Appendix for 'R.E.M. 2.0 An estimated DSGE model for Romania'

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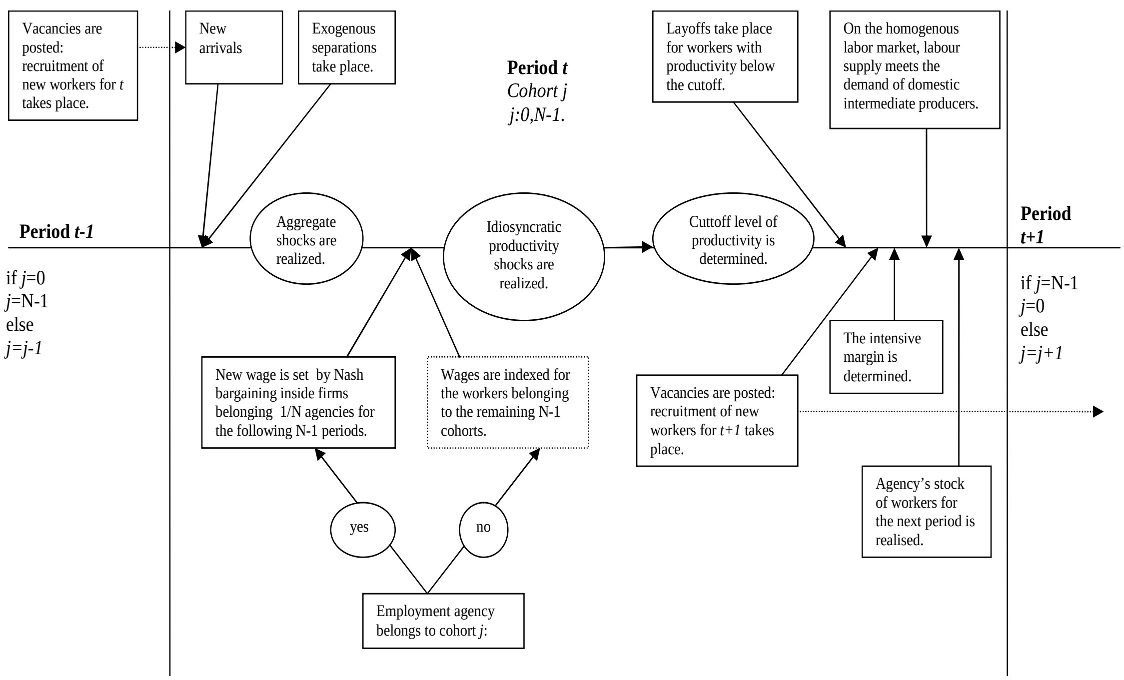
A The role of labor market frictions

Labor services are offered to the domestic intermediate producers by employment agencies inside which labor market decisions are taken. Labor force contains workers, with each household having many of them. Each worker enters one period either employed or unemployed with a certain agency, alternating between having one of these states, while remaining part of the same agency. The latter are uniformly and permanently distributed across N cohorts. While unemployed, workers do undirected search, while if employed, workers separate from agencies either exogenously or endogenously (i.e. if their individual productivity is below a certain, endogenously determined, cutoff).

Figure A.1: *One period for an employment agency*



Based on Christiano et al. (2011)

Figure A.1 presents the developments taking place in period t, inside an employment agency belonging to cohort j, with $j : 0, N-1$. For ease of exposition, the figure is realized based on the assumption that for employment agencies belonging to cohort j, wage is renegociated in period t. Given the stock of workers from the previous period, new arrivals, determined by recruitment of new workers in the previous period, and exogenous separations take place at the beginning of period t. Afterward, aggregate shocks are realized. As mentioned before, if the employment agency belongs to cohort j a new wage is set by atomistic Nash bargaining inside the $1/N$ proportion of firms for the following $N-1$ periods. Otherwise, each period, wages are indexed for the workers belonging to the remaining $N-1$ cohorts to a combination of previous consumer inflation, current inflation target and (partially to) equilibrium growth of the economy. Wages being set, idiosyncratic productivity shocks are realized. Workers with productivity below the endogenously determined threshold are separated from the agency, while the rest continue their activity. In the next step, employment agencies post vacancies and recruit new workers for period $t+1$. Afterward, the intensive margin of labour supply is chosen and the supply of labor meets the demand of domestic intermediate producers on the homogenous labor market. Similar to Christiano et al. (2011), the developments are presented in a reversed order, as the bargaining problem internalizes the future developments taking place inside the period.

The intensive margin is determined by equating worker's marginal disutility of working in monetary terms (right-hand side of the below equation) with the marginal benefit accruing to the employment agency (left-hand side), when hours worked increase by one unit.

$$W_t \varsigma_t^j = \zeta_t^h A_L \left(\varsigma_{j,t}\right)^{\sigma_L} \frac{1}{\upsilon_t \frac{1-\tau^y}{1+\tau^w}};\ j = 0, ...N-1 \tag{A.1}$$

where: W_t is the remuneration paid by the domestic intermediate producers to the employment agency for one unit of labor; $\varsigma_{j,t}$ represent the hours worked at time t by a worker from cohort j; $\varsigma_t^j = \frac{\int_{\bar{a}_t^j}^{\infty} a dF(a,\sigma_{a,t})}{1-\int_0^{\bar{a}_t^j} dF(a,\sigma_{a,t})}$ is the expected productivity of a worker conditional that he is not endogenously separated.

In the previous step, for each cohort, j $(0, ..., N-1)$, (monotonic transformations of) *vacancies* are chosen such that the value functions of the employment agencies are maximized. Equation (A.2) below is the value function for an employment agency from cohort $i = 0$ that renegotiates the wage at time t, with workforce, after exogenous separations and new arrivals, l_t^0, after the wage was set (i.e. $\mathring{\omega}_t$ is an arbitrary value of the wage).

$$F(l_t^0, \mathring{\omega}_t) = \sum_{i=0}^{N-1} \beta^j E_t \frac{\upsilon_{t+i}}{\upsilon_t} \max_{\left(\tilde{\nu}_{t+i}^i, \bar{a}_{t+i}^i\right)} \left[\begin{array}{c} \int_{\bar{a}_{t+i}^i}^{\infty} \left(W_{t+i} a - \Gamma_{t,i} \mathring{\omega}_t\right) \varsigma_{i,t+i} dF(a) \\ -P_{t+i} \frac{\kappa z_{t+i}^{+}}{\varphi} \left(\tilde{\nu}_{t+i}^i\right)^{\varphi} \left(1 - \int_0^{\bar{a}_{t+i}^i} dF(a, \sigma_{a,t+i})\right) \end{array} \right] l_{t+i}^i \tag{A.2}$$
$$+ \beta^N E_t \frac{\upsilon_{t+N}}{\upsilon_t} F(l_{t+N}^0, \tilde{W}_{t+N})$$

where: $\Gamma_{t,i}$ is an indexation factor given by equation (A.3) below; $\tilde{\nu}_{t+i}^i$ is the monotonic transformation of vacancies given by formula (A.4) below; l_{t+i}^i is the workforce of agency i at time $t+i$ that evolves according to (A.6); $\frac{\kappa z_{t+i}^{+}}{\varphi} \left(\tilde{\nu}_{t+i}^i\right)^{\varphi}$ are the adjustment costs per vacancy; $\tilde{W}_{t+N}$ is the Nash wage corresponding to the next bargaining round taking place at $t+N$, and taken as given at time t.

$$\Gamma_{t,i} \equiv \left\{ \begin{array}{ll} \tilde{\pi}_{w,t+i} ... \tilde{\pi}_{w,t+1}, & i > 0 \\ 1....., & i = 0 \end{array} \right. \tag{A.3}$$

$$\tilde{\nu}_{t+i}^i \equiv \frac{Q_{t+i}^{\iota} \nu_{t+i}^i}{\left(1 - \int_0^{\bar{a}_{t+i}^i} dF(a, \sigma_{a,t+i})\right) l_{t+i}^i} \tag{A.4}$$

where: Q_{t+i} is the probability of a vacancy being filled; ι is a parameter governing the existence of internal ($\iota = 1$) or search ($\iota = 0$) costs in adjusting the number of workers. The indexation factor is a product of previous indexations to a combination of past consumption inflation, current inflation target and (partially) equilibrium growth of the economy, with:

$$\tilde{\pi}_{w,t+1} \equiv \left(\pi_t^c\right)^{\kappa_w} \left(\bar{\pi}_{t+1}^c\right)^{1-\kappa_w} \left(\mu_{z^+}\right)^{\vartheta_w} \tag{A.5}$$

Also the labor force for cohort i $(i = 0, ..., N-1)$, l_{t+1}^{i+1}, evolves according to:

$$l_{t+1}^{i+1} = \left(\chi_t^i + \rho\right)\left(1 - \int_0^{\bar{a}_t^i} dF(a, \sigma_{a,t})\right) l_t^i \tag{A.6}$$

In equation (A.6), χ_t^i is the hiring rate of the employment agency that depends on vacancies according to: $\chi_t^i = Q_t^{1-\iota}\tilde{\nu}_t^i$ and ρ is the probability that a worker with an agency survives the exogenous separation.

The equation (A.7) below shows the value function of a worker after he survived the endogenous separation. Hence, at time t, the value of being a worker with an agency from cohort j is equal with the wages received in period t minus the disutility of working (in monetary terms) plus the discounted value of next period's value function. The latter term represents the weighted sum of the value function in case the worker survives both exogenous and endogenous separations in period $t+1$, $\left(\rho(1 - \int_0^{\bar{a}_{t+1}^{j+1}} dF(a, \sigma_{a,t+1}) V_{t+1}^{j+1}\right)$, and the utility of being unemployed in case the worker does not survive the exogenous *or* the endogenous separation process.

$$V_t^j = \Gamma_{t-j,j}\tilde{W}_{t-j}\varsigma_{j,t}\frac{1-\tau^y}{1+\tau^w} - \zeta_t^h A_L \frac{(\varsigma_{j,t})^{\sigma_L}}{(1+\sigma_L)\,\upsilon_t} + \tag{A.7}$$

$$\beta E_t \frac{\upsilon_{t+1}}{\upsilon_t}\left[\rho(1 - \int_0^{\bar{a}_{t+1}^{j+1}} dF(a, \sigma_{a,t+1}) V_{t+1}^{j+1} + \left(1 - \rho + \rho\int_0^{\bar{a}_{t+1}^{j+1}} dF(a, \sigma_{a,t+1})\right) U_{t+1}\right]$$

The value function of being unemployed is shown in equation (A.8). It is the sum of unemployment benefits in monetary terms, adjusted for eventual income taxes, and next period's discounted value function. The latter is also the probability adjusted sum of the utility of being still unemployed in period $t+1$, $(1-f_t)U_{t+1}$, and the value function in case the unemployed person finds a job with an employment agency, $f_t V_{t+1}^x$.The latter term, V_{t+1}^x, presented in equation (A.9), is the sum of value functions of workers, $\tilde{V}_{t+1}^{j+1}$ (before being endogenously separated), adjusted with the across cohorts probabilities of being matched with an employment agency.

$$U_t = P_t z_t^+ b^u (1-\tau^y) + \beta E_t \frac{\upsilon_{t+1}}{\upsilon_t}\left[f_t V_{t+1}^x + (1-f_t)U_{t+1}\right] \tag{A.8}$$

$$V_{t+1}^x = \sum_{j=0}^{N-1} \frac{\chi_t^j \left(1 - \int_0^{\bar{a}_t^j} dF(a, \sigma_{a,t})\right) l_t^j}{m_t} \tilde{V}_{t+1}^{j+1} \tag{A.9}$$

where total matches m_t is given by $m_t = \sum_{j=0}^{N-1} \chi_t^j \left(1 - \int_0^{\bar{a}_t^j} dF(a, \sigma_{a,t})\right) l_t^j$ and $\tilde{V}_t^j$ evolves according to (A.10).

$$\tilde{V}_t^j = U_t \int_0^{\bar{a}_t^j} dF(a, \sigma_{a,t}) + (1 - \int_0^{\bar{a}_t^j} dF(a, \sigma_{a,t}))V_t^j \tag{A.10}$$

The *endogenous separation* process is modeled by Christiano et al. (2011) in a similar way with the approach taken in the case of entrepreneurs when financial frictions are added to the baseline model. As mentioned before, each worker from the labor force within an agency from cohort j (l_t^j) experiences a productivity shock, a, drawn from distribution F. If the shock is below a certain threshold, $\bar{a}_t^j$, the worker separates, while he stays with the agency if the shock is above the threshold.

Christiano et al. (2011) present multiple ways of determining the cutoff inside one agency, based on different weights given to the surplus of the agency and that of the workers inside it. Since we estimated the model with all the weight given to agency's surplus, only the corresponding choice is presented here, while the reader is instructed to consult Christiano et al. (2011) for the detailed discussion.

The agency's surplus, defined in equation (A.2), is linear in the workforce attached to it, where the agency is assumed again, for simplicity, to belong to cohort 0. $F(l_t^0, \mathring{\omega}_t)$ can be rewritten as $F(l_t^0, \mathring{\omega}_t) = J(\mathring{\omega}_t) l_t^0$, where $J(\mathring{\omega}_t)$ represents the surplus per worker and is given by:

$$J(\mathring{\omega}_t) = \max_{\bar{a}_t^0} \left[1 - \int_0^{\bar{a}_t^0} dF(a, \sigma_{a,t}) \right] \tilde{J}(\mathring{\omega}_t; \bar{a}_t^0) \tag{A.11}$$

where:

$$\tilde{J}(\mathring{\omega}_t; \bar{a}_t^0) = \max_{\nu_t^0} \left\{ \left(W_t \varsigma_t^0 - \omega_t \right) \varsigma_{0,t} - P_t \frac{\kappa z_t^+}{\varphi} \left(\tilde{\nu}_t^0 \right)^{\varphi} + \beta \frac{\upsilon_{t+1}}{\upsilon_t} (\chi_t^0 + \rho) J_{t+1}^1 (\mathring{\omega}_t) \right\} \tag{A.12}$$

Therefore, for cohort 0, when only employer's surplus is taken into account, $\bar{a}_t^0$ is chosen to maximize $F(l_t^0, \mathring{\omega}_t)$, which given the above equations can be rewritten as:

$$\max_{\bar{a}_t^0} \left[1 - \int_0^{\bar{a}_t^0} dF(a, \sigma_{a,t}) \right] \tilde{J}(\mathring{\omega}_t; \bar{a}_t^0) l_t^0 \tag{A.13}$$

with the associated first order condition given by:

$$\tilde{J}_{\bar{a}_t^0}(\mathring{\omega}_t; \bar{a}_t^0) = \tilde{J}(\mathring{\omega}_t; \bar{a}_t^0) \frac{dF(\bar{a}_t^0)}{1 - \int_0^{\bar{a}_t^0} dF(a, \sigma_{a,t})} \tag{A.14}$$

The *Nash bargaining* problem, the second step in the timeline described in figure (A.1), after the exogenous separations and new arrivals take place, is solved by maximizing the agency's and worker's surpluses, weighted by their bargaining power, with $\tilde{W}_t$ being the resulting wage.

$$\max_{\mathring{\omega}_t} \left(\tilde{V}_t^0 - U_t \right)^{\eta} J(\mathring{\omega}_t)^{1-\eta} \tag{A.15}$$

where η is the bargaining power of the worker and $1 - \eta$ is the bargaining power of the employment agency. Similar problems with the above ones are valid for agencies belonging to cohorts other than 0 and their associated workers.

Relative to the standard small open economy model, the aggregate resource constraint, as presented in section 1.8, is modified to reflect the costs of posting vacancies in terms of domestic intermediate goods.

B Equilibrium conditions

B.1 Equilibrium in the financial sector

Market clearing conditions for deposits:

$$\int_0^1 D_{t+1}^{DC}(j)dj = \text{Deposit supply in DC} \tag{B.1}$$

$$= \text{Deposit demand in DC} = \int_0^{\omega_k} D_{t+1}^{DC}(i)di = \omega_k D_{t+1}^{DC} \tag{B.2}$$

$$\int_0^1 D_{t+1}^{FC,hh}(j)dj + \int_0^1 FB_{t+1}(j)dj = \text{Deposit supply in FC} \tag{B.3}$$

$$= \text{Deposit demand in FC} = \int_{\omega_k}^1 D_{t+1}^{FC}(i)di = (1-\omega_k)D_{t+1}^{FC} \tag{B.4}$$

Market clearing conditions for loans between banks and entrepreneurs:

$$\omega_k D_{t+1}^{DC} = \text{Supply of DC loans}$$
$$= \text{Demand of DC loans} = \int_0^{\omega_k} L_{t+1}^{DC}(i)di = \omega_k L_{t+1}^{DC}$$

$$(1-\omega_k)D_{t+1}^{FC} = \text{Supply of FC loans}$$
$$= \text{Demand of FC loans} = \int_{\omega_k}^1 L_{t+1}^{FC}(i)di = (1-\omega_k)L_{t+1}^{FC}$$

B.2 Aggregate variables and (other) market clearing conditions

Aggregate net worth is the defined as:

$$\bar{N}_{t+1}^{total} = \omega_k \bar{N}_{t+1}^{DC} + (1-\omega_k)\bar{N}_{t+1}^{FC} \tag{B.5}$$

while total loans given to entrepreneurs, expressed in domestic currency are given by:

$$L_{t+1}^{total} = \omega_k L_{t+1}^{DC} + (1-\omega_k)S_t^{RON/EUR} L_{t+1}^{FC} \tag{B.6}$$

The total stock of physical capital is given by:

$$\bar{K}_{t+1}^{total} = \omega_k \bar{K}_{t+1}^{DC} + (1-\omega_k)\bar{K}_{t+1}^{FC} \tag{B.7}$$

The aggregate leverage ratio is given by:

$$\varrho_t^{total} = \frac{\text{total assets}}{\text{total net worth}} = \frac{P_t P_{k',t}\bar{K}_{t+1}^{total}}{\bar{N}_{t+1}^{total}} = \frac{P_t P_{k',t}\left(\omega_k \bar{K}_{t+1}^{DC} + (1-\omega_k)\bar{K}_{t+1}^{FC}\right)}{\omega_k \bar{N}_{t+1}^{DC} + (1-\omega_k)\bar{N}_{t+1}^{FC}} \tag{B.8}$$

The capital rental market clearing conditions are given by:

$$\int_0^1 K_{i,t}^{DC,int} di = \int_0^{\omega_k} K_{i,t}^{DC,entrep.} di = \omega_k K_t^{DC} = \omega_k u_t^{DC} \bar{K}_t^{DC} \tag{B.9}$$

and

$$\int_0^1 K_{i,t}^{FC,int} di = \int_{\omega_k}^1 K_{i,t}^{FC,entrep.} di = (1-\omega_k) K_t^{FC} = (1-\omega_k) u_t^{FC} \bar{K}_t^{FC} \ . \tag{B.10}$$

The total transfers from households to both type of entrepreneurs are given by:

$$W_t^{e,HH} = \omega_k W_t^{e,DC} + (1-\omega_k) W_t^{e,FC}$$

B.3 Aggregate external variables and (real effective) exchange rates

Given the modeling of the external sector, the following variables need to be defined, with ω_q being the weight of external trade with goods and services made by domestic agents in EUR and $1-\omega_q$ in USD:

- aggregate effective foreign output, Y_t^*, a variable that enters the equation reflecting the foreign demand of domestic (Romanian in our case) exports of goods and services, that is (50):

$$\log\left(\frac{Y_t^*}{Y^*}\right) = \omega_q y_t^{EUR,gap} + (1-\omega_q) y_t^{US,gap} \tag{B.11}$$

- aggregate effective foreign inflation rate, defined as:

$$\pi_t^* = \left(\pi_t^{EUR}\right)^{\omega_q} \left(\pi_t^{US}\right)^{1-\omega_q} \tag{B.12}$$

- aggregate effective foreign interest rate:

$$R_t^* = \left(R_t^{EUR}\right)^{\omega_q} \left(R_t^{US}\right)^{1-\omega_q} \tag{B.13}$$

- the effective real exchange rate:

$$\begin{aligned} q_t &= \left(q_t^{RON/EUR}\right)^{\omega_q} \left(q_t^{RON/USD}\right)^{1-\omega_q} \\ &= \left(\frac{S_t^{RON/EUR} P_t^{EUR}}{P_t^c}\right)^{\omega_q} \left(\frac{S_t^{RON/USD} P_t^{US}}{P_t^c}\right)^{1-\omega_q} \\ &= \left[\left(S_t^{RON/EUR}\right)^{\omega_q} \left(S_t^{RON/USD}\right)^{1-\omega_q}\right] \left[\left(\frac{P_t^{EUR}}{P_t^c}\right)^{\omega_q} \left(\frac{P_t^{US}}{P_t^c}\right)^{1-\omega_q}\right] \\ &= \left(\frac{S_t^{ef} P_t^*}{P_t^c}\right) \end{aligned} \tag{B.14}$$

In our case, trade with financial assets and/or liabilities takes place exclusively in domestic currency and EUR. Implicitly, the uncovered interest rate equation for the domestic economy is in terms of these currencies. The USD/EUR exchange rate is determined outside the domestic economy, as shown above. Implicitly, the domestic currency to USD (real) exchange rate is determined from the cross rates.

B.4 Foreign sector

IS curves:

$$
\begin{aligned}
y_t^{EUR,gap} &= is_{eur,bl} y_{t-1}^{EUR,gap} + (1 - is_{eur,bl})\, y_{t+1}^{EUR,gap} \\
&- is_{eur,r} \left[\left(R_t^{EUR} - \pi_{t+1}^{EUR} \right) - \left(R^{EUR} - \pi^{EUR} \right) \right] \\
&- is_{eur,q} \left(q_{t-1}^{USD/EUR} - q^{USD/EUR} \right) + is_{eur,f} y_{t-1}^{USD,gap} + \varepsilon_{y^{EUR},t}
\end{aligned} \tag{B.15}
$$

$$
\begin{aligned}
y_t^{US,gap} &= is_{us,bl} y_{t-1}^{US,gap} + (1 - is_{us,bl})\, y_{t+1}^{US,gap} \\
&- is_{us,r} \left[\left(R_t^{US} - \pi_{t+1}^{US} \right) - \left(R^{US} - \pi^{US} \right) \right] \\
&+ is_{us,q} \left(q_{t-1}^{USD/EUR} - q^{USD/EUR} \right) + is_{us,f} y_{t-1}^{EUR,gap} + \varepsilon_{y^{US},t}
\end{aligned} \tag{B.16}
$$

Phillips curves:

$$
\begin{aligned}
\pi_t^{EUR} - \pi^{EUR} &= pc_{eur,bl} \left(\pi_{t-1}^{EUR} - \pi^{EUR} \right) + (1 - pc_{eur,bl}) \left(\pi_{t+1}^{EUR} - \pi^{EUR} \right) \\
&+ pc_{eur,mc} y_t^{EUR,gap} - pc_{eur,q} \left(\Delta q_t^{USD/EUR} - \Delta q^{USD/EUR} \right) \\
&+ pc_{eur,oil1} \log \left(\frac{poil_t^{USD}}{poil^{USD}} / \frac{q_t^{USD/EUR}}{q^{USD/EUR}} \right) + pc_{eur,oil2} \log \left(\frac{poil_{t-1}^{USD}}{poil^{USD}} / \frac{q_{t-1}^{USD/EUR}}{q^{USD/EUR}} \right) + \varepsilon_{\pi^{EUR},t}
\end{aligned} \tag{B.17}
$$

$$
\begin{aligned}
\pi_t^{US} - \pi^{US} &= pc_{us,bl} \left(\pi_{t-1}^{US} - \pi^{US} \right) + (1 - pc_{us,bl}) \left(\pi_{t+1}^{US} - \pi^{US} \right) \\
&+ pc_{us,mc} y_t^{US,gap} + pc_{us,q} \left(\Delta q_t^{USD/EUR} - \Delta q^{USD/EUR} \right) \\
&+ pc_{us,oil1} \log \left(\frac{poil_t^{USD}}{poil^{USD}} \right) + pc_{us,oil2} \log \left(\frac{poil_{t-1}^{USD}}{poil^{USD}} \right) + \varepsilon_{\pi^{US},t}
\end{aligned} \tag{B.18}
$$

Taylor rules:

$$
R_t^{EUR} - R^{EUR} = tr_{eur,bl} \left(R_{t-1}^{EUR} - R^{EUR} \right) + (1 - tr_{eur,bl}) \left[tr_{eur,y} y_t^{EUR,gap} + tr_{eur,\pi} \left(\pi_t^{EUR} - \pi^{EUR} \right) \right] + \varepsilon_{R^{EUR},t} \tag{B.19}
$$

$$
R_t^{US} - R^{US} = tr_{us,bl} \left(R_{t-1}^{US} - R^{US} \right) + (1 - tr_{us,bl}) \left[tr_{us,y} y_t^{US,gap} + tr_{us,\pi} \left(\pi_t^{US} - \pi^{US} \right) \right] + \varepsilon_{R^{US},t} \tag{B.20}
$$

UIP relation:

$$
(1 - uip^*)\, E_t \Delta S_{t+1}^{USD/EUR} = uip^* \Delta S_t^{USD/EUR} + \left(R_t^{US} - R_t^{EUR} \right) - \varepsilon_{uip^*,t} \tag{B.21}
$$

The USD/EUR real exchange rate is defined as:

$$
q_t^{USD/EUR} = \frac{S_t^{USD/EUR} P_t^{EUR}}{P_t^{US}} \tag{B.22}
$$

The real price of oil:

$$\log(poil_t^{USD}) = ar_{1,oil}\log(poil_{t-1}^{USD}) + ar_{2,oil}\log\left(\frac{poil_{t-1}^{USD}}{poil_{t-2}^{USD}}\right) + (1-ar_{1,oil})\,poil^{USD} + \varepsilon_{oilusd,t} \quad \text{(B.23)}$$

where:

$$\log(poil_t^{USD}) = \log\left(\frac{P_t^{oil,USD}}{P_t^{US}}\right) \quad \text{(B.24)}$$

C Measurement equations and model-consistent filtering

The model's balanced growth path is ensured by the z_t^+ aggregate trend, which is a combination of investment-specific and neutral technologies (see subsection C.3 below). However, for emerging economies the observed variables usually display specific growth rates rendering the balanced growth approach, in either nominal or real terms, inconsistent with actual data. In order to implement imbalanced trends within the model we follow Argov et al. (2012) approach for model-consistent filtering used in building MOISE, the DSGE model for the Israeli economy. The multivariate procedure doesn't require any pre-filtering of the data (e.g. demeaning), while the excess trends of each variable with respect to the model-implied common trend are removed when estimating the model in a consistent way. The excess trends are specified when linking endogenous and observed variables. From a technical point of view, these components can be also interpreted as non-zero, auto-correlated measurement errors. For those observed variables with no excess trends, we still allow for standard white noise measurement errors.

C.1 Domestic variables

Inflation target measurement equation and the corresponding excess trend are given by:

$$\bar{\pi}_t^{c,data} - EXT_t^{\bar{\pi}^c} = 400\log\bar{\pi}_t^c \quad \text{(C.1)}$$

$$EXT_t^{\bar{\pi}^c} = (1-\rho^{\bar{\pi}^c,EXT})(\mu^{\bar{\pi}^c} - \bar{\pi}) + \rho^{\bar{\pi}^c,EXT} EXT_{t-1}^{\bar{\pi}^c} + \varepsilon_t^{\bar{\pi}^c,EXT} \quad \text{(C.2)}$$

Note that the excess trend follows a first order auto-regressive process, determining a steady state value equal to the deviation of sample mean of inflation rate target ($\mu^{\bar{\pi}^c}$) from the model implied steady state ($\bar{\pi}$). In what follows, $\varepsilon_t^{\bullet,EXT}$ have the interpretation of disturbances to the excess trend components (or from a technical point of view, innovations in the measurement errors).

Excess trends of the other observed inflation rates over the model implied ones are specified as the *sum of inflation target excess trend and a specific excess trend, with the latter explaining the difference between data mean of a certain variable and sample mean of the inflation rate target.*

The GDP deflator inflation is linked to its model counterpart using the following specification:

$$\pi_t^{GDP,data} - EXT_t^{\bar{\pi}^c} - EXT_t^{\pi^{GDP}} = 400\log\pi_t^{GDP} \quad \text{(C.3)}$$

$$EXT_t^{\pi^{GDP}} = (1-\rho^{\pi^{GDP},EXT})(\mu^{\pi^{GDP}} - \mu^{\bar{\pi}^c}) + \rho^{\pi^{GDP},EXT} EXT_{t-1}^{\pi^{GDP}} + \varepsilon_t^{\pi^{GDP},EXT} \quad \text{(C.4)}$$

The trend of GDP deflator inflation has two components, namely the inflation target excess trend in (C.2) and a specific term in (C.4), the latter given by the difference between its data mean and the inflation target mean in the data ($\mu^{\pi^{GDP}} - \mu^{\bar{\pi}^c}$). The corresponding equations for the remaining price indices are similar:

$$\pi_t^{j,data} - EXT_t^{\bar{\pi}^c} - EXT_t^{\pi^j} = 400 \log \pi_t^j \tag{C.5}$$

$$EXT_t^{\pi^j} = (1 - \rho^{\pi^j,EXT})(\mu^{\pi^j} - \mu^{\bar{\pi}^c}) + \rho^{\pi^j,EXT} EXT_{t-1}^{\pi^j} + \varepsilon_t^{\pi^j,EXT} \tag{C.6}$$

where $j \in \{c, core1, adm, m, x, i\}$. There are three exceptions form the expressions above, given by some particularities described below. First, for the administered prices ($j \in \{adm\}$) we compute the excess trend as a residual given the total consumption and CORE1 inflation rates' specific trends:

$$EXT_t^{\pi^{adm}} = \frac{EXT_t^{\pi^c} - (1 - \omega_{adm}) EXT_t^{\pi^{core1}}}{\omega_{adm}} + \varepsilon_t^{\pi^{adm},EXT} \tag{C.7}$$

Second, inflation rate of exported goods ($j \in \{x\}$) measurement equation is slightly different given the local currency pricing concept used in the model (the export prices in the model are expressed in foreign currency, while the deflator measured in the data is expressed in domestic currency):

$$\pi_t^{x,data} - EXT_t^{\bar{\pi}^c} - EXT_t^{\pi^x} = 400 \log \left(\pi_t^x \frac{S_t^{ef}}{S_{t-1}^{ef}} \right) \tag{C.8}$$

Third, the price inflation of the investment goods purchased to increase the stock of physical capital (the gross fixed capital formation component of GDP, $j \in \{i\}$) is affected by the presence of the investment specific trend[1]:

$$EXT_t^{\pi^i} = (1 - \rho^{\pi^i,EXT})(\mu^{\pi^i} - \mu^{\bar{\pi}^c} - 400 \log \mu_\psi) + \rho^{\pi^i,EXT} EXT_{t-1}^{\pi^i} + \varepsilon_t^{\pi^i,EXT} \tag{C.9}$$

The measurement equations and specific trends for the real quantities are defined equivalently. The common trend determined by the balanced growth path, $\mu_{z^+,t}$, is linked to the real GDP data:

$$\Delta \log GDP_t^{data} = 100(\log \mu_{z^+,t} + \Delta \log GDP_t) + \varepsilon_t^{y,ME} \tag{C.10}$$

The other GDP components contain specific excess trends above or below the GDP trend $\mu_{z^+,t}$. The specific trends are modeled as AR(1) processes with the equilibria calibrated at the deviation of component's mean growth rate (μ^j) from that of the real GDP (μ_{z^+}). Since investment volume is also affected by the specific component $\mu_{\psi,t}$, its measurement and excess trend equations are:

$$\Delta \log I_t^{data} - EXT_t^i = 100(\log(\mu_{z^+,t}\mu_{\psi,t}) + \Delta \log i_t) \tag{C.11}$$

$$EXT_t^i = (1 - \rho^{i,EXT})(\mu^i - 100 \log(\mu_{z^+}\mu_\psi)) + \rho^{i,EXT} EXT_{t-1}^i + \varepsilon_t^{i,EXT} \tag{C.12}$$

For the remaining components the corresponding relations are given by:

[1] The unit root (with drift) shock, ψ_t, that captures the decline in the relative price of investment goods might make the use of the excess trend concept for the investment volume and inflation rate redundant when taking the model to the data. This is an aspect that necessitates care when estimation is done.

$$\Delta \log J_t^{data} - EXT_t^j = 100(\log \mu_{z^+,t} + \Delta \log j_t) \tag{C.13}$$

$$EXT_t^j = (1-\rho^{j,EXT})(\mu^j - 100\log \mu_{z^+}) + \rho^{j,EXT} EXT_{t-1}^j + \varepsilon_t^{j,EXT} \tag{C.14}$$

where $j \in \{c, x, m, g\}$. Note that the specific trend of imports is common for all three types of imported goods and also for the oil imports, since in terms of volumes we observe only aggregate imports. The only exception to the above formulas is related to the excess trend of government consumption (EXT_t^g), which is calculated as a residual such as the weighted sum of excess trends of GDP components is zero, similar to Argov et al. (2012):

$$s^g EXT_t^g + s^c EXT_t^c + s^i(EXT_t^i + 100\log \mu_{\psi,t}) + s^x EXT_t^x - s^m EXT_t^m = 0 \tag{C.15}$$

where the weights are equal to the corresponding steady state nominal shares of component j in GDP, as in equation (102).

The remaining measurement equations don't contain any specific trends and are listed below. Observed data for statistical discrepancy share in GDP, change in inventories share in gross fixed capital formation and (demeaned) foreign transfers ratio to GDP are connected to their model counterparts as follows:

$$j_t^{data} = 100 j_t + \varepsilon_t^{j,ME} \tag{C.16}$$

where $j \in \{sd, \Delta inv, \Delta \widehat{ft}\}$.

The measurement equations for the financial variables, that are all demeaned, are:

$$R_t^{data} = 400(R_t - R) \tag{C.17}$$

$$\Delta \log Spread_t^{DC,data} = 100\Delta \log spread_t^{DC} + \varepsilon_t^{spread^{DC},ME} \tag{C.18}$$

$$\Delta \log Spread_t^{FC,data} = 100\Delta \log spread_t^{FC} + \varepsilon_t^{spread^{FC},ME} \tag{C.19}$$

$$\Delta \log S_t^{RON/EUR,data} = 100\log(s_t^{RON/EUR} - s^{RON/EUR}) + \varepsilon_t^{s^{RON/EUR},ME} \tag{C.20}$$

where the model implied equations for the spreads are defined in (78) and (79) and $s_t^{RON/EUR}$ represents the log variation in the RON/EUR nominal exchange rate. Note that the only variable for which we don't use any measurement error is the monetary policy interest rate.

As for hours worked and unemployment rate, we use demeaned first difference of the observed data:

$$\Delta H_t^{data} = 100\Delta \log \left(\sum_{j=0}^{N-1} \chi_t^j \left(1 - \int_0^{\bar{a}_t^j} dF(a, \sigma_{a,t}) \right) l_t^j \right) + \varepsilon_t^{H,ME} \tag{C.21}$$

$$\Delta \log U_t^{data} = 100\Delta \log(1 - L_t) + \varepsilon_t^{U,ME} \tag{C.22}$$

The demeaned observed variation in the nominal wage is linked to the employment-weighted average Nash bargained wage across the cohorts $\omega_t^{avg} = \frac{1}{L}\sum_{j=0}^{N-1} l_t^j G_{t-j,t}\omega_{t-j}\bar{\omega}_{t-j}$:

$$\Delta \log W_t^{data} = 100(\log \mu_{z^+,t} - \log \mu_{z^+} + \bar{\pi}_t^c - \bar{\pi}^c + \Delta \log \omega_t^{avg}) + \varepsilon_t^{W,ME} \tag{C.23}$$

There are additional (demeaned) data series related to financial and labor markets one can use as observables when estimation is performed. The data we are referring to is (demeaned): change in vacancies, change in real net worth, change in the volume of new loans to non-financial corporations in domestic currency expressed in real terms and the volume of new loans to non-financial corporations in foreign currency, expressed in domestic currency, real terms[2].

$$\Delta \log Vacancy_t^{data} = 100\Delta \log(\nu_t) + \varepsilon_t^{\nu,ME} \tag{C.24}$$

$$\Delta \log N_t^{data} = 100(\log \mu_{z^+,t} - \log \mu_{z^+} + \Delta \log n_t) + \varepsilon_t^{n,ME} \tag{C.25}$$

$$\Delta \log L_t^{DC,data} = 100(\log \mu_{z^+,t} - \log \mu_{z^+} + \omega_k \Delta \log L_t^{DC}) + \varepsilon_t^{L^{DC},ME} \tag{C.26}$$

$$\Delta \log L_t^{FC,data} = 100(\log \mu_{z^+,t} - \log \mu_{z^+} + (1-\omega_k)\Delta \log L_t^{FC}) + \varepsilon_t^{L^{FC},ME} \tag{C.27}$$

where ν_t represents the model measure of vacancies across cohorts. For a list of actual observable variables used in estimation see table 1.

C.2 External variables

Taking into account both the exogeneity of the external sector block relative to the domestic one, and also the fact that the specific trends approach magnifies the already relatively high dimension of the estimated parameters space in the context of a relatively short data sample, we choose to estimate the external sector outside the main model. Taking into account that in the data foreign variables have different growth rates than the model-implied ones, we extend the specific trends approach to these variables also, including them in the estimation of the external sector.

Euro area and US inflation and interest rates measurement and excess trend equations are:

$$\pi_t^{j,data} - EXT_t^{\pi^j} = 400\pi_t^j \tag{C.28}$$

$$EXT_t^{\pi^j} = (1-\rho^{\pi^j,EXT})(400\log \pi^* - \mu^{\pi^j}) + \rho^{\pi^j,EXT} EXT_{t-1}^{\pi^j} + \varepsilon_t^{\pi^j,EXT} \tag{C.29}$$

$$R_t^{j,data} - EXT_t^{R^j} = 400(R_t^j - 1) \tag{C.30}$$

$$EXT_t^{R^j} = (1-\rho^{R^j,EXT})(400R^* - \mu^{R^j} - 400) + \rho^{R^j,EXT} EXT_{t-1}^{R^j} + \varepsilon_t^{R^j,EXT} \tag{C.31}$$

where $j \in \{EUR, US\}$. Again, the excess trends control for larger model inferred steady states (π^* and R^*; these are equal for both foreign economies) than sample data averages (μ^{π^j} and μ^{R^j}). The nominal USD/EUR exchange rate and price of oil in USD are linked to the model with:

$$\Delta \log S_t^{USD/EUR,data} - EXT_t^{S^{USD/EUR}} = 100\Delta \log\left(\frac{S_t^{USD/EUR}}{S_{t-1}^{USD/EUR}}\right) = 100 \log s_t^{USD/EUR} \tag{C.32}$$

[2] In choosing the model counterpart of new loans to non-financial corporations, only the loans demanded by entrepreneurs are considered. An alternative version would add to the loans taken by entrepreneurs the working capital loans taken by intermediate producers and exporters (in domestic currency), while those taken by importers of consumption, investment and export goods would be added to the volume of loans in foreign currency.

$$EXT_t^{S^{USD/EUR}} = (1 - \rho^{S^{USD/EUR},EXT})\mu^{S^{USD/EUR}} + \rho^{S^{USD/EUR},EXT} EXT_t^{S^{USD/EUR}} + \varepsilon_t^{S^{USD/EUR},EXT} \tag{C.33}$$

$$\pi_t^{oil,USD,data} - EXT_t^{\pi_t^{oil,USD}} = 400 \log \pi_t^{oil,USD} \tag{C.34}$$

$$EXT_t^{\pi^{oil,USD}} = (1 - \rho^{\pi^{oil,USD},EXT})(\mu^{\pi^{oil,USD}} - 400 \log \pi^*) + \rho^{\pi^{oil,USD},EXT} EXT_{t-1}^{\pi_t^{oil,USD}} + \varepsilon_t^{\pi^{oil,USD},EXT} \tag{C.35}$$

When dealing with the output of the foreign economies (Euro area and US, with the latter as a proxy for the rest of the world) we use a different approach. When (separately) estimating the external sector, output gaps are needed. Therefore, we use the (quarterly interpolated) output gaps for Euro area and US real GDP measures, as they resulted from the European Commission Autumn 2014 regular forecast exercise. The measurement equation for external real GDP used in the estimation of the foreign sector outside the main model is:

$$Y_t^{j,data,gap} = y_t^{j,gap} + \varepsilon_t^{y^j,ME} \tag{C.36}$$

where $j \in \{EUR, US\}$.

C.3 Scaling and defining variables

The scaling of variables in the presence of one neutral technology shock and an unit-root investment specific shock is described below. Similar to Christiano et al. (2011) the neutral technology shock is z_t and its growth rate is $\mu_{z,t}$:

$$\mu_{z,t} = \frac{z_t}{z_{t-1}} \tag{C.37}$$

There is also one specific investment technology shock, ψ_t, an unit root (with drift) shock for investment used in building physical capital bought by each type of entrepreneurs.

The aggregate trend, z_t^+, is defined as the following combination of neutral and investment technology shocks:

$$z_t^+ = z_t (\psi_t)^{\frac{\alpha}{1-\alpha}} \tag{C.38}$$

$$\mu_{z^+,t} = \mu_{z,t} (\mu_{\psi,t})^{\frac{\alpha}{1-\alpha}} \tag{C.39}$$

Given the above, the scaling of variables (mostly those affected by the introduction of an additional investment specific technology trend) is presented below. For those not mentioned, the scaling is similar with that in Christiano et al. (2011).

$$k_{t+1}^{DC} = \frac{K_{t+1}^{DC}}{z_t^+ \psi_t},\ \bar{k}_{t+1}^{DC} = \frac{\bar{K}_{t+1}^{DC}}{z_t^+ \psi_t},\ k_{t+1}^{FC} = \frac{K_{t+1}^{FC}}{z_t^+ \psi_t},\ \bar{k}_{t+1}^{FC} = \frac{\bar{K}_{t+1}^{FC}}{z_t^+ \psi_t},\ y_t = \frac{Y_t}{z_t^+}$$
$$i_t = \frac{I_t}{z_t^+ \psi_t},\ i_t^d = \frac{I_t^d}{z_t^+},\ i_t^m = \frac{I_t^m}{z_t^+},\ p_t^i = \frac{\psi_t P_t^i}{P_t}$$
$$\bar{r}_{r,t}^{k,DC} = r_t^{k,DC} \psi_t = \frac{R_t^{k,DC}}{\frac{P_t}{\psi_t}},\ \bar{r}_{r,t}^{k,FC} = r_t^{k,FC} \psi_t = \frac{R_t^{k,FC}}{\frac{P_t}{\psi_t}},\ p_{k',t} = \psi_t P_{k',t}.$$

C.4 Data revisions

The uncertainty related to the observed variables becomes obvious when analyzing the revisions magnitudes operated by the Romanian National Institute of Statistics (NIS) to the quarterly seasonally adjusted National Accounts data. We show three vintages (October 2014, October 2013 and October 2012) of GDP and components data in figures C.1 (real quantities) and C.2 (deflators). The sizable revisions, particularly for the crisis period, suggest little reliability of the published data and the need for measurement errors when modeling the national accounts data.

Nalban (2015) analyzes the pattern of past revisions and tries to quantify the “true” GDP data (net of potential revisions) and its associated uncertainty. The findings show that revisions' pattern of Romanian data does not always comply with model's hypotheses, as sometimes more distant observations are also revised, not only the recent ones (as it is visible also in figures C.1 and C.2). Furthermore, the operated revisions present noise effects, meaning there is significant evidence in favor of random measurement errors contained in official releases. Although there was not signaled the existence of systematic errors (i. e. on average the revisions are null), relatively to the United Kingdom and the US data, the estimated variance of the measurement error is about three times larger, suggesting an increased uncertainty associated to the Romanian time series.

Figure C.1: *Data revisions across three vintages - 100*qoq growth rates, percent - volumes*

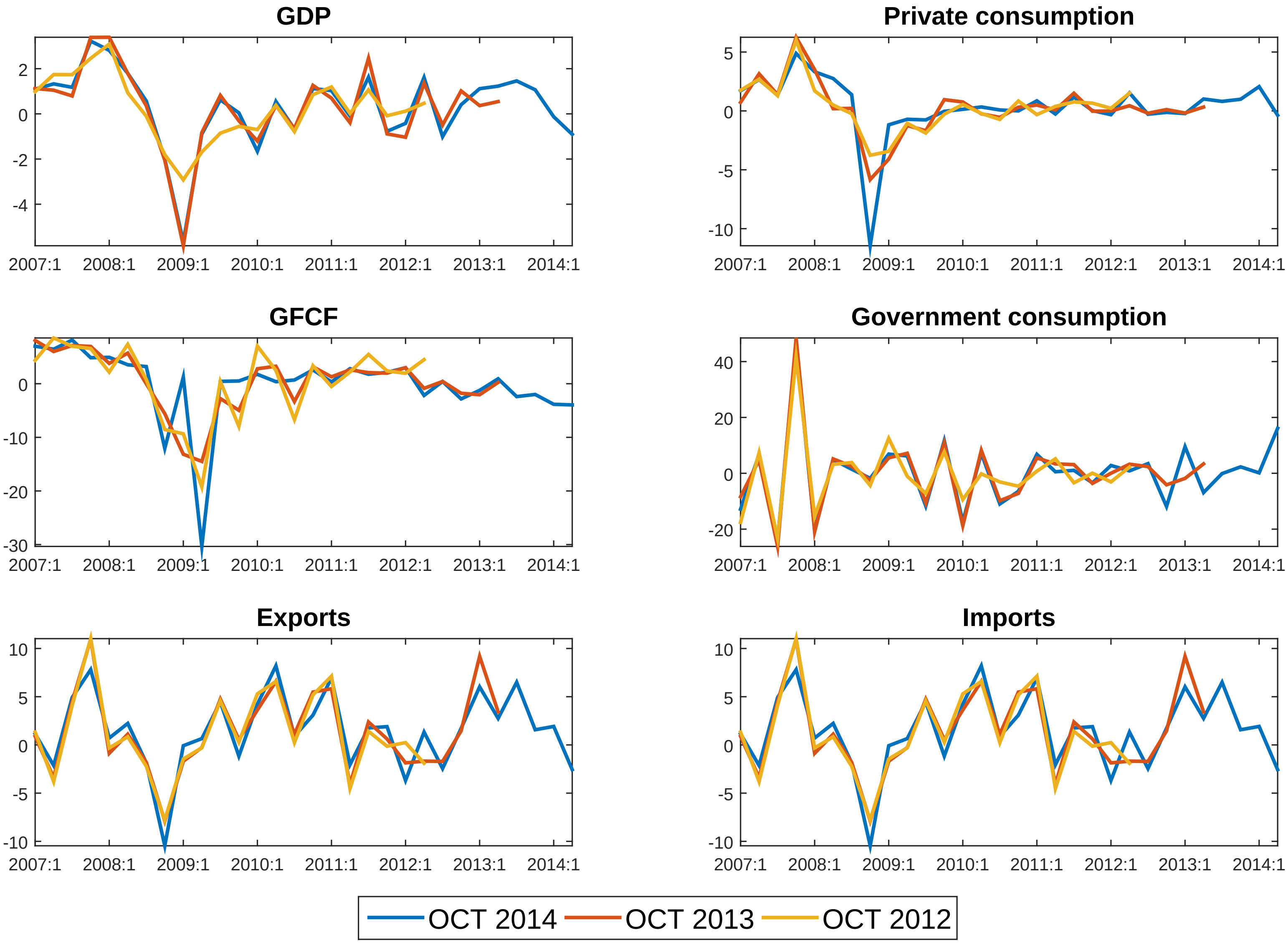
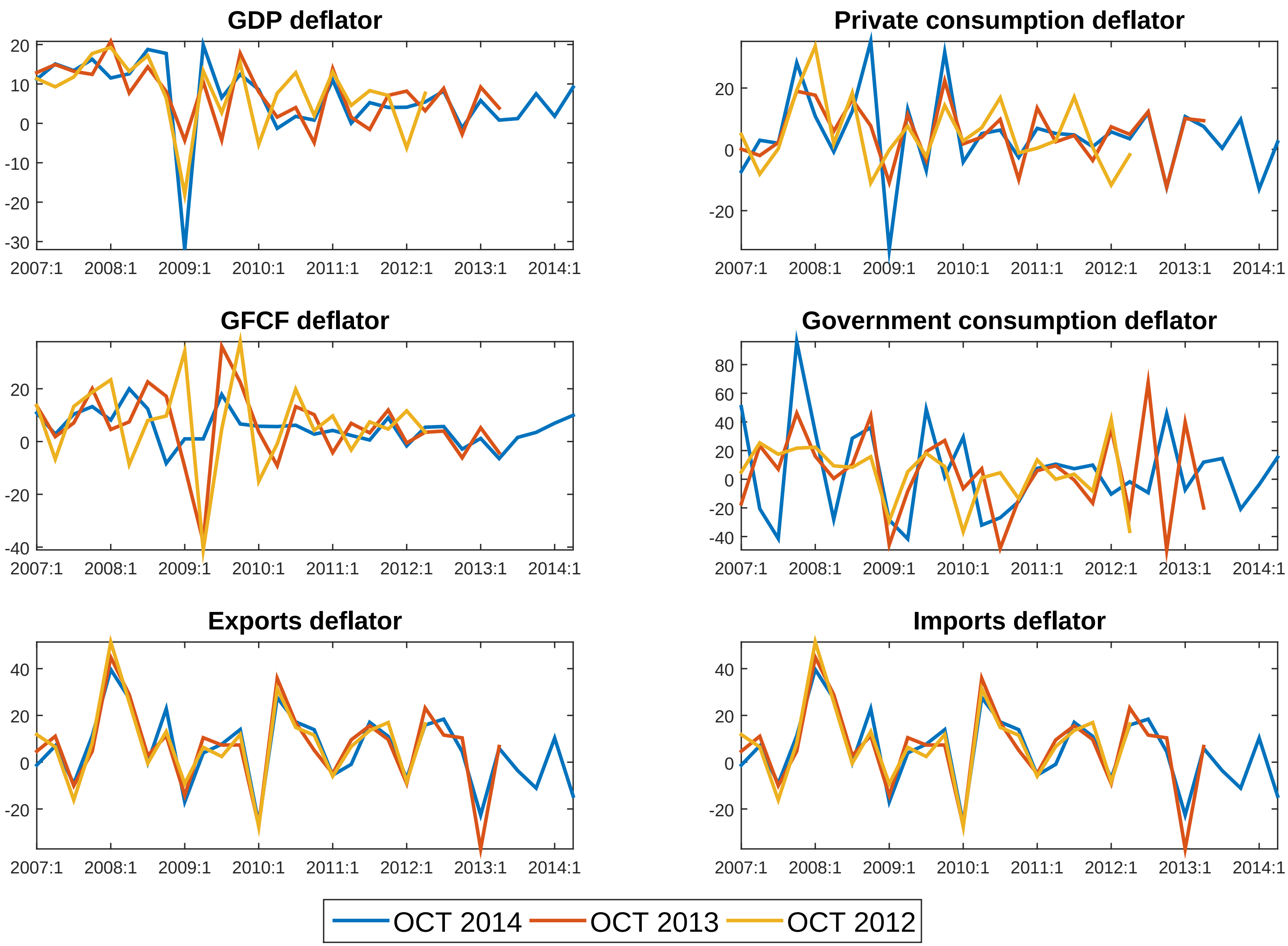


Figure C.2: *Data revisions across three vintages - 400*qoq growth rates, percent - deflators*



D Estimated external sector

As mentioned throughout the paper and described in details in section 1.7, the estimation of the external sector is performed outside the main model. Given this latter aspect, the semi-structural nature of the external sector model and, implicitly, the relatively high number of coefficients to be estimated, we chose to work with data that covers a longer time span than that used for the Romanian economy, taking also into account its availability for the US and Eurozone economies. The series used in estimation cover the 1995Q2-2014Q3 period and are presented in table D.2 and plotted in figure D.1 below.

When feeding data into the external sector model, we take into account that in the data foreign variables have different growth rates than the domestic model-implied ones. Therefore, we extend the specific trends approach to these variables also. The measurement equations used are the ones presented in section C.2 of the paper.

Estimated parameters and standard deviations of the shocks are presented in tables D.3 and D.4 below.

Similar with the main model, we use the endogenous priors procedure as proposed by Christiano et al. (2011) when estimating the external sector model. Table D.1 presents the means and the standard deviations in the data as well as those generated by the model. While the specific trends approach helps us in matching the means of the used data series (excepting the output gaps, for which the excess trend components are not specified), the endogenous priors approach does an excellent job in matching the variability in the series, as measured by their standard deviations (including oil prices, for which a high sampling uncertainty is encountered).

Table D.1: *External sector: data and model moments (in percent)*

External sector: 1995Q2-2014Q3						
Variable	Explanation	Means		St. dev.		Sampling uncertainty
		Data	Model	Data	Model	
Euro area						
100*$y^{EUR,gap}$	GDP gap	-0.2	0	1.8	1.5	0.6
400*π^{EUR}	Inflation	1.9	1.9	1.2	1.2	0.3
400*$(R^{EUR}-1)$	Interest rate	2.9	2.9	1.8	1.5	0.6
United States						
100*$y^{US,gap}$	GDP gap	-0.2	0	1.4	1.3	0.5
400*π^{US}	Inflation	2.3	2.3	2.0	2.1	2.0
400*$(R^{US}-1)$	Interest rate	2.9	2.9	2.3	2.0	0.6
100*$s^{USD/UER}$	USD/EUR exchange rate	0.1	0.1	4.1	3.9	2.6
400*$\pi^{oil,USD}$	Oil inflation	8.9	8.9	53.9	49.0	1021.9

Table D.2: *Series used in the estimation of the external sector: 1995Q2-2014Q3*

	Description	*Details*	*Source of primary data*
π_t^{EUR}	Euro area inflation rate	HICP inflation, quarterly rate	ECB
π_t^{US}	US inflation rate	CPI, quarterly rate	FRED
R_t^{EUR}	Euro area interest rate	Euribor, 3 months market rate	Eurostat
R_t^{US}	US interest rate	Federal funds rate	FRED
π_t^{EUR}	Euro area inflation rate	HICP inflation, quarterly rate	ECB
Logged first difference			
$\Delta S_t^{USD/EUR}$	Nominal USD/EUR exchange rate	Nominal USD/EUR exchange rate	NBR
$\Delta Poil_t^{USD}$	Change in oil prices	Brent Oil price, USD/barrel	EIA
Filtered log level (output gaps)			
$y_t^{EUR,gap}$	Euro area GDP gap	Interpolated from annual data	EC
$y_t^{US,gap}$	US GDP gap	Interpolated from annual data	EC

Figure D.1: *Observed data series and estimated model consistent trends: external sector*

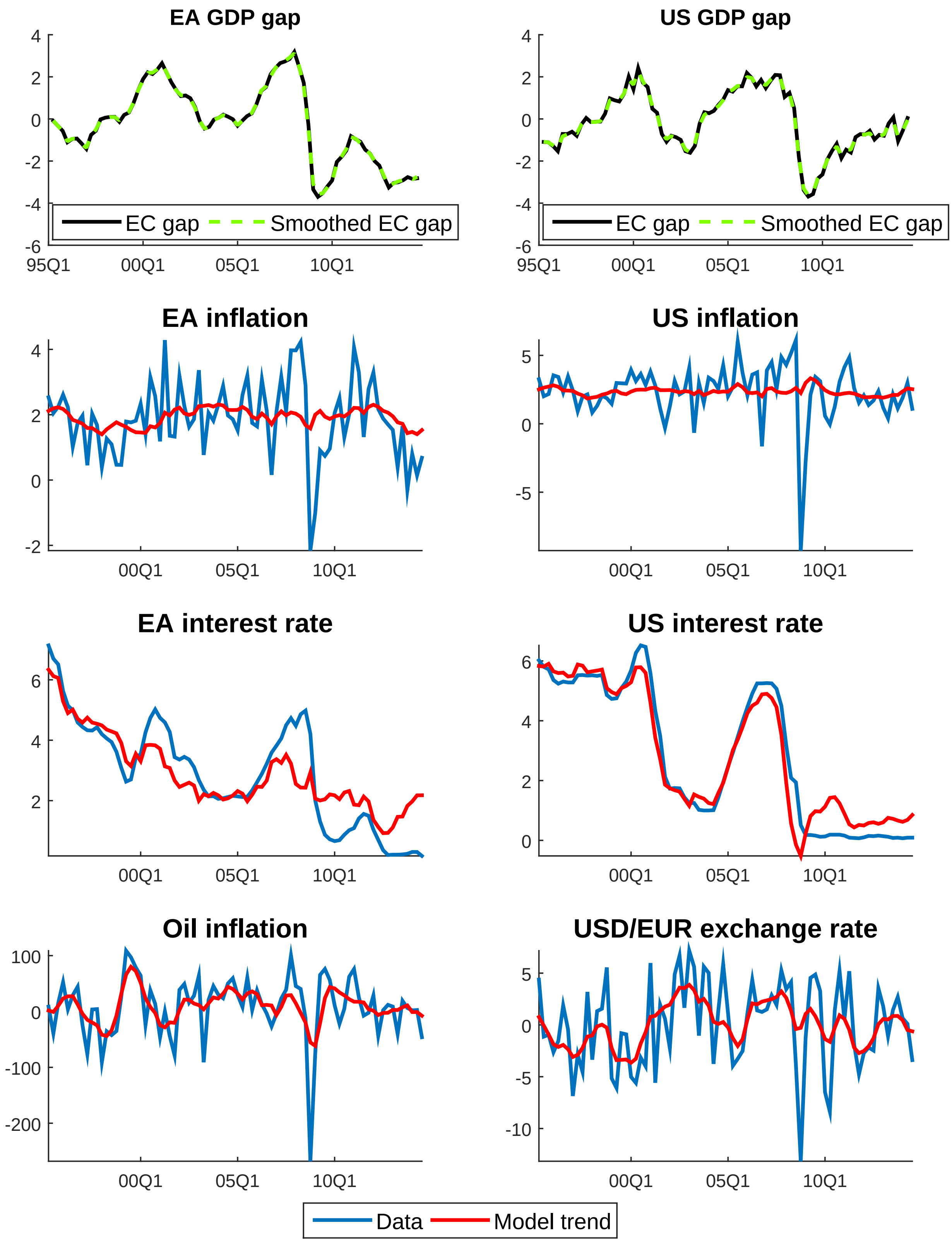


Table D.3: *Estimated parameters: external sector*

Based on single Metropolis chain with 400,000 draws, after a burn in period of 200,000 draws.					
Parameter	Prior			Posterior	
	Distr.	Mean	s.d./dof	Mean	s.d.
Euro area aggregate demand curve					
$is_{eur,bl}$	β	0.4	0.05	0.504	0.025
$is_{eur,r}$	Γ	0.1	0.025	0.095	0.024
$is_{eur,q}$	Γ	0.05	0.01	0.020	0.004
$is_{eur,f}$	Γ	0.025	0.01	0.078	0.012
$100\sigma_{y^{EUR}}$	Inv-Γ	0.25	2	0.262	0.036
Euro area Phillips curve					
$pc_{eur,bl}$	β	0.3	0.1	0.052	0.020
$pc_{eur,mc}$	Γ	0.1	0.015	0.047	0.006
$pc_{eur,q}$	Γ	0.025	0.015	0.012	0.005
$pc_{eur,oil1}$	Γ	0.005	0.001	0.004	0.001
$pc_{eur,oil2}$	Γ	0.005	0.001	0.003	0.001
$100\sigma_{\pi^{EUR}}$	Inv-Γ	0.25	2	0.143	0.017
Euro area Taylor rule					
$tr_{eur,bl}$	β	0.7	0.01	0.845	0.024
$tr_{eur,y}$	Γ	0.125	0.05	0.127	0.035
$tr_{eur,\pi}$	Γ	1.7	0.15	1.690	0.148
$1000\sigma_{R^{EUR}}$	Inv-Γ	1.5	2	0.485	0.100
US aggregate demand curve					
$is_{us,bl}$	β	0.4	0.05	0.432	0.030
$is_{us,r}$	Γ	0.1	0.025	0.120	0.027
$is_{us,q}$	Γ	0.025	0.01	0.016	0.004
$is_{us,f}$	Γ	0.01	0.005	0.009	0.004
$100\sigma_{y^{USD}}$	Inv-Γ	0.25	2	0.215	0.040
US Phillips curve					
$pc_{us,bl}$	β	0.3	0.1	0.072	0.026
$pc_{us,mc}$	Γ	0.1	0.015	0.078	0.011
$pc_{us,q}$	Γ	0.05	0.015	0.054	0.012
$pc_{us,oil1}$	Γ	0.005	0.001	0.006	0.001
$pc_{us,oil2}$	Γ	0.005	0.001	0.004	0.001
$100\sigma_{\pi^{USD}}$	Inv-Γ	0.5	2	0.322	0.036
US Taylor rule					
$tr_{us,bl}$	β	0.7	0.1	0.912	0.018
$tr_{us,y}$	Γ	0.125	0.05	0.166	0.053
$tr_{us,\pi}$	Γ	1.5	0.15	1.432	0.143
$1000\sigma_{R^{USD}}$	Inv-Γ	2.5	2	0.666	0.116
Uncovered interest parity condition					
uip^*	β	0.65	0.1	0.427	0.038
$100\sigma_{uip^*}$	Inv-Γ	1	2	1.944	0.133
Price of oil in USD					
$ar_{1,oil}$	β	0.7	0.15	0.313	0.075
$ar_{2,oil}$	N	0	0.1	0.335	0.078
$10\sigma_{oilusd}$	Inv-Γ	0.5	2	0.821	0.077

Table D.4: *Estimated parameters: external sector, excess trends*

Based on single Metropolis chain with 400,000 draws, after a burn in period of 200,000 draws.					
Parameter	Prior			Posterior	
	Distr.	Mean	s.d./dof	Mean	s.d.
Excess trends AR coefficients					
$\rho^{R^{EUR},EXT}$	β	0.8	0.05	0.889	0.026
$\rho^{R^{US},EXT}$	β	0.8	0.05	0.928	0.011
$\rho^{\pi^{EUR},EXT}$	β	0.8	0.05	0.754	0.049
$\rho^{\pi^{US},EXT}$	β	0.8	0.05	0.758	0.052
$\rho^{S^{USD/EUR},EXT}$	β	0.5	0.15	0.725	0.063
$\rho^{\pi^{oil,USD},EXT}$	β	0.5	0.15	0.741	0.079
Standard deviations					
$\sigma_{R^{EUR},EXT}$	Inv-Γ	$\sqrt{0.3}$	10	0.533	0.014
$\sigma_{R^{US},EXT}$	Inv-Γ	$\sqrt{0.54}$	10	0.719	0.019
$\sigma_{\pi^{EUR},EXT}$	Inv-Γ	$\sqrt{0.13}$	10	0.285	0.044
$\sigma_{\pi^{US},EXT}$	Inv-Γ	$\sqrt{0.42}$	10	0.513	0.085
$\sigma_{S^{USD/EUR},EXT}$	Inv-Γ	$\sqrt{1.7}$	10	1.321	0.038
$\sigma_{\pi^{oil,USD},EXT}$	Inv-Γ	$\sqrt{295}$	10	17.661	0.523
$\sigma_{y^{EUR},ME}$	Inv-Γ	$\sqrt{0.04}$	10	0.165	0.029
$\sigma_{y^{US},ME}$	Inv-Γ	$\sqrt{0.04}$	10	0.194	0.039

E Estimated parameters - excess trends

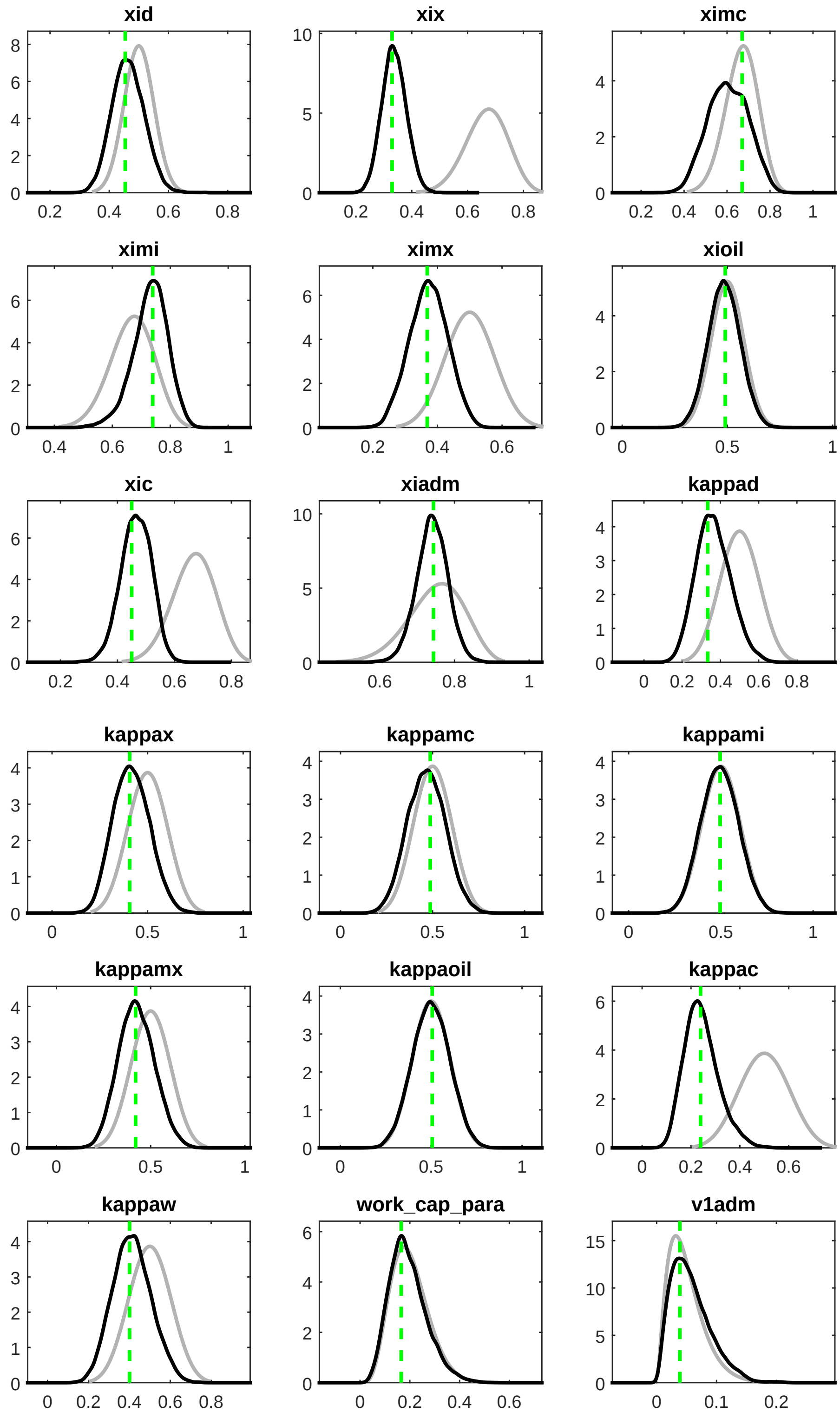
Table E.1: *Estimated auto-regressive parameters and st. deviations - excess trends*

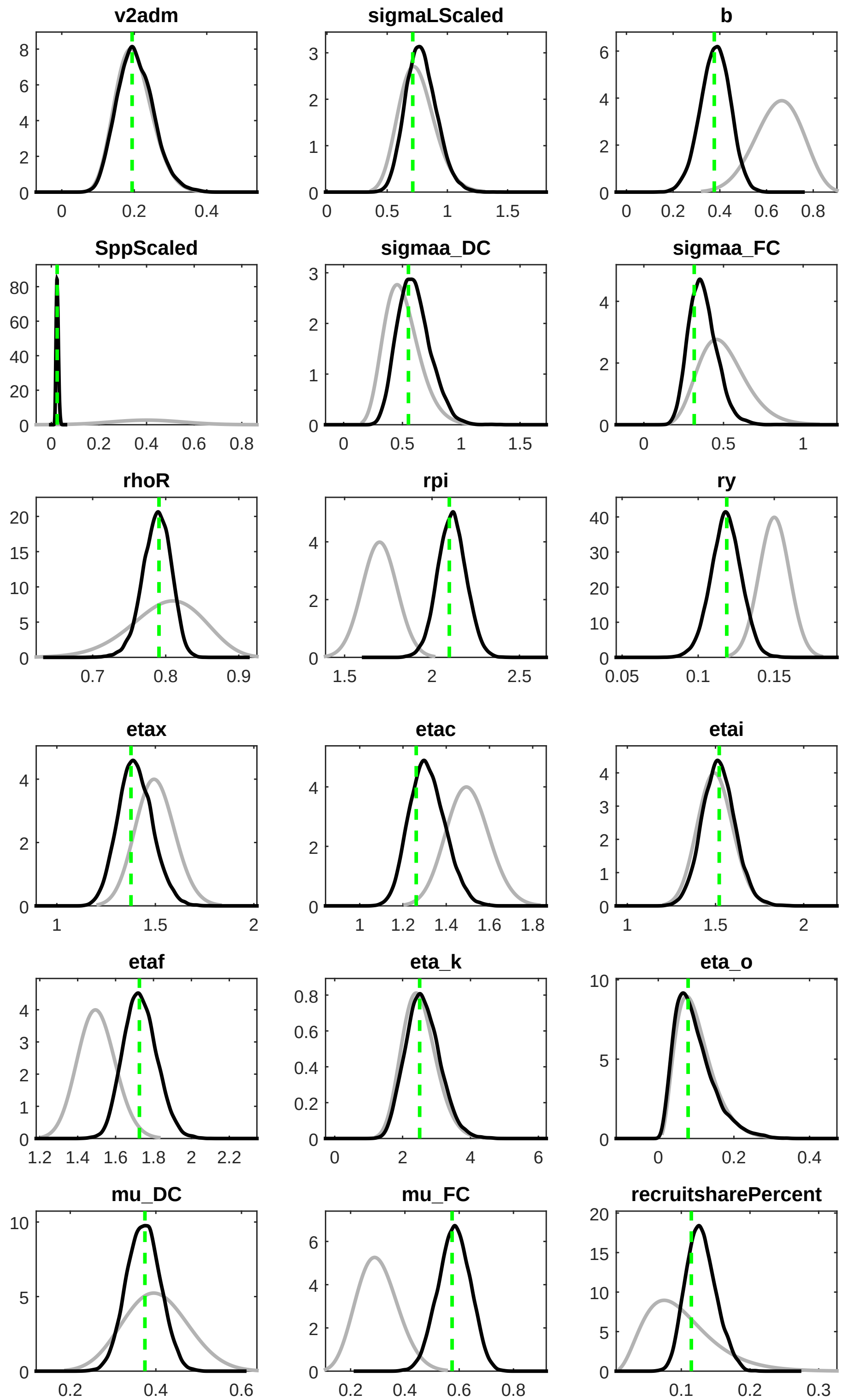
Based on single Metropolis chain with 400,000 draws, after a burn in period of 200,000 draws.

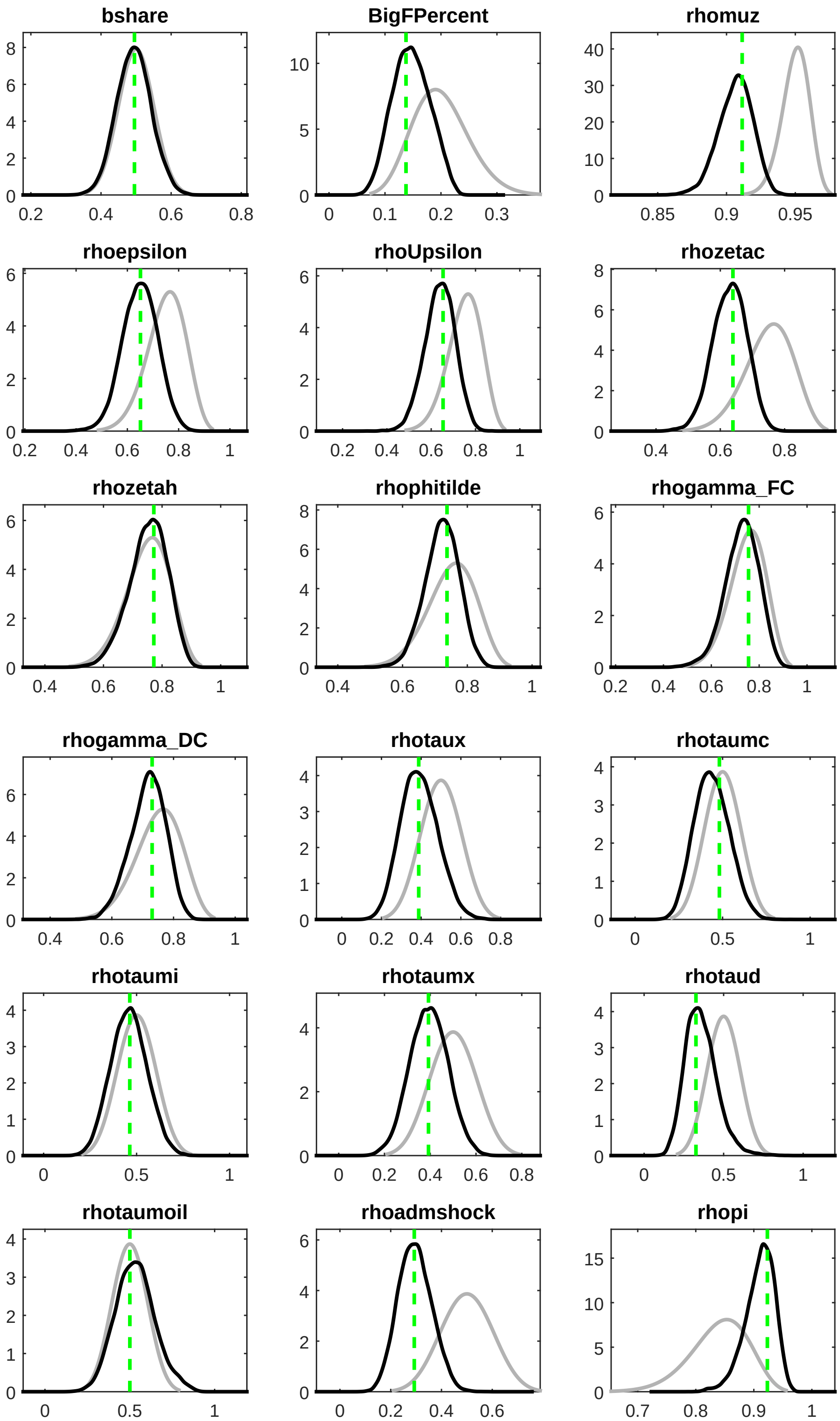
Parameter	Prior			Posterior			
	Distr.	Mean	s.d.	Mean	s.d.	10%	90%
$\rho^{\bar{\pi}^c,EXT}$	β	0.1	0.025	0.104	0.026	0.060	0.144
$\rho^{\pi^{GDP},EXT}$	β	0.15	0.05	0.103	0.035	0.046	0.159
$\rho^{\pi^c,EXT}$	β	0.15	0.05	0.112	0.037	0.050	0.169
$\rho^{\pi^{core1},EXT}$	β	0.15	0.05	0.112	0.037	0.052	0.169
$\rho^{\pi^i,EXT}$	β	0.15	0.05	0.106	0.037	0.045	0.164
$\rho^{\pi^x,EXT}$	β	0.15	0.05	0.130	0.043	0.059	0.197
$\rho^{\pi^m,EXT}$	β	0.15	0.05	0.136	0.045	0.063	0.208
$\rho^{c,EXT}$	β	0.15	0.05	0.142	0.048	0.066	0.221
$\rho^{i,EXT}$	β	0.15	0.05	0.160	0.052	0.074	0.241
$\rho^{x,EXT}$	β	0.15	0.05	0.173	0.056	0.081	0.263
$\rho^{m,EXT}$	β	0.15	0.05	0.131	0.043	0.062	0.198
Parameter	Prior			Posterior			
	Distr.	Mean	df.	Mean	s.d.	10%	90%
$\sigma_{\bar{\pi}^c,EXT}$	Inv-Γ	0.35	100	0.338	0.023	0.299	0.375
$\sigma_{\pi^{GDP},EXT}$	Inv-Γ	2.25	100	4.197	0.254	3.784	4.624
$\sigma_{\pi^c,EXT}$	Inv-Γ	0.96	100	0.797	0.036	0.740	0.856
$\sigma_{\pi^{core1},EXT}$	Inv-Γ	1.05	100	0.803	0.034	0.750	0.860
$\sigma_{\pi^{adm},EXT}$	Inv-Γ	1.55	100	1.533	0.087	1.393	1.675
$\sigma_{\pi^i,EXT}$	Inv-Γ	5.78	100	13.40	1.026	11.66	15.04
$\sigma_{\pi^x,EXT}$	Inv-Γ	4.56	100	5.488	0.425	4.769	6.171
$\sigma_{\pi^m,EXT}$	Inv-Γ	4.29	100	4.652	0.370	4.044	5.255
$\sigma_{\Delta y,ME}$	Inv-Γ	0.36	100	0.440	0.041	0.374	0.506
$\sigma_{\Delta c,EXT}$	Inv-Γ	0.68	100	0.716	0.056	0.625	0.806
$\sigma_{\Delta i,EXT}$	Inv-Γ	2.45	100	2.831	0.218	2.472	3.184
$\sigma_{\Delta x,EXT}$	Inv-Γ	1.90	100	1.651	0.148	1.410	1.890
$\sigma_{\Delta m,EXT}$	Inv-Γ	1.38	100	1.928	0.146	1.689	2.164
$\sigma_{\Delta ft,ME}$	Inv-Γ	4.36	100	4.694	1.185	2.870	6.469
$\sigma_{\Delta spread^{DC}}$	Inv-Γ	5.62	100	7.602	0.590	6.635	8.585
$\sigma_{\Delta spread^{FC}}$	Inv-Γ	2.65	100	3.001	0.276	2.541	3.440
$\sigma_{\Delta s^{RON/EUR}}$	Inv-Γ	1.00	100	1.295	0.103	1.128	1.469
$\sigma_{\Delta H}$	Inv-Γ	0.35	100	0.344	0.024	0.306	0.382
$\sigma_{\Delta U}$	Inv-Γ	1.31	100	1.608	0.138	1.376	1.828
$\sigma_{\Delta W}$	Inv-Γ	0.62	100	0.969	0.078	0.841	1.091

F Prior and posterior distributions

F.1 Domestic sector




v2adm
0 2 4 6 8
0 0.2 0.4
sigmaLScaled
0 1 2 3
0 0.5 1 1.5
b
0 2 4 6
0 0.2 0.4 0.6 0.8
SppScaled
0 20 40 60 80
0 0.2 0.4 0.6 0.8
sigmaa_DC
0 1 2 3
0 0.5 1 1.5
sigmaa_FC
0 2 4
0 0.5 1
rhoR
0 5 10 15 20
0.7 0.8 0.9
rpi
0 2 4
1.5 2 2.5
ry
0 10 20 30 40
0.05 0.1 0.15
etax
0 2 4
1 1.5 2
etac
0 2 4
1 1.2 1.4 1.6 1.8
etai
0 1 2 3 4
1 1.5 2
etaf
0 1 2 3 4
1.2 1.4 1.6 1.8 2 2.2
eta_k
0 0.2 0.4 0.6 0.8
0 2 4 6
eta_o
0 5 10
0 0.2 0.4
mu_DC
0 5 10
0.2 0.4 0.6
mu_FC
0 2 4 6
0.2 0.4 0.6 0.8
recruitsharePercent
0 5 10 15 20
0.1 0.2 0.3


bshare
8
6
4
2
0
0.2
0.4
0.6
0.8
BigFPercent
10
5
0
0
0.1
0.2
0.3
rhomuz
40
30
20
10
0
0.85
0.9
0.95
rhoepsilon
6
4
2
0
0.2
0.4
0.6
0.8
1
rhoUpsilon
6
4
2
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0.2
0.4
0.6
0.8
1
rhozetac
8
6
4
2
0
0.4
0.6
0.8
rhozetah
6
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2
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0.6
0.8
1
rhophitilde
8
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2
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0.4
0.6
0.8
1
rhogamma_FC
6
4
2
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0.4
0.6
0.8
1
rhogamma_DC
6
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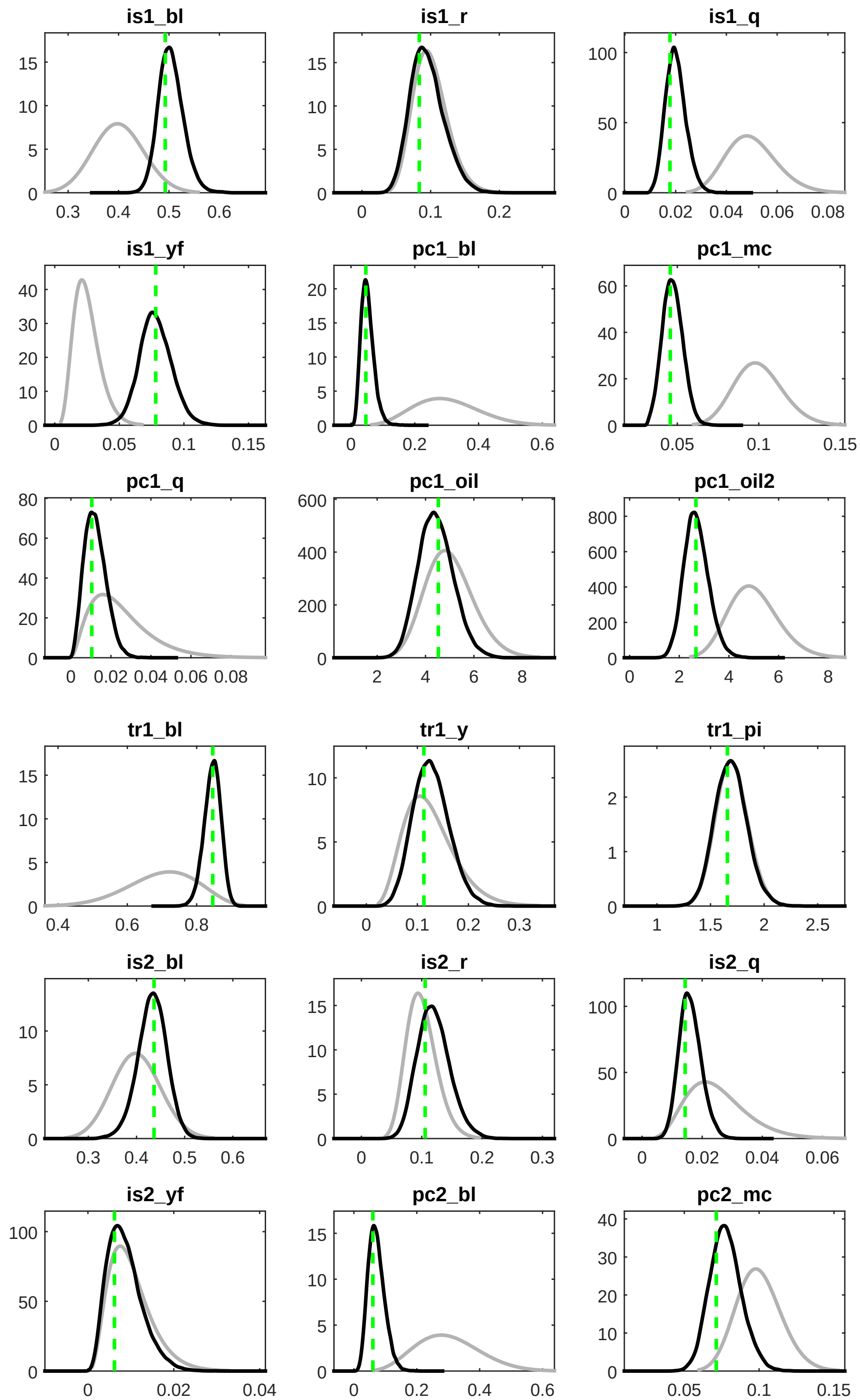
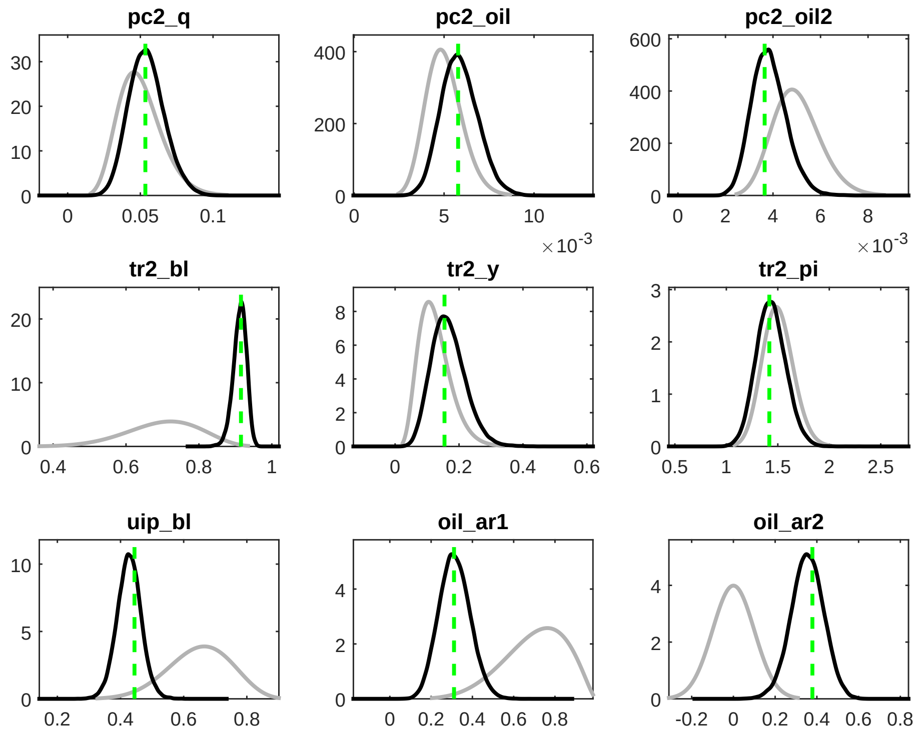
0.4
0.6
0.8
1
rhotaux
4
3
2
1
0
0
0.2
0.4
0.6
0.8
rhotaumc
4
3
2
1
0
0
0.5
1
rhotaumi
4
3
2
1
0
0
0.5
1
rhotaumx
4
2
0
0
0.2
0.4
0.6
0.8
rhotaud
4
3
2
1
0
0
0.5
1
rhotaumoil
4
3
2
1
0
0
0.5
1
rhoadmshock
6
4
2
0
0
0.2
0.4
0.6
rhopi
15
10
5
0
0.7
0.8
0.9
1

F.2 External sector




pc2_q
pc2_oil
pc2_oil2
×10-3
tr2_bl
tr2_y
tr2_pi
uip_bl
oil_ar1
oil_ar2

G Impulse response functions

Figure G.1: *IRFs to the unit root neutral technology shock*

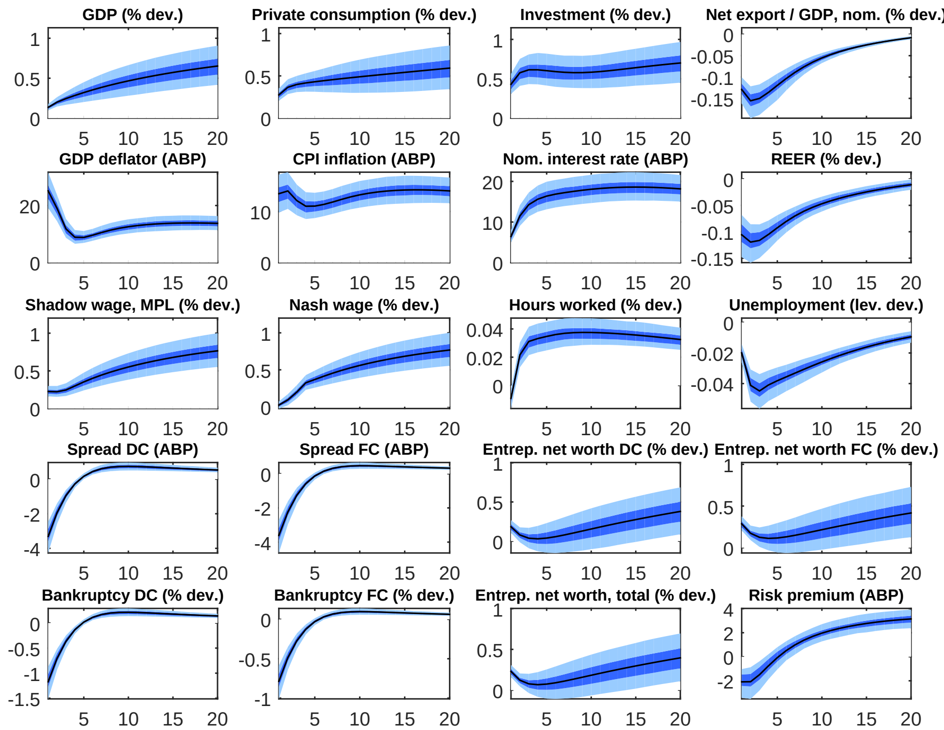


Figure G.2: *IRFs to the marginal efficiency of investment shock*

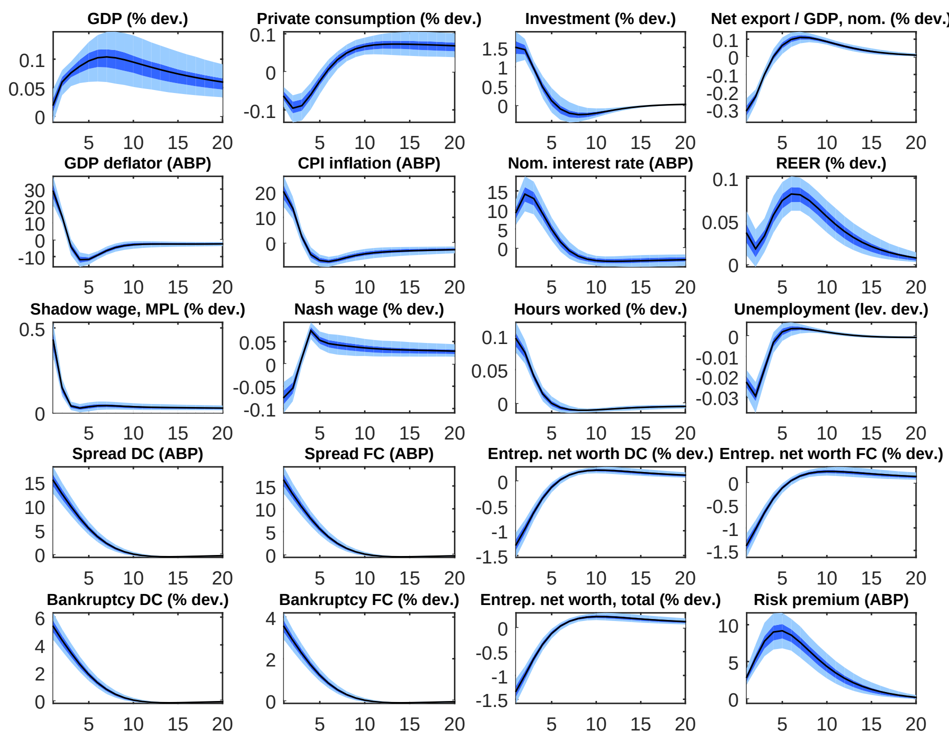


Figure G.3: *IRFs to the labor disutility shock*

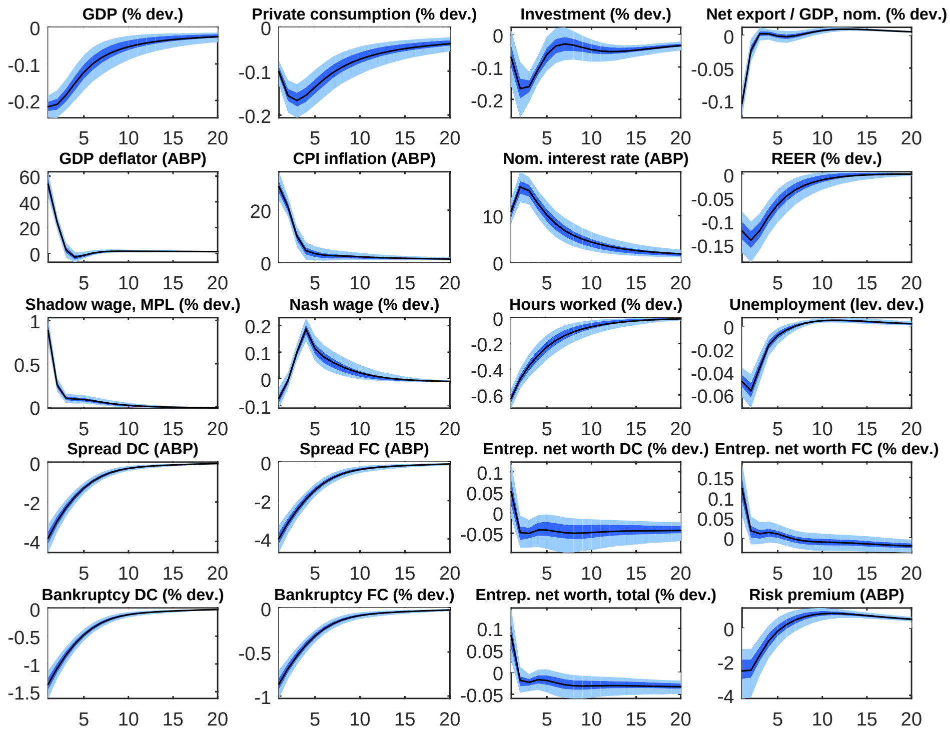


Figure G.4: *IRFs to the government expenditure shock*

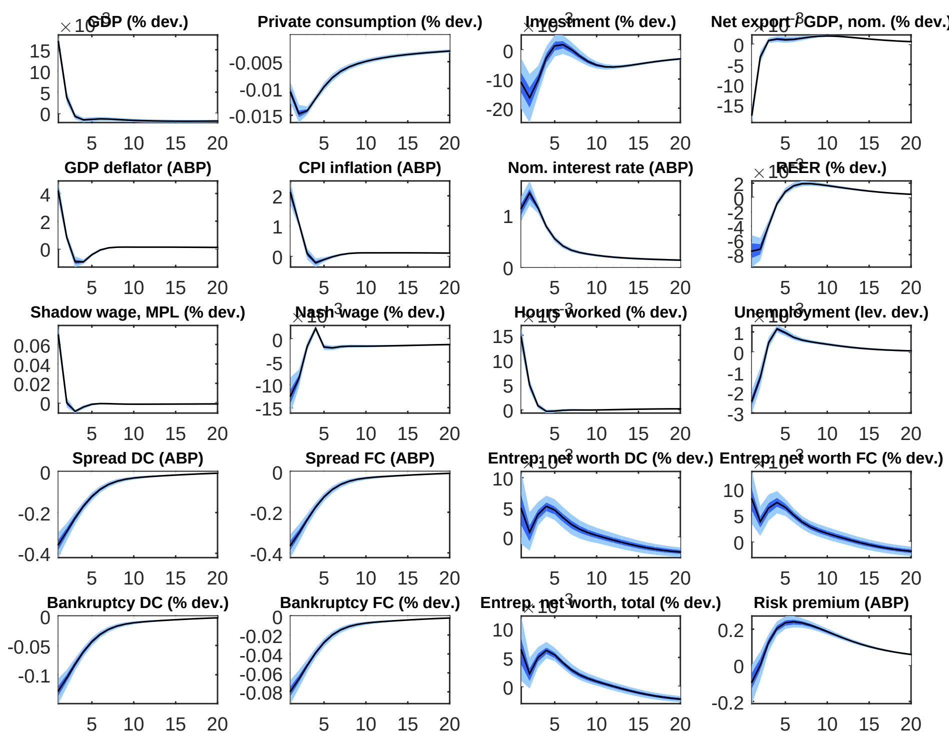


Figure G.5: *IRFs to the consumption preference shock*

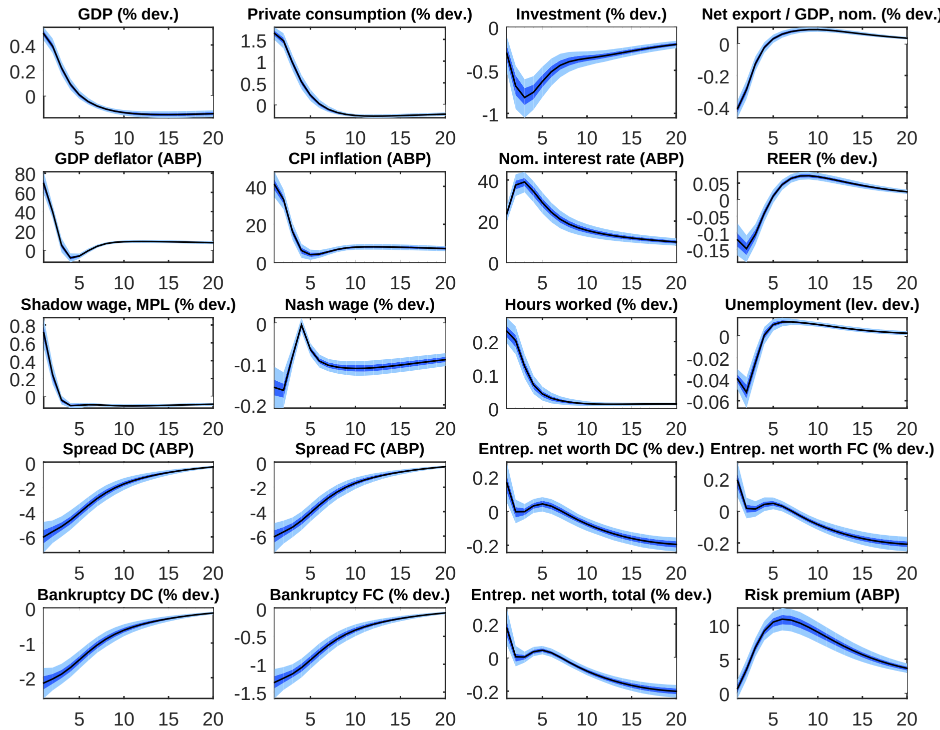


Figure G.6: *IRFs to the markup shock for domestic intermediate goods producers*

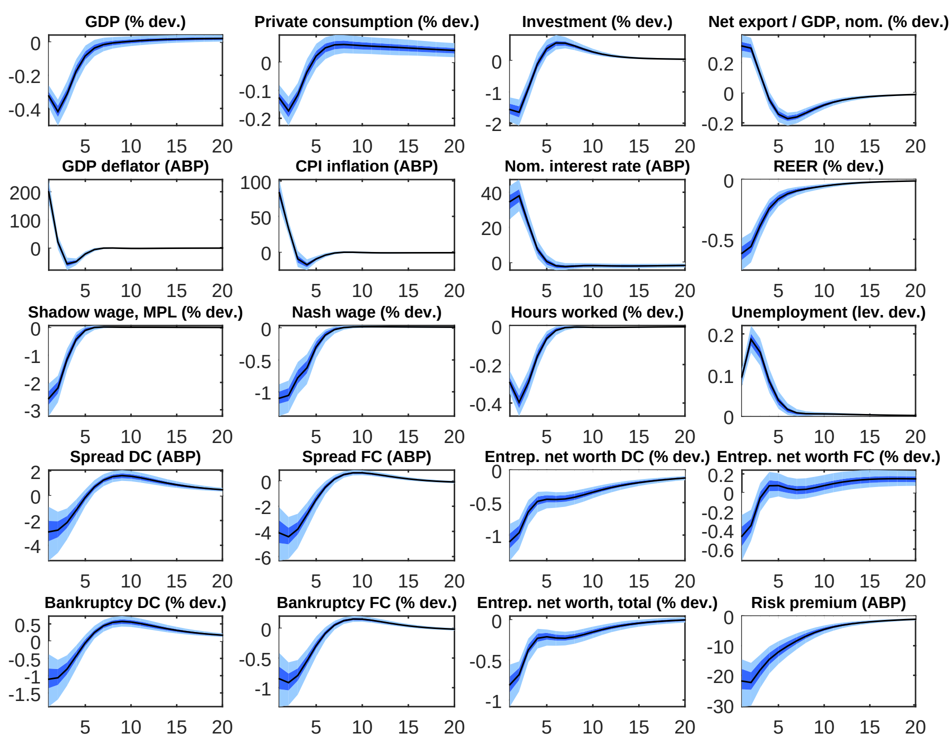


Figure G.7: *IRFs to the exports markup shock*

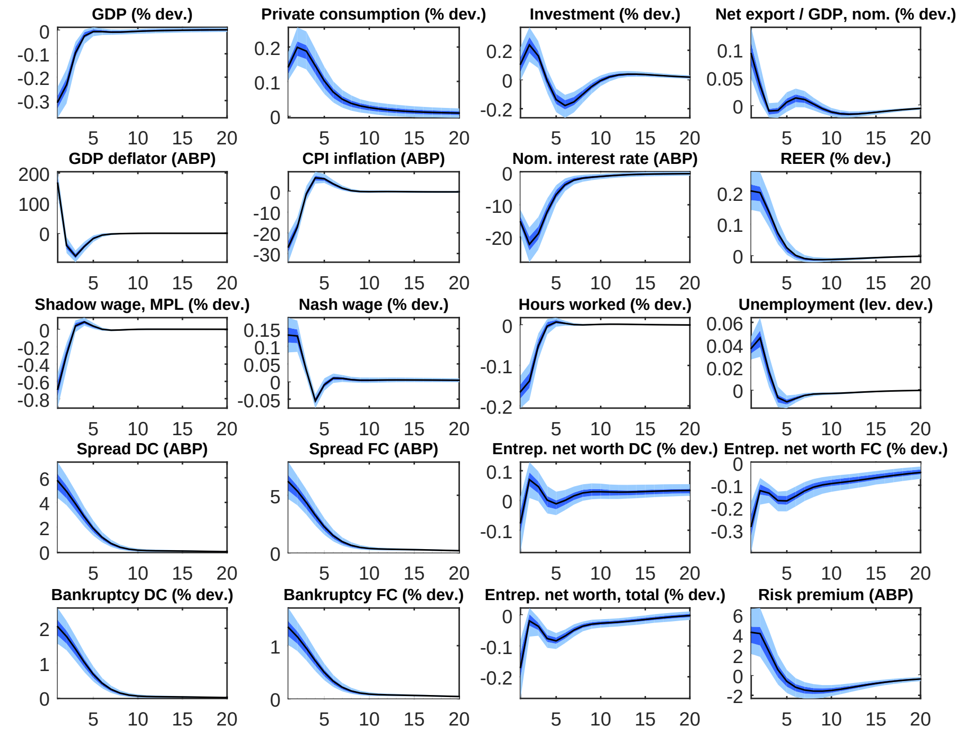


Figure G.8: *IRFs to the imported consumption markup shock*

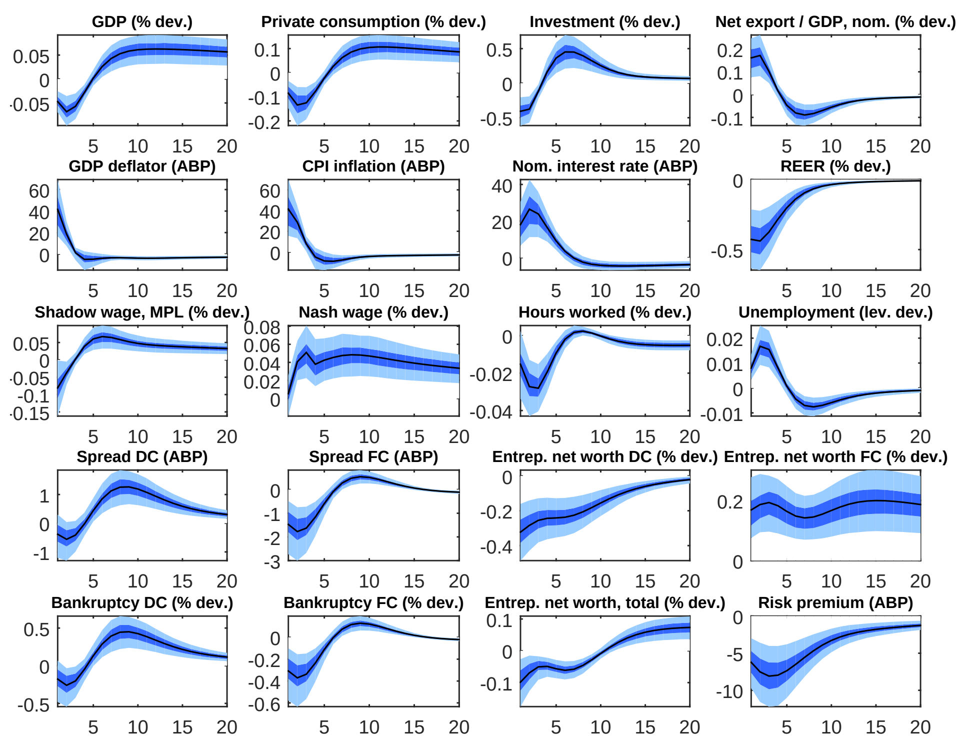


Figure G.9: *IRFs to the imported investment markup shock*

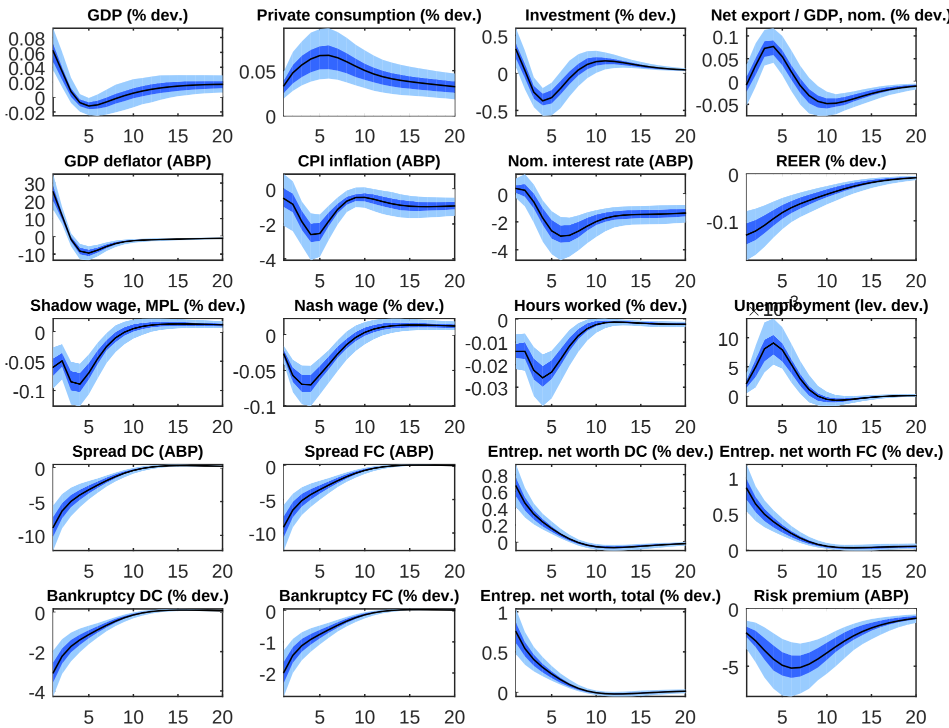


Figure G.10: *IRFs to the imported exports markup shock*

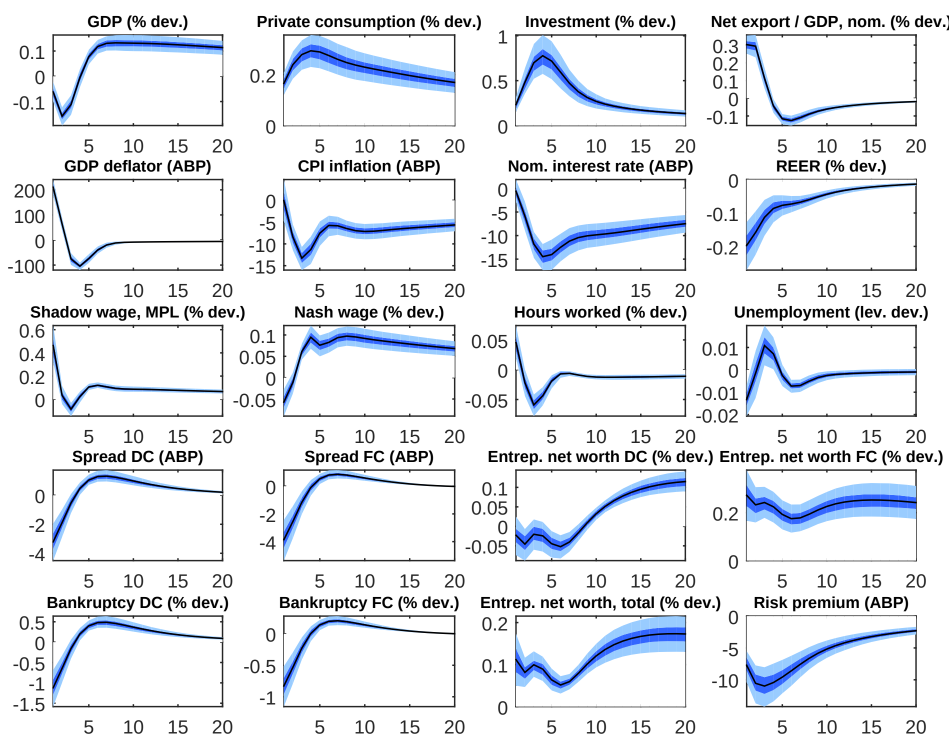


Figure G.11: *IRFs to the imported oil markup shock*

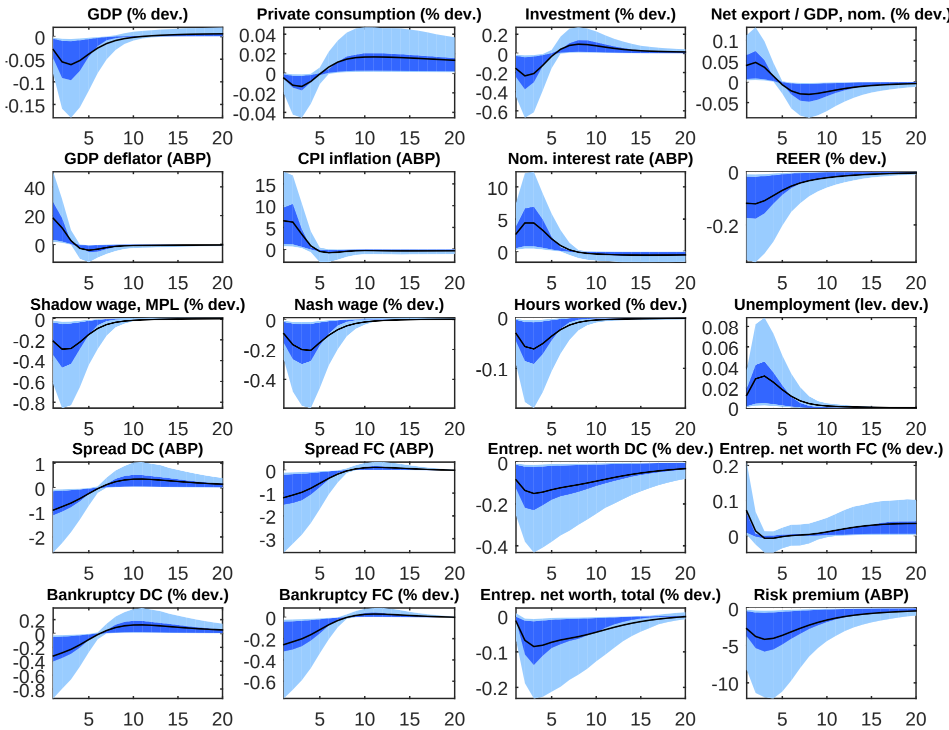


Figure G.12: *IRFs to the entrep. net worth shock, FC*

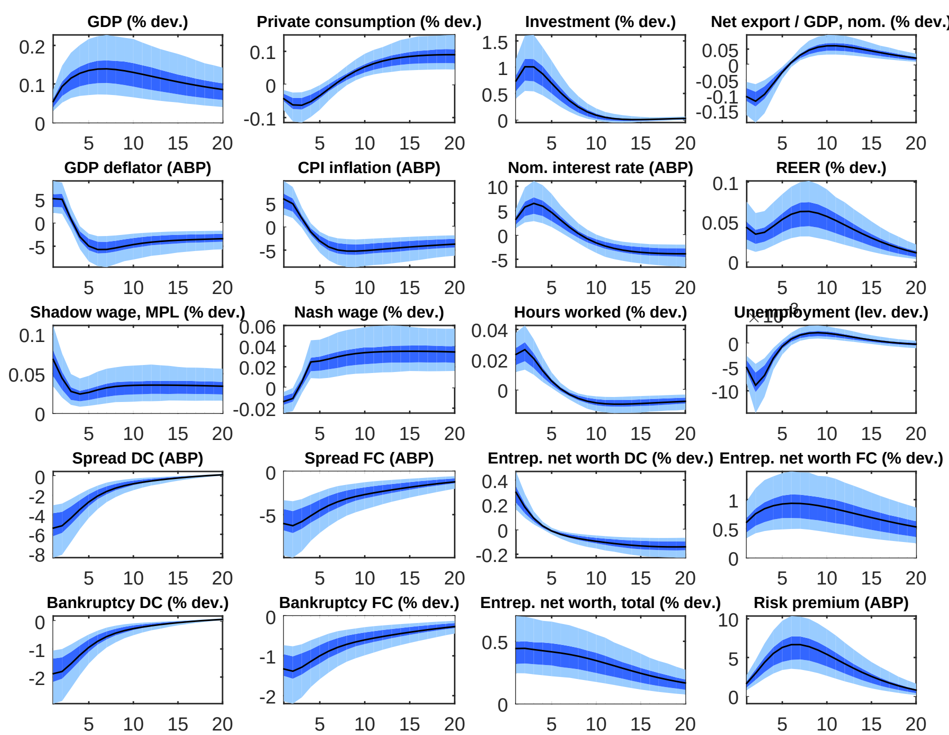


Figure G.13: *IRFs to the Euro area GDP shock*

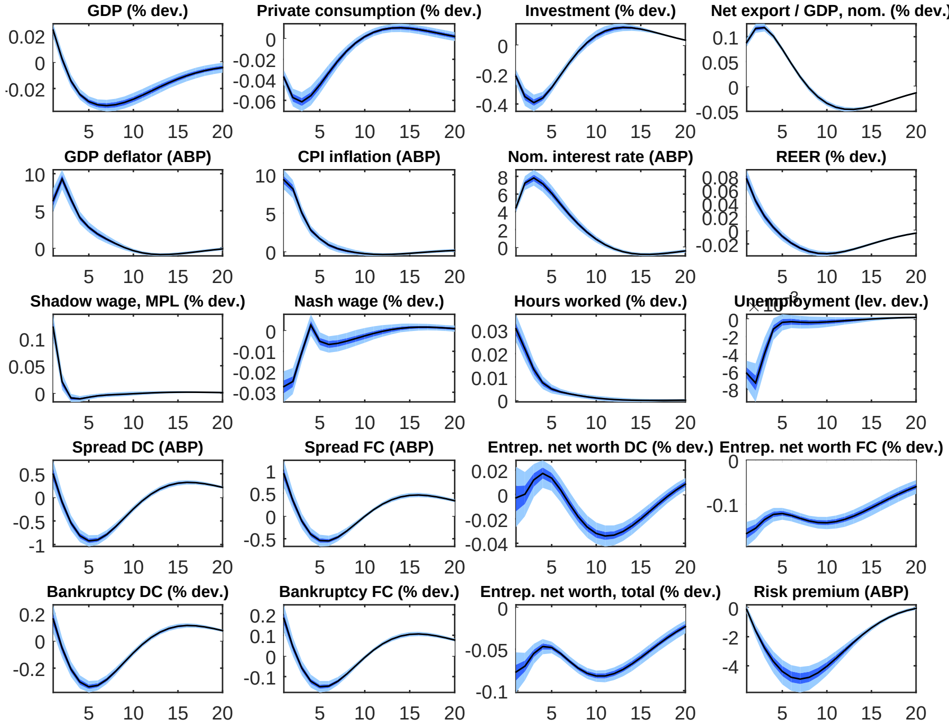


Figure G.14: *IRFs to the US GDP shock*

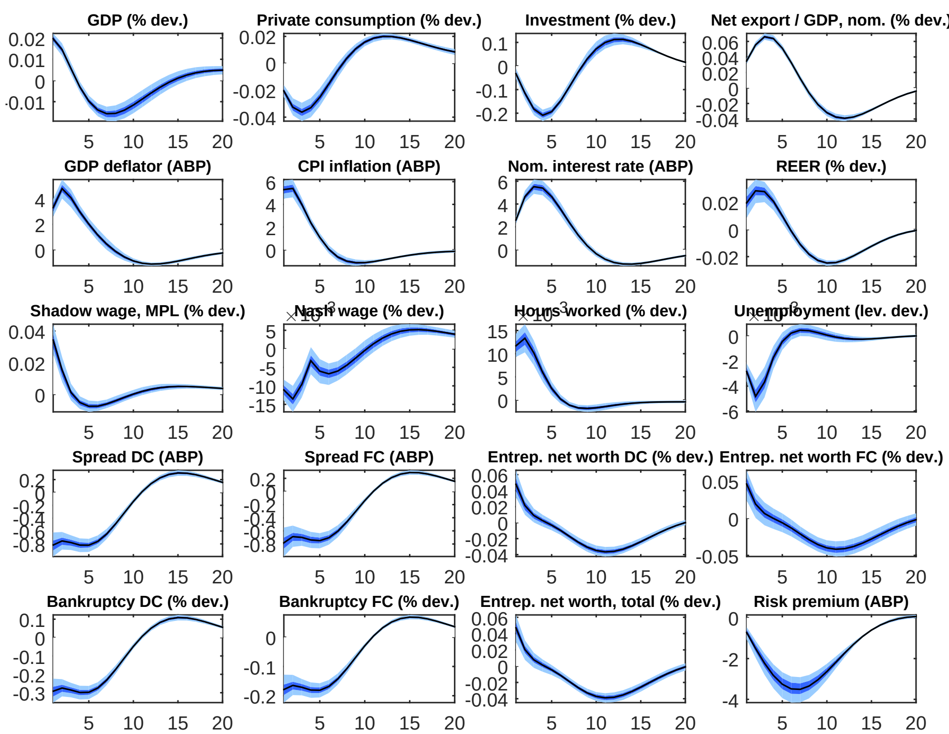


Figure G.15: *IRFs to the Euro area inflation shock*

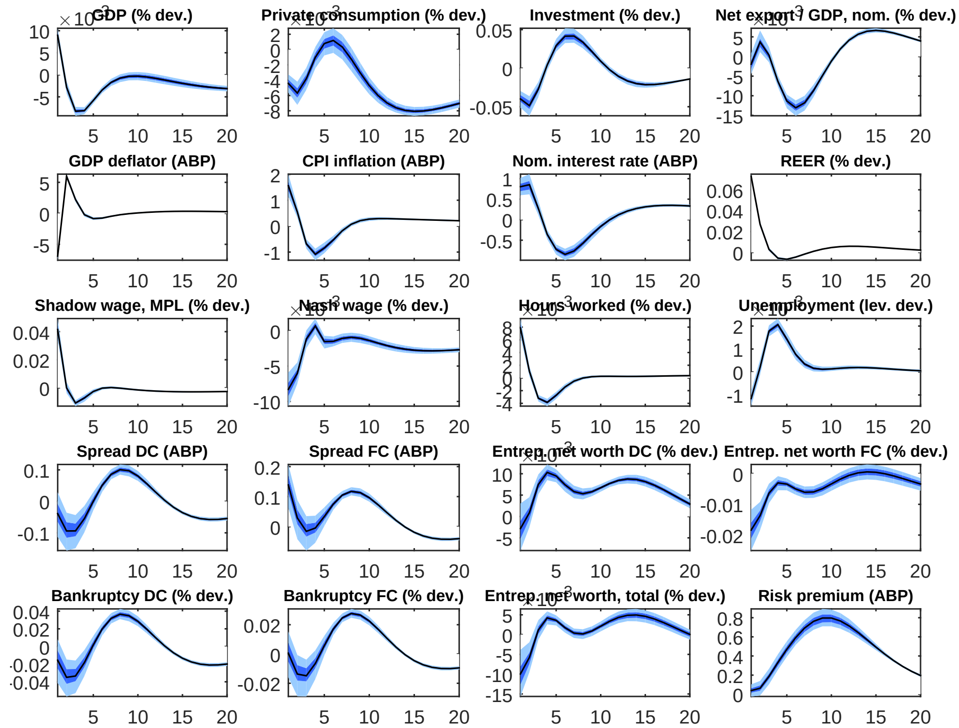


Figure G.16: *IRFs to the US inflation shock*

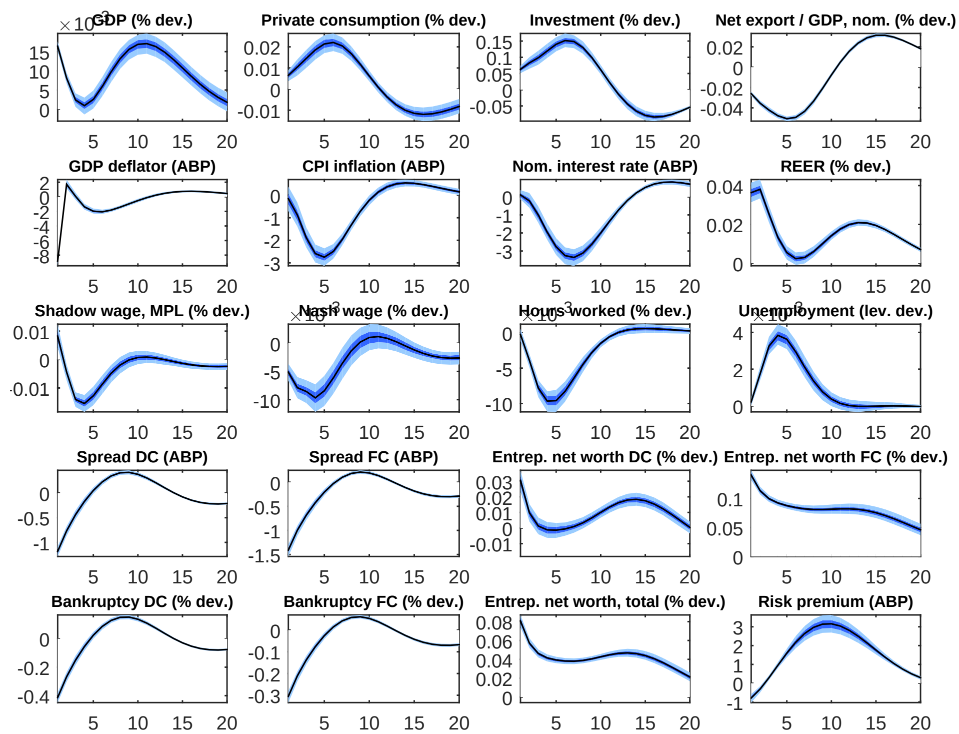


Figure G.17: *IRFs to the Euro area monetary policy shock*

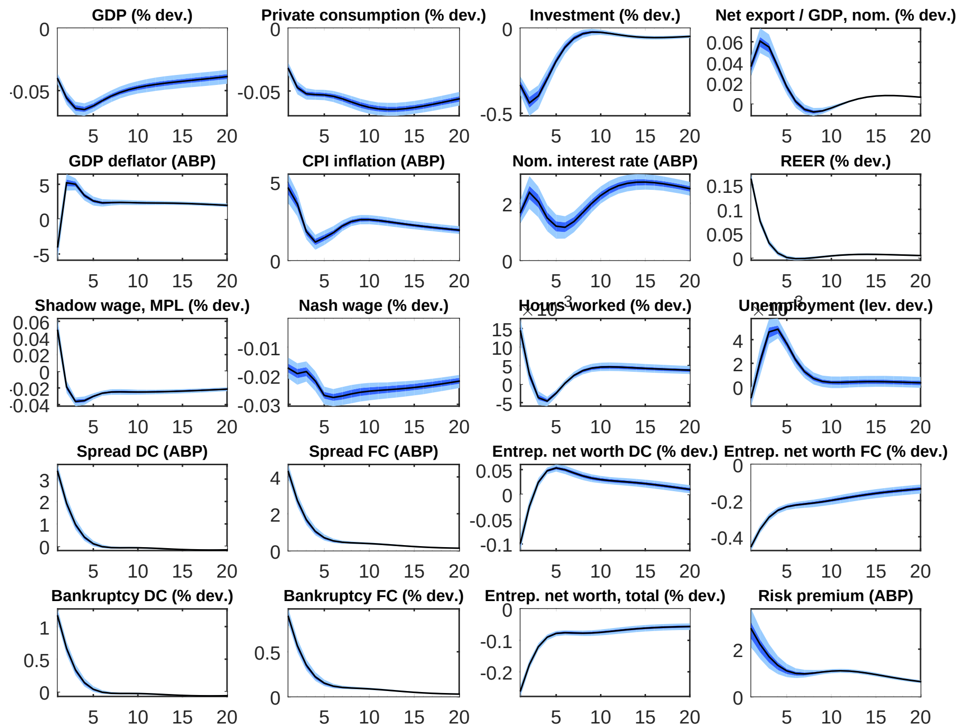


Figure G.18: *IRFs to the US monetary policy shock*

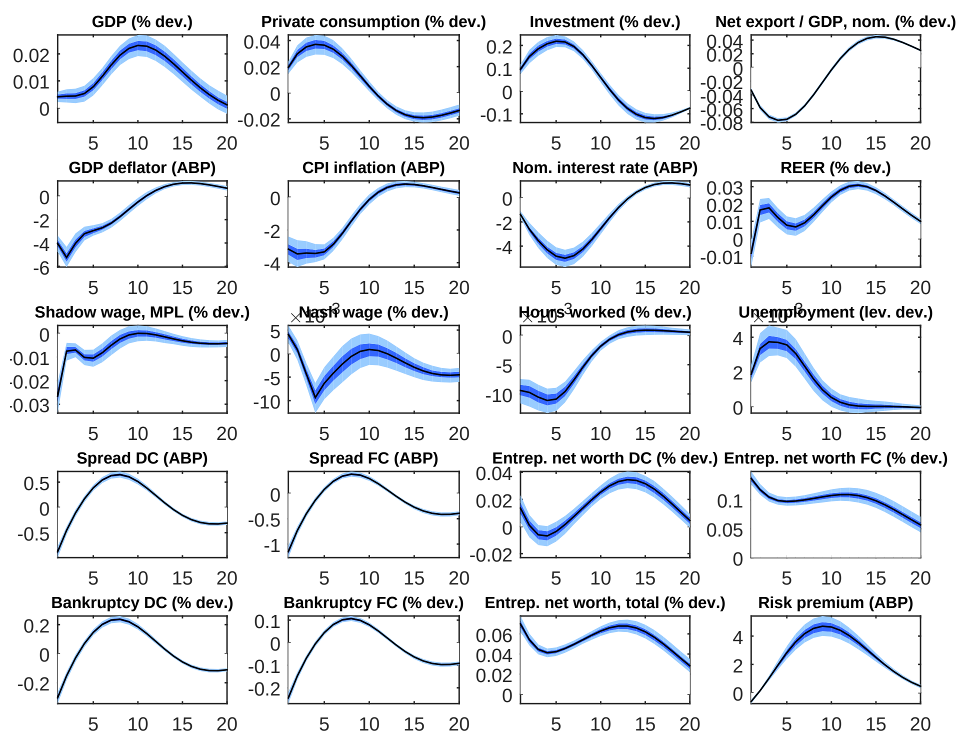


Figure G.19: *IRFs to the EUR/USD UIP shock*

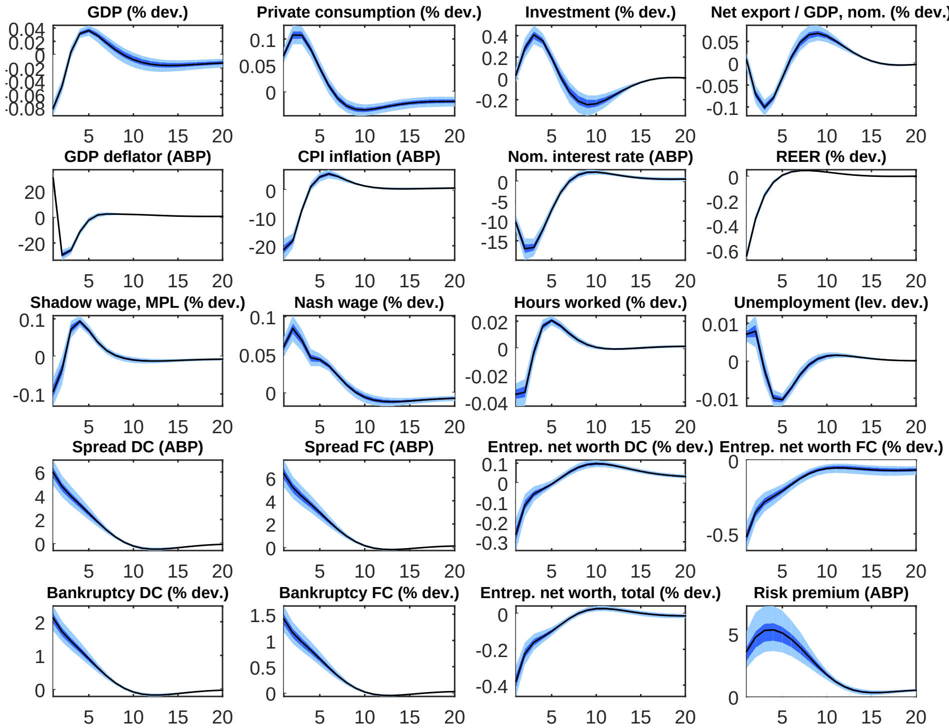


Figure G.20: *IRFs to the oil price shock*

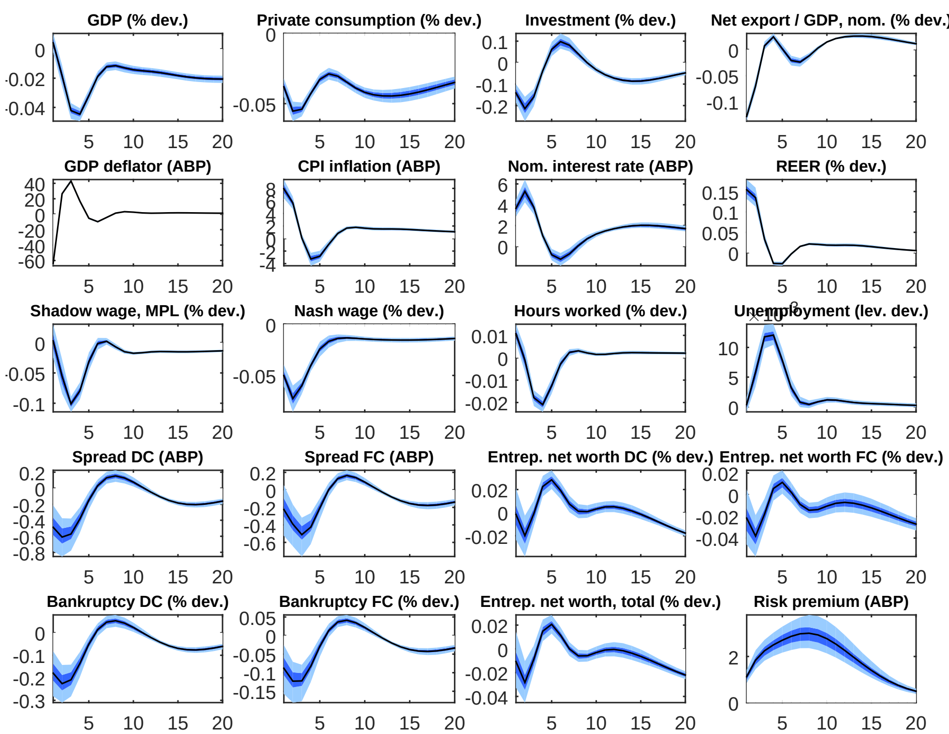
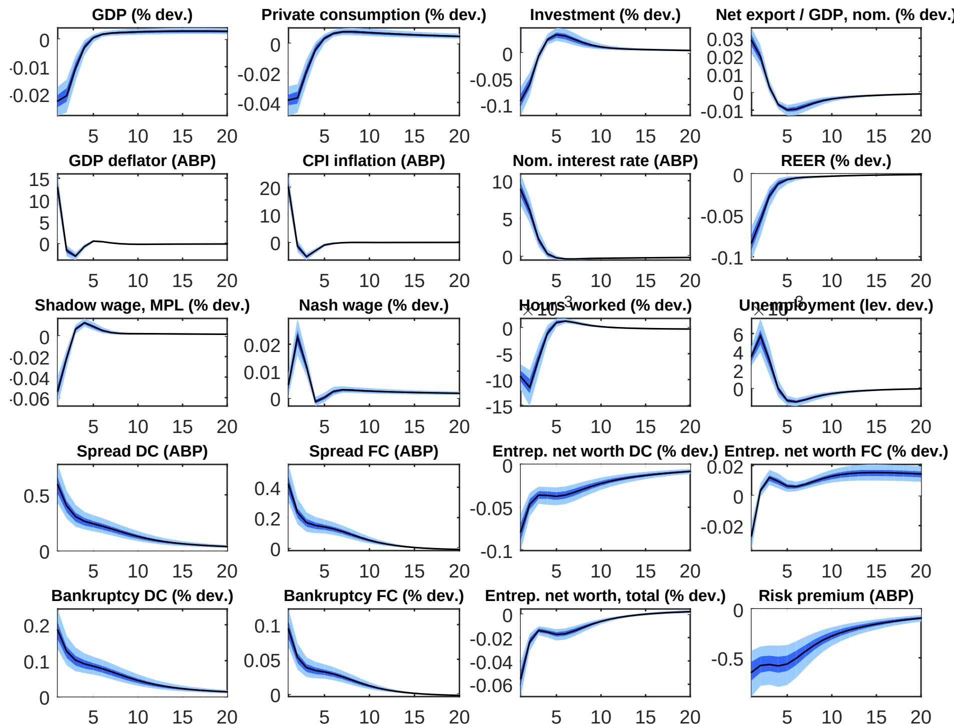


Figure G.21: *IRFs to the administered prices shock*



H Alternative models

In this section, we compare the baseline estimated model with two alternative specification: the first one *(Alternative 1)* is the main model estimated without endogenous priors, while the second one *(Alternative 2)* differs only with respect to the Taylor rule used. Namely, we specify a Taylor rule in which the monetary authority, besides the current deviation of output from its steady state value, responds to the deviation of the 4 quarters ahead expected annual inflation (i.e. $\frac{\pi^c_{t+4}+\pi^c_{t+3}+\pi^c_{t+2}+\pi^c_{t+1}}{4}$) from the corresponding target. In estimating all three models, we use for the exogenously estimated external sector the results associated with the baseline specification[3].

When looking at the differences, we focus on the following two dimensions: standard deviations matching and impulse response functions. At least the following two observations emerge:

- There is a tendency in the no endogenous priors model of generating higher model implied standard deviations relative to the ones observed in the data (see table H.1). This is especially the case for inflation rates, nominal interest rate, change in nominal wages and variations in spreads. This is also true when the baseline specification is used as a benchmark, with the exception of change in real GDP, for which the *Alternative 1* matches a volatility closer to the one present in the data.

[3]The results presented here use, for each model, the mean values of the parameters based on single Metropolis chain with 400,000 draws, after a burn in period of 200,000 draws. The acceptance rates were 0.2368 for *Alternative 1*, 0.2487 for *Alternative 2* and 0.2389 for the baseline model.

Table H.1: *Data and moments (%) - baseline versus alternative models*

Romania, 2005Q3-2014Q3 (January 2015 vintage)						
Variable	Explanation	St. dev.				Sampling
		Data	Baseline	Alternative 1	Alternative 2	uncertainty
				No endog. priors	Taylor modified	
$100^{*}\Delta GDP$	GDP growth	1.6	1.2	1.5	1.2	1.2
$100^{*}\Delta c$	Consumption growth	2.1	2.2	2.1	2.2	1.9
$100^{*}\Delta i$	Investment growth	7.7	6.6	8.2	6.0	35.0
$100^{*}\Delta x$	Export growth	4.4	5.1	5.8	5.6	5.9
$100^{*}\Delta m$	Import growth	5.5	5.0	5.8	5.3	10.7
$400^{*}\bar{\pi}^{c}$	Inflation target	1.1	1.4	0.9	1.4	0.6
$400^{*}\pi^{GDP}$	Domestic inflation	7.1	6.6	13.4	6.9	12.7
$400^{*}\pi^{i}$	Investment inflation	18.3	13.9	16.2	13.9	66.7
$400^{*}\pi^{x}$	Exports inflation	14.4	13.3	21.0	14.8	81.6
$400^{*}\pi^{m}$	Imports inflation	13.6	10.6	21.6	11.8	54.7
$400^{*}\pi^{c}$	CPI inflation	3.0	3.0	12.0	3.5	2.3
$400^{*}\pi^{core1}$	CORE1 inflation	3.3	3.3	12.5	3.9	2.7
$400^{*}\pi^{adm}$	Adm. prices inflation	4.9	7.2	14.7	7.3	4.9
$400^{*}R$	Nom. interest rate	2.3	2.8	13.6	2.8	2.0
$100^{*}\Delta H$	Total hours growth	1.1	1.0	1.3	1.0	0.4
$100^{*}\Delta w$	Nominal wage growth	2.0	1.3	3.8	1.5	1.1
$100^{*}\Delta u$	Unempl.rate growth	4.1	3.8	6.6	4.0	5.1
$100^{*}\Delta spread^{DC}$	Spread growth DC	17.8	16.6	32.4	16.2	98.7
$100^{*}\Delta spread^{FC}$	Spread growth FC	8.4	10.0	13.9	10.0	30.0
$100^{*}\Delta\log(S^{RON/EUR})$	Nominal ER	3.2	2.4	4.8	2.6	3.7
$100^{*}\Delta ftr$	ΔFTR balance to GDP	13.8	12.9	13.9	13.5	45.7

- The *Alternative 2* model, that uses a modified Taylor rule, has a relatively similar performance as the baseline specification in terms of matching the standard deviation of the observed series (even more so when one also take into account the sampling uncertainty measure). However, we prefer the baseline given: its (slightly) better performance in terms of matching CPI and CORE1 inflation rates' volatilities and the shape of the impulse response function of investment to a temporary technological shock, as illustrated in figure H.1. Regarding the latter fact, in the *Alternative 2* model, investment falls following a temporary technological shock, while it increases in the baseline specification. The reason for the drop in investment is similar with the one mentioned by Christiano et al. (2011) when a Taylor rule reacting to lagged inflation is used in the presence of nominal debt contracts for entrepreneurs. Namely, in the *Alternative 2* model, except the first quarter, the fall in inflation is stronger and more persistent, as the monetary policy reacts each period to 4 quarters ahead expected annual inflation, which, given the return of inflation to its steady state value from below, is smaller than the current period inflation rate. Thus, in the *Alternative 2* model, the initial reaction of the interest rate is not strong enough to outweigh the surprise disinflation that affects investment through the debt inflation channel.

Figure H.1: *IRFs in baseline and alternative models*