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Output gap uncertainty and the optimal fiscal policy in the EU

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JEL classifications: D84, E32, E62

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Abstract

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1 Introduction

The cyclical adjustment of the government budget balance is nowadays a standard tool in fiscal governance. For example, at the core of the EU's fiscal policy framework is the cyclically-adjusted budget balance (CAB) that measures the budgetary position of public finances, when the effects of economic cycles are eliminated. In principle, the use of cyclical adjustments makes the fiscal rules smarter and clarify the execution of fiscal policy and its control. As long as the fiscal policy does not have an effect on the CAB, it can be thought to correctly fulfil its stabilization task. If the policy instead has an effect on the CAB, it can be regarded as independent of the cycle, and should be carefully regulated by the fiscal rules. However, in practice the use of the CAB has proven to be problematic. The main concern is the output gap uncertainty that results from the difficulty to divide economic shocks into trend and cyclic ones in real time.

In this paper I quantify the magnitude of the EU-27 countries' output gap revisions in 2002-2014 by using a novel real-time dataset[1], and then study the implications of this uncertainty for the optimal fiscal policy with a DSGE model. I analyze the output gap uncertainty with a model in which a sovereign makes decisions to maximize the utility of its constituents. However, consistently with the data, the sovereign does not observe the true output gap. Rather, the sovereign makes inferences on the output gap by using a Kalman filter while receiving noisy signals about the true value of the output gap. I find that the theoretical model

[1]This paper uses the Firstrun dataset, a collection of Ameco data vintages for the years 2002-2017. The dataset is publicly available on the Firstrun web page http://www.firstrun.eu/research/data/

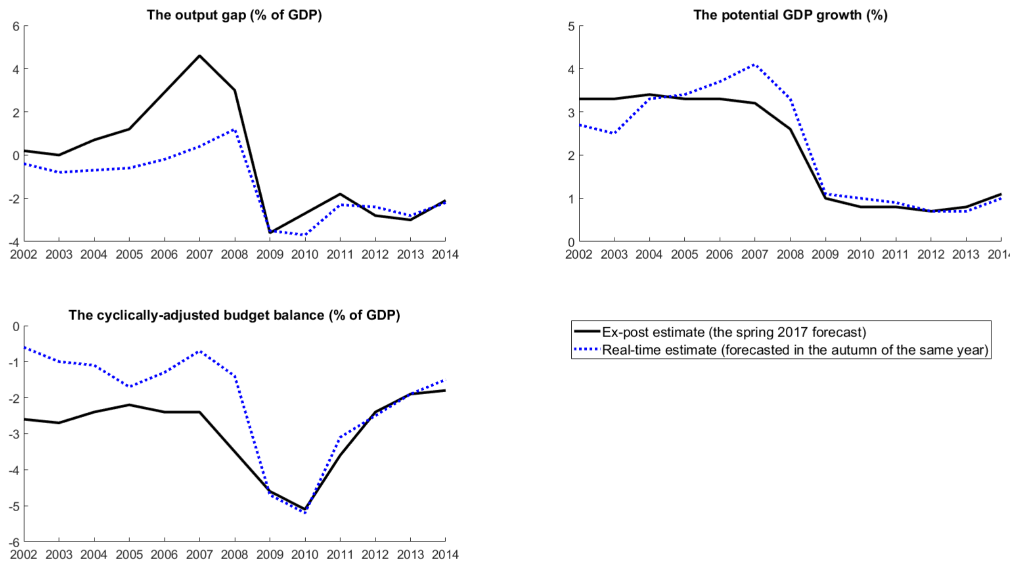

Figure 1: Revisions of the output gap, potential output growth and the cyclically-adjusted budget balance. Source: Ameco data and author's own calculations.

introduced by Thwaites (2006) fits well with the time-series properties of the current data, and it is sufficiently tractable to analyse the policy implications of the output gap uncertainty. I calibrate the model to match the estimated signal noise in the dataset and solve it using global approximation methods[2]. Then I use its impulse responses and stochastic simulations to make inferences on the optimal policy under the output gap uncertainty.

To give the first impression of the uncertainty's magnitude, Figure 1 shows how the view about the output gap and other key fiscal variables has changed in 2002-2014. The figure shows the average output gaps, potential growth rates, and the cyclically-adjusted budget balances both in real time and ex post for the EU-27. The real-time view consists of the forecasts of the variables made in the fall of the same year, while the ex-post view is based on the most recent available,

[2]I use the Chebyshev polynomial approximations, and employ the Smolyak algorithm to maintain the underlying optimization problem tractable (Judd et al. 2014).

the fall 2017 forecast. The results illustrates well how difficult it has been to detect the true phase of the business cycle. It became apparent only in the ex post view that the economies were on average facing a business-cycle peak rather than a period of strong potential output growth before the crisis.[3] The output gap uncertainty also had a direct effect on the CAB estimates. In real time, the positive output gap was considered to be small during the economic upturn, and thus the positive contribution of the cycle to the fiscal position was not perceived.

After analysing the impact of output gap uncertainty on the optimal policy in the EU-27 countries, I make the following conclusions. First, the results underscore the role of the output gap uncertainty in explaining the dynamics of the net lending of the EU member states. Because of the output gap uncertainty, the response of the economy to cyclical shocks becomes more cautious: The initial response is typically neutral while the policy responds more stronger as information regarding the true nature of the shock gathers in. In a median EU-27 country, the primary net lending is mildly countercyclical when the economy is subjected to the output gap uncertainty, i.e. the correlation between the output gap and the primary net lending turns from positive to marginally negative. This finding, resulting from the possibility that the cycle is partly driven by trend shocks, contrasts with the procyclical policy under the full output gap information. It is, however, consistent with the countercyclicality of the net primary lending in the EU-27 during the last 25 years. Instead, the average, net debt-to-GDP ratios are not significantly affected by the output gap uncertainty. Rather, the average net debt is found to be more directly influenced by the cost of finance as well as the expected growth rate and variance of the potential output.

Furthermore, I analyse the implications of the output gap uncertainty for

[3] A look on the country-level data shows that similar problems in detecting the true output gap was experienced in virtually all EU-27 countries. Previous findings by for example Kuusi (2017) suggests that the problems may affect both upturns and downturns.

fiscal policy, as measured by the CAB. To measure the government balance, a part of the net lending is considered to be private, and assumed to response to the changing business cycle according to its historical behaviour. Furthermore, the cyclically adjusted balance is constructed based on the OECD estimates of the output gap semi-elasticity. When the output gap is uncertain, I find that the CAB becomes only weakly countercyclical due to the output gap uncertainty. During fiscal crises, when the CAB falls below the limits of the Stability and Growth Pact, the breach should be constrained to be smaller and the adjustment of the CAB to be slower than in the case of perfect output gap information. For a median country, the pace of adjustment is close to the -0.5 % of GDP per year benchmark used in the EU's fiscal framework.

Finally, I find that the implications of the output gap uncertainty are very different across countries, both because of the heterogeneity in the income processes and the magnitude of the uncertainty. In a few EU countries, the effect of uncertainty is substantial and generates strongly countercyclical net lending responses. However, I do not find strong evidence suggesting that the fiscal policy should be steered differently due to this heterogeneity, at least not in terms of the CAB responses. Rather, the private sector's reactions and the cyclical adjustments of the government balances may be sufficient to deal with it.

This paper relates to a large previous literature analysing the determinants of fiscal policy. A few papers focus on the output gap information and consider its implications on the design of fiscal rules (see, e.g, Portes and Wren-Lewis 2015; Bergman and Hutchison 2015; Sacchi and Salotti 2015; Kuusi, 2017), while the literature has also stressed other determinant such as the role of fiscal rules in curtailing adverse political incentives (Besley 2007; Hallerberg et al. 2007; Begg 2014; Begg, 2016). Another related literature focuses on providing evidence on the role of the trend and cyclical shocks, and studied their policy implications.

In their seminal work, Aguiar and Gopinath (2007) find that trend shocks may explain a large portion of the business cycles in the emerging market economies. Similarly to this paper, they argue that the trend shocks may account for the strongly counter-cyclical current accounts. Interestingly, Boz et al. (2011) argue that in order for the Aguiar and Gopinath's (2007) perfect output gap information model to better account for the key features of emerging market business cycles, uncertainty about the nature of the shocks has to be introduced to the model. Similar to this work, some papers have quantified the output gap uncertainty directly from the actual data-revisions. Edge et al. (2007) introduces empirical long-run productivity growth forecasts to a stylized DSGE model and solve it using global solution techniques. Kuang and Mitra (2016) also use a stylized real business cycle (RBC) model in which agents learn about the long-run growth rate of endogenous variables in an adaptive learning model. Similarly to their work, I report a strong connection between the uncertainty regarding the long-run output growth forecasts and cyclical activities.

This paper is organized as follows. Section 2 introduces the model and describes the formulation of the output gap uncertainty. In Section 3, I describe how the model is calibrated by using the real-time data. Section 4 reports the results of this paper, and Section 5 concludes.

2 The economy

2.1 The sovereign's problem

The economic optimization concerns a sovereign which uses the national income and its capacity to borrow in order to maximize the utility of its constituents. I make the customary assumption in the literature (see, e.g., Aguiar et al. 2016) that the sovereign is employed with enough instruments to implement any feasible consumption sequence as a competitive equilibrium and, thus, abstract from the problem of individual residents of the economy. This does not mean that the government necessarily shares the preferences of its constituents, but rather that it is the relevant decision maker vis-a-vis international financial markets.

The national income constitutes of an exogenous endowment Y_t that the sovereign observes, but, importantly, its growth falls into two elements that are not directly observed: (1) Trend growth, g_t, that affects the long-term production potential of the economy, and (2) changes in the output gap, $\Delta\epsilon$, that builds a wedge between the short-term production dynamics, and the long-term growth potential. In order to grasp the uncertainty related to the components, the sovereign only receives a noisy signal regarding a change in the phase of the business cycle.

The preferences of the sovereign are described by the constant relative risk aversion (CRRA) preferences. The present value of the stream of utility from consumption is

$$U_t = E_t \sum_{k=t}^{\infty} \beta^k (\frac{C_k}{1-\theta})^{1-\theta} \tag{1}$$

where C_k is the aggregate domestic consumption C_k, β is the time preference parameter, and θ is the constant relative risk aversion parameter. To finance the consumption, the sovereign receives each year the endowment and in addition she can lend/borrow funds from abroad. Formally, in each time period it holds $C_k = Y_k - PB_k$. If the primary net lending PB_k is negative, the international resources are borrowed to support domestic total demand above the current income. As a result of the policy, the debt level of the economy accumulates according to the equation

$$D_t = (1 - r_t)D_{t-1} - PB_t \tag{2}$$

Finally, the interest rate of the economy is debt-elastic and follows a standard specification in the literature:

$$r_t = exp(\gamma \frac{D_t}{Y_t}) + \epsilon_t^r, \tag{3}$$

where γ is the debt-elasticity of the interest rate, and ϵ_t^r is the normally distributed interest rate shock.

2.2 Modelling the income process uncertainty

The components of the income growth (Δy_t) are specified formally as follows:

$$\Delta y_t = g_t + \Delta\epsilon_t \tag{4}$$

$$\epsilon_t = \rho_\epsilon * \epsilon_{t-1} + \eta_t^\epsilon \tag{5}$$

$$g_t = \bar{g} * (1 - \rho_g) + \rho_g * g_{t-1} + \eta_t^g \tag{6}$$

where η_t^ϵ and η_t^g are normally distributed shocks. The trend growth g_t is assumed to follow a damped trend series about a constant trend, $\bar{g}$; an assumption that is commonly used in the estimation of the potential output. This specification implies that the growth rate of the income process is mean reverting, but the level of income may exhibit permanent shifts, reflecting for example structural shocks to the value generating capacity of the economy. On the other hand, the level of the output gap is assumed to follow a stationary AR(1) process implying that all changes in the output gap are temporary. ρ_ϵ and ρ_g denote $AR(1)$ coefficients of the output gap and trend growth, respectively.

The sovereign does not observe the relevant state vector $\xi_t = [\epsilon_t, \epsilon_{t-1}, g_t]$, but rather receives observable signals regarding the state of the economy: (1) the overall growth rate of the economy, Δy_t, (2) a noisy signal of the output gap's change, Δe_t, as well as (3) the current interest rate of the government debt, r_t. The noisy signal concerning the growth rate of the output gap is formally specified as

$$\Delta e_t = \Delta \epsilon_t + \eta_t^e \tag{7}$$

where η_t^e is a normally distributed signal shock with 0 mean and the variance σ_e^2. In each time period, a new innovation of the signal vector $x_t = [y_t, e_t, r_t]$ arrives.

The system of equations can be written in state-space form as

$$x_t = H^T \xi_t + G + w_t \tag{8}$$

$$\xi_t = F \xi_{t-1} + \nu_t \tag{9}$$

where

$$x_t = \begin{bmatrix} \Delta y_t \\ \Delta e_t \\ \epsilon_t^r \end{bmatrix}, H = \begin{bmatrix} 1 & 1 & 0 \\ -1 & -1 & 0 \\ 1 & 0 & 0 \end{bmatrix}, w_t = \begin{bmatrix} 0 \\ \nu_t^e \\ \epsilon_t^r \end{bmatrix}, G = \begin{bmatrix} 0 \\ 0 \\ \bar{g} * (1 - \rho_g) \end{bmatrix}, F = \begin{bmatrix} \rho_\epsilon & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & \rho_g \end{bmatrix} \tag{10}$$

I assume that the policymaker knows F, the covariance matrix of signal equation shocks R, and the covariance matrix of state-equation shocks Q:

$$R = \begin{bmatrix} 0 & 0 & 0 \\ 0 & \sigma_e^2 & 0 \\ 0 & 0 & \sigma_{\eta^r}^2 \end{bmatrix}, Q = \begin{bmatrix} \sigma_{\eta^\epsilon}^2 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & \sigma_{\eta^g}^2 \end{bmatrix} \tag{11}$$

The policy maker uses the Kalman filter to produce real-time estimates of the state vector $\hat{\xi}_{t|t}$ based on the observable variables x_t, as well as the past estimates of the state, using the Kalman filters recursive formula. In particular, inferences regarding the state of the economy are made based on the current beliefs about the state, while the new innovations of the shocks may alter that view. The optimal update of the current view on the state is dependent on the degree of uncertainty that the innovations hold on the actual state of the economy. Formally, the Kalman gain can be expressed as

$$\hat{\xi}_{t|t} = F\hat{\xi}_{t-1|t-1} + PH(H^T PH + R)^{-1}(x_t - x_{t|t-1}). \tag{12}$$

$x_{t|t-1}$ are the one period ahead forecasts of the observed variables (that is, the previous expectation of the observables):

$$x_{t|t-1} = H^T F\hat{\xi}_{t-1|t-1} \tag{13}$$

Matrix P is the covariance matrix of the state-variable shocks. For practical purposes, it is assumed that the policymaker has observed a sufficiently long history of the economy for the Kalman gain coefficients (that is, elements of the matrix P) to have converged to their steady-state values. P is solved from the steady-state of the discrete-time Riccatti equation:

$$P = F(P - PH(H^T * PH + R)^{-1} H^T P)F^T + Q. \tag{14}$$

Alternatively, the elements of the P matrix could be allowed to change over time. However, that would increase the dimensionality of the problem considerably, and thus this option is not considered here.

2.3 Solving the policy function

In this paper, a non-linear method is used to solve the optimal policy rule of the policymaker. Due to the large size of the recent economic shocks, as well as the potential non-linearities that the state-contingent fiscal multipliers may generate, a linearized model would arguably generate imprecise results.

For a non-linear estimation procedure, the dimensionality of the problem is relatively high, given that the policy function is contingent on 7 state variables. To deal with the high dimensionality, I resort to the Chebyshev polynomial approximation of the policy function, and use the Smolyak's method to decrease the computation burden of the estimation (in particular, I use the approach and software made available by Judd et al. 2014).

The key idea of Smolyak's (1963) algorithm is that some elements produced by tensor-product rules (typically used to provide a global estimation of the policy function) are more important for representing multidimensional functions than the others. The Smolyak method orders all elements produced by a tensor product rule by their potential importance for the quality of approximation and selects a relatively small number of the most important elements. A parameter, called a level of approximation, controls how many tensor-product elements are included into the Smolyak grid. By increasing the level of approximation,one can add new elements and improve the quality of approximation. (Judd et al. 2014)

Following the advice of Judd et al. (2014), I estimate the Euler equation using fixed point iteration. They argue that in large-scale economic applications, a solution algorithm based on Smolyak interpolation has substantially lower expense when it uses derivative-free fixed-point iteration instead of standard time iteration.

In the exercise, I find that adequate accuracy is received at the level of approximation 3, which in the specification with 7 state variables, implies that the order of the Chebyshev polynomial used in the approximations is 10. To analyze the precision of the solution, I randomly pick state variables outside the Smolyak grid, and solve the corresponding Euler equation errors. In each case, I find that the errors are small, being less than 10^{-5}.

Furthermore, I resort to monomial rules combined with Cholesky decomposition in order to numerically integrate the expectations of the policy maker (see Judd et al. (2011) for a detailed description of these techniques). In practice, for each element, the expectation involves taking the numerical integral over the distribution of the errors in the current state variables (with covariance matrix P), as well as the distributions of the expected potential and output gap income shocks, the output gap noise, and the interest rate shock. I find that the traditional Gauss-Hermite quadrature method is not tractable in the current, high-dimensional problem.

3 Calibration of the model

3.1 Parameterization of the income process based on the real-time Ameco data

In the estimation of the output gap uncertainty, this paper uses the Firstrun dataset, a collection of Ameco data vintages for the years 2002-2017. [4] This paper builds on the idea that the output gaps and potential output can be estimated from

[4] The dataset is available on the Firstrun web page http://www.firstrun.eu/research/data/

the data after a reasonable time period, while the uncertainty related to the output gap affects mostly the real-time estimates. This approach seems reasonable, as the data revisions become substantially smaller in few years.

Following this logic, I estimate the parameters of the underlying income process from the latest forecast revision of the Ameco dataset, that is, spring 2017 data. Standard maximum likelihood estimation techniques, and the ex-post output gap and potential output estimates are used to solve the parameters of the corresponding equations ($1990 \leq t \leq 2014$):

$$\epsilon_t = \rho_\epsilon * \epsilon_{t-1} + \eta_t^\epsilon \tag{15}$$

$$g_t = \bar{g} * (1 - \rho_g) + \rho_g * g_{t-1} + \eta_t^g \tag{16}$$

After that, the parameter values and their estimated uncertainty are inserted to a maximum likelihood estimation of the noise shocks. In particular, given the other parameter values and the data regarding both the real time and the ex-post (true) estimates of the state variables, I use indirect inference to tease out the noisy signal shocks η_t^e in $\Delta e_t = \Delta \epsilon_t + \eta_t^e$. In particular, given other parameter values, I search for the σ_e^2, that maximizes the likelihood of the conditional shock estimates $\hat{\eta}_t^e$.

The shock estimates $\hat{\eta}_t^e$ are obtained by finding the shock that exactly generates the actual, real-time estimate of the change in the output gap conditional on the current vector of parameters. Formally, from the optimal Kalman gain it follows

$$\hat{\xi}_{t|t} = F * \hat{\xi}_{t-1|t-1} + K * (x_t - x_{t|t-1}) \tag{17}$$

$$\implies K * x_t = \hat{\xi}_{t|t} - F * \hat{\xi}_{t-1|t-1} + K * x_{t|t-1} \tag{18}$$

$$\tag{19}$$

I denote the resulting (3,1) vector $K * x$ by KX_t, while its third element (responding to the change in the potential output) is $kx_{3,t}$. Then, given that the interest rate shock does not directly affect other signal variables (that is, K matrix element $k_{3,2} = 0$), and the GDP growth signal $x_{1,t} = \Delta y_t$ is observable, the signal shock that exactly generates the observed change in the potential output (and thus the output gap as $\Delta\epsilon_t = \Delta y_t - g_t$) can be solved from the equation:

$$\Delta e_t = \frac{kx_{3,t} - k_{3,1} * \Delta y_t}{k_{3,2}}. \tag{20}$$

The ML estimates of η^e_t and σ^2_e are the parameter values that maximizes the probability of the observed $\hat{\eta}^e_t$ given $\hat{\sigma}^2_e$ and other parameter values. The estimation is conducted with a numerical search algorithm in MATLAB.

The parameter estimates are provided in Table 1. The autocorrelation coefficient of the output gap process ρ_ϵ typically exceeds 0.5 but is significantly lower than 1. The median, 0.67, implies that roughly 80 % of a typical output gap shock's impact decays in 4 years. The AR(1) coefficient of the potential output growth, ρ_ϵ, is considerably higher, the median being 0.94. Despite being high, in most cases, the unit root can be rejected. [5]. In terms of the shock volatilities σ_{η_ϵ} and σ_{η_g}, the cyclical shock is typically more volatile than the potential growth

[5] In case of Portugal, the high AR(1) coefficient makes the solution algorithm unstable, and thus the model is not estimated for it.

shock. In a median case, the volatility of the cyclical component is four times as large as for the trend growth component.

The maximum likelihood estimation provides estimates for both the expected volatility of the signal noise shock σ_e^{filter} and the volatility of the actual noise shocks σ_e^{obs}. The expected volatility is typically large, only moderately smaller than the output gap shock volatility. The largest volatility is seen in Estonia, Latvia and Finland. Typically, the expected volatility has been smaller than the actual noise volatility, as measured by the standard deviations of the shocks σ_e^{filter} and σ_e^{obs}.

It should be acknowledged that the model provides a simplification of the true output gap noise because there is only one noise shock in the model. While the estimation procedure calibrates the shock so that it perfectly matches the current perception of the changes in the output gap in the data and the model, a perfect match with the data would necessitate having two shocks (or at least calibrated parameters). That is because in the actual data there are two real-time data series that could be matched: the real-time output gap and its lag.

However, I find that in practice it may be sufficient to use the single shock specification. A good way to show this is to consider the differences between the output gaps in the calibrated model and the data in levels. As the level of output gap is not directly matched in the estimation, the model and the data may potentially provide different views. However, while I find that the replication of the data is not perfect, as Figure 7 in the Appendix shows, I also find that the average errors of the models are relatively small, and the filter replicates the dynamics of the real-time output gap vis-a-vis the ex-post output gaps quite well.

Alternatively, I replicate the main simulated results for a specification of the signal noise in case that the levels of the current output gaps are matched in the data.[6] In both cases I find that the estimates of the noise are large and the simulated moments of the policy are similar (see the next section). However, I find that the likelihood of the specification that matches ($\Delta\epsilon$) is considerably higher than the specification that matches the output gap levels. In case of the levels, the expected noise error volatility used in the filtration σ_e^{filter} is moderately lower (0.061) than when the changes are matched, but the standard errors of the actual realizations are large: for the median EU-country it is 3.3 times higher than the perceived standard error of the shocks. Instead, in the specification that matches the changes in the output gap, the standard deviation of the actual realizations are only 1.1 times higher than the standard deviation of the. Thus, the likelihood of the model given the data is very low when the levels are matched: The result implies that the policy maker would make consistently very large mistakes by failing to expect large signal noise. Thus, in the spirit of the generalized method of moments estimation, the large disparity in the likelihoods suggest that almost all weight should be given to the moment that matches the differences.

There are several other remarks to be made. First, it is useful to relate the current specification to the time-series features of the output gap and the potential output in the data. On average, the AR(1) processes represent well the structure of the underlying time series. Their autocorrelation functions decay slowly, while the partial autocorrelation functions have a sharp cutoff at lag 2. While these features of the data are the most common, it should be, however, mentioned that for some countries the variables show cyclical evolution that could be explained by an AR(2) process that have negative roots corrensponding to a sinusoidal structure of the autocorrelation.

Second, while the underlying model assumes that the parameters of the output gap and the potential growth models are constant, it could be the case that the

[6]Instead, I do not consider matching the lagged levels of the output gap

parameters change over time. Conducted tests of structural breaks indeed suggest that in most countries there have structural breaks in the series that starts from the year 1960. Thus, in order to avoid problems related to structural breaks, only relatively recent data is used starting from the year 1990.

Third, the specification assumes that the shocks to output gap and potential output are independent via contemporaneous covariance matrices, and there is no dynamic propagation across the variables via lag polynomials, such as, for example, in a standard VAR model. While potentially these assumptions are restrictive, here their use is justified by the structure of the data. Both the output gap and the potential output are originally estimated by the European Commission, and the methods typically separate the output gap and the potential under the assumption that the resulting innovations in both series are independent of each other.

Of course, only in an ideal case the European Commission's estimation method would provide an exact estimate of the true output gap and the structural output. Furthermore, the underlying specification of the model is not exactly identical to the Commission's way to estimate the output gap. The filtration is, for example, made separately to estimate the level of the structural total-factor productivity and the structural unemployment (Havik et al. 2014). Therefore, the error terms of the current econometric model are likely to reflect both the differences with respect to the Commission's model, and the error in the Commission's original estimates.

3.2 Other features of the model

The model includes other calibrated variables. In terms of the specification of the utility function, I resort to standard calibration. The time preference β is set at 0.96, implying a 4% discounting at an annual rate. The risk-aversion parameter

	ρ_ϵ	ρ_g	$\bar{g}$	σ_{η_ϵ}	σ_{η_g}	σ_e^{filter}	σ_e^{obs}	σ_r	r_f	κ	θ	β
AT	0.38	0.96	0.020	0.011	0.002	0.007	0.009	0.017	0.020	1.92	2	0.96
BE	0.45	0.95	0.016	0.011	0.002	0.004	0.009	0.017	0.020	1.92	2	0.96
BG	0.47	0.87	0.020	0.023	0.010	0.017	0.010	0.017	0.020	1.92	2	0.96
CY	0.88	0.95	0.012	0.019	0.007	0.014	0.018	0.017	0.020	1.92	2	0.96
CZ	0.69	0.85	0.018	0.019	0.008	0.010	0.010	0.017	0.020	1.92	2	0.96
DE	0.40	0.94	0.019	0.015	0.002	0.007	0.009	0.017	0.020	1.92	2	0.96
DK	0.76	0.94	0.013	0.016	0.003	0.017	0.050	0.017	0.020	1.92	2	0.96
EE	0.67	0.83	0.031	0.045	0.011	0.058	0.212	0.017	0.020	1.92	2	0.96
EL	0.96	0.97	0.001	0.024	0.006	0.024	0.027	0.017	0.020	1.92	2	0.96
ES	0.95	0.95	0.017	0.015	0.006	0.025	0.046	0.017	0.020	1.92	2	0.96
FI	0.58	0.95	0.010	0.025	0.005	0.039	0.088	0.017	0.020	1.92	2	0.96
FR	0.75	0.96	0.017	0.012	0.002	0.005	0.008	0.017	0.020	1.92	2	0.96
HU	0.66	0.93	0.022	0.019	0.005	0.012	0.012	0.017	0.020	1.92	2	0.96
IE	0.74	0.94	0.035	0.020	0.009	0.016	0.022	0.017	0.020	1.92	2	0.96
IT	0.68	0.91	0.009	0.014	0.004	0.009	0.010	0.017	0.020	1.92	2	0.96
LH	0.52	0.84	0.041	0.044	0.012	0.016	0.028	0.017	0.020	1.92	2	0.96
LU	0.64	0.92	0.041	0.025	0.005	0.012	0.021	0.017	0.020	1.92	2	0.96
LV	0.63	0.85	0.035	0.043	0.017	0.065	0.093	0.017	0.020	1.92	2	0.96
MT	0.22	0.55	0.028	0.012	0.005	0.008	0.013	0.017	0.020	1.92	2	0.96
NL	0.70	0.98	0.018	0.013	0.003	0.003	0.005	0.017	0.020	1.92	2	0.96
PL	0.74	0.85	0.038	0.015	0.004	0.019	0.086	0.017	0.020	1.92	2	0.96
PT	0.86	0.98	0.013	0.014	0.004	0.006	0.006	0.017	0.020	1.92	2	0.96
RO	0.70	0.78	0.024	0.029	0.013	0.020	0.013	0.017	0.020	1.92	2	0.96
SE	0.57	0.90	0.018	0.019	0.003	0.008	0.017	0.017	0.020	1.92	2	0.96
SI	0.65	0.94	0.021	0.027	0.006	0.007	0.013	0.017	0.020	1.92	2	0.96
SK	0.60	0.79	0.038	0.026	0.007	0.009	0.011	0.017	0.020	1.92	2	0.96
UK	0.73	0.94	0.017	0.013	0.002	0.008	0.018	0.017	0.020	1.92	2	0.96
median	0.67	0.94	0.019	0.019	0.005	0.012	0.013	0.017	0.020	1.92	2	0.96

Table 1: Estimated parameters. Note: The output gap uncertainty is estimated using the revisions of the changes in the output gaps.

θ is calibrated to 2, another standard choice in the literature (see, e.g., Aguiar et al. 2016; Thwaites 2005).

There is less guidance in fixing the parameters of the interest rate equation. I calibrate the risk-free rate r_f to 2%. In order to pin down the debt-elasticity of the interest rate (1.92), I estimate Equation 3 by regressing the interest rate variable in logs on the net foreign asset position to GDP ratios in the EU countries after the year 1999 while controlling for year- and country-fixed effects. The annual net foreign asset positions and nominal GDPs are obtained from the Worldbank database. As interest rate variable, I use the long-term government interest rate. In the estimation, I consider only observations with negative foreign asset positions, leaving me with 73 observations from 12 different EU countries.[7]

In the described time period, the parametrization of the interest rate reflects the evidence of increased sensitivity of Euro area interest rates to both government and external debt in the early part of the European sovereign debt crisis. In a detailed analysis, Turner and Spinelli (2013) estimated that the response of the government borrowing on the interest rate is very sensitive to the net foreign asset position of the country. For example, a 1 percentage point increase in the government-debt-to-GDP ratio above the 75% threshold varies as follows: for countries which start with positive net external assets the interest rate effect is about 2.5 basis points; for countries with net external debt of about 25% of GDP (similar to Italy) the increase in interest rates is more than double that (about 5.5 basis points); but for a country with initial net external debt of 100% of GDP the corresponding increase in interest rates is nearly five times greater (about 12 basis points). While this paper does not explicitly model both the private and the public debt stock, the current specification is in line with the aforementioned

[7] It should be acknowledged that the estimation of the interest rate elasticity involves great deal of uncertainty, and detailed estimations of country-specific risk profiles are beyond the scope of this paper.

elasticities. In case that the net foreign asset position is 0, one percent increase in the net debt-to-GDP ratio increases the interest rate by 2 basis points, whereas the effect is 13.6 basis points when the external debt is 100 % of GDP.

Finally, the variance of the interest rate shocks is calibrated to be 0.0003 (std. = 0.017); a number that is close to the mean error magnitude in the estimated interest rate equation (std. = 0.015) when Greece is excluded. If Greece is included, the mean std. increases to 0.024.

4 Results

4.1 The influence of the output gap uncertainty for a median country

In Figure 2, I illustrate the uncertainty regarding the nature of the income shocks in the case that the economy is hit by a one-time negative shock to either the output gap or the potential output growth. On the top row of the figure (panels a and b) there are two impulse responses of the perceived output gap and the potential output, to a 1 std. negative shock to the output gap. The bottom row of the figure shows the same responses to a negative 1 std. structural shock. In period 1 the economy starts from the stochastic steady state in which the debt level is at its long-run steady state value. The state variables are expected to be in their steady state values, but the state is expected to be stochastic, so that the uncertainty follows the stationary covariance matrix of the state-variable shocks, P. The shock of interest hits the economy in period 2. [8]

The black lines show the full output gap information impact of the shock.[9] The

[8] Because the model features almost symmetric responses to similar positive shocks, they are not separately reported in this paper.

[9] In practice, the full information counterfactual is approximated with a model in which the standard deviations of both the expected and the actualized output gap noise shocks are lowered to 1% of the original.

underlying processes exhibit the estimated median parameters of the EU member countries. In the upper figures the effect show up as a transitory negative effect on the output gap, while there is no effect on the potential output. In the lower figures the effect show up as no effect on the output gap, while there is a permanent effect on the potential output because the shock hits to the growth rate of the potential, rather than its level.

On the other hand, the perceptions under imperfect output gap information are illustrated with the blue, dashed lines. In particular, the estimates include the medians of the estimated variance of the signal noise in the used Kalman filter. As the reported shock is the only shock that hits the economy, the noisy signal regarding the change of the output gap is in each case the actual change of the output gap. However, as the policy maker has to consider the possibility that the signal is noisy, the perception still deviates from the full output gap information case. As time goes by, there is no additional signals (or equally they are the ones exactly expected by the policy maker) in the example, and thus the economy gradually reaches the full output gap information state.

The results show that for both shocks it takes considerable amount of time to learn the true nature of the shocks' impact and the initial deviations in case of the imperfect output gap information are large from the true state of the economy. In case of an output gap shock, the output gap is perceived to be only half of the true output gap, while a substantial part of the true output gap shock is rather assigned as a fall in the potential output. In case of a structural shock, the policy maker first believes that the shock is partly of cyclical nature, while the potential output is overestimated.

Recall that by construction the GDP itself is observable, so the uncertainty relates to the beliefs about the persistence of its decline. For example, in case of a cyclical shock the actual shock resolves itself in only a few years, while due to the existence of the potential growth element in the imperfect output gap information case the persistence of the shock is much longer. In case of a structural shock, the persistence is rather underestimated. The same problems occur in case of positive shock, but with opposite signs.

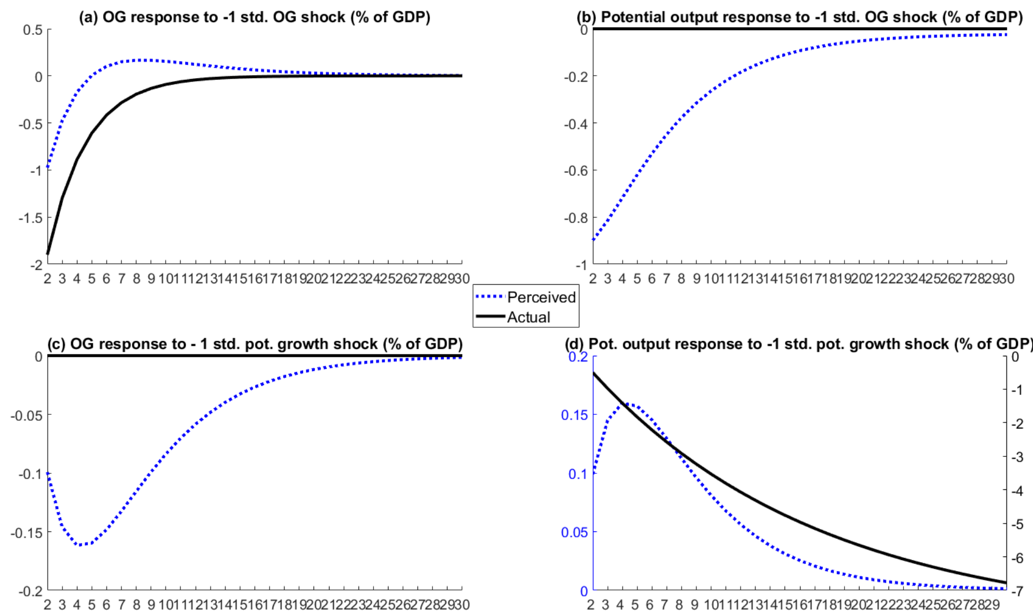

Figure 2: Uncertainty about the components of the GDP growth in the model, some examples. Note: The impulse responses are for a one-time shock without any other shocks, and the economy starts from the stochastic steady state. The calibration uses the median parameters of the EU-27 countries (see, Table 1).

Naturally, the uncertainty has relatively large effect on the optimal policy. Following the logic of the permanent income hypothesis, the policy responses to short-lived and permanent shocks are different, and thus it can be expected that the policy becomes less responsive to both kinds of shocks when it is not certain which shock hits the economy.

A first view on the effects is given in Figure 3. It shows the optimal response of the primary net lending (PB_t) including both the private and the public net

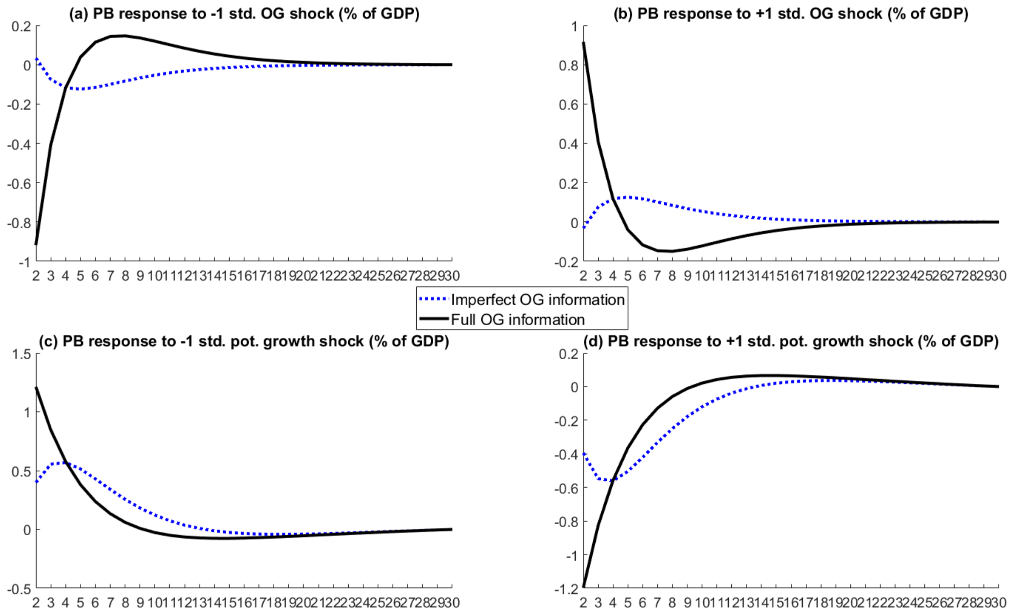

Figure 3: Primary net lending impulse responses for the median country. Note: The impulse responses are for a one-time shock without any other shocks, and the economy starts from the stochastic steady state. The calibration uses the median parameters of the EU-27 countries (see, Table 1).

lending. The impulse responses on the right-hand side of the figure correspond exactly with the shocks that were analyzed in Figure 2. The economy again starts from the stochastic steady state and a one-time, one-standard-deviation, negative shock hits the economy in period 2. The right-hand side of Figure 3 shows the associated responses to a similar, positive shock. Again, the black line shows the full output gap information response and the blue, dashed line shows the imperfect output gap information response.

Figure 3 confirms that the total net-lending of the economy becomes less sensitive to the output gaps and changes in the potential output due to the imperfect output gap information. In case of the full output gap information, the policy aligns well with the permanent income hypotheses (see, e.g., Boz et al. 2011).

When there is a negative transitory shock to output, the policy maker decreases consumption but this decrease is smaller than the decrease in output. Because the policy maker knows that the output will gradually increase back to its previous level, she borrows to cover a part of the decrease in output; in line with the standard consumption-smoothing effect in the presence of transitory shocks. When the shock is permanent, the agent observes a decrease in output today but she also realizes that future output will be also lower. The optimal response is then to immediately decrease her consumption in line with the fall in output.

However, when the output gap information is imperfect, the response of the economy to cyclical shocks becomes more cautious: The initial response is typically neutral while the policy responds more stronger as information regarding the true nature of the shock gathers in. Under the output gap uncertainty, the output responses are perceived to be combinations of cyclical and trend shocks, and therefore it is not surprising that mixing them together mutes the responses of both cyclical and trend shocks. For example, in case of a negative cyclical shock, the impulse responses in Figure 3 (panel a and c) suggests that the policy maker sees an equiproportional decline both in the cyclical and the potential component of the GDP. Similar behavior is observed in case of a positive shock, as the uncertainty regarding the nature of the shock is symmetric for positive and negative shocks. Over time the perceptions change as more information regarding the true nature of the shock is filtered.

I next turn to analyze the implications of output gap uncertainty to purely public spending. To maintain the analysis tractable, the set-up is changed as little as possible. In particular, the approach still builds on the idea that the public policy is steered in a manner that ensures the optimal net lending dynamics solved in the original model. However, part of the net lending is considered to be private, and assumed to response to the changing business cycle according to its historical behaviour.[10] The sovereign observes the private sector's responses, and adjusts its own net lending so that the total net lending still matches the optimal total net lending.

In practice, the private sector responses to the perceived output gap with an (estimated) elasticity ρ^{priv}. Furthermore, the public balance also has a cyclical component that moves according to the semielasticity ρ^{cyc} that is estimated using the OECD methodology (Mourre et al. 2013). Then, the cyclically-adjusted government balance can be solved from the equation:

$$PB_t + r_t D_t = CAB_t^{gov} + \rho^{cyc}\hat{\epsilon}_{t|t} + \rho^{priv}\hat{\epsilon}_{t|t} \tag{21}$$

where $\hat{\epsilon}_t$ is the real-time estimate of the output gap solved in the model. Furthermore, the net lending $PB_t + r_t * D_t$ is the optimal total net lending solved in the model. In order to calibrate the model, the country-specific elasticities are collected in Table 4 . For the EU 27 countries, the median output gap elasticity of the private sector net lending is -1.16; a number that is calibrated to the benchmark model. Furthermore, the cyclically adjusted balance is constructed based on the OECD estimates of the output gap semi-elasticity. In the benchmark case, the elasticity is set at 0.5.

I report the impulse responses to the one standard deviation shocks in Figure 4. The main conclusion is that the fiscal policy, as measured by the CAB, remains much less countercyclical than in the case of full output gap information. That is, the policy is less efficient in countering the effect of the economic slumps or

[10]Although the historical behaviour may not be optimal from the perspective of the private sector, that is a natural starting point of the analysis. The logic again builds on the assumption that the sovereign has instruments to enforce a particular competitive equilibrium. A more elaborate perspective would be to model the private sector optimization conditional on the public policy, but that is beyond the scope of this paper.

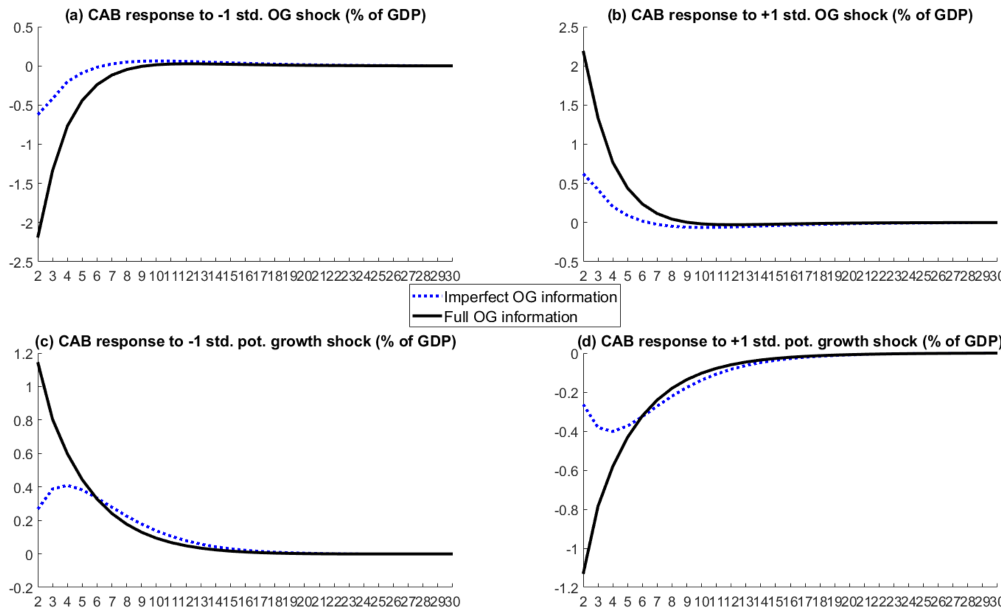

Figure 4: CAB impulse responses for the median country. Note: The impulse responses are for a one-time shock without any other shocks, and the economy starts from the stochastic steady state. The calibration uses the median parameters of the EU-27 countries (see, Table 1). CAB = The cyclically-adjusted government budget balance

upturns on the overall consumption. In downturns, the policy stance is weakly expansionary, but almost neutral (panel a). On the other hand, the CAB still responds restrictively to the positive output gap (panel b); a reminiscent of the non-linearity of the PB responses and the fact that the automatic stabilizers move to the restrictive direction in the case of positive output gap. In case of structural shocks, the policy response is more cautious. In case of a negative potential growth shock, the response is immediately restrictive while in case of a positive shock the response becomes gradually more expansionary.

To give further insight on the key moments of the policy, I simulate 20.000 periods of shocks using the median parametrization. In order to measure how sensitive the policy's response to the output gap is, the table includes the corre-

	Correlation (PB,rtime OG) (a)	Correlation (PB,true OG) (b)	Average net debt to GDP (c)	Correlation (CAB,rtime OG) (d))	Correlation (CAB,true OG) (e)	Average CAB if CAB < -0.5 (f)	Average ΔCAB if CAB < -0.5 (g)
Benchmark	-0.19	-0.14	39.37	0.47	0.24	-1.86	0.64
No noise	0.27	0.26	38.96	0.79	0.79	-2.74	1.01
Data 90-	-0.58	-0.36	32.3	0.46	0.49	-3.4	-0.2 (0.53)*

Table 2: Note: The results are based on 20.000 periods of simulated shocks for each country with a 100 period burn-in phase following the initiation. The average net debt to GDP ratio in column (b) is the average D_t/Y_t of the simulated periods (in %). The data row includes the corresponding EU-27 cross-country medians for the years 1990. The exact time span depends on the availability of the data for the particular variable. (*) = The median of all adjustments paces in the EU-27 after the year 2010.

lation between the primary net lending PB_t and the real-time and true output gaps $\hat{\epsilon_t}$. It also reports the average net debt during the simulation, as well as the key moments for the CAB_t.

The results are reported in Table 2, and Table 5 in the Appendix reports the sensitivity of the results to changes in the key parameters. The results suggest that when the output gap uncertainty is introduced to the model, the optimal primary net lending turns from pro- to moderately countercyclical in the median EU country, i.e., the correlation between the real-time OG and the PB variable turns from positive to negative (column a). The correlation is less negative in case of the true OG (column b). As the impulse responses are moderately procyclical, the countercyclical response follows from taking into account the full scale of stochastic shocks and variation in the state of the economy.

The countercyclical responses are also consistent with the data, albeit in the data this feature is somewhat stronger.[11] Several factors may contribute to the

[11] The sensitivity analysis in Table 5 suggests that the countercyclicality is more pronounced when there is less output gap variance, the output gap shocks are more persistent, or when the potential output growth is more volatile and persistent. In each case, the probability of a short-lived cyclical smaller. In terms of the preference parameters, the cyclicality is particularly sensitive to changes in the time preference. If the discount factor decreases by 10%, suggesting that the agent puts less weight on the consumption in the future periods, the net lending becomes more countercyclical. That is because during the upturns the agent is less anxious to pay back debt.

difference between the data and the model behavior. First, in the simulations I do not aim to capture the deep shocks experienced during the Great Recession, and thus the model correlation may represent more normal times. Second, the model does not include the political short-sightedness that may have caused the net lending to be strongly countercyclical during the upturn that preceded the European Sovereign Debt Crisis.

On the other hand, the simulation show that for a median country the effect of uncertainty on the average net debt-to-GDP ratio is small, while the model captures relatively well the median net debt position in the data (column c). The fact that the model appears not to lead into precautionary retrenchment of debt is consistent with the fairly symmetrical treatment of positive and negative shocks in the impulse responses despite moderate changes in the initial amount of debt (see Figure 9 in the Appendix). The debt-to-GDP ratio also exhibits wide and persistent swings around its steady state value (see Figure 8 in the Appendix); a fact that supports my choice to use a global solution algorithm when solving the model.

The sensitivity analysis in Table 5 suggests that the debt ratio is instead governed by the growth rate and the variance of the long-term productivity growth. The debt ratio is lower if the mean potential growth is lower, or if the volatility of the potential growth is higher, either because of more volatile or more persistent potential growth shocks. The debt ratio also increases if the interest rate is less sensitive to the debt level or it exhibits lower risk-free rate. Furthermore, the debt ratio is higher when the discount factor is smaller and the risk aversion parameter is higher.

In terms of the cyclically-adjusted balance (CAB), the fiscal policy in the median country is mildly countercyclical under the output gap uncertainty, as oppose to strongly countercyclical under the full output gap information (column d and e). This feature is again in line with the empirical evidence. The results also suggests that the impact is large. The response to cyclical shocks is almost four times smaller when the output gap uncertainty exists, while for trend shocks the effect is even stronger.[12]

It is useful to analyze the adjustment pace of the cyclically-adjusted balance in more detail, as that is one of the key indicator in the EU's fiscal framework. In particular, it is studied how the CAB adjusts if there is a fiscal crisis, that is, the CAB is less than -0.5% of GDP, the usual limit in the EU's framework for an excessive structural deficit. The main finding is that the CAB deteriorates less during fiscal crisis than under the full output gap information. The adjustment of the CAB is gradual under the imperfect output gap information, close to -0.5 % of GDP per year for the median country. The results show that in such cases the average CAB is on average -1.73 % of GDP in case of imperfect output gap information, and -2.77 % under the full output gap information.[13]

[12] In terms of the factors that define the degree to which the policy is procyclical, the results are very similar to the net lending. Table 5 suggests that the procyclicality is more pronounced when there is less output gap variance, the output gap shocks are more persistent, or when the potential output growth is more volatile and persistent.

[13] It is noteworthy that the main features of the simulated policy remains similar even if the output gap uncertainty is estimated from the levels of the current output gaps instead of the changes, as Table 7 in the Appendix shows. In a median EU-country, the primary net lending still becomes much less procyclical due to the output gap uncertainty. The optimal fiscal policy, as measured by the cyclically-adjusted budget balance (CAB), turns from strongly to weakly countercyclical. However, there are some differences. The policy maker is prone to make very large mistakes in interpreting the current state of the economy (see the previous section for a discussion): the sovereign considers making very countercyclical policy in real time , but ends up doing much less countercyclical policy. Second, due to the failure to assess the true uncertainty in the output gap, the CAB are allowed to deteriorate much more than in the benchmark specification. On the other hand, the adjustments of the CAB are on average very strong, suggesting abrupt changes in the policy.

4.2 The influence of the output gap uncertainty, comparison across EU countries

In this subsection, I analyze the impacts of the output gap uncertainty at the EU-country level. The calibration of the models follow Table 1 . The table shows that the variation of parameters is rather large both in terms of the income process characteristics as well as the uncertainty related to the nature of individual shocks.

For each country, the implications of the output gap uncertainty are analysed by simulating the models for 20.000 periods both without the OG uncertainty (i.e., with 1 % noise standard deviations as compared to the original) and under the imperfect output gap information. Table 3 shows the key results.[14]

In Table 3, the countries are ordered based on the average correlation between the observed, real-time output gap and the primary net lending. A negative correlation suggests that the model exhibits countercyclical responses to the output gap. The results show that there are marked differences across countries in the cyclicality of the primary net lending responses. The most countercyclical responses are seen in the EU's emerging economies, but also in some developed countries such as Finland and Ireland. On the other hand, the most procyclical responses are seen in Malta, Belgium, Germany and Sweden. The simulations also suggest that there is large, cross-country variation in the average net debt due to the differences in the income process. Interestingly, the correlation categorizes countries similarly in the data, as Figure 5 suggests. Several eastern European transition countries are among the ones with the strongest countercyclical primary net lending both in the data and simulated responses. Again, the large shocks experienced during the current crisis and political short-sightedness are likely factors to explain why the variation in the data is larger than in the model.

To further analyse the heterogeneity, the role of the output gap uncertainty is

[14]The full set of moments is available in Table 6

	Correlation (PB,rtime OG), OG uncertainty (a)	Net debt (% of GDP), OG uncertainty (b)	Δ Corr due to the OG uncertainty (c)	Δ debt due to the OG uncertainty (d)
LV	-0.45	47.9	-0.71	1.12
BG	-0.31	39.8	-0.65	0.71
RO	-0.26	43.5	-0.52	0.34
FI	-0.19	29.9	-0.6	0.9
HU	-0.18	42.6	-0.45	0.31
IE	-0.15	50.1	-	-
IT	-0.13	31.5	-0.44	0.28
ES	-0.12	37	-0.09	0.66
CY	-0.1	27.1	-0.17	1.47
PL	-0.09	56	-0.14	-0.03
CZ	-0.07	39.9	-0.33	0.26
DK	-0.06	35.7	-0.34	0.02
LU	-0.06	56.4	-0.33	0.04
EE	-0.05	47.5	-0.33	-0.06
FR	-0.04	39.7	-0.35	0.04
EL	-0.03	-5.6	-0.07	-2.02
UK	-0.03	39.9	-0.32	0.04
AT	-0.02	42.5	-0.5	0.09
SK	0.05	55.2	-0.3	0.03
NL	0.08	38.7	-0.18	0.09
LH	0.1	53.9	-0.31	0.17
SI	0.1	40.4	-0.22	0.25
SE	0.15	40.8	-0.35	0.03
BE	0.21	39.2	-0.32	0.04
DE	0.22	41.7	-0.38	0.06
MT	0.36	48.8	-0.28	0.01
Median	-0.05	40.4	-0.33	0.09

Table 3: Note: The results are based on 20.000 periods of simulated shocks for each country with a 100 period burn-in phase following the initiation. The net debt in column (b) is the average D_t/GDP_t over the simulation. In order to measure the importance of the output gap uncertainty, in columns (c) and (d) the simulations are first repeated without the OG uncertainty (i.e., with 1 % noise standard deviations as compared to the original), and the change, Δ, is then measured by comparing the full and imperfect OG information specifications.

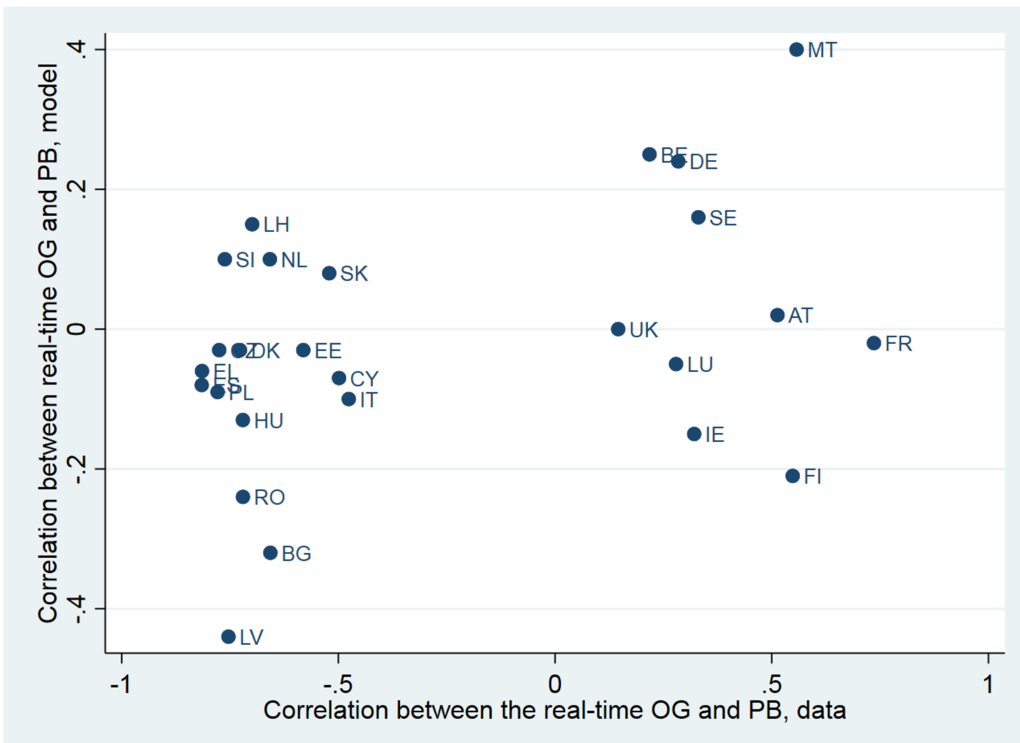

Figure 5: Scatter plot of the PB and the real-time OG, data vs. model

first explicitly measured in Table 3. The results show the direct effect of output gap uncertainty on the primary net lending and the net debt for each country (column c and d), as the difference of these variables in the simulations with imperfect output gap information and full output gap information.[15] In a few EU countries, the effect of the output gap uncertainty is substantial and generates strong countercyclical net lending responses. The implications of the output gap uncertainty are usually strongest in the countries that would also otherwise have more countercyclical policy responses.[16]

On the other hand, the average net debt is not typically very sensitive to the output gap uncertainty. In most cases the effects are very small, the only exception being the lowering effect on Greece. Rather, a cross-country regression over the model parameters suggests that the main factors behind the variation are the differences in the volatility of the potential output and its long-term average growth rate $\hat{g}$. The average net debt is negatively affected by an increase of the potential growth's AR(1) coefficient and the potential shock variance. They imply larger long-run volatility in the income process. On the other hand, an increase in the long-term average growth rate $\hat{g}$ increases the average net foreign asset position.[17]

From the perspective of the fiscal policy, it is also important to analyse how much the heterogeneity is reflected in the CAB. If the CAB responses are very heterogeneous, it would be problematic from the perspective of using the common, numerical fiscal rules to guide the level and changes of the CAB. On the other

[15]Again, the full information counterfactual is approximated with a model in which the standard deviations of both the expected and the actualized output gap noise shocks are lowered to 1% of the original.

[16]A cross-country regression over the model parameters suggests that the main, other driving force behind the varying net lending responses is the underlying variance of the output gap shock. When the variance is, ceteris paribus, higher, the reaction of the primary net lending is more procyclical; a result that is in line with the previous subsection's robustness analysis.

[17]The interest rate and the preference factors naturally would affect the results, too, as the previous subsection's results suggest, but they are held constant in the country-specific models.

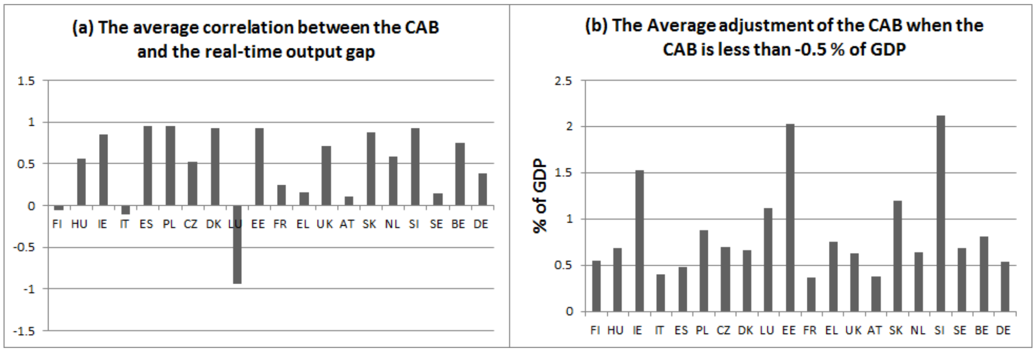

Figure 6: The degree of countercyclicality of the net lending responses in comparison to the (1) degree of countercyclicality of the CAB responses, and (2) the rate at which the CAB is corrected during a fiscal crisis. Note: On the x-axis countries are ordered based on their average correlation of net lending with the real-time output gap, with the ordering from smaller to larger.

hand, it may be the case that the private sector reactions are sufficient to deal with the heterogeneity caused by the OG uncertainty. Furthermore, the sizing of automatic stabilizers is also conditional on how large the output gap is perceived to be; a fact that may also unify the optimal policy in terms of the adjustments of the CAB.

In order to analyse this question, I compare the degree of countercyclicality of the net lending responses to the (1) degree of countercyclicality of the CAB responses, and (2) the rate at which the CAB is corrected during a fiscal crisis. In both terms, a strong relationship would indicate that the cross-country heterogeneity in the income process would necessitate different, optimal fiscal policy responses. The results, however, suggest that there is no systematic relationship between these variables. That is, the cyclical adjustment and the private sector reactions may be sufficient to deal with the heterogeneity of the OG uncertainty. Therefore, at least from the perspective of the output gap uncertainty, a common policy designed with the CAB may be a sensible one.

5 Conclusions

The cyclical adjustment of the government budget balance is nowadays a standard tool in fiscal governance. For example, at the core of the EU's fiscal policy framework is the cyclically-adjusted budget balance (CAB) that measures the budgetary position of public finances, when the effects of economic cycles are eliminated. However, despite evidence of large revisions in the output gaps during the Great Recession, there is still fairly little guidance on how the output gap uncertainty should be taken into consideration when optimal fiscal policy is designed.

Using a novel dataset, I quantify the magnitude of the EU-27 countries' output gap revisions in 2002-2014, and study the implications of this uncertainty for the optimal fiscal policy with a DSGE model. Taking the output gap uncertainty into account has large implications for both the total net lending behaviour and the fiscal policy in the EU-27. I find that in a median EU-country, the primary net lending turns from procyclical to countercyclical when the economy is subjected to the output gap uncertainty. The fiscal policy as measured by the CAB remains weakly countercyclical: the optimal policy is less expansive during the downturns and less restrictive during the upturns. The debt-to-GDP ratios exhibit wide and persistent swings around the long-run averages.

Furthermore, the output gap uncertainty implies significant amount of cross-country heterogeneity in the dynamics of the net primary lending in the EU. In a few EU countries, the effect of output gap uncertainty is substantial and generates strong countercyclical reactions of the net lending. However, despite the heterogeneity, the optimal policy in terms of the CAB adjustments is not systematically different across countries. That is, the private sector responses to the economic cycle and the cyclical corrections of the public balance may be sufficient to deal with the heterogeneity.

All in all, the results suggest that the output gap uncertainty is an important determinant of fiscal policy. Having said that, there are of course other determinants of fiscal policy, such as the quality of governance and the influence of adverse political interests, that this paper does not directly address. While I left their analysis for future research, it is not hard to imagine that the output gap uncertainty has far-reaching effects also in these respects. Thus, it seems safe to conclude that the development of new, powerful fiscal indicators and the designing of policies to deal with the output gap ambiguity should continue to be a key policy priority in the EU.

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Appendix

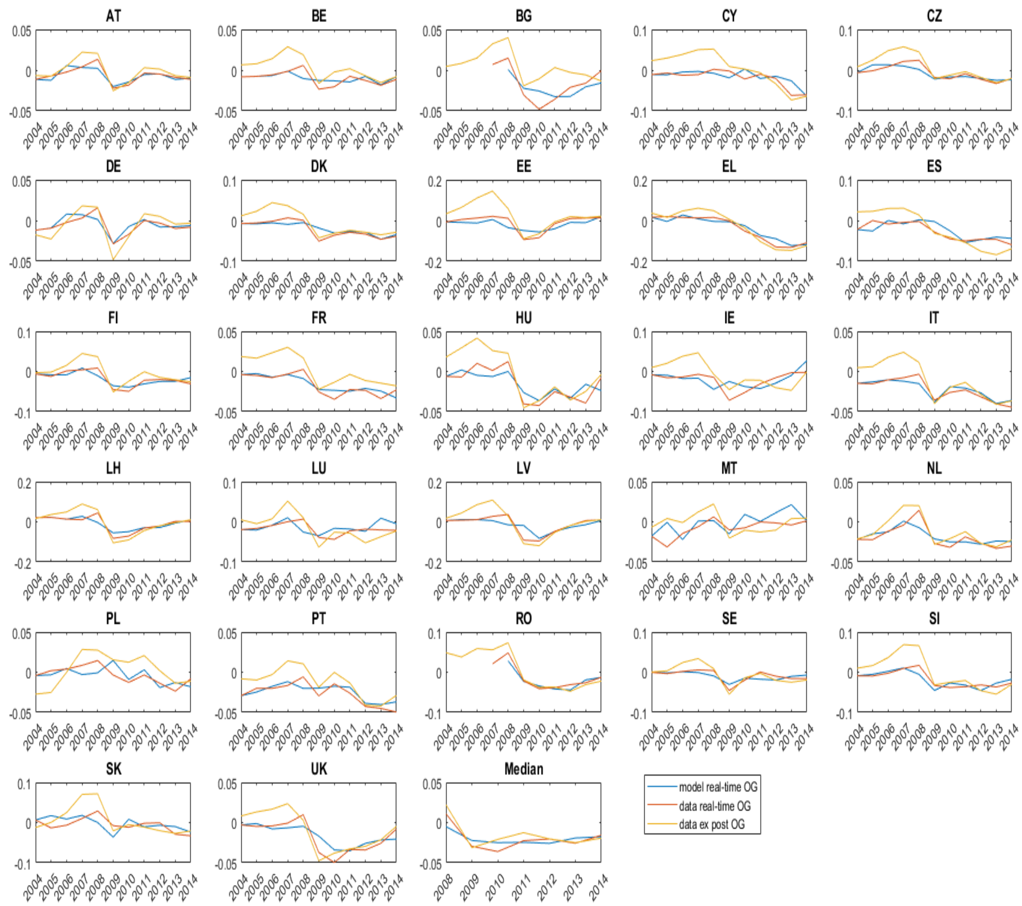

Figure 7: The differences between the output gaps in the calibrated model and the data in levels.

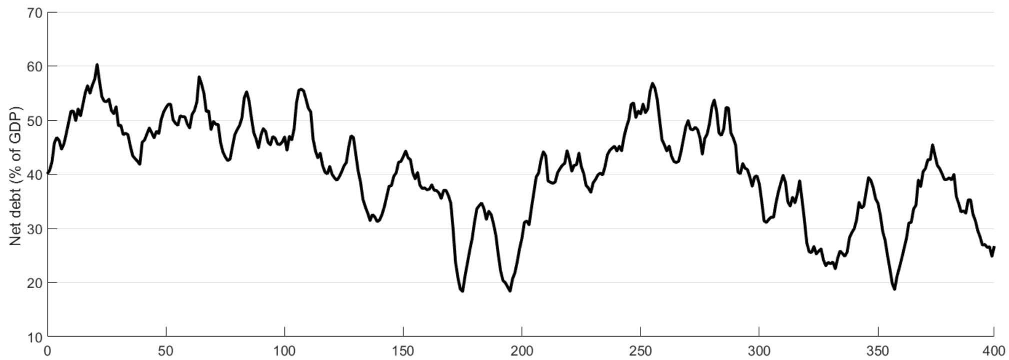

Figure 8: The simulated debt dynamics in the Benchmark model. Note: A random sample of 400 simulated years

	The OG elasticity of the private net lending	The OG Semi-elasticity of the government balance (OECD method)
AT	-0.65	0.58
BE	-1.26	0.61
BG	-	0.31
CY	-	0.52
CZ	-0.98	0.43
DE	-0.6	0.55
DK	-1.88	0.62
EE	-1.78	0.44
EL	-0.71	0.48
ES	-3.39	0.54
FI	-0.63	0.57
FR	-0.65	0.6
HU	-1.27	0.49
IE	-3.35	0.53
IT	-0.52	0.54
LH	-	0.41
LU	1.54	0.44
LV	-	0.38
MT	-	0.46
NL	-1.08	0.65
PL	-2.26	0.52
PT	-3.22	0.51
RO	-	0.34
SE	-0.46	0.59
SI	-2.16	0.48
SK	-1.2	0.39
UK	-1.17	0.59
Median	-1.17	0.52

Table 4: Estimated elasticities of private net lending and the output gap semi-elasticity of the government budget balance. Note: The elasticity of the private lending is estimated by first calculating the net lending of the private sector from the OECD national accounts (code NFB9P), including non-financial corporations, financial corporations, and households and non-profit institutions serving households. The data is typically available after the mid-1990s and the most recent year is 2012. The elasticity is then calculated by regressing the variable on the real-time OG.

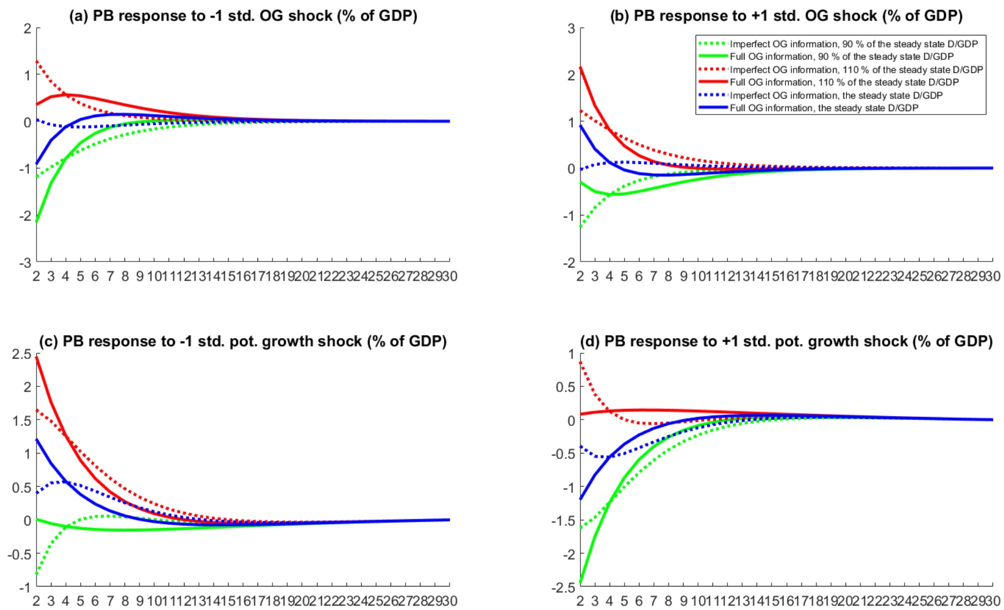

Figure 9: Primary net lending impulse responses for the median country, the effect of different levels of the initial debt-to-GDP ratio.

	Correlation (PB,rtime OG) (a)	Correlation (PB,true OG) (b)	Average net debt (c)	Correlation (CAB,rtime OG) (d))	Correlation (CAB,true OG) (e)	Average CAB if CAB < -0.5 (f)	Average ΔCAB if CAB < -0.5 (g)
Benchmark (matched OG changes)	-0.19	-0.14	39.37	0.47	0.24	-1.86	0.64
Matched OG levels	0.06	0.02	39.6	0.70	0.27	-4.13	2.04
Responses to parameter changes as compared to the benchmark:							
-10% AR(output gap)	0.02	0	0.01	-0.01	0	0.02	0.04
-10% AR(potential growth)	0.04	0.03	1.26	0.27	0.19	0.32	-0.03
-10% potential growth	0.01	0.01	-1.8	0	0	-0.02	0.01
-10% OG shock σ^2	-0.02	-0.01	0.05	-0.04	-0.04	0.05	-0.02
-10% pot. shock σ^2	0	0	0.19	0.03	0.02	0.05	-0.02
-10% Debt-IR elasticity	0	0	4.37	-0.03	-0.02	-0.08	0.01
-10% riskfree IR	-0.01	-0.01	3.49	-0.02	-0.01	-0.03	0.01
-10% risk aversion	0	0	-1.38	0.02	0.01	0.04	0
-10% time preference	-0.26	-0.15	33.54	-0.05	-0.03	0.1	-0.02

Table 5: Sensitivity analysis. Note: The results are based on 20.000 periods of simulated shocks for each specification with a 100 period burn-in phase following the initiation.

	Correlation (PB,rtime OG) (a)	Correlation (PB,true OG) (b)	Average net debt (c)	Correlation (CAB,rtime OG) (d))	Correlation (CAB,true OG) (e)	Average CAB if CAB < -0.5 (f)	Average ΔCAB if CAB < -0.5 (g)
AT	-0.02	-0.06	42.54	0.11	0.01	-1.11	0.38
BE	0.21	0.09	39.18	0.75	0.40	-1.64	0.81
BG	-0.31	-0.12	39.80	-	-	-	-
CY	-0.10	-0.06	27.12	-	-	-	-
CZ	-0.07	-0.04	39.92	0.52	0.36	-1.79	0.69
DE	0.22	0.14	41.67	0.39	0.25	-1.13	0.54
DK	-0.06	-0.14	35.72	0.92	0.25	-3.07	0.66
EE	-0.05	-0.15	47.48	0.93	0.27	-7.72	2.03
EL	-0.03	0.00	-5.58	0.16	0.08	-3.74	0.75
ES	-0.12	-0.04	37.04	0.95	0.20	-6.39	0.48
FI	-0.19	-0.23	29.85	-0.06	-0.20	-1.84	0.55
FR	-0.04	-0.04	39.65	0.25	0.10	-0.97	0.37
HU	-0.18	-0.12	42.59	0.56	0.34	-1.90	0.68
IE	-0.15	-0.13	50.07	0.85	0.36	-5.50	1.53
IT	-0.13	-0.09	31.45	-0.11	-0.08	-1.28	0.40
LH	0.10	0.05	53.90	-	-	-	-
LU	-0.06	-0.09	56.39	-0.94	-0.57	-5.13	1.12
LV	-0.45	-0.28	47.87	-	-	-	-
MT	0.36	0.18	48.82	-	-	-	-
NL	0.08	0.07	38.73	0.59	0.42	-1.73	0.64
PL	-0.09	-0.16	56.02	0.95	0.19	-4.40	0.88
PT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RO	-0.26	-0.12	43.53	-	-	-	-
SE	0.15	0.07	40.81	0.15	0.02	-1.49	0.68
SI	0.10	0.09	40.37	0.92	0.62	-6.25	2.12
SK	0.05	0.04	55.16	0.88	0.65	-2.65	1.20
UK	-0.03	-0.09	39.91	0.71	0.23	-1.74	0.63

Table 6: Note: The results are based on 20.000 periods of simulated shocks for each country with a 100 period burn-in phase following the initiation.