to its level, but only small shocks to its change, the usual maximum likelihood estimation procedures will tend to obtain standard deviations of the shocks to the change of zero, even though that may not be the case. In this particular case, the standard deviations of the innovations to z and the growth rate of potential output (ε_t^z and ε_t^g) will be biased towards zero. This problem has been addressed by Stock and Watson (1998), proposing a technique, the median unbiased estimator, which is shown to better capture the true size of small shocks to the growth rate of potential output than maximum likelihood estimation⁴. Basically, the authors propose a median-unbiased estimator of the signal-to-noise ratios $\lambda_g = \sigma_g/\sigma_T$ and $\lambda_z = \sigma_z \times \alpha_r/\sigma_y$. These ratios are imposed when estimating the remaining model parameters by maximum likelihood, i.e. $\alpha_1, \alpha_2, \alpha_r, \beta_\pi, \beta_y, \sigma_y, \sigma_\pi$ and σ_T .

The estimation approach can be decomposed in three sequential steps. In the first step, the methodology of Kuttner (1994) is adopted and the Kalman filter is used to estimate potential output, omitting the real interest rate gap from equation (1) and assuming that the growth rate of potential output (g_t) is constant. This is equivalent to omitting equations (4) and (5). The exponential Wald statistic of Andrews and Ploberger (1994) for a structural break with unknown break date is computed on the first difference of the estimated potential output, to obtain the median unbiased estimate of λ_g .

In the second stage, the ratio λ_g is imposed and the Kalman filter is applied again, this time including the real interest rate gap in equation (1) and assuming that z_t is constant, so that g_t

⁴ The authors depart from the idea that if there is a shock to the growth rate of potential output, then if one were to run a test looking for the growth rate's structural stability, that test would tend to reject the null hypothesis of structural stability. On top of this, the larger the variance of the shock to the growth rate of potential output relative to the shock to the level of potential output, the stronger would be the evidence in support of the rejection of structural stability. Stock and Watson (1998) provide a table (table 3, page 354) for mapping from the results on a structural break to the size of standard error of the growth rate shock.

is no longer constant. Once again, the exponential Wald test is performed, this time for an intercept shift in the output gap equation at an unknown date, to obtain an estimate of λ_z .

In the third stage, the estimates of λ_g and λ_z are imposed and the remaining parameters of the model are estimated by maximum likelihood, as in Harvey (1989). It is important to notice that Holston, Laubach and Williams (2016) impose constraints on the slopes of the IS curve and the Phillips curve. In fact, they impose that α_r must be negative and β_y must be positive⁵, in accordance with economic theory. Given that the authors claim these are minimal constraints to facilitate the convergence of the optimization of the model, they are also imposed in this research.

4. RESULTS

4.1. Parameter Estimates

Estimation results are reported in Table 2 in Appendix 2. The value of λ_g is quite similar for both economies (0.038) and seems to indicate a small time-variation in the estimates of the growth rate of potential output. This value is close to the Holston, Laubach and Williams' (2016) (HLW) Euro Area estimate of 0.030. However, the values of λ_z are quite different between countries (0.041 for Italy, 0.122 for the Netherlands and 0.042 for the HLW Euro Area estimation). This suggests that the time variation of the NIR is greater for the Netherlands, something that is confirmed by the smaller value of α_r for this economy. Besides this, the uncertainty regarding the estimates of the NIR seem to be related to the statistical significance of both α_r and β_y . These coefficients are not statistically significant for the Netherlands and, in fact, the average standard errors of both the NIR and potential output are relatively greater than those of Italy.

⁵ More specifically, the authors impose that $\alpha_r \leq -0.0025$ and $\beta_y \geq 0.025$. Together with the constraint that $\alpha_1 + \alpha_2 < 1$, the convergence of the model is simplified.

It is also important to notice that the output gap is estimated to be less persistent in Italy, due to the smaller value of $\alpha_1 + \alpha_2$, but inflation in Italy is more affected by these temporary fluctuations in the output gap, given its higher β_y .

The results seem to suggest that both the output gap and the real interest rate gap are well identified for the case of Italy, given the slope coefficients of α_r and β_y . However, it is important to notice that there is some imprecision in the estimates of the NIR, given the sample average standard error of 1.787 percentage points. These mismeasurement issues are even greater when looking at the one-sided estimates, which, by using only current and past observations in estimating the state, are a better proxy for “real-time estimates”. As it is possible to see, the final observation standard errors (representing the one-sided estimates’ mismeasurement when the true values of λ_g and λ_z are assumed to be known) are even greater. This effect is amplified for the Netherlands.

Figure 1⁶ plots the filtered (one-sided) estimate of the natural rate of interest and its smoothed (two-sided) estimate for Italy. It is clear that the two-sided estimates are smoother, which can be explained by the fact that these account for all the information available in the sample, past and future, to compute current estimates of a variable, i.e. they recursively update their estimates based on previous estimates. The same analysis is true for the case of the Netherlands, displayed in Figure 2. Both figures demonstrate a pattern of declining NIRs, decreasing at a faster pace after 2007, confirming the Secular Stagnation hypothesis.

4.2. Estimates of the Output Gap, Real Interest Rate Gap and the Growth Rate of Potential Output

Figures 3 and 4 show the one-sided estimates of the output gap and the real interest rate gap for both economies. The shaded regions indicate the Euro Area recession periods⁷. As one would expect, apart from a few exceptions, output gap moves downwards in periods of

⁶ All figures can be found in Appendix 3.

⁷ Source: CEPR Euro Area Business Cycle Dating Committee

recessions and, in fact, has remained negative since the financial crisis. On the other hand, the real interest rate gap moves in the inverse direction of output gap, meaning that a negative real interest rate gap is usually accompanied by increases in the output gap and vice-versa. In the case of Italy, until the late 1990's, the real interest rate gap is quite large, which is reflected on a negative output gap, but around 2000, after the introduction of the single currency, the former gap becomes more stable around zero, yielding a similar effect on the output gap, which becomes positive and stable. In the Dutch case, the real interest rate gap does not stabilise around zero after 2000. In fact, it becomes more volatile and larger, something that turns the output gap negative.

Figures 5 and 6 suggest an even more interesting result. These display the estimates of the NIR and the growth rate of potential output for Italy and the Netherlands, respectively. In fact, both figures seem to be in accordance with the Secular Stagnation hypothesis (Summers, 2014) – the idea that the economy is stagnating for the past 20 years, observed through the decrease in inflation, interest rates and growth rates of the economy. The NIR has been declining in Italy for the past 20 years and this process appears to have accelerated after the 2008 financial crisis reaching a negative value in 2012. The same is true for the Netherlands but the results suggest that the NIR has been negative since 2003, increasing from 2006 to 2007 (becoming positive) and turning negative again following the financial crisis.

The growth rate of potential output has moved in a quite similar fashion as the NIR in Italy, also experiencing a downward trend since 2008. However, curiously, it has remained quite stable in the Netherlands, suggesting that the random walk factor, z , may be the main cause of the variations in the NIR.

4.3. Comparing with HP Filter

A detailed analysis of Table 2 seems to corroborate the initial idea that one must be careful with any estimate of the NIR, given the already mentioned imprecision of the Kalman filter estimates. Therefore, this section compares these estimates with those from a univariate filter. Since the results for Italy are better suited for a statistical analysis (the coefficients are statistically significant and the standard errors are friendlier), the Netherlands will not be addressed in this section.

Figure 7 plots the proxy for the ex-ante real interest rate (described in the data section), the two-sided estimate of the NIR, its one-sided estimate and the NIR estimated through a univariate filter. More specifically, the univariate filter used is the Hodrick – Prescott (1997) (HP) filter, with a smoothing parameter λ of 6400, following Laubach and Williams (2003). This parametrization is chosen so that the resulting estimates correspond to the low-frequency components, like the Kalman filter.

Given the fact that the univariate estimates are two-sided weighted averages by nature, they tend to be quite close to the actual rate and, consequently, do not capture the effects of movements in inflation. Until the early 1990's, the univariate estimate is quite close to the actual rate even though there was a considerable decrease in inflation during that period. On the other hand, the Kalman filter estimates (both the one-sided and the two-sided estimates) show little movement of the NIR during periods of volatile inflation (such as the one that lasted until the late 1990's). Therefore, the Kalman filter approach seems to be more capable of estimating lower-frequency movements in the NIR than the univariate method.

As Orphanides and Williams (2002) put it, univariate filters “separate the cyclical component of a series from its secular trend and use the latter as a proxy for the natural level of the detrended series”, which makes them extremely easy to implement. On the other hand, multivariate filters such as the Kalman filter take more information in consideration since

they recursively update their estimations, i.e. they make an initial prediction of the states based on initial information which is then updated based on the outcome of the following estimation. Therefore, they can provide more accurate estimates.

Univariate filters have difficulty in making a clear distinction between the secular and cyclical fluctuations of a series, meaning that the greater the dataset is, the more accurate these estimates will be. This problem is not so present in multivariate filters because, in this case, the estimates of the NIR are updated based on inflation surprises (only real-time information is used).

To sum up, given their higher complexity and accuracy, multivariate filters such as the Kalman filter, seem to be better suited for performing real-time estimates of the NIR. However, one must be careful when making such conclusion because these filters perform under the premise that the low-frequency components' behaviour is well modelled, something that may not necessarily be true, thus turning the multivariate estimations false.

4.4. Estimates of the Natural Interest Rate

Figure 8 plots the one-sided estimates of the NIR for Italy and the Netherlands, as well as the one-sided estimates performed by Holston, Laubach and Williams (2016) for the Euro Area. It is important to mention that Italy and the Netherlands share the same currency since 1999. According to Mundell (1961), the optimality of an Optimum Currency Area (OCA) depends on the importance of asymmetric shocks within the union but also in the existence of adjustment mechanisms to tackle them. The Euro Area is currently composed by 19 countries, with different growth rates, inflation rates and unemployment rates so that one can say that the Euro Area is a very heterogeneous monetary union. On top of this, as De Grauwe (2003) points out, since it is a quite large group, there is a higher probability of occurrence of asymmetric shocks. Given that a monetary union implies a single interest rate set by a single common central bank, it becomes extremely hard to set a rate that pleases the needs of all

countries. This issue was also raised by Moons and Van Poeck (2008) who claimed that, before the 2004 Euro Area enlargement, the interest rate set by the ECB (Main Refinancing Operations rate – MRO) did not fit all the monetary union countries in an equal manner.

Consequently, the single rate tends to be closer to the needs of the larger countries, such as Germany, France, Italy and Spain, which represent more than 50% of the total Euro Area GDP. Nechio (2011) and Darvas and Meller (2013), using a simple Taylor-rule function, showed that even though the MRO was in line with the recommendation for the Euro Area as a whole, once they decomposed the countries into two distinct groups, the actual rate was closer to the recommendation for the core group (Austria, Belgium, Finland, France, Germany, Italy and The Netherlands) than for the periphery group (Greece, Ireland, Portugal and Spain), implying that the single interest rate does not seem to be optimal. This also means that for countries such as Germany the current stance of monetary policy may be too loose.

Following this line of reasoning, it would be expectable that countries that belong to a monetary union share similar economic indicators but would also be similar on their fundamentals, i.e. NAIRU, potential output and the NIR. By looking at the graph, one can see that estimates for the Euro Area and those for Italy and the Netherlands start diverging at a faster pace in the late 1990's, during the implementation of the single currency. This may contradict the claim by Frankel and Rose (1998) that more integration promotes more business cycle correlation. Curiously enough, the estimates for Italy and the Euro Area seem to converge during the 2008 financial crisis, diverge afterwards, and converge again in 2015. The main point here is that Italy and the Netherlands have widely different NIRs between themselves and different from those of the Euro Area, thus suggesting that a single nominal interest rate may not be advisable since this group of countries is fairly heterogeneous, even in the fundamentals, and, consequently, the monetary union may not be so optimal. However,

one should once again mention that these estimates are subject to a high degree of uncertainty and are quite dependent on the specifications of the model so that any inference and conclusions must be dealt with caution.

Besides this, Figure 8 shows that the equilibrium interest rates have been decreasing in all the mentioned economies, reaching negative values. In the case of Italy, the growth rate of potential output has followed this negative trend, seeming to embody the ‘Secular Stagnation’ hypothesis.

5. CONCLUSION

The ability of the European Central Bank to adopt policies that can satisfy all the Euro Area members has been under discussion given these countries’ different economic characteristics. In this research, the methodology of Laubach and Williams (2003) was applied to jointly estimate the output gap, the growth rate of potential output and the NIR for Italy and the Netherlands.

The findings suggest that the ‘Wicksellian’ rate of interest in these economies has been declining for the past 20 years, reaching a negative point. This idea corroborates the results of Holston, Laubach and Williams (2016), who observed a similar phenomenon for Canada, the Euro Area, the United Kingdom and the United States. In line with the authors, these estimates are also subject to a high degree of uncertainty.

A lower average real interest rate implies that episodes, such as the current one in the Euro Area, of “monetary policy being constrained at the effective zero lower bound are likely to be more frequent and longer” (Laubach and Williams, 2016). Therefore, this research results can help policymakers on their decisions regarding future monetary policy, as central bankers can respond to this, for instance, by increasing the inflation objective, or by allowing nominal interest rates to be negative.

Since the sustained decline in the NIR seems to be an international phenomenon, more research ought to be made on the drivers of this rate to improve the credibility of these estimates. The analysis of this research could be repeated for the other Euro Area countries, studying their business cycles and checking whether the monetary union is in fact optimal or not, given their fundamentals. Furthermore, this should inform a discussion on the limits of monetary policy.

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APPENDIX 1 – State-Space Representation

To estimate the Kalman filter, equations (1) to (6) must be rewritten in State-Space form:

$$(1) Y_t = A \cdot x_t + H \cdot \gamma_t + v_t$$

$$(2) \gamma_t = F \cdot \gamma_{t-1} + \varepsilon_t$$

where Y_t is a vector of contemporaneous endogenous observed variables, x_t is a vector of exogenous and lagged exogenous variables, and γ_t is a vector of unobserved states. The matrices A, H and F are the coefficient matrices. The vectors v_t and ε_t are the stochastic disturbances and are assumed to be Gaussian and mutually uncorrelated, with mean zero and variance-covariance matrices R and Q, respectively. Matrix R is assumed to be diagonal. The following parametrization refers to the third stage of the model i.e. the full model:

$$\begin{aligned}
 Y_t &= [y_t \quad \pi_t]' \\
 x_t &= [y_{t-1} \quad y_{t-2} \quad r_{t-1} \quad r_{t-2} \quad \pi_{t-1} \quad \pi_{t-2} \quad \pi_{t-3} \quad \pi_{t-4}]' \\
 \gamma_t &= [y_t^T \quad y_{t-1}^T \quad y_{t-2}^T \quad r_{t-1}^* \quad r_{t-2}^* \quad z_t \quad g_t]' \\
 H &= \begin{bmatrix} 1 & -\alpha_1 & -\alpha_2 & -\frac{\alpha_r}{200} & -\frac{\alpha_r}{200} & 0 & 0 \\ 0 & -100\beta_y & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \\
 A &= \begin{bmatrix} \alpha_1 & \alpha_2 & \frac{\alpha_r}{200} & \frac{\alpha_r}{200} & 0 & 0 & 0 & 0 \\ 100\beta_y & 0 & 0 & 0 & \beta_\pi & \frac{(1-\beta_\pi)}{3} & \frac{(1-\beta_\pi)}{3} & \frac{(1-\beta_\pi)}{3} \end{bmatrix}
 \end{aligned}$$

$$F = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad Q = \begin{bmatrix} (1 + \lambda_g^2)\sigma_T^2 & 0 & 0 & 0 & 0 & 0 & (\lambda_g\sigma_T)^2 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & (\frac{\lambda_z\sigma_y}{\alpha_r})^2 & 0 \\ (\lambda_g\sigma_T)^2 & 0 & 0 & 0 & 0 & 0 & (\lambda_g\sigma_T)^2 \end{bmatrix}$$

The initial conditions for the variable z_t were set to zero. For the remaining state variables, the Hodrick-Prescott (HP) filter was applied to the observed counterpart of the series and this series was used to initialize the state vector. The coefficients were initialized with the coefficient values obtained from simple OLS regressions using the filtered HP series.

APPENDIX 2 – Tables

Table 1 – Augmented Dickey-Fuller Unit Root Tests, Test Statistics

| Variable | Italy | The Netherlands |
|-----------------------|------------|-----------------|
| Inflation | -3.435 * | -3.936 ** |
| Real rate | -1.421 | -1.624 |
| (first-difference) | -10.098 ** | -5.651 ** |
| Logarithm of real GDP | -2.321 | -2.116 |
| (first-difference) | -5.800 ** | -5.650 ** |

Note: * represents that the null hypothesis of unit roots can be rejected with a 5% level of significance and ** represents that it can be rejected with a 1% level of significance

Table 2 – Parameter Estimates

| Parameter | Italy | The Netherlands |
|---|-----------------|-----------------|
| Sample | 1980Q1 – 2016Q3 | 1986Q1 – 2016Q3 |
| λ_g | 0.038 | 0.038 |
| λ_z | 0.041 | 0.122 |
| $\alpha_1 + \alpha_2$ | 0.893 | 0.973 |
| α_r | -0.063 | -0.027 |
| (t-stat) | (1.970) | (0.866) |
| β_y | 0.135 | 0.025 |
| (t-stat) | (2.041) | (0.657) |
| σ_y | 0.206 | 0.237 |
| σ_π | 0.937 | 0.909 |
| σ_T | 0.615 | 0.615 |
| σ_g | 0.023 | 0.023 |
| σ_z | 0.136 | 1.062 |
| $\sigma_r = \sqrt{\sigma_g^2 + \sigma_z^2}$ | 0.138 | 1.062 |
| S.E. (sample average) | | |
| r^* | 1.787 | 9.342 |
| g | 0.378 | 0.447 |
| y^T | 1.248 | 2.678 |
| S.E. (final observation) | | |
| r^* | 2.437 | 14.588 |
| g | 0.473 | 0.633 |
| y^T | 1.159 | 5.016 |

APPENDIX 3 – Figures

Figure 1 – One-sided vs. Two-sided estimates of the Natural Interest Rate, Italy.

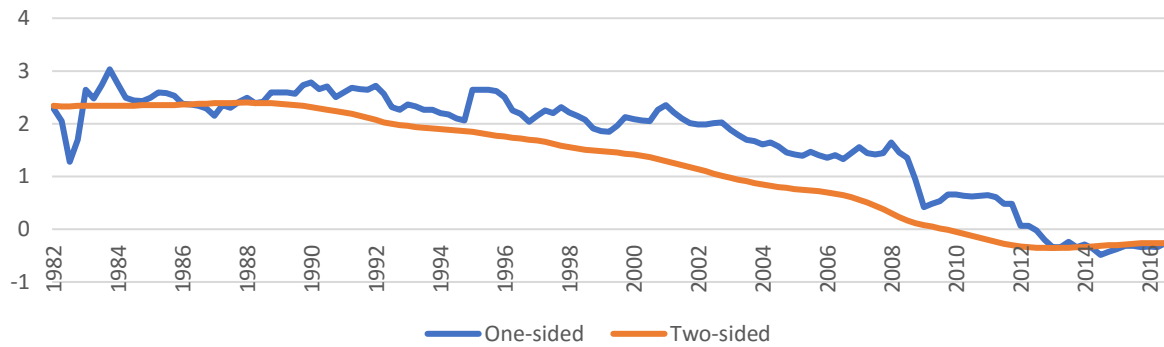


Figure 2 – One-sided vs. Two-sided estimates of the Natural Interest Rate, The Netherlands.

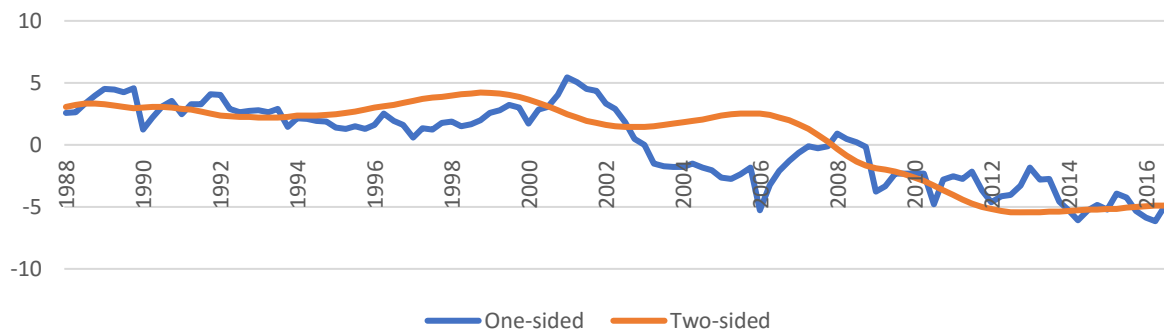


Figure 3 – Real Interest Rate Gap and Output Gap, Italy.

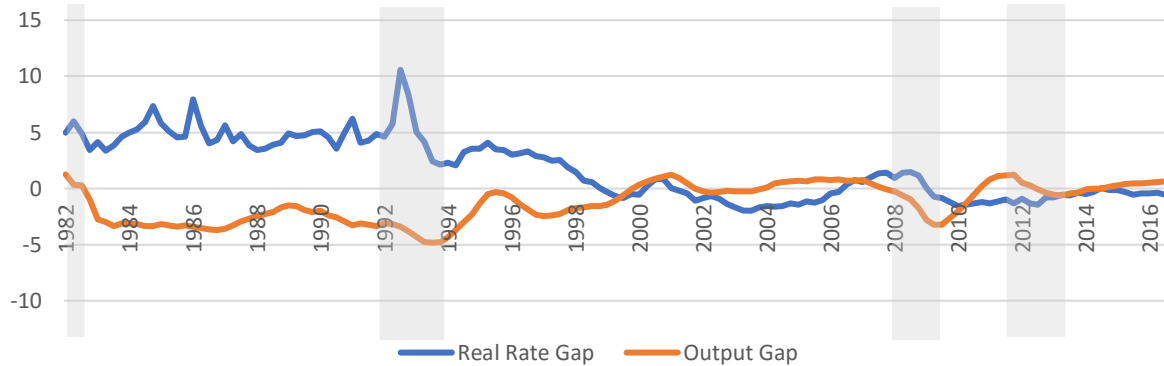


Figure 4 – Real Interest Rate Gap and Output Gap, The Netherlands.

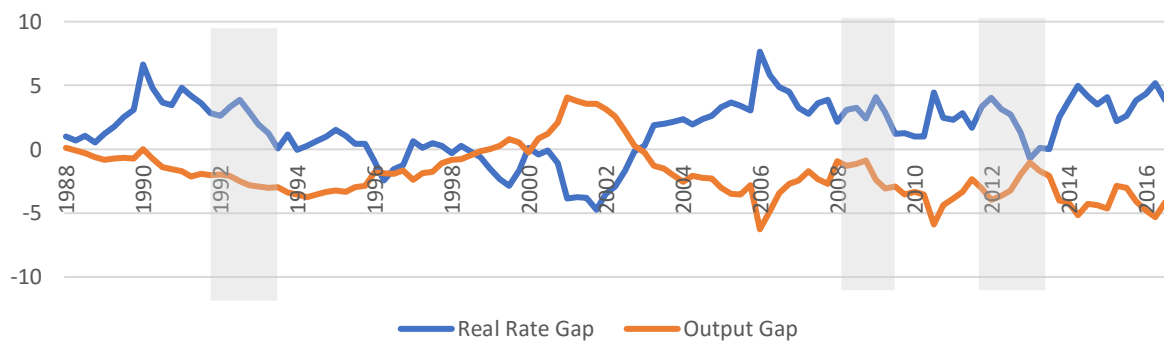


Figure 5 – Estimates of the Natural Interest Rate and the Growth Rate of Potential Output, Italy.

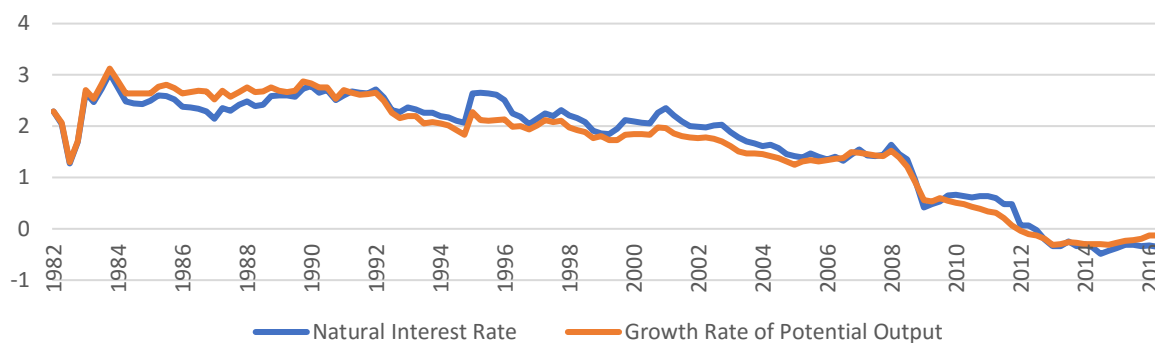


Figure 6 – Estimates of the Natural Interest Rate and the Growth Rate of Potential Output, The Netherlands.

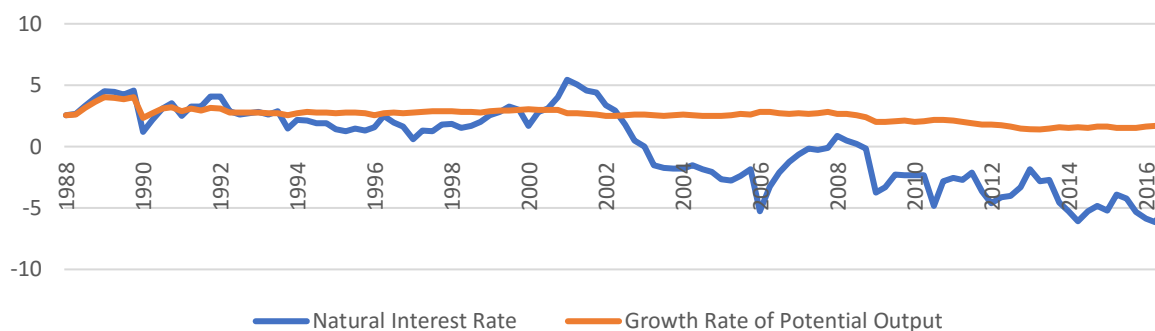


Figure 7 – Comparison of the estimates of the Hodrick-Prescott filter and the Kalman filter, Italy.

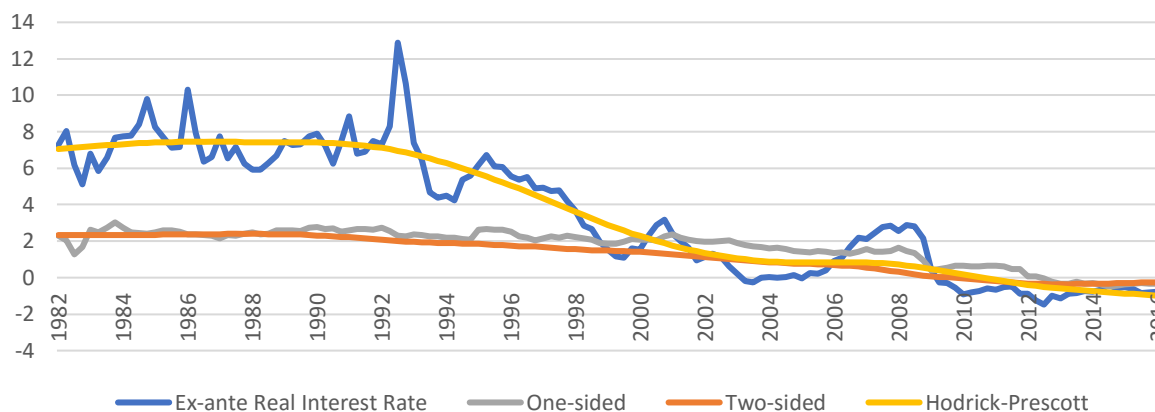


Figure 8 – Comparison of the estimates of the Natural Interest Rate for Italy and the Netherlands with those estimated by Holston, Laubach and Williams (2016) for the Euro Area.

