

Equilibrium Real Interest Rates, Secular Stagnation, and the Financial Cycle: Empirical Evidence for Euro-Area Member Countries

A. Belke, J. Klose

Working paper No. 2019/1 | February 2019 | ISSN 2516-5933



Equilibrium Real Interest Rates, Secular Stagnation, and the Financial Cycle: Empirical Evidence for Euro-Area Member Countries¹

by

Ansgar Belke

(University of Duisburg-Essen, Centre for European Policy Studies, Brussels, DAFM,
London, & Institute for the Study of Labor, Bonn)

and

Jens Klose

(THM Business School, Giessen)

Essen, Brussels and Giessen

February 22, 2019

Abstract

Is the Euro area as a whole, or are individual Euro-area member countries facing a period of sustained lower economic growth, a phenomenon known as secular stagnation? Secular stagnation is likely to occur when real interest rates are higher than equilibrium levels. We expand the standard model to incorporate the financial cycle and show how this affects estimates of equilibrium real interest rates and potential output, and hence assessments of secular stagnation.

Keywords: equilibrium real interest rate, Euro area, financial cycle, heterogeneity, monetary policy, secular stagnation

JEL-codes: E43, F45, C32

¹ Acknowledgement: The authors would like to thank the participants of the 17th Annual Conference of the European Economics and Finance Society (London, 2018) and Sushanta Mallick for comments on earlier versions of this paper.

1. Introduction

The financial crisis has affected European economies in a variety of ways. Perhaps the most important change appears to be evidence of a diminished growth dynamics in Europe as well as other industrialized countries. Summers (2014a, 2014b, 2014c) views this low-growth era as a new period of secular stagnation and thus as a structural and non-temporary phenomenon.² Is the Euro area as a whole, or are individual Euro-area member countries facing a period of sustained lower economic growth, a phenomenon known as secular stagnation? Secular stagnation is likely to occur when real interest rates are higher than equilibrium levels.³

However, standard models to estimate the equilibrium real interest rate do not explicitly model important parts of the economy that have changed over the course of the financial crisis. The most important missing determinant is obviously the financial cycle, as proxied, for instance, by the public and private debt level, which in turn should have an influence on the equilibrium real rate (Claessens et al., 2011, Drehmann et al., 2012, Rey, 2015, and Stremmel, 2015). This is especially important since the financial cycle is well known to influence the business cycle (Borio, 2014; Pontines, 2017; Jorda et al., 2017). Moreover, financial stress or financial uncertainty are crucial for business cycle fluctuations (Mallick and Sousa, 2013; Yildirim-Karaman, 2018). While there is a direct link between financial markets and the business cycle this may at least in part be due to monetary policy influencing either financial markets (see e.g. Granville and Mallick, 2009) and the business cycle (see e.g. Rafiq and Mallick, 2008).

Hence, we expand the standard model to incorporate the financial cycle and show how this affects estimates of equilibrium real interest rates and potential output, and hence assessments of secular stagnation.

² For a critical review of this hypothesis see Belke (2018).

³ See, e.g., Borio et al. 2017 upon this issue.

The main contribution of this paper is thus to augment the model by adding the financial cycle to the Euro area and its individual member countries as Juselius et al. (2017) did for the US. Augmenting the model in this way has the potential to change the estimated equilibrium real rate considerably and thus to change our inferences as to whether or not countries face secular stagnation. If our estimates of the equilibrium real interest rates based on the financial cycle-augmented models turn out to be higher than the standard ones without incorporating the financial cycle, we feel justified to conclude that real monetary policy rates were set even more systematically and consistently below (or not as far above) the natural real rate. In other words, this would prove that attributing the decline in real interest rates primarily to an exogenously caused reduction in the natural interest rate and not taking financial factors into account leads to erroneous conclusions (Borio, 2016).

We thus estimate two versions of the unobserved equilibrium real interest rate, one including the financial cycle and the other omitting it. The latter is the standard model in this respect up to date. Moreover we compare both estimates to the actual real rate in order to assess whether a country faces secular stagnation. We do so for the Euro area as a whole and for nine individual member countries.

The remainder of the paper is organized as follows. In Section 2 we present the theoretical basis for secular stagnation and discuss the role of equilibrium real rates and the financial cycle in it. Section 3 presents the standard Laubach-Williams model, being the model most widely used to estimate the equilibrium real interest rate, and our expansion thereof to incorporate the financial cycle. In Section 4, the data used for our estimations are explained in detail, while Section 5 presents our empirical results. Section 6 finally concludes.

2. Equilibrium real interest rates, secular stagnation and the financial cycle

The financial crisis of 2008/09 reduced output in leading developed countries considerably. But even after the most severe tensions had been eased, output growth remained consistently lower than before the crisis. This phenomenon may be explained by the permanent drop in potential output,⁴ and has therefore been referred to as “secular stagnation” (Summers, 2014a, 2014b, 2014c, and Teulings and Baldwin, 2014).⁵

The secular stagnation hypothesis focuses on the real interest rate and its equilibrium value. Under normal circumstances, both should be equalized at the point where aggregate investments equal aggregate savings. However, in a crisis period, and even afterwards, this may no longer be the case. The reason for this is quite simple. While the equilibrium real rate floats freely, the actual real rate faces a lower bound. The latter is due on the one hand to the zero lower bound on nominal interest rates, because individuals can hold excess savings in cash rather than in their bank accounts, thus generating a nominal interest rate of zero.⁶ On the other hand, inflation rates or, more precisely, inflation expectations are too low to generate significantly negative real rates. For example, inflation expectations are mainly anchored at about 2 percent in the countries under investigation, being the inflation target of the ECB.⁷

- Figure 1 about here -

⁴ Summers 2014a and 2014b presents empirical evidence of this drop based on potential output growth forecasts for the US and the Euro area.

⁵ In fact, Summers was not the first to detect and make a case for secular stagnation. This term goes back to 1939, when Hansen first developed this theory in what may be considered a similar situation.

⁶ Please note that there are ways to incorporate the expansionary monetary policy of central banks into a so-called shadow rate (Wu and Xia, 2016), thus this shadow can reach lower levels than zero. However, we refrain from using this indicator because data on shadow rate are not available for all countries under investigation and those interest rates are in itself estimates and not observed market rates.

⁷ This being said, one way to significantly lower the actual real rates is to increase the inflation target. For example, Blanchard et al. (2010) proposed increasing the target to about four percent. However, the ECB has not yet changed its inflation target of close to but below two percent in the medium term.

However, if the equilibrium real interest rate falls below the lower bound of the actual real rate, there is no longer an equilibrium of aggregate investments and savings (Figure 2). So a liquidity trap via excess savings occurs (Crafts, 2015). This permanently lowers the growth rates in the respective country by reducing potential output growth (Teulings and Baldwin, 2014). Secular stagnation is thus a structural problem which has long term consequences, leading, e.g., to permanently higher unemployment rates. While shorter periods of negative real interest rates may be tackled by an expansionary monetary policy or fiscal demand-side stimulus, long-term challenges are best met by appropriate supply-side reforms or a combination of supply-side reforms and aggregate demand policies (two-handed approach under hysteresis, Draghi, 2014).

In terms of altered savings and investments, several determinants have been proposed that may have forced economies into secular stagnation since the financial crisis started. On the one hand, these include determinants that only influence savings, for instance, the preference for safe assets, which led to an increase in savings (Caballero and Farhi, 2014), or income inequality (Summers, 2014b). On the other hand, there are determinants that only influence investments, for instance, the degree of innovation (Gordon, 2014, Mokyr, 2014 and Glaeser, 2014), regulation (Jimeno et al., 2014 and Barnes et al., 2013), and declining investment good prices (Summers, 2014b or Glaeser, 2014). Finally, there are determinants such as demographics that affect both savings and investments (Browning and Crossley, 2001, Jimeno et al., 2014 or Gros, 2014).

One other driver of savings and investments is the financial cycle, which affects the ratio of public and private debt to non-financial assets held by households and non-financial corporations (Alcidi, 2017). A high degree of private and public debt relative to assets depresses investment even at low interest rates because individuals and fiscal authorities need to consolidate in the wake of the financial crisis. Moreover, savings are increased to reduce the level of debt. However, supporters of the secular stagnation hypothesis see the key to breaking

the vicious circle of permanently lower growth rates in reducing the pressure to consolidate. They tend to propose a lower speed of consolidation and instead favor increasing public investment (Summers, 2014a, Krugman, 2014 and Koo, 2014). In this paper, we implement the financial cycle as proposed by Juselius et al. (2017) in an otherwise standard Laubach-Williams model, which is frequently used to estimate the unobservable equilibrium real interest rate. We explain the way the financial cycle is implemented into the model in the next section.

3. The Laubach-Williams model and the financial cycle

The Laubach-Williams model we use consists of two signal equations and three state equations. All variables are measured as quarterly growth rates. The signal equation (1) is an IS-curve measuring the effect of the first two lags of the real interest rate gap ($r - r^*$) on the output gap ($Y - \bar{Y}$). Additionally, two lags of the output gap are added to the equation. Equation (2) is the second signal equation, which measures a Phillips curve estimating the influence of the output gap on prices (π). Moreover, the prices are assumed to vary with lagged energy prices (π^o) since those are a crucial input factor in the production process.⁸ Again, lagged values of the dependent variable are added. In this case, and in line with Laubach and Williams (2003), we add eight lags assuming the second to fourth and fifth to eighth lags to have the same influence. Moreover, the coefficients of the lagged inflation rates are restricted to unity, in line with the aforementioned seminal paper.

$$Y_t - \bar{Y}_t = \alpha_{y,1}(Y_{t-1} - \bar{Y}_{t-1}) + \alpha_{y,2}(Y_{t-2} - \bar{Y}_{t-2}) + \frac{\alpha_r}{2}[(r_{t-1} - r_{t-1}^*) + (r_{t-2} - r_{t-2}^*)] + \varepsilon_{1,t} \quad (1)$$

⁸ Laubach and Williams (2003) also use import prices as a variable in their Phillips curve specification. We are unable to proceed in that manner here because import price data for most of the Euro-area countries under investigation here are not available for our whole sample period. This would have shortened our sample period considerably, leading to imprecise estimates owing to low degrees of freedom. Garnier and Wilhelmsen (2009) face the same problem when estimating the model for the Euro area. Moreover, Laubach and Williams (2003) added hours worked to their Phillips curve as a robustness check. We also refrain from adding this specification because of data availability and are thus in this respect again in line with Garnier and Wilhelmsen (2009).

$$\pi_t = \beta_{\pi,1}\pi_{t-1} + \frac{\beta_{\pi,2}}{3}(\pi_{t-2} + \pi_{t-3} + \pi_{t-4}) + \frac{1-\beta_{\pi,1}-\beta_{\pi,2}}{4}(\pi_{t-5} + \pi_{t-6} + \pi_{t-7} + \pi_{t-8}) + \beta_y(Y_{t-1} - \bar{Y}_{t-1}) + \beta_o(\pi_{t-1}^o - \pi_{t-1}) + \varepsilon_{2,t} \quad (2)$$

$$\bar{Y}_t = \bar{Y}_{t-1} + g_{t-1} + \varepsilon_{3,t} \quad (3)$$

$$g_t = g_{t-1} + \varepsilon_{4,t} \quad (4)$$

$$z_t = z_{t-1} + \varepsilon_{5,t} \quad (5)$$

$$r_t = i_t - \pi_{t-1} \quad (6)$$

$$r_t^* = c g_t + z_t \quad (7)$$

The state equations model the time-series generating process of the two unobservable variables, potential output and equilibrium real interest rate. The potential output \bar{Y} is a function of its lagged own value and its unobservable growth rate g (Equation (3)). The growth rate of the potential output is in itself a state variable following a random walk (Equation (4)) as well as the last state variable z (Equation (5)), measuring additional determinants of the equilibrium real rate, such as the time preference of households. The last two equations, (6) and (7), show how the real rate and its equilibrium value are built. In order to save degrees of freedom, the inflation expectations in the real rate are modelled simply by the using adaptive expectations, thus being the lagged inflation rate. This is in line with other studies estimating the equilibrium real rate for the Euro area (Mesonnier and Renne, 2007, Garnier and Wilhelmsen, 2009, Belke and Klose, 2013 and 2017, Beyer and Wieland, 2017, Klose, 2017 or Fries et al., 2018). The equilibrium real rate is generated in line with Laubach and Williams (2003), representing the sum of trend growth and any additional factors. These additional factors are restricted to have an influence of unity on the equilibrium real rate.

To implement the financial cycle into the standard Laubach-Williams framework, Juselius et al. (2017) propose to expand the model by an additional signal equation covering the leverage gap (l) which is expected to be influenced by its own lag the real interest rate gap and the debt-service ratio (dsr) as shown in equation (8).

$$l_t = \gamma_l l_{t-1} + \gamma_r [(r_{t-1} - r_{t-1}^*) + (r_{t-2} - r_{t-2}^*)] + \frac{\gamma_s}{2} (dsr_{t-1} + dsr_{t-2}) + \varepsilon_{6,t} \quad (8)^9$$

Moreover, the IS-equation (1) is modified to include the leverage gap since a high leverage gap should also lower output since the economy tends to invest less and needs to consolidate. This implies a negative coefficient of the leverage gap. But also a positive coefficient is possible due to wealth effects as Juselius et al. (2016) find them for the US. Thus increasing leverage is used e.g. for consumption purposes thus boosting output.

$$Y_t - \bar{Y}_t = \alpha_{y,1}(Y_{t-1} - \bar{Y}_{t-1}) + \alpha_{y,2}(Y_{t-2} - \bar{Y}_{t-2}) + \frac{\alpha_r}{2} [(r_{t-1} - r_{t-1}^*) + (r_{t-2} - r_{t-2}^*)] + \alpha_l l_t + \varepsilon_{1,t} \quad (1a)$$

However, Laubach and Williams (2013) point out that the error terms in the state equations (4) and (5) are biased towards zero if the model is estimated in one step. This is due to the so-called econometric “pile-up problem” (Stock, 1994).¹⁰ They therefore recommend estimating the model in sequential steps and computing the median unbiased estimator (Stock and Watson, 1998) to solve this problem. We follow this procedure strictly, estimating the model in four steps.

⁹ Juselius et al. (2017) use only the contemporaneous real interest rate gap in their leverage gap equation as they also do in their IS equation. However, the original Laubach-Williams model uses the first two lags in the latter. That is why we decided to use also the first two lags in the leverage gap equation for reasons of comparability. The same holds with respect to the debt-service gap where we also use two lags in the leverage gap equation instead of only one as in Juselius et al. (2017).

¹⁰ The pile-up problem emerges when pure maximum likelihood methods tend to estimate the standard deviations equal to zero. Given that this is very likely to be the case in our random walk equations (4) and (5), we have to correct for this.

Firstly, both signal equations are estimated separately via OLS to generate reliable starting values. Potential output is proxied by the HP-filter of Y (Hodrick and Prescott, 1997). In the IS equation, the real interest rate gap is omitted at this stage.¹¹

Second, the signal equations are estimated with the Kalman filter, assuming the growth rate of potential output is constant. With these results, we are able to compute the median unbiased estimator $\lambda_g = \frac{\sigma_4}{\sigma_3}$.

This relationship is used in the third step as a starting point. There we also add the real interest rate gap to the IS equation and model the growth rate of potential output as a time-varying variable. Based on these results, we compute the median unbiased estimator for the additional variables affecting the equilibrium real interest rate as $\lambda_z = \frac{\sigma_5}{\sigma_1} \cdot \frac{\alpha_r}{\sqrt{2}}$.

In the fourth and final step of the standard Laubach-Williams model, we estimate the whole model via maximum likelihood, using the two signal-to-noise ratios.

We have restricted the two coefficients α_r and c to lie in the range of -0.3 to 0 and 0.5 to 1.5, respectively. With these restrictions we are well in line with the findings of previous studies where all estimated coefficient parameters fall within these margins.

In order to expand the model by including the leverage gap equation we expand the estimation by two more steps. Since the debt-service ratio is only available for some countries in our study and also only from 1999 onwards, which turned out to be too short a period to generate reliable estimates, we also treat this variable as unobservable, like the potential growth rate and the additional factors. But we follow Juselius et al. (2017) who add lagged the leverage gap because of the feedback loop of new debt on the debt service ratio and the change in the average nominal

¹¹ This corresponds with the standard procedure according to Laubach and Williams (2003, 2015). For a further practical application see, for instance, Belke and Klose (2017).

interest rate ($\Delta i_{L_{t-1}}$). This average is used since debt service is not only influenced by the current but also by previous interest rates.

$$dsr_t = dsr_{t-1} + \delta_s l_{t-1} + \delta_i \Delta i_{L_{t-1}} + \varepsilon_{7,t} \quad (9)$$

In a fifth step, we therefore add the leverage gap equation (8) and the modified IS-equation (1a) to the standard Laubach-Williams model. In the leverage gap equation, we do not, at this stage, add the debt-service ratio because the pile-up problem occurs for this unobservable variable as well.

Therefore, we use the results of step five to estimate the median unbiased estimator as $\lambda_s = \frac{\sigma_7}{\sigma_6} \cdot \frac{\gamma_s}{\sqrt{2}}$. Using this parameter, we can estimate the whole model via maximum likelihood. To do so, we also restrict the parameter γ_s to lie in a wide range between 0 and 10. This was the case in all our estimations presented below.

4. The data issue

The standard Laubach-Williams model estimates two unobservable variables: the equilibrium real interest rate and potential output. The method is frequently used to estimate the equilibrium real interest rate.¹² Also for the Euro area, Mesonnier and Renne (2007), Garnier and Wilhelmsen (2009), Belke and Klose (2013), Beyer and Wieland (2017) and Holston et al. (2017) have used the model to find a measure of the equilibrium real interest rate. Fries et al. (2018) estimate the model for the four largest Euro area economies while Belke and Klose (2017) do it for even 12 Euro-area member countries. However, all of those papers use some version of the standard Laubach-Williams model.

¹² See, e.g., Trehan and Wu (2004), Clark and Kozicki (2005), Kiley (2015) or Laubach and Williams (2015) for the US. Holston et al. (2017) estimate the model for the US, Canada, the UK, and the Euro area.

Our approach expands the model by introducing the financial cycle into it, as Juselius et al. (2017) proposed in a slimmed version for the United States. The financial cycle is introduced here by implementing two additional variables: the leverage gap and the debt-to-service ratio. Since in our case the latter is not available for a period dating far enough into the past to obtain reliable estimates, we model it as an unobservable variable. The leverage gap is modelled in line with Juselius et al. (2017) as the sum of credit to households and non-financial corporations and dividing this by the non-financial assets of the same two groups.¹³ The gap is then calculated by dividing the ratio by its sample mean. The resulting leverage gaps whose changes represent the financial cycle are shown in Figure (2).

- Figure 2 about here -

In general, the leverage gaps appear to exhibit a positive trend for almost all Euro-area member countries.¹⁴ But especially for Greece and Italy, the economic setback resulting after the financial crisis in the years 2011/12 is clearly visible, since the leverage gap dropped suddenly in value around this time, having increased strongly before.

We estimate the model with respect to nine Euro- area member countries, eight of which were founding members of the Euro area,¹⁵ and Greece, which was the first country to join the monetary union in 2001. Moreover, we estimate the model for the Euro area as a whole. For most of our nine countries and the Euro area in the sample, we obtained quarterly data dating back to 1995. However, for France, the time series date back to 1978, and for Germany to 1991.

¹³ As a robustness check we also used only the real estate assets. The results are broadly the same as for the non-financial assets. Moreover, we model only private debt while public debt may in principle have the same effects on savings and investments and thus the equilibrium real rate.

¹⁴ Please note that this positive trend does not cause any estimation problems because the leverage gap enters into the model with its quarterly growth rate which appears to be stationary for all countries.

¹⁵ Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, and the Netherlands. For the remaining three founding members, Ireland, Portugal, and Spain, we were unable to calculate the leverage gap due to missing data. The other seven countries that have now adopted the Euro were also excluded due to data non-availability.

The end of the sample period is 2015Q4 for all countries under investigation, due to data availability issues.

For each of these countries, we have collected the data on real GDP, consumer prices, energy prices, and interest rates besides the leverage gap explained above. All data are seasonally adjusted and taken from the OECD database. As the relevant interest rate, we use the three-month interbank rate in line with several of the other studies in this field cited above. Since the countries in question have not had their own interbank rates since the Euro area was established, we added the data from the three-month EURIBOR for all dates where each respective country was a member of the monetary union, that is, starting in 1999 for the eight founding members and in 2001 for Greece.

Our interpretation of the results is based on a comparison of the estimated equilibrium real rate and the observed real rate. For this purpose, we make use of two concepts in measuring the latter: ex-ante and ex-post real rates. The former represents the nominal interest rate minus the expected inflation, which in our case is specified as the lagged inflation rate according to the adaptive expectations hypothesis ($r_t = i_t - \pi_{t-1}$), while the latter is formulated as the interest rate minus the observed inflation rate until maturity ($r_t = i_t - \pi_t$).¹⁶ Even though the estimated real interest rates turn out to differ depending on the concept used, this will have only a minor influence on the results, i.e., whether or not we are able to conclude that secular stagnation may be a relevant problem in a Euro-area member country.

¹⁶ See also Hamilton et al. (2015) upon this issue.

5. Results

Our results of the standard Laubach Williams model (Table 1)¹⁷ indicate that the coefficients are generally in line with previous studies. This holds also for the restrictions set on some coefficients. However, especially with respect to α_r , the influence of the real interest rate gap on output, we are unable to obtain significant parameter estimates. However, other studies (Mesonnier and Renne, 2007, Garnier and Wilhelmsen, 2009, and Belke and Klose, 2017) encountered similar problems when estimating the model. Only for France do we indeed find a significantly negative coefficient. But the point estimates, which are about -0.15 in most of the cases, are very stable over the various countries. With respect to the parameter c , which represents the influence of potential growth on the equilibrium real rate and is inserted into our IS equation, we find significant estimates for two countries (Finland and Greece). Moreover, the point estimates vary widely, with a range of 0.5 to 1.5, although none of these actually hits the boundaries we set at the end of Section 3. Our median unbiased estimators λ_g are generally in line with estimates for other countries in previous studies. The estimate of λ_z is, however, slightly lower.¹⁸ But the remaining parameter estimates and variances are well in line with other studies in this field. Thus, we feel justified in concluding at this stage that the parameter estimates are generally comparable with those from other studies.

- Table 1 about here -

Expanding the model to include the financial cycle, the coefficient estimates does not change much in most cases; thus, our results remain robust (Table 2). Moreover, most of the coefficients associated with the leverage gap show the expected signs, i.e a positive influence

¹⁷ Only the final estimates of the fourth step are presented here. The results for the previous steps are available from the authors upon request.

¹⁸ Please note that we explicitly estimate the median unbiased estimator. Other studies in this field so far (Mesonnier and Renne, 2007, Garnier and Wilhelmsen, 2009, or Beyer and Wieland, 2017) had to restrict this coefficient to obtain reasonable results.

of the real rate gap in the leverage gap equation, although the coefficients remain insignificant in the majority of the cases. The same holds with respect to the leverage gap response in the IS-curve. In four out of ten cases it is (insignificantly) negative, pointing to the need for consolidation, and in the remaining six countries it is positive, hinting to wealth effect of increased leverage. Only for Austria the response is, however, found to be significant. The restriction imposed on the debt-service ratio proves to be valid, with only two countries coming close to the lower bound of zero but actually not meeting it. We can therefore also conclude for the expanded model including the financial cycle that coefficient estimates are generally plausible.

- Table 2 about here -

5.1. Output gap

The Laubach-Williams model estimates not only the equilibrium real interest rates but also the potential output, thus allowing the output gap to be estimated. Here we have generated two estimates of the output gap: The first is based on the standard Laubach-Williams model and the second on the extended model, incorporating the leverage gap in the IS equation (Figure 3). The output gaps are based on the predicted or one-sided estimates. However, the results for the smoothed or two-sided estimates present a similar picture, and are available from the authors upon request.

- Figure 3 about here -

Thus, the output gaps should differ because of this different setting. However, for the Euro area as a whole, and most Euro-area member countries, the output gaps are broadly comparable when the financial cycle is included in the model. Only for Austria, Belgium, and Germany do the output gaps tend to increase when the financial cycle is included, while the output gap

decreases when the model is augmented with the financial cycle in the case of Luxembourg. The latter is possibly due to important role of the financial industry in Luxembourg.

5.2 Ex-ante real interest rates

Concerning the estimates of the equilibrium real interest rate, we first compare them to the ex-ante real rates. The one-sided (predicted) estimates deliver some interesting results (Figure 4).

- Figure 4 about here -

First, for the Euro area as a whole, the equilibrium real interest rate incorporating the financial cycle in the Laubach-Williams model leads to slightly lower rates than in the standard model. Our findings for the Euro area therefore differ from those of Juselius et al. (2017), who estimated higher equilibrium rates for the United States when the financial cycle was added. However, the real interest rate is even lower in these cases. Hence, there is no indication that secular stagnation has been a problem in recent years, even if the financial cycle is taken into account. The same holds for Austria and Luxembourg.

Second, for some countries, the equilibrium real rate tends to be higher when the financial cycle is added to the model. This holds for Belgium, Italy, and the Netherlands. But for Italy and the Netherlands, the actual real rate was even lower than the equilibrium real rate excluding the financial cycle. So with our extended model, for these countries, it becomes even clearer that they are not facing a period of secular stagnation. However, for Belgium, both equilibrium real rate estimates are clearly negative at the end of the sample period and thus even lower than the actual real rate, suggesting that secular stagnation may be a problem in this case from a Bayesian viewpoint. It must be admitted, however, that the estimation uncertainty surrounding the equilibrium real rate estimates is quite large, making it difficult to identify significant differences from the actual real rate. This holds not only for Belgium but also for all other countries.

Third, for the remaining countries, there is no clear inference whether the equilibrium real rate estimated with the model including the financial cycle is higher or lower. For one country (Greece), the estimates are indeed quite similar, while for others (Finland, France and Germany), the estimates with the extended model are below the standard model estimates in one period and above in other periods. Especially with respect to France, the equilibrium real interest rate seems to be more volatile when the financial cycle is added to the model. There are several periods where both estimates of the equilibrium real rate well below -2 percentage points, which may cause problems of secular stagnation. The same also holds for Greece, where both equilibrium real rate estimates are considerably lower than the actual real rate; thus, secular stagnation may be present in this country as well.

- Figure 5 about here -

The results are reinforced further when the two-sided (smoothed) estimates are considered (Figure 5). The same trends can be identified in the equilibrium real rate with and without the financial cycle. Moreover, there are concerns whether Belgium, France, or Greece face secular stagnation, but these exist irrespective of the model used.¹⁹

5.3 Ex-post real interest rates

When we employ ex-post realized real interest rates instead of ex-ante rates, the estimates for the equilibrium rates remain almost unchanged: They are only shifted backwards by four quarters, but the estimates themselves remain the same (see Figure 6 for the one-sided time-series, and Figure 7 for the two-sided estimates). However, the empirical realizations of the real interest rates might be different. While we observe that the values are indeed different from those obtained with the ex-ante data, the overall results remain robust. Hence, our observations

¹⁹ Please note that Belke and Klose (2017) found only Greece to be facing problems of secular stagnation in a standard Laubach-Williams model that was more or less the same as ours. However, the results differ for Belgium and France because of the considerably shorter sample period due to limitations in data availability with respect to the financial cycle.

in the previous section regarding the differences between the two equilibrium real rates estimated with our two models are still valid. Only Belgium, France, and Greece therefore face problems concerning secular stagnation.

- Figures 6 and 7 about here -

6. Conclusions

In this paper, we have investigated whether the Euro area as a whole or individual Euro-area member countries face a period of sustained lower economic growth, a phenomenon known as secular stagnation. We have addressed this question by estimating equilibrium real interest rates in the Euro area, employing the Laubach-Williams method, and comparing them to actual real rates. Since the financial crisis has altered the degree of leverage in several European economies, we have expanded our model to incorporate the financial cycle.

We have estimated the models with respect to the Euro area as a whole and individually for nine Euro area member countries. We have shown that incorporating the financial cycle indeed changes the estimated equilibrium real interest rates. For a few Euro-area member countries, our estimates of the equilibrium real interest rate are clearly higher than the standard ones. We thus show that attributing the decline in real interest rates primarily to an exogenously caused reduction in the natural interest rate is inadequate and does not take financial factors into account. In other cases, including our estimates for the Euro area as a whole, the estimated equilibrium real rates are slightly lower than without taking the financial cycle into account, but are still higher than the actual rates. This indicates that real monetary policy rates were set even more systematically and consistently below (or not as far above) the natural real rate. Comparing the sequence of actual and equilibrium real rates, only Belgium, France, and Greece may potentially be facing a period of secular stagnation. Even though incorporating the

financial cycle changes the estimated equilibrium real interest rate considerably in some cases, the inference of secular stagnation thus remains overall robust for nearly all countries.

The finding that some Euro area countries may be subject to secular stagnation while others are not has important implications for economic policy. E.g. the ECB seems to face some kind of heterogeneity in the Euro area with respect to secular stagnation. Therefore, it cannot be guaranteed monetary policy by the ECB will be kept the monetary stance too loose for too long to help those countries. If this is the case, this does not only affect the countries in the Euro area but also other countries which are quite dependent on ECB monetary policy. This holds especially for other European countries like the United Kingdom, Norway, Denmark or Switzerland. These countries may capital inflows once they normalize their monetary policy while the ECB is still being accommodative in order to let all Euro area countries overcome a period of secular stagnation.

However, some caveats to the financial cycle-augmented model introduced by Juselius et al. (2017) should be noted that point to areas requiring further research: First, in the current setting, the leverage gap is added to the model as an additional explanatory variable, which is influenced by the real rate gap and thus the equilibrium real rate. But our remarks in Section 2 suggest that the mechanism may also work the other way around, i.e., leverage may determine the equilibrium real interest rate. Therefore, the state equation forming the additional factors could be expanded by the leverage gap.

Second, this study uses only private-sector leverage data. However, public debt is also a problem especially in several southern European countries. Therefore, the analysis could be expanded to incorporate public debt or leverage as well.

Third, statistical inference regarding secular stagnation is difficult due to the large confidence bands around our estimated equilibrium real rates. This holds irrespectively of whether the

standard Laubach-Williams model or the financial cycle-augmented version is used. The main reason for this is the short sample period, starting in 1995 for most of the countries. Therefore, more (and earlier) data should be collected to allow for more robust inferences.

References

Alcidi, C. (2017): Fiscal Policy Stabilisation and the Financial Cycle in the Euro Area, Discussion Paper 52, Fellowship Initiative “Challenges to Integrated Markets”, European Commission, Brussels, July.

Barnes, S., Bouis, R., Briard, P., Dougherty, S. and Eris, M. (2013): The GDP Impact of Reforms - A Simple Simulation Framework, OECD Economics Department Working Papers, No. 834.

Belke, A. (2018): Secular Stagnation, Unemployment Hysteresis and Monetary Policy in EMU: Scratches but Not Scars?, Economist’s Voice, 4 December, <https://doi.org/10.1515/ev-2018-0034>.

Belke, A. and Klose, J. (2013): Modifying Taylor-Reaction Functions in the Presence of the Zero-Lower-Bound - Evidence for the ECB and the Fed, Economic Modelling, Vol. 35, pp. 515-527.

Belke, A. and Klose, J. (2017): Equilibrium Real Interest Rates and Secular Stagnation: An Empirical Analysis for Euro-Area Member Countries, Journal of Common Market Studies, Vol 55(6), pp. 1221-1238.

Beyer, R.C.M. and Wieland, V. (2017): Instability, Imprecision and Inconsistent Use of Equilibrium Real Interest Rate Estimates, IMFS Working Paper, No. 110, Frankfurt/Main.

Blanchard, O., Dell'Ariccia G. and Mauro, P. (2010): Rethinking Macroeconomic Policy, IMF Staff Position Note 10/03.

Borio, C. (2014): The Financial Cycle and **Macroeconomics: What have we learnt?**, Journal of Banking and Finance, Vol. 45, pp. 182-198.

Borio, C. (2016): Revisiting Three Intellectual Pillars of Monetary Policy, Cato Journal, Vol. 36(2), pp. 213-238.

Borio, C., Disyatat, P., Juselius, M. and Rungcharoenkitkul, P. (2017): Why so Low for so Long? A Long-Term View of Real Interest Rates, Bank of Finland Research Paper No. 36/2017.

Browning, M. and Crossley, T.F. (2001): The Life-Cycle Model of Consumption and Savings Journal of Economic Perspectives, Vol. 15(3), pp. 3-22.

Caballero, R.J. and Farhi, E. (2014): On the Role of Safe Assets Shortages in Secular Stagnation in “Secular Stagnation: Facts, Causes and Cures” VoxEU (2014), pp. 111–122.

Clark, T.E. and Kozicki, S. (2005): Estimating Equilibrium Real Interest Rates in Real Time, The North American Journal of Economics and Finance, Vol. 16(3), pp. 395-413.

Claessens, S., Kose, M.A., and Terrones, M.E. (2011): How Do Business and Financial Cycles Interact?, IMF Working Paper WP/11/88, International Monetary Fund, Washington/DC.

Crafts, N. (2015): Is Secular Stagnation the Future for Europe?, The University of Warwick Working Paper Series No. 225, University of Warwick/UK.

Draghi, M. (2014): Unemployment in the Euro Area, Speech at the Annual Central Bank symposium in Jackson Hole, United States, 22 August, web (access 18 January, 2018): <http://www.ecb.europa.eu/press/key/date/2014/html/sp140822.en.html>.

Drehmann, M., Borio, C., and Tsatsaronis, K. (2012): Characterising the Financial Cycle: Don't Lose Sight of the Medium Term!, BIS Working Paper 380, Bank for International Settlements, Basle.

Fries, S., Mesonnier, J.S., Mouabbi, S. and Renne, J.P. (2018): National Natural Rates of Interest and the Single Monetary Policy in the Euro Area, *Journal of Applied Econometrics*, Vol. 33, pp. 763-779.

Garnier, J. and Wilhelmssen, B.J. (2009): The Natural Rate of Interest and the Output Gap in the Euro Area: A Joint Estimation, *Empirical Economics*, Vol. 36, pp. 297-319.

Granville, B. and Mallick, S.K. (2009) Monetary and Financial Stability in the Euro Area: Procyclicality versus Trade-off, *Journal of International Financial Markets, Institutions & Money*, 19 (4), pp. 662–674.

Glaeser, E. (2014): Secular Joblessness, in "Secular Stagnation: Facts, Causes and Cures", VoxEU, pp. 69-82.

Gordon, R. (2014): The Turtle's Progress: Secular Stagnation Meets the Headwinds, in "Secular Stagnation: Facts, Causes and Cures", VoxEU, pp. 47-60.

Gros, D. (2014): Investment as the Key to Recovery in the Euro Area, CEPS Policy Briefs, 18. November 2014, Brussels.

Hansen, A. (1939): Economic Progress and Declining Population Growth, *American Economic Review*, Vol. 29(1), pp. 1-15.

Holston, K., Laubach, T. and Williams J.C. (2017): Measuring the Natural Rate of Interest: International Trends and Determinants, *Journal of International Economics*, Vol. 108(S1), pp. S59-S75.

Jimeno, J., Smets, F. and Yiangou, J. (2014): Secular Stagnation: A view from the Eurozone, in "Secular Stagnation: Facts, Causes and Cures", VoxEU, pp. 153-164.

Jorda, O., Schularik, M. and Taylor, A. (2017): Macrofinancial History and the New Business Cycle Facts, NBER Macroeconomics Annual, Vol. 31(1), pp. 213-263.

Juselius, M., Borio, C., Disyatat, P. and Drehmann, M. (2016): Monetary Policy, the Financial Cycle and Ultra-Low Interest Rates, BIS Working Paper, No. 569.

Juselius, M., Borio, C., Disyatat, P. and Drehmann, M. (2017): Monetary Policy, the Financial Cycle and Ultra-Low Interest Rates, International Journal of Central Banking, Vol. 13(3), pp. 55-90.

Kiley, M.T. (2015): What Can the Data Tell Us About the Equilibrium Real Interest Rate?, Finance and Economics Discussion Series 2015-077, Board of Governors of the Federal Reserve System.

Klose, J. (2017): Secular Stagnation in Non-EMU-European Countries: Equilibrium Real Rate Approach, Journal of Economic Integration, Vol. 32(2), pp. 400-432.

Koo, R. (2014): Balance Sheet Recession is the Reason for Secular Stagnation, in "Secular Stagnation: Facts, Causes and Cures", VoxEU, pp. 131-142.

Krugman, P. (2014): Four Observations on Secular Stagnation, in "Secular Stagnation: Facts, Causes and Cures", VoxEU, pp. 61-68.

Laubach, T. and Williams J.C. (2003): Measuring the Natural Rate of Interest, The Review of Economics and Statistics, Vol. 85(4), pp. 1063-1070.

Laubach, T. and Williams J.C. (2015): Measuring the Natural Rate of Interest Redux, FRBSF Working Paper, 2015-16.

Mallick, S.K. and Sousa, R.M. (2013): The Real Effects of Financial **Stress in the Eurozone**, International Review of Financial Analysis, Vol. 30, pp. 1-17.

Mesonnier, J.S. and Renne, J.P. (2007): A Time-Varying "Natural" Rate of Interest for the Euro Area, European Economic Review, Vol. 51, pp. 1768-1784.

Mokyr, J. (2014): Secular Stagnation? Not in your life, in "Secular Stagnation: Facts, Causes and Cures", VoxEU, pp. 83-90.

Pontines, V. (2017): The Financial Cycles in Four East Asian **Economies**, Economic Modelling, Vol. 65, pp. 51-66.

Rafiq, M.S. and Mallick, S.K. (2008), The Effect of Monetary Policy on Output in EMU3: A Sign Restriction Approach, Journal of Macroeconomics, 30 (4), pp. 1756-1791.

Rey, H. (2015): Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence, NBER Working Paper No. 21162, National Bureau of Economic Research, Cambridge/MA.

Stock, J. (1994): Unit Roots, Structural Breaks and Trends, in Engle, R. and McFadden, D., Handbook of Econometrics, Vol. 4, pp. 2739-2841, Amsterdam.

Stock, J. and Watson, M. (1998): Median Unbiased Estimator of Coefficient Variance in a Time-Varying Parameter Model, Journal of the American Statistical Association, Vol. 93, pp. 349-358.

Stremmel H. (2015): Capturing the Financial Cycle in Europe, ECB Working Paper 1811, European Central Bank, Frankfurt/Main, June.

Summers, L. (2014a): U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound, Business Economics, Vol. 49(2), pp. 65-73.

Summers, L. (2014b): Reflections on the "New Secular Stagnation Hypothesis", in "Secular Stagnation: Facts, Causes and Cures", VoxEU, pp. 27-38.

Summers, L. (2014c): Low Equilibrium Real Rates, Financial Crisis and Secular Stagnation, in "Across the Great Divide: New Perspectives on the Financial Crisis", pp. 37-50.

Teulings, C. and Baldwin, R. (2014): Secular Stagnation: Facts, Causes and Cures, VoxEU.

Trehan, B. and Wu, T. (2004): Time Varying Equilibrium Real Rates and Monetary Policy Analysis, FRBSF Working Paper, 2004-10.

Wu, J. and Xia, F. (2016): Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound, Journal of Money, Credit and Banking, Vol. 48, No. 2-3, pp. 253-291.

Yildirim-Karaman, S. (2018): Uncertainty in Financial Markets and Business Cycles, Economic Modelling, Vol. 68, pp. 329-339.

Tables

Table 1: Parameter estimates standard Laubach-Williams model

	EA	AT	BE	DE	FI	FR	GR	IT	LU	NL
<i>IS-curve</i>										
$\alpha_{y,1}$	1.63*** (0.14)	1.84*** (0.16)	1.49*** (0.15)	1.24*** (0.22)	0.62 (0.62)	1.62*** (0.15)	0.04 (0.38)	1.62*** (0.10)	0.08 (0.12)	1.68*** (0.20)
$\alpha_{y,2}$	-0.62*** (0.14)	-0.89*** (0.15)	-0.51*** (0.13)	-0.36 (0.24)	-0.19 (0.59)	-0.67*** (0.13)	0.66* (0.39)	-0.61*** (0.10)	0.93*** (0.10)	-0.78*** (0.18)
α_r	-0.16 (0.15)	-0.15 (0.15)	-0.16 (0.10)	-0.16 (0.15)	-0.15 (0.09)	-0.16* (0.09)	-0.15 (0.20)	-0.16 (0.15)	-0.16 (0.15)	-0.16 (0.15)
c	0.50 (1.50)	1.31 (1.32)	0.51 (1.36)	0.92 (1.49)	1.42* (0.85)	0.60 (0.42)	1.50*** (0.08)	0.51 (1.50)	0.50 (1.50)	1.07 (1.17)
<i>Phillips-curve</i>										
$\beta_{\pi,1}$	0.60** (0.24)	0.58** (0.23)	0.83*** (0.17)	0.39*** (0.15)	0.53*** (0.20)	0.66*** (0.10)	0.37** (0.17)	0.80*** (0.19)	0.53** (0.22)	0.10 (0.24)
$\beta_{\pi,2}$	0.21 (0.21)	0.17 (0.24)	-0.01 (0.19)	0.56*** (0.18)	0.41 (0.27)	0.07 (0.11)	0.27 (0.22)	0.01 (0.17)	0.21 (0.19)	0.32 (0.21)
$1 - \beta_{\pi,1} - \beta_{\pi,2}$	0.19	0.25	0.18	0.05	0.06	0.27	0.36	0.19	0.26	0.58
β_y	0.00 (0.00)	-0.00 (0.02)	0.00 (0.02)	-0.00 (0.02)	-0.09 (0.08)	0.03** (0.01)	0.12 (0.09)	0.00 (0.00)	0.00 (0.01)	0.13** (0.07)
β_o	-0.63 (0.44)	-0.40** (0.19)	-0.57*** (0.19)	-0.03 (0.57)	0.75 (0.78)	-0.10 (0.10)	-1.20** (0.51)	-0.77** (0.30)	-0.75 (0.96)	-0.26 (0.25)
<i>Variance</i>										
σ_1	0.2280	0.0407	0.1192	0.5609	0.0001	0.0398	0.0000	0.2612	0.0000	0.0730
σ_2	0.0617	0.0781	0.1728	0.0813	0.1273	0.0927	0.2026	0.0496	0.1398	0.0857
σ_3	0.0001	0.2635	0.0116	0.0001	1.4241	0.0721	1.1262	0.0000	3.3359	0.1900
σ_4	0.0000	0.0002	0.0002	0.0000	0.0012	0.0003	0.0001	0.0000	0.0068	0.0021
σ_5	0.0005	0.0001	0.2558	0.0010	0.0000	0.0866	0.0000	0.0011	0.0000	0.0007
λ_g	0.1176	0.0275	0.1218	0.0124	0.0296	0.0628	0.0006	0.0277	0.0452	0.1049
λ_z	0.0006	0.0006	0.0453	0.0006	0.0006	0.0280	0.0006	0.0006	0.0006	0.0006
<i>log - likelihood</i>	-50.18	-79.41	-76.28	-116.51	-145.90	-101.58	-161.89	-47.98	-171.37	-86.23

Notes: ML-estimation; EA=Euro-Area, AT=Austria, BE=Belgium, DE=Germany, FI=Finland, FR=France, GR=Greece, IT=Italy, LU=Luxembourg, NL=Netherlands; standard errors in parenthesis; ***/**/* means significance at the 1%/5%/10% level.

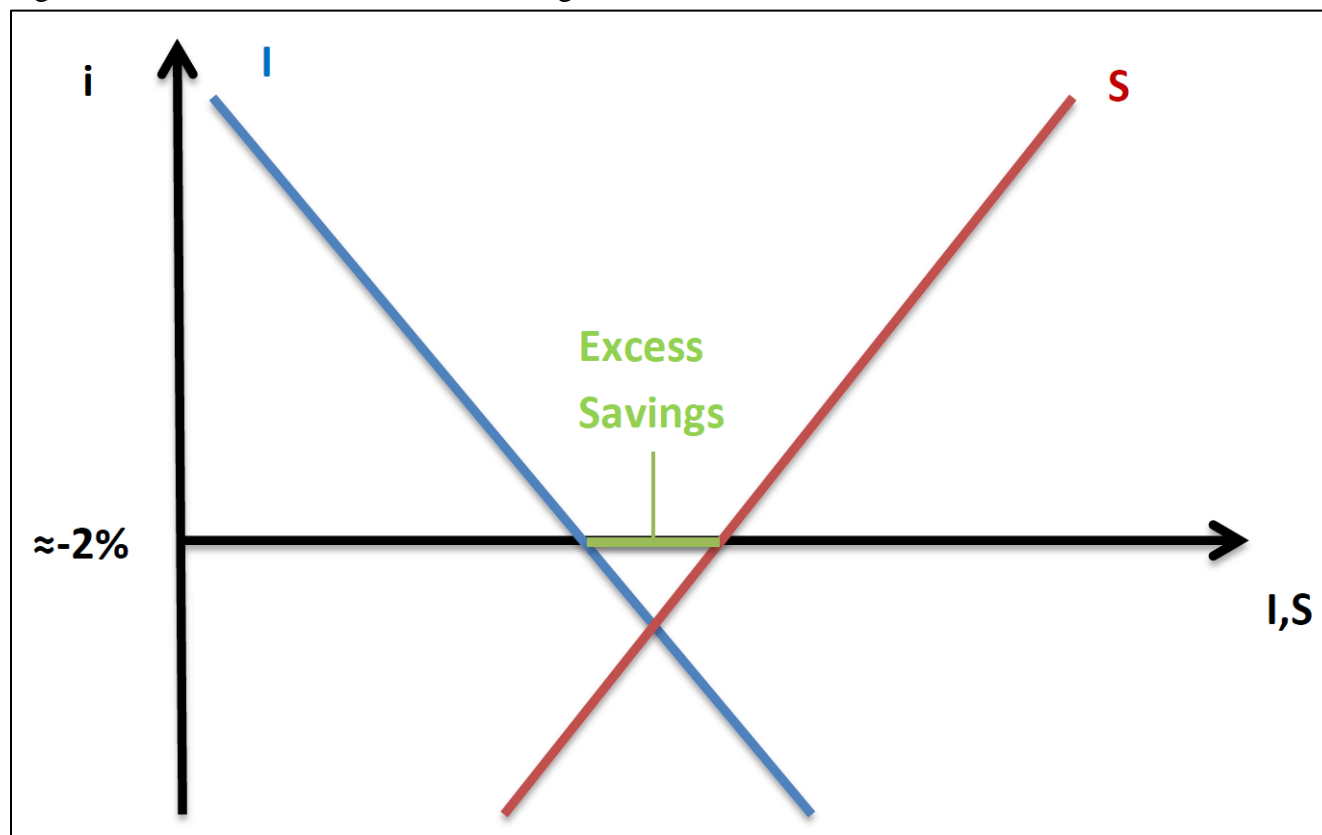
Table 2: Parameter estimates Laubach-Williams model including financial cycle

	EA	AT	BE	DE	FI	FR	GR	IT	LU	NL
<i>IS-curve</i>										
$\alpha_{y,1}$	1.59*** (0.26)	1.87*** (0.06)	1.50*** (0.15)	1.40*** (0.13)	0.54 (1.30)	1.50*** (0.24)	0.37 (0.39)	1.60*** (0.19)	1.13* (0.67)	1.79*** (0.07)
$\alpha_{y,2}$	-0.60** (0.25)	-0.95*** (0.07)	-0.51*** (0.14)	-0.39*** (0.11)	0.49 (1.33)	-0.63*** (0.19)	0.29 (0.31)	-0.59*** (0.19)	-0.15 (0.66)	-0.89*** (0.07)
α_r	-0.15 (0.16)	-0.15 (0.14)	-0.16 (0.11)	-0.16 (0.15)	-0.15 (0.13)	-0.15 (0.12)	-0.15 (0.30)	-0.16 (0.15)	-0.16 (0.23)	-0.16 (0.19)
c	0.50 (1.50)	1.04 (1.21)	0.50 (1.42)	0.50 (1.49)	0.50 (3.52)	0.69 (0.45)	1.49*** (0.10)	0.50 (1.50)	0.50 (0.83)	1.32*** (0.41)
α_l	0.25 (0.25)	0.69** (0.30)	0.05 (0.13)	0.07 (0.35)	-2.05 (3.37)	-0.10 (0.16)	0.11 (0.10)	-0.02 (0.24)	0.13 (0.13)	-0.16 (0.11)
<i>Phillips-curve</i>										
$\beta_{\pi,1}$	0.72*** (0.27)	0.57** (0.23)	0.84*** (0.18)	0.40** (0.18)	0.54** (0.25)	0.59*** (0.09)	0.38** (0.16)	0.75*** (0.16)	0.88* (0.49)	0.15 (0.22)
$\beta_{\pi,2}$	0.09 (0.23)	0.17 (0.23)	-0.02 (0.19)	0.49** (0.24)	0.32 (0.28)	0.10 (0.10)	0.27 (0.18)	0.05 (0.17)	-0.03 (0.28)	0.21 (0.24)
$1 - \beta_{\pi,1} - \beta_{\pi,2}$	0.09	0.26	0.18	0.11	0.14	0.31	0.35	0.20	0.15	0.64
β_y	0.01 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.00)	0.04** (0.01)	0.08 (0.08)	0.00 (0.00)	0.00 (0.00)	0.27* (0.14)
β_o	-0.62 (0.51)	-0.87 (0.70)	-0.58*** (0.19)	-0.66 (0.65)	2.72 (4.93)	-0.06 (0.12)	-0.91 (0.67)	-0.10 (0.16)	0.04 (0.12)	-0.49 (0.30)
<i>Leverage-gap</i>										
γ_l	0.43*** (0.11)	0.11 (0.12)	0.18 (0.15)	0.03 (0.13)	-0.06 (0.15)	0.13 (0.14)	0.00 (0.35)	-0.20 (0.23)	0.40* (0.24)	-0.19* (0.12)
γ_r	0.03 (0.11)	0.08 (0.06)	0.08 (0.13)	0.17 (0.17)	-0.07 (0.11)	-0.24 (0.18)	0.05 (0.18)	1.03 (0.88)	3.53 (3.64)	-0.76* (0.48)
γ_s	-0.92*** (0.18)	0.00 (0.06)	-0.14 (0.16)	-0.66*** (0.18)	5.58 (7.49)	0.13 (0.12)	0.66 (0.61)	0.00 (0.43)	2.60*** (0.37)	6.68 (13.44)
<i>Debt-service ratio</i>										
δ_s	-0.01 (0.02)	0.01 (0.00)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.07)	-0.01 (0.01)	-0.04 (0.03)	-0.00 (0.06)	0.00 (0.07)	-0.01 (0.07)
δ_l	0.09 (0.16)	0.05 (0.08)	-0.19 (0.40)	0.42 (0.90)	-0.36 (0.81)	0.02 (0.07)	-0.57 (0.67)	0.15 (0.32)	-0.03 (0.08)	0.01 (0.09)
<i>Variance</i>										
σ_1	0.1954	0.0000	0.1159	0.6229	0.0000	0.0218	0.6653	0.2720	0.0000	0.0000
σ_2	0.0549	0.0779	0.1730	0.0838	0.1289	0.0926	0.1927	0.0496	0.1205	0.0814
σ_3	0.0177	0.2818	0.0145	0.0000	1.6125	0.0788	0.0922	0.0000	2.3887	0.2377
σ_4	0.0001	0.0002	0.0002	0.0000	0.0014	0.0003	0.0000	0.0000	0.0049	0.0026
σ_5	0.0004	0.0000	0.2287	0.0031	0.0000	0.4364	0.0233	0.0013	0.0000	0.0000
σ_6	0.3969	1.6729	0.0000	0.5170	1.9006	1.1398	1.9307	4.4408	17.5976	4.6361
σ_7	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.1191	0.0000	0.0001	0.0001
λ_g	0.0166	0.0275	0.1218	0.0124	0.0296	0.0628	0.0006	0.0277	0.0452	0.1049
λ_z	0.0006	0.0006	0.0453	0.0006	0.0006	0.0280	0.0006	0.0006	0.0006	0.0006
λ_s	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0244	0.0006	0.0006	0.0006
<i>log - likelihood</i>	-109.43	-193.06	-175.26	-190.39	-232.66	-318.57	-286.15	-163.68	-249.27	-230.66

Notes: ML-estimation; EA=Euro-Area, AT=Austria, BE=Belgium, DE=Germany, FI=Finland, FR=France, GR=Greece, IT=Italy, LU=Luxembourg, NL=Netherlands; standard errors in parenthesis; ***/**/* means significance at the 1%/5%/10% level.

Figures

Figure 1: Real interest rates and secular stagnation



Notes: i =real interest rate, I =aggregate investments, S =aggregate savings, approximately -2 percent as intercept is chosen because the minimum should be given at a zero nominal rate minus the ECB inflation target of about two percent.

Figure 2: Leverage gap for the Euro area and nine Euro-area countries

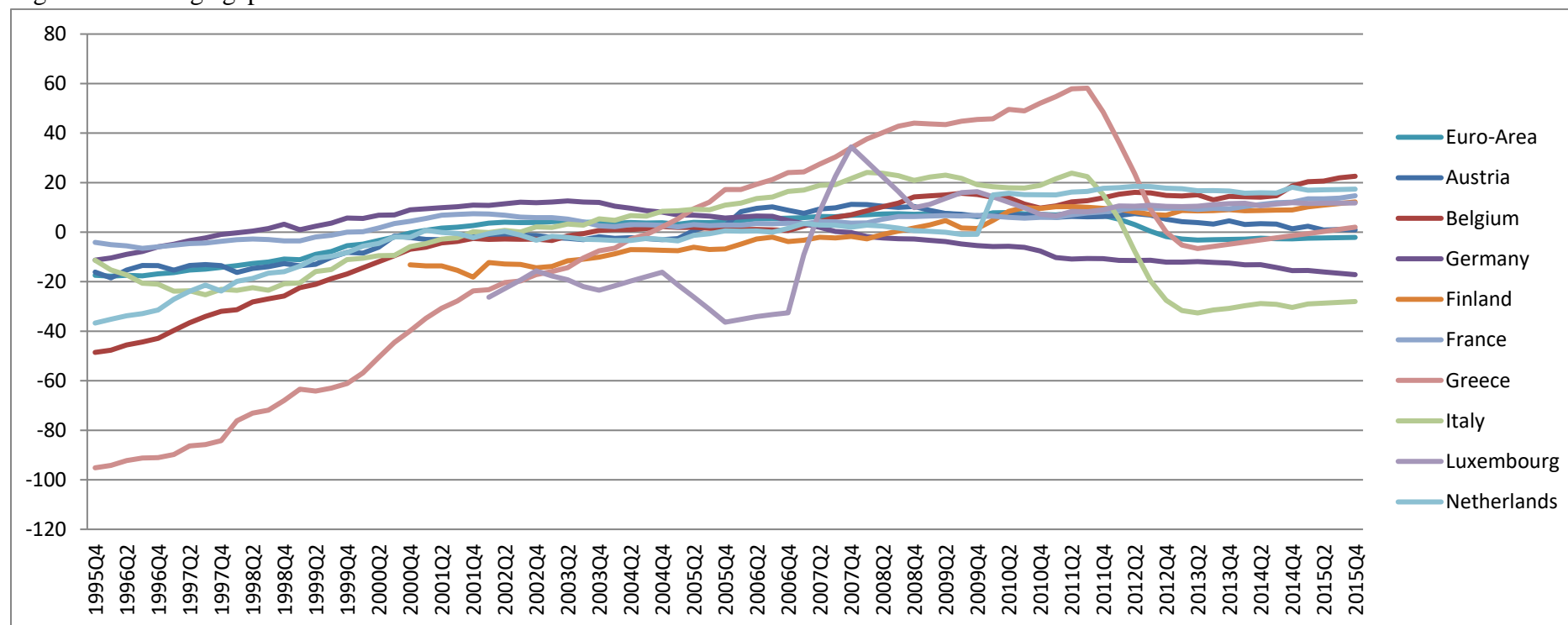
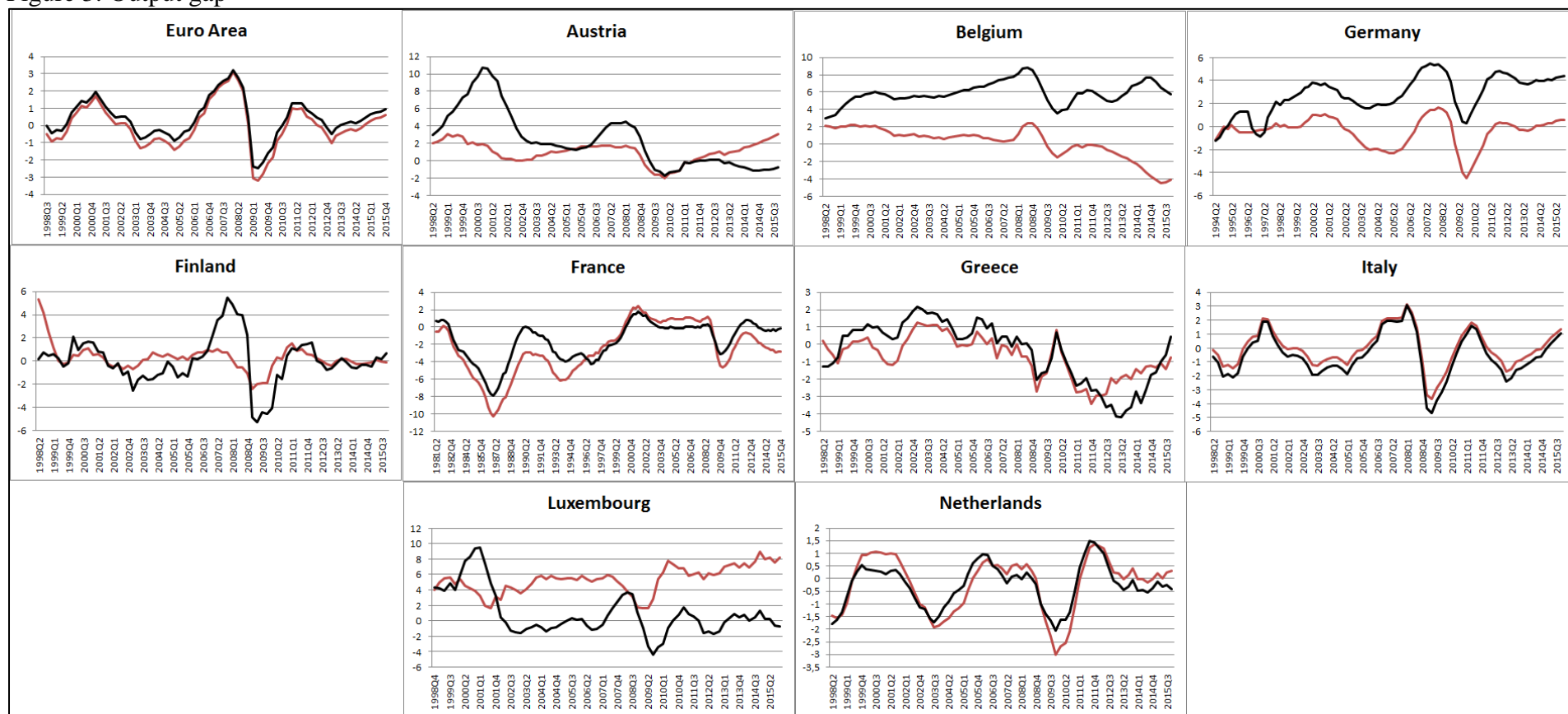
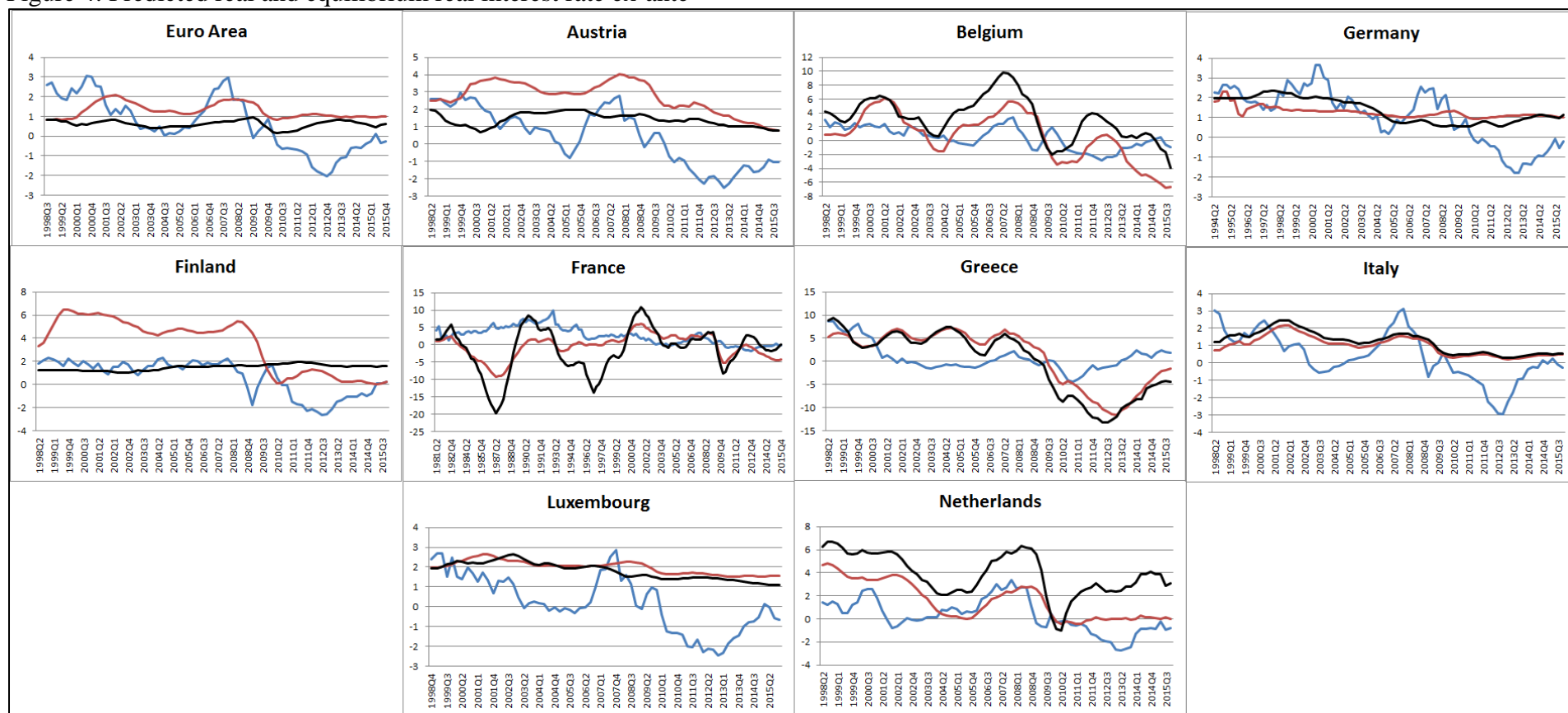


Figure 3: Output gap



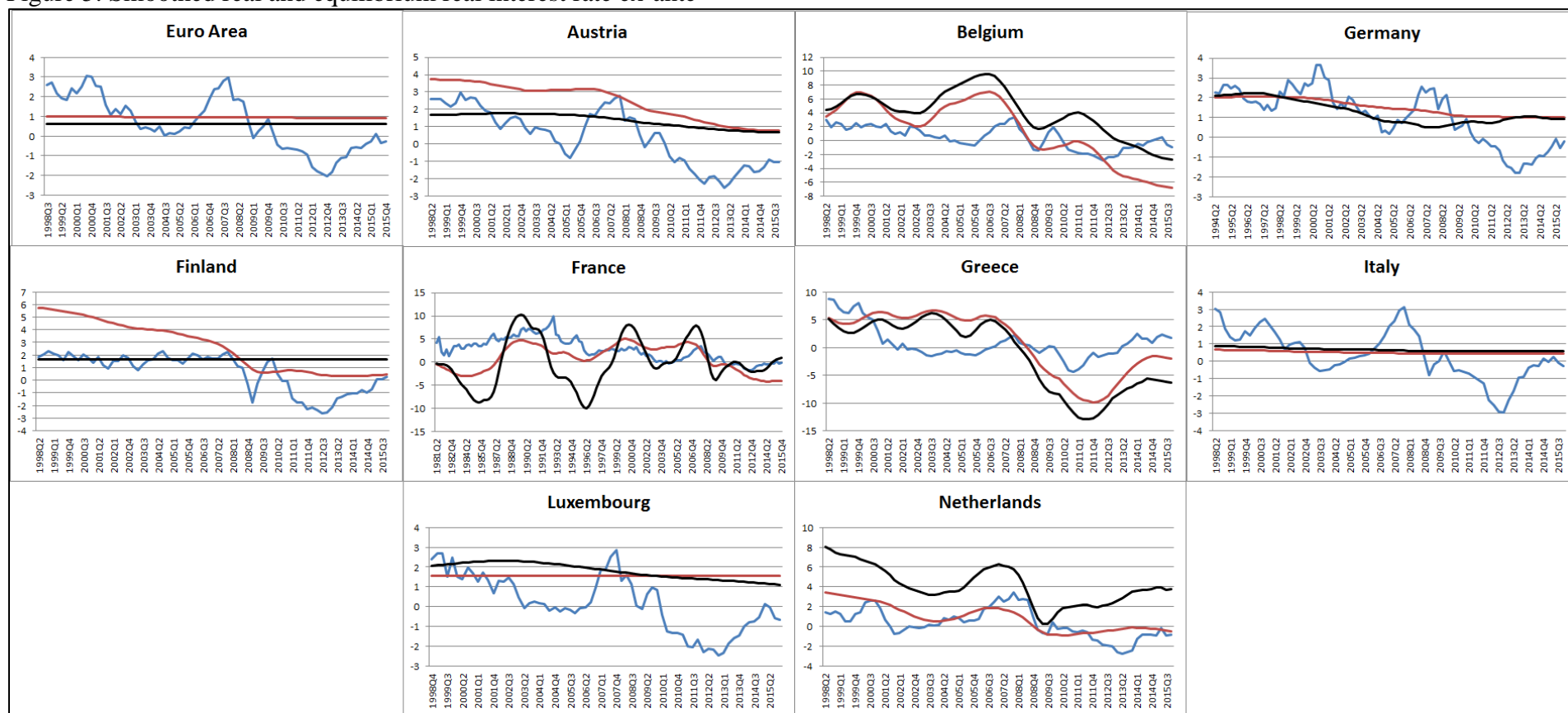
Notes: Output gap standard Laubach-Williams model = red line, output gap with financial cycle = black line.

Figure 4: Predicted real and equilibrium real interest rate ex-ante



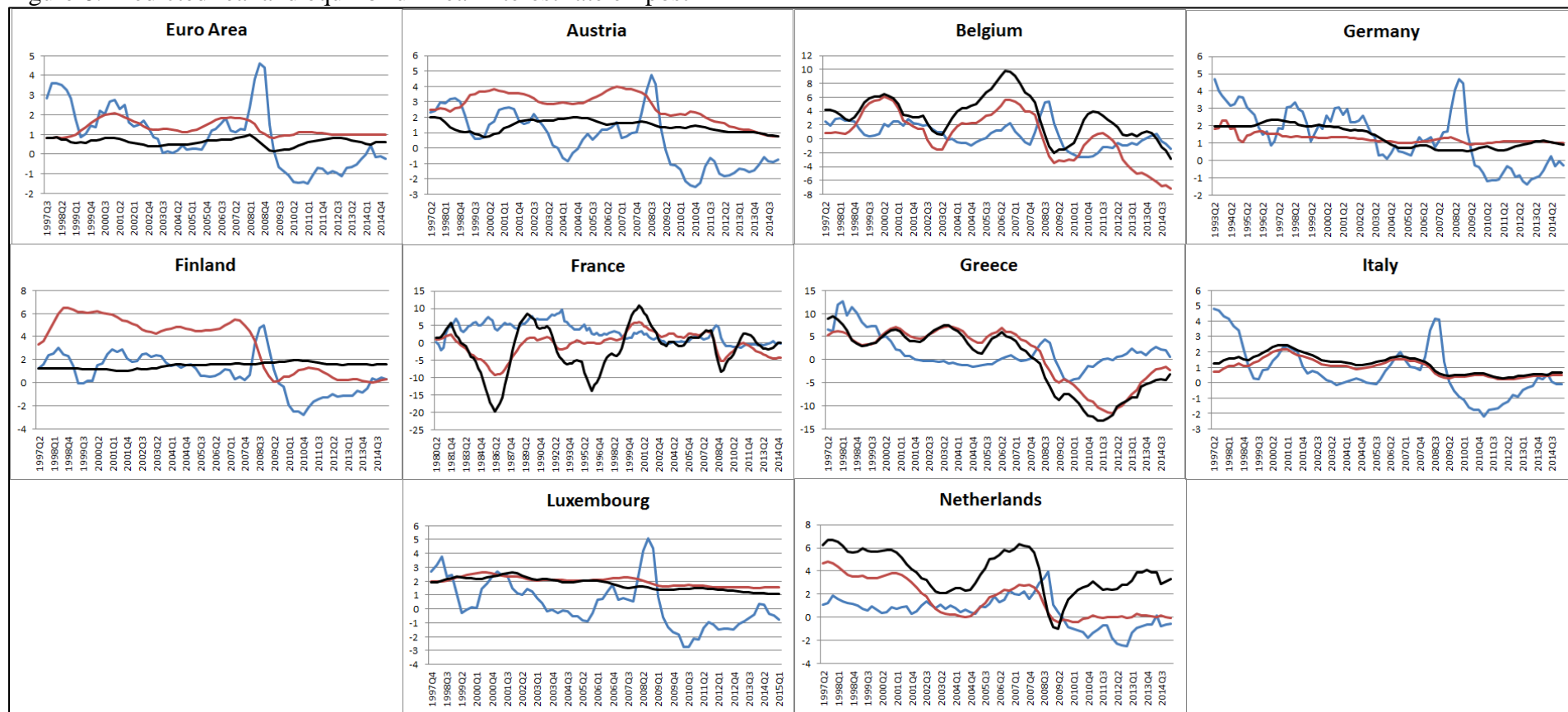
Notes: Real interest rate = blue line, equilibrium real interest rate standard Laubach-Williams model = red line, equilibrium real interest rate with financial cycle = black line.

Figure 5: Smoothed real and equilibrium real interest rate ex-ante



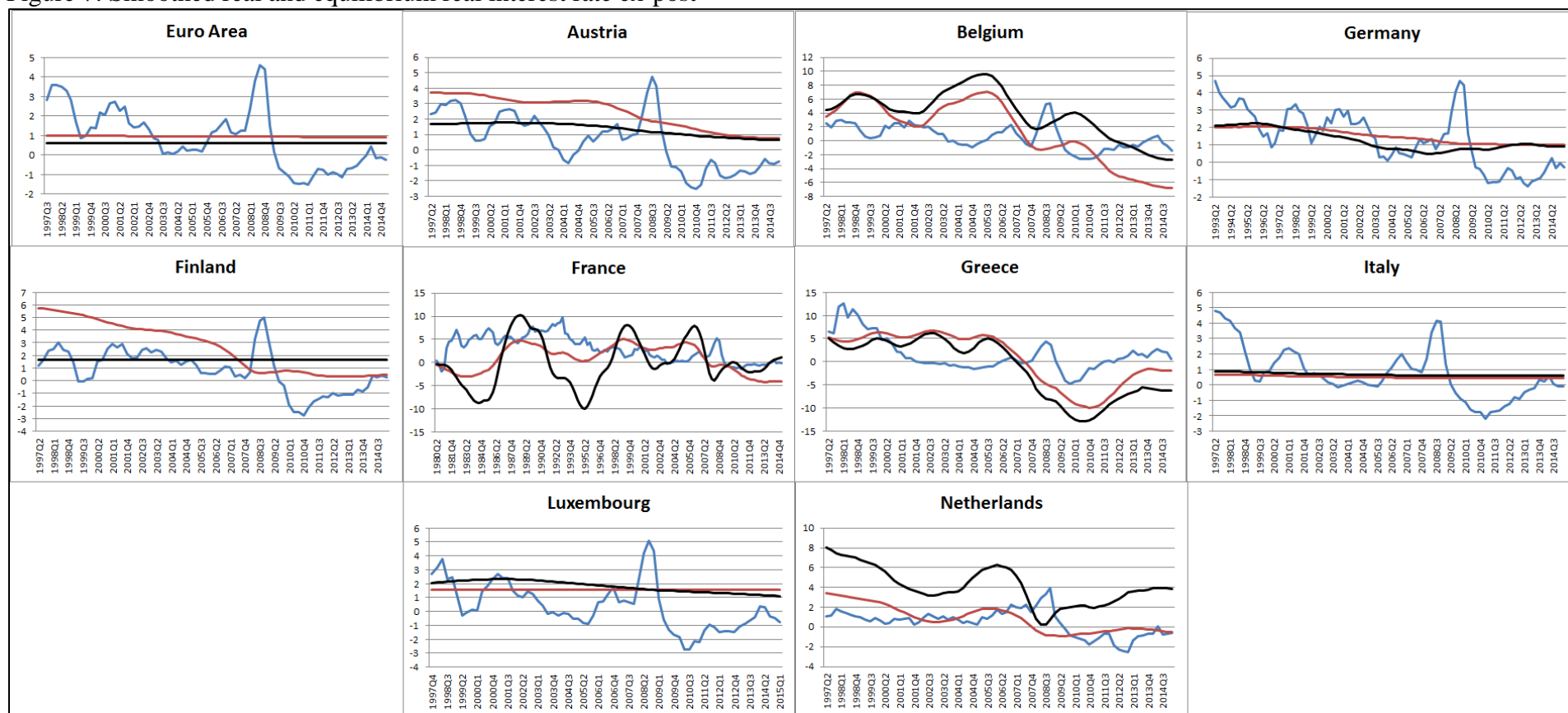
Notes: Real interest rate = blue line, equilibrium real interest rate standard Laubach-Williams model = red line, equilibrium real interest rate with financial cycle = black line.

Figure 6: Predicted real and equilibrium real interest rate ex-post



Notes: Real interest rate = blue line, equilibrium real interest rate standard Laubach-Williams model = red line, equilibrium real interest rate with financial cycle = black line.

Figure 7: Smoothed real and equilibrium real interest rate ex-post



Notes: Real interest rate = blue line, equilibrium real interest rate standard Laubach-Williams model = red line, equilibrium real interest rate with financial cycle = black line.

The Data Analytics for Finance and Macro (DAFM) Research Centre

Forecasting trends is more important now than it has ever been. Our quantitative financial and macroeconomic research helps central banks and statistical agencies better understand their markets. Having our base in central London means we can focus on issues that really matter to the City. Our emphasis on digitalisation and the use of big data analytics can help people understand economic behaviour and adapt to changes in the economy.

Find out more at kcl.ac.uk/dafm

This work is licensed under a Creative Commons Attribution Non-Commercial Non-Derivative 4.0 International Public License.

You are free to:

Share – copy and redistribute the material in any medium or format

Under the following terms:

Attribution – You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

Non Commercial – You may not use the material for commercial purposes.

No Derivatives – If you remix, transform, or build upon the material, you may not distribute the modified material.

**KING'S
BUSINESS
SCHOOL**

**Data Analytics
for Finance
& Macro
Research Centre**

