Estimation of an open economy DSGE model for Romania. Do nominal and real frictions matter?

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Aims of the thesis

- Estimating an open economy DSGE model for Romania, based on the model developed by Adolfson et al. (2005);
- Using Bayesian estimation techniques for recovering the posterior mode and distribution for the transitory (non-steady state related) parameters;
- Assesing the significance of various nominal and real frictions in explaining the data generating process with the help of marginal likelihood density.

(Dis)Advantages of DSGE models (Tovar, 2008)

- Advantages:
  - Help to identify (unobservable) sources of fluctuations;
  - Answer questions about structural changes;
  - Forecast and predict the effect of policy changes, which based on the presence of expectations doesn't make them subject to Lucas' critique;
  - Perform counterfactual experiments.
- Disadvantages:
  - Require very complex modeling skills;
  - Solving and estimating them require great technical and computing capacity;
  - Sims (2006) argues that there is no aggregate capital or consumption good, and that DSGE models are only story telling tools.

Brief literature review

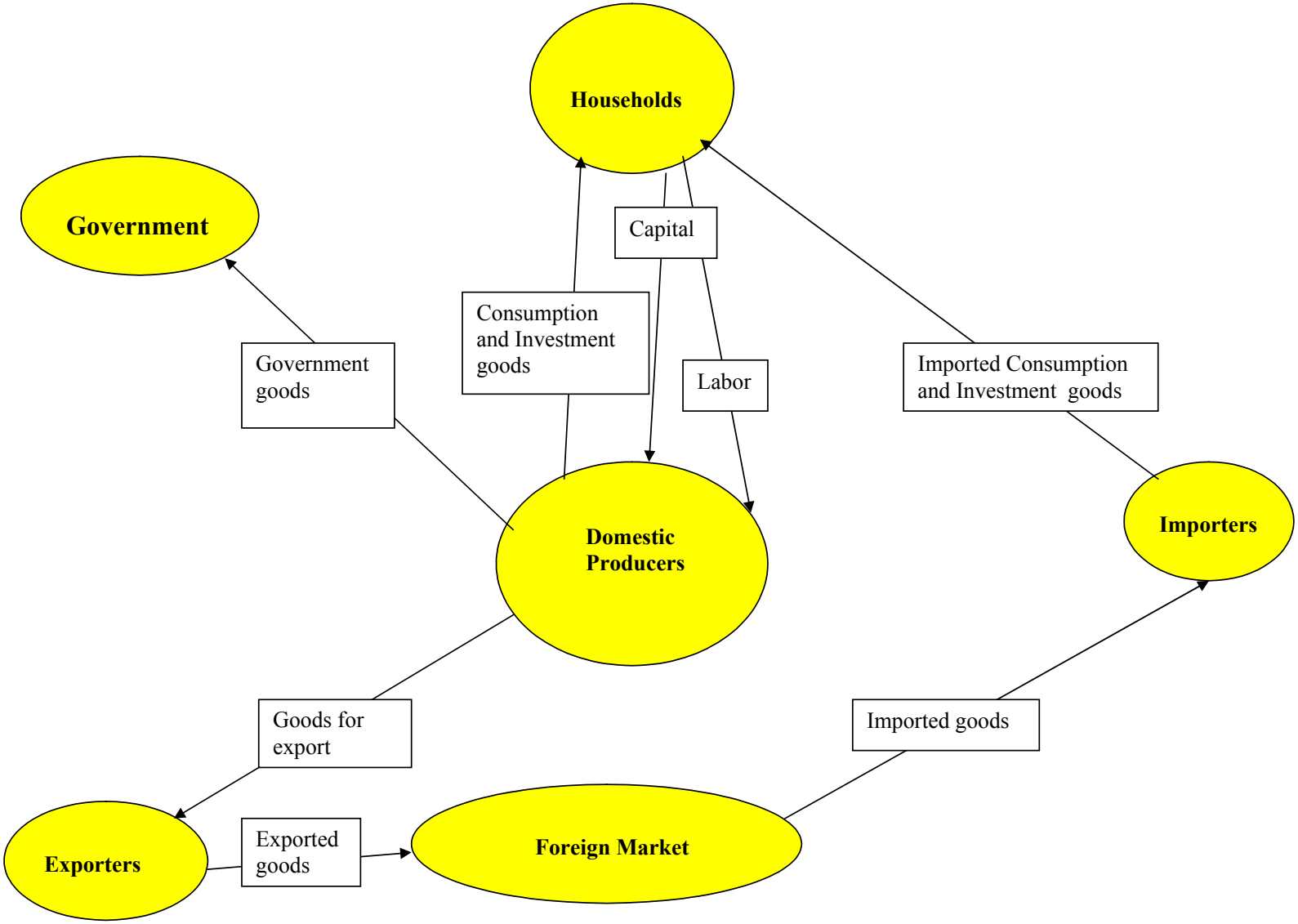
- Seminal paper of Kydland and Prescott (1982) as a foundation for the development of modern DSGE models;
- Different nominal and real frictions added on top of the basic RBC model (e.g. sticky prices, sticky wages, investment adjustment cost, variable capital utilization, working capital channel);
- Important new keynesian based contributions: Clarida et al. (1999),Erceg et al. (2000),Monacelli (2003), Christiano et al. (2005).

Model features

The selected model, as develped by Adolfson et al. (2005), Adolfson et al. (2007) incorporates some (state of the art currently) new keynesian features, like:

- Sticky prices via Calvo (1983) type pricing;
- Sticky wages (Erceg et al., 2000);
- Incomplete exchange rate passthrough (Monacelli, 2003);
- Variable capital utilization, capital adjustment cost (Christiano et al., 2005);
- Working capital channel.

Assumed economy structure, flow of goods



Domestic producers - Final good producer

Final good producing technology:

$$Y_t = \left[\int_0^1 Y_{j,t}^{\frac{1}{\lambda_{d,t}}} \, dj \right]^{\lambda_{d,t}} \tag{1}$$

Solve first order condition of profit maximization problem to obtain a demand for each intermediate good and an aggregated price level P_t:

$$Y_{j,t} = \left(\frac{P_t}{P_{j,t}} \right)^{\frac{\lambda_{d,t}}{\lambda_{d,t}-1}} Y_t. \tag{2}$$

Intermediate good producing firms

A continuum $j \in (0,1)$ use capital, labor and technology with production function:

$$Y_{j,t} = z_t^{1-\alpha} \epsilon_t K_{j,t}^{\alpha} H_{j,t}^{1-\alpha} - z_t \phi. \tag{3}$$

- Cost minimization problem FOCs' yields demand for capital and labor and real marginal cost:

$$\widehat{mc}_t = \alpha \hat{r}_t^k + (1-\alpha)\left(\hat{w}_t + \hat{R}_t^f\right) - \hat{\epsilon}_t \tag{4}$$

- Calvo type pricing, optimize with probability $1-\xi_d$ or update by $P_{t+1} = \pi_t P_t$ with probability ξ_d.
- Log linearization of FOC coming from the maximization of all discounted future profits yields a Phillips curve.

Importing&Exporting firms

Importing firms:

- Import consumption and investment good;
- Real marginal cost $\frac{S_t P_t^*}{P_t^{m,j}}$.

Exporting firms:

- Satisfy external demand by exporting domestic final goods;
- Real marginal cost $\frac{P_t}{S_t P_t^x}$.

For both types of firms sticky prices á la Calvo togheter with LCP (Local Currency Pricing) results in incomplete exchange rate pass-through.

Households

Gain utility from: *consumption, leisure* and *cash balances*.

$$\zeta_t^c \ln\left(C_{j,t} - bC_{j,t-1}\right) - \zeta_t^h A_L \frac{h_{j,t}^{1+\sigma_L}}{1+\sigma_L} + A_q \frac{\left(\frac{Q_{j,t}}{z_t P_t}\right)^{1-\sigma_q}}{1-\sigma_q} \tag{5}$$

Decide on:

- demand for: consumption goods, cash holdings, domestic and foreign bond holdings;
- supply of: labor, capital (utilization rate) stock.

Capital motion law is:

$$\bar{K}_{t+1} = (1-\delta)\bar{K}_t + \Upsilon_t F\left(I_t, I_{t-1}\right) + \Delta_t \tag{6}$$

Households' budget constraint

Households take into account the following budget constraint:

$$M_{j,t+1} + S_t B^*_{j,t+1} + P^c_t C_{j,t}(1+\tau^c_t) + P^i_t I_{j,t} + P_t(a(u_{j,t})\bar{K}_{j,t} +$$
$$+ P_{k',t}\Delta_t) = R_{t-1}\left(M_{j,t} - Q_{j,t}\right) + Q_{j,t} + \left(1-\tau^k_t\right)\Pi_t +$$
$$+ (1-\tau^y_t)\frac{W_{j,t}}{1+\tau^w_t}h_{j,t} + \left(1-\tau^k_t\right)R^k_t u_{j,t}\bar{K}_{j,t} +$$
$$+ R^*_{t-1}\Phi\left(\frac{A_{t-1}}{z_{t-1}}, \tilde{\phi}_{t-1}\right)S_t B^*_{j,t} - \tau^k_t[(R_{t-1}-1)(M_{j,t}-Q_{j,t}) +$$
$$+ \left(R^*_{t-1}\Phi\left(\frac{A_{t-1}}{z_{t-1}}, \tilde{\phi}_{t-1}\right) - 1\right)S_t B^*_{j,t} - B^*_{j,t}(S_t - S_{t-1})] + TR_t$$

Sticky wages

- Based on Erceg et al. (2000);
- Households monopolistically supply a differentiated labor good to an "employment agency";
- Can reoptimize their wage with probability $1 - \xi_w$ or they can update it by a rule of thumb: $W_{j,t+1} = \pi_t^c \mu_{z,t+1} W_{j,t}$, with probability ξ_w.

Extensive versus intensive margins labor supply adjustement

- Based on Smets and Wouters (2003);
- Since data on aggregate hours worked is not available, employment is modelled;
- Furthermore, since employment is likely to respond more slowly to shocks than hours, it is modelled on a Calvo basis;
- Thus, firms can reoptimize their employment with probability $1 - \xi_e$ or they can keep it the same with probability ξ_e, the difference being taken up by the each worker's labor input.

Government and Monetary Policy

Government:

- Collects taxes;
- Consumes final produced goods;
- Transfers funds to households;
- Balanced governamental budget - no governamental debt.

Central Bank:

- Follows a Taylor type rule (Smets and Wouters, 2003):

$$\hat{R}_t = \rho_R \hat{R}_{t-1} + (1-\rho_R)(\hat{\bar{\pi}}_t^c + r_\pi(\hat{\pi}_{t-1}^c - \hat{\bar{\pi}}_t^c) + r_y \hat{y}_{t-1} + r_x \hat{x}_{t-1}) + r_{\Delta\pi}\Delta\hat{\pi}_t^c + r_{\Delta y}\Delta\hat{y}_t + \varepsilon_t^R \quad (7)$$

Foreign variables

- Small open economy;
- Foreign variables are exogenious;
- Log linearized variables follow AR(1) processes.

Market clearing

- *Domestic goods market*: Supply of domestic goods equals demand for domestic goods;
- *Net foreign asset position*: Domestic investment in foreign bonds equals net position of importing and exporting firms;
- *Loan market*: Supply of money and domestic deposits of households equal firms' demand for loans

Data

Observable series:

- GDP, consumption, investment, imports, exports, real gross wage growth rate;
- GDP deflator, consumption deflator, investment deflator, CPI;
- Real exchange rate and employment as percent deviation from their mean;
- ROBOR ON expressed as quarterly gross interest rate;
- EA 16 GDP and GDP deflator, EURIBOR ON (Eonia).

Data sources: NIS, EUROSTAT, NBR, www.euribor.org.

Calibrated parameters

Parameter	Value	Parameter	Value
$\tau^k = \tau^y$	0.16	α	0.33
τ^c	0.19	δ	0.0123
τ^w	0.3	A_L	8
β	0.999	λ_w	1.5
μ	1.01	$\lambda_d = \lambda_{m,c} =$	
		$= \lambda_{m,i}$	1.2
μ_z	1.005	$\tilde{S}''$	13
g	0.13	ξ_e	0.7
A_q	0.46	σ_L	1
ω_c	0.49	$\rho_{\bar{\pi}}$	0.975
ω_i	0.57	ρ_{y^*}	0.51
ν	1	ρ_{R^*}	0.93
σ_q	10.62	ρ_{π^*}	0.1
σ_a	0.049	$\sigma_{\varepsilon^\Upsilon}$	0.1
		$\sigma_{\varepsilon_{\mu_z}}$	0.2

Prior distributions of Parameters

Parameter	Distribution	Mean	Std. err.
Calvo wages ξ_w	Beta	0.75	0.1
Calvo domestic price ξ_d	Beta	0.67	0.1
Calvo import consumption price $\xi_{m,c}$	Beta	0.67	0.1
Calvo import investment price $\xi_{m,i}$	Beta	0.67	0.1
Calvo export price ξ_x	Beta	0.67	0.1
Consumption habit b	Beta	0.85	0.05
Elasticity of substitution investment η_i	Inverse Gamma	1.5	2
Elasticity of substitution foreign η_f	Inverse Gamma	1.5	2
Elasticity of substitution consumption η_c	Inverse Gamma	1.5	2
Risk premium ϕ_a	Inverse Gamma	0.01	2
Taylor interes rate smoothing ρ_R	Beta	0.85	0.05
Taylor inflation r_π	Normal	1.3	0.05
Taylor RER r_x	Normal	0.01	0.005
Taylor output gap r_y	Normal	0.2	0.05
Taylor change in inflation $r_{\Delta\pi}$	Normal	0.3	0.1
Taylor change in output gap $r_{\Delta y}$	Normal	0.0625	0.05
AR parameters ρ	Beta	0.85	0.05

Bayesian estimation

- Start with prior $p(\theta|M)$ and log likelihood $p(Y|\theta, M)$;
- Use Bayes theorem twice to obtain: $p(\theta|Y, M) = \frac{p(Y|\theta,M)p(\theta,M)}{p(Y|M)}$;
- Maximize log posterior kernel;
- Simulate posterior distribution using Metropolis Hastings.
- Compute marginal density;

Baseline model results

Param.	Post. mode	Post. Mean	Lo conf. band	Up. conf. band (10%)
ξ_w	0.7817	0.7249	0.5353	0.9212
ξ_d	0.3554	0.3578	0.2852	0.4247
$\xi_{m,c}$	0.2875	0.2828	0.2047	0.3529
$\xi_{m,i}$	0.3395	0.3329	0.2316	0.4232
ξ_x	0.4687	0.4097	0.285	0.5439
b	0.9586	0.9593	0.9577	0.9610
η_i	0.7144	0.8737	0.4585	1.3181
η_f	0.5628	0.5879	0.3198	0.8795
η_c	2.2422	2.1607	1.4258	3.0272
ϕ_a	0.0045	0.0055	0.0027	0.0084
ρ_R	0.7446	0.7428	0.6693	0.8029
r_π	1.3309	1.3312	1.2633	1.3987
r_x	0.005	0.0055	-0.001	0.0138
r_y	-0.0013	-0.0021	-0.0062	0.0014
$r_{\Delta\pi}$	0.3921	0.4003	0.2297	0.5743
$r_{\Delta y}$	0.1686	0.1668	0.1051	0.2269
ρ	$\in (0.8, 0.9)$			

Scenarios

Scenario	Missing freaction compared to baseline model	Log data density
Baseline	-	**1103.4**
1	No variable capital capital utilization rate	**1121.9**
2	No sticky wages	1098.6
3	No sticky prices	1037.8
4	No habit in consumption	1035.3
5	No investment adjustment cost	1085.9
6	No working capital channel	1027.59

Conclusions

- Wages adjust once in 4 quarters;
- Prices adjust more frequently than 2 quarters (estimation in line with Copaciu et al. (2010));
- Habit in consumption plays a significant role in determining DGP;
- Monetary policy responds to inflation deviation (satisfying Taylor principle), and to speed of growth of output gap and inflation, interest rate smoothing plays significant role;
- Data prefers a model without variable capital utilization rate to the baseline model;
- In case of the model with no variable capital utilization rate, shocks to domestic markups are very persistent.

Thank you!

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