Shocks and Frictions in Euro Area and Turkey Business Cycles: a Bayesian DSGE Approach

Cristina Farràs, Serkan Kocabaş, Cecilia Mariotti

Advisor: Albert Marcet

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Abstract

This paper estimates a New Keynesian DSGE model for the Euro Area and the Turkish economy using Bayesian estimation techniques and seven macroeconomic time series. The setting of the model features a number of nominal and real frictions and seven structural shocks are introduced. An analysis of the response of the two economies to these types of shocks is provided in a comparative fashion along with a study of the driving forces of the main macroeconomic dynamics through shock decomposition, with a focus on output and consumption.

JEL classification: E37,E40, E52, E53,E60, E63, E66

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1. Introduction

An accurate analysis of business cycles has become crucial in the decision making process of both policymakers and market players. In this paper we approach this type of analysis from a theoretical point of view, following the recent developments in the New Keynesian models, which involve the estimation of DSGE (Dynamic Stochastic General Equilibrium) models.

We provide a version of the DSGE model à la Smets and Wouters (2007) for the Euro-Area-19 and Turkey. The model includes a number of nominal and real rigidities, such as sticky prices, sticky wages that adjust following a Calvo mechanism and investment adjustment costs. The theoretical framework encompasses seven orthogonal disturbances for each structural equation: a productivity shock, an investment-specific technology shock, a risk premium shock, wage and price mark-up shocks (generally referred to as "cost-push" shocks), exogenous spending and monetary policy shocks. Using Bayesian techniques and data on seven macroeconomic variables, real GDP, hours worked, consumption, investment, real wages, prices and short-term nominal interest rate, the estimated model aims at describing the main features of the economies for policy analysis.

The purpose of this paper is twofold: on one side, we elaborate on the framework offered by the New Keynesian DSGE models, comparing its ability to capture data dynamics for two intrinsically different economies, Turkey, an emerging, small open economy, and the Euro-Area, an advanced economy. On the other side, we assess the relative importance of the different structural shocks as sources of business cycle movements in the two economies considered. In particular we focus on the identification of the main drivers of output and consumption dynamics.

The remainder of the paper is structured as follows. Section 2 provides a brief overview of the New Keynesian estimation tradition. Section 3 provides the details of the underlying model. Section 4 presents the steady state solution of the linearized model. In Section 5 the estimation procedure is discussed along with the description of the data used, the calibrated parameters and the prior distributions for the estimated parameters. Section 6 includes the analysis of the impulse responses of the various structural shocks and the variance decomposition of the observed variables, with a focus on output and consumption dynamics. Section 7 concludes.

2. Literature Review

The DSGE modelling (Dynamic Stochastic General Equilibrium Models) is a methodology that aims at explaining the aggregate macroeconomic phenomena, such as economic growth or the effects of fiscal and monetary policies on the basis of macroeconomic models grounded in microeconomic principles. Being micro founded, DSGE models are not vulnerable to the Lucas' critique. The framework for DSGE models was first introduced by Rotemberg and Woodford in 1997[1] and extended by other authors such as Goodfriend and King (1997)[2], Clarida, Galí and Gertler (1999)[3].

A new generation of small-scale monetary business cycle models with sticky prices and wages has recently become popular in monetary policy analysis in the context of New Keynesian models. In the seminal paper by Smets and Wouters (2003)[4] a DSGE model for the euro area is estimated using a Bayesian approach. The model features a number of frictions to capture the empirical persistence in macro indicators and exhibits both sticky nominal prices and wages that adjust following a Calvo mechanism. The importance of this paper resides not only in the model and in the methodology adopted, but also in the results that contribute to identify the sources of business cycle movements in the Euro Area. The main results we can extract from this paper are the fact that the appropriate estimate of potential output should only take into account the part of the natural level of output that is driven by shocks arising from preferences and technologies. Moreover productivity shocks only account for 10 percent of the long-run output variance, while preference shocks, labor supply shocks and monetary policy shocks are the most important source of variation in output, inflation and the interest rates.

Few years after this publication, Smets and Wouters published another paper[5] presenting a new version of the model for the US, based on Christiano, Eichenbaum and Evans (CEE, 2005)[6]. Also in this case Bayesian estimation methodology is used. This version of the model represents the benchmark for our analysis.

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[1] Rotemberg, J. J., & Woodford, M. (1997). An optimization-based econometric framework for the evaluation of monetary policy. *NBER macroeconomics annual*, *12*, 297-346.
[2] Goodfriend, M., & King, R. G. (1997). The new neoclassical synthesis and the role of monetary policy. *NBER macroeconomics annual*, 12, 231-283.
[3] Clarida, R., Gali, J., & Gertler, M. (1999). The science of monetary policy: a new Keynesian perspective (No. w7147). National bureau of economic research.
[4] Smets, Frank, and Raf Wouters (2003), An Estimated Stochastic Dynamic General Equilibrium Model of the Euro Area., Journal of the European Economic Association, 1(5), 1123.1175.
[5] Smets, F., & Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *The American Economic Review*, *97*(3), 586-606
[6] Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of political Economy*, *113*(1), 1-45.

The literature related to the estimation of New Keynesian DSGE models for the Turkish economic in particular and for emerging economies in general has recently taken momentum thanks to Cebi (2011)[7]. In the latter the same model is estimated along the lines of Smets and Wouters (2007). The findings of the paper show that the values of structural and policy parameters are consistent with the ones for most developed countries. It is also shown that the monetary authority reacts actively to inflation but weakly to the output gap. They also find significant fiscal policy feedbacks on debt for both spending and tax rules, which resulted in debt stabilisation but not in output gap stabilization. As it was found in the studies related to the Euro Area and the United States, past and expected future inflations are key factors in determining current inflation and backward looking behaviour remains predominant.

[7] Cebi, C. 2011. "The Interaction between Monetary and Fiscal Policies in Turkey: An Estimated New Keynesian DSGE Model." Working Paper No. 11/04, Central Bank of Turkey (January).

3. The Model

The reference model for our study is the DSGE model described in Smets and Wouters (2007). In this section we provide a summary of the model useful to define the sources of the shocks and their impact on the variables[8].

a. Firms

i. Final good producers

The final good Y_t is a composite made of a continuum of intermediate goods $Y_t(i)$. The final good is produced by a continuum of firms. They buy intermediate goods on the market, and package them, resulting in the final good Y_t sold to consumers, investors and the government in a perfectly competitive market. The maximization problem for the firms producing the final good is:

$$\max_{Y_t, Y_t(i)} P_t Y_t - \int_0^1 P_t(i) Y_t(i) di$$

$$s.t. \left[\int_0^1 G\left(\frac{Y_t(i)}{Y_t}; \lambda_{p,t}\right) di\right] = 1$$

where P_t and $P_t(i)$ arte the price of the final and intermediate goods respectively and G is a strictly concave and increasing function characterized by $G(1) = 1$, which implies that the demand for intermediate goods as inputs is decreasing in their relative price and the elasticity of demand is a negative function of the relative output.

ii. Intermediate good producers

Intermediate good producer i uses the following technology:

$$Y_t(i) = \varepsilon_t^a K_t^s(i)^\alpha [\gamma^t L_t(i)]^{1-\alpha} - \gamma^t \Phi$$

where $K_t^s(i)$ is capital services used in production, $L_t(i)$ is aggregate labor input and Φ is a fixed cost. γ^t represents the labor-augmenting deterministic growth rate in the economy and ε_t^a is total factor productivity and follows the process:

$$ln\varepsilon_t^a = (1 - \varrho_z) ln\varepsilon^a + \varrho_z ln\varepsilon_{t-1}^a + \eta_t^a, \qquad \eta_t^a \sim N(0, \sigma_a)$$

[8] For further details regarding the model and its assumptions we refer to the Model Appendix in Smets and Wouters (2007).

The firm's profit is given by:

$$P_t(i)Y_t(i) - W_tL_t(i) - R_t^kK_t(i)$$

where W_t is the aggregate nominal wage rate and R_t^k is the rental rate on capital.

b. Households

Household j chooses consumption $C_t(j)$, hours worked $L_t(j)$, bonds $B_t(j)$, investment $I_t(j)$ and capital utilization $Z_t(j)$ and maximizes the objective function:

$$\max_{C_t(j),L_t(j),I_t(j),B_t(j),Z_t(j),} E_t\sum_{s=0}^{\infty}\beta^s\left[\frac{1}{1-\sigma_c}(C_{t+s}(j)-\lambda C_{t+s-1})^{1-\sigma_c}\right]\exp(\frac{\sigma_c-1}{1+\sigma_l}L_{t+s}(j)^{1+\sigma_l})$$

Subject to the budget constraint:

$$C_{t+s}(j)+I_{t+s}(j)+\frac{B_{t+s}(j)}{\varepsilon_t^bR_{t+s}P_{t+s}}-T_{t+s}(j)$$
$$\leq\frac{B_{t+s-1}(j)}{P_{t+s}}+\frac{W_{t+s}^hL_{t+s}(j)}{P_{t+s}}+\frac{R_{t+s}^kZ_{t+s}(j)K_{t+s-1}(j)}{P_{t+s}}-a\big(Z_{t+s}(j)\big)K_{t+s-1}(j)+\frac{DIV_{t+s}}{P_{t+s}}$$

And the capital accumulation equation:

$$K_t(j)=(1-\delta)_{t-1}(j)+\varepsilon_t^i\left[1-S\left(\frac{I_t(j)}{I_{t-1}(j)}\right)\right]I_t(j)$$

The parameter λ captures external habit formation. The one-period bond is expressed on a discount basis. ε_t^b is an exogenous premium in bonds returns, which might reflect inefficiencies in the financial sector leading to some premium on the deposit rate versus the risk free rate set by the central bank, or a risk premium that households require to hold the one period bond. ε_t^b follows the stochastic process:

$$ln\varepsilon_t^b=\varrho_bln\varepsilon_{t-1}^b+\eta_t^b,\qquad\eta_t^b\sim N(0,\sigma_b)$$

δ is the depreciation rate, $S(\cdot)$ is the adjustment cost function and ε_t^i is stochastic shock to the price of investment relative to consumption goods and follows an exogenous process:

$$ln\varepsilon_t^i=\varrho_iln\varepsilon_{t-1}^i+\eta_t^i,\qquad\eta_t^i\sim N(0,\sigma_b)$$

T_{t+s} are lump-sum taxes or subsidies and DIV_{t+s} are the dividends distributed by labor unions.

Households also choose the utilization rate of capital. The amount of effective capital that households can rent to firms is:

$$K_t^s(j) = Z_t(j)K_{t-1}(j)$$

The income from renting capital services is $R_t^k Z_t(j)K_{t-1}(j)$, and the cost of changing capital utilization is $P_t a\big(Z_t(j)\big)K_{t-1}(j)$

c. Intermediate labor union sector

Households supply their homogenous labor to an intermediate labor union which allocate and differentiate the labor services from the households and have market power: they choose the wage subject to the labor demand equation. In other words, the unions set wages subject to a Calvo scheme. Moreover, there are labor packers who buy labor from the unions, package this labor Lt, and resell it to the intermediate goods producer.

Labor packers maximize profits in a perfectly competitive environment. The FOCs of the labor packers are:

$$L_t = \left[\int_0^1 L_t(l)^{\frac{1}{1+\lambda_{w,t}}} dl\right]^{1+\lambda_{w,t}}$$

We assume that $\lambda_{w,t}$ follows the exogenous ARMA process:

$$\ln\big(\lambda_{w,t}\big) = (1-\varrho_w)\ln(\lambda_w) + \varrho_w \ln\big(\lambda_{w,t-1}\big) - \theta_w \epsilon_{w,t-1} + \epsilon_{w,t}, \epsilon_{w,t} \sim \ldots$$

The household's budget constraint is modified by the presence of the unions in such a way to include the dividends distributed to the households. Dividends come from the fact that now unions can choose the wage according to the labor demand of the intermediate firms i.e. from the bargaining power of the unions.

Unions readjust wages with probability $(1-\zeta_w)$ in each period. For those that cannot adjust wages, $W_t(l)$ will increase as a function of the deterministic growth rate γ, the weighted average of the steady state inflation π_* and of last period's inflation (π_{t-1}). For those that can adjust, the problem is to choose a wage $\widetilde{W}_t(l)$ that maximizes the wage income in all states of nature where the union is stuck with that wage in the future:

$$\max_{\widetilde{W}_t(l)} E_t \sum_{s=0}^{\infty} \zeta_w^s \left[\frac{\beta^s E_{t+s} P_t}{E_t P_{t+s}}\right] \left[W_{t+s}(l) - W_{t+s}^h\right] L_{t+s}(l)$$

And $L_{t+s}(l) = L_{t+s}(\frac{W_{t+s}(l)}{W_{t+s}})^{-\frac{1+\lambda_{w,t+s}}{\lambda_{w,t+s}}}$

With $W_{t+s}(l) = \widetilde{W}_t(l)\left(\prod_{l=1}^{s} \gamma \pi_{t+l-1}^{\iota_w} \pi_*^{1-\iota_w}\right)$ $for\ s = 1,2,\ldots,\infty$

d. Government policies

The central bank follows a nominal interest rate rule by adjusting its instrument in response to deviations of inflation and output from their respective target levels:

$$\frac{R_t}{R^*} = \left(\frac{R_t}{R^*}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi^*}\right)^{\psi_1} \left(\frac{Y_t}{Y_t^*}\right)^{\psi_2}\right]^{1-\rho_R} \left(\frac{Y_t/Y_{t-1}}{Y_t^*/Y_{t-1}^*}\right)^{\psi_2} r_t$$

where R^* is the steady state nominal rate (gross rate) and Y_t^* is the natural output. The parameter ϱ_R determines the degree of interest rate smoothing. The monetary policy shock r_t is determined as

$$\ln(r_t) = \varrho_r \ln(r_{t-1}) + \epsilon_{r,t}$$

The central bank supplies the money demanded by the household to support the desired nominal interest rate.

The government budget constraint is of the form $P_t G_t + B_{t-1} = T_t + \frac{B_t}{R_t}$

where T_t are nominal lump-sum taxes (or subsidies) that also appear in household's budget constraint. Government spending expressed relative to the steady state output path $g_t = \frac{G_t}{Y\gamma^t}$ follows the process:

$$\ln(g_t) = \left(1 - \varrho_g\right)\ln(g) + \varrho_g \ln(g_{t-1}) + \varrho_{ga}\ln(Z_t) - \varrho_{ga}\ln(Z_{t-1}) + \epsilon_{g,t}, \epsilon_{g,t} \sim \ldots$$

The natural output level is defined as the output in the economy characterized by flexible prices and wages.

e. Resource constraints

To obtain the market clearing condition for the final goods market, we first need to integrate the HH budget constraint across households (with the changes introduced by unions), and combine it with the government budget constraint:

$$P_tC_t + P_tI_t + P_tG_t \leq \pi_t + \int W_t^h(j)L_t(j)dj + DIV_t + R_t^k \int K_t(j)dj - P_t a(u_t) \int \overline{K}_{t-1}(j)dj$$

f. Exogenous processes (shocks):

There are seven exogenous processes in the model:

Technology process:

- $\ln Z_t = (1-\varrho_z)lnZ + \varrho_z lnZ_{t-1} + \epsilon_{z,t}$

Investment relative price process:

- $\ln \mu_t = \left(1-\varrho_\mu\right)ln\mu + \varrho_\mu ln\mu_{t-1} + \epsilon_{\mu,t}$

Intertemporal preference shifter (financial risk premium process):

- $\ln b_t = (1-\varrho_b)lnb + \varrho_b lnb_{t-1} + \epsilon_{b,t}$

Government spending process:

- $\ln(g_t) = \left(1-\varrho_g\right)\ln(g) + \varrho_g \ln(g_{t-1}) + \varrho_{ga}\ln(Z_t) - \varrho_{ga}\ln(Z_{t-1}) + \epsilon_{g,t}, \epsilon_{g,t} \sim \ldots$

Monetary Policy Shock:

- $\ln(r_t) = \varrho_r \ln(r_{t-1}) + \epsilon_{r,t}$

Price Mark-up shock:

- $\ln\left(\lambda_{p,t}\right) = \left(1-\varrho_p\right)\ln\left(\lambda_p\right) + \varrho_p \ln\left(\lambda_{p,t-1}\right) - \theta_p\epsilon_{p,t-1} + \epsilon_{p,t}, \epsilon_{p,t} \sim \ldots$

Wage Mark-up shock:

- $\ln\left(\lambda_{w,t}\right) = (1-\varrho_w)\ln(\lambda_w) + \varrho_w \ln\left(\lambda_{w,t-1}\right) - \theta_w\epsilon_{w,t-1} + \epsilon_{w,t}, \epsilon_{w,t} \sim \ldots$

and where the innovations ϵ are distributed as i.i.d. Normal innovations $\epsilon_{i,t} \sim N(0, \sigma_i)$

4. Equilibrium and model solution

This is a log-linearized version of the DSGE model, where all variables are log-linearized around their steady state balanced growth path. Starred variables denote steady-state values.

a. Aggregate demand side of the model

Aggregate resources constraint: $y_t = c_y c_t + i_y i_t + z_y z_t + \varepsilon_t^g$. Where

- $c_y = 1 - g_y - i_y$
- $i_y = (\gamma - 1 + \delta)k_y$
- $z_y = R_*^k \cdot k_y$

where (y_t) is output that is a function of consumption (c_t), investment (i_t), capital-utilization cost (z_t) (which are a function of the capital utilization rate) and exogenous spending (ε_t^g). c_y is the steady state share of consumption in output where g_y is the steady state exogenous spending output ratio and i_y is the steady state exogenous investment ratio. The steady state exogenous investment ratio is a function of the steady state growth rate (γ), the depreciation rate (δ) and the steady state capital output ratio (k_y). Finally, R_*^k is the steady state rental rate of capital.

We assume that the exogenous spending follows an AR(1) with IID-normal error term and is affected by the productivity shock as follows: $\varepsilon_t^g = \varrho_g \varepsilon_{t-1}^g + \eta_t^g + \varrho_{ga}\eta_t^a$

The consumption Euler equation is given by: $c_t = c_1 c_{t-1} + (1 - c_1)E_t\{c_{t+1}\} + c_2(l_t - E_t\{l_{t+1}\}) - c_3(r_t - E_t\{\pi_{t+1}\} + \varepsilon_t^b)$; where:

$$c_1 = \frac{\lambda/\gamma}{1 + \lambda/\gamma}$$

$$c_2 = \frac{(\sigma_c - 1)\dfrac{W_*^h L_*}{C_*}}{\sigma_c \dfrac{1+\lambda}{\gamma}}$$

$$c_3 = \frac{1 - \lambda/\gamma}{(1 + \lambda/\gamma)\sigma_c}$$

where current consumption (c_t) depends on expected future $E_t\{c_{t+1}\}$ and a weighted average past consumption c_{t-1}, expected growth in hours worked $(l_t - E_t\{l_{t+1}\})$, the ex ante real interest rate

$(r_t - E_t\{\pi_{t+1}\})$ and disturbance term ε_t^b. Finally, σ_c is the risk aversion.

The disturbance terms is assumed to follow an AR(1) process with IID normal error term: $\varepsilon_t^b = \varrho_b \varepsilon_{t-1}^b + \eta_t^b$

The <u>investment Euler equations</u> is given by: $i_t = i_1 i_{t-1} + (1 - i_1)E_t\{i_{t+1}\} + i_2 q_t + \varepsilon_t^i)$; where

$$i_1 = \frac{1}{1 + \beta\gamma(1 - \sigma_c)}$$

$$i_2 = \frac{1}{(1 + \beta\gamma(1 - \sigma_c))\gamma^2\varphi}$$

where φ is the steady state elasticity of the capital adjustment cost function and $\beta$is the discount factor. Also, q_t is the real value of the existing capital stock.

The disturbance terms is assumed to follow an AR(1) process with IID normal error term: $\varepsilon_t^i = \varrho_i \varepsilon_{t-1}^i + \eta_t^i$

The arbitrage equation for the value of capital is:

$$q_t = q_1 E_t\{q_{t+1}\} + (1 - q_1)E_t\{r_{t+1}^k\} - (r_t -* E_t\{\pi_{t+1}\} + \varepsilon_t^b)$$

and

$$q_1 = \beta\gamma^{-\sigma_c}(1 - \delta) = [\frac{1 - \delta}{R_*^k + (1 - \delta)}]$$

where the current value of capital stock q_t is a function of expected future value $E_t\{q_{t+1}\}$, the expected real rental rate on capital $E_t\{r_{t+1}^k\}$ and the ex ante real interest rate $r_t - E_t\{\pi_{t+1}\}$.

b. Supply side

The aggregate production function is given by

$y_t = \phi_p[\alpha k_t^s + (1 - \alpha)l_t + \varepsilon_t^a]$

$k_t^s = k_{t-1} + z_t$

where α is the share of capital in production and ϕ_p is one plus the share of fixed costs in production which reflects the presence of fixed cost in the production.

TFP is assumed to follow an AR(1) such that $\varepsilon_t^a = \varrho_a \varepsilon_{t-1}^a + \eta_t^a$..

The current capital used in production (k_t^s) is a function of the capital previously installed (k_{t-1}) and the degree of capital utilization (z_t).

The degree of capital utilization is a positive function of the rental rate of capital $z_t = z_1 r_t^k$, , where $z_1 = \frac{1-\psi}{\psi}$ where ψ is a positive function of the elasticity of the capital utilization adjustment cost function.

The accumulation of installed capital is given by

$$k_t = k_1 k_{t-1} + (1-k_1) i_t + k_2 \varepsilon_t^i,$$

$$k_1 = \frac{1-\delta}{\gamma}$$

$$k_2 = (1 - \frac{1-\delta}{\gamma})(1+\beta\gamma^{1-\sigma_c})\gamma^2\varphi \, ..$$

Since we are in a monopolistic competitive goods market environment, cost minimization by firms implies that price markup (μ_t^p) is equal to the difference between the marginal product of labor (mpl_t) and the real wage(w_t): $\mu_t^p = mpl_t - w_t = \alpha(k_t^s - l_t) + \varepsilon_t^a - w_t$

Due to price stickiness and partial indexation to lagged inflation of those prices that can not be re-optimized period by period, prices adjust only sluggishly to their desired mark-up. Therefore the Phillips curve adopt the following form; $\pi_t = \pi_1 \pi_{t-1} + \pi_2 E_t \pi_{t+1} - \pi_3 \mu_t^p + \varepsilon_t^p$; where $\pi_1 = \frac{\iota_p}{1+\beta\gamma^{1-\sigma_c}\iota_p}$; $\pi_2 = \frac{\beta\gamma^{1-\sigma_c}}{1+\beta\gamma^{1-\sigma_c}\iota_p}$ and $\pi_3 = \frac{1}{1+\beta\gamma^{1-\sigma_c}\iota_p}\left[\frac{\left(1-\beta\gamma^{1-\sigma_c}\xi_p\right)\left(1-\xi_p\right)}{\xi_p\left(\left(\phi_p - 1\right)\varepsilon_p + 1\right)}\right]$

Inflation (π_t) depends on past (π_{t-1}), expected future inflation($E_t\pi_{t+1}$) and the current price mark-up(μ_t^p) and positively on a price mark-up disturbance ε_t^p. ι_p is the degree of indexation, ξ_p is the degree of price stickiness and ε_p is the curvature of the Kimball goods market aggregator.
The price mark-up disturbance is assumed to follow an ARMA(1,1) process $\varepsilon_t^p = \varrho_p \varepsilon_{t-1}^p + \eta_t^p - \mu_p \eta_{t-1}^p$

Cost minimization by firms will also imply that the rental rate of capital is negatively related to the capital-labor ratio and positively to the real wage $r_t^k = -(k_t - l_t) + w_t$.

Due to the monopolistically competitive labor market, the wage mark-up will be equal to the difference between the real wage and the marginal rate of substitution between working and consuming $\mu_t^w = w_t - mrs_t = w_t - (\sigma_t l_t + \frac{1}{1-\frac{\lambda}{\gamma}}\left(c_t - \frac{\lambda}{\gamma c_{t-1}}\right))$.

Due to nominal wage stickiness and partial indexation of wages to inflation, real wages adjust only gradually to the desired wage mark-up and will have the following form:

$$w_t = w_1 w_{t-1} + (1 - w_1)(E_t w_{t+1} + E_t \pi_{t+1}) - w_2 \pi_t + w_3 \pi_{t-1} - w_4 \mu_t^w + \varepsilon_t^w, \text{ with } w_1 = \frac{1}{1+\beta\gamma^{1-\sigma_c}},$$

$$w_2 = \frac{1+\beta\gamma^{1-\sigma_c}\iota_w}{1+\beta\gamma^{1-\sigma_c}}, w_3 = \frac{\iota_w}{1+\beta\gamma^{1-\sigma_c}} \text{ and } w_4 = \frac{1}{1+\beta\gamma^{1-\sigma_c}}\left[\frac{(1-\beta\gamma^{1-\sigma_c}\xi_w)(1-\xi_w)}{\xi_w\left((\phi_w-1)\varepsilon_w+1\right)}\right]$$

where the real wage (w_t) is a function of expected ($E_t w_{t+1}$) and past real wages (w_{t-1}), expected, current, and past inflation ($E_t \pi_{t+1}, \pi_t, \pi_{t-1}$), the wage mark-up (μ_t^w), and a wage markup disturbance ε_t^w. ξ_w is the degree of wage stickiness , ι_w is the wage indexation and $\varepsilon_w$is the the curvature of the Kimball labor market aggregator.

The wage mark-up disturbance is assumed to follow an ARMA (1,1) process with an IID normal error term $\varepsilon_t^w = \varrho_w \varepsilon_{t-1}^w + \eta_t^w - \mu_w \eta_{t-1}^w$

The empirical monetary policy reaction function is:

$$r_t = \varrho r_{t-1} + (1-\varrho)\{r_\pi \pi_t + r_Y(y_t - y_t^p)\} + r_{\Delta y}[(y_t - y_t^p) - (y_{t-1} - y_{t-1}^p)] + \varepsilon_t^r$$

where the parameter ϱ captures the degree of interest rate smoothing. Moreover, there is a short run feedback from the change in the output gap.

We assume that the monetary policy shocks follow a first order autoregressive process with an IID-normal error term $\varepsilon_t^r = \varrho_r \varepsilon_{t-1}^r + \eta_t^r$

Finally, the errors/stochastic shocks are:

- ε_t^a: total factor productivity
- ε_t^i: investment specific technology shock
- ε_t^b: risk premium shock
- ε_t^g: spending shock
- ε_t^p: price mark-up disturbance

- ε_t^r: monetary policy shock
- ε_t^w: wage mark-up disturbance

5. Estimation of the model

a. Data

We estimate the Smets and Wouters (2007) model for the Euro Area (19 member countries) and Turkey. The estimation of the model for the Euro Area is based on seven selected quarterly macroeconomic time series from 1970Q1 until 2015Q4 with base year 1995Q2 from the 16th update of the Area Wide Model (AWM) database (*Fargan et al. 2001*): output, household consumption, gross fixed capital formation (investment), employment, hours worked, real wage, GDP deflator and 3 months interbank rate from SDW[9], backdated with the corresponding series contained in the BIS[10] and AMECO[11] databases. The AWM is the standard reference database used to estimate DSGE models for the Euro Area (*Adjemian et al. 2007*). All variables are seasonally and calendar adjusted and linearly detrended (HP filtered) before estimation. Moreover the aggregate variables are expressed in per capita terms over the active population.

The same quarterly time series are used to estimate the models for Turkey. The database for Turkey covers the period from 2006Q1 to 2016Q4 with 2010 as base year. All the data are from the FRED database.

Data are treated analogously in the Euro Area and in the Turkish case in the following way:

- LNSindex: Labor force / labor force (2005Q3)
- consumption: LN (CONS/GDPdef) / LNSindex)*100
- investment: LN (GFCP/GDPdef) / LNSindex)*100
- output: LN (GDP / LNSindex) * 100
- hours: LN ((employ/100)/LNSindex) *100[12]
- inflation: LN (GDPdef/GDPdef(-1)) *100
- real wage: LN (Hourcomp/GDPdef) *100
- interest rate: EURIBOR / 4

[9] European Central Bank Statistical Warehouse
[10] Bank of International Settlement
[11] Annual macroeconomic database of the European Commission's Directorate General for Economic and Financial Affairs.
[12] In the original paper they used the following formula: hours: LN ((weekhours*employ/100)/LNSindex) *100

c. Variable description

- CONS: Consumption - Final consumption expenditure of households - Chain linked volumes (2005), million euro
- GDP : Gross domestic product - Gross domestic product at market prices - Chain linked volumes (2005), million euro
- GDPdef: GDP deflator - GDP Implicit Price Deflator in Spain, Index 2005Q3=100
- GFCP: Gross fixed capital formation - Chain linked volumes (2005), million euro
- employ : Employment - Thousand people
- Hourcomp: Index 2005Q3=100
- EURIBOR: 3 months Euribor
- Labor force : Labor force (active) - Thousand people

Notice that we lose two observations due to the data transformations we perform, in particular by applying the HP filter and expressing the variables in log-differences.

The issues encountered in terms of data homogeneity and data availability are addressed following a standard interpolation procedure (*Chow Lin, 1971*): this technique consists in running a linear regression with the available data and estimating the missing values of the variable of interest using as regressors the other variables for which a full set of observations is available.

d. Calibration and prior distributions

i. Methodology

The model is estimated using Bayesian techniques and Dynare, a matlab toolkit, is used to achieve linearization around the steady state. After setting the prior distributions, which are mainly borrowed from the literature on the DSGE model, we estimate the mode of the posterior distribution by maximizing the log posterior function and an approximate standard error based on the corresponding Hessian. Since the posterior distribution is difficult to characterize, we generate 2500 draws through the Metropolis-Hastings algorithm[13] to evaluate the marginal likelihood of the model. Bayesian techniques as in *Fernandez Villaverde, Rubio-Ramirez (2001)* allow us to incorporate in our analysis information coming from previous microeconometric and macroeconometric studies. This is a particularly valuable contribution especially when data availability is limited to small samples, as it is the case for Turkey.

[13] Enough to guarantee convergence of the Metropolis Hastings and to perform MCMC diagnostic tests.

ii. Parameters estimates

A number of parameters, that are either difficult to identify within the specific structure of this model or better estimated using micro data, are set in advance following the literature on the estimation of the DSGE model for the Euro Area (*Adjeman 2007, Smets and Wouters 2003*) and Turkey (*Yüksel 2013*). The starting values for the parameters are displayed in Table 1.

The calibration for the Euro Area and for Turkey presents some differences, which are interesting from an economic point of view since they allow to take into account characteristics that are specific to the economies considered, that is an advanced economy and a developing one. We first illustrate the calibration for Europe; we then highlight the difference in the model estimation for the Turkish case.

In the estimation of the model for the Euro Area, the discount factor β is set at 0.99, consistent with the ECB's definition of price stability entailing inflation to be below, but close to 2%, the quarterly depreciation rate δ at 0.025, the mark-up in the labour market at 1.5 and the steady state spending share over GDP is exogenously set at 0.18.

Table 1. Calibration of structural parameters

Parameter	Description	Calibrated value (Turkey)	Calibrated value (Euro area)
β	Discount factor	0,9928	0,99
α	Capital share	0,4	0,3
δ	Depreciation rate	0,035	0,025
g	Exogenous spending GDP-ratio	0,18	0,18
λ	Steady state mark-up rate for wages	1,5	1,5

The definition of the parameters for the Turkish case follows *Yüksel 2013*, imposing a discount factor β of 0.9928 to obtain an annual risk free rate approximately equal to 3% and to better match the higher inflation target of the Turkish Central Bank, which has been defined at 5% since 2012. The inflation target regime, which officially started in 2006, conveniently characterizes the whole period we are considering in our analysis so that we avoid the risk of obtaining estimates biased by regime switching. The quarterly depreciation rate δ is set at 0.035 and the capital share is at 0.4, implying a lower steady state share of labour income in total output with respect to the European case.

iii. Prior distributions of the structural parameters

In setting the prior distribution of the model parameters common practices are followed: a beta distribution is assumed for all parameters whose values are in between 0 and 1, a gamma distribution is set for the positive ones, while the unbounded parameters are assumed to be normally distributed. The choice of more or less strong priors is key in Bayesian estimation: in general, fairly loose priors work well in the context of the DSGE model since data tend to be very informative, making it desirable to allow them to have a considerable weight. In our case, beta priors are quite strong priors, while inverse gamma are looser priors. Moreover, we prefer to assume beta priors instead of Uniform ones for all AR coefficients since they are particularly suited for model estimation and guarantee that the estimates are off the boundaries, but still responding quite strongly to what the data demand. The predefined priors for the model structural parameters are summarized in Table 2.

The prior mean of the first order autoregressive coefficient of all the shocks is set at 0.8 in the Turkish case and at 0.85 for the Euro Area, with a standard deviation of 0.1[14] in both cases. The standard errors of all the innovations follow an inverse Gamma distribution with a mean of 0.1 in Europe and 0.3 in Turkey with 2 degrees of freedom, enough to allow the data determine the size of the shocks as freely as possible, obtaining a positive and fairly large variance.

As far as the parameters of the utility functions are concerned, the habit parameter is centered around 0.7 with a standard error of 0.1. The elasticity of labor supply is assumed to fluctuate around 2 with a standard error of 0.75 in the European case, while for Turkey we impose it to be centered around 1, signifying a relatively more inelastic labor supply.

The prior on the investment adjustment cost is a Normal centered around 4 in Europe and 5 in Turkey, while the capacity utilization adjustment cost is centered around 0.2 and 0.05 for Europe and Turkey respectively.

The parameters entering the Taylor rule follow the standard modelling of monetary policy: a Normal distribution with mean 1.5 and 0.125 and standard errors 0.25 and 0.05 describes the long-

[14]The choice of such a strict standard error follows the lines of Smets and Wouters 2003 and allows to distinguish between persistent and non-persistent shocks.

run reaction on inflation and the output gap (in levels) respectively. In the case of output, the calibration suggests a gradual long-run adjustment. It is important to underline that the time span considered for the Euro Area is not characterized by a homogenous monetary policy: before the Treaty of Maastricht in 1992, in fact, single member countries had maintained their monetary policy independence. In view of this asymmetry any conclusion about the drivers and the importance of monetary policy within this model must be taken with care. Future research will be able to include an estimation of the model for the period after the introduction of the euro.

Finally, we briefly describe the distributions assumed for the parameters employed for price and wage setting. In particular, the Calvo probabilities are assumed to be around 0.75 for both prices and wages, which signifies an average duration of price and wage contracts of about four quarters. When calibrating the model for the US, the Calvo probabilities are commonly centered around 0.5, but we believe that a higher value is better able to represent the lower flexibility of the European job market, and more specifically of the Southern European one. The degree of indexation to past inflation is centered around 0.5.

Table 2. Prior Distribution of structural parameters

			Turkey		Euro Area	
Parameter - Description		Type	Mean	St. error	Mean	St. error
Shock persistence						
ϱ_a	Persistence of productivity shock	Beta	0,8	0,1	0,85	0,1
ϱ_b	Persistence risk premium shock	Beta	0,8	0,1	0,85	0,1
ϱ_g	Persistence spending shock	Beta	0,8	0,1	0,85	0,1
ϱ_i	Persistence investment specific shock	Beta	0,8	0,1	0,85	0,1
ϱ_r	Persistence monetary policy shock	Beta	0,8	0,1	0,85	0,1
ϱ_p	Persistence price markup shock	Beta	0,8	0,1	0,85	0,1
ϱ_w	Persistence wage markup shock	Beta	0,8	0,1	0,85	0,1
Shock volatility						
σ_a	Productivity shock	Inv. Gamma	0,3	2*	0,4	2*
σ_b	Risk premium shock	Inv. Gamma	0,3	2*	0,1	2*
σ_g	Spending shock	Inv. Gamma	0,3	2*	0,3	2*
σ_i	Investment specific technology shock	Inv. Gamma	0,3	2*	0,1	2*

σ_r	Monetary policy shock	Inv. Gamma	0,3	2*	0,1	2*
σ_p	Price markup shock	Inv. Gamma	0,3	2*	0,15	2*
σ_w	Wage markup shock	Inv. Gamma	0,3	2*	0,25	2*
Other parameters						
φ	Investment adjustment cost	Normal	5	1	4	1,5
ψ	Capacity utilization adjustment cost	Normal	0,05	0,5	0,2	0,075
Φ	Fixed Cost	Normal	1,25	0,125	1,45	0,25
h	Consumption habit	Beta	0,7	0,1	0,7	0,1
ξ_w	Calvo parameter wages	Beta	0,75	0,1	0,75	0,05
ξ_p	Calvo parameter prices	Beta	0,75	0,1	0,75	0,05
ι_w	Indexation to past wages	Beta	0,5	0,1	0,75	0,15
ι_p	Indexation to past prices	Beta	0,5	0,1	0,75	0,15
ϱ	Interest rate persistence	Beta	0,75	0,1	0,8	0,1
r_y	Taylor output level feedback	Normal	0,125	0,05	0,125	0,05
$r_{\Delta y}$	Taylor output growth feedback	Normal	0,05	0,05	0,0625	0,05
r_π	Taylor inflation feedback	Normal	1,4	0,25	1,5	0,25
				*degrees of freedom		

iv. <u>Posterior distributions of the structural parameters</u>

Table 3 summarizes the estimation results by reporting the mode and the standard deviation of our estimates obtained by maximizing the log of the posterior distribution, together with the mean, the 10 and 90 percentiles of the posterior distribution from the Metropolis Hastings algorithm, while the graphs in Annex 1 provide a visual representation of the prior and posterior distributions allowing for an immediate understanding of how informative the data are about the parameters of interest. We think it is worth providing some details about the economic intuition behind the estimation obtained in each of the case considered in order to better understand the characteristics of the individual countries and assess the ability of the model to explain different economies.

In the Turkish case, the persistence parameters of the exogenous shocks take value between 0.49 and 0.98, with the wage mark-up shocks being the most persistent, followed by the productivity shock. Also the persistence for the AR(1) processes defining the dynamic of the price mark up shock and of the government spending shock is significantly different from zero. Therefore the data prove to be really informative about the exogenous disturbances, imposing their weight even in the case of relatively strong priors like the assumed beta. The standard errors of all the shocks results significantly different to zero.

The wages Calvo probability is around 0.8, higher than the Calvo for good prices. This result is consistent with the economic intuition and it suggests a fairly high degree of wage stickiness. It is worth noticing that although in both cases we set a quite tight prior, the data strongly demanded higher stickiness. The parameter of the indexation to past prices is around 0.37, signaling that the inflation component of the Phillips curve is significantly backward looking.

As long as the estimation of the parameters of the Taylor rule is concerned, the responsiveness of inflation to deviations from target is around 1.7, close to the value obtained by Taylor (1993) and in line with our expectations, since, as already pointed out, the time span considered in our analysis coincides with a period of strong inflation targeting on the part of the Turkish Central Bank. Along the same line of reasoning, it is sensible to observe a lower degree of reaction to output deviations and to the interest rate (as already reported in Alp and Elekdağ (2011)). It is worth noticing, however, that the Turkish Central Bank is reported to have reacted exceptionally strongly during the crisis, so this estimate could prove to be not entirely reliable. To briefly comment the estimates of the remaining parameters in the model, we can notice how the external consumption habit parameter is rather high, turning out to be 70% of past consumption, while the adjustment costs to investment and capacity utilization are respectively higher and lower with respect to the results obtained in Yüksel (2013).

A general overview of Graphs A.2 in Annex 1, it is evident that the data are very much informative about almost all the estimates. To have a closer look at the estimates for the parameters in the Euro Area case, we can start from the nominal side, in particular from the Calvo probabilities, which are somewhat smaller than in Smets and Wouters 2003. Moreover as in the Turkish case and in contrast to Smets and Wouters 2003 that defined a different process driving marginal costs, we register a higher degree of wage rather than price stickiness. As far as the indexation is concerned, the one for wage is significantly higher than the one for prices. The estimates of the parameters of the utility function show that the data demand an even higher habit persistence than the one suggested by the prior, which is a reasonable phenomenon in the Euro Area and in line with the estimates in CEE(2001).

Considering now the estimates of the coefficients of the autoregressive processes for the exogenous shocks, all the shock except the investment and risk premium are very persistent. This result is generally consistent with the usual shock analysis for Europe in the DSGE context, although it has been argued in some literature that this is a signal of the model not being able to generate enough persistence endogenously (*Burriel et al. 2009*). Except for the price markup shock which seems to be less important, the standard errors of the shocks are estimated to be significantly different from zero.

Table 3. Posterior distributions of the structural parameters

		Estimated maximum posterior				Posterior distribution MH					
		Turkey		Euro Area		Turkey			Euro Area		
Parametar-Description		Mode	St. error	Mode	St. error	Mean	10%	90%	Mean	10%	90%
Shock persistence											
ϱ_a	Persistence of productivity shock	0,9681	0,0148	0,9624	0,0158	0,9714	0,9511	0,9851	0,9615	0,944	0,9776
ϱ_b	Persistence risk premium shock	0,3814	0,2976	0,3074	0,0925	0,6581	0,5203	0,8482	0,2997	0,2103	0,3943
ϱ_g	Persistence spending shock	0,5827	0,1476	0,9879	0,0052	0,7667	0,6624	0,8921	0,9872	0,9812	0,9926
ϱ_i	Persistence investment specific shock	0,5109	0,2551	0,2372	0,0948	0,8497	0,7503	0,9412	0,2582	0,1624	0,3386
ϱ_r	Persistence monetary policy shock	0,3511	0,1217	0,8915	0,0283	0,4887	0,363	0,5758	0,8956	0,8731	0,9224
ϱ_p	Persistence price markup shock	0,7765	0,1246	0,9968	0,0018	0,6166	0,516	0,6974	0,9974	0,9956	0,9991
ϱ_w	Persistence wage markup shock	0,9584	0,0211	0,7518	0,0848	0,9407	0,9214	0,9647	0,7119	0,6209	0,7892
Shock volatility											
σ_a	Productivity shock	3	0,3942	0,2793	0,0231	2,8319	2,6534	2,9941	0,2836	0,2594	0,31
σ_b	Risk premium shock	1,0216	0,3552	0,1507	0,019	0,9042	0,5342	1,3151	0,1528	0,1268	0,173
σ_g	Spending shock	1,6012	0,1964	0,2699	0,0184	1,5674	1,3531	1,9361	0,2611	0,2408	0,282
σ_i	Investment specific technology shock	1,1351	0,3664	0,4871	0,0555	0,7733	0,595	0,9629	0,4788	0,425	0,5376
σ_r	Monetary policy shock	0,4396	0,0664	0,0132	0,0014	0,458	0,4022	0,5636	0,0135	0,0119	0,0149
σ_p	Price markup shock	1,2768	0,3058	0,0277	0,0059	1,509	1,3102	1,7587	0,0285	0,0236	0,0327
σ_w	Wage markup shock	0,0754	0,0285	0,156	0,0159	0,0941	0,0638	0,1196	0,1609	0,1459	0,1777
Other parameters											
φ	Investment adjustment cost	6,8547	1,063	8,0211	1,2899	6,1202	4,35	7,2394	8,2785	6,6642	9,9104
ψ	Capacity utilization adjustment cost	0,635	0,1376	0,462	0,1064	0,5189	0,3794	0,6354	0,5883	0,4948	0,6786
Φ	Fixed Cost	1,5191	0,1089	2,045	0,1	1,5509	1,3653	1,6771	1,9875	1,9305	2,0449

h	Consumption habit	0,7327	0,0691	0,8754	0,0219	0,7337	0,697	0,7852	0,8779	0,8535	0,8997
ξ_w	Calvo parameter wages	0,8148	0,0407	0,6705	0,0366	0,9053	0,8355	0,9485	0,6614	0,576	0,7182
ξ_p	Calvo parameter prices	0,5963	0,1016	0,5295	0,0504	0,8871	0,8198	0,9499	0,5462	0,5001	0,5817
ι_w	Indexation to past wages	0,1335	0,0436	0,694	0,1062	0,1903	0,1488	0,2301	0,7033	0,5616	0,8663
ι_p	Indexation to past prices	0,3695	0,1677	0,0821	0,0357	0,4127	0,2757	0,5091	0,0983	0,0598	0,1247
ϱ	Interest rate persistence	0,8679	0,026	0,975	0,0056	0,8567	0,7963	0,8919	0,9725	0,9695	0,975
r_y	Taylor output level feedback	0,0599	0,0356	0,1206	0,0456	0,059	0,022	0,0797	0,1326	0,0899	0,1942
$r_{\Delta y}$	Taylor output growth feedback	0,1106	0,0415	0,001	0,0023	0,1005	0,0553	0,1538	0,0021	0,001	0,0035
r_π	Taylor inflation feedback	1,7336	0,2074	1,5692	0,1955	1,465	1,0668	1,7242	1,5133	1,3352	1,6665

6. Applications

In this section we use the estimated DSGE model to study some relevant macroeconomics dynamics, by analyzing the impulse response functions to the shocks we introduced in our setting and identifying the driving forces of the macroeconomic variables through shock decomposition. This exercise is particularly useful to getting insights on the evolution of the analyzed economies in the past years. We will proceed in a comparative fashion, pointing out the differences and similarities in the responses of the variables for each country included in our estimation and providing some economic intuition.

6.1 Impulse Response Analysis

The following figures show the impulse response functions (IRFs) to the structural shocks of the model measured in unit changes in standard deviation: each figure shows the response of each macroeconomic series for each of the countries considered to one specific shock.

In all figures the order of variables from top to bottom is output, consumption, investment, employment, inflation, real wages and short-term interest rate. The left column shows the results for Turkey, the right one for the Euro Area.

Figure 1 - Impulse response function to a total factor productivity shock - Turkey vs Euro Area.

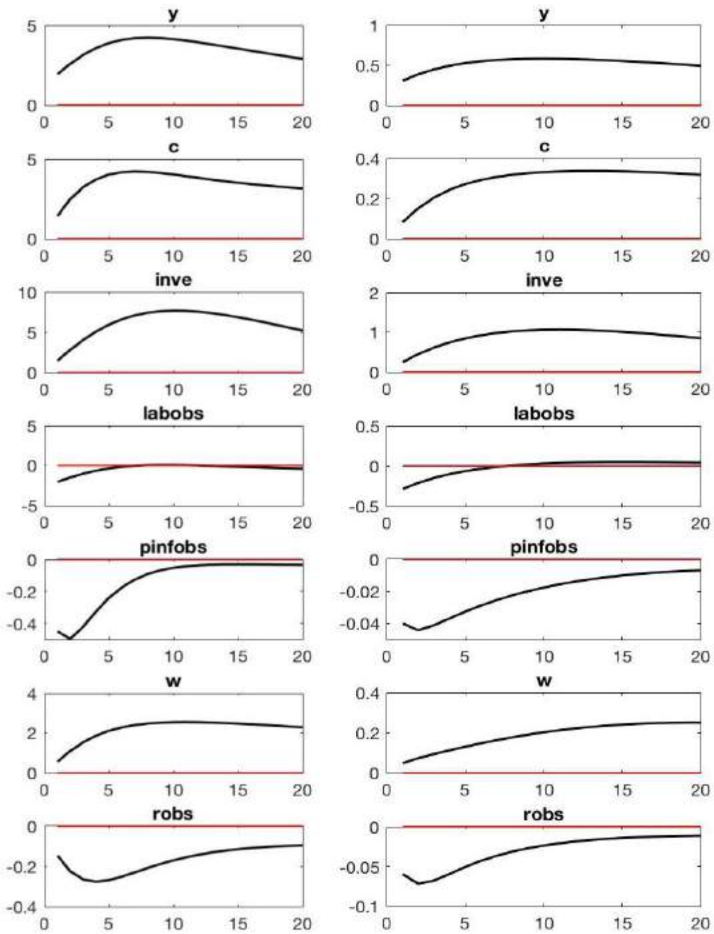


Figure 1 reports the IRFs to a positive productivity shock in Turkey and in the Euro Area. We can observe that the response of output, consumption, and investment is gradually positive and persistent in both cases, but the Turkish economy responds much more strongly than the Euro Area. We remind here that the time span over which the model is estimated in the two cases is different and in the case of Turkey it coincides with the global crisis period (and a short pre and post period interval). Notice also that, since Turkey has more the characteristics of a developing economy, not surprisingly it turns out to be characterized by higher instability and a strong reaction to changes that hit it. In general, the prediction of a response to a productivity is confirmed: the natural level of output increases while the natural level of interest rate decreases, leading to a fall in the actual interest rate both in real and nominal terms, stimulating the economy.

Employment, instead, decreases; the intuition behind this can be explained by referring to the environment of our economy characterized by sticky prices and wages, which implies short run rigidities in labor demand (Galì, 1999). The bottom line is that, as a consequence of a positive productivity shock, less workers are needed to produce the same amount of output as before. Due to higher productivity, marginal cost decreases pushing inflation and nominal interest rates down: in fact the response of the monetary authority is not strong enough to offset the fall in marginal cost. Notice that the effect on inflation is quite prolonged both in the Euro Area and Turkey (after 20 periods, inflation has approached but not yet recovered its steady state value), but it is quantitatively more significant in Turkey. Finally, as in Smets and Wouters (2003), real wages increase slowly and by a relatively tiny amount in the Euro Area case, while in Turkey we see a more considerable increase.

Figure 2. Impulse response function to an investment technology shock - Turkey vs Euro Area

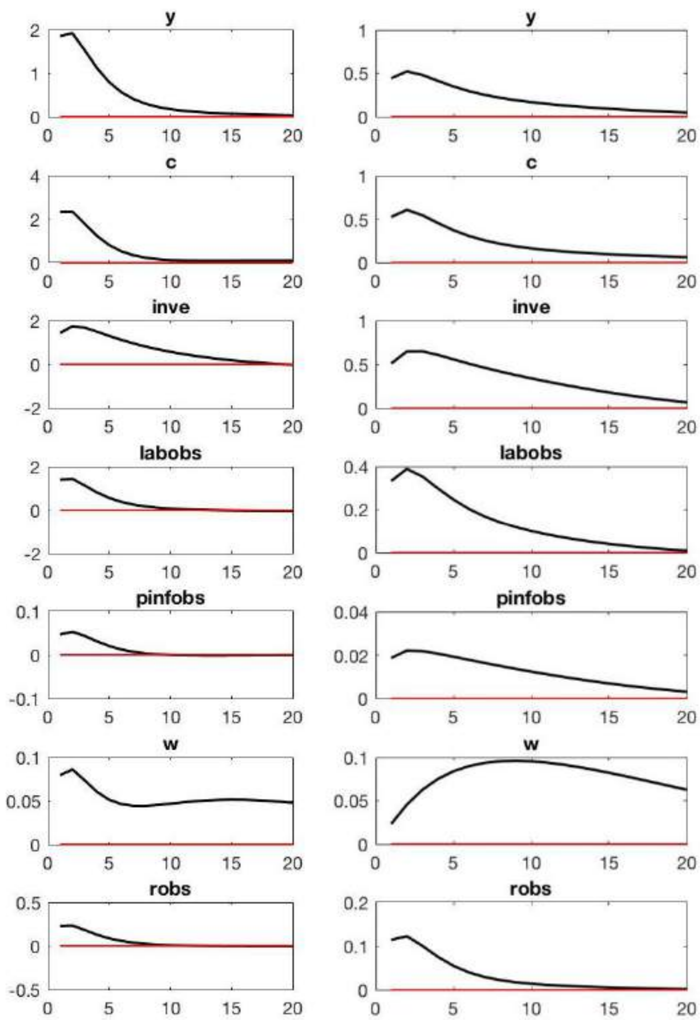
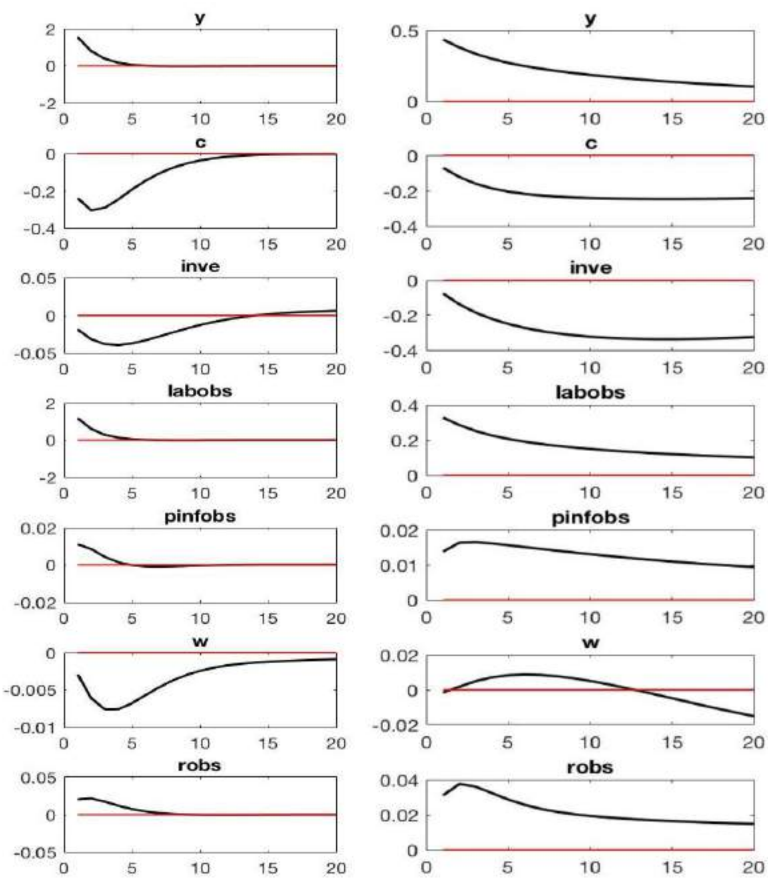


Figure 2 plots the IRFs for an investment-specific technology shock. In the Turkish case, output increases a lot, a result consistent on a vast literature that identify permanent technology shocks as key drivers of macroeconomic dynamics in developing countries (*Aguiar and Gopinath, 2007, Medina and Soto, 2007 and Alp and Elekdağ, 2011*), but it gradually converges back to its steady state value. Also real wages and investment go up rapidly, but since the productivity of the economy does not improve in the short run, the increase in investment occurs at the expense of a decrease in consumption. In the Euro Area, instead, the aggregate level of consumption slowly increases, which means that the overall increase in investment is not achieved at the expense of consumption, but by employing more labour. We also observe an immediate positive response of the interest rate and a decrease some periods after the shock.

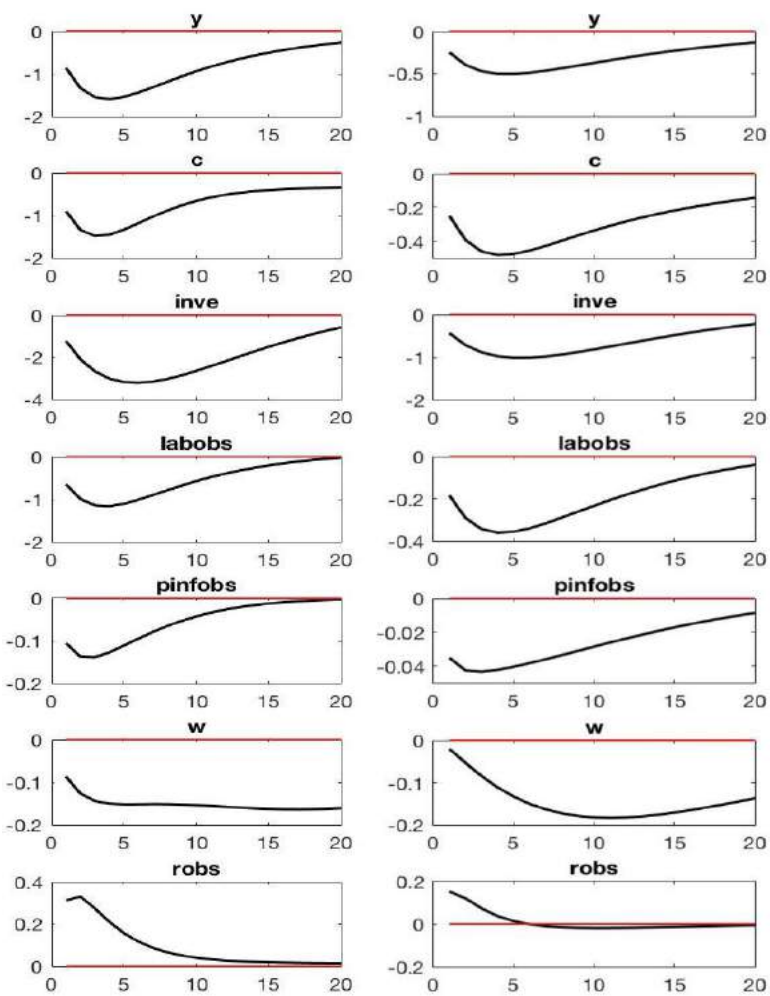
Figure 3. Impulse response functions to spending shock - Turkey vs Euro Area.



Figures 3 shows the responses of the economies to two policy shocks: a positive government spending and an expansionary monetary policy shock. When hit by an increase in public spending, consumption and investment decrease, but in the Euro Area case they stabilize at a lower value with respect to the steady state one, while in the Turkish economy they recover after around 10 periods. Evidences of this crowding-out effect, particularly strong in the Euro Area, are already present in Smets and Wouters (2003) and in some studies by Blanchard and Perotti (2002). Moreover higher public expenditure stimulates output more persistently in the Euro Area than in Turkey, as supported by the estimated coefficients for the relative AR(1) process in Table 2.

In both cases, an expansionary monetary policy translates into higher nominal and real interest rates and a hump-shaped fall in output, consumption, investment and inflation (*Peersman 2001*), with the effect being quantitatively more significant in Turkey. Investment is deteriorating more than consumption. Overall the model suggests that an expansionary monetary policy is more effective in controlling inflation rather than in stabilizing output.

Figure 4. Impulse response functions to monetary policy shock - Turkey vs Euro Area.



We now analyze the impact of a positive shock in cost-push shocks. The effects of a persistent change in the inflation objective are strikingly different in two respects. First, there is no liquidity effect, as nominal interest rates start increasing immediately as a result of the increased inflation expectations. This is in line with the arguments made in Gali (2000) that the presence (or lack thereof) of a liquidity effect following a monetary policy shock will depend on the persistence of the monetary policy shock. Second, because the change in policy is implemented gradually and expectations have time to adjust, the output effects of the change in inflation are much smaller. As displayed in Figure 4, inflation raises, and nominal interest rate is increased in the attempt of stabilizing inflation. A positive change in the wage mark-up gradually reduces output and employment by around 0.6 and 0.4 respectively in the Euro Area and by significantly more in Turkey (around 3 and 2).

Figure 5. Impulse response functions to price markup shock Turkey vs Euro-area.

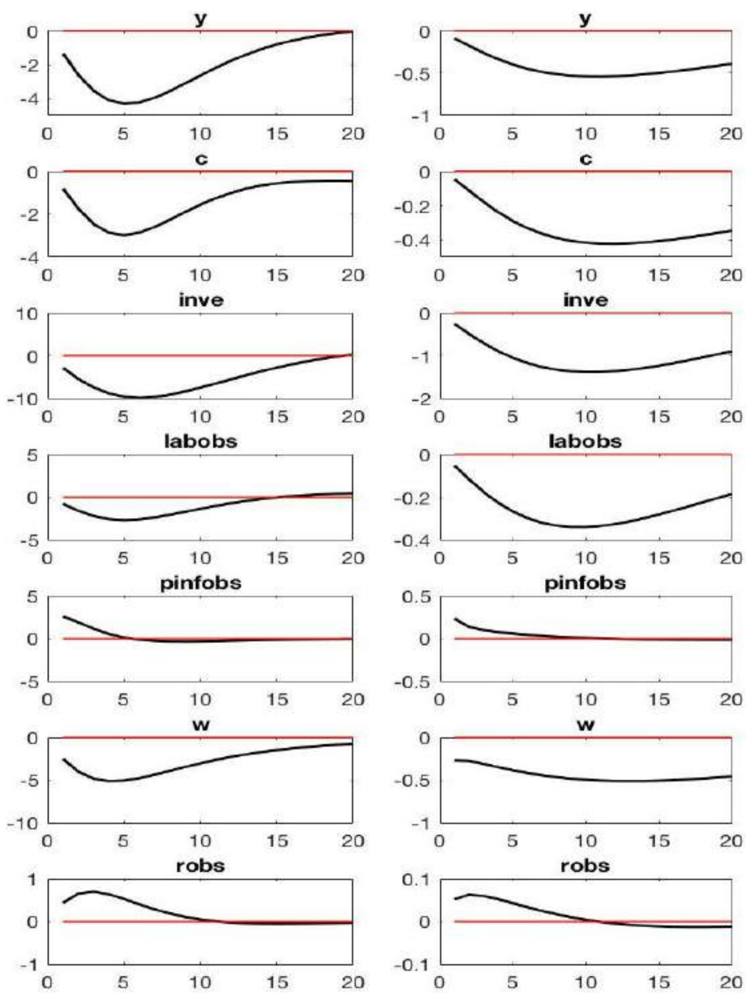


Figure 6. Impulse response functions to risk premium shock Turkey vs Euro-area.

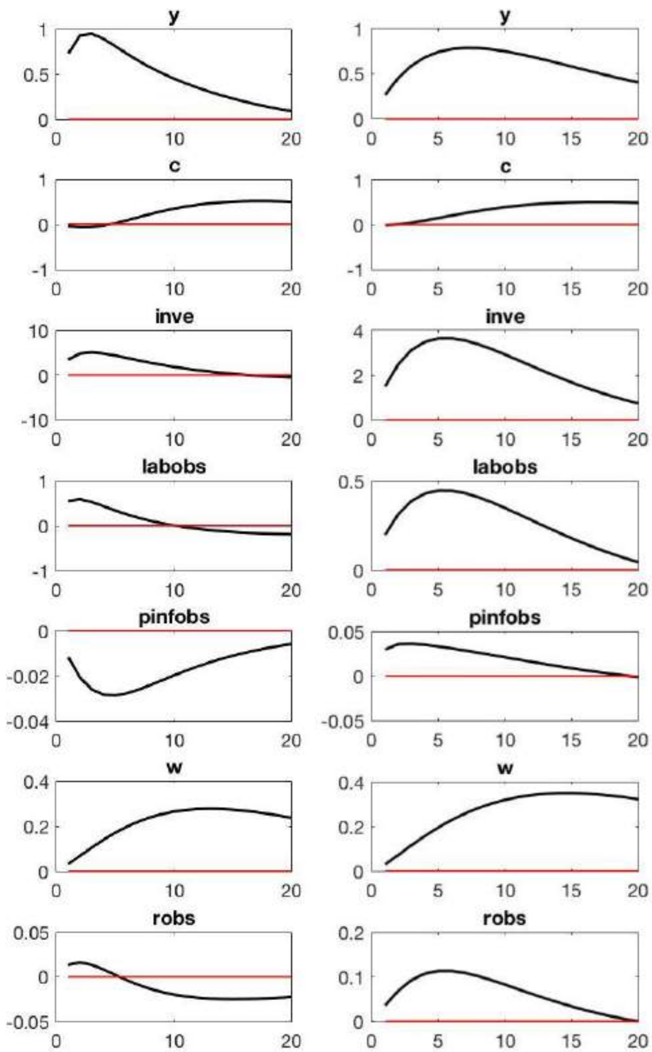
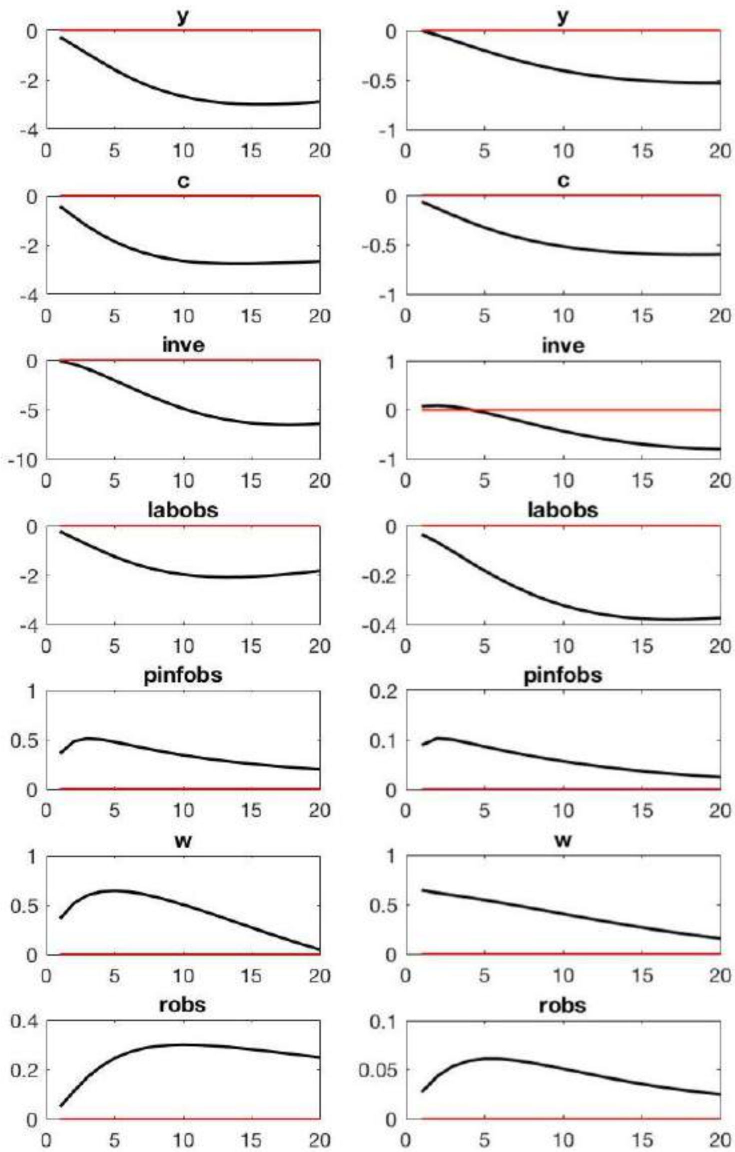


Figure 7. Impulse response functions to wage markup shock Turkey vs Euro-area respectively



6.2 Shock Decomposition

In this section we analyze the contribution of each shock to the macroeconomic variables of interest to understand which are their main determinants and driving forces.

First we look at the dynamics for output and consumption growth (Figure 8 and 9).

Figure 8. Fluctuations in output growth in Turkey

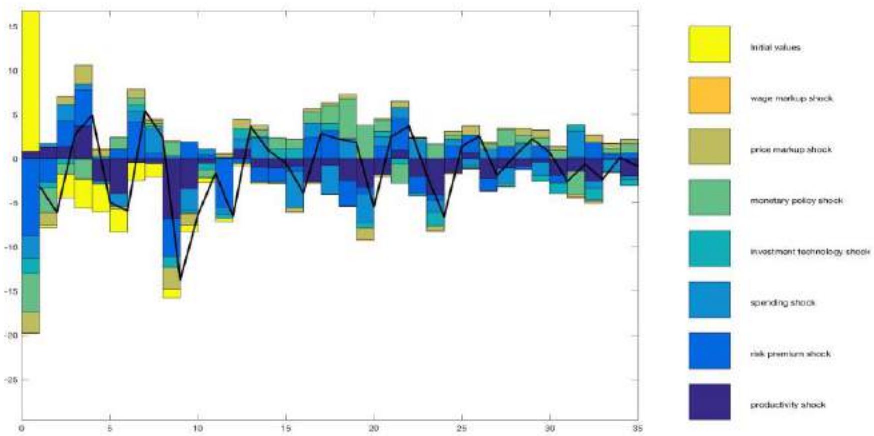
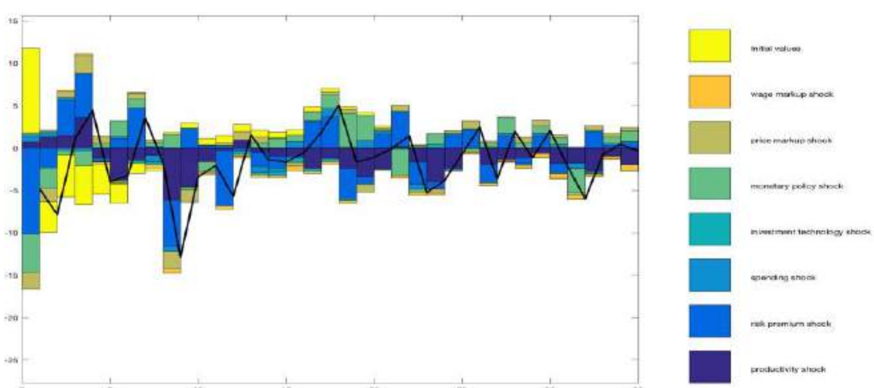


Figure 9. Fluctuations in consumption growth in Turkey



Two main results appear evident: first, the risk premium shock and the productivity shock is determining the great percentage of output and consumption growth fluctuations in the Turkish economy along the whole time span considered. Previous studies (*Alp et al 2012*) showed a strong positive correlation between output and consumption over the business cycle and the risk premium and productivity shocks generate consistent co-movements in Turkey. Second, the exogenous monetary policy shock has a relevant effect on GDP and consumption growth fluctuations in the medium run. The impulse response functions to a monetary policy shock show that a monetary policy shock starts affecting the economy in the short run, it is still influential in the medium run and finally goes back to its initial level in the long-run. Moreover, the productivity shock has a persistent effect on the fluctuations of GDP and consumption growth: in fact, the impulse response functions of this shock suggests a permanent effect on the economy. On the other hand, wage and price markup shocks have limited role in determining output and consumption growth fluctuations in the economy.

Premium shocks also have a leading role in explaining the consumption path and in particular the quite high consumption volatility relative to GDP that characterizes Turkey (*Alp et al. 2012)*. These findings are in line with Augiar and Gopiath (2007) who observed that emerging markets are characterized by volatile trend growth rates and shocks to the trend growth constitute the primary source of fluctuations in emerging markets. Finally, considering the specific time span of our analysis, it is important to mention that the business cycle properties of some key variables change pre- and post- 2001 (*Alp et al. 2012*) due to changes in monetary policy and some set of structural reforms that have a huge impact on the Turkish economy.

Figure 10. Fluctuations in the interest rate in Turkey

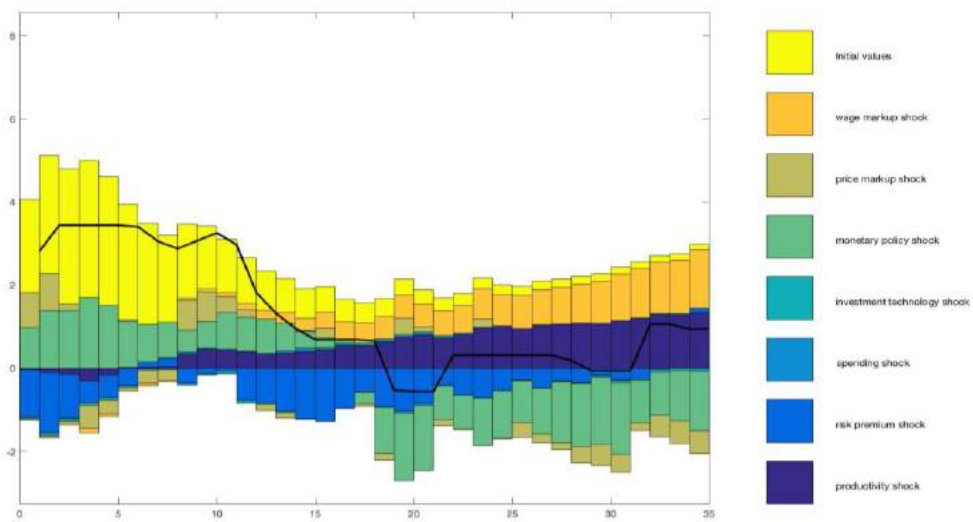


Figure 10 shows that the contribution of each structural shock to the variability in the 3-months interbank interest rate in Turkey: we can distinguish on one side the effects of demand shocks (risk premium, spending and monetary policy shocks) and of supply (productivity, wage and price markup shocks). Demand shocks account for most of the variance in the interest rate fluctuations, while supply shocks account for a larger proportion of the fluctuation in the interest rate in Turkish business cycle. The graph shows that most of the variation in the interest rate is driven by the monetary policy shock and very little variation is driven by the price markup shock. The monetary policy shock also significantly contributes to the interest rate variability after 2001, when Turkish authorities have been successful in counteracting the inflationary implications of such shocks. As for the supply side, the productivity and wage markup shocks play the biggest role in explaining interest rate fluctuations.

Figure 11. Fluctuations in output growth in the Euro Area

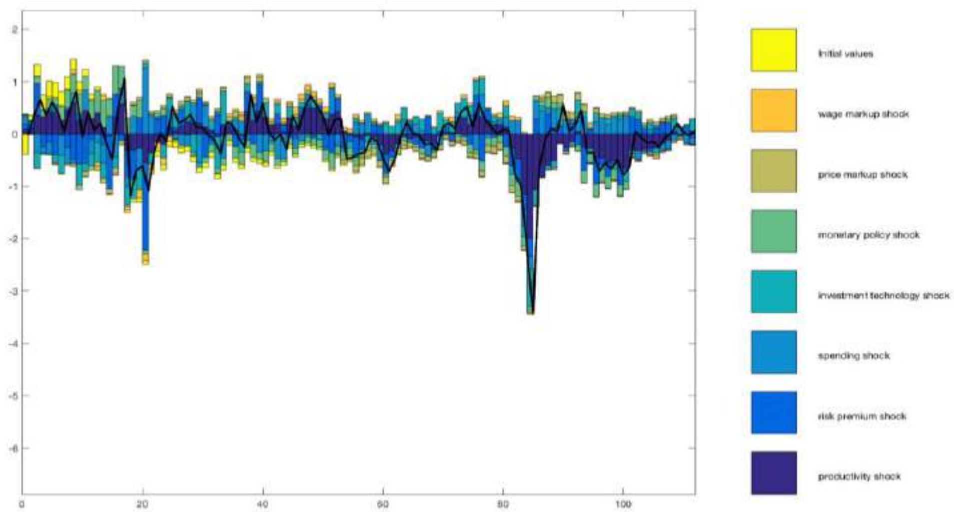
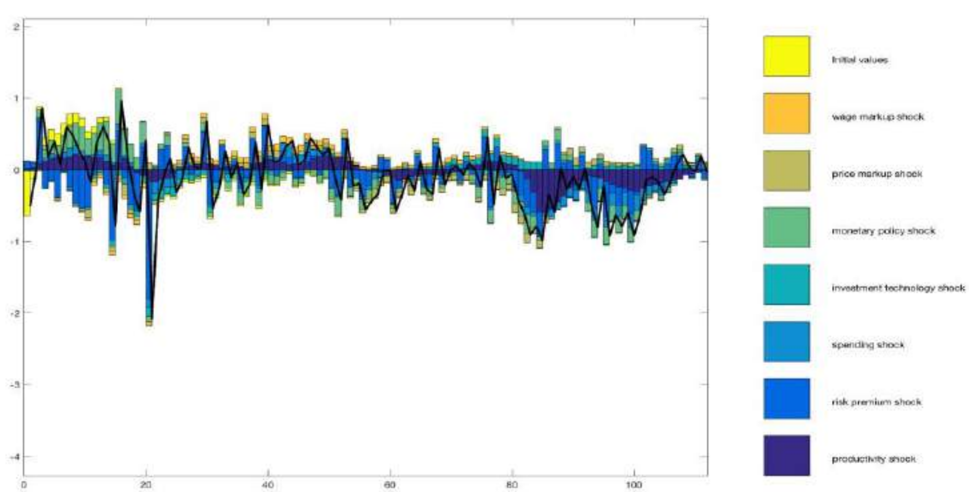


Figure 12. Fluctuations in consumption growth in the Euro Area



Figures 11 and 12 displays the shock decomposition of GDP and consumption growth for the Euro Area case: also in this case, demand shocks account for most of the variance in GDP and consumption growth, while supply shocks account for larger proportion of fluctuations in GDP and consumption growth. Moreover, we observe that the productivity shock is the main driver of the variance in GDP and consumption growth, together with the monetary policy, the preference and the wage markup shock. From the figure, the strong recession in the second half seem to have been mainly driven by the negative productivity shock. Supply shocks are led by the productivity shock, while demand shocks by the monetary policy shock and the risk premium shock. The monetary policy shock, the productivity shock and the risk premium shock are very persistent over time. The monetary policy shock is a particularly important driver of the output and consumption path in the whole time period considered (*Smets and Wouters, 2003*), but especially after the crisis, due to the strong and homogenous response of the ECB. Therefore, in the long run, variations of output and consumption growth are mainly driven by the above mentioned shocks, with wage markup shock having only a short run effect. To comment on the behavior of the price markup shock during the boom and recession periods, it appears clear how in each recession period the price markup shock affects output and consumption growth negatively. In Smets and Wouters (2003) it is shown that the Euro Area was characterized by a disinflation in those periods, which is explained by a fall in the inflation objective.

7. Conclusion

In this paper we have investigated the macroeconomics dynamics of two different economies, Turkey and the Euro Area, through the lenses of a DSGE model estimated with Bayesian techniques. The model introduces seven structural shocks along the lines of Smets and Wouters (2007).

First, the results obtained suggest that, as long as the transmission of non monetary shocks is concerned, the response of the macroeconomic variables are in general consistent across the countries, although the intensities and the persistence in the response differ. Turkey responds in a stronger way to the productivity shock, the investment specific technology shocks, the government spending shock and to cost-push shocks with respect to the Euro Area, along the lines of a great part of the literature that points out a higher volatility in emerging economies and therefore a more pronounced response to the different shocks. The same applies also to the transmission of the monetary policy shock, registering a quantitatively more significant response of the Turkish variables, mainly output, consumption, investment and inflation.

Secondly, our analysis shows how the sources of business cycle fluctuations, and specifically those related to the output and consumption dynamics, differ in their importance from country to country. As a matter of fact, the findings indicate that a productivity shock is the main driver of macroeconomic fluctuations in Turkey, a result consistent with the growing literature on the importance of productivity shocks in emerging and developing economies. For advanced economies like the Euro Area, productivity shocks are still relevant, but relatively less due to the crucial role played by the monetary policy shock, the preference shock and the wage mark-up shock in driving output and consumption.

A further step in this exercise could be to compare our results with the predictions of a standard VAR or BVAR as it is common practice in the New Keynesian DSGE literature. Moreover, in the future, it could become more reasonable thanks to higher data availability, to estimate the Euro Area model only from the beginning of the EMU[15] to enhance both the quality of the interpretation of the results related to the transmission of the monetary policy shock and the comparability with other countries characterized by common and unique monetary regime.

[15] European Monetary Union

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Annex 1. Prior and posterior distributions of the structural parameters

Figure A1.1 - Prior and posterior distribution of the structural parameters – Turkey1

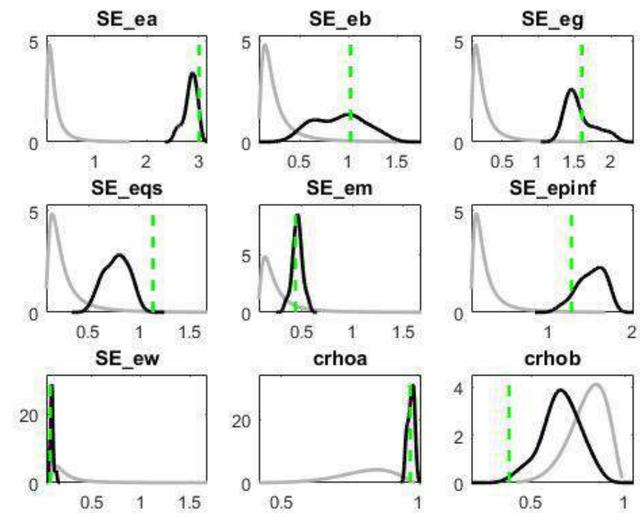


Figure A1.2 - Prior and posterior distribution of the structural parameters – Turkey2

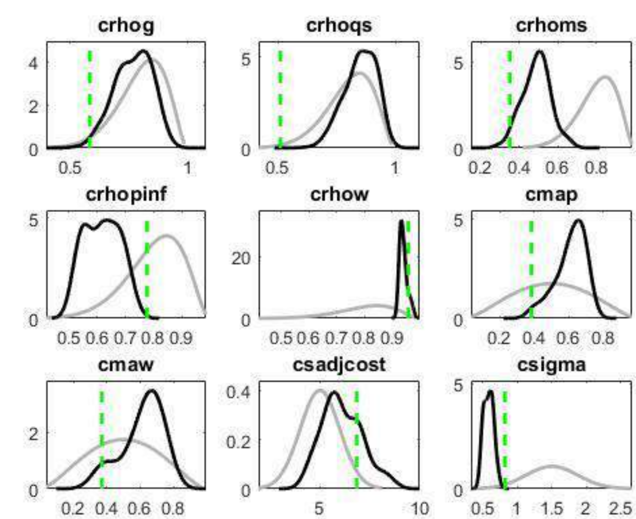


Figure A1.3 - Prior and posterior distribution of the structural parameters – Turkey3

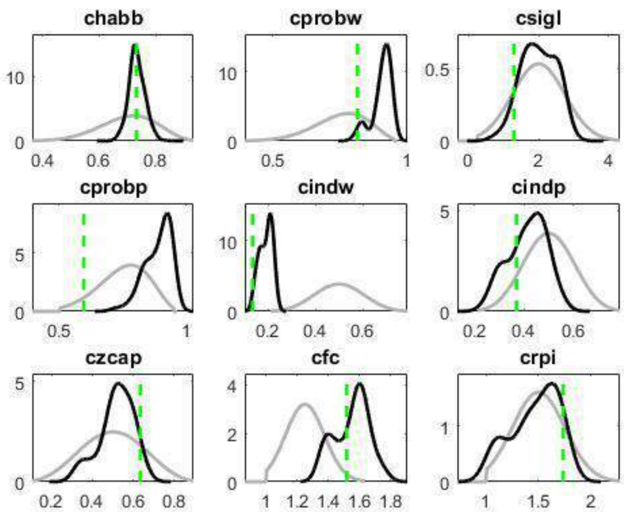


Figure A1.4 - Prior and posterior distribution of the structural parameters – Turkey4

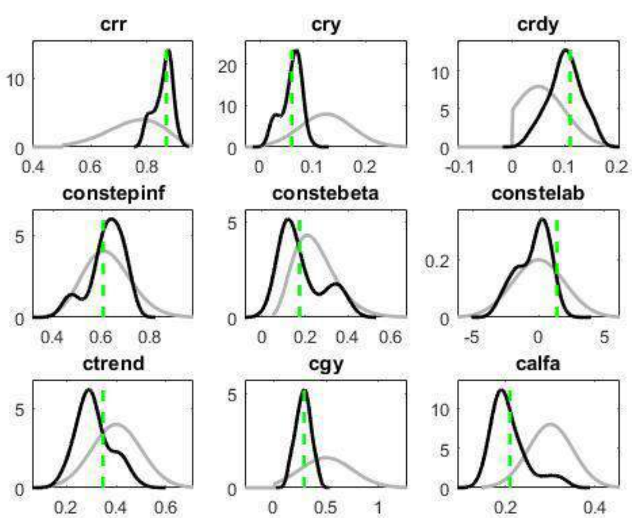


Figure A1.5 - Prior and posterior distribution of the structural parameters – EuroArea1

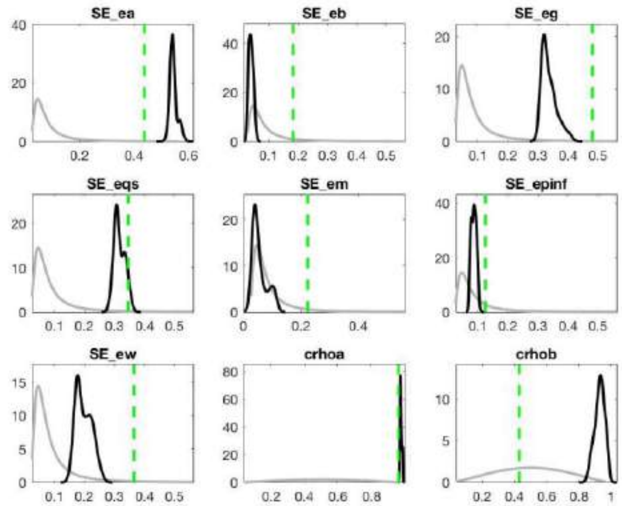


Figure A1.6 - Prior and posterior distribution of the structural parameters – EuroArea2

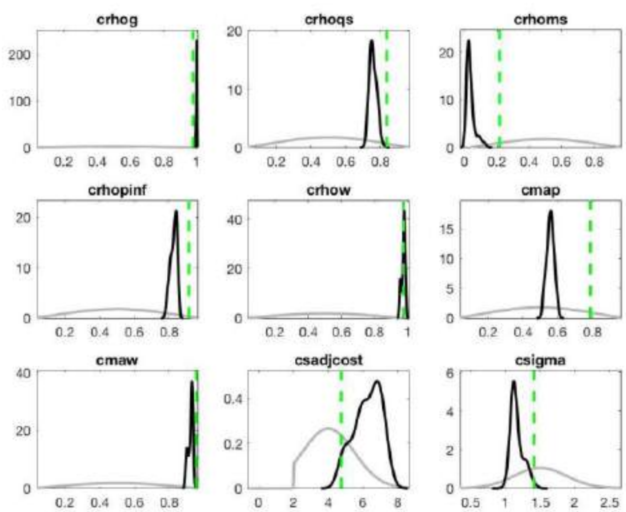


Figure A1.7 - Prior and posterior distribution of the structural parameters – EuroArea3

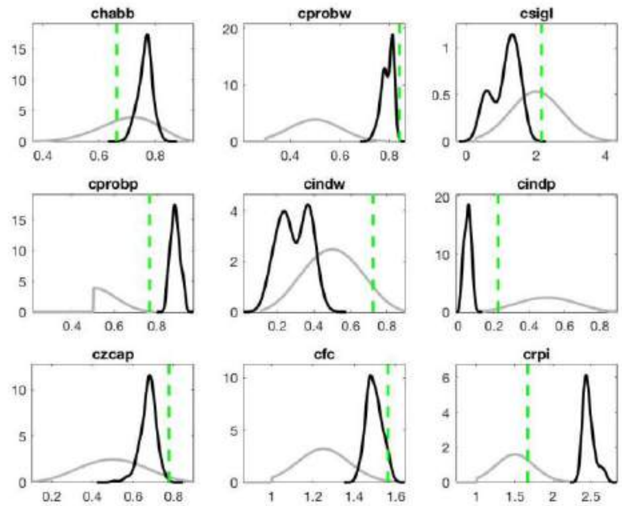
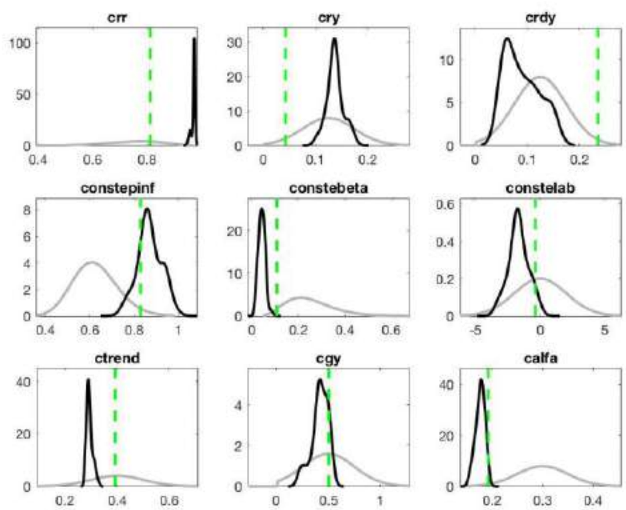


Figure A1.8 - Prior and posterior distribution of the structural parameters – EuroArea4



Annex 2. Smoothed errors

Figure A2.1 –Smoothed shocks – Turkey

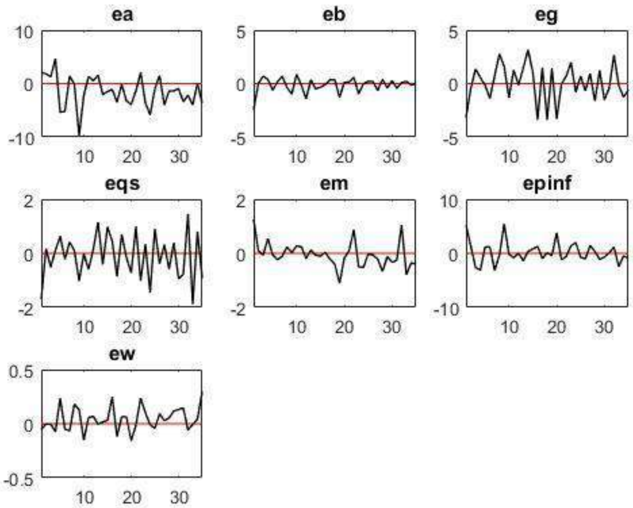


Figure A2.2 –Smoothed errors – EuroArea