WP/20/86

IMF Working Paper

How Loose, How Tight? A Measure of Monetary and Fiscal Stance for the Euro Area

by Nicoletta Batini, Alessandro Cantelmo, Giovanni Melina and Stefania Villa

INTERNATIONAL MONETARY FUND

 WP/20/86

IMF Working Paper

Research Department

How Loose, How Tight? A Measure of Monetary and Fiscal Stance for the Euro Area[1]

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Authorized for distribution by Chris Papageorgiou

May 2020

Abstract

This paper builds a model-based dynamic monetary and fiscal conditions index (DMFCI) and uses it to examine the evolution of the joint stance of monetary and fiscal policies in the euro area (EA) and in its three largest member countries over the period 2007-2018. The index is based on the relative impacts of monetary and fiscal policy on demand using actual and simulated data from rich estimated models featuring also financial intermediaries and long-term government debt. The analysis highlights a short-lived fiscal expansion in the aftermath of the Global Financial Crisis, followed by a quick tightening, with monetary policy left to be the "only game in town" after 2013. Individual countries' DMFCIs show that national policy stances did not always mirror the evolution of the aggregate stance at the EA level, due to heterogeneity in the fiscal stance.

JEL Classification Numbers: E4, E5, E6
Keywords: policy stance, euro area, monetary policy, fiscal policy.

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"Here what becomes really very important is fiscal policy [...] if there were to be a significant worsening in the Eurozone economy, it's unquestionable that fiscal policy – a significant fiscal policy, mostly in some countries but also at the euro area level – becomes of the essence."

Mario Draghi, Press Conference, ECB. July 25, 2019.

"The extraordinary [monetary] stimulus may have to last a long time if there is no support from fiscal policy"

Mario Draghi, Financial Times. September 29, 2019.

1 Introduction

The euro area (EA) suffered a much deeper and protracted slump than the United States after the Global Financial Crisis (GFC). This dynamic is frequently ascribed to the fact that the United States implemented a bolder fiscal stimulus—besides the monetary stimulus—while in the EA the stimulus had to come primarily from monetary policy, mainly reflecting constraints posed by the Stability and Growth Pact. The decision by the European Central Bank (ECB) in late 2019 to provide a new round of monetary easing in support of Europe's ailing economy has revived the debate about the appropriate policy mix for the EA. This debate has taken even larger proportions in the face of the threats posed by the COVID-19 outbreak in early 2020.

At the institutional level, the fiscal framework of the EA limits fiscal policy actions of individual member states but contains no instruments to ensure that the aggregate fiscal stance of the EA is appropriately countercyclical. Consequently, the limited space for the deployment of fiscal policy (see e.g. IEO, 2016; Caprioli et al., 2017; Orphanides, 2018; Rigon and Zanetti, 2018) has increased the burden on monetary policy (Draghi, 2015). On the monetary policy side, the institutional framework of the ECB allows, in principle, the adoption of the most appropriate stance for the EA, considering the fiscal policy stance for the area as given. For instance, if contractionary fiscal policy contributes to disinflationary concerns, monetary policy can compensate with additional accommodation. Nonetheless, conventional monetary policy easing has been constrained by the effective lower bound to the policy rate and ECB policy has been faced by the unique challenges of implementing quantitative easing (QE).

Against this background, this paper constructs dynamic monetary and fiscal conditions indices (DMFCIs) to study the historical evolution of the fiscal and monetary mix in the

EA based on an estimated dynamic stochastic general equilibrium (DSGE) model. DMFCIs represent indicators of the overall policy stance that help assess whether demand policy has become tighter or looser relative to a previous reference period. The same indices are built also for the EA's three largest economies (France, Germany and Italy). These indices are useful at least on four grounds. First, from a communication point of view, DMFCIs provide a synthetic measure of the stance that can be more easily conveyed to the public, compared to model-centric tools, such as the results of an estimated DSGE model (e.g. da Silva, 2018). For instance, Gerlach (2017) points out that the complex nature of the DSGE models limits their usefulness as communication devices since it is difficult to convey their results in a compelling way. Second, unlike decomposition of structural shocks, they capture both the expected and the unexpected components of the policy stance. This feature turns out particularly useful for the analysis of the fiscal stance. Third, the DMFCIs allow assessing the overall degree of policy stance in the EA and in individual countries, while the two components of the DMFCI (monetary and fiscal) help disentangle the contribution of the area-wide monetary policy and the collection of the individual countries' fiscal policies. Fourth, the information contained in the aggregate index and in its components may contribute to the design of a balanced policy response. This last function is especially important in the case of the EA where the co-existence of a common monetary policy intersects with regionally-decentralized fiscal policies.

This paper makes an important contribution to the literature on indices of policy stance (for works on Monetary Condition Indices (MCIs) see, e.g., Bernanke and Mihov, 1998; Gerlach and Smets, 2000; Osborne-Kinch and Holton, 2010). While a handful of monetary and financial condition indices (e.g. MCIs by the European Commission and the FCIs by the IMF) are routinely produced, and fiscal stance is usually measured through the cyclically-adjusted primary balance (e.g. by the IMF), the idea of a combined monetary and fiscal index that dynamically tracks the policy stance is new. The DMFCI is derived estimating the impact of monetary and fiscal policy on output in a regression based on data obtained simulating a rich estimated DSGE model of the EA economy (or of the individual EA member country economies), and combining these estimates with historical data. Broadly speaking, this trails conceptually the early literature on MCIs that are derived as weighted averages of (calibrated or estimated) coefficients of the interest rate and the exchange rate in an IS equation. However, the paper innovates relative to the early literature on MCIs by: (i) simulating data from a fully-fledged structural model; (ii) embedding lags in the construction of the index to capture the dynamic effect of policy actions, in line with the contribution of Batini and Turnbull (2002) on MCIs; and (iii) incorporating fiscal policy (captured through changes in the cyclically-adjusted primary balance, CAPB) as a second policy instrument. One of the advantages of using an estimated DSGE model relative to estimated non-structural models is the possibility of accounting for the general equilibrium effects of shocks and policies. [1]

The model used for the simulations is a DSGE model estimated on EA and French, German and Italian data over the period 1999Q1-2018Q3. It is used as a data generating process to compute the weights of the DMFCIs, and therefore their properties can be intuitively explained in the light of the estimated models. The DSGE model embeds four specific features crucial for the analysis. First, we account for households' limited asset market participation, as in other models of the EA (see, Forni et al., 2009, Ratto et al., 2009, Coenen et al. 2012; 2013 and Albonico et al., 2016, among others). This feature is key to introduce New-Keynesian effects of fiscal policies, which would otherwise be absent, as explained by Mankiw (2000) and Galí et al. (2007). Second, we introduce a financial sector in which financial intermediaries (FIs, henceforth) purchase long-term private and government bonds, as in Carlstrom et al. (2017). This modeling block is relevant because the maturity transformation performed by FIs introduces a transmission channel for credit shocks, which had a prominent role during the GFC.[2] Third, we specify a detailed government sector whereby government debt is long-term. The fiscal authority levies distortionary taxes to finance expenditures and stabilize government debt, via fiscal rules that allow also for automatic stabilizers. Fourth, it accounts also for unconventional monetary policy, such as large-scale asset purchases (QE) and forward guidance, by using the shadow monetary policy rate of Wu and Xia (2017) as an observable variable.

Two versions of the model are developed: a closed-economy version estimated on aggregate EA data; and a currency-union version estimated using also individual country data for France, Germany and Italy. Accordingly, four DMFCIs are derived over the period 2007-2018 and are used to: (i) assess the joint impact of monetary and fiscal policies on demand as well as examine the relative impact of individual policies; (ii) compare the results on the policy

[1] Given the use of a DSGE model as the basis to construct the indices, the paper is also naturally connected with the DSGE literature. For instance, various DSGE models assess fiscal policy in the EA. Forni et al. (2009) make the argument that tax cuts are more expansionary than expenditures increases. Along these lines, Coenen et al. (2013) conclude that the fiscal stimulus package implemented in the EA, known as the European Economic Recovery Plan, generated a fiscal multiplier smaller than one since it comprised both revenues and expenditure measures. Moreover, while Ratto et al. (2009) find a general countercyclical role of fiscal policy before the financial crisis, Kollmann et al. (2016) argue that austerity measures weighed on the EA recovery until the end of 2014, whereas Albonico et al. (2016) find evidence of muted fiscal policy.

[2] Although for the case of Italy, Caivano et al. (2010) find that the crisis of 2007-2008 occurred mainly due to international trade factors, while domestic financial shocks have played a minor though non-negligible role.

stance of the DMFCI with the historical contribution of the policy shocks in the estimated DSGE models; and (iii) analyze their dynamics properties in the light of the DSGE model.

Four key results emerge. First, the DMFCI suggests that the EA's overall policy became looser in the aftermath of the crisis, but not before the recession was in full swing, with most of the loosening manifesting itself between 2009 and 2011. The overall stance was then tightened during the sovereign debt crisis before being loosened again around 2014 when the ECB embraced more drastic accommodative policy actions. Second, the patterns observed looking at the aggregate EA DMFCI do not tally one to one with changes observed at the national level, where the evolution of the overall stance since the GFC was, in fact, quite heterogeneous due to the fiscal stance. Indeed, we find that fiscal policy was strongly expansionary in France during the GFC while becoming restrictive in the aftermath of the sovereign debt crisis. Conversely, Germany implemented a restrictive fiscal policy except for a short period after the GFC, while in Italy the fiscal stance is found to be always tighter than the pre-crisis period. In other words, the examination of the dynamics of the policy components of the DMFCI confirms recent analysis and commentary stating that monetary policy in the EA has been the "only game in town" (e.g., IMF, 2019), after 2013-14 — a story that repeats itself at the national level. Third, the monetary policy component of the historical shock decomposition is sizable and provides information in line with that of the DMFCI. In contrast, the fiscal policy component of the historical shock decomposition is small and correlates much more poorly with that of the DMFCI. The latter finding can be rationalized considering that the shock decomposition only captures the effects that unexpected policy innovations have on the model's endogenous variables. While these were quantitatively important on the monetary policy side (including quantitative easing), they were much weaker on the fiscal side. Capturing the expected (anticipated) and unexpected (unanticipated) component of policy makes the DMFCI a more appropriate indicator for the stance in general, and the fiscal policy stance in particular. Fourth, the dynamic cross-correlations of the DMFCI with GDP, combined with the analysis of the estimated impulse response functions, reveal that monetary policy has historically led GDP while fiscal policy generally did not.

The paper is organized as follows. Section 2 describes the DSGE model used to simulate the data on which DMFCI coefficients are estimated. Section 3 reports the model's Bayesian estimates. Section 4 explains the computation of the DMFCI, compares its evolution with the historical shock decomposition, and discusses its dynamics. Section 5 offers conclusions and policy implications. The full model, technical details and additional results are appended to the paper.

2 Model

The model used to simulate the data with which the weights of the DMFCIs are estimated is a New-Keynesian model with the usual nominal and real frictions, as in Smets and Wouters (2007), as well as certain other features relevant for the EA during and in the aftermath of the GFC. In this section, we present the main features of a closed economy version of the model, suitable to study the EA as a whole ('EA model'), and of a 2-bloc currency union (CU, henceforth) model, where the home country represents France, Germany or Italy, and the foreign country represents the rest of the EA. The CU model is formed by a home country h of size n and a foreign country f (i.e. countries in the rest of the currency union) of size $1 - n$. The home and foreign countries are assumed to be completely symmetric. Given that we estimate the CU model three times, considering each time one of the three countries as the domestic country, we refer to these three estimated models as CUF, CUG and CUI, respectively.

The frictions of the model include price (θ_p) and wage (θ_w) stickiness (à la Rotemberg, 1982), investment adjustment costs as in Christiano et al. (2005a) (ψ_i; IAC, henceforth) and habit formation in consumption (h). The model is further augmented with: (i) a mix of ω optimizers (or Ricardian) and $1 - \omega$ "rule-of-thumbers" (or non-Ricardian) households – as in Galí et al. (2007); (ii) financial intermediaries accumulating net worth and short-term liabilities to finance the purchase of long-term private investment and government bonds as in Carlstrom et al. (2017); (iii) a detailed fiscal bloc, according to which the government purchases goods and services, provides transfers to households, and finances the budget by levying distortionary taxes on households and firms, and, residually, by issuing debt at different maturities.

As a result of this specification, within each country the economy consists of eight agents: optimizing and rule-of-thumb households, labor unions that assemble labor services supplied by households, financial intermediaries, non-financial firms, capital producers, the fiscal authority and the central bank. The addition of financial intermediaries and long-term (private and government) bonds following Carlstrom et al. (2017) allow us to introduce a term-premium and a credit shock, which in turn enables us to stylize some of the key disturbances that presented themselves in the course of the GFC.[3]

[3]Carlstrom et al. (2017) estimate the model for the US economy up to 2008Q4 and then, although not the main focus of their paper, exploit these features by simulating the effects of quantitative easing (QE), e.g. purchases of long-term government bonds by the central bank (see Sec. II.B of their paper). In this paper we take a different approach by estimating the model over a period in which the QE has been in place by using the shadow policy rate as an observable. FIs have been introduced in DSGE models of the EA also by Gerali et al. (2010) and Kollmann et al. (2013). These papers, however, do not allow FIs to hold

Financial intermediaries are the sole buyers of long-term investment bonds, $\bar{F}_t$, and long-term government bonds, $\bar{B}_t^{FI}$. They finance these purchases by collecting deposits, D_t, from optimizing households, although their ability to do so is constrained by their net worth, N_t. This constraint generates a friction in the credit market. The severity of the friction is then determined by the ability of financial intermediaries to adjust their net worth in response to shocks, which is costly as governed by parameter $\psi_n \in [0, \infty)$. Credit shocks propagate to the real economy because all capital investment is financed by issuing long-term debt. A tighter borrowing constraint of financial intermediaries, who can only sluggishly adjust their net worth, translates into a higher term premium and hence lower economic activity.

Finally, the model features a detailed fiscal sector conducted at the country level, as in Ferrero (2009) and Burlon et al. (2018),[4] and a common central bank that sets a standard Taylor-type interest rate rule for the entire currency union.

Given the importance of demand policies in the paper we report a detailed description of the two policymakers: the central bank and the fiscal authority.[5] A full description of all model features, equilibrium conditions and steady state can be found in Sections A, B and C, respectively, of the Appendix.

Policymakers

Central bank. The central bank conducts monetary policy according to a Taylor-type interest-rate rule, which determines the nominal interest rate R_t according to:

$$\log\left(\frac{R_t}{R}\right) = \rho_r \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_r)\left\{\rho_\pi \log\left(\frac{\Pi_t^u}{\Pi^u}\right) + \rho_y \log\left(\frac{Y_t^u}{\tilde{Y}_t^u}\right)\right\} + e_t^m. \tag{1}$$

Π_t^u and Y_t^u are the union-wide inflation and output, defined as

$$\Pi_t^u = (\Pi_t)^n (\Pi_t^*)^{1-n}, \tag{2}$$

$$Y_t^u = nY_t + (1-n)Y_t^*, \tag{3}$$

government debt.

[4]The remaining abovementioned literature has employed models of a currency union only to study monetary policy, while models of the euro area used to study fiscal policy are either closed-economy or small-open-economy.

[5]Given the positive nature of the analysis, monetary and fiscal policy are captured by estimated simple Taylor-type rules as common in the literature (see, e.g., Smets and Wouters, 2007; Leeper et al., 2013, among many others).

where Π_t^* and Y_t^* are inflation and output in the rest of the euro area. Parameter ρ_r governs the interest rate smoothing, while ρ_π and ρ_y are the monetary responses to inflation deviations from steady state and output gap, defined as deviations from output in the equilibrium that would prevail without nominal rigidities and markup shocks. Finally, e_t^m is a AR(1) monetary policy shock.

Fiscal authority. The government finances government spending, G_t and lump-sum transfers τ_t^l, via long-term debt and a mix of distortionary taxes T_t, hence its budget constraint reads as

$$\bar{B}_t = \frac{R_t^L}{\Pi_t}\bar{B}_{t-1} + \bar{G}_t - T_t, \tag{4}$$

where $\bar{G}_t = G_t + \tau_t^l$ denotes total government expenditure. Total real tax revenues, T_t are given by the sum on tax revenue on consumption, C_t, on labor income, W_tH_t, and return on capital, $\left(R_t^k - \delta P_t^k\right) K_t$:

$$T_t = \tau_t^C C_t + \tau_t^W W_t H_t + \tau_t^k \left(R_t^k - \delta P_t^k\right) K_t. \tag{5}$$

The primary balance to GDP, PB_t^Y, is defined as

$$PB_t^Y = \frac{T_t - \bar{G}_t}{Y_t}. \tag{6}$$

In order to reduce the number of tax instruments to two, we follow Cantore et al. (2017) and assume that distortionary taxes τ_t^C, τ_t^W and τ_t^k as well as the two types of government expenditure deviate from their respective steady state by the same proportion, i.e. $\tau_t^C = \tau_t \tau^C$, $\tau_t^W = \tau_t \tau^W$, $\tau_t^k = \tau_t \tau^k$, $G_t = g_t G$, and $\tau_t^l = g_t \tau^l$. The government uses the following fiscal rules to stabilize debt and react to deviations of output from its steady state:

$$\log\left(\frac{\tau_t}{\tau}\right) = \rho_\tau \log\left(\frac{\tau_{t-1}}{\tau}\right) + \rho_{\tau b}\log\left(\frac{\bar{B}_{t-1}}{\bar{B}}\right) + \rho_{\tau y}\log\left(\frac{Y_t}{Y}\right) + \left(1-\vartheta_\tau\right)\epsilon_t^\tau + \vartheta_\tau \epsilon_{t-1}^\tau, \tag{7}$$

$$\log\left(\frac{g_t}{g}\right) = \rho_g \log\left(\frac{g_{t-1}}{g}\right) - \rho_{gb}\log\left(\frac{\bar{B}_{t-1}}{\bar{B}}\right) - \rho_{gy}\log\left(\frac{Y_t}{Y}\right) + \left(1-\vartheta_g\right)\epsilon_t^g + \vartheta_g \epsilon_{t-1}^g, \tag{8}$$

where ρ_g and ρ_τ govern the persistence of the fiscal policy instruments, while $\rho_{\tau b}$ and ρ_{gb} define their responsiveness to deviations of government debt its from steady state, and $\rho_{\tau y}$ and ρ_{gy} determine their reaction to deviations of output from its steady state, to introduce an automatic stabilizer component. Finally, ϵ_t^g and ϵ_t^τ are i.i.d. government spending and tax shocks, respectively. Following Leeper et al. (2013), we allow for pre-announcement effects of fiscal policy via the parameters $\vartheta_\tau, \vartheta_g \in [0,1]$. Such a specification of the fiscal rules is important to account for anticipated effects of fiscal policies and avoid biased estimates. If $\vartheta_i = 1$, with $i \in \{\tau, g\}$, then agents have perfect foresight of fiscal policies as, at time t, they can perfectly observe g_{t+1} and τ_{t+1}. Conversely, if $\vartheta_i = 0$ agents have no foresight at all and receive news only about contemporaneous government spending and tax rates. Values of ϑ_i between 0 and 1 imply a limited degree of fiscal foresight by private agents.[6]

In the currency union model, where "*" denotes variables belonging to the foreign bloc, the fiscal rules of the rest of the EA are given analogously by

$$\log\left(\frac{\tau_t^*}{\tau^*}\right) = \rho_\tau^* \log\left(\frac{\tau_{t-1}^*}{\tau^*}\right) + \rho_{\tau b}^* \log\left(\frac{\bar{B}_{t-1}^*}{\bar{B}^*}\right) + \rho_{\tau y}^* \log\left(\frac{Y_t^*}{Y^*}\right) + (1-\vartheta_\tau^*)\,\epsilon_t^{\tau,*} + \vartheta_\tau^* \epsilon_{t-1}^{\tau,*}, \quad (9)$$

$$\log\left(\frac{g_t^*}{g^*}\right) = \rho_g^* \log\left(\frac{g_{t-1}^*}{g^*}\right) - \rho_{gb}^* \log\left(\frac{\bar{B}_{t-1}^*}{\bar{B}^*}\right) - \rho_{gy}^* \log\left(\frac{Y_t^*}{Y^*}\right) + \left(1-\vartheta_g^*\right)\epsilon_t^{g,*} + \vartheta_g^* \epsilon_{t-1}^{g,*}. \quad (10)$$

3 Bayesian Estimation

We use Bayesian estimation methods to estimate the four DSGE models.[7] Throughout we employ EA data over the period 1999Q1 until 2018Q3, that is, encompassing much of the history of the European Monetary Union (EMU),[8] as well as key turning points in the EA's business cycle, namely the GFC, the sovereign debt crisis and the implementation of the Public Sector Purchase Programme (PSPP) started by the ECB in March 2015.

For the EA model we use 10 observable variables, while for each CU model we employ 19 observable variables. Variables for the EA model include real GDP, real private consumption, real private investment, real wage, real government spending (which includes government consumption, investment and transfers), real total revenues, inflation, the term premium, the ratio of the primary fiscal balance to GDP, and the nominal interest rate for the EA model. To these 10 variables we add the corresponding first 9 variables (that is, all except the nominal interest rate) for the rest of the EA when estimating the three variants of the CU model for France, Germany and Italy.[9] Appendix E discusses data transformations and

[6] In the empirical literature these announced policy changes are studied also in a narrative approach (see, e.g., Amaglobeli et al., 2018)

[7] The Kalman filter is used to evaluate the likelihood function, which combined with the prior distribution of the parameters yields the posterior distribution. Then, the Monte-Carlo-Markov-Chain Metropolis-Hastings (MCMC-MH) algorithm with two parallel chains of 500,000 draws each is used to generate a sample from the posterior distribution in order to perform inference.

[8] The precise starting date of the estimation, however, changes slightly across countries due to data availability. In particular, the sample starts in 1999Q2 for the EA and France, in 2001Q1 for Italy, and in 2002Q2 for Germany.

[9] We use data on eleven countries of the EA, namely Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain; and aggregate them weighting by nominal GDP. This choice is dictated by the fact that these countries are the founding members of the currency union and

reports the measurement equations.

Since the data used in estimation encompasses both the GFC and the sovereign debt crisis, the sample includes a period in which the Euro Interbank Offered Rate (EONIA), which is usually used as a proxy for the ECB policy rate, approached the ZLB (2012Q1) and then turned negative (2014Q4) and remained stuck at the effective lower bound (ELB), thus posing potential issues in the estimation of the model. One way to deal with the ZLB would be to estimate the model up to period before the ELB started binding and then use non-linear techniques to simulate it with a binding ELB.[10] However, there is little agreement about which non-linear method is more appropriate,[11] and such a strategy would miss the effects of unconventional monetary policy. Alternatively, one can estimate the DSGE model replacing the policy rate with a shadow rate, as Mouabbi and Sahuc (2019) do for the EA. The shadow rate is a counterfactual policy rate that takes into account the effects of all the unconventional monetary policies implemented by the central bank and is free to move in the negative territory, thus circumventing the estimation issues posed by the ZLB. In this paper, we follow this route and estimate the models as done in Mouabbi and Sahuc (2019), using the Eonia shadow rate constructed by Wu and Xia (2017).[12]

Structural parameters and steady state values are calibrated at a quarterly frequency. Tables 1 and 2 present the calibration of the EA and country-specific parameters, respectively. The calibration of the households' discount factor ($\beta = 0.99$, as commonly used), the capital depreciation rate ($\delta = 0.025$, which implies a 10% annual capital depreciation rate) and the capital share of income ($\alpha = 0.33$) are standard in the DSGE literature and are set at the values of choice of other studies on the EA (see, Smets and Wouters 2003, 2005, among others). The elasticities of substitution in goods and labor markets ε^p and ε^w

hence data is available for the entire sample selected. On the contrary, we exclude Greece because quarterly Greek fiscal data is not fully available. In each of the CU models the rest of the EA is represented by all these eleven countries minus the country that is taken as the domestic economy.

[10]See Chen et al. (2012), Del Negro et al. (2015), Drautzburg and Uhlig (2015), Hirose and Inoue (2016), Lindé et al. (2016), Gust et al. (2017) and Anzoategui et al. (2019).

[11]See, e.g., Fratto and Uhlig (2020). Moreover, Kollmann et al. (2016) estimate a DSGE model of the EA up to 2016Q4 without accounting for the ZLB and then, as a robustness check, re-estimate the model using the method developed by Guerrieri and Iacoviello (2015). They find only marginal changes in their results and argue that the ZLB was not a significant constraint on monetary policy, in line with the conclusions of Lindé et al. (2016).

[12]Mouabbi and Sahuc (2019) construct their own shadow rate which is similar to the one constructed by Wu and Xia (2017) but it is not publicly available. The main difference between the two is that the latter allows for a time-varying lower bound of the interest rate, although none of them capture the effects of Outright Monetary Transactions (see Albertazzi et al., 2020). By construction the shadow rate equals the actual rate until unconventional policies are implemented at the ZLB. The series constructed by Wu and Xia (2017) starts in 2004Q4 hence we extend it back to 1999Q1 using the Eonia rate given that the two coincide in normal times.

Table 1: Calibrated Euro Area Parameters.

Parameter		Value / steady state target
Discount factor	β	0.99
Capital depreciation rate	δ	0.025
Capital share of income	α	0.33
Elasticity of substitution goods	ε^p	6
Elasticity of substitution labor	ε^w	6
Government spending to GDP	g_y^*	0.20
Government debt to GDP	b_y^*	0.78
Steady state Tax rate consumption	$\tau^{c,*}$	0.20
Steady state Tax rate capital	$\tau^{k,*}$	0.30
Steady state Tax rate labor income	$\tau^{w,*}$	0.38
Duration of long-term bonds	$(1-\kappa)^{-1}$	40
Disutility of labor	B, B^*	$H = 1$
FI additional discount	ζ, ζ^*	$L = 6$

Table 2: Calibrated Country-Specific Parameters.

Parameter		Value		
		France	Italy	Germany
Country size	n	0.22	0.18	0.29
Government spending to GDP	g_y	0.23	0.19	0.19
Government debt to GDP	b_y	0.79	1.14	0.69
Steady state Tax rate consumption	τ^c	0.20	0.17	0.20
Steady state Tax rate capital	τ^k	0.47	0.30	0.22
Steady state Tax rate labor income	τ^w	0.40	0.43	0.38
Exports to GDP	x_y	0.27	0.26	0.40
Imports to GDP	m_y	0.28	0.25	0.35

equal 6 in order to target a steady-state gross mark-up of 20%, as in Gerali et al. (2010). The ratios of government spending, government debt, exports and imports to GDP are set in line with the data from Eurostat.[13] Steady-state tax rates are calculated from the European Commission's Taxation Trends Report 2018.[14] We calibrate κ such that the duration of the long-term bonds is set to 10 years. The scale parameter of the disutility of labor B is set to match steady state hours equal to 1, whereas the additional discount factor of the FIs is set to match a steady state leverage of 6, as in Villa (2016). Finally, each country's size $n \in [0, 1]$ is set as the share of nominal GDP among the EA countries considered.

Tables E.3-E.6 in Appendix E summarize the prior and posterior distributions of the

[13] We compute averages over the years 2000-2018.

[14] See https://ec.europa.eu/taxation_customs/news/taxation-trends-report-2018_en. We calculate averages over the years 2003-2016.

parameters and the shocks.[15] The choice of the priors corresponds to a large extent to those in previous studies of the EA. We generally follow Smets and Wouters (2003; 2005) in choosing the prior distribution of the structural parameters and the parameters governing the shock processes. We set the prior mean of the inverse Frisch elasticity η to 0.5. Estimated DSGE models of the EA largely agree in setting the prior mean of the habit parameter h to 0.70. Turning to the share of optimizing households, we start from a prior whereby their share equals that of rule-of-thumbers, as common in the literature. We follow Gerali et al. (2010) by setting the prior distributions of the IAC ψ_i and price and wages stickiness parameters, including indexation. In particular, prices are *a priori* assumed to last 3.7 quarters while wages are assumed to last 2.5 quarters. Given the lack of previous estimates for the parameter of FIs' net worth adjustment for the EA, we center our prior on the estimate of Carlstrom et al. (2017) for the US economy. In particular, we assume that ψ_n takes a Normal prior distribution with mean 0.785 and standard deviation 0.10. This prior distribution is sufficiently loose to include cases of low and high degrees of financial frictions.

The priors of the tax rules coefficients are taken from Zubairy (2014) and are broadly consistent with existing EA studies, e.g. the ones by Forni et al. (2009) and Kollmann et al. (2013). We are agnostic about the countercyclicality of government spending, and accordingly, we set a Normal prior distribution for ρ_{gy}, ρ^*_{gy} with mean 0.10 and standard deviation 0.05, thus not excluding the case of procyclical government spending should the parameter take negative values. Finally, the prior distributions of the parameters of the Taylor rule are standard, with the interest rate smoothing parameter, ρ_r, set to have a prior mean 0.80 and with a stronger response of the central bank to inflation than output. In general, we use the Beta (B) distribution for all parameters bounded between 0 and 1. We use the Inverse Gamma (IG) distribution for the standard deviation of the shocks for which we set a loose prior with 2 degrees of freedom.

In general, our estimates are broadly in line with existing studies. The fraction of optimizing households is rather high, ranging from 0.74 in France to 0.90 in Italy. These estimates of ω are relatively close to Coenen et al. (2012; 2013), who estimate a fraction of rule-of-thumbers of 18% in the EA, but farther from Forni et al. (2009), Ratto et al. (2009) and Albonico et al. (2016), who estimate a larger share (of around 35%) using different models and a variety of alternative datasets. We also find sizable IACs with ψ_i generally

[15] While it might be argued that the GFC represented a structural break thus potentially changing the distribution of the shocks, we follow the convention by assuming that the distribution of the shocks is time-invariant. Several models estimated over a sample including the GFC make the same assumption (see e.g. Gerali et al., 2010; Coenen et al., 2013; Kollmann et al., 2013; Kollmann et al., 2016; Hohberger et al., 2019, for the EA and Albonico et al., 2017 for the US). We nevertheless set rather loose priors for the standard deviations of the shocks (inverse gamma distribution with shape parameter 0.1 and scale parameter 2).

close in size to what found by Smets and Wouters (2005) and Forni et al. (2009). Turning to the posterior estimate of ψ_n, we find a non-negligible degree of financial frictions. We also detect a substantial degree of nominal rigidities, this being in line with estimates of the EA by Smets and Wouters (2003, 2005), Forni et al. (2009), Coenen et al. (2012; 2013), Quint and Rabanal (2014), and Villa (2016).

Estimates of the fiscal rules reveal slightly stronger responses of government spending than taxes to government debt and output deviations from steady state in the EA, while these responses are essentially equal in France, Italy and Germany. Government spending is estimated to be countercyclical given the positive values of ρ_{gy} and ρ_{gy}^*. Estimates of the parameters governing the degree of fiscal foresight reveal that agents foresee these shocks at least in part, with stronger pre-announcement effects of government spending than taxes $\left(\vartheta_g > \vartheta_\tau, \vartheta_g^* > \vartheta_\tau^*\right)$. Finally, the Taylor rule parameters and the parameters of the shock processes take standard values.

4 Dynamic Monetary-Fiscal Condition Indices (DMFCIs)

In this section we use the estimated DSGE models presented in the previous sections to compute the weights of dynamic monetary-fiscal condition indices (DMFCIs) for the EA as a whole, as well as and for France, Germany and Italy taken individually, for a total of four DMFCIs. Specifically, Subsection 4.1 discusses the relation with the literature on monetary condition indices. Subsection 4.2 describes the computation of the DMFCIs. Subsection 4.3 shows the evolution of the DMFCIs in the countries/region of interest. Subsection 4.4 makes a comparison with alternative available indices. Subsection 4.5 compares the evolution of the DMFCIs with the historical contribution of policy shocks to GDP over the sample period. Finally, Subsection 4.6 presents dynamic properties of these indices combined with the analysis of selected impulse response functions obtained from the estimated DSGE models.

4.1 Relation with the Literature

DMFCIs represent indicators of the overall policy stance which can help establish whether demand policy has become tighter or looser relative to a previous reference period. The DMFCIs presented in this paper are novel relative to other indices of economic policy stance (see, e.g., Gerlach and Smets, 2000; Osborne-Kinch and Holton, 2010) along three dimensions.

First, they measure the *combined* effect on output of multiple macroeconomic policy levers (monetary and fiscal), while they can also be conveniently decomposed to analyze individual contributions to changes in the overall grip of demand policy. In addition, by using the shadow monetary policy rate, they take also the effects of unconventional monetary policy into account.

Second, following Batini and Turnbull (2002), they are *dynamic*. So contrary to other measures of monetary conditions or other measures of fiscal stance, which only focus on the first difference of changes in the fiscal balance, the DMFCIs consider the impact over time of the interest rate and fiscal instruments on output. Since it measures the effect of policy variables given (i) past changes in those variables and (ii) the time it takes for those changes to have an impact on output, the DMFCIs should be interpreted as a "contemporaneous" indicator of stance.[16]

Third, the weights of the DMFCI are derived from a *system of equations*, rather than just one equation. In particular, the weights here arise from a DSGE model which specifies relationships as suggested by economic theory.

4.2 Computation of the DMFCI

In essence, DMFCIs are linear combinations of lagged changes in the monetary policy rate (proxied by the shadow rate to measure both conventional and unconventional monetary policy) and lagged changes in the cyclically-adjusted primary balance (CAPB, to measure fiscal policy), relative to their values in a given base period. Given that the base period is chosen arbitrarily, no significance is attached to the value of the index per se; rather, the index is meant to show the degree of tightening or loosening in monetary and fiscal conditions from the base or some other historical period.

The estimated DSGE models are key in the computation of the DMFCIs for two reasons. First, they allow computing model-implied CAPBs, which are not directly observable variables; and second, they can be used to produce a large set of simulated macroeconomic variables useful to determine the appropriate weights for the DMFCIs, based on the impact that the shadow rate and the CAPB have on output.

Three steps are needed to compute the DMFCI. First, we draw 1,000 sets of stochastic realizations of all shocks for a number of quarters equal to $T = 1,500$ and use the estimates of structural parameters and shock processes of the DSGE models to produce stochastic

[16]Notably, because it is expressed in terms of lags of the policy variables, the DMFCI can be projected forward in order to obtain a forecast of the future policy stance. This may help understand the effects, at each point in time, of changes in monetary and fiscal conditions given the monetary and fiscal impulses that are already built into the transmission mechanism. At the same time, it can help establish whether, conditional on policy impulses already in the pipeline, the policy mix between monetary and fiscal policy can be expected to be balanced or not.

simulations of the models' endogenous variables.[17] The 1,000 time series (each 1,000 periods long, after discarding the first 500 periods as burn-in) are saved for the following variables: detrended output, $\hat{y}_t$;[18] the real shadow monetary policy rate, $\hat{r}_t \equiv \hat{R}_t - E_t\hat{\Pi}_{t+1}$; the domestic CAPB as a fraction of potential output, $capb_t \equiv \frac{CAPB_t}{\tilde{Y}_t}$; the analogous ratio of CAPB to potential output of the rest of the EA, $capb_t^* \equiv \frac{CAPB_t^*}{\tilde{Y}_t^*}$; and all domestic and rest-of-EA non-policy demand shocks (preference, investment-specific and credit shocks) e_t^{κ} and $e_t^{\kappa^*}$, where $\kappa = \{b, \mu, \phi\}$.

The definitions of potential output and of the CAPB deserve more explanation. Potential output $\tilde{Y}_t$ is the natural scaling variable since the CAPB measures what the fiscal balance would have been if output had been at its potential level. In the context of a DSGE model the potential level of output is the level prevailing in the absence of price and wage stickiness as well as price and wage mark-up shocks. To compute $capb_t$, define the cyclically-adjusted component of government revenue as $T_t^{CA} \equiv T_t \left(\frac{\tilde{Y}_t}{Y_t}\right)^{\eta^T}$, where η^T is the elasticity of revenues with respect to the output gap, $gap_t \equiv \frac{Y_t - \tilde{Y}_t}{\tilde{Y}_t}$; and the cyclically-adjusted component of government expenditures as $\bar{G}_t^{CA} \equiv \bar{G}_t \left(\frac{\tilde{Y}_t}{Y_t}\right)^{\eta^G}$, where η^G is the elasticity of government expenditures with respect to the output gap. Therefore, the following relationship holds: $capb_t \equiv \frac{CAPB_t}{\tilde{Y}_t} = \frac{T_t^{CA}}{\tilde{Y}_t} - \frac{\bar{G}_t^{CA}}{\tilde{Y}_t} = \frac{T_t}{Y_t}\left(\frac{\tilde{Y}_t}{Y_t}\right)^{\eta^T - 1} - \frac{\bar{G}_t}{Y_t}\left(\frac{\tilde{Y}_t}{Y_t}\right)^{\eta^G - 1} = \frac{T_t}{Y_t}\left(1 + gap_t\right)^{-\left(\eta^T - 1\right)} - \frac{\bar{G}_t}{Y_t}\left(1 + gap_t\right)^{-\left(\eta^G - 1\right)}$.[19]

Second, on each set of these artificial data, we run a regression of output on lags of the monetary policy rate, lags of the CAPB, lags of the rest-of-EA CAPB, and exogenous regressors (all domestic and rest-of-EA non-policy demand shocks, i.e. preference, investment-

[17] Stochastic simulations are performed by Dynare, relying on a Taylor approximation of the expectation functions by using perturbation methods (see Collard and Juillard, 2001). This technique differs from bootstrapping, which is a statistical technique based on simulations to trace out sampling variability.

[18] Variables with a ˆ denote log-deviations from the steady state.

[19] Following Fedelino et al. (2009) we set $\eta^G = 0$ and $\eta^T = 1$, given that these elasticities are close to those estimated for OECD countries. In particular, the OECD and European Commission elasticities (European Commission, 2005; Girouard and André, 2005; Price et al., 2015) computed for specific tax categories yield an aggregate revenue elasticity close to 1. Similarly the aggregate spending elasticity is close to zero, as most spending is not correlated to the output gap (see, e.g., Frankel et al., 2013, Price et al., 2015, and Vegh and Vuletin, 2015).

specific and credit shocks), as follows:

$$\hat{y}_t = \alpha^0 + \sum_{j=1}^{N^r} \alpha_j^r \hat{r}_{t-j} + \sum_{j=1}^{N^{capb}} \alpha_j^{capb} capb_{t-j} + \sum_{j=1}^{N^b} \alpha_j^b e_{t-j}^b + \sum_{j=1}^{N^\mu} \alpha_j^\mu e_{t-j}^\mu + \sum_{j=1}^{N^\phi} \alpha_j^\phi e_{t-j}^\phi$$
$$+ \sum_{j=1}^{N^{capb^*}} \alpha_j^{capb^*} capb_{t-j}^* + \sum_{j=1}^{N^{b^*}} \alpha_j^{b^*} e_{t-j}^{b^*} + \sum_{j=1}^{N^{\mu^*}} \alpha_j^{\mu^*} e_{t-j}^{\mu^*} + \sum_{j=1}^{N^{\phi^*}} \alpha_j^{\phi^*} e_{t-j}^{\phi^*} + \epsilon_t. \quad (11)$$

The lag structure for equation (11) is chosen as the one that maximizes the median adjusted R-squared, $\bar{R}^2$, across all 1,000 regressions. Clearly, all rest-of-EA variables are not present in the closed-economy EA regression. As far as the sign is concerned, we expect a negative coefficient on both the shadow rate and the CAPB, α_j^r and α_j^{capb} respectively, consistently with the standard contractionary effects on output of a tightening in monetary and fiscal policy. Selected quantiles from the distribution of regression coefficients and the median $\bar{R}^2$ are reported in Appendix F (Tables F.1-F.4).

Finally, we use the coefficients on the monetary policy rate and the CAPB from regression (11) to build the Dynamic Monetary-Fiscal Conditions Index (DMFCI). Algebraically, the DMFCI is given by:

$$DMFCI_t = DMFCI_t^M + DMFCI_t^F + DMFCI_t^{F*}, \quad (12)$$

where:

$$DMFCI_t^M = \sum_{j=1}^{N^r} \tilde{\alpha}_j^r \left(\hat{r}_{t-j}^s - \hat{r}_{b-j+1}^s \right), \quad (13)$$

$$DMFCI_t^F = \sum_{j=1}^{N^{capb}} \tilde{\alpha}_j^{capb} \left(capb_{t-j}^s - capb_{b-j+1}^s \right), \quad (14)$$

and

$$DMFCI_t^{F*} = \sum_{j=1}^{N^{capb^*}} \tilde{\alpha}_j^{capb^*} \left[\left(capb_{t-j}^* \right)^s - \left(capb_{b-j+1}^* \right)^s \right], \quad (15)$$

where $\tilde{\alpha}_j^r$, $\tilde{\alpha}_j^{capb}$, and $\tilde{\alpha}_j^{capb^*}$ are coefficients on the lags of $\hat{r}_t$, $capb_t$, and $capb_t^*$, respectively; while $\hat{r}_t^s$, $capb_t^s$, and $(capb_t^*)^s$ are the smoothed real shadow rate, CAPB, and CAPB of the rest of the EA, respectively (the latter variable is clearly used only for computing DMFCIs of the three member countries in the context of CU models). The term b is a chosen base period. As highlighted by equation (12), the DMFCI is given by the algebraic sum of the monetary, the domestic fiscal and the the rest-of-EA fiscal components. This makes it straightforward to compute the overall policy stance, as well as its monetary and fiscal contributions.[20] Given the distribution of coefficients across the 1,000 regressions, we build distributions of the indices and report its median together with its 5$^{\text{th}}$ and 95$^{\text{th}}$percentiles.

By construction, a positive value of the index represents a looser policy stance while a negative value represents a tighter one with respect to the base year, which we set to be 2005q1. Given the lag structure and the observations available for each country, the choice of the base year allows us to compute the indices from some quarter between 2006 and 2007 for all countries and to compute the stance relative to the same pre-crisis period.[21] The choice of 2005q1 as a base quarter is dictated by two main considerations. First and foremost, the difference between the steady-state interest rate and its actual value is the lowest precisely in 2005q1 and the value of the model-implied CAPB in 2005 is close to zero (0.2) in the EA. Second, the choice of the base quarter is also restricted by the optimal lag structure in equation (11) combined with the starting date of the dataset in Germany, which is 2002q2. To allow immediate comparability we report all indices starting from 2007.

For all countries, in cumulative terms, the signs of these coefficients are in line with the theory. There are some notable country-specific differences. For instance, in France the effects of monetary and fiscal policies are rather short-lived contrary to Italy, where these effects are protracted, with Germany showing a lag structure in between those reported for France and Italy.

4.3 Evolution of DMFCIs in the Euro Area

Figure 1 plots the DMFCI (solid lines) for the period 2007-2018, while the dotted lines represent the 5$^{\text{th}}$ and 95$^{\text{th}}$ percentiles.[22] This figure provides three pieces of information on: (1) whether policy has become looser (a positive DMFCI) or tighter (a negative DMFCI) with respect to the base year; (2) which component of the DMFCI (monetary or fiscal) is quantitatively more important within each country; and (3) whether the stance is different from the base year with high probability. Three main results emerge.

First, the overall stance of demand policies was loosened in all countries from 2008 on-

[20]The monetary policy component of the index differs across countries because of the different inflation expectations that make the real interest rates country-expectations.

[21]More specifically, indices start in 2007q1, 2006q1, 2006q2 and 2006q3 for the EA, France, Germany and Italy, respectively. Table F.3 shows that six lags of the policy instruments maximize the adjusted R-squared in Germany. The base date cannot thus be before 2004q1.

[22]Figure 1 reports the yearly averages. The components of the index – monetary, fiscal, and fiscal of the rest of the EA – are divided by the standard deviation of the country' total DMFCI in order to make a quantitative comparison within each country across the different components of the DMFCI.

ward. While this loosening came to a halt during the period 2011-14, mostly reflecting a reversal of fiscal loosening, the policy stance became accommodative again thereafter, mostly reflecting monetary accommodation by the ECB.

Second, the degree of overall policy loosening in the aftermath of the GFC was heterogeneous, and therefore the evolution of the aggregate EA DMFCI does not necessarily mirror the evolution of individual countries' DMFCIs. More specifically, the figure suggests that the loosening of fiscal policies was more pronounced in France, less strong in Germany, and absent in Italy.[23] And while in France and Germany the initial accommodation was strengthened further by the ECB's loosening that started in 2014, in Italy the overall stance remained tighter than pre-crisis until later, because fiscal policy accommodation was never in place, and became even tighter in 2011 due to the fiscal consolidation measures implemented in response to the sovereign debt crisis.[24] In addition, the role of fiscal policies of the rest of the EA has a marginal role in the three EA economies.

Finally, results reaffirm the notion that the euro area's policy mix since the GFC has been dominated by monetary policy, in that fiscal policy has somewhat rowed against the cycle, especially in the case of Italy and Germany, for which monetary easing indeed has been the "only game in town" (IMF, 2019). This finding tallies with estimates by Rostagno et al. (2019) that the policy package as a whole implemented by the ECB contributed almost 3 percentage points to euro-area real GDP growth between 2015 and 2018 and is responsible for a part of the job creation observed in the EA. In their analysis, 3/4 million people found a job thanks to the measures the ECB put in place since 2014.

4.4 Comparison with Alternative Available Indices

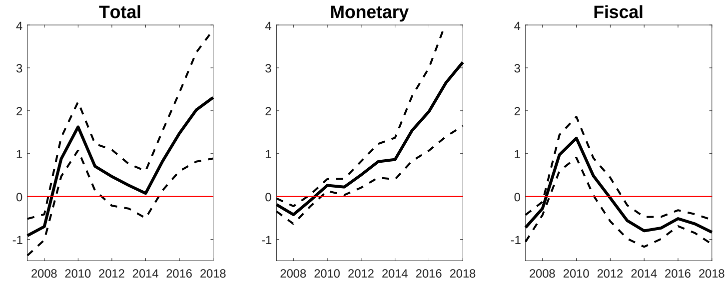
We now compare our DMFCIs with alternative available indices. As already noted, the DMFCI is the first index combining monetary and fiscal stances, also able to account for periods of unconventional monetary policy. Reflecting this, to compute the unconditional correlations reported in Table 3, we use closest available benchmarks for comparison. In contrast to our indices, positive (negative) values of those alternative indices represent a tightening (loosening), therefore a negative correlation means that the two indices go in the same direction. In particular, we correlate: (i) year-on-year changes in the $DMFCI^M$ for the EA with year-on-year changes in the Monetary Condition Index (MCI) computed

[23] These results are broadly in line with other contributions on the fiscal stance (Mauro et al., 2015; Fournier, 2019).

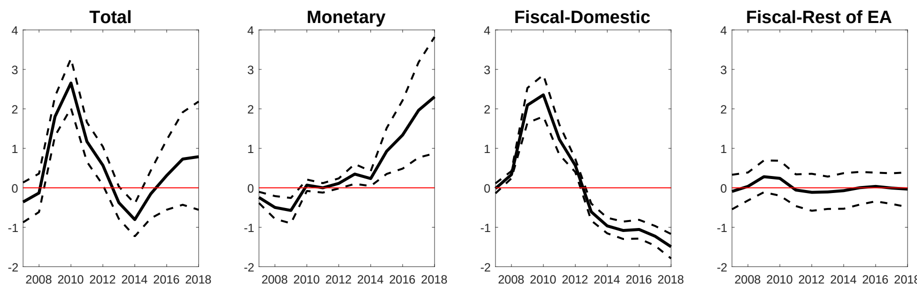
[24] Accordingly, Busetti and Cova (2013) find that the fiscal consolidation implemented in 2011 in Italy lowered output growth by 1%. In addition, Gerali et al. (2015) find evidence that the fiscal consolidation, which has been achieved mainly through higher taxes, reduced Italy's potential output by about 1.2pp.

Figure 1: Dynamic Monetary-Fiscal Condition Indices—Rescaled Yearly Averages.

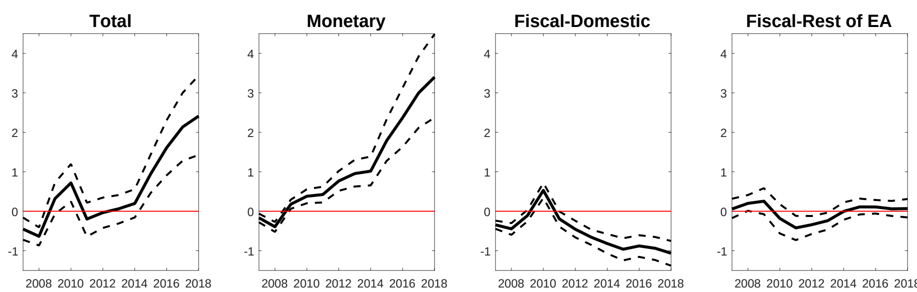
(a) Euro area



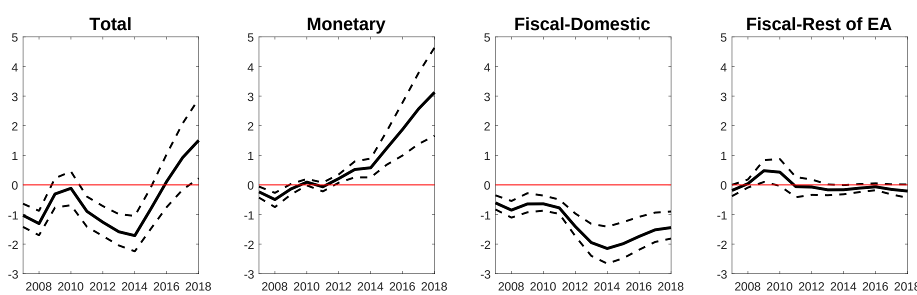
(b) France



(c) Germany



(d) Italy



Notes: Solid lines represent median DMFCI while dotted lines represent the 5^{th} and 95^{th} percentiles. For each country DMFCI are rescaled by the standard deviation of the respective total DMFCI.

Table 3: Correlation Between Changes of the DMFCI ($DMFCI^M$ and $DMFCI^F$) and Those of Alternative Indices.

Indices	Period/Country	Correlation coefficient
$DMFCI^M$ $EA - MCI$ EC	2008Q1-2018Q3	-0.26
	2008Q1-2013Q4	-0.58
$DMFCI^M - FCI$ IMF	EA	-0.59
	France	-0.55
	Germany	-0.52
	Italy	-0.49
$DMFCI^F - CAPB$ IMF	EA	-0.92
	France	-0.96
	Germany	-0.89
	Italy	-0.73

Notes: The correlation coefficients of the MCI and FCI are negative because by construction a negative value of the MCI and FCI represents a loosening in contrast with the construction of the $DMFCI^M$.

by the European Commission (European Commission, 2019);[25] (ii) the $DMFCI^M$ for the EA and the single countries with the Financial Condition Index (FCI) computed by the International Monetary Fund (IMF);[26] and (iii) yearly changes in our annualized $DMFCI^F$ for France, Germany and Italy with yearly changes in the corresponding IMF's cyclically-adjusted primary balance (CAPB, as a share of potential output).[27]

The first row of Table 3 shows that the correlation between our $DMFCI^M$ and the EC's MCI is somewhat weak between 2008 and the third quarter of 2018, mainly due to the fact that our index includes unconventional monetary policy whereas this index does not.[28] By restricting the sample to the period before the implementation of the PSPP (second row

[25] The EC's MCI (constructed for the whole euro area) is a weighted average of the real short-term interest rate and the real effective exchange rate relative to their value in a base period, where the weight of the interest rate component is six times the one of the exchange rate component, i.e. the relative weights are 6:1. These weights reflect each variable's relative impact on GDP after two years and are derived from simulations in the OECD's Interlink model. It is computed at a monthly frequency, therefore we first transform it to a quarterly index and then calculate the year-on-year changes.

[26] The IMF's FCI is calculated as a combination of interest rates, asset prices, exchange rate and volatility measures, as detailed in the Annex 3.2 to the Chapter 3 of the October 2017 IMF's Global Financial Stability Report and in Matheson (2012). To the best of our knowledge, this is the only FCI available for EA countries (e.g. Aramonte et al., 2017 assess a variety of FCIs for the US economy). Similarly to the MCI by the EA, in the FCI a positive value represents a tightening and *viceversa*. And again, the correlation between the $DMFCI^M$ and the FCI is negative.

[27] We retrieve the IMF's CAPB (in percent of potential output) from the Fiscal Monitor dataset. Since it is published at an annual frequency, we annualize our quarterly $DMFCI^F$ and compare the yearly changes between the two indices.

[28] Figure G.1 in Appendix G shows that the values of the two indices are close during the period 2007-2014 when they start to diverge, with the $DMFCI^M$ showing a clear increasing trend differently from the MCI.

of Table 3), the correlation between the two indices increases substantially, from −0.26 to −0.58. Our $DMFCI^M$ displays also a high correlation with the IMF's FCI for the EA and the single economies considered (see third to sixth row of Table 3), again by virtue of the fact that we include unconventional monetary measures that affect both long-term and market interest rates, capturing similar financial trends embedded in the information used to build the FCI.[29] Finally, the last three rows of Table 3 show that our $DMFCI^F$ is strongly correlated with the IMF's CAPB (in percent of potential output).

Overall, our subindices show comovement with other existing indices or measures that proxy the policy stance. When they do not, it is because our index captures some important feature not included in other indices, such as unconventional monetary policies, crucial to provide a more precise assessment of the policy stance. Finally, our monetary and fiscal indices conveniently add up to an index of the overall demand policy stance, a feature that is missing in all other indices.

4.5 Comparison between DMFCIs and Historical Contribution of Shocks in the DSGE Model

To what extent do the DMFCIs provide information beyond the historical shock variance decomposition of the estimated DSGE models? This section addresses this question by comparing: (i) the information embedded in the policy components of the historical shock decomposition of GDP in the DSGE model and (ii) the information provided by changes in the DMFCI.

It is worth clarifying that while the historical decomposition of output captures the unexpected discretionary policy changes that go beyond the systematic response to economic conditions, the DMFCI captures all policy changes. In other words, the historical shock decomposition focuses on the role of ϵ_t^m, ϵ_t^g and ϵ_t^τ in equations (1), (7), (8), respectively,[30] and thus captures the effect that *unexpected* policy innovations have on the model's endogenous variables. In contrast, the first difference of the DMFCI shows whether the stance has become looser or tighter relative to the previous period, taking the overall impact on output of the two policy instruments (the shadow rate and the CAPB) into account. In other words, the changes in these two variables are driven by the total monetary and fiscal stance, without distinguishing between the expected (anticipated) and unexpected (unanticipated) policy

[29] The correlation between the EC's MCI and the IMF's FCI is close to zero for the EA.

[30] In the currency-union version of the model, the historical shock decomposition captures also fiscal policy of the rest of the EA.

innovations.[31]

Figure 2 shows the contribution of policy shocks to GDP growth (blue bars) and the first difference in the yearly DMFCI (red lines). As far as the former is concerned, three key findings are common to the euro area and its major economies. First, discretionary monetary policy has played a more prominent role in supporting output growth than discretionary fiscal policy. Second, monetary policy has been generally countercyclical during the financial crisis and the sovereign debt crisis, and it continued to display a positive contribution to output growth also in the subsequent period. Overall, discretionary monetary policy has supported output growth from 2009 to 2018, with the exception of a few episodes in 2010. Third, discretionary fiscal policy has played a minor role in supporting output and its counter/pro-cyclical nature is less clear-cut. The fiscal stance emerging from the historical decomposition reveals that it is difficult to identify episodes when fiscal shocks played an important role, in line with other contributions (Coenen et al., 2012, 2013; Albonico et al., 2016; Caprioli et al., 2017; Drygalla et al., 2018). Fiscal policies of the rest of the EA also played a very limited role, even more limited than domestic fiscal policy.

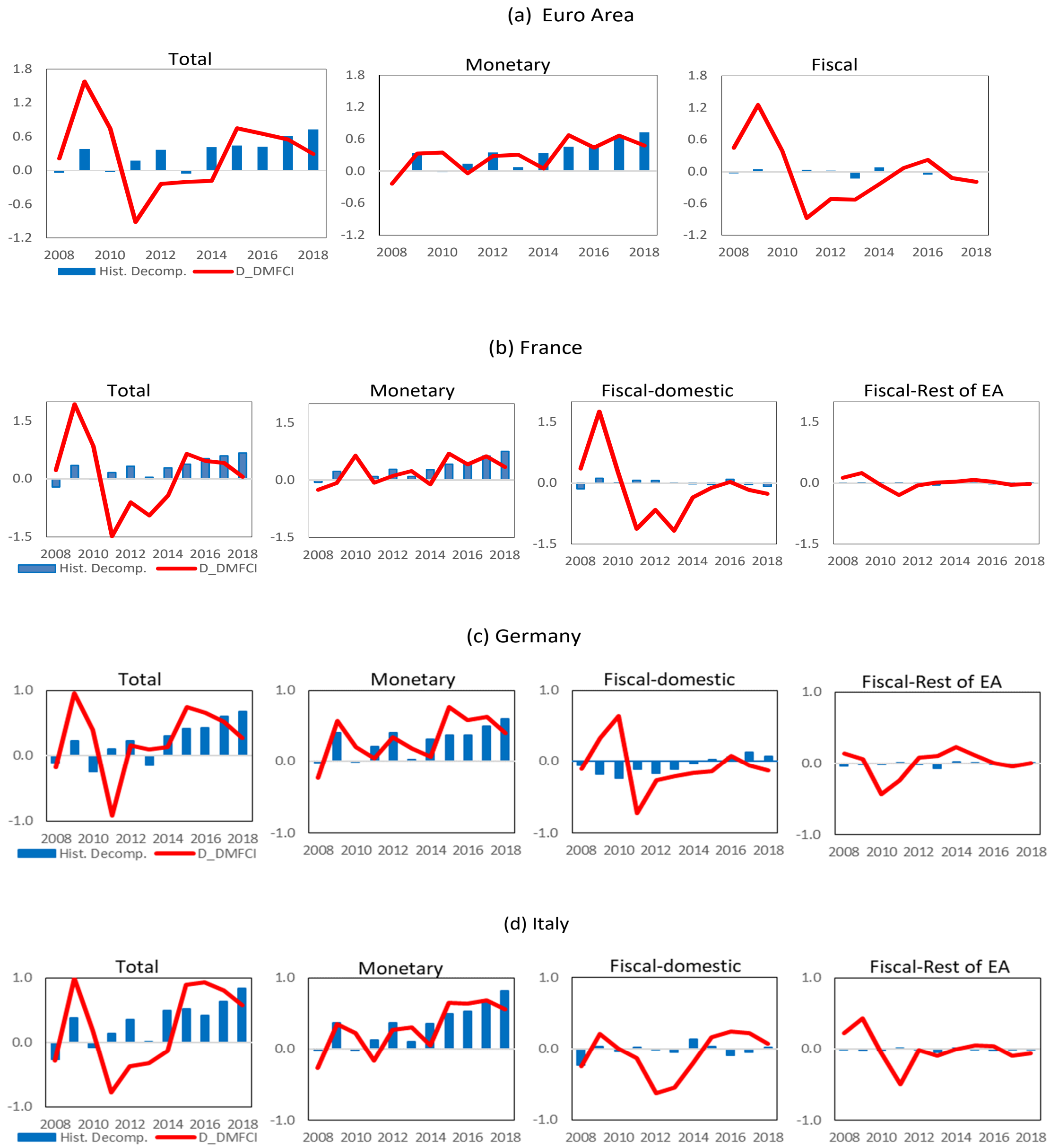
The yearly change in the monetary component of the DMFCI is generally positive, revealing a more and more accommodative monetary policy during the period 2007-2018. The change in the fiscal component of the DMFCI is negative in all countries during the period 2011-2013, while it oscillates around zero afterwards. This is in line with Banca d'Italia (2017) and Golinelli et al. (2017), who found that in the years 2011-13 fiscal policies were restrictive in the EA, France, Germany and Italy while they became essentially neutral on average in the years 2014-2016.

From a comparative point of view, the information provided by the monetary component of the DMFCI is qualitatively similar to the one of the historical decomposition for the monetary component of the DMFCI in the EA and its three main economies. This is particularly true from 2014 onward, when unconventional monetary policy has been implemented. The latter, in fact, is mainly captured by the discretionary response of monetary policy, i.e. from ϵ_t^m, which directly affects the policy instrument (the shadow rate). This explains why the monetary policy stance that emerges from the DMFCI is broadly in line with that of the historical decomposition.

In contrast, there is a mismatch between DMFCI and historical decomposition as far as

[31] In the DSGE literature unexpected policy innovations are interchangeably labeled as discretionary because they represent the residual change in the policy instrument that is not governed by the fiscal rule (e.g. Coenen et al., 2012, 2013) known to forward-looking agents. This definition is different from that used in the public finance literature (e.g. Caprioli et al., 2017), where discretionary fiscal policy is the change in the budget balance due to changes in the fiscal legislation. In the latter context, this is often taken as the fiscal stance.

Figure 2: Historical Contribution of Policy Shocks to GDP Growth (blue bars) against the First Differences of the Yearly DMFCI (red lines).



Notes: The historical decomposition for fiscal-domestic is given by the sum of tax and government spending shocks. The historical decomposition for fiscal-rest of EA is given by the sum of tax and government spending shocks of the rest of the EA. The historical decomposition for "total" is given by the sum of all the policy shocks.

the stance of fiscal policy is concerned. The contribution of fiscal policy shocks to GDP is very limited for all four economies, differently from the change in the fiscal stance captured by the DMFCI.[32]

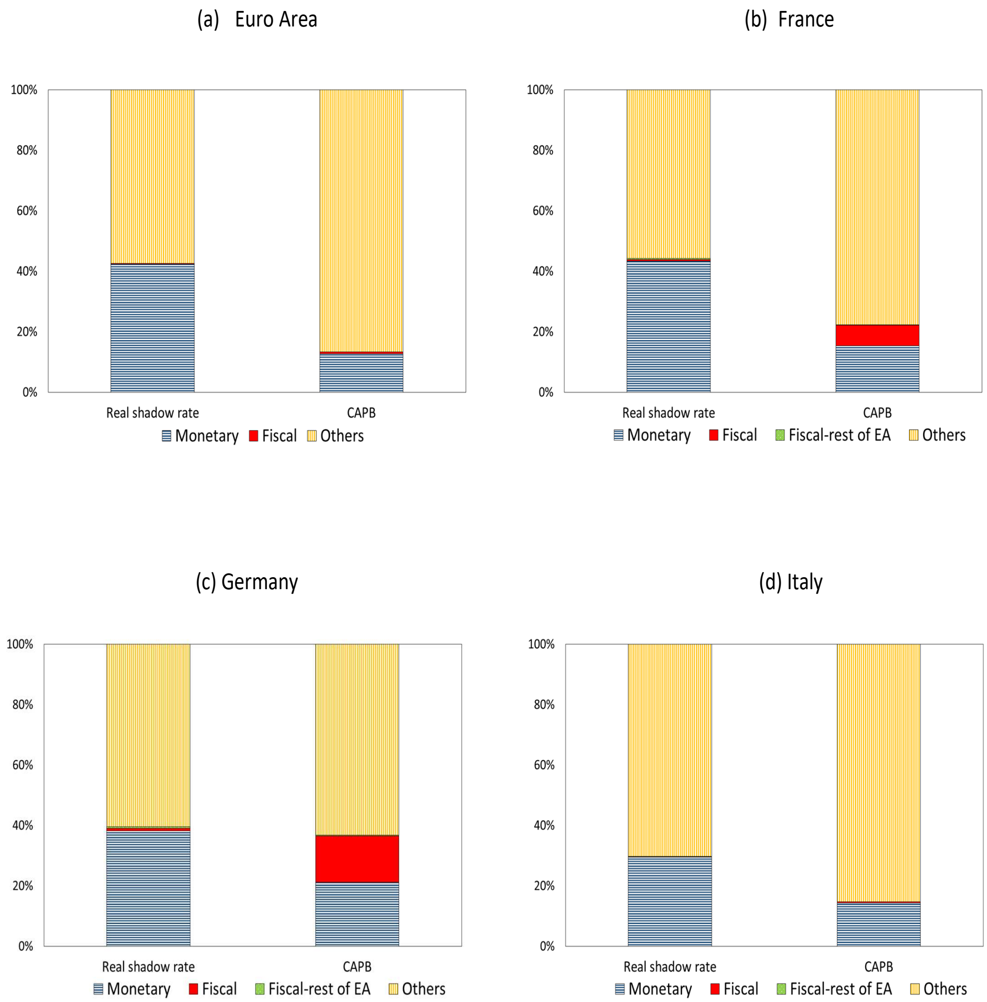
To better explain why these two measures differ, we evaluate the extent to which unexpected policy innovations have on monetary and fiscal outcomes. We compute the share of variation of our synthetic policy variables, the shadow rate and the CAPB, attributable to unexpected fiscal and monetary policy shocks, versus the share attributable to all other shocks in the DSGE model. Results are shown in Figure 3. It turns out that unexpected monetary policy shocks explain approximately between 30 and 40 percent of the variance of the real shadow rate (depending on the country). In contrast, unexpected fiscal shocks explain between less than 1 percent (Italy and EA overall) and 15 percent (Germany) of the variance of the CAPB. In other words, the bulk of fiscal outcomes are driven by shocks other than unexpected fiscal shocks. This makes the historical contribution of fiscal shocks to output an unsatisfactory representation of the fiscal stance.

The fact that much of the fiscal action is anticipated is not new in the literature (e.g. Schmitt-Grohe and Uribe, 2012). In our DSGE model we take anticipation effects into account by including a MA component of the shocks in the fiscal rules, equations (7) and (8), as proposed by Leeper et al. (2013) and find that these effects are indeed strong (see Table E.3). In addition, it is often argued that the EA fiscal rules do not leave much room for bold discretionary policy actions, and that unexpected fiscal shocks played a limited role in affecting macroeconomic outcomes (Coenen et al., 2012, 2013; Albonico et al., 2016; Drygalla et al., 2018). Finally, it should be noted that unexpected fiscal shocks excludes the role of automatic stabilizers. Most of the fiscal support in 2008-2010 has occurred through automatic stabilizers in the euro area (Caivano et al., 2010, for Italy and Caprioli et al., 2017) rather than discretionary policy decisions.

The comparison between the total DMFCI and the contribution of all policy shocks to output inherits the mismatch for the fiscal stance. The discrepancy between the information provided by the DMFCI and the historical contributions of policy shocks is larger before 2014. After 2014, the increasing role of monetary policy both in the DMFCI and the historical decomposition explains the better comovement of these two indicators of policy stance. By using actual monetary and fiscal outcomes (real shadow rate and CAPB), irrespective of what determined their variation (discretionary/systematic and unexpected/anticipated policy changes), DMFCIs more thoroughly capture the evolution of the actual monetary and

[32] Caprioli et al. (2017) also find that the use of discretionary fiscal policy by EA member states has been quite limited, even if it would have provided a useful contribution to macroeconomic stabilization, especially during the crisis.

Figure 3: Historical Decomposition of the Real Shadow Rate and the CAPB.



Notes: The historical decomposition for fiscal-domestic is given by the sum of tax and government spending shocks. The historical decomposition for fiscal-rest-of-EA is given by the sum of tax and government spending shocks of the rest of the EA. The historical decomposition for others is given by the sum of all the other shocks.

fiscal stance. As a robustness exercise, we show that using an alternative definition of the output gap does not change this general picture (Figure G.2 in Appendix G).

4.6 Dynamic Properties of the DMFCI in the Light of the DSGE Model

Can the DMFCIs (total, monetary or fiscal) help predict GDP? This subsection first investigates the dynamic properties of the DMFCI as a leading/coincident/lagging indicator of GDP. It then explains the results by analyzing the impulse response functions (IRFs) of the estimated DSGE model.

Figure 4 reports the dynamic correlations of the $DMFCI^M$ (red bars) and of the $DMFCI^F$ (blue bars) with and the year-on-year change of real GDP over the sample 2008Q1-2018Q3.[33] To be consistent with the lag structure in equation (11), we report the correlation of the DMFCI at time $t-i$, with $i = [-6, -5, ..., 0]$, and GDP growth at time t. Panel (a) of Figure 4 evidences that, as expected, our measure of monetary stance *leads* the business cycle in the EA while our measure of fiscal stance generally does not. Specifically, a looser monetary policy is associated with higher GDP growth after three quarters, with a correlation coefficient of 0.66. A change in the fiscal stance, instead, is negatively and significantly associated with the cycle in a contemporaneous way, providing some evidence for a countercyclical fiscal stance. This correlation analysis is in line with the evidence on the more effective role of the monetary stance compared to the fiscal stance provided in the rest of the paper.

Similar argument applies to France (panel b) and Germany (panel c), with the monetary policy stance leading the cycle by two quarters, and the fiscal stance coincident with the cycle. In Italy (panel d), the change in the monetary policy stance leads GDP growth by three quarters (with correlation coefficients equal to 0.71). Differently from the other countries, in Italy a looser (tighter) fiscal policy is associated with larger (smaller) GDP growth after four quarters, with a correlation coefficient equal to 0.42, likely capturing the contractionary effect of fiscal policy over the sample considered.

How can we interpret this correlations in the light of the DSGE model? To address this question, Figure 5 reports estimated IRFs to monetary policy and government spending shocks[34] in the EA and its three major economies.

For the sake of the argument, all the shocks are set such that the policy changes are expansionary, but results are completely symmetric. The size of monetary and fiscal policy shocks is set equal to the estimated standard deviation for each country and reported in Table E.6. Figure (5) helps rationalize the different leading properties of the monetary and fiscal component of the DMFCI. First, it is worth noticing that the boost in GDP is much more accentuated, delayed and persistent in response to a monetary policy shock, with similar effects for inflation.[35] Next, while the fall in the CAPB following a monetary policy shock is

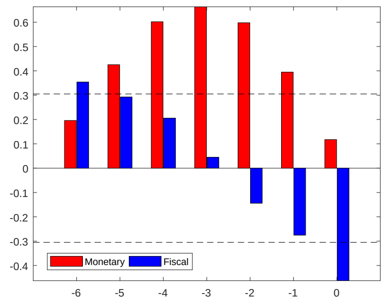
[33]The component of the fiscal policy of the rest of the EA, $DMFCI^{F*}$, is not reported since its role is very limited.

[34]The model features two fiscal policy shocks, government spending and tax rate. When disentangling the role of the two discretionary fiscal policy instruments in the historical decomposition, it is clear that the role of tax shocks is more limited than that of government spending shocks (on this see also Coenen et al., 2013 and Blomer et al., 2015). Hence, we are reporting the responses of the government spending shocks, which are quantitatively more important.

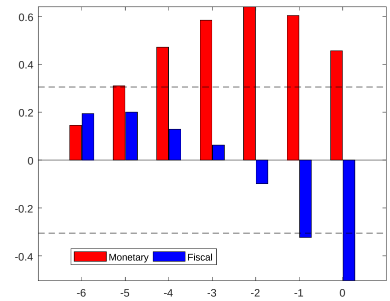
[35]The large effect of monetary policy on inflation can be partly due to the fact that our observable variable is GDP deflator inflation instead of HIPC inflation (see Conti and Nobili, 2019).

Figure 4: Dynamic Correlations Between the Year-On-Year Change in GDP and the Year-on-Year Change in the DMFCI Over the Sample 2008Q1-2018Q3 (lagged six quarters and contemporaneous).

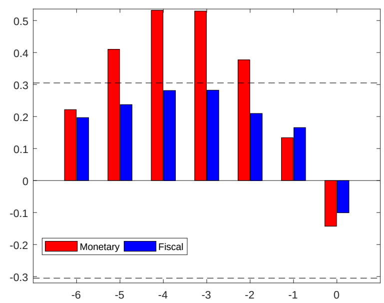
(a) Euro Area



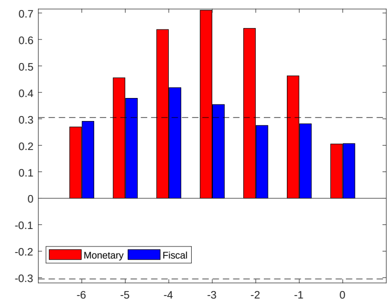
(b) France



(c) Germany



(d) Italy



Notes: Black dashed line represent 95% confidence bounds.

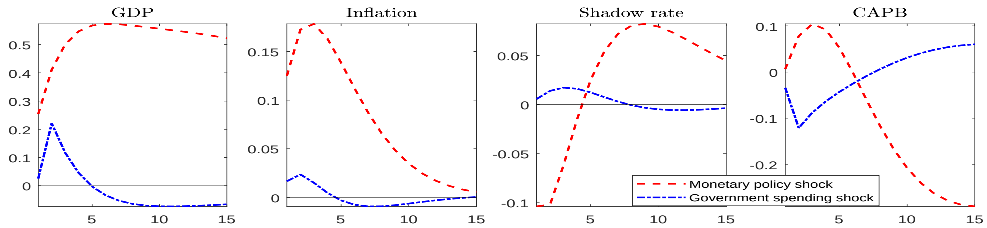
explained by the countercyclical response of the fiscal instruments to the monetary-policy-induced expansion, its fall after the government spending shock is explained by the simulated rise in government spending. Finally, having set the sizes of the shock equal to the estimated standard deviation, IRFs can be interpreted as responses to "typical" historical shocks. It follows that typical monetary policy shocks have a greater effect on output than typical fiscal policy shocks. This finding helps explain why the monetary policy component of the DMFCI leads GDP growth, while this is not the case for fiscal policy.

5 Concluding Remarks

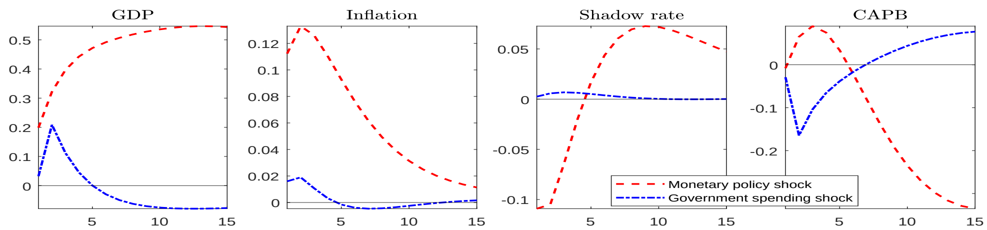
The global financial crisis, the subsequent sovereign debt crisis, the large demand-supply shock hitting the euro area and the world as a consequence of the COVID-19 pandemic have triggered a lively debate about the appropriate policy reactions. To accomplish this difficult

Figure 5: Estimated Impulse Response Functions to Monetary Policy and Government Spending Shocks.

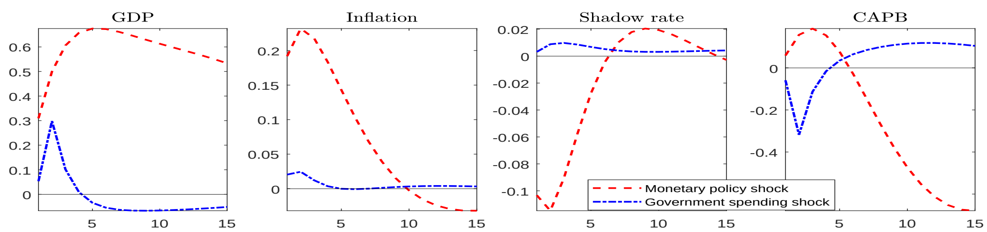
(a) Euro Area



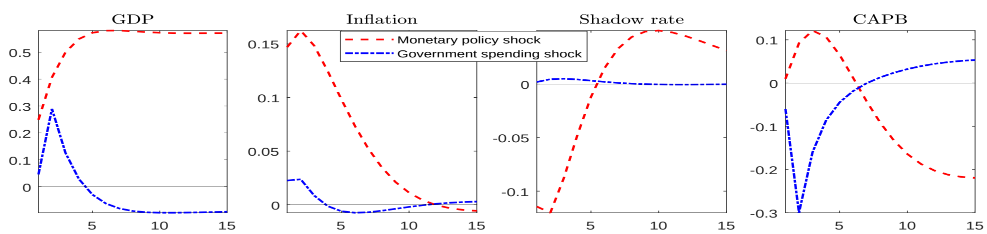
(b) France



(c) Germany



(d) Italy



Notes: Mean IRF are reported without credible intervals to facilitate the comparison. The sizes of the shocks are those estimated and reported in Table E.6. X-axes in quarters; Y-axes are in percent deviations from steady state, except for the CAPB where deviations are absolute.

task, it is crucial to understand what drives the EA business cycle and to assess the role of fiscal and monetary policies in affecting economic fluctuations.

Our analysis contributes to this debate by building a model-based dynamic monetary and fiscal conditions index (DMFCI) to examine the separate and combined monetary and fiscal policy stance in the EA and its three largest member countries.

Results show first that the EA's overall policy became looser in the aftermath of the crisis, following a short-lived fiscal expansion, with most of the loosening manifesting itself between 2009 and 2011. The overall policy stance of the EA was then tightened before being loosened again around 2014, when the ECB embraced more drastic accommodative policy actions, and monetary policy was left to be the "only game in town." Second, we find heterogeneity in the policy stance among EA, France, Germany and Italy. Specifically, the loosening of fiscal policy during the GFC was bold in France, less strong in Germany, and absent in Italy. Third, the comparison between the DMFCI and the information embedded in the historical contribution of policy shocks to GDP growth (in the estimated DSGE model) reveals that the DMFCI provides a more comprehensive measure of fiscal stance. Both measures provide a similar message concerning the monetary policy stance. In addition, the DMFCI overcomes one further shortcoming of historical model shock decompositions: the fact that they are complex communication devices (Blanchard, 2017). On the contrary, the DMFCI shows information on the policy stance and its components in a simple manner.

Our results carry the policy implication that, having the ECB done the lion's share of the economic stimulus for several years, a more expansionary fiscal policy could play an important role in boosting economic activity in the EA. This is particularly relevant for dealing effectively with the economic consequences of the COVID-19 pandemic. Indeed, at least at the initial stages of the latest crisis, EA policymakers seem to be deploying a more balanced policy mix.

References

Adolfson, M., Laséen, S., Lindé, J., and Villani, M. (2007). Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics*, 72(2):481–511.

Albertazzi, U., Nobili, A., and Signoretti, F. M. (2020). The bank lending channel of conventional and unconventional monetary policy. *Journal of Money, Credit and Banking*. Forthcoming.

Albonico, A., Paccagnini, A., and Tirelli, P. (2016). In search of the Euro area fiscal stance. *Journal of Empirical Finance*, 39(PB):254–264.

Albonico, A., Paccagnini, A., and Tirelli, P. (2017). Great recession, slow recovery and muted fiscal policies in the US. *Journal of Economic Dynamics and Control*, 81(C):140–161.

Amaglobeli, M. D., Crispolti, M. V., Dabla-Norris, M. E., Karnane, P., and Misch, F. (2018). Tax policy measures in advanced and emerging economies: a novel database. IMF Working Papers 18/110, International Monetary Fund.

Anzoategui, D., Comin, D., Gertler, M., and Martinez, J. (2019). Endogenous technology adoption and R&D as sources of business cycle persistence. *American Economic Journal: Macroeconomics*, 11(3):67–110.

Aramonte, S., Rosen, S., and Schindler, J. W. (2017). Assessing and combining financial conditions indexes. *International Journal of Central Banking*, 13(1):1–52.

Banca d'Italia (2017). Fiscal policy in the euro area during the crisis years. In Banca d'Italia, editor, *Annual Report*, volume 1 of *1*, chapter 3, pages 30–33. Banca d'Italia.

Batini, N. and Turnbull, K. (2002). A dynamic monetary conditions index for the UK. *Journal of Policy Modeling*, 24(3):257–281.

Bernanke, B. S. and Mihov, I. (1998). Measuring monetary policy. *The Quarterly Journal of Economics*, 113(3):869–902.

Blanchard, O. (2017). Do DSGE models have a future? In Gürkaynak, R. S. and Tille, C., editors, *DSGE Models in the Conduct of Policy: Use as intended*, pages 93–100. CEPR Press.

Blomer, M. J., Dolls, M., Fuest, C., Loffler, M., and Peichl, A. (2015). German public finances through the financial crisis. *Fiscal Studies*, 36:453–474.

Burlon, L., Gerali, A., Notarpietro, A., and Pisani, M. (2018). Non-standard monetary policy, asset prices and macroprudential policy in a monetary union. *Journal of International Money and Finance*, 88:25 – 53.

Busetti, F. and Cova, P. (2013). The macroeconomic impact of the sovereign debt crisis: a counterfactual analysis for the Italian economy. Questioni di Economia e Finanza (Occasional Papers) 201, Bank of Italy, Economic Research and International Relations Area.

Caivano, M., Rodano, L., and Siviero, S. (2010). The transmission of the global financial crisis to the Italian economy. A counterfactual analysis, 2008-2010. Questioni di Economia e Finanza (Occasional Papers) 64, Bank of Italy, Economic Research and International Relations Area.

Cantore, C., Levine, P., Melina, G., and Pearlman, J. (2017). Optimal fiscal and monetary policy, debt crisis, and management. *Macroeconomic Dynamics*, pages 1–39.

Caprioli, F., Romanelli, M., and Tommasino, P. (2017). Discretionary fiscal policy in the euro area: past, present, future. Questioni di Economia e Finanza (Occasional Papers) 398, Bank of Italy, Economic Research and International Relations Area.

Carlstrom, C. T., Fuerst, T. S., and Paustian, M. (2017). Targeting long rates in a model with segmented markets. *American Economic Journal: Macroeconomics*, 9(1):205–242.

Chen, H., Curdia, V., and Ferrero, A. (2012). The macroeconomic effects of large scale asset purchase programmes. *Economic Journal*, 122(564):289–315.

Christiano, L., Eichenbaum, M., and Evans, C. (2005a). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005b). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Coenen, G., Straub, R., and Trabandt, M. (2012). Fiscal policy and the Great Recession in the euro area. *American Economic Review*, 102(3):71–76.

Coenen, G., Straub, R., and Trabandt, M. (2013). Gauging the effects of fiscal stimulus packages in the euro area. *Journal of Economic Dynamics and Control*, 37(2):367–386.

Colciago, A. (2011). Rule of thumb consumers meet sticky wages. *Journal of Money, Credit and Banking*, 43:325–353.

Collard, F. and Juillard, M. (2001). Accuracy of stochastic perturbation methods: The case of asset pricing models. *Journal of Economic Dynamics and Control*, 25(6-7):979–999.

Conti, A. M. and Nobili, A. (2019). Wages and prices in the euro area: exploring the nexus. Questioni di Economia e Finanza (Occasional Papers) 518.

da Silva, L. A. P. (2018). In defence of central bank DSGE modelling. Introductory Remarks by Luiz Awazu Pereira da Silva at the Seventh BIS Research Network meeting on ”Pushing the frontier of central banks' macro-modelling”.

Del Negro, M., Giannoni, M. P., and Schorfheide, F. (2015). Inflation in the Great Recession and New Keynesian models. *American Economic Journal: Macroeconomics*, 7(1):168–196.

Draghi, M. (2015). Speech "Monetary policy and structural reforms in the euro area". European Central Bank.

Drautzburg, T. and Uhlig, H. (2015). Fiscal stimulus and distortionary taxation. *Review of Economic Dynamics*, 18(4):894–920.

Drygalla, A., Holtemöller, O., and Kiesel, K. (2018). The effects of fiscal policy in an estimated DSGE model–the case of the German stimulus packages during the Great Recession. *Macroeconomic Dynamics*, pages 1–31.

European Commission (2005). New and updated budgetary sensitivities for the EU budgetary surveillance. Information note for the Economic and Policy Committee ECFIN/B/6(2005)REP54508, European Commission.

European Commission (2019). Monetary conditions index. Technical report, European Commission.

Fedelino, M. A., Horton, M. M. A., and Ivanova, A. (2009). Computing cyclically-adjusted balances and automatic stabilizers. Technical notes and manuals, International Monetary Fund.

Ferrero, A. (2005). Fiscal and monetary rules for a currency union. Working Paper Series 502, European Central Bank.

Ferrero, A. (2009). Fiscal and monetary rules for a currency union. *Journal of International Economics*, 77(1):1–10.

Forni, L., Monteforte, L., and Sessa, L. (2009). The general equilibrium effects of fiscal policy: Estimates for the euro area. *Journal of Public Economics*, 93(3):559 – 585.

Fournier, J.-M. (2019). The appropriate fiscal stance in France: A model-based assessment. Selected Issues Paper, IMF Country Report 19/246, International Monetary Fund.

Frankel, J. A., Vegh, C. A., and Vuletin, G. (2013). On graduation from fiscal procyclicality. *Journal of Development Economics*, 100(1):32–47.

Fratto, C. and Uhlig, H. (2020). Accounting for post-crisis inflation: A retro analysis. *Review of Economic Dynamics*, 35:133–153.

Furlanetto, F. and Seneca, M. (2012). Rule-of-thumb consumers, productivity, and hours. *Scandinavian Journal of Economics*, 114(2):658–679.

Galí, J., López-Salido, J. D., and Vallés, J. (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, 5(1):227–270.

Gerali, A., Locarno, A., Notarpietro, A., and Pisani, M. (2015). Every cloud has a silver lining. The sovereign crisis and Italian potential output. Temi di discussione (Economic working papers) 1010, Bank of Italy, Economic Research and International Relations Area.

Gerali, A., Neri, S., Sessa, L., and Signoretti, F. M. (2010). Credit and banking in a DSGE

model of the euro area. *Journal of Money, Credit and Banking*, 42(s1):107–141.
Gerlach, S. (2017). DSGE models in monetary policy committees. In Gürkaynak, R. S. and Tille, C., editors, *DSGE Models in the Conduct of Policy: Use as intended*, pages 93–100. CEPR Press.
Gerlach, S. and Smets, F. (2000). MCIs and monetary policy. *European Economic Review*, 44(9):1677–1700.
Gertler, M. and Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, 58(1):17–34.
Gertler, M. and Karadi, P. (2013). QE 1 vs. 2 vs. 3. . . : A framework for analyzing large-scale asset purchases as a monetary policy tool. *International Journal of Central Banking*, 9(1):5–53.
Girouard, N. and André, C. (2005). Measuring cyclically-adjusted budget balances for OECD countries. *OECD Economics Department Working Papers*, 434:1–42.
Golinelli, R., Mammi, I., and Rizza, P. (2017). The cyclicality of fiscal policy in the euro area over the crisis. *Proc. 19th Banca d'Italia Workshop on Public Finance*. mimeo.
Guerrieri, L. and Iacoviello, M. (2015). OccBin: A toolkit for solving dynamic models with occasionally binding constraints easily. *Journal of Monetary Economics*, 70(C):22–38.
Gust, C., Herbst, E., Lopez-Salido, D., and Smith, M. E. (2017). The empirical implications of the interest-rate lower bound. *American Economic Review*, 107(7):1971–2006.
Hirose, Y. and Inoue, A. (2016). The zero lower bound and parameter bias in an estimated DSGE model. *Journal of Applied Econometrics*, 31(4):630–651.
Hohberger, S., Priftis, R., and Vogel, L. (2019). The macroeconomic effects of quantitative easing in the euro area: Evidence from an estimated DSGE model. *Journal of Economic Dynamics and Control*, 108:103756.
Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review*, 95(3):739–764.
IEO (2016). *The IMF and the Crises in Greece, Ireland, and Portugal: An Evaluation by the Independent Evaluation Office (July 8)* . Independent Evaluation Office of the IMF.
IMF (2019). *World Economic Outlook: Global Manufacturing Downturn, Rising Trade Barriers.* International Monetary Fund.
Kollmann, R., Pataracchia, B., Raciborski, R., Ratto, M., Roeger, W., and Vogel, L. (2016). The post-crisis slump in the Euro Area and the US: Evidence from an estimated three-region DSGE model. *European Economic Review*, 88(C):21–41.
Kollmann, R., Ratto, M., Roeger, W., and in?t Veld, J. (2013). Fiscal policy, banks and the financial crisis. *Journal of Economic Dynamics and Control*, 37(2):387–403.
Leeper, E. M., Walker, T. B., and Yang, S. S. (2013). Fiscal foresight and information flows. *Econometrica*, 81(3):1115–1145.
Lindé, J., Smets, F., and Wouters, R. (2016). Challenges for central banks' macro models. In *Handbook of macroeconomics*, volume 2, pages 2185–2262. Elsevier.
Mankiw, N. G. (2000). The savers-spenders theory of fiscal policy. *American Economic Review*, 90(2):120–125.
Matheson, T. D. (2012). Financial conditions indexes for the United States and euro area. *Economics Letters*, 115(3):441–446.
Mauro, P., Romeu, R., Binder, A., and Zaman, A. (2015). A modern history of fiscal

prudence and profligacy. *Journal of Monetary Economics*, 76:55–70.
Mouabbi, S. and Sahuc, J.-G. (2019). Evaluating the macroeconomic effects of the ECB's unconventional monetary policies. *Journal of Money, Credit and Banking*, 51(4):831–858.
Orphanides, A. (2018). Independent central banks and the interplay between monetary and fiscal policy. *International Journal of Central Banking*, 14(3):447–470.
Osborne-Kinch, J. and Holton, S. (2010). A discussion of the monetary condition index. *Quarterly Bulletin Articles, Central Bank of Ireland*, pages 68–80.
Price, R., Dang, T.-T., and Botev, J. (2015). Adjusting fiscal balances for the business cycle: New tax and expenditure elasticity estimates for OECD countries. OECD Economics Department Working Papers 1275, OECD.
Quint, D. and Rabanal, P. (2014). Monetary and macroprudential policy in an estimated DSGE model of the euro area. *International Journal of Central Banking*, 10(2):169–236.
Ratto, M., Roeger, W., and Veld, J. i. t. (2009). QUEST III: An estimated open-economy DSGE model of the euro area with fiscal and monetary policy. *Economic Modelling*, 26(1):222–233.
Rigon, M. and Zanetti, F. (2018). Optimal monetary policy and fiscal policy interaction in a non-ricardian economy. *International Journal of Central Banking*, 14(3):389–436.
Rostagno, M., Altavilla, C., Carboni, G., Lemke, W., Motto, R., Saint Guilhem, A., and Yiangou, J. (2019). A tale of two decades: the ECB's monetary policy at 20. Working Paper Series 2346, European Central Bank.
Rotemberg, J. J. (1982). Monopolistic price adjustment and aggregate output. *Review of Economic Studies*, 49(4):517–31.
Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of international Economics*, 61(1):163–185.
Schmitt-Grohe, S. and Uribe, M. (2012). What's news in business cycles. *Econometrica*, 80(6):2733–2764.
Smets, F. and Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European Economic Association*, 1(5):1123–1175.
Smets, F. and Wouters, R. (2005). Comparing shocks and frictions in US and euro area business cycles: a Bayesian DSGE approach. *Journal of Applied Econometrics*, 20(2):161–183.
Smets, F. and Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American Economic Review*, 97(3):586–606.
Vegh, C. A. and Vuletin, G. (2015). How is tax policy conducted over the business cycle? *American Economic Journal: Economic Policy*, 7(3):327–70.
Villa, S. (2016). Financial frictions in the euro area and the United States: A Bayesian assessment. *Macroeconomic Dynamics*, 20(05):1313–1340.
Woodford, M. (2001). Fiscal requirements for price stability. *Journal of Money, Credit and Banking*, 33(3):669–728.
Wu, J. C. and Xia, F. D. (2017). Time-varying lower bound of interest rates in Europe. Technical Report 17-06, Chicago Booth Research Paper Chicago Booth Research Paper 17-06.
Zubairy, S. (2014). On fiscal multipliers: Estimates from a medium scale DSGE model. *International Economic Review*, 55(1):169–195.

Appendix

A Detailed description of the model

This section details the description of the model. Being the home and foreign countries completely symmetric, we will outline the model for the home economy. The full set of equilibrium conditions and the steady state are reported in Sections B and C.

A.1 Households

The economy is populated by a continuum $i \in [0,1]$ of households, a fraction ω of which is optimizer (o), while the remaining fraction $1-\omega$ is rule-of-thumb (r). Optimizing households have access to financial markets hence they smooth consumption via the purchase of short-term deposits whereas rule-of-thumb households do not have access to saving or borrowing, hence each period they consume their entire disposable income. As common in the literature, preferences are assumed to be identical across the two types of households.

A.1.1 Optimizing Households

Optimizing households derive utility from consumption, C_t^o and disutility from providing labor services, H_t^o, in a monopolistically competitive labor market. The intertemporal utility function is given by

$$E_t \left\{ \sum_{s=0}^{\infty} e_t^b \beta^{t+s} \left[\ln \left(C_{t+s}^o - h C_{t+s-1}^o \right) - \frac{B}{1+\eta} \left(H_{t+s}^o \right)^{1+\eta} \right] \right\}, \tag{A.1}$$

where E_t is the expectation operator at time t, e_t^b is a preference shock to the discount factor $\beta \in (0,1)$, $h \in (0,1)$ is the internal habit formation parameter, $B > 0$ is the disutility weight of labor, $\eta > 0$ is the inverse of the intertemporal elasticity of substitution of the labor supply.

Optimizing households have access to three assets: short-term deposits (D_t^o) in financial intermediaries (FIs henceforth), physical capital (K_t^o) and foreign assets (NFA_t^o) that earn a gross foreign interest rate R_t^*. They may also hold short-term government bonds (T-bills) and short-term debt issued by the central bank to finance its QE programme, but since these are perfect substitute with deposits and move endogenously to hit the central bank's short term interest rate target, D_t^o can be treated as the households' net resource flow into FIs. To prevent NFA_t^o from being a unit-root process we assume that there exists a premium for holding net foreign assets over GDP (see Schmitt-Grohé and Uribe, 2003)

$$\Psi_t \equiv \exp\left\{\psi_1\left(\frac{NFA_t^o}{Y_t} - \frac{NFA^o}{Y}\right)\right\} - 1, \tag{A.2}$$

inversely related to their deviations from their steady state, where $\psi_1 > 0$ makes the interest rate paid on foreign debt instruments elastic to net foreign asset holdings.

The need for financial intermediation arises because all the investment, I_t^o, needs to be financed by issuing long-term bonds purchased by FIs. As in Carlstrom et al. (2017), these are assumed to be perpetual bonds with cash flows 1, κ, κ^2, ... (see, e.g. Woodford, 2001). In other words, if Q_t is the time-t price of a new issue, κQ_t is the time-t price of the perpetuity issued in period $t-1$ and so on. The duration of these bonds is defined by $(1-\kappa)^{-1}$ and their gross yield to maturity by $Q^{-1} + \kappa$. Define CI_t as the number of perpetuities issued at time t to finance investment, then the representative household's overall nominal liability is:

$$F_t^o = CI_t + \kappa CI_{t-1} + \kappa^2 CI_{t-2} + ..., \tag{A.3}$$

with the time-t new issue of perpetuities defined as

$$CI_t = F_t^o - \kappa F_{t-1}^o. \tag{A.4}$$

In maximizing life-time utility (A.1), optimizing households face three constraints:

$$\begin{aligned}(1+\tau_t^c)\,C_t^o + \frac{D_t^o}{P_t} + P_t^k I_t^o + \frac{F_{t-1}^o}{P_t} + \frac{NFA_t^o}{P_t} \leq (1-\tau_t^w)\,W_t H_t^o + \frac{R_{t-1}D_{t-1}^o}{P_t} + \left(1-\tau_t^k\right) R_t^k K_t^o +\\ +\delta P_t^k \tau_t^k K_t^o + \frac{Q_t\left(F_t^o - \kappa F_{t-1}^o\right)}{P_t} + R_{t-1}^*\Psi_{t-1}\frac{NFA_{t-1}^o}{P_t} + \tau_t^l - \Phi_t + \mathcal{P}_t,\end{aligned} \tag{A.5}$$

$$K_{t+1}^o \leq (1-\delta)\,K_t^o + I_t^o, \tag{A.6}$$

$$P_t^k I_t^o \leq \frac{Q_t\left(F_t^o - \kappa F_{t-1}^o\right)}{P_t} = \frac{Q_t CI_t}{P_t}. \tag{A.7}$$

The consumption good is the numeraire of the economy hence P_t is the price level. P_t^k is the real price of capital while R_t^k is its real rental rate; R_{t-1} is the gross nominal interest rate on deposits; W_t is the real wage; $\delta \in (0,1)$ is the capital depreciation rate; τ_t^c, τ_t^w and τ_t^k are distortionary tax rates on consumption, labor income and the return on capital, respectively; $\delta P_t^k \tau_t^k K_t^o$ is a depreciation allowance for tax purposes; τ_t^l is a lump-sum transfers; Φ_t is a labor union membership fee; and $\mathcal{P}_t$ are profits from all financial and non-financial firms. Equation (A.5) is the households' budget constraint, equation (A.6) represents the capital accumulation equation, while equation (A.7) is a "loan-in-advance" constraint, which increases the cost of purchasing investment goods, i.e. all investment projects must be financed by issuing perpetuities purchased by FIs, therefore the total expenditure on investment cannot exceed the total value of perpetuities.

Assuming that constraints hold with equality, substituting for (A.6) into (A.5) and (A.7), and taking first-order conditions with respect to C_t^o, D_t^o, K_{t+1}^o, F_t^o and NFA_t^o yields:

$$\left(1+\tau_t^c\right)\Lambda_t^o = \frac{e_t^b}{C_t^o - hC_{t-1}^o} - h\beta E_t\left[\frac{e_{t+1}^b}{C_{t+1}^o - hC_t^o}\right], \tag{A.8}$$

$$\Lambda_t^o = \beta E_t\left[\Lambda_{t+1}^o \frac{R_t}{\Pi_{t+1}}\right], \tag{A.9}$$

$$\Lambda_t^o P_t^k M_t = \beta E_t\left\{\Lambda_{t+1}^o\left[\left(1-\tau_{t+1}^k\right)R_{t+1}^k + \delta P_{t+1}^k \tau_{t+1}^k + (1-\delta)P_{t+1}^k M_{t+1}\right]\right\}, \tag{A.10}$$

$$\Lambda_t^o Q_t M_t = \beta E_t\left[\Lambda_{t+1}^o \frac{1+\kappa Q_{t+1}M_{t+1}}{\Pi_{t+1}}\right], \tag{A.11}$$

$$R_t = \Psi_t R_t^*, \tag{A.12}$$

where Λ_t^o is the Lagrange multiplier associated to the budget constraint (A.5), $\Pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$ is the gross inflation rate, and $M_t \equiv 1 + \frac{\vartheta_t}{\Lambda_t^o}$ is a dynamic distortion caused by market segmentation, where ϑ_t is in turn the multiplier associated to the loan-in-advance constraint (A.7). As shown by Carlstrom et al. (2017), the distortion M_t arises because of financial market segmentation (to be explained in further detail below) and is approximated by the discounted sum of the spread between the one-period loan and the deposit rates. Equation (A.8) is the marginal utility of consumption which, together with equation (A.9), determines the usual Euler equation of consumption. Equations (A.10) and (A.11) are asset price equations for capital and investment bonds, respectively. Finally, equation (A.12) is the uncovered interest parity condition.

A.1.2 Rule-of-Thumb Households

Rule-of-thumb households have the same instantaneous utility function as that of intertemporal optimizing consumers:

$$E_t\left\{\sum_{s=0}^{\infty} e_t^b \beta^{t+s}\left[\ln\left(C_{t+s}^r - hC_{t+s-1}^r\right) - \frac{B}{1+\eta}\left(H_{t+s}^r\right)^{1+\eta}\right]\right\}. \tag{A.13}$$

They do not have access to financial markets hence they cannot smooth consumption by saving and borrowing. It follows that their consumption is entirely determined by their budget constraint:

$$\left(1+\tau_t^c\right) C_t^r=\left(1-\tau_t^w\right) W_t H_t^r+\tau_t^l-\Phi_t, \tag{A.14}$$

while their marginal utility of consumption, useful to derive the wage-setting equation in Section A.1.3 is:

$$\left(1+\tau_t^c\right) \Lambda_t^r=\frac{e_t^b}{C_t^r-h C_{t-1}^r}-h \beta E_t\left[\frac{e_{t+1}^b}{C_{t+1}^r-h C_t^r}\right]. \tag{A.15}$$

The presence of rule-of-thumb households helps capturing Keynesian effects of fiscal policy as the economy is thus populated also by agents for which the Ricardian equivalence does not hold. Intuitively, the Keynesian effect of fiscal policy is larger the larger the share of rule-of-thumbers in the economy, i.e. the larger $1-\omega$.

A.1.3 Wage Setting

Each type of household provides labor to a continuum of labor unions $z \in[0,1]$. Each union sets the wage rate for its members and aggregates labor services according to a Dixit-Stiglitz aggregator such that labor demanded by firms to each union is $H_t^z=\left(\frac{W_t^z}{W_t}\right)^{-e_t^w \varepsilon^w} H_t$, where ε^w is the intratemporal elasticity of substitution between labor services and e_t^w is a wage markup shock. As in Colciago (2011) and Furlanetto and Seneca (2012), among others, each period the union z chooses the wage rate W_t^z to maximize a weighted average utility of its members:

$$\max_{W_t^z} E_t \sum_{k=0}^{\infty} \beta^{t+k}\left[\omega U_{t+k}^o+(1-\omega) U_{t+k}^r\right], \tag{A.16}$$

subject to the labor demand functions and the households' budget constraints (A.5) and (A.14). Each union is subject to quadratic adjustment costs of wages as in Rotemberg (1982), which are ultimately paid by its members through a membership fee,

$$\Phi_t=\frac{\theta_w}{2}\left[\frac{W_t^z}{\Pi_{t-1}^{\iota_w} W_{t-1}^z} \Pi_t-\Pi^{1-\iota_w}\right]^2 W_t H_t, \tag{A.17}$$

where θ_w governs the degree of nominal wages stickiness while $\iota_w \in[0,1]$ denotes the degree of wage indexation to past inflation.[36] Firms do not discriminate between optimizing and rule-of-thumb households, hence labor supply is identical across households, that is $H_t^o=$

[36]Steady-state inflation Π is raised to the power $1-\iota_w$ to ensure that wage adjustment costs are zero in steady-state. A similar specification applies to price adjustment costs, see Section A.3.

$H_t^r = H_t$.[37] The wage schedule thus reads as

$$0 = \left\{ \left(1-\tau_t^w\right)\left(1-e_t^w \varepsilon^w\right) - \theta_w \left[\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} - \Pi^{1-\iota_w}\right] \frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} \right\} + \frac{B\left(H_t\right)^\eta}{\bar{\Lambda}_t W_t} e_t^w \varepsilon^w + $$
$$+ \beta E_t \left\{ \frac{\bar{\Lambda}_{t+1}}{\bar{\Lambda}_t} \theta_w \left[\frac{\Pi_{t+1}^w}{\Pi_t^{\iota_w}} - \Pi^{1-\iota_w}\right] \frac{\Pi_{t+1}^w W_{t+1} H_{t+1}}{\Pi_t^{\iota_w} W_t H_t} \right\}, \tag{A.18}$$

where $\Pi_t^w = \frac{W_t}{W_{t-1}} \Pi_t$ denotes the nominal wage inflation, $\bar{\Lambda}_t = \omega \Lambda_t^o + \left(1-\omega\right) \Lambda_t^r$ represents a weighted average of the marginal utilities of consumption across types of households, and the term $\frac{B(H_t)^\eta}{\bar{\Lambda}_t W_t}$ is the (inverse of the) wage markup, that is the marginal rate of substitution between consumption and leisure divided by the nominal wage.[38] Setting $\theta_w = 0$ implies that nominal wages are flexible and set as a constant markup of the marginal rate of substitution between consumption and leisure.

A.1.4 Aggregation

Aggregate consumption is given by a weighted average of consumption of each type of consumers. Rule-of-thumb consumers do not hold any assets or liabilities, therefore aggregate deposits, liabilities, investment and capital reflect this feature:

$$C_t = \omega C_t^o + \left(1-\omega\right) C_t^r, \tag{A.19}$$
$$D_t = \omega D_t^o, \tag{A.20}$$
$$F_t = \omega F_t^o, \tag{A.21}$$
$$I_t = \omega I_t^o, \tag{A.22}$$
$$K_t = \omega K_t^o. \tag{A.23}$$

A.2 Financial Intermediaries

Financial intermediaries are modeled as in Carlstrom et al. (2017). They are the sole buyers of investment bonds F_t and long-term government bonds B_t^{FI}, which are perfect substitutes, and hence are sold at the same price of a time-t issue Q_t.[39] The FI's portfolio is financed by collecting deposits D_t from optimizing households and by accumulating net worth N_t. Let

[37] This is a standard assumption in models with rule-of-thumbers and nominal wage stickiness, see e.g. Colciago (2011), Furlanetto and Seneca (2012), Coenen et al. (2012) and Albonico et al. (2017), among many others.

[38] The detailed derivation of the wage setting equation is in Appendix D.

[39] Long-term government bonds have exactly the same structure as investment bonds, hence they are modeled as perpetuities with maturity $\left(1-\kappa\right)^{-1}$.

$\bar{F}_t = \frac{F_t}{P_t} Q_t$ and $\bar{B}_t^{FI} = \frac{B_t^{FI}}{P_t} Q_t$ denote the real values of investment and long-term government bonds, respectively. Then, the FI's balance sheet reads as:

$$\bar{B}_t^{FI} + \bar{F}_t = \frac{D_t}{P_t} + N_t = L_t N_t, \tag{A.24}$$

where L_t is leverage which is assumed to be taken as given by FIs while long-term investment and government bonds constitute the asset side of the FI's balance sheet (A.24). Each period, FIs raise profits determined by the spread between the lending and borrowing rates. In particular:

$$prof_t \equiv \left[\left(R_t^L - R_{t-1} \right) L_{t-1} + R_{t-1} \right] \frac{N_{t-1}}{\Pi_t}, \tag{A.25}$$

where $R_t^L \equiv \left(\frac{1+\kappa Q_t}{Q_{t-1}} \right)$ denotes the return on FIs' assets.[40] A share of the profits are then distributed to households as dividends (div_t), while the rest is retained as net worth.[41] It follows that each FI chooses dividends and net worth to solve:

$$V_t \equiv \max_{N_t, div_t} E_t \sum_{j=0}^{\infty} (\beta\zeta)^j \Lambda_{t+j}^o div_{t+j}, \tag{A.26}$$

subject to the following budget constraint

$$div_t + N_t \left[1 + f(N_t) \right] \leq prof_t, \tag{A.27}$$

which states that dividends are limited by the amount of profits not devoted to net worth. The discount factor $\beta\zeta < \beta < 1$ implies that FIs discount future profits at a lower rate than optimizing households discount future utility, i.e. the former are more impatient than the latter.[42] The portfolio adjustment cost function $f(N_t) = \frac{\psi_n}{2} \left(\frac{N_t - \bar{N}}{\bar{N}} \right)^2$ prevents the FI from fully adjusting its assets side of the balance sheet in response to shocks, as governed by parameter $\psi_n \in [0, \infty)$.[43] Financial frictions are introduced via a simple hold-up problem. Each period, before aggregate shocks realize, FIs can default on their debt towards depositors

[40] The interest rate paid on deposits, R_t^d, equals the risk free (policy) rate hence we directly use R_t in the FIs' profit function.

[41] As noted by Carlstrom et al. (2017), this assumption differs from Gertler and Karadi (2011; 2013), who assume that dividends are paid only upon the FIs' exogenous death. However, this mechanism delivers the same implication as the one designed by Gertler and Karadi (2011; 2013), namely that FIs are not able to infinitely accumulate net worth hence they have to borrow in order to purchase investment and government bonds.

[42] This assumption is necessary to induce FIs to borrow in equilibrium from households and is in the same spirit of the one employed by Iacoviello (2005) between patient and impatient households.

[43] Note that V_t is increasing in the spread between the return on assets R_{t+1}^L and the interest rate on deposits R_t, while it is decreasing in $f(N_t)$.

and retain a fraction $\Theta_t < 1$ of the assets. It follows that, in order for optimizing households to be willing to lend to FIs, the following incentive compatibility constraint (ICC) must hold:

$$E_t V_{t+1} \geq \Theta_t L_t N_t E_t \frac{\Lambda^o_{t+1}}{\Pi_{t+1}} R^L_{t+1}, \tag{A.28}$$

according to which net worth limits the amount FIs can borrow from optimizing households, i.e. the expected value of the FI, V_{t+1}, needs to be at least as great as the amount it can divert. Variable Θ_t determines the extent of the financial friction and depends negatively on N_t and positively on an exogenous credit shock e^ϕ_t. Unexpected increases in e^ϕ_t exacerbate the financial friction thus lowering real activity, with larger effects the larger the portfolio adjustment costs. Assuming that the ICC is binding, equation (A.28) can be explicitly defined as

$$L_t = \frac{E_t\left(\frac{\Lambda^o_{t+1}}{\Pi_{t+1}}\right)}{E_t\left(\frac{\Lambda^o_{t+1}}{\Pi_{t+1}}\right) + \left(e^\phi_t - 1\right) E_t\left(\frac{\Lambda^o_{t+1}}{\Pi_{t+1}}\right)\frac{R^L_{t+1}}{R_t}}. \tag{A.29}$$

It is evident that leverage depends only on aggregate variables and not on each FI's net worth, hence only aggregate net worth is required to analyze the model's dynamics.[44] Aggregate net worth is chosen to maximize the representative FI's value (A.26) subject to (A.27) and (A.29) thus yielding the following optimal accumulation of net worth:

$$\Lambda^o_t \left[1 + N_t f'(N_t) + f(N_t)\right] = E_t \frac{\Lambda^o_{t+1}\beta\zeta}{\Pi_{t+1}} \left[R_t + L_t\left(R^L_{t+1} - R_t\right)\right]. \tag{A.30}$$

The main channel through which the financial friction affects real activity is a limit to arbitrage between the return on long-term bonds R^L_{t+1} and the deposit rate R_t. The leverage constraint (A.29) poses a limit on the ability of the FI to collect deposits, which can be alleviated by a higher net worth. However, adjustments in net worth are lumpy thus limiting arbitrage. Indeed, increases in net worth allow the FI to collect deposits at a lower rate and exploit arbitrage opportunities with respect to the lending rate. A slow increase in net worth due to adjustment costs prevents the FI from taking advantage of these arbitrage opportunities. Given that investments are feasible only through financial intermediation, the FI's inability to quickly adjust its net worth implies that central bank purchases of long-term government bonds alter the supply of those bonds, hence the composition of the FI's portfolio and, ultimately, affect the real economy. Indeed, an increase in the central bank holdings of long-term government bonds decreases the amount held by FIs, which utilize the spare net worth to purchase investment bonds causing an increase in private investment.

[44]This is the reason why the single FI takes leverage as given in maximizing its value.

The introduction of long-term bonds entails the presence of a term premium in the economy. Consider a ten-year bond, then the term premium is defined as the difference between the observed yield on the this bond and the corresponding yield calculated by applying the expectation hypothesis (EH) of the term structure to the series of short rates (see Carlstrom et al., 2017). Let the yield on the ten-year bond under EH be

$$R_t^{10,EH} = \kappa + \frac{1}{Q_t^{EH}}, \tag{A.31}$$

with its price satisfying

$$R_t = \frac{1 + \kappa Q_{t+1}^{EH}}{Q_t^{EH}}. \tag{A.32}$$

Then, in gross terms, the term premium is defined as

$$TP_t = 1 + R_t^{10} - R_t^{10,EH}. \tag{A.33}$$

A.3 Non-Financial Firms

A continuum of monopolistically competitive firms indexed by $i \in [0,1]$ buys capital, K_{it-1} and hires labor, H_{it}, to produce differentiated goods, Y_{it}, with convex technology $F(H_{it}, K_{it-1})$, sold at price $P_{h,it}$, and faces a Dixit-Stiglitz firm-specific demand:

$$Y_{it} = \left(\frac{P_{h,it}}{P_{h,t}}\right)^{-e_t^p \varepsilon^p} Y_t, \tag{A.34}$$

where ε^p is the elasticity of substitution across goods varieties and e_t^p is a price mark-up shock. At the end of period $t-1$ firms acquire capital from capital producers for use in production in period t. Firms also face quadratic price adjustment costs $\frac{\theta_p}{2}\left(\frac{P_{hit}}{\Pi_{h,t-1}^{\iota_p} P_{h,it-1}} - \Pi_h^{1-\iota_p}\right)^2 Y_t$, as in Rotemberg (1982) – where parameters $\theta_p \in [0,\infty]$ and $\iota_p \in [0,1]$ measure the degree of price stickiness and price indexation, respectively – and maximize the following flow of discounted profits:

$$J_{it} = E_t \left\{ \sum_{s=0}^{\infty} \beta^{t+s} \frac{\Lambda_{t+s}^o}{\Lambda_{t+s-1}^o} \left[\begin{array}{c} \frac{P_{h,it+s}}{P_{h,t+s}} Y_{it+s} - P_{t+s}^k R_{t+s}^K K_{it+s} \\ -w_{t+s} H_{it+s} - \frac{\theta_p}{2}\left(\frac{P_{h,it+s}}{\Pi_{h,t+s-1}^{\iota_p} P_{h,it+s-1}} - \Pi_h^{1-\iota_p}\right)^2 Y_t \end{array} \right] \right\}, \tag{A.35}$$

with respect to K_{it+s}, H_{it+s}, and $P_{h,it+s}$, subject to the firm's resource constraint

$$Y_{it} = F(e_t^a, H_{it}, K_{it}), \tag{A.36}$$

where $F(e_t^a, H_{it}, K_{it}) = e_t^a K_{it}^{\alpha} H_{it}^{1-\alpha}$, with α being the labor share of income and e_t^a being a total factor productivity shock. The corresponding first-order conditions for this problem are

$$R_t^k = MC_t MPK_t, \tag{A.37}$$

$$W_t = MC_t MPL_t, \tag{A.38}$$

$$\begin{aligned} 0 &= 1 + e_t^P \varepsilon^p (MC_t - 1) - \theta_p \left(\frac{\Pi_{h,t}}{\Pi_{h,t-1}^{\iota_p}} - \Pi_h^{1-\iota_p} \right) \frac{\Pi_{h,t}}{\Pi_{h,t-1}^{\iota_p}} + \\ &+ \theta_p E_t \left[\beta \frac{\Lambda_{t+1}^o}{\Lambda_t^o} \left(\frac{\Pi_{h,t+1}}{\Pi_{h,t}^{\iota_p}} - \Pi^{1-\iota_p} \right) \frac{\Pi_{h,t+1}}{\Pi_{h,t}^{\iota_p}} \frac{Y_{t+1}}{Y_t} \right], \end{aligned} \tag{A.39}$$

where MC_t is the Lagrange multiplier associated with resource constraint (A.36) and $\Pi_{h,t}$ is inflation of the single good produced in the home economy. In particular, MC_t is the shadow value of output and represents the firm's real marginal cost, while $MPK_t = \alpha e_t^a H_t^{1-\alpha} K_t^{\alpha-1}$, and $MPL_t = (1-\alpha) e_t^a K_t^{\alpha} H_t^{-\alpha}$ are the marginal products of capital and labor, respectively. When prices are flexible ($\theta_p = 0$), equation (A.39) implies that prices are set as a constant markup over the marginal cost.

A.4 New Capital Producers

New capital is produced by firms that take investment goods I_t and convert them into $P_t^k e_t^{\mu} \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t$ units of new capital goods. These firms are owned by optimizing households and maximize the following profit function:

$$P_t^k e_t^{\mu} \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t - I_t, \tag{A.40}$$

where $S\left(\frac{I_t}{I_{t-1}}\right) \equiv \frac{\psi_i}{2} \left(\frac{I_t}{I_{t-1}} - 1\right)^2$ represents the investment adjustment costs as governed by parameter ψ_i, while e_t^{μ} is an investment-specific shock.[45] Maximizing (A.40) with respect to

[45] As in Christiano et al. (2005b), the adjustment costs function $S(\cdot)$ satisfies $S(1) = S^{'}(1) = 0$ and $S^{''}(1) > 0$.

I_t yields the following asset price equation for investment:

$$P_t^k e_t^\mu \left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - S'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right]$$
$$= 1 - E_t\left[\beta\frac{\Lambda_{t+1}^o}{\Lambda_t^o} e_{t+1}^\mu P_{t+1}^k S'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right]. \tag{A.41}$$

A.5 Trade and Market Clearing

We start by describing how prices evolve in the home country. As in Ferrero (2009), the price index in the home country is $P_t = \left[\varphi P_{h,t}^{1-\chi} + (1-\varphi) P_{f,t}^{1-\chi}\right]^{\frac{1}{1-\chi}}$, with $P_{h,t}$ and $P_{f,t}$ being the prices of the home and foreign goods in the home country, respectively. It follows that inflation in the home country is defined as

$$\Pi_t = \left[\varphi\left(\Pi_{h,t} p_{h,t-1}\right)^{1-\chi} + (1-\varphi)\left(\Pi_{f,t} p_{f,t-1}\right)^{1-\chi}\right]^{\frac{1}{1-\chi}}, \tag{A.42}$$

where $p_{h,t}$ and $p_{f,t}$ are the relative prices of the home and foreign goods in the home country, respectively. $\Pi_{h,t}$ and $\Pi_{f,t}$ represent inflation of the goods produced in the home and foreign country, respectively.[46] The terms of trade is defined as the relative price of the foreign basket of goods in terms of the home goods basket, $TOT_t = P_{f,t}/P_{h,t}$, which evolves according to:

$$\frac{TOT_t}{TOT_{t-1}} = \frac{\Pi_{f,t}}{\Pi_{h,t}}. \tag{A.43}$$

Finally, from the definition of the price index P_t it follows that movements in the terms of trade are linked to changes in relative prices and cause shifts in demand across countries according to:

$$(p_{h,t})^{\chi-1} = \varphi + (1-\varphi)\, TOT_t^{1-\chi}, \tag{A.44}$$
$$(p_{f,t})^{\chi-1} = \varphi TOT_t^{\chi-1} + (1-\varphi). \tag{A.45}$$

Turning to quantities, private and public consumption and investment are constant-elasticity-of-substitution (CES) baskets of home and foreign goods:

$$\mathit{\Gamma}_t = \left[\varphi^{\frac{1}{\chi}}\left(\mathit{\Gamma}_{h,t}\right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}}\left(\mathit{\Gamma}_{f,t}\right)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}, \tag{A.46}$$

[46] We closely follow Ferrero (2009), see also the more detailed working paper version in Ferrero (2005).

with $\Gamma = C, I, G$, where φ indicates the home good bias and $\chi > 0$ is the intratemporal elasticity of substitution between home and foreign goods.[47] It follows that imports and exports are defined as:

$$IMP_t = (1-\varphi)(p_{f,t})^{-\chi}(C_t + G_t + I_t), \tag{A.47}$$

$$EXP_t = \frac{1-n}{n}(1-\varphi^*)\left(p^*_{h,t}\right)^{-\chi^*}(C^*_t + G^*_t + I^*_t), \tag{A.48}$$

where variables with a "*" refer to the foreign country.

The balance of payments equilibrium requires the current account balance to be equal to the change in net foreign assets:

$$\overline{NFA}_t - \frac{\overline{NFA}_{t-1}}{\Pi_t} = p_{h,t}EXP_t - p_{f,t}IMP_t + \left(R^*_{t-1}\Psi_{t-1} - 1\right)\frac{\overline{NFA}_{t-1}}{\Pi_t}, \tag{A.49}$$

where the real value of net foreign assets is defined as $\overline{NFA}_t = \frac{NFA_t}{P_t}$. Given that assets are entirely traded within the currency union, equilibrium also requires that

$$0 = n\overline{NFA}_t + (1-n)\,\overline{NFA}^*_t\frac{p_{h,t}}{p^*_{h,t}}. \tag{A.50}$$

A.6 Equilibrium and Exogenous Processes

In equilibrium all markets clear and the model is closed by the resource constraint:

$$\begin{aligned} Y_t = {} & C_t + I_t + G_t + p_{h,t}EXP_t - p_{f,t}IMP_t + \\ & + \frac{\theta_p}{2}\left(\frac{\Pi_{h,t}}{\Pi^{\iota_p}_{h,t-1}} - \Pi_h^{1-\iota_p}\right)^2 Y_t + \frac{\theta_w}{2}\left[\frac{\Pi^w_t}{\Pi^{\iota_w}_{t-1}} - \Pi^{1-\iota_w}\right]^2 W_t H_t. \end{aligned} \tag{A.51}$$

As in Smets and Wouters (2007), the wage markup and the price markup shocks follow ARMA(1,1) processes:

$$\log\left(\frac{e^{\varkappa}_t}{e^{\varkappa}}\right) = \rho_{\varkappa}\log\left(\frac{e^{\varkappa}_{t-1}}{e^{\varkappa}}\right) + \epsilon^{\varkappa}_t - \vartheta_{\varkappa}\epsilon^{\varkappa}_{t-1}, \tag{A.52}$$

with $\varkappa = [p, w]$, whereas all other exogenous variables follow an AR(1) process:

$$\log\left(\frac{e^{\kappa}_t}{e^{\kappa}}\right) = \rho_{\kappa}\log\left(\frac{e^{\kappa}_{t-1}}{e^{\kappa}}\right) + \epsilon^{\kappa}_t + \Im\epsilon^{\kappa,COM}_t, \tag{A.53}$$

[47] We follow Adolfson et al. (2007) and make the simplifying assumption that the elasticity of substitution χ is the same for all goods.

where $\kappa = [b, \mu, m, a, \phi]$; $\rho_{\varkappa}$ and ρ_{κ} are autoregressive parameters; ϑ_i are the moving average parameters; $\epsilon_t^{\varkappa}$ and ϵ_t^{κ} are i.i.d shocks with zero mean and standard deviations $\sigma_{\varkappa}$ and σ_{κ}. We follow Quint and Rabanal (2014) and try to better capture correlations of macroeconomic variables and spillovers of shocks across countries, by adding a common component to the processes of total factor productivity and credits shocks by setting $\Im = 1$ for $\kappa = [a, \phi]$, as well as by assuming that the AR(1) and MA(1) coefficients of the shocks are the same across countries while keeping the standard deviation of the shocks to be country-specific. Overall the currency-union model features eight structural shocks for the home economy, eight structural shocks for the foreign country (i.e. countries in the rest of the currency union), and three common shocks, including the monetary policy shock, for a total of 19 exogenous disturbances. In the EA model, instead, the model features 9 structural shocks.

B Equilibrium Conditions of the Detrended System

B.1 Domestic Country

$$(1+\tau_t^c)\,\Lambda_t^o = \frac{e_t^b}{C_t^o - \frac{h}{\gamma}C_{t-1}^o} - h\beta E_t\left[\frac{e_{t+1}^b}{\gamma C_{t+1}^o - hC_t^o}\right] \tag{B.1}$$

$$\Lambda_t^o = \beta E_t\left[\Lambda_{t+1}^o \frac{R_t}{\gamma \Pi_{t+1}}\right] \tag{B.2}$$

$$P_t^k M_t = \beta E_t\left\{\frac{\Lambda_{t+1}^o}{\Lambda_t^o \gamma}\left[\left(1-\tau_{t+1}^k\right) R_{t+1}^k + \delta P_{t+1}^k \tau_{t+1}^k + (1-\delta)\, P_{t+1}^k M_{t+1}\right]\right\} \tag{B.3}$$

$$Q_t M_t = \beta E_t\left[\frac{\Lambda_{t+1}^o}{\Lambda_t^o}\frac{1+\kappa Q_{t+1} M_{t+1}}{\gamma \Pi_{t+1}}\right] \tag{B.4}$$

$$1 = \beta E_t\left[\frac{\Lambda_{t+1}^o}{\Lambda_t^o}\frac{(1+R_t^*)\,\Psi_t}{\gamma \Pi_{t+1}}\right] \tag{B.5}$$

$$\Psi_t = \exp\left\{\psi_1\left(\frac{NFA_t^o}{Y_t} - \frac{NFA^o}{Y}\right)\right\} - 1 \tag{B.6}$$

$$(1+\tau_t^c)\, C_t^r = (1-\tau_t^w)\, W_t H_t^r + \tau_t^l - \Phi_t \tag{B.7}$$

$$(1+\tau_t^c)\,\Lambda_t^r = \frac{e_t^b}{C_t^r - \frac{h}{\gamma}C_{t-1}^r} - h\beta E_t\left[\frac{e_{t+1}^b}{\gamma C_{t+1}^r - hC_t^r}\right] \tag{B.8}$$

$$0 = \bar{\Lambda}_t \left\{ (1-\tau_t^w)(1-\varepsilon^w e_t^w) - \theta_w \left[\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} - \gamma \Pi^{1-\iota_w} \right] \frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} \right\} W_t + B H_t^\eta e_t^w \varepsilon^w +$$

$$+ \beta E_t \left\{ \bar{\Lambda}_{t+1} \theta_w \left[\frac{\Pi_{t+1}^w}{\Pi_t^{\iota_w}} - \gamma \Pi^{\iota_w} \right] \frac{\Pi_{t+1}^w H_{t+1}}{\Pi_t^{\iota_w} H_t} W_{t+1} \right\} \tag{B.9}$$

$$\bar{\Lambda}_t = \omega \Lambda_t^o + (1-\omega) \Lambda_t^r \tag{B.10}$$

$$\Pi_t^w = \frac{\gamma W_t}{W_{t-1}} \Pi_t \tag{B.11}$$

$$C_t = \omega C_t^o + (1-\omega) C_t^r \tag{B.12}$$

$$\bar{F}_t = \omega \bar{F}_t^o \tag{B.13}$$

$$I_t = \omega I_t^o \tag{B.14}$$

$$K_t = \omega K_t^o \tag{B.15}$$

$$N_t L_t = \bar{B}_t^{FI} + \bar{F}_t \tag{B.16}$$

$$L_t = \frac{1}{1 + \left(e_t^\phi - 1\right) E_t \frac{R_{t+1}^L}{R_t}} \tag{B.17}$$

$$P_t^k I_t = \bar{F}_t - \frac{\kappa \bar{F}_{t-1}}{\gamma \Pi_t} \frac{Q_t}{Q_{t-1}} \tag{B.18}$$

$$1 = \beta \zeta \frac{\Lambda_{t+1}^o}{\Lambda_t^o \gamma \Pi_{t+1}} \left[R_t + L_t \left(R_{t+1}^L - R_t \right) \right] \left[1 + N_t f'(N_t) \gamma + f(N_t) \right]^{-1} \tag{B.19}$$

$$f(N_t) = \frac{\psi_n}{2} \left(\frac{N_t - \bar{N}}{\bar{N}} \right)^2 \tag{B.20}$$

$$f'(N_t) = \psi_n \left(N_t - \bar{N} \right) \left(\frac{1}{\bar{N}} \right)^2 \tag{B.21}$$

$$R_{t+1}^L = \frac{1 + \kappa Q_{t+1}}{Q_t} \tag{B.22}$$

$$R_t^{10} = \kappa + \frac{1}{Q_t} \tag{B.23}$$

$$R_t = \frac{1 + \kappa Q_{t+1}^{EH}}{Q_t^{EH}} \tag{B.24}$$

$$R_t^{10,EH} = \kappa + \frac{1}{Q_t^{EH}} \tag{B.25}$$

$$TP_t = 1 + R_t^{10} - R_t^{10,EH} \tag{B.26}$$

$$Y_t = e_t^a K_t^\alpha H_t^{1-\alpha} \tag{B.27}$$

$$MPK_t = \alpha e_t^a K_t^{\alpha-1} H_t^{1-\alpha} \tag{B.28}$$

$$MPL_t = (1-\alpha) e_t^a K_t^\alpha H_t^{-\alpha} \tag{B.29}$$

$$R_t^k = MC_t \, MPK_t \tag{B.30}$$

$$W_t = MC_t \, MPL_t \tag{B.31}$$

$$0 = 1 + e_t^P \epsilon_p \left(MC_t - 1\right) - \theta_p \left(\frac{\Pi_{h,t}}{\Pi_{h,t-1}^{\iota_p}} - \Pi_h^{1-\iota_p} \right) \frac{\Pi_{h,t}}{\Pi_{h,t-1}^{\iota_p}} + \tag{B.32}$$

$$+ \theta_p E_t \left[\beta \frac{\Lambda_{t+1}^o}{\Lambda_t^o} \left(\frac{\Pi_{h,t+1}}{\Pi_{h,t}^{\iota_p}} - \Pi_h^{1-\iota_p} \right) \frac{\Pi_{h,t+1}}{\Pi_{h,t}^{\iota_p}} \frac{Y_{t+1}}{Y_t} \right] \tag{B.33}$$

$$\Pi_{h,t} = \frac{P_{h,t}}{P_{h,t-1}} \tag{B.34}$$

$$1 = P_t^k e_t^\mu \left[1 - S\left(\gamma \frac{I_t}{I_{t-1}} \right) - S'\left(\gamma \frac{I_t}{I_{t-1}} \right) \gamma \frac{I_t}{I_{t-1}} \right] + \tag{B.35}$$

$$+ E_t \left[\beta \frac{\Lambda_{t+1}^o}{\gamma \Lambda_t^o} e_{t+1}^\mu P_{t+1}^k S'\left(\gamma \frac{I_{t+1}}{I_t} \right) \left(\gamma \frac{I_{t+1}}{I_t} \right)^2 \right] \tag{B.36}$$

$$\gamma K_{t+1} = \left(1 - \delta\right) K_t + I_t e_t^\mu \left[1 - S\left(\gamma \frac{I_t}{I_{t-1}} \right) \right] \tag{B.37}$$

$$S = \frac{\psi_i}{2} \left(\frac{I_t}{I_{t-1}} - \gamma \right)^2 \tag{B.38}$$

$$S' = \psi_i \left(\frac{I_t}{I_{t-1}} - \gamma \right) \tag{B.39}$$

$$\bar{B}_t = \frac{R_{t-1}^L}{\gamma \Pi_t} \bar{B}_{t-1} + \bar{G}_t - T_t \tag{B.40}$$

$$PB_t^Y = \frac{T_t - \bar{G}_t}{Y_t} \tag{B.41}$$

$$T_t = \tau_t^c C_t + \tau_t^w W_t H_t + \tau_t^k \left[\left(R_t^k - \delta P_t^k \right) K_t \right] - \tau_t^l \tag{B.42}$$

$$\log\left(\frac{\tau_t}{\tau} \right) = \rho_\tau \log\left(\frac{\tau_{t-1}}{\tau} \right) + \rho_{\tau b} \log\left(\frac{\bar{B}_{t-1}}{\bar{B}} \right) + \rho_{\tau y} \log\left(\frac{Y_t}{Y} \right) + \left(1 - \vartheta_\tau\right) \epsilon_t^\tau + \vartheta_\tau \epsilon_{t-1}^\tau \tag{B.43}$$

$$\log\left(\frac{g_t}{g} \right) = \rho_g \log\left(\frac{g_{t-1}}{g} \right) - \rho_{gb} \log\left(\frac{\bar{B}_{t-1}}{\bar{B}} \right) - \rho_{gy} \log\left(\frac{Y_t}{Y} \right) + \left(1 - \vartheta_g\right) \epsilon_t^g + \vartheta_g \epsilon_{t-1}^g \tag{B.44}$$

$$G_t = g_t G \tag{B.45}$$

$$\tau_t^l = g_t \tau^l \tag{B.46}$$

$$\bar{G}_t = G_t + \tau_t^l \tag{B.47}$$

$$\tau_t^c = \tau_t \tau^c \tag{B.48}$$

$$\tau_t^k = \tau_t \tau^k \tag{B.49}$$

$$\tau_t^w = \tau_t \tau^w \tag{B.50}$$

B.2 Foreign Country

$$\left(1+\tau_t^{c,*}\right)\Lambda_t^{o,*} = \frac{e_t^{b,*}}{C_t^{o,*}-\frac{h^*}{\gamma}C_{t-1}^{o,*}} - h^*\beta E_t\left[\frac{e_{t+1}^{b,*}}{\gamma C_{t+1}^{o,*}-h^*C_t^{o,*}}\right] \tag{B.51}$$

$$\Lambda_t^{o,*} = \beta E_t\left[\Lambda_{t+1}^{o,*}\frac{R_t}{\gamma\Pi_{t+1}^*}\right] \tag{B.52}$$

$$P_t^{k,*}M_t^* = \beta E_t\left\{\frac{\Lambda_{t+1}^{o,*}}{\Lambda_t^{o,*}\gamma}\left[\left(1-\tau_{t+1}^{k,*}\right)R_{t+1}^{k,*}+\delta P_{t+1}^{k,*}\tau_{t+1}^{k,*}+(1-\delta)P_{t+1}^{k,*}M_{t+1}^*\right]\right\} \tag{B.53}$$

$$Q_t^*M_t^* = \beta E_t\left[\frac{\Lambda_{t+1}^{o,*}}{\Lambda_t^{o,*}}\frac{1+\kappa Q_{t+1}^*M_{t+1}^*}{\gamma\Pi_{t+1}^*}\right] \tag{B.54}$$

$$1 = \beta E_t\left[\frac{\Lambda_{t+1}^{o,*}}{\Lambda_t^{o,*}}\frac{\left(1+R_t^*\right)\Psi_t}{\gamma\Pi_{t+1}^*}\right] \tag{B.55}$$

$$\left(1+\tau_t^{c,*}\right)C_t^{r,*} = \left(1-\tau_t^{w,*}\right)W_t^*H_t^{r,*}+\tau_t^{l,*}-\Phi_t^* \tag{B.56}$$

$$\left(1+\tau_t^{c,*}\right)\Lambda_t^{r,*} = \frac{e_t^{b,*}}{C_t^{r,*}-\frac{h^*}{\gamma}C_{t-1}^{r,*}} - h^*\beta E_t\left[\frac{e_{t+1}^{b,*}}{\gamma C_{t+1}^{r,*}-h^*C_t^{r,*}}\right] \tag{B.57}$$

$$0 = \bar{\Lambda}_t^*\left\{\left(1-\tau_t^{w,*}\right)\left(1-\varepsilon^w e_t^{w,*}\right)-\theta_w^*\left[\frac{\Pi_t^{w,*}}{\left(\Pi_{t-1}^*\right)^{\iota_w}}-\gamma\left(\Pi^*\right)^{1-\iota_w}\right]\frac{\Pi_t^{w,*}}{\left(\Pi_{t-1}^*\right)^{\iota_w}}\right\}W_t^*+ \tag{B.58}$$

$$+B^*\left(H_t^*\right)^\eta\varepsilon^w e_t^{w,*}+\beta E_t\left\{\bar{\Lambda}_{t+1}^*\theta_w^*\left[\frac{\Pi_{t+1}^{w,*}}{\left(\Pi_t^*\right)^{\iota_w}}-\gamma\left(\Pi^*\right)^{\iota_w}\right]\frac{\Pi_{t+1}^{w,*}H_{t+1}^*}{\left(\Pi_t^*\right)^{\iota_w}H_t^*}W_{t+1}^*\right\} \tag{B.59}$$

$$\bar{\Lambda}_t^* = \omega^*\Lambda_t^{o,*}+\left(1-\omega^*\right)\Lambda_t^{r,*} \tag{B.60}$$

$$\Pi_t^{w,*} = \frac{\gamma W_t^*}{W_{t-1}^*}\Pi_t^* \tag{B.61}$$

$$C_t^* = \omega^*C_t^{o,*}+\left(1-\omega^*\right)C_t^{r,*} \tag{B.62}$$

$$\bar{F}_t^* = \omega^*\bar{F}_t^{o,*}, \tag{B.63}$$

$$I_t^* = \omega^*I_t^{o,*}, \tag{B.64}$$

$$K_t^* = \omega^*K_t^{o,*}, \tag{B.65}$$

$$N_t^*L_t^* = \bar{B}_t^{FI,*}+\bar{F}_t^{\,*} \tag{B.66}$$

$$L_t^* = \frac{1}{1+\left(e_t^{\phi,*}-1\right)E_t\frac{R_{t+1}^{L,*}}{R_t}} \tag{B.67}$$

$$P_t^{k,*} I_t^* = \bar{F}_t^* - \frac{\kappa \bar{F}_{t-1}^*}{\gamma \Pi_t^*} \frac{Q_t^*}{Q_{t-1}^*} \tag{B.68}$$

$$1 = \frac{\Lambda_{t+1}^{o,*} \beta \zeta^*}{\Lambda_t^{o,*} \gamma \Pi_{t+1}^*} \left[R_t + L_t^* \left(R_{t+1}^{L,*} - R_t \right) \right] \left[1 + N_t^* f' \left(N_t^* \right) \gamma + f \left(N_t^* \right) \right]^{-1} \tag{B.69}$$

$$f \left(N_t^* \right) = \frac{\psi_n^*}{2} \left(\frac{N_t^* - \bar{N}^*}{\bar{N}^*} \right)^2 \tag{B.70}$$

$$f' \left(N_t^* \right) = \psi_n^* \left(N_t^* - \bar{N}^* \right) \left(\frac{1}{\bar{N}^*} \right)^2 \tag{B.71}$$

$$R_{t+1}^{L,*} = \frac{1 + \kappa Q_{t+1}^*}{Q_t^*} \tag{B.72}$$

$$R_t^{10,*} = \kappa + \frac{1}{Q_t^*} \tag{B.73}$$

$$TP_t^* = 1 + R_t^{10,*} - R_t^{10,EH} \tag{B.74}$$

$$Y_t^* = e_t^{a,*} \left(K_t^* \right)^{\alpha} \left(H_t^* \right)^{1-\alpha} \tag{B.75}$$

$$MPK_t^* = \alpha e_t^{a,*} \left(K_t^* \right)^{\alpha-1} \left(H_t^* \right)^{1-\alpha} \tag{B.76}$$

$$MPL_t^* = \left(1 - \alpha \right) e_t^{a,*} \left(K_t^* \right)^{\alpha} \left(H_t^* \right)^{-\alpha} \tag{B.77}$$

$$R_t^{k,*} = MC_t^* MPK_t^* \tag{B.78}$$

$$W_t^* = MC_t^* MPL_t^* \tag{B.79}$$

$$0 = 1 + e_t^{P,*} \epsilon_p^* \left(MC_t^* - 1 \right) - \theta_p^* \left(\frac{\Pi_{f,t}}{\Pi_{f,t-1}^{\iota_p^*}} - \Pi_f^{1-\iota_p^*} \right) \frac{\Pi_{f,t}}{\Pi_{f,t-1}^{\iota_p^*}} + \tag{B.80}$$

$$+ \theta_p^* E_t \left[\beta \frac{\Lambda_{t+1}^{o,*}}{\Lambda_t^{o,*}} \left(\frac{\Pi_{f,t+1}}{\Pi_{f,t}^{\iota_p^*}} - \Pi_f^{1-\iota_p^*} \right) \frac{\Pi_{f,t+1}}{\Pi^{\iota_p^*}{}_{f,t}} \frac{Y_{t+1}^*}{Y_t^*} \right] \tag{B.81}$$

$$\Pi_{f,t} = \frac{P_{f,t}}{P_{f,t-1}} \tag{B.82}$$

$$1 = P_t^{k,*} e_t^{\mu,*} \left[1 - S \left(\gamma \frac{I_t^*}{I_{t-1}^*} \right) - S' \left(\gamma \frac{I_t^*}{I_{t-1}^*} \right) \gamma \frac{I_t^*}{I_{t-1}^*} \right] + \tag{B.83}$$

$$+ E_t \left[\beta \frac{\Lambda_{t+1}^{o,*}}{\gamma \Lambda_t^{o,*}} e_{t+1}^{\mu,*} P_{t+1}^{k,*} S' \left(\gamma \frac{I_{t+1}^*}{I_t^*} \right) \left(\gamma \frac{I_{t+1}^*}{I_t^*} \right)^2 \right] \tag{B.84}$$

$$\gamma K_{t+1}^* = \left(1 - \delta \right) K_t^* + I_t^* e_t^{\mu,*} \left[1 - S \left(\gamma \frac{I_t^*}{I_{t-1}^*} \right) \right] \tag{B.85}$$

$$S = \frac{\psi_i^*}{2} \left(\frac{I_t^*}{I_{t-1}^*} - \gamma \right)^2 \tag{B.86}$$

$$S' = \psi_i^* \left(\frac{I_t^*}{I_{t-1}^*} - \gamma \right) \tag{B.87}$$

$$\bar{B}_t^* = \frac{R_{t-1}^{L,*}}{\gamma \Pi_t^*} \bar{B}_{t-1}^* + \bar{G}_t^* - T_t^* \tag{B.88}$$

$$PB_t^{Y,*} = \frac{T_t^* - \bar{G}_t^*}{Y_t^*} \tag{B.89}$$

$$T_t^* = \tau_t^{c,*} C_t^* + \tau_t^{w,*} W_t^* H_t^* + \tau_t^{k,*} \left[\left(R_t^{k,*} - \delta P_t^{k,*} \right) K_t^* \right] - \tau_t^{l,*} \tag{B.90}$$

$$\log\left(\frac{\tau_t^*}{\tau^*}\right) = \rho_\tau^* \log\left(\frac{\tau_{t-1}^*}{\tau^*}\right) + \rho_{\tau b}^* \log\left(\frac{\bar{B}_{t-1}^*}{\bar{B}^*}\right) + \rho_{\tau y}^* \log\left(\frac{Y_t^*}{Y^*}\right) + (1 - \vartheta_\tau^*)\, \epsilon_t^{\tau,*} + \vartheta_\tau^* \epsilon_{t-1}^{\tau,*} \tag{B.91}$$

$$\log\left(\frac{g_t^*}{g^*}\right) = \rho_g^* \log\left(\frac{g_{t-1}^*}{g^*}\right) - \rho_{gb}^* \log\left(\frac{\bar{B}_{t-1}^*}{\bar{B}^*}\right) - \rho_{gy}^* \log\left(\frac{Y^*}{Y^*}\right) + \left(1 - \vartheta_g^*\right) \epsilon_t^{g,*} + \vartheta_g^* \epsilon_{t-1}^{g,*} \tag{B.92}$$

$$G_t^* = g_t^* G^* \tag{B.93}$$

$$\tau_t^{l,*} = g_t^* \tau^{l,*} \tag{B.94}$$

$$\bar{G}_t^* = G_t^* + \tau_t^{l,*} \tag{B.95}$$

$$\tau_t^{c,*} = \tau_t^* \tau^{c,*} \tag{B.96}$$

$$\tau_t^{k,*} = \tau_t^* \tau^{k,*} \tag{B.97}$$

$$\tau_t^{w,*} = \tau_t^* \tau^{w,*} \tag{B.98}$$

B.3 Market Clearing and Trade

$$\Pi_t = \left[\varphi \left(\Pi_{h,t} p_{h,t-1}\right)^{1-\chi} + (1-\varphi)\left(\Pi_{f,t} p_{f,t-1}\right)^{1-\chi} \right]^{\frac{1}{1-\chi}} \tag{B.99}$$

$$\Pi_t^* = \left[\varphi^* \left(\Pi_{f,t} p_{f,t-1}^*\right)^{1-\chi^*} + (1-\varphi^*)\left(\Pi_{h,t} p_{h,t-1}^*\right)^{1-\chi^*} \right]^{\frac{1}{1-\chi^*}} \tag{B.100}$$

$$\frac{TOT_t}{TOT_{t-1}} = \frac{\Pi_t^*}{\Pi_t} \tag{B.101}$$

$$\left(p_{h,t}\right)^{\chi-1} = \varphi + (1-\varphi)\, TOT_t^{1-\chi} \tag{B.102}$$

$$\left(p_{f,t}\right)^{\chi-1} = \varphi TOT_t^{\chi-1} + (1-\varphi) \tag{B.103}$$

$$\left(p_{h,t}^*\right)^{\chi^*-1} = \varphi^* TOT_t^{1-\chi^*} + (1-\varphi^*) \tag{B.104}$$

$$\left(p_{f,t}^*\right)^{\chi^*-1} = \varphi^* + (1-\varphi^*)\, TOT_t^{\chi^*-1} \tag{B.105}$$

$$IMP_t = (1-\varphi)(p_{f,t})^{-\chi}(C_t + G_t + I_t) \tag{B.106}$$

$$EXP_t = (1-\varphi^*)\left(p^*_{h,t}\right)^{-\chi^*}(C^*_t + G^*_t + I^*_t) \tag{B.107}$$

$$IMP^*_t = (1-\varphi^*)\left(p^*_{h,t}\right)^{-\chi^*}(C^*_t + G^*_t + I^*_t) \tag{B.108}$$

$$EXP^*_t = (1-\varphi)(p_{f,t})^{-\chi}(C_t + G_t + I_t) \tag{B.109}$$

$$n\left(\overline{NFA}_t - \frac{\overline{NFA}_{t-1}}{\gamma\Pi_t}\right) = \frac{(1-n)\,EXP_t - nIMP_t}{TOT_t} + (1+R_{t-1})\,\Psi_{t-1}n\frac{\overline{NFA}_{t-1}}{\gamma\Pi_t} \tag{B.110}$$

$$0 = n\overline{NFA}_t + (1-n)\,\overline{NFA}^*_t\frac{p_{h,t}}{p^*_{h,t}} \tag{B.111}$$

$$Y_t = C_t + I_t + G_t + \frac{(1-n)}{n}EXP_t - IMP_t + \tag{B.112}$$

$$+\frac{\theta_p}{2}\left(\frac{\Pi_{h,t}}{\Pi^{\iota_p}_{h,t-1}} - \Pi_h^{1-\iota_p}\right)^2 Y_t + \frac{\theta_w}{2}\left[\frac{\Pi^w_t}{\Pi^{\iota_w}_{t-1}} - \gamma\Pi^{1-\iota_w}\right]^2 W_t H_t \tag{B.113}$$

$$Y^*_t = C^*_t + I^*_t + G^*_t + \frac{n}{(1-n)}EXP^*_t - IMP^*_t + \tag{B.114}$$

$$+\frac{\theta^*_p}{2}\left(\frac{\Pi_{f,t}}{\Pi^{\iota^*_p}_{f,t-1}} - \Pi_f^{1-\iota^*_p}\right)^2 Y^*_t + \frac{\theta^*_w}{2}\left[\frac{\Pi^{w,*}_t}{\left(\Pi^*_{t-1}\right)^{\iota_w}} - \gamma^*\left(\Pi^*\right)^{1-\iota_w}\right]^2 W^*_t H^*_t \tag{B.115}$$

B.4 Central Bank

$$\log\left(\frac{R_t}{R}\right) = \rho_r\log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_r)\left\{\rho_\pi\log\left(\frac{\Pi^u_t}{\Pi^u}\right) + \rho_y\log\left(\frac{Y^u_t}{Y^u}\right)\right\} + e^m_t \tag{B.116}$$

$$\Pi^u_t = (\Pi_t)^n\left(\Pi^*_t\right)^{1-n} \tag{B.117}$$

$$Y^u_t = nY_t + (1-n)\,Y^*_t \tag{B.118}$$

B.5 Exogenous Processes

$$\log\left(\frac{e^a_t}{e^a}\right) = \rho_a\log\left(\frac{e^a_{t-1}}{e^a}\right) + \epsilon^a_t + \epsilon^{a,COM}_t \tag{B.119}$$

$$\log\left(\frac{e^\phi_t}{e^\phi}\right) = \rho_\phi\log\left(\frac{e^\phi_{t-1}}{e^\phi}\right) + \epsilon^\phi_t + \epsilon^{\phi,COM}_t \tag{B.120}$$

$$\log\left(\frac{e^\mu_t}{e^\mu}\right) = \rho_\mu\log\left(\frac{e^\mu_{t-1}}{e^\mu}\right) + \epsilon^\mu_t \tag{B.121}$$

$$\log\left(\frac{e_t^w}{e^w}\right) = \rho_w \log\left(\frac{e_{t-1}^w}{e^w}\right) + \epsilon_t^w - \vartheta_w \epsilon_{t-1}^w \tag{B.122}$$

$$\log\left(\frac{e_t^p}{e^p}\right) = \rho_p \log\left(\frac{e_{t-1}^p}{e^p}\right) + \epsilon_t^p - \vartheta_p \epsilon_{t-1}^p \tag{B.123}$$

$$\log\left(\frac{e_t^b}{e^b}\right) = \rho_b \log\left(\frac{e_{t-1}^b}{e^b}\right) + \epsilon_t^b \tag{B.124}$$

$$\log\left(\frac{e_t^m}{e^m}\right) = \rho_m \log\left(\frac{e_{t-1}^m}{e^m}\right) + \epsilon_t^m \tag{B.125}$$

$$\log\left(\frac{e_t^{a,*}}{e^{a,*}}\right) = \rho_a \log\left(\frac{e_{t-1}^{a,*}}{e^{a,*}}\right) + \epsilon_t^{a,*} + \epsilon_t^{a,COM} \tag{B.126}$$

$$\log\left(\frac{e_t^{\phi,*}}{e^{\phi *}}\right) = \rho_\phi \log\left(\frac{e_{t-1}^{\phi,*}}{e^{\phi,*}}\right) + \epsilon_t^{\phi,*} + \epsilon_t^{\phi,COM} \tag{B.127}$$

$$\log\left(\frac{e_t^{\mu,*}}{e^{\mu,*}}\right) = \rho_\mu \log\left(\frac{e_{t-1}^{\mu,*}}{e^{\mu,*}}\right) + \epsilon_t^{\mu,*} \tag{B.128}$$

$$\log\left(\frac{e_t^{w,*}}{e^{w,*}}\right) = \rho_w \log\left(\frac{e_{t-1}^{w,*}}{e^{w,*}}\right) + \epsilon_t^{w,*} - \vartheta_w \epsilon_{t-1}^{w,*} \tag{B.129}$$

$$\log\left(\frac{e_t^{p,*}}{e^{p,*}}\right) = \rho_p \log\left(\frac{e_{t-1}^{p,*}}{e^{p,*}}\right) + \epsilon_t^{p,*} - \vartheta_p \epsilon_{t-1}^{p,*} \tag{B.130}$$

$$\log\left(\frac{e_t^{b,*}}{e^{b,*}}\right) = \rho_b \log\left(\frac{e_{t-1}^{b,*}}{e^{b,*}}\right) + \epsilon_t^{b,*} \tag{B.131}$$

C Steady State

In the deterministic steady state all expectation operators are removed and for each variable it holds that $x_t = x_{t+1} = x$ and the stochastic shocks are absent. All relative prices and the terms of trade are set equal to 1. The variables C^r and $C^{r,*}$ solve equations (B.7) and (B.56), respectively. The remaining variables are found recursively as follows:

$$\Pi = 1 + \bar{\mathit{\Pi}} \tag{C.1}$$

$$\Pi^* = \Pi \tag{C.2}$$

$$\Pi_h = \Pi \tag{C.3}$$

$$\Pi_f = \Pi \tag{C.4}$$

$$\Pi^w = \gamma\Pi \tag{C.5}$$

$$\Pi^{w,*} = \gamma\Pi \tag{C.6}$$

$$R = \frac{\gamma \Pi}{\beta} \tag{C.7}$$

$$f(N) = 0 \tag{C.8}$$

$$f'(N) = 0 \tag{C.9}$$

$$Q^{EH} = (R - \kappa)^{-1} \tag{C.10}$$

$$R^{10,EH} = \kappa + \frac{1}{Q^{EH}} \tag{C.11}$$

$$R^L = \frac{\left(1 + \bar{TP}\right) \gamma \Pi}{\beta} \tag{C.12}$$

$$Q = \left(R^L - \kappa\right)^{-1} \tag{C.13}$$

$$R^{10} = R^L \tag{C.14}$$

$$TP = 1 + R^{10} - R^{10,EH} \tag{C.15}$$

$$e^{\phi} = 1 - \frac{L - 1}{L \frac{R^L}{R}} \tag{C.16}$$

$$M = \beta \left[\gamma \Pi \left(1 - \frac{\beta \kappa}{\gamma \Pi} \right) Q \right]^{-1} \tag{C.17}$$

$$\zeta = \frac{\gamma \Pi}{\beta \left[R + L \left(R^L - R \right) \right]} \tag{C.18}$$

$$MC = \frac{\epsilon_p - 1}{\epsilon_p} \tag{C.19}$$

$$P^k = 1 \tag{C.20}$$

$$S = 0 \tag{C.21}$$

$$S' = 0 \tag{C.22}$$

$$R^k = \left[P^k M \left(1 - \frac{(1 - \delta) \beta}{\gamma} \right) - \frac{\beta}{\gamma} \delta P^k \tau^k \right] \left(\frac{\beta}{\gamma} \left(1 - \tau^k \right) \right)^{-1} \tag{C.23}$$

$$\frac{K}{Y} = \frac{\alpha MC}{R^k} \tag{C.24}$$

$$K = H \left(\frac{K}{Y} \right)^{\frac{1}{1-\alpha}} \tag{C.25}$$

$$Y = K^{\alpha} H^{1-\alpha} \tag{C.26}$$

$$I = \left[\gamma - (1 - \delta) \right] K \tag{C.27}$$

$$G = g_y Y \tag{C.28}$$

$$MPK = \alpha \frac{Y}{K} \tag{C.29}$$

$$MPL = (1 - \alpha) \frac{Y}{H} \tag{C.30}$$

$$W = MC\left(1-\alpha\right)\frac{Y}{H} \tag{C.31}$$

$$I^{o} = \frac{I}{\omega} \tag{C.32}$$

$$K^{o} = \frac{K}{\omega} \tag{C.33}$$

$$IMP = m_{y}Y \tag{C.34}$$

$$EXP = x_{y}Y \tag{C.35}$$

$$C = Y - I - G - EXP + IMP \tag{C.36}$$

$$C^{o} = \frac{C-\left(1-\omega\right)C^{r}}{\omega} \tag{C.37}$$

$$\Lambda^{r} = \left[\left(C^{r}\left(1-\frac{h}{\gamma}\right)\right)^{-1} - \frac{\beta h}{C^{r}\left(\gamma-h\right)}\right]\left[\left(1+\tau^{c}\right)\right]^{-1} \tag{C.38}$$

$$\Lambda^{o} = \left[\left(C^{o}\left(1-\frac{h}{\gamma}\right)\right)^{-1} - \frac{\beta h}{C^{o}\left(\gamma-h\right)}\right]\left[\left(1+\tau^{c}\right)\right]^{-1} \tag{C.39}$$

$$B = \left(\varepsilon^{w}-1\right)W\left(1-\tau^{w}\right)\left[\omega\Lambda^{o}+\left(1-\omega\right)\Lambda^{r}\right]\left[\varepsilon^{w}H^{\eta}\right]^{-1} \tag{C.40}$$

$$\overline{NFA} = \left(IMP-EXP\right)\left(1-\frac{R}{\gamma\Pi}\right)^{-1} \tag{C.41}$$

$$\varphi = 1 - \frac{IMP}{C+G+I} \tag{C.42}$$

$$EXP^{*} = \frac{n}{1-n}IMP \tag{C.43}$$

$$IMP^{*} = \frac{n}{1-n}EXP \tag{C.44}$$

$$\bar{F} = P^{k}I\left(1-\frac{\kappa}{\gamma\Pi}\right)^{-1} \tag{C.45}$$

$$\bar{F}^{o} = \frac{\bar{F}}{\omega} \tag{C.46}$$

$$\bar{B} = b_{y}4Y \tag{C.47}$$

$$\bar{B}^{FI} = \bar{B} \tag{C.48}$$

$$N = \frac{\bar{B}^{FI}+\bar{F}}{L} \tag{C.49}$$

$$T = \tau^{c}C + \tau^{w}WH + \tau^{k}\left[\left(R^{k}-\delta P^{k}\right)K\right] \tag{C.50}$$

$$\tau^{l} = T - G + \left(1-\frac{R^{L}}{\gamma\Pi}\right)\bar{B} \tag{C.51}$$

$$\bar{G} = G + \tau^{l} \tag{C.52}$$

$$PB^{Y} = \frac{T-\bar{G}}{Y} \tag{C.53}$$

$$R^{*} = R \tag{C.54}$$

$$f\left(N^{*}\right) = 0 \tag{C.55}$$

$$f'\left(N^{*}\right) = 0 \tag{C.56}$$

$$Q^{EH,*} = Q^{EH} \tag{C.57}$$

$$R^{L,*} = \left(1 + \bar{TP}^{*}\right) R \tag{C.58}$$

$$Q^{*} = \left(R^{L,*} - \kappa\right)^{-1} \tag{C.59}$$

$$R^{10,*} = R^{L,*} \tag{C.60}$$

$$TP^{*} = 1 + R^{10,*} - R^{10,EH} \tag{C.61}$$

$$e^{\phi,*} = 1 - \frac{L^{*} - 1}{L^{*} \frac{R^{L,*}}{R}} \tag{C.62}$$

$$M^{*} = \beta \left[\gamma \Pi^{*} \left(1 - \frac{\beta \kappa}{\gamma \Pi^{*}}\right) Q^{*}\right]^{-1} \tag{C.63}$$

$$\zeta^{*} = \frac{\gamma \Pi^{*}}{\beta \left[R + L^{*} \left(R^{L,*} - R\right)\right]} \tag{C.64}$$

$$MC^{*} = \frac{\epsilon_{p} - 1}{\epsilon_{p}} \tag{C.65}$$

$$P^{k,*} = 1 \tag{C.66}$$

$$R^{k,*} = \left[P^{k,*} M^{*} \left(1 - \frac{(1-\delta)\beta}{\gamma}\right) - \frac{\beta}{\gamma} \delta P^{k,*} \tau^{k,*}\right] \left(\frac{\beta}{\gamma}\left(1 - \tau^{k,*}\right)\right)^{-1} \tag{C.67}$$

$$\frac{K^{*}}{Y^{*}} = \frac{\alpha MC^{*}}{R^{k,*}} \tag{C.68}$$

$$K^{*} = H^{*} \left(\frac{K^{*}}{Y^{*}}\right)^{\frac{1}{1-\alpha}} \tag{C.69}$$

$$Y^{*} = \left(K^{*}\right)^{\alpha} \left(H^{*}\right)^{1-\alpha} \tag{C.70}$$

$$I = \left[\gamma - (1-\delta)\right] K \tag{C.71}$$

$$G^{*} = g_{y}^{*} Y^{*} \tag{C.72}$$

$$MPK^{*} = \alpha \frac{Y^{*}}{K^{*}} \tag{C.73}$$

$$MPL^{*} = (1-\alpha) \frac{Y^{*}}{H^{*}} \tag{C.74}$$

$$W^{*} = MC^{*} (1-\alpha) \frac{Y^{*}}{H^{*}} \tag{C.75}$$

$$I^{o,*} = \frac{I^{*}}{\omega^{*}} \tag{C.76}$$

$$K^{o,*} = \frac{K^{*}}{\omega^{*}} \tag{C.77}$$

$$C^* = Y^* - I^* - G^* - EXP^* + IMP^* \tag{C.78}$$

$$C^{o,*} = \frac{C^* - (1-\omega^*)\, C^{r,*}}{\omega^*} \tag{C.79}$$

$$\Lambda^{r,*} = \left[\left(C^{r,*} \left(1 - \frac{h^*}{\gamma} \right) \right)^{-1} - \frac{\beta h^*}{C^{r,*}\,(\gamma - h^*)} \right] [(1+\tau^{c,*})]^{-1} \tag{C.80}$$

$$\Lambda^{o,*} = \left[\left(C^{o,*} \left(1 - \frac{h^*}{\gamma} \right) \right)^{-1} - \frac{\beta h^*}{C^{o,*}\,(\gamma - h^*)} \right] [(1+\tau^{c,*})]^{-1} \tag{C.81}$$

$$B^* = (\varepsilon^w - 1)\, W^* \,(1 - \tau^{w,*})\, [\omega^* \Lambda^{o,*} + (1-\omega^*)\, \Lambda^{r,*}]\, [\varepsilon^w\, (H^*)^\eta]^{-1} \tag{C.82}$$

$$\overline{NFA}^* = \frac{n}{1-n} \overline{NFA} \tag{C.83}$$

$$\varphi^* = 1 - \frac{n}{1-n} \frac{EXP}{C^* + G^* + I^*} \tag{C.84}$$

$$\bar{F}^* = P^{k,*} I^* \left(1 - \frac{\kappa}{\gamma \Pi^*} \right)^{-1} \tag{C.85}$$

$$\bar{F}^{o,*} = \frac{\bar{F}^*}{\omega^*} \tag{C.86}$$

$$\bar{B}^* = b_y^* 4 Y^* \tag{C.87}$$

$$\bar{B}^{FI,*} = \bar{B}^* \tag{C.88}$$

$$N^* = \frac{\bar{B}^{FI,*} + \bar{F}^*}{L^*} \tag{C.89}$$

$$T^* = \tau^{c,*} C^* + \tau^{w,*} W^* H^* + \tau^{k,*} \left[\left(R^{k,*} - \delta P^{k,*} \right) K^* \right] \tag{C.90}$$

$$\tau^{l,*} = T^* - G^* + \left(1 - \frac{R^{L,*}}{\gamma \Pi^*} \right) \bar{B}^* \tag{C.91}$$

$$\bar{G}^* = G^* + \tau^{l,*} \tag{C.92}$$

$$\left(PB^Y \right)^* = \frac{T^* - \bar{G}^*}{Y^*} \tag{C.93}$$

$$\Pi^u = (\Pi)^n\, (\Pi^*)^{1-n} \tag{C.94}$$

$$Y^u = nY + (1-n)\, Y^* \tag{C.95}$$

D Detailed Derivation of the Wage Setting Equation

Remember that the union objective is to:

$$\max_{W_t^z} E_t \sum_{k=0}^{\infty} \beta^{t+k} \left[\omega U_{t+k}^o + (1-\omega) U_{t+k}^r\right]$$

subject to the labor demand functions $H_t^z = \left[\frac{W_t^z}{W_t}\right]^{-e_t^w \varepsilon^w} H_t$ and the budget constraints (A.5) and (A.14). Notice also that $U_t^i = f\left(C_t^i, N_t^z\right)$ and $C_t^i = g\left(W_t^z, N_t^z\right)$, whit $i = o, r$. Then the first-order condition of the union with respect to W_t^z reads as:

$$\begin{aligned} 0 = {} & \omega \frac{\partial U_t^o}{\partial C_t^o} \frac{\partial C_t^o}{\partial W_t^z} + (1-\omega) \frac{\partial U_t^r}{\partial C_t^r} \frac{\partial C_t^r}{\partial W_t^z} + \omega \frac{\partial U_t^o}{\partial H_t^z} \frac{\partial H_t^z}{\partial W_t^z} + (1-\omega) \frac{\partial U_t^r}{\partial H_t^z} \frac{\partial H_t^z}{\partial W_t^z} \\ & + \beta E_t \left[\omega \frac{\partial U_{t+1}^o}{\partial C_{t+1}^o} \frac{\partial C_{t+1}^o}{\partial W_t^z} + (1-\omega) \frac{\partial U_{t+1}^r}{\partial C_{t+1}^r} \frac{\partial C_{t+1}^r}{\partial W_t^z}\right] \end{aligned} \quad \text{(D.1)}$$

Given the demand function $H_t^z = \left[\frac{W_t^z}{W_t}\right]^{-e_t^w \varepsilon^w} H_t$, we have

$$\begin{aligned} \frac{\partial U_t^o}{\partial H_t^z} &= -B \left(H_t^z\right)^\eta, \\ \frac{\partial U_t^r}{\partial H_t^z} &= -B \left(H_t^z\right)^\eta, \\ \frac{\partial H_t^z}{\partial W_t^z} &= -e_t^w \varepsilon^w \frac{H_t^z}{W_t^z}. \end{aligned}$$

The derivatives from the households budget constraints read as

$$\begin{aligned} \frac{\partial C_t^i}{\partial W_t^z} &= \frac{\partial \left\{\left(1-\tau_t^w\right) W_t^z N_t^z\right\}}{\partial W_t^z} - \frac{\partial \Phi_t}{\partial W_t^z}, \\ \frac{\partial C_{t+1}^i}{\partial W_t^z} &= \frac{\partial \Phi_{t+1}}{\partial W_t^z}, \end{aligned}$$

with

$$
\begin{aligned}
\frac{\partial \left\{ W_t^z N_t^z \right\}}{\partial W_t^z} &= \frac{\partial \left\{ \left(1-\tau_t^w\right) W_t^z \left[\frac{W_t^z}{W_t} \right]^{-e_t^w \eta} H_t \right\}}{\partial W_t^z} \\
&= \left(1-\tau_t^w\right) \left[\frac{W_t^z}{W_t} \right]^{-e_t^w \varepsilon^w} H_t - \left(1-\tau_t^w\right) e_t^w \varepsilon^w \left[\frac{W_t^z}{W_t} \right]^{-e_t^w \varepsilon^w - 1} \frac{W_t^z}{W_t} H_t \\
&= \left(1-\tau_t^w\right) \left[\frac{W_t^z}{W_t} \right]^{-e_t^w \varepsilon^w} H_t - \left(1-\tau_t^w\right) e_t^w \varepsilon^w \left[\frac{W_t^z}{W_t} \right]^{-e_t^w \varepsilon^w} H_t \\
&= \left(1-\tau_t^w\right) \left(1-e_t^w \varepsilon^w\right) \left[\frac{W_t^z}{W_t} \right]^{-e_t^w \varepsilon^w} H_t \\
&= \left(1-\tau_t^w\right) \left(1-e_t^w \varepsilon^w\right) H_t^z.
\end{aligned}
$$

and

$$
\begin{aligned}
\frac{\partial \Phi_t}{\partial W_t^z} &= \theta_w \left[\frac{W_t^z}{\Pi_{t-1}^{\iota_w} W_{t-1}^z} \Pi_t - \Pi^{1-\iota_w} \right] \frac{W_t^z}{\Pi_{t-1}^{\iota_w} W_{t-1}^z} \Pi_t H_t, \\
\frac{\partial \Phi_{t+1}}{\partial W_t^z} &= \theta_w \left[\frac{W_{t+1}^z}{\Pi_t^{\iota_w} W_t^z} \Pi_{t+1} - \Pi^{1-\iota_w} \right] \frac{W_{t+1}^z}{\Pi_t^{\iota_w} \left(W_t^z\right)^2} \Pi_{t+1} W_{t+1}^z H_{t+1}.
\end{aligned}
$$

Finally, remember that $\frac{\partial U_t^o}{\partial C_t^o} = \Lambda_t^o$ and $\frac{\partial U_t^r}{\partial C_t^r} = \Lambda_t^r$. Then, substituting all the derivatives into (D.1) and assuming symmetry so that $W_t^z = W_t$ and $H_t^z = H_t$ yields

$$
\begin{aligned}
0 = {} & \omega \Lambda_t^o \left\{ \left(1-\tau_t^w\right)\left(1-e_t^w \varepsilon^w\right) - \theta_w \left[\frac{W_t}{\Pi_{t-1}^{\iota_w} W_{t-1}} \Pi_t - \Pi^{1-\iota_w} \right] \frac{W_t}{\Pi_{t-1}^{\iota_w} W_{t-1}} \Pi_t \right\} H_t \\
& + \left(1-\omega\right) \Lambda_t^r \left\{ \left(1-\tau_t^w\right)\left(1-\varepsilon^w e_t^w\right) - \theta_w \left[\frac{W_t}{\Pi_{t-1}^{\iota_w} W_{t-1}} \Pi_t - \Pi^{1-\iota_w} \right] \frac{W_t}{\Pi_{t-1}^{\iota_w} W_{t-1}} \Pi_t \right\} H_t \\
& + B \left(H_t\right)^\eta e_t^w \varepsilon^w \frac{H_t}{W_t} \\
& + \beta E_t \Bigg\{ \omega \Lambda_{t+1}^o \theta_w \left[\frac{W_{t+1}}{\Pi_t^{\iota_w} W_t} \Pi_{t+1} - \Pi^{1-\iota_w} \right] \frac{W_{t+1}}{\Pi_t^{\iota_w} W_t^2} \Pi_{t+1} H_{t+1} \\
& + \left(1-\omega\right) \Lambda_{t+1}^r \theta_w \left[\frac{W_{t+1}}{\Pi_t^{\iota_w} W_t} \Pi_{t+1} - \Pi^{1-\iota_w} \right] \frac{W_{t+1}}{\Pi_t^{\iota_w} W_t^2} \Pi_{t+1} W_{t+1} H_{t+1} \Bigg\}.
\end{aligned}
$$

Multiply by $\frac{W_t}{H_t}$ and define the nominal wage inflation as $\Pi_t^w = \frac{W_t}{W_{t-1}}\Pi_t$:

$$\begin{aligned}
0 = &\omega\Lambda_t^o \left\{ \left(1-\tau_t^w\right)\left(1-e_t^w\varepsilon^w\right) - \theta_w \left[\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} - \Pi^{1-\iota_w}\right]\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} \right\} W_t \\
&+ \left(1-\omega\right)\Lambda_t^r \left\{ \left(1-\tau_t^w\right)\left(1-e_t^w\varepsilon^w\right) - \theta_w \left[\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} - \Pi^{1-\iota_w}\right]\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} \right\} W_t \\
&+ B\left(H_t\right)^\eta e_t^w\varepsilon^w \\
&+ \beta E_t \Bigg\{ \omega\Lambda_{t+1}^o\theta_w \left[\frac{\Pi_{t+1}^w}{\Pi_t^{\iota_w}} - \Pi^{1-\iota_w}\right]\frac{\Pi_{t+1}^w H_{t+1}}{\Pi_t^{\iota_w} H_t} \\
&+ \left(1-\omega\right)\Lambda_{t+1}^r\theta_w \left[\frac{\Pi_{t+1}^w}{\Pi_t^{\iota_w}} - \Pi^{1-\iota_w}\right]\frac{\Pi_{t+1}^w H_{t+1}}{\Pi_t^{\iota_w} H_t} W_{t+1} \Bigg\}.
\end{aligned}$$

Factorizing the terms in the curly brackets yields:

$$\begin{aligned}
0 = &\left[\omega\Lambda_t^o + \left(1-\omega\right)\Lambda_t^r\right] \left\{ \left(1-\tau_t^w\right)\left(1-e_t^w\varepsilon^w\right) - \theta_w \left[\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} - \Pi^{1-\iota_w}\right]\frac{\Pi_t^w}{\Pi_{t-1}^{\iota_w}} \right\} W_t \\
&+ B\left(H_t\right)^\eta e_t^w\varepsilon^w \\
&+ \beta E_t \left\{ \left[\omega\Lambda_{t+1}^o + \left(1-\omega\right)\Lambda_{t+1}^r\right]\theta_w \left[\frac{\Pi_{t+1}^w}{\Pi_t^{\iota_w}} - \Pi^{1-\iota_w}\right]\frac{\Pi_{t+1}^w H_{t+1}}{\Pi_t^{\iota_w} H_t} W_{t+1} \right\}.
\end{aligned}$$

Finally, dividing by $\left[\omega\Lambda_t^o + \left(1-\omega\right)\Lambda_t^r\right] W_t$ and defining $\bar{\Lambda}_t = \omega\Lambda_t^o + \left(1-\omega\right)\Lambda_t^r$ yields the wage schedule (A.18).

E Data, Measurement Equations, and Estimates

We collect data on the following countries: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. Nominal data are then transformed to real series by dividing for the respective country's GDP deflator. All series are seasonally adjusted. Euro-Area variables are created by aggregating countries series weighted by countries' nominal GDP. Table E.1 reports the data used and the sources while Table E.2 shows the transformation to construct the observables for the Bayesian estimation.

The sets of measurement equations for both the currency union and EA models are given by equations (E.1) and (E.2). Variables with a ˆ are in log-deviations from their own steady state, γ is the deterministic growth rate as in Smets and Wouters (2007). Our set of observable variables include the real variables for each term of the resource constraint

(A.51) with the exception of net exports. In order to avoid any possible issue of stochastic singularity, we follow Schmitt-Grohe and Uribe (2012) and overcome this issue by introducing an i.i.d. measurement error ϵ_t^{me} in the measurement equation of output. In addition, we include a measurement error for the ratio of primary balance to GDP to account for a possible mismatch between the fiscal variable in the model and that in the data. Prior and posterior distributions are reported in Tables E.3-E.6.

Table E.1: Data Sources.

Series	Definition	Source	Reference
Y^N	Nominal GDP	Eurostat	Table namq_10_gdp
P	GDP Deflator	OECD	Economic Outlook N.4, Nov. 2018
I^{TOT}	Gross Fixed Capital Formation	Eurostat	Table namq_10_gdp
I^G	General Government Gross Fixed Capital Formation	Eurostat	Table gov_10q_ggnfa
C	Household and NPISH Final Consumption Expenditure	Eurostat	Table namq_10_gdp
G	Total General Government Expenditure	Eurostat	Table gov_10q_ggnfa
R^G	Interest payable by General Government	Eurostat	Table gov_10q_ggnfa
T	General Government Total Revenue	Eurostat	Table gov_10q_ggnfa
W	Hourly Earnings, Private Sector	OECD	Main Economic Indicators
R^L	Long-Term Government Bond Yields: 10-year	OECD	Main Economic Indicators
R	EONIA Shadow Rate	Wu and Xia (2017)	Authors' estimates

Table E.2: Data Transformation - Observables.

Variable	Description	Construction
Y_t^o	Real GDP	$\ln\left(\frac{Y_t^N}{P_t}\right) \times 100$
I_t^o	Real private investment	$\ln\left(\frac{I_t^{TOT}-I_t^G}{P_t}\right) \times 100$
C_t^o	Real private consumption	$\ln\left(\frac{C_t}{P_t}\right) \times 100$
W_t^o	Real wage	$\ln\left(\frac{W_t}{P_t}\right) \times 100$
G_t^o	Real government expenditure	$\ln\left(\frac{G_t-R_t^G}{P_t}\right) \times 100$
T_t^o	Real government revenue	$\ln\left(\frac{T_t}{P_t}\right) \times 100$
Π_t^o	Inflation	$\ln\left(\frac{P_t}{P_{t-1}}\right) \times 100$
R_t^o	Shadow rate	$\frac{R_t}{4}$
TP_t^o	Term premium	$\frac{R_t^L-R_t}{4}$
$PB^{Y,o}$	Primary balance to GDP	$\frac{T_t-G_t}{Y_t}$

$$
\tilde{\Xi}^{CU} = \begin{bmatrix} \Delta Y_t^o \\ \Delta C_t^o \\ \Delta I_t^o \\ \Delta W_t^o \\ \Delta G_t^o \\ \Delta T_t^o \\ \Pi_t^o \\ TP_t^o \\ PB_t^{Y,o} \\ \Delta Y_t^{o,*} \\ \Delta C_t^{o,*} \\ \Delta I_t^{o,*} \\ \Delta W_t^{o,*} \\ \Delta G_t^{o,*} \\ \Delta T_t^{o,*} \\ \Pi_t^{o,*} \\ TP_t^{o,*} \\ PB_t^{Y,o,*} \\ R_t^o \end{bmatrix} = \begin{bmatrix} \hat{Y}_t - \hat{Y}_{t-1} \\ \hat{C}_t - \hat{C}_{t-1} \\ \hat{I}_t - \hat{I}_{t-1} \\ \hat{W}_t - \hat{W}_{t-1} \\ \hat{\bar{G}}_t - \hat{\bar{G}}_{t-1} \\ \hat{T}_t - \hat{T}_{t-1} \\ \hat{\Pi}_t \\ T\hat{P}_t \\ PB_t^Y - PB^Y \\ \hat{Y}_t^* - \hat{Y}_{t-1}^* \\ \hat{C}_t^* - \hat{C}_{t-1}^* \\ \hat{I}_t^* - \hat{I}_{t-1}^* \\ \hat{W}_t^* - \hat{W}_{t-1}^* \\ \hat{\bar{G}}_t^* - \hat{\bar{G}}_{t-1}^* \\ \hat{T}_t^* - \hat{T}_{t-1}^* \\ \hat{\Pi}_t^* \\ T\hat{P}_t^* \\ PB_t^{Y,*} - PB^{Y,*} \\ \hat{R}_t \end{bmatrix} + \begin{bmatrix} \gamma + \varepsilon_t^{me} \\ \gamma \\ \gamma \\ \gamma \\ \gamma \\ \gamma \\ \bar{\mathit{\Pi}} \\ T\bar{P} \\ P\bar{B}^Y + \varepsilon_t^{me,pb} \\ \gamma + \varepsilon_t^{me,*} \\ \gamma \\ \gamma \\ \gamma \\ \gamma \\ \gamma \\ \bar{\mathit{\Pi}} \\ T\bar{P}^* \\ P\bar{B}^{Y,*} + \varepsilon_t^{me,pb,*} \\ \bar{R} \end{bmatrix}, \qquad \text{(E.1)}
$$

$$
\tilde{\Xi}^{EA} = \begin{bmatrix} \Delta Y_t^o \\ \Delta C_t^o \\ \Delta I_t^o \\ \Delta W_t^o \\ \Delta G_t^o \\ \Delta T_t^o \\ \Pi_t^o \\ TP_t^o \\ PB_t^{Y,o} \\ R_t^o \end{bmatrix} = \begin{bmatrix} \hat{Y}_t - \hat{Y}_{t-1} \\ \hat{C}_t - \hat{C}_{t-1} \\ \hat{I}_t - \hat{I}_{t-1} \\ \hat{W}_t - \hat{W}_{t-1} \\ \hat{\bar{G}}_t - \hat{\bar{G}}_{t-1} \\ \hat{T}_t - \hat{T}_{t-1} \\ \hat{\Pi}_t \\ T\hat{P}_t \\ PB_t^Y - PB^Y \\ \hat{R}_t \end{bmatrix} + \begin{bmatrix} \gamma + \varepsilon_t^{me} \\ \gamma \\ \gamma \\ \gamma \\ \gamma \\ \gamma \\ \bar{\mathit{\Pi}} \\ T\bar{P} \\ P\bar{B}^Y + \varepsilon_t^{me,pb} \\ \bar{R} \end{bmatrix}, \qquad \text{(E.2)}
$$

Table E.3: Prior Distributions of Estimated Parameters.

Parameter			Prior	
		Distr.	Mean	Sd/df
Structural				
Inv. Frisch elasticity	η, η^*	N	0.50	0.10
Habits in consumption	h, h^*	B	0.70	0.10
Home good bias	χ, χ^*	G	1.50	0.50
Fraction of optimizing households	ω, ω^*	B	0.50	0.10
Investment adjustment cost	ψ_i, ψ_i^*	N	2.50	1.00
Net worth adjustment costs	ψ_n, ψ_n^*	N	0.785	0.10
Price stickiness	θ_p, θ_p^*	G	50	10.0
Price indexation	ι_p, ι_p^*	B	0.50	0.175
Wage stickiness	θ_w, θ_w^*	G	50	10.0
Wage indexation	ι_w, ι_w^*	B	0.50	0.175
Tax smoothing	ρ_τ, ρ_τ^*	B	0.70	0.10
Tax reaction to debt	$\rho_{\tau b}, \rho_{\tau b}^*$	G	0.10	0.025
Tax reaction to output	$\rho_{\tau y}, \rho_{\tau y}^*$	G	0.10	0.025
Tax anticipation effect	$\vartheta_\tau, \vartheta_\tau^*$	B	0.25	0.10
Government spending smoothing	ρ_g, ρ_g^*	B	0.70	0.20
Government spending reaction to debt	ρ_{gb}, ρ_{gb}^*	G	0.10	0.05
Government spending reaction to output	ρ_{gy}, ρ_{gy}^*	N	0.10	0.05
Government spending anticipation effect	$\vartheta_g, \vartheta_g^*$	B	0.25	0.10
Inflation -Taylor rule	ρ_π	N	1.70	0.10
Output -Taylor rule	ρ_y	G	0.125	0.05
Interest rate smoothing	ρ_r	B	0.80	0.10
Elasticity of risk premium to NFA	ψ_1	IG	0.10	2.00
Exogenous processes				
AR(1) coefficients	ρ	B	0.85	0.10
MA(1) coefficients	ϑ	B	0.50	0.20
Standard deviations	σ	IG	0.10	2.0
Measurement errors	σ_{me}	IG	0.10	2.0

Table E.4: Prior Distributions of Constants in Measurement Equations.

Parameter			Prior				
		Distr.	Mean				Sd/df
			France	Italy	Germany	Euro Area	
Constant							
Trend	γ	N	0.38	0.21	0.38	0.35	0.10
Inflation	$\bar{\Pi}$	G	0.36	0.41	0.36	0.38	0.10
Interest rate	$\bar{R}$	G	0.18	0.18	0.18	0.18	0.10
Term premium	$\bar{TP}$	G	0.38	0.59	0.38	0.42	0.10
	$\bar{TP}^*$	G	0.43	0.38	0.43	\	0.10
Primary balance to GDP	$\bar{PB}^Y$	N	-1.02	1.55	1.02	0.49	0.10
	$\bar{PB}^{Y,*}$	N	0.96	0.05	0.00	\	0.10

Table E.5: Posterior Distributions of Etimated Structural Parameters (90% Confidence Bands in Square Brackets).

Parameter		Posterior Mean			
		France	Italy	Germany	Euro Area
Structural					
Inv. Frisch elasticity	η	0.53 [0.46;0.59]	0.51 [0.47;0.54]	0.46 [0.42;0.50]	0.50 [0.42;0.58]
	η^*	0.45 [0.36;0.54]	0.50 [0.47;0.52]	0.55 [0.50;0.61]	/
Habits in consumption	h	0.73 [0.68;0.79]	0.77 [0.73;0.82]	0.79 [0.74;0.84]	0.79 [0.74;0.85]
	h^*	0.82 [0.78;0.86]	0.81 [0.77;0.85]	0.83 [0.79;0.86]	/
Home good bias	χ	1.43 [0.97;1.90]	1.23 [0.93;1.57]	1.09 [0.78;1.37]	/
	χ^*	1.20 [0.82;1.58]	1.10 [0.79;1.42]	0.74 [0.57;0.92]	/
Fraction of optimizing households	ω	0.74 [0.68;0.80]	0.90 [0.87;0.94]	0.85 [0.80;0.91]	0.85 [0.79;0.90]
	ω^*	0.85 [0.79;0.81]	0.86 [0.80;0.93]	0.83 [0.77;0.89]	/
Investment adjustment cost	ψ_i	6.58 [5.66;7.49]	4.29 [3.63;4.93]	5.38 [4.19;6.56]	4.97 [3.81;6.12]
	ψ_i^*	4.46 [3.33;5.56]	4.98 [3.94;5.88]	3.13 [2.28;3.97]	/
Net worth adjustment costs	ψ_n	0.70 [0.60;0.81]	0.97 [0.87;1.08]	0.89 [0.80;0.98]	0.75 [0.59;0.91]
	ψ_n^*	0.63 [0.52;0.72]	0.55 [0.45;0.64]	0.58 [0.48;0.69]	/
Price stickiness	θ_p	65.9 [49.6;81.4]	52.1 [44.8;58.3]	66.3 [51.3;80.7]	64.9 [47.0;82.6]
	θ_p^*	76.7 [62.0;90.0]	107.8 [99.4;116.7]	65.4 [51.0;80.6]	/
Price indexation	ι_p	0.27 [0.08;0.45]	0.12 [0.04;0.21]	0.30 [0.11;0.47]	0.46 [0.20;0.72]
	ι_p^*	0.22 [0.09;0.35]	0.40 [0.26;0.56]	0.26 [0.10;0.42]	/
Wage stickiness	θ_w	69.0 [56.3;81.1]	51.4 [45.6;57.0]	60.4 [50.5;71.6]	69.4 [51.6;86.3]
	θ_w^*	76.7 [60.1;96.1]	89.8 [81.4;98.1]	85.3 [70.4;106]	/
Wage indexation	ι_w	0.35 [0.14;0.59]	0.76 [0.66;0.86]	0.48 [0.25;0.66]	0.65 [0.44;0.88]
	ι_w^*	0.62 [0.41;0.82]	0.50 [0.36;0.62]	0.61 [0.45;0.79]	/
Tax smoothing	ρ_τ	0.83 [0.77;0.90]	0.57 [0.49;0.64]	0.88 [0.82;0.94]	0.80 [0.72;0.89]
	ρ_τ^*	0.66 [0.55;0.78]	0.86 [0.80;0.91]	0.75 [0.63;0.86]	/
Tax reaction to debt	$\rho_{\tau b}$	0.13 [0.10;0.16]	0.13 [0.11;0.15]	0.16 [0.14;0.18]	0.09 [0.07;0.12]
	$\rho_{\tau b}^*$	0.10 [0.07;0.12]	0.08 [0.06;0.10]	0.09 [0.07;0.12]	/
Tax reaction to output	$\rho_{\tau y}$	0.07 [0.05;0.10]	0.06 [0.04;0.07]	0.09 [0.06;0.12]	0.07 [0.04;0.09]
	$\rho_{\tau y}^*$	0.09 [0.06;0.12]	0.05 [0.03;0.06]	0.12 [0.07;0.15]	/
Tax anticipation effect	ϑ_τ	0.19 [0.08;0.29]	0.23 [0.12;0.33]	0.11 [0.05;0.18]	0.24 [0.08;0.41]
	ϑ_τ^*	0.13 [0.04;0.21]	0.15 [0.07;0.24]	0.18 [0.10;0.26]	/
Gov. spending smoothing	ρ_g	0.71 [0.60;0.83]	0.60 [0.52;0.69]	0.46 [0.34;0.60]	0.71 [0.60;0.82]
	ρ_g^*	0.63 [0.51;0.75]	0.82 [0.72;0.91]	0.90 [0.84;0.96]	/
Gov. spending reaction to debt	ρ_{gb}	0.08 [0.05;0.10]	0.11 [0.10;0.13]	0.10 [0.07;0.14]	0.11 [0.08;0.14]
	ρ_{gb}^*	0.09 [0.04;0.14]	0.08 [0.06;0.09]	0.07 [0.05;0.10]	/
Gov. spending reaction to output	ρ_{gy}	0.10 [0.07;0.14]	0.11 [0.08;0.13]	0.08 [0.05;0.10]	0.11 [0.07;0.14]
	ρ_{gy}^*	0.13 [0.10;0.16]	0.14 [0.11;0.17]	0.11 [0.09;0.13]	/
Gov. spending anticipation effect	ϑ_g	0.79 [0.73;0.86]	0.80 [0.64;0.85]	0.81 [0.75;0.88]	0.82 [0.76;0.88]
	ϑ_g^*	0.79 [0.73;0.85]	0.80 [0.75;0.85]	0.77 [0.71;0.84]	/
Inflation -Taylor rule	ρ_π	1.94 [1.84;2.05]	1.94 [1.84;2.07]	1.70 [1.56;1.81]	1.88 [1.74;2.02]
Output -Taylor rule	ρ_y	0.13 [0.09;0.19]	0.21 [0.16;0.25]	0.22 [0.17;0.27]	0.08 [0.03;0.14]
Interest rate smoothing	ρ_r	0.80 [0.76;0.84]	0.85 [0.81;0.88]	0.85 [0.80;0.89]	0.82 [0.78;0.86]
Elasticity of risk premium to NFA	ψ_1	0.005 [0.003;0.008]	0.003 [0.002;0.004]	0.004 [0.002;0.005]	/

Table E.6: Posterior Distributions of Estimated Constants and Shock Processes (90% Confidence Bands in Square Brackets).

Parameter		Posterior Mean			
		France	Italy	Germany	Euro Area
Constant					
Trend	γ	0.46 [0.42;0.50]	0.35 [0.31;0.40]	0.27 [0.22;0.33]	0.44 [0.39;0.49]
Inflation	$\bar{\Pi}$	0.15 [0.09;0.21]	0.18 [0.14;0.23]	0.08 [0.04;0.11]	0.26 [0.17;0.35]
Interest rate	$\bar{R}$	0.13 [0.04;0.22]	0.25 [0.16;0.33]	0.17 [0.05;0.29]	0.13 [0.03;0.23]
Term premium	$\bar{TP}$	0.29 [0.18;0.39]	0.39 [0.32;0.46]	0.22 [0.11;0.32]	0.39 [0.28;0.50]
	$\bar{TP}^*$	0.44 [0.36;0.51]	0.40 [0.32;0.49]	0.32 [0.23;0.41]	/
Primary balance to GDP	$\bar{PB}^Y$	-1.06 [-1.41;-0.69]	1.34 [1.19;1.48]	1.10 [0.90;1.28]	0.51 [0.18;0.85]
	$\bar{PB}^{Y,*}$	0.98 [0.72;1.28]	0.32 [0.20;0.45]	-0.12 [-0.32;0.09]	/
Exogenous processes					
Technology	ρ_a	0.76 [0.51;0.99]	0.75 [0.67;0.80]	0.64 [0.50;0.79]	0.99 [0.98;0.99]
	σ_a	0.13 [0.02;0.28]	1.71 [1.47;1.95]	0.12 [0.02;0.28]	0.77 [0.64;0.89]
	σ_a^*	0.38 [0.03;0.58]	0.62 [0.27;0.93]	0.37 [0.03;0.65]	/
	σ_a^{COM}	0.48 [0.33;0.64]	0.17 [0.02;0.56]	0.31 [0.03;0.55]	/
Monetary Policy	ρ_m	0.48 [0.38;0.58]	0.46 [0.42;0.51]	0.55 [0.45;0.65]	0.52 [0.42;0.61]
	σ_m	0.16 [0.13;0.18]	0.15 [0.13;0.17]	0.15 [0.12;0.17]	0.15 [0.12;0.17]
Preference	ρ_b	0.80 [0.73;0.89]	0.83 [0.76;0.90]	0.78 [0.71;0.86]	0.78 [0.65;0.90]
	σ_b	2.19 [1.67;2.70]	4.96 [4.05;5.83]	5.68 [4.41;6.87]	2.46 [1.91;3.02]
	σ_b^*	2.74 [2.09;3.36]	2.96 [2.34;3.56]	3.02 [2.40;3.64]	/
Investment specific	ρ_μ	0.72 [0.66;0.78]	0.78 [0.73;0.83]	0.80 [0.73;0.87]	0.70 [0.61;0.78]
	σ_μ	5.45 [4.42;6.45]	8.73 [7.27;10.3]	8.54 [6.57;10.5]	6.35 [4.62;8.03]
	σ_μ^*	6.99 [5.37;8.67]	7.14 [5.80;8.38]	6.07 [4.75;7.42]	/
Price mark-up	ρ_p	0.95 [0.86;0.99]	0.96 [0.93;0.99]	0.86 [0.79;0.94]	0.87 [0.73;0.99]
	ϑ_p	0.81 [0.71;0.90]	0.84 [0.77;0.91]	0.873 [0.61;0.87]	0.70 [0.54;0.86]
	σ_p	3.43 [2.57;4.28]	8.44 [7.29;9.60]	6.56 [4.90;8.39]	2.58 [1.89;3.24]
	σ_p^*	3.51 [2.67;4.34]	3.21 [2.61;3.79]	3.29 [2.39;4.15]	/
Wage mark-up	ρ_w	0.92 [0.89;0.95]	0.93 [0.91;0.96]	0.90 [0.85;0.95]	0.90 [0.85;0.95]
	ϑ_w	0.70 [0.63;0.79]	0.77 [0.71;0.83]	0.72 [0.61;0.84]	0.69 [0.57;0.81]
	σ_w	6.99 [5.38;8.55]	13.9 [12.3;15.7]	14.8 [11.5;18.2]	8.24 [6.08;10.4]
	σ_w^*	9.23 [7.07;11.5]	9.10 [7.96;10.3]	6.85 [5.56;8.25]	/
Government spending	σ_g	1.21 [0.98;1.43]	2.35 [1.94;2.75]	2.52 [1.94;3.09]	1.18 [0.97;1.40]
	σ_g^*	1.45 [1.17;1.73]	1.44 [1.16;1.72]	1.38 [1.10;1.67]	/
Tax	σ_τ	1.25 [0.81;1.64]	0.10 [0.02;0.18]	2.31 [1.85;2.77]	0.21 [0.02;0.57]
	σ_τ^*	1.10 [0.84;1.36]	0.39 [0.02;0.81]	1.09 [0.82;1.36]	/
Credit	ρ_ϕ	0.83 [0.79;0.87]	0.89 [0.85;0.93]	0.95 [0.91;0.99]	0.87 [0.80;0.94]
	σ_ϕ	0.11 [0.02;0.19]	0.09 [0.02;0.17]	0.09 [0.02;0.16]	4.35 [2.52;6.08]
	σ_ϕ^*	2.20 [1.74;2.66]	3.76 [3.03;4.44]	2.89 [1.97;3.76]	/
	σ_ϕ^{COM}	5.77 [4.53;7.05]	4.68 [3.64;5.56]	2.86 [1.82;3.82]	/
Measurement errors	σ_{me}	0.39 [0.34;0.44]	0.61 [0.52;0.69]	0.59 [0.51;0.68]	0.47 [0.41;0.53]
	σ_{me}^*	0.52 [0.45;0.59]	0.52 [0.45;0.59]	0.51 [0.43;0.58]	/
	$\sigma_{me,pb}$	0.25 [0.21;0.28]	0.17 [0.15;0.20]	0.13 [0.11;0.15]	0.40 [0.35;0.45]
	$\sigma_{me,pb}^*$	0.47 [0.41;0.53]	0.42 [0.36;0.47]	0.12 [0.10;0.14]	/
Log-likelihood		-1198.73	-11583.87	-1251.46	-595.95

F DMFCI – Regression Coefficients

Table F.1: Selected Percentiles from the Distribution of DMFCI Regression Coefficients—Euro Area.

Dependent variable: $\hat{y}_t$

Variable	Coefficient			Variable	Coefficient			Variable	Coefficient		
	5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl
$\hat{r}_{t-1}$	-3.73	-2.49	-1.38	e^b_{t-7}	-0.01	0.05	0.10	e^ϕ_{t-5}	-0.07	-0.04	-0.01
$\hat{r}_{t-2}$	-1.12	-0.72	-0.36	e^b_{t-8}	-0.02	0.04	0.09	e^ϕ_{t-6}	-0.06	-0.03	0.00
$\hat{r}_{t-3}$	-1.18	-0.75	-0.35	e^b_{t-9}	-0.03	0.02	0.08	e^ϕ_{t-7}	-0.05	-0.02	0.00
$\hat{r}_{t-4}$	-1.02	-0.59	-0.23	e^b_{t-10}	-0.04	0.02	0.07	e^ϕ_{t-8}	-0.04	-0.02	0.01
$\hat{r}_{t-5}$	-0.92	-0.49	-0.08	e^b_{t-11}	-0.15	0.02	0.17	e^ϕ_{t-9}	-0.05	-0.02	0.00
$\hat{r}_{t-6}$	-0.83	-0.37	0.00	e^μ_{t-1}	0.16	0.22	0.30	e^ϕ_{t-10}	-0.04	-0.01	0.03
$\hat{r}_{t-7}$	-0.72	-0.32	0.12	e^μ_{t-2}	0.10	0.13	0.17	e^ϕ_{t-11}	-0.03	0.00	0.03
$\hat{r}_{t-8}$	-0.66	-0.26	0.18	e^μ_{t-3}	0.08	0.11	0.14	e^ϕ_{t-12}	-0.03	0.00	0.03
$\hat{r}_{t-9}$	-0.52	-0.06	0.47	e^μ_{t-4}	0.06	0.09	0.12	e^ϕ_{t-13}	-0.03	0.00	0.03
$\hat{r}_{t-10}$	-0.35	-0.03	0.30	e^μ_{t-5}	0.05	0.07	0.11	e^ϕ_{t-14}	-0.02	0.001	0.04
$\hat{r}_{t-11}$	-1.36	-0.30	0.91	e^μ_{t-6}	0.04	0.06	0.09	e^ϕ_{t-15}	-0.02	0.01	0.04
$capb_{t-1}$	-3.48	-2.47	-1.59	e^μ_{t-7}	0.03	0.05	0.08	e^ϕ_{t-16}	-0.02	0.01	0.04
$capb_{t-2}$	-0.15	0.07	0.33	e^μ_{t-8}	0.01	0.04	0.08	e^ϕ_{t-17}	-0.02	0.01	0.04
$capb_{t-3}$	-0.24	-0.00	0.24	e^μ_{t-9}	-0.02	0.03	0.06	e^ϕ_{t-18}	-0.02	0.01	0.04
$capb_{t-4}$	-0.23	-0.01	0.25	e^μ_{t-10}	-0.02	0.02	0.06	e^ϕ_{t-19}	-0.02	0.01	0.04
$capb_{t-5}$	-0.24	-0.01	0.20	e^μ_{t-11}	-0.02	0.01	0.04	e^ϕ_{t-20}	-0.02	0.01	0.04
$capb_{t-6}$	-0.26	-0.03	0.21	e^μ_{t-12}	-0.03	0.01	0.04	e^ϕ_{t-21}	-0.01	0.01	0.04
$capb_{t-7}$	-0.28	-0.03	0.21	e^μ_{t-13}	-0.03	0.00	0.04	e^ϕ_{t-22}	-0.01	0.01	0.04
$capb_{t-8}$	-0.28	-0.04	0.24	e^μ_{t-14}	-0.03	0.00	0.03	e^ϕ_{t-23}	-0.01	0.01	0.03
$capb_{t-9}$	-0.53	0.23	1.03	e^μ_{t-15}	-0.03	0.00	0.03	e^ϕ_{t-24}	-0.01	0.01	0.04
e^b_{t-1}	0.06	0.22	0.39	e^μ_{t-16}	-0.03	-0.00	0.02	e^ϕ_{t-25}	-0.01	0.01	0.04
e^b_{t-2}	0.08	0.14	0.21	e^μ_{t-17}	-0.09	-0.02	0.04	e^ϕ_{t-26}	-0.01	0.01	0.04
e^b_{t-3}	0.06	0.11	0.17	e^ϕ_{t-1}	-0.13	-0.03	0.07	e^ϕ_{t-27}	-0.02	0.01	0.04
e^b_{t-4}	0.03	0.09	0.15	e^ϕ_{t-2}	-0.11	-0.08	-0.05	e^ϕ_{t-28}	-0.01	0.01	0.04
e^b_{t-5}	0.02	0.07	0.13	e^ϕ_{t-3}	-0.09	-0.06	-0.03	e^ϕ_{t-29}	-0.02	0.01	0.04
e^b_{t-6}	0.00	0.06	0.12	e^ϕ_{t-4}	-0.08	-0.05	-0.02	e^ϕ_{t-30}	-0.03	0.05	0.15

Median $\bar{R}^2 = 0.64$

Table F.2: Selected Percentiles from the Distribution of DMFCI Regression Coefficients—France.

Dependent variable: $\hat{y}_t$											
Variable	Coefficient			Variable	Coefficient			Variable	Coefficient		
	5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl
$\hat{r}_{t-1}$	-1.21	-0.61	-0.01	e^{μ}_{t-10}	0.00	0.02	0.03	$capb^*_{t-5}$	-0.07	0.04	0.15
$\hat{r}_{t-2}$	-0.73	-0.47	-0.22	e^{μ}_{t-11}	0.00	0.01	0.03	$capb^*_{t-6}$	-0.09	0.04	0.17
$\hat{r}_{t-3}$	-0.57	-0.31	-0.07	e^{μ}_{t-12}	0.00	0.01	0.03	$capb^*_{t-7}$	-0.03	0.08	0.19
$\hat{r}_{t-4}$	-1.15	-0.52	0.13	e^{μ}_{t-13}	0.00	0.01	0.03	$capb^*_{t-8}$	-0.24	0.00	0.23
$capb_{t-1}$	-1.35	-1.10	-0.84	e^{μ}_{t-14}	0.00	0.01	0.02	$e^{b^*}_{t-1}$	-0.03	0.04	0.10
$capb_{t-2}$	-0.02	0.08	0.19	e^{μ}_{t-15}	0.00	0.01	0.02	$e^{b^*}_{t-2}$	0.00	0.03	0.05
$capb_{t-3}$	-0.14	-0.04	0.07	e^{μ}_{t-16}	-0.01	0.01	0.02	$e^{b^*}_{t-3}$	-0.01	0.02	0.05
$capb_{t-4}$	-0.35	-0.11	0.14	e^{μ}_{t-17}	-0.01	0.01	0.02	$e^{b^*}_{t-4}$	-0.01	0.01	0.04
e^{b}_{t-1}	0.11	0.18	0.27	e^{μ}_{t-18}	-0.01	0.01	0.02	$e^{b^*}_{t-5}$	-0.01	0.02	0.05
e^{b}_{t-2}	0.05	0.08	0.11	e^{μ}_{t-19}	-0.01	0.01	0.02	$e^{b^*}_{t-6}$	-0.01	0.01	0.04
e^{b}_{t-3}	0.03	0.07	0.10	e^{μ}_{t-20}	-0.01	0.02	0.06	$e^{b^*}_{t-7}$	-0.02	0.01	0.03
e^{b}_{t-4}	0.02	0.05	0.08	e^{ϕ}_{t-1}	-0.11	-0.02	0.06	$e^{b^*}_{t-8}$	-0.06	0.00	0.07
e^{b}_{t-5}	0.01	0.04	0.07	e^{ϕ}_{t-2}	-0.07	-0.03	0.00	$e^{\mu^*}_{t-1}$	0.04	0.07	0.09
e^{b}_{t-6}	0.00	0.03	0.06	e^{ϕ}_{t-3}	-0.06	-0.02	0.01	$e^{\mu^*}_{t-2}$	0.02	0.04	0.05
e^{b}_{t-7}	-0.01	0.02	0.06	e^{ϕ}_{t-4}	-0.05	-0.02	0.02	$e^{\mu^*}_{t-3}$	0.02	0.03	0.05
e^{b}_{t-8}	-0.03	0.05	0.14	e^{ϕ}_{t-5}	-0.05	-0.02	0.02	$e^{\mu^*}_{t-4}$	0.01	0.02	0.04
e^{μ}_{t-1}	0.09	0.13	0.16	e^{ϕ}_{t-6}	-0.08	0.00	0.08	$e^{\mu^*}_{t-5}$	0.01	0.02	0.04
e^{μ}_{t-2}	0.04	0.05	0.07	e^{ϕ}_{t-7}	-0.03	-0.02	-0.01	$e^{\mu^*}_{t-6}$	-0.01	0.02	0.04
e^{μ}_{t-3}	0.03	0.05	0.07	e^{ϕ}_{t-8}	-0.03	-0.01	0.00	$e^{\phi^*}_{t-1}$	-0.10	-0.02	0.06
e^{μ}_{t-4}	0.03	0.05	0.06	e^{ϕ}_{t-9}	-0.02	-0.01	0.00	$e^{\phi^*}_{t-2}$	-0.04	-0.01	0.02
e^{μ}_{t-5}	0.03	0.04	0.06	e^{ϕ}_{t-10}	-0.04	-0.02	0.02	$e^{\phi^*}_{t-3}$	-0.05	-0.01	0.02
e^{μ}_{t-6}	0.02	0.03	0.05	$capb^*_{t-1}$	-0.38	-0.10	0.16	$e^{\phi^*}_{t-4}$	-0.04	-0.01	0.02
e^{μ}_{t-7}	0.01	0.03	0.04	$capb^*_{t-2}$	-0.19	-0.08	0.03	$e^{\phi^*}_{t-5}$	-0.05	-0.01	0.02
e^{μ}_{t-8}	0.01	0.02	0.04	$capb^*_{t-3}$	-0.12	-0.02	0.10	$e^{\phi^*}_{t-6}$	-0.11	-0.02	0.06
e^{μ}_{t-9}	0.01	0.02	0.03	$capb^*_{t-4}$	-0.11	0.01	0.12				
Median $\bar{R}^2 = 0.77$											

Table F.3: Selected Percentiles from the Distribution of DMFCI Regression Coefficients—Germany.

Dependent variable: $\hat{y}_t$

Variable	Coefficient			Variable	Coefficient			Variable	Coefficient		
	5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl
$\hat{r}_{t-1}$	-2.04	-1.53	-1.08	e^{μ}_{t-1}	0.10	0.12	0.15	$capb^*_{t-1}$	-0.55	-0.26	0.06
$\hat{r}_{t-2}$	-0.63	-0.41	-0.16	e^{μ}_{t-2}	0.05	0.06	0.07	$capb^*_{t-2}$	-0.15	0.02	0.18
$\hat{r}_{t-3}$	-0.63	-0.41	-0.16	e^{μ}_{t-3}	0.04	0.06	0.07	$capb^*_{t-3}$	-0.14	0.02	0.18
$\hat{r}_{t-4}$	-0.55	-0.29	-0.03	e^{μ}_{t-4}	0.04	0.05	0.06	$capb^*_{t-4}$	-0.11	0.05	0.20
$\hat{r}_{t-5}$	-0.49	-0.24	-0.01	e^{μ}_{t-5}	0.03	0.04	0.06	$capb^*_{t-5}$	-0.17	-0.01	0.17
$\hat{r}_{t-6}$	-0.92	-0.42	0.05	e^{μ}_{t-6}	0.03	0.04	0.05	$capb^*_{t-6}$	0.10	0.39	0.72
$capb_{t-1}$	-0.86	-0.66	-0.49	e^{μ}_{t-7}	0.02	0.03	0.05	$e^{b^*}_{t-1}$	-0.02	0.05	0.12
$capb_{t-2}$	-0.06	0.03	0.13	e^{μ}_{t-8}	0.02	0.03	0.04	$e^{b^*}_{t-2}$	-0.01	0.03	0.06
$capb_{t-3}$	-0.12	-0.03	0.06	e^{μ}_{t-9}	0.01	0.02	0.04	$e^{b^*}_{t-3}$	-0.01	0.02	0.06
$capb_{t-4}$	-0.11	-0.02	0.07	e^{μ}_{t-10}	0.01	0.02	0.03	$e^{b^*}_{t-4}$	-0.02	0.02	0.05
$capb_{t-5}$	-0.10	-0.01	0.09	e^{μ}_{t-11}	0.01	0.02	0.03	$e^{b^*}_{t-5}$	-0.07	0.00	0.07
$capb_{t-6}$	-0.30	-0.10	0.07	e^{μ}_{t-12}	0.00	0.01	0.03	$e^{\mu^*}_{t-1}$	0.04	0.08	0.12
e^{b}_{t-1}	0.08	0.12	0.15	e^{μ}_{t-13}	0.00	0.01	0.02	$e^{\mu^*}_{t-2}$	0.03	0.05	0.06
e^{b}_{t-2}	0.05	0.06	0.08	e^{μ}_{t-14}	0.00	0.01	0.02	$e^{\mu^*}_{t-3}$	0.01	0.04	0.06
e^{b}_{t-3}	0.03	0.05	0.06	e^{μ}_{t-15}	0.00	0.01	0.02	$e^{\mu^*}_{t-4}$	0.01	0.03	0.05
e^{b}_{t-4}	0.03	0.05	0.06	e^{μ}_{t-16}	0.00	0.01	0.02	$e^{\mu^*}_{t-5}$	0.00	0.02	0.04
e^{b}_{t-5}	0.02	0.04	0.06	e^{μ}_{t-17}	0.00	0.01	0.02	$e^{\mu^*}_{t-6}$	-0.04	-0.01	0.01
e^{b}_{t-6}	0.02	0.04	0.05	e^{μ}_{t-18}	0.00	0.01	0.02	$e^{\mu^*}_{t-7}$	-0.02	0.00	0.02
e^{b}_{t-7}	0.01	0.03	0.05	e^{μ}_{t-19}	0.00	0.01	0.02	$e^{\mu^*}_{t-8}$	-0.02	0.00	0.02
e^{b}_{t-8}	0.01	0.03	0.05	e^{μ}_{t-20}	0.00	0.01	0.02	$e^{\mu^*}_{t-9}$	-0.02	0.00	0.02
e^{b}_{t-9}	0.01	0.02	0.04	e^{μ}_{t-21}	0.00	0.01	0.02	$e^{\mu^*}_{t-10}$	-0.02	0.00	0.02
e^{b}_{t-10}	0.00	0.02	0.04	e^{μ}_{t-22}	0.00	0.01	0.02	$e^{\mu^*}_{t-11}$	-0.02	0.00	0.01
e^{b}_{t-11}	0.00	0.02	0.04	e^{μ}_{t-23}	0.00	0.01	0.02	$e^{\mu^*}_{t-12}$	-0.02	0.00	0.01
e^{b}_{t-12}	0.00	0.02	0.03	e^{μ}_{t-24}	0.00	0.01	0.02	$e^{\mu^*}_{t-13}$	-0.02	0.00	0.01
e^{b}_{t-13}	0.00	0.02	0.03	e^{μ}_{t-25}	0.00	0.01	0.02	$e^{\mu^*}_{t-14}$	-0.02	0.00	0.01
e^{b}_{t-14}	0.00	0.01	0.03	e^{μ}_{t-26}	0.00	0.01	0.02	$e^{\mu^*}_{t-15}$	-0.02	0.00	0.01
e^{b}_{t-15}	0.00	0.01	0.03	e^{μ}_{t-27}	0.00	0.01	0.02	$e^{\mu^*}_{t-16}$	-0.02	-0.01	0.01
e^{b}_{t-16}	0.00	0.01	0.03	e^{μ}_{t-28}	0.00	0.01	0.02	$e^{\mu^*}_{t-17}$	-0.02	-0.01	0.01
e^{b}_{t-17}	0.00	0.01	0.03	e^{μ}_{t-29}	0.00	0.01	0.02	$e^{\mu^*}_{t-18}$	-0.02	-0.01	0.01
e^{b}_{t-18}	-0.01	0.01	0.03	e^{μ}_{t-30}	0.01	0.03	0.05	$e^{\mu^*}_{t-19}$	-0.02	0.00	0.01
e^{b}_{t-19}	-0.01	0.01	0.03	e^{ϕ}_{t-1}	-0.19	-0.09	0.00	$e^{\mu^*}_{t-20}$	-0.06	-0.02	0.01
e^{b}_{t-20}	-0.01	0.01	0.03	e^{ϕ}_{t-2}	-0.11	-0.06	-0.02	$e^{\phi^*}_{t-1}$	-0.11	-0.04	0.03
e^{b}_{t-21}	-0.01	0.01	0.03	e^{ϕ}_{t-3}	-0.10	-0.04	-0.01	$e^{\phi^*}_{t-2}$	-0.07	-0.04	0.00
e^{b}_{t-22}	-0.01	0.01	0.03	e^{ϕ}_{t-4}	-0.11	-0.04	0.03	$e^{\phi^*}_{t-3}$	-0.06	-0.03	0.00
e^{b}_{t-23}	-0.01	0.01	0.03	e^{ϕ}_{t-5}	-0.09	-0.06	-0.02	$e^{\phi^*}_{t-4}$	-0.09	-0.03	0.04
e^{b}_{t-24}	-0.01	0.01	0.03	e^{ϕ}_{t-6}	-0.07	-0.04	0.00			.	.
e^{b}_{t-25}	-0.01	0.01	0.03	e^{ϕ}_{t-7}	-0.07	-0.04	0.00			.	.
e^{b}_{t-26}	-0.01	0.01	0.03	e^{ϕ}_{t-8}	-0.07	-0.04	0.00			.	.
e^{b}_{t-27}	-0.01	0.01	0.03	e^{ϕ}_{t-9}	-0.06	-0.02	0.01			.	.
e^{b}_{t-28}	-0.01	0.01	0.03	e^{ϕ}_{t-10}	-0.05	-0.02	0.01				
e^{b}_{t-29}	-0.01	0.01	0.03	e^{ϕ}_{t-11}	-0.05	-0.01	0.02				
e^{b}_{t-30}	0.00	0.03	0.07	e^{ϕ}_{t-12}	-0.08	-0.01	0.06				

Median $\bar{R}^2 = 0.87$

Table F.4: Selected Percentiles from the Distribution of DMFCI Regression Coefficients—Italy.

Dependent variable: $\hat{y}_t$

Variable	Coefficient			Variable	Coefficient			Variable	Coefficient		
	5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl		5th pctl	50th pctl	95th pctl
$\hat{r}_{t-1}$	-3.33	-2.29	-1.31	e^{μ}_{t-5}	0.04	0.06	0.08	$e^{\mu^*}_{t-1}$	-0.01	0.06	0.12
$\hat{r}_{t-2}$	-1.06	-0.66	-0.29	e^{μ}_{t-6}	0.03	0.05	0.07	$e^{\mu^*}_{t-2}$	0.02	0.05	0.08
$\hat{r}_{t-3}$	-1.03	-0.61	-0.24	e^{μ}_{t-7}	0.02	0.05	0.07	$e^{\mu^*}_{t-3}$	0.02	0.04	0.07
$\hat{r}_{t-4}$	-0.79	-0.35	0.04	e^{μ}_{t-8}	0.02	0.04	0.06	$e^{\mu^*}_{t-4}$	0.00	0.06	0.12
$\hat{r}_{t-5}$	-0.88	-0.42	0.00	e^{μ}_{t-9}	0.01	0.03	0.05	$e^{\phi^*}_{t-1}$	-0.10	0.01	0.11
$\hat{r}_{t-6}$	-1.66	-0.83	0.11	e^{μ}_{t-10}	0.00	0.02	0.04	$e^{\phi^*}_{t-2}$	-0.06	-0.02	0.01
$capb_{t-1}$	-1.31	-0.97	-0.65	e^{μ}_{t-11}	0.00	0.02	0.03	$e^{\phi^*}_{t-3}$	-0.05	-0.02	0.01
$capb_{t-2}$	-0.31	-0.19	-0.08	e^{μ}_{t-12}	0.00	0.01	0.03	$e^{\phi^*}_{t-4}$	-0.05	-0.02	0.01
$capb_{t-3}$	-0.25	-0.13	-0.02	e^{μ}_{t-13}	-0.01	0.01	0.02	$e^{\phi^*}_{t-5}$	-0.12	-0.02	0.08
$capb_{t-4}$	-0.20	-0.08	0.05	e^{μ}_{t-14}	-0.01	0.00	0.02				
$capb_{t-5}$	-0.21	-0.09	0.02	e^{μ}_{t-15}	-0.01	0.00	0.02				
$capb_{t-6}$	-0.32	-0.16	0.03	e^{μ}_{t-16}	-0.04	0.01	0.05				
$capb_{t-7}$	-0.35	-0.07	0.26	e^{ϕ}_{t-1}	-0.19	-0.06	0.07				
e^{b}_{t-1}	0.07	0.14	0.22	e^{ϕ}_{t-2}	-0.10	-0.06	-0.02				
e^{b}_{t-2}	0.06	0.09	0.11	e^{ϕ}_{t-3}	-0.09	-0.05	-0.01				
e^{b}_{t-3}	0.04	0.07	0.10	e^{ϕ}_{t-4}	-0.09	-0.05	-0.01				
e^{b}_{t-4}	0.04	0.06	0.09	e^{ϕ}_{t-5}	-0.14	-0.04	0.06				
e^{b}_{t-5}	0.02	0.05	0.08	e^{ϕ}_{t-6}	-0.06	-0.03	0.00				
e^{b}_{t-6}	0.02	0.04	0.07	e^{ϕ}_{t-7}	-0.07	-0.04	-0.01				
e^{b}_{t-7}	0.01	0.04	0.07	e^{ϕ}_{t-8}	-0.06	-0.03	-0.01				
e^{b}_{t-8}	0.01	0.03	0.06	e^{ϕ}_{t-9}	-0.05	-0.02	0.00				
e^{b}_{t-9}	0.00	0.03	0.05	e^{ϕ}_{t-10}	-0.04	-0.02	0.01				
e^{b}_{t-10}	0.00	0.02	0.05	e^{ϕ}_{t-11}	-0.10	-0.02	0.06				
e^{b}_{t-11}	-0.01	0.02	0.04	$capb^*_{t-1}$	-1.32	-0.68	-0.08				
e^{b}_{t-12}	-0.01	0.01	0.04	$capb^*_{t-2}$	-0.29	-0.06	0.18				
e^{b}_{t-13}	-0.01	0.01	0.04	$capb^*_{t-3}$	-0.27	-0.03	0.21				
e^{b}_{t-14}	-0.01	0.01	0.03	$capb^*_{t-4}$	-0.42	-0.09	0.24				
e^{b}_{t-15}	-0.02	0.01	0.03	$capb^*_{t-5}$	-0.04	0.27	0.57				
e^{b}_{t-16}	-0.04	0.04	0.11	$capb^*_{t-6}$	-0.27	0.25	0.80				
e^{μ}_{t-1}	0.11	0.15	0.20	$e^{b^*}_{t-1}$	-0.09	0.04	0.18				
e^{μ}_{t-2}	0.07	0.09	0.11	$e^{b^*}_{t-2}$	0.00	0.05	0.09				
e^{μ}_{t-3}	0.06	0.08	0.10	$e^{b^*}_{t-3}$	-0.01	0.04	0.09				
e^{μ}_{t-4}	0.05	0.07	0.09	$e^{b^*}_{t-4}$	-0.08	0.06	0.19				

Median $\bar{R}^2 = 0.81$

G DMFCI – Additional Results

Figure G.1 shows the monetary component of the DMFCI in the euro area and the MCI by the European Commission. Our dynamic fiscal condition indices ($DMFCI^F$) can also reveal insights about how synchronized fiscal policies are across the EA by looking at the cross correlations. Table G.1 shows that there is a high correlation between France, Germany

Figure G.1: Dynamic Monetary Condition Index ($DMFCI^M$) in the Euro Area and the Monetary Condition Index (MCI) by the European Commission over the Sample 2007Q1-2018Q3.

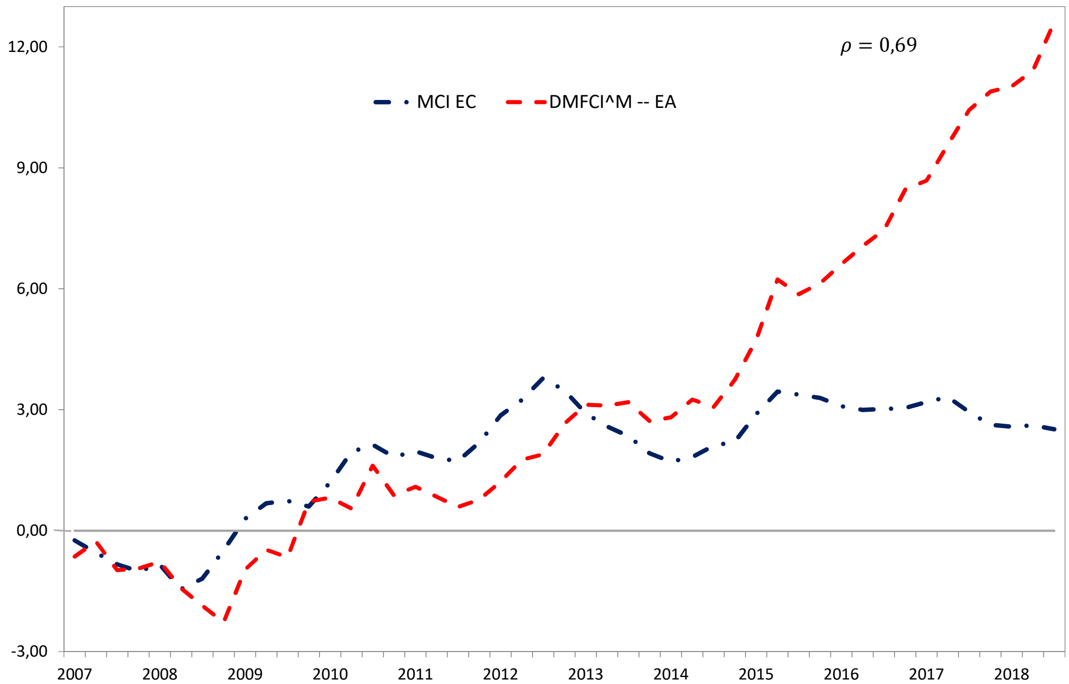


Table G.1: Correlations between Fiscal Indices $\left(DMFCI^F\right)$.

	EA	France	Germany	Italy
EA	1.00	–	–	–
France	0.78	1.00	–	–
Germany	0.72	0.40	1.00	–
Italy	0.57	0.42	0.32	1.00

and Italy and the rest of the EA. Conversely, the cross-correlations among the three largest economies are slightly weaker but still they display some degree of synchronization.

Figure G.2 shows that the main results on the comparison between DMFCI and historical decomposition of structural shocks are preserved under the alternative measure of output gap. In fact, we still observe that the monetary components of the DMFCIs exhibit a comovement with the historical contribution of monetary shocks to output. In contrast, the fiscal components of the DMFCIs exhibit almost no comovement with the historical

Figure G.2: Historical Contribution of Policy Shocks to GDP Growth (blue bars) Against the First Differences of the Yearly DMFCI (Red Lines) in the Case of an Alternative Definition of Output Gap (Potential Output is the Trend Level of Output).

Notes: The historical decomposition for fiscal-domestic is given by the sum of tax and government spending shocks. The historical decomposition for fiscal-rest of EA is given by the sum of tax and government spending shocks of the rest of the EA. The historical decomposition for "total" is given by the sum of all the policy shocks.

contribution of fiscal shocks to output.

We finally investigate the extent to which the alternative definitions of output gap affect

Table G.2: Correlation Between the Change in the DMFCI and its Components Computed with Two Alternative Definitions of Potential Output (*Efficient* Level of Output and *Trend* Level of Output).

Indices	Country	Correlation Coefficient
$DMFCI$	EA	0.92
	France	0.91
	Germany	0.95
	Italy	0.85
$DMFCI^M$	EA	0.98
	France	1.00
	Germany	1.00
	Italy	0.98
$DMFCI^F$	EA	0.87
	France	0.90
	Germany	0.94
	Italy	0.90
$DMFCI^{F*}$	France	0.81
	Germany	0.90
	Italy	0.83

the evolution of the total DMFCI and its components (monetary, fiscal domestic, and fiscal of the rest of the EA). Table G.2 reports the correlation between the yearly changes in the two DMFCIs computed using the *efficient* level output or *trend* level of output as a proxy for potential output. Correlations are generally highest for the monetary component and lowest for the fiscal component of the rest of the EA, though never below 0.81. Overall, the different measures of output gap provide a consistent information about the evolution of the policy stance in the EA and its three main economies.