Commodity Cycles and Financial Instability in Emerging Economies

M.Andreev, [1] M. U. Peiris, [2] A. Shirobokov, [3] D. P. Tsomocos [4]

Macroprudential Policy Effectiveness: Theory and Practice
July 3, 2019
Bank of Russia
Saint-Petersburg, Russia

[1]Bank of Russia
[2]ICEF, National Research University Higher School of Economics
[3]National Research University Higher School of Economics
[4]Saïd Business School and St Edmund Hall, University of Oxford; ICEF, National Research University Higher School of Economics

Introduction

- Kydland and Prescott's RBC model captures aggregate fluctuations through TFP shocks and adjustment costs to capital.
- Nominal and Financial frictions improve how investment and inflation are captured (NK model)
- McGrattan, Kehoe and Chari (2007) point out that these correspond to *wedges*
- In small open economies, *observable* exogenous shocks (real exchange rates/interest rates) have been studied at least since Mendoza (1995)
- Relative importance of observable shocks (e.g. oil prices) and unobservable ones (e.g. total factor productivity, discount factor shocks) inconclusive

Introduction

We ask

- Does the contribution of observable shocks to aggregates depend on the inclusion of endogenous, *time-varying* wedges from financial frictions?
- What are the macroprudential policy implications of a model with endogenous wedges from financial frictions?

We

- Build a new-Keynesian model with a banking system and firms allowed to default on their contractual obligations
- Estimate the model using Russian data for the period 2001-2018.
- Compare the model with time-varying cost of financial frictions and time-invariant cost of financial frictions.
- Study the role of monetary and macroprudential policies

Relation to the literature

The dynamic model is based on the

- Static analysis of financial (in)stability of Tsomocos (2003), Goodhart et al. (2006)
- Dynamic model of De Walque et al. (2010) and Goodhart et al. (2017)

New-Keynsian DSGE models: Smets and Wouters (2007), Christiano et al. (2015)

Banking and Default: Bernanke et al. (1999),Tsomocos (2003), Goodhart et al. (2006), Kiyotaki and Gertler (2008), Clerc et al. (2015),

Collateral: Kiyotaki and Moore (1997)

Small open economy: Mendoza (1995), Drechsel and Tenreyro (2018)

Macroprudential policy: Catharineu-Rabell et al (2003), Kashap et al. (2019)

What do we do and what do we get?

We find

- oil price shock represents a significant part of the observed series
- the model with endogenous financial frictions better fits the data
- With endogenous financial frictions, structural shocks explain a larger contribution series

What do we do and what do we get?

Modeling domestic financial frictions wedges as endogenous

- crucially affects the identification of the relative importance of commodity price shocks
- results in 65.1% of the variation in GDP being explained by commodity price shocks vs. 55.1% for the case when frictions are modeled as exogenous
- results in 30.9% of the variation in GDP being explained by unobservable shock (TFP) vs. 41.1% for the case when frictions are modeled as exogenous
- 'Non-structural' discount factor shock falls significantly in explaining consumption, loans, interest rates and deposits.

Dynamics of the key macro-variables I

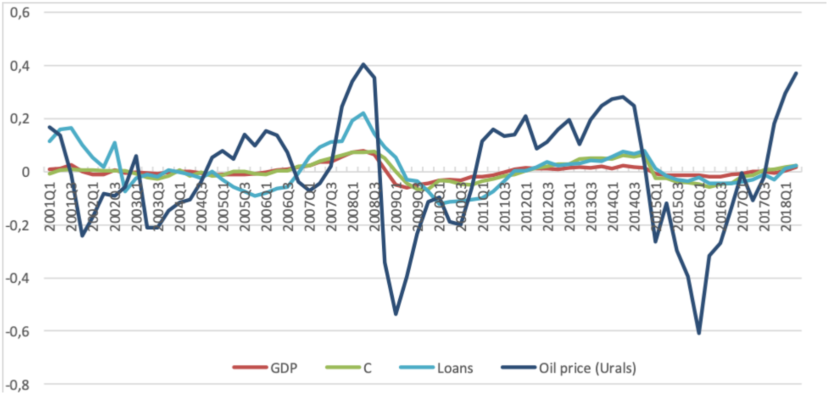

Figure: GDP, consumption, real loans, oil price. In relative deviations from the trend.

Loan origination in Russia

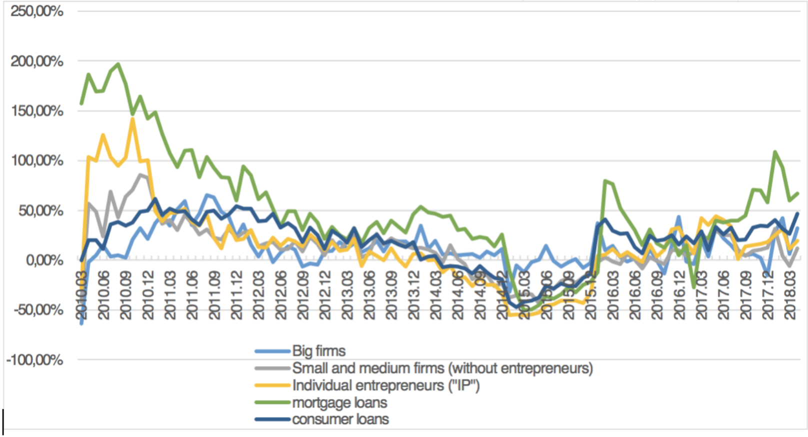

Figure: Loan origination in Russia by types of borrowers (y/y growth rate, monthly, nominal terms)

The fraction of nonperforming loans (default rates) increases following the shock

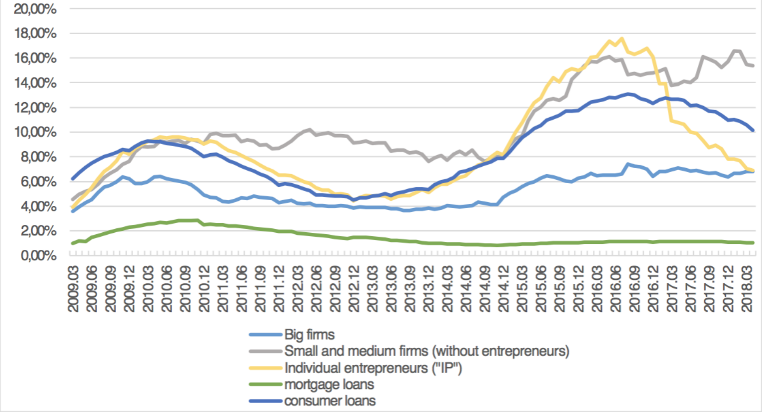

Figure: Non-performing loans (y/y growth rate, monthly, nominal terms)

Empirical Regularities of the Russian economy

- **Strong correlation of consumption and output with oil price**
- **Negative correlation between GDP and NPLs**
- Strong positive relation between GDP and loans
- Negative correlation of GDP and interest rates

Small open commodity exporting New-Keynesian DSGE model with price and wage rigidities

Particular features:

- Heterogenous 2-period lived Firms with idiosyncratic risk and default
- 2-period lived banks and capital requirements
- This also includes a role for Monetary Policy and Regulation
- Default rates by firms vary endogenously over the business cycle
- Firms are subject to a collateral constraint
- Oil profits constitute an important part of the government's revenues

Modeling Default

Our Approach

- We model default as a moral hazard problem, costly for the borrower (Shubik and Wilson, 1977, Dubey et al., 2005)
- We obtain procyclicality of debt (Borio, 2003)

Bernanke, Gertler and Gilchrist, 1995

- Our mechanism through which default works is similar to BGG
- Default depends on debt, capital and TFP
- The return on capital is equated with the gross-of-default interest rate
- We employ a more general and falsifiable specification

Circular Flow of Funds

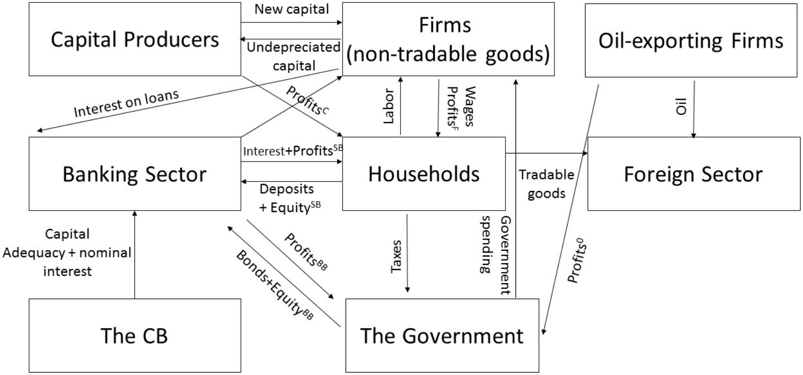

Figure: Circular Flows Diagram

Sectors in the model

Saver household

- infinitely lived
- have standard preferences over consumption and leisure
- owns all the firms and banks in the economy
- supplies labor monopolistically competitive to output producers
- deposits money at the bank

▸ saver's problem

Sectors in the model

Firms

- have OLG structure
- identical ex-ante but are subject to idiosyncratic TFP shock ex-post
- issue secured and unsecured debt to banks in the first period and can default on the unsecured one
- the marginal cost of renegotiating debt (default) is governed by a macrovariable, termed ‘credit conditions’
- the debtor firm takes the credit-conditions variable as given since creditors are capable of imposing institutional arrangements that are non-negotiable

Firms

Production function:

$$y_t^j = A_t^j (k_t^j)^\alpha (l_t^j)^{1-\alpha}. \tag{1}$$

The first period budget constraint:

$$p_t^K k_{t+1}^w + T_t^w + A_t^{c,w} = \mu_{t+1}^w + e_t^{w,total}, \tag{2}$$

Collateral contarint:

$$\mathbb{E}(1 + r_{t+1}^{w,s})\mu_{t+1}^{w,s} \leq coll(1-\tau)k_{t+1}^w \, \mathbb{E}\, p_{t+1}^K \tag{3}$$

Second period profit:

$$\Pi_{t+1}^{w} = p_{t+1}^{N} A_{t+1}^{w} (k_{t+1}^{w})^{\alpha} (l_{t+1}^{w})^{1-\alpha} \; - (1-\delta_{t+1}^{w}) \mu_{t+1}^{w,u} (1+r_t^{w,u}) - \mu_{t+1}^{w,s} (1+r_t^{w,s}) \\ - w_{t+1} l_{t+1}^{w} - \frac{\Omega_{t+1}^{w}}{1+\psi} \left(\delta_{t+1}^{w} \mu_{t+1}^{w,u} (1+r_t^{w,u}) \right)^{1+\psi} + p_{t+1}^{K} k_{t+1}^{w} (1-\tau) \tag{4}$$

- Ω_t^j is a credit conditions variable:

$$\Omega_t^w = const\left(\frac{GDP_t}{\int \mu_t^{w,u} df (1+r_t^{w,u})}\right)^{\omega} \frac{1}{(\delta_t^w)^{\gamma}}. \tag{5}$$

- $\frac{\Omega_{t+\mathbf{1}}^{j}}{1+\psi}\left(\delta_{t+1}^{j}\mu_{t+1}^{j}(1+r_{t+1}^{w,u})\right)^{1+\psi}$ is a "pecuniary" renegotiation cost

Firms solve: $\max_{k_{t+\mathbf{1}}^{w}, \mu_{t+\mathbf{1}}^{w,u}, \mu_{t+\mathbf{1}}^{w,s}, l_{t+\mathbf{1}}^{w}, \delta_{t+\mathbf{1}}^{w}} \mathbb{E}_t \beta^{sav} \lambda_{t+1}^{sav} \left[\Pi_{t+1}^{w} \right]$

Sectors in the model

Exporters

- infinitely lived
- use domestically produced final goods and imported goods to produce exported good

▸ exporters' problem

Capital producers

- infinitely lived
- use undepreciated capital and imported good to produce capital

▸ capital producers' problem

Sectors in the model

Oil producers

- A representative oil-extracting firm makes a decision of an oil extraction.
- At the beginning of a period t, the economy has some units of oil reserves (res_t) and discovers a further number of units ($disc_t$).
- Government receives profits of oil firms

▸ oil producers' problem

Banks

- two period lived
- accept deposits from savers and extend secured and unsecured loans to firms
- subject to aggregate risk
- subject to loan provision requirement
- subject to capital requirement
- New-born banks are capitalised with equity of e_t^{bank}.

First period budget constraint:

$$\mu_{t+1}^{bank,s} + \mu_{t+1}^{bank,u} + A_t^b = d_{t+1}^{bank} + e_t^{bank} \tag{6}$$

The capital adequacy ratio:

$$k_t^{bank} = \frac{e_t^{bank}}{rwa_t^{bank}} = \frac{e_t^{bank}}{\left(\int r\bar{w}_t^{bank}\mu_{t+1}^{bank,u}df + \int r\bar{w}_t^{bank}\mu_{t+1}^{bank,s}df\right)} \quad (7)$$

Profit function:

$$\Pi_{t+1}^{bank} = [\theta_w(1 + r_{t+1}^{w,u})(1 - \delta_{t+1}^{w})\mu_{t+1}^{bank,u} + (1 - \theta_w)(1 + r_{t+1}^{w,u})\mu_{t+1}^{bank,u} + \\ + (1 + r_{t+1}^{w,s})\mu_{t+1}^{bank,s} - [(1 + r_{t+1}^{d})d_{t+1}^{bank}], \quad (8)$$

Given $\left\{\delta_{t+1}^{f}, r_{t+1}^{w,u}, r_{t+1}^{w,s}, r_{t+1}^{d}\right\}$, banks maximize:

$$\max_{\mu_{t+1}^{bank,u},\mu_{t+1}^{bank,s},d_{t+1}^{bank}} \mathbb{E}_t\beta^{bank}\frac{(\Pi_{t+1}^{bank})^{1-\varsigma_{bank}}}{1-\varsigma_{bank}} - a_{cap}0.5[k_t^{bank} - \bar{k}^{bank}]^2 \quad (9)$$

Sectors in the model: Central Bank and Government

- The Central Bank controls the interest rate i_t^b according to the following rule:

$$\frac{1+i_t^b}{1+i_{ss}^b} = \Big(\frac{1+i_{t-1}^b}{1+i_{ss}^b}\Big)^{r_R}\big(\big(\frac{1+\pi_t^{cpi}}{1+\pi_{ss}^{cpi}}\big)\big)^{1+r_\pi}\big(\frac{GDP_t}{GDP_{ss}}\big)^{r_Y}\epsilon_t^R \tag{10}$$

- The Government Budget Constraint:

$$G_t + p_t^{imp} G_t^{imp} + B_{t-1}^g \frac{(1+i_{t-1}^b)}{1+\pi_t} \leq B_t^g + \Pi_t^o + cost^{ext}(res_t, ext_t) + T_t^{net} \tag{11}$$

Endogenous vs. Exogenous Financial Frictions Wedges

To move from endogenous to exogenous case we:

- fix loss given default rate at the steady state level
- exclude collateral constraint
- include fixed wedges into firm's FOCs for secured and unsecured borrowing to make them correspond to the endogenous case in the steady state
- fix firm's default cost at the steady state level
- fix aggregate credit conditions at the steady state level

$$\mathbb{E}_t \frac{(\delta^{w}_{t+1})(r^{w,u}_{t+1} - r^{w,u,ss})}{1 + r^{w,u,ss}} \tag{12}$$

Data

For the estimation we use the follwoing data series over the period Q1 2001 - Q2 2018:

- GDP
- consumption
- dollar oil price
- CPI inflation
- interbank loan rate
- Loans to firms
- the ratio of non-performing loans to loans to firms
- Deposits

Data preparation and Model shocks

We transform our data in the following way:
$var = ((log(var) - log(var(-1)) - E[log(var) - log(var(-1))])$
We have 13 exogenous variables (5 shocks and 8 measurement errors (one for each observable series)):

- foreign oil price shock
- TFP shock
- foreign interest rate shock
- monetary policy shock
- saver's time-preference shock
- measurement error for each observable

Observation equations are specified as:
$var^{obs} = (log(var) - log(var(-1))) + me_t^{var}$

Goodness-of-fit: Endogenous vs. Exogenous financial frictions

	Endogenous case	Exogenous case
Marginal likelihood	1118	801

Table: Marginal Likelihood for Endogenous and Exogenous financial frictions cases

Posterior odds ratio ≈ 1

▸ calibrated parameters

Estimation results

		Prior Distribution			Posteior Distribution			
					Endog		Exog	
		Distr.	Mean	Std.	Mode	Std.	Mode	Std.
Adjustment costs								
saver's to deposits	$a^{s,d}$	InvG	0.008	0.005	0.059	0.006	0.075	0.008
saver's to foreign bonds	$a^{s,b,f}$	InvG	0.008	0.005	0.063	0.031	0.042	0.017
saver's to bank's equity	$a^{s,b,e}$	InvG	0.008	0.005	0.039	0.014	0.005	0.002
saver's to firm's equity	$a^{s,f,e}$	InvG	0.008	0.005	0.039	0.009	0.014	0.002
firm's to capital	$a^{w,k}$	InvG	0.008	0.005	0.098	0.054	0.028	0.015
firm's to secured loans	$a^{w,s}$	InvG	0.008	0.005	0.003	0.001	0.111	0.079
firm's to unsecured loans	$a^{w,u}$	InvG	0.008	0.005	0.005	0.002	0.006	0.002
bank's to deposits	$a^{b,d}$	InvG	0.008	0.005	0.005	0.006	0.003	0.001
bank's to secured loans	$a^{b,s}$	InvG	0.008	0.005	0.023	0.010	0.334	0.219
bank's to unsecured loans	$a^{b,u}$	InvG	0.008	0.005	0.004	0.002	0.020	0.001
cap prod to investment	$\varkappa$	InvG	0.5	0.5 (0.75)	0.185	0.070	0.682	0.529

Table: Estimated parameters for endogenous and exogenous financial frictions wedges

Estimation results

		Prior Distribution			Posteior Distribution			
					Endog		Exog	
		Distr.	Mean	Std.	Mode	Std.	Mode	Std.
Price and wage setting								
Wage stickiness	$\theta^{p,w}$	Beta	0.5	0.1	0.165	0.081	0.406	0.036
Price stickiness	$\theta^{p,s}$	Beta	0.5	0.1	0.349	0.062	0.105	0.022
Taylor rule								
interest rate coefficient	ρ^{i}	InvG	0.5	0.5 (0.25)	0.680	0.283	0.268	0.066
inflation rate coefficient	ρ^{π}	InvG	1	0.5 (0.25)	0.868	2.871	0.835	0.213
GDP growth rate coefficient	ρ^{gdp}	InvG	0.05	0.05 (0.25)	0.025	0.013	0.036	0.014
Credit conditions								
gamma	γ	InvG	1 (-)	0.1 (-)	1.562	0.036	-	-
omega^{par}	ω	InvG	1 (-)	0.1 (-)	0.811	0.060	-	-
def cost	ψ	InvG	2 (-)	0.1 (-)	1.931	0.083	-	-

Table: Estimated parameters for endogenous and exogenous financial frictions cases

Estimation results

		Prior Distribution			Posteior Distribution			
					Endog		Exog	
		Distr.	Mean	Std.	Mode	Std.	Mode	Std.
Shocks' persistence								
AR(1) oil price shock	$\rho^{p,o}$	Beta	0.95	0.005	0.954	0.005	0.951	0.005
AR(1) TFP shock	ρ^{a}	Beta	0.95	0.005	0.955	0.005	0.951	0.005
AR(1) monetary policy shock	ρ^{mon}	Beta	0.2 (0.3)	0.1	0.024	0.020	0.147	0.048
AR(1) foreign interest shock	$\rho^{i,for}$	Beta	0.9	0.02	0.913	0.018	0.900	0.020
AR(1) saver's beta shock	$\rho^{\beta,sav}$	Beta	0.2 (0.4)	0.1	0.101	0.069	0.813	0.036
Shocks								
Std. oil price shock	$\epsilon^{p,o}$	InvG	0.15	0.01	0.129	0.007	0.135	0.008
Std. TFP shock	ϵ^{a}	InvG	0.05	0.01	0.033	0.003	0.032	0.003
Std. monetary policy shock	ϵ^{mon}	InvG	0.01	0.01	0.015	0.023	0.015	0.002
Std. foreign interest shock	$\epsilon^{i,for}$	InvG	0.01	0.01	0.007	0.001	0.004	0.001
Std. saver's beta shock	$\epsilon^{\beta,sav}$	InvG	0.05	0.01	0.030	0.003	0.028	0.003

Table: Estimated parameters for endogenous and exogenous financial frictions cases

What drives the dynamics?

	Endogenous						Exogenous					
	$\epsilon^{p,o}$	ϵ^{a}	ϵ^{mon}	$\epsilon^{i,for}$	$\epsilon^{\beta,sav}$	ϵ^{me}	$\epsilon^{p,o}$	ϵ^{a}	ϵ^{mon}	$\epsilon^{i,for}$	$\epsilon^{\beta,sav}$	ϵ^{me}
GDP	**65.1**	**30.9**	0.81	0.29	0.54	2.42	**55.1**	**41.1**	0.68	0.10	1.15	1.88
$cons$	8.02	59.1	0.94	3.08	26.4	2.47	1.55	51.6	0.58	1.24	**43.8**	1.23
$Loans$	**41.5**	12.0	0.30	35.5	3.39	7.36	8.21	40.4	0.52	0.90	**46.4**	3.56
$\frac{NPL}{Loans}$	**64.1**	11.7	0.09	12.5	1.12	10.4	4.52	28.6	0.47	1.02	26.0	39.4
π^{cpi}	16.8	0.12	65.4	8.54	1.61	7.47	10.2	5.02	63.3	5.67	8.57	7.21
i^{b}	52.6	0.34	0.84	33.0	6.56	6.68	25.9	12.8	0.31	18.6	38.7	3.74
$p^{o,*}$	88.4	0	0	0	0	11.6	89.4	0	0	0	0	10.6
Dep	**78.8**	11.4	0.24	3.11	0.96	5.42	24.6	49.1	2.24	7.63	15.3	1.08

Table: Error variance decomposition: endogenous and exogenous financial frictions wedges.

Policy experiments

Countercyclical policies contingent on credit conditions effective (Cecchetti, 2015)

Countercyclical Policy rules

- reserve requirement
- capital requirement
- LATW type Taylor Rule

Discretionary policies, less so

Counterfactual experiments

- collateral margin
- deposit requirement
- capital adequacy

Concluding Remarks

- Identification of relative importance of observable shocks depends on modeling financial frictions (default and collateral constraint)
- As the effect of the observable shock is better identified in the endogenous case, such a framework will be more relevant for policy analysis
- Results are robust to varying share of imports in consumption and investment as well as to passing the varying default rates for exogenous case

De Walque, Gregory, Olivier Pierrard and Abdelaziz Rouabah (2010), 'Financial (in)stability, supervision and liquidity injections: A dynamic general equilibrium approach*', The Economic Journal **120**(549), 1234–1261.

Goodhart, Charles AE, Pojanart Sunirand and Dimitrios P Tsomocos (2006), 'A model to analyse financial fragility', Economic Theory **27**(1), 107–142.

Goodhart, Charles, Nuwat Nookhwun and Dimitrios Tsomocos (2017), 'Bank risk-taking in the dsge model with heterogeneous firms, endogenous default and financial regulation'.

Saver Households

Consumption bundle:

$$c_t = (c_t^N)^{\varphi}(c_t^T)^{1-\varphi} \tag{13}$$

Budget Constraint of a Household:

$$\begin{aligned} d_{t+1}^{sav} &+ p_t^{imp} c_t^{sav,imp} + c_t^{sav,N} + e_t^{w,total} + e_t^{bank} + Q_t B_t^f + B_t^g \\ &\leq (1+r_t^d) d_t^{sav} Q_t B_{t-1}^f (1+r_t^f) + B_{t-1}^g (1+r_t^b) + w_t l_t^{sav} + (1-\theta)\bar{\Pi}_t^w + \theta \underline{\Pi}_t^w \\ &\quad + \Pi_t^{bank} + \Pi_t^{cap} + \Pi_t^{ret} + \Pi_t^{exp} - A_t^s \end{aligned} \tag{14}$$

where Q_t is an exchange rate, $e_t^{w,total} = (e_t^w + (1-\tau) p_t^K k_t^w)$, A_t^s - adjustment costs of saver HH, $A_t^s = 0.5 a^{s,b,e}(e_t^{bank} - e_{ss}^{bank})^2 + 0.5 a^{s,w,e}(e_t^{w,total} - e_{ss}^{w,total})^2 + 0.5 a^{s,d}(d_t^{sav} - d_{ss}^{sav})^2 + 0.5 a^{s,b,f}(Q_t B_t^f - Q_{ss} B_{ss}^f)^2 + 0.5 a^{s,b,g}(B_t^g - B_{ss}^g)^2$.

Savers maximize their discounted utility s.t. their BC:

$$\max_{c_t^{sav,imp}, c_t^{sav,N}, e_t^{w,total}, e_t^{bank}, d_{t+1}^{sav}, w_t} \sum_{t=0}^{\infty} (\beta^{sav})^t [\frac{(c_t^{sav})^{1-\sigma}}{1-\sigma} - \gamma^{sav} \frac{(l_t^{sav})^2}{2}]$$

back

Exporters

Exporters use final consumption $ex_t^{Y^{ret}}$ and imported ex_t^{imp} goods in production of exported goods. We assume a Cobb-Douglas production function:

$$Y_t^{exp} = A_t^{exp} (ex_t^{imp})^{\phi^e} (ex_t^{Y^{ret}})^{(1-\phi^e)} \tag{15}$$

They maximize:

$$\max_{ex_t^{imp}, ex_t^{Y^{ret}}} \mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^{sav})^t \lambda_t^{sav} \left[p_t^{exp} Y_t^{exp} - p_t^{imp} ex_t^{imp} - ex_t^{Y^{ret}} - Q_t \frac{\varkappa^e}{2} \left(\frac{ex_t^{imp}}{ex_{t-1}^{imp}} - 1 \right)^2 \right], \tag{16}$$

where the last term in the profit's expression represents the costs of an export producer associated with the adjustment of imported goods purchases.

back

Capital producers

- Capital producers purchase undepreciated capital $(1-\tau)K_t = (1-\tau)\int k_t^j dj$ at price p_t^K from both types of firms and imported goods i_t at price p_t^{imp}.
- Capital Producers combine both components into producing new capital $K_{t+1} = \int k_{t+1}^j dj$.
  The production function takes the form:

$$K_{t+1} = (1-\tau)K_t + i_t\left(1 - \frac{\varkappa}{2}\left(\frac{\epsilon_t^K i_t}{i_{t-1}} - 1\right)^2\right) \quad (17)$$

  Each capital producer, therefore, maximizes:

$$\max_{i_t} E_0 \sum_{t=0}^{\infty} (\beta^{sav})^t \lambda_t^{sav} \left[p_t^K (K_{t+1} - (1-\tau)K_t) - i_t p_t^{imp}\right] \quad (18)$$

back

Oil producers

The resource constraint is:

$$res_{t+1} + ext_t = res_t + disc_t. \tag{19}$$

Profits in real terms are given by:

$$\Pi_t^{ext} = p_t^o ext_t - cost^{ext}(res_t, ext_t) \tag{20}$$

A representative firm solves then:

$$max_{ext_t, res_{t+1}} \mathbb{E}_0 \sum_{t=0}^{\infty} \left[(\beta^{sav})^t \lambda_t^{sav} \Pi_t^o \right] \tag{21}$$

back

Calibrated parameters

Parameters	Value	Description
$\beta^{sav,ss}$	0.977	Saver's time preference
θ^{sav}	1	Saver's disutility from labor
γ^{sav}	1	Saver's labor elasticity
σ^{sav}	1.5	Saver's risk aversion
ϕ^{sav}	0.35	Saver's preference for domestic goods
δ^{f}	0.5	Loss given default
k^{bank}	0.115	Capital requirments for banks
τ	0.025	Depraciation rate
α	0.33	Capital share in production of wholesalers
coll	0.5	Collateral value of capital
θ_f	0.05	Fraction of firms that default
θ^c	3	Elasticity of retailer's output
ξ_{bank}	1	Risk aversion of a bank
ψ^e	0.75	Share of imported goods in exporter's input

Table: Calibrated Parameters and Ratios back