Financial intermediaries in an estimated DSGE model for the UK

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Motivation

- Gertler and Karadi (GK) (2009) combined financial intermediation and unconventional monetary policy in a DSGE framework, calibrated for the US economy.
- Bean (2009) emphasized the role of the banks in the transmission mechanism of the shocks, in particular in the recent recession.
- Our objective: Empirical properties of the GK model estimated for the UK economy with Bayesian estimation techniques:
  - Model fit
  - Empirical importance of different frictions
  - Relative importance of different shocks
  - Credit policy

Selected related literature

The GK model:

- Financial frictions on non-financial firms: Bernanke, Gertler and Gilchrist (1999), Kiyotaki and Moore (1997).
- The role of bank capital: Aikman and Paustian (2006), Meh and Moran (2010), Gertler and Kiyotaki (October 2009).
- Standard DSGE modelling with frictionless capital markets: Christiano, Eichenbaum and Evans (2005), Smets and Wouters (SW)(2007).

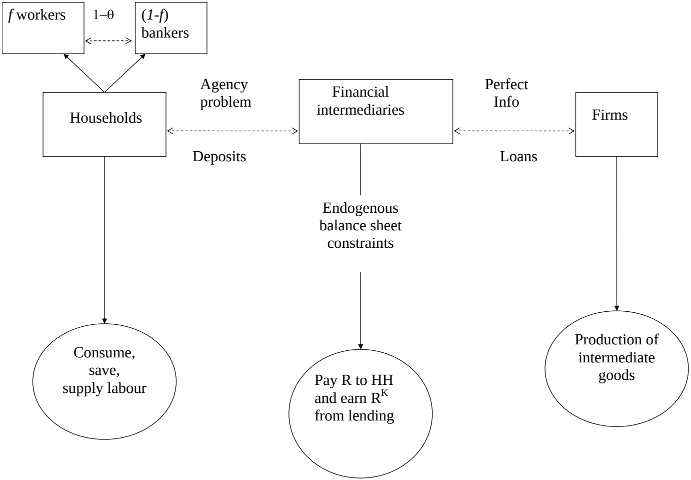
Bayesian estimation of DSGE: SW, Adolfson et al. (2007), Heideken (2009).

The GK Model

The agents in the model:

- households
- intermediate goods firms
- capital producers
- monopolistically competitive retailers
- financial intermediaries
- *and* the central bank.

Financial intermediaries: a graphical representation



Financial intermediaries: some equations

$$N_{t+1} = R^k_{t+1} Q_t S_t - R_t B_t \Rightarrow N_{t+1} = (R^k_{t+1} - R_t) Q_t S_t + R_t N_t \qquad (1)$$

where N_t is FI capital (or net worth), R^k_t is the lending rate, S_t is the quantity of financial claims, Q_t is the price of each claim, B_t stands for deposits and R_t is the riskless interest rate on deposit.

$$V_t = \max E_t \sum_i (1-\theta)\theta^i \beta^i \Lambda_{t,t+i}(N_{t+1+i}) \qquad (2)$$

where V_t is the FI expected terminal wealth and θ is the survival rate. The FI will want to expand its assets indefinitely by borrowing additional funds from households.

Financial intermediaries: the agency problem

The FI can divert a fraction λ of total assets back to its family. The incentive constraint for the lenders to supply funds to the FI is

$$V_t \geq \lambda Q_t S_t \tag{3}$$

When the constraint binds:

$$Q_t S_t = \phi_t N_t \tag{4}$$

where ϕ stands for the FI leverage ratio.
According to equation (4) the assets the FI can acquire depend positively on its equity capital. The agency problem introduces an endogenous constraint on the bank's ability to acquire assets.

The Central Bank

The Central Bank conducts both conventional and unconventional monetary policy: Taylor rule and the following feedback rule for credit policy:

$$\psi_t = \psi + \nu[(R^k_{t+1} - R_t) - (R^k - R)] \quad \text{with} \quad Q_t S_{gt} = \psi_t Q_t S_t \quad (5)$$

where $Q_t S_{gt}$ is the value of assets intermediated via the CB. The CB expands credit as the spread increases relative to its steady-state value.

Bayesian estimation: the dataset

There are five shocks: technology, conventional monetary policy, government, quality of capital, FI capital (bank capital).
The observables are:

1. GDP
2. Consumption
3. CPI (SA) inflation
4. corporate bond spread
5. lending to PNFCs

The sample period is 1979-2009Q2.

Some statistical properties of the data

			cross correlation with GDP_{t+k}		
Variable$_t$	std	relative std	k= -2	k= 0	k=2
Full sample					
GDP	0.014				
consumption	0.015	1.06	0.57	0.85	0.56
inflation	0.010	0.74	0.25	0.33	0.15
lending	0.052	3.65	0.33	0.34	0.11
spread	0.008	0.59	0.04	-0.36	-0.26
1993-2009Q2					
GDP	0.011				
consumption	0.008	0.74	0.16	0.78	0.51
inflation	0.004	0.31	0.22	0.38	0.27
lending	0.046	4.13	0.33	0.46	0.19
spread	0.010	0.93	0.18	-0.54	-0.38

Calibration

Parameter	**Value**
α, capital income share	0.33
β, discount factor	0.99
δ, depreciation rate	0.025
ϵ, price elasticity of demand	11
χ, fraction of assets given to the new bankers	0.002
ϕ, inverse of Frisch elasticity of labour supply	0.33
ν, feedback parameter for unconventional mo. po.	0

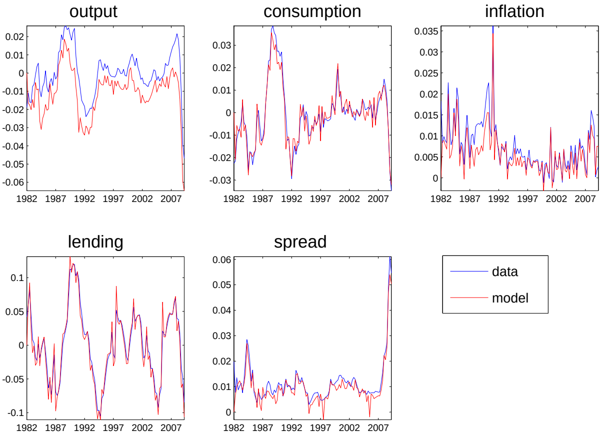
Estimated parameters: Priors and Posteriors (1)

Parameters	Prior distr			Posterior	
	Distr	Mean	St. Dev.	Mode	Mean
σ, Calvo parameter	Beta	0.7	0.05	0.67	0.67
σ_p, price indexation	Beta	0.5	0.05	0.50	0.49
S'', Inv. adj. costs	Gamma	5.48	0.05	5.48	5.56
ζ, elasticity of k utilizat	Gamma	1	0.1	1.00	0.96
h, habit parameter	Beta	0.7	0.1	0.58	0.58
θ, survival rate	Beta	0.952	0.05	0.966	0.966
λ, divertable assets	Beta	0.25	0.05	0.21	0.18
ρ_π, Taylor rule	Normal	1.5	0.1	1.51	1.49
ρ_y, Taylor rule	Normal	0.125	0.1	0.12	0.12
ρ_i, Taylor rule	Normal	0.5	0.1	0.50	0.50

Estimated parameters: Priors and Posteriors (2)

	Prior distr			Posterior	
Parameters	Distr	Mean	St. Dev./df	Mode	Mean
ρ_a, persist of tech shock	Beta	0.85	0.1	0.93	0.94
ρ_k, persist of capital shock	Beta	0.5	0.1	0.51	0.51
ρ_g, persistence of gov shock	Beta	0.5	0.1	0.57	0.57
σ_a, std of tech shock	IG	0.2	2	0.02	0.02
σ_k, std of capital shock	IG	0.1	2	0.03	0.02
σ_i, std of monetary shock	IG	0.1	2	0.02	0.02
σ_n, std of FI capital shock	IG	0.1	2	0.22	0.26
σ_g, std of gov shock	IG	0.1	2	0.06	0.06

Model fit


output
consumption
inflation
lending
spread
data
model
1982
1987
1992
1997
2002
2007

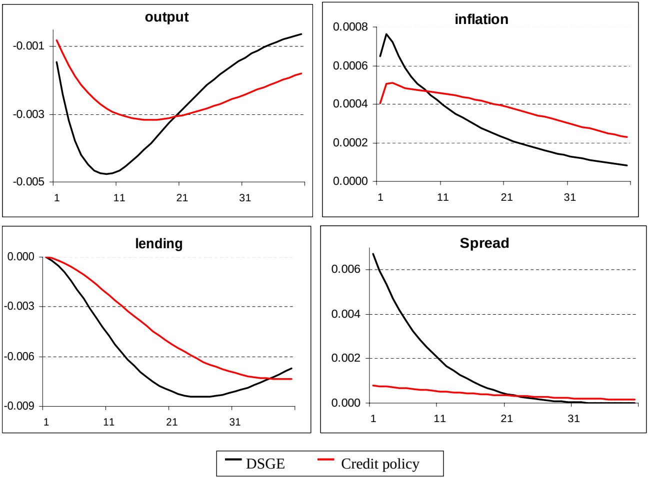
The empirical importance of different frictions

The marginal data density provides an indication of the overall likelihood of the model given the data (Chang et al. 2002, Neri 2004).

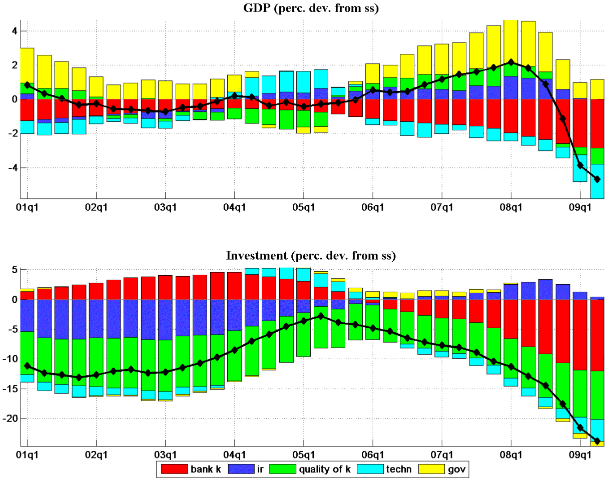
Model	Data density
Baseline model	1743
Calvo parameter, $\sigma = 0.1$	1580
Price indexation, $\sigma_p = 0$	1432
Inv. adj. costs, $S'' = 0.1$	1347
Habit, $h = 0.1$	1704
Elasticity of k utilization, $\zeta = 2.5$	1617
No financial frictions	1003

The data strongly favour the model with financial frictions in the UK economy.

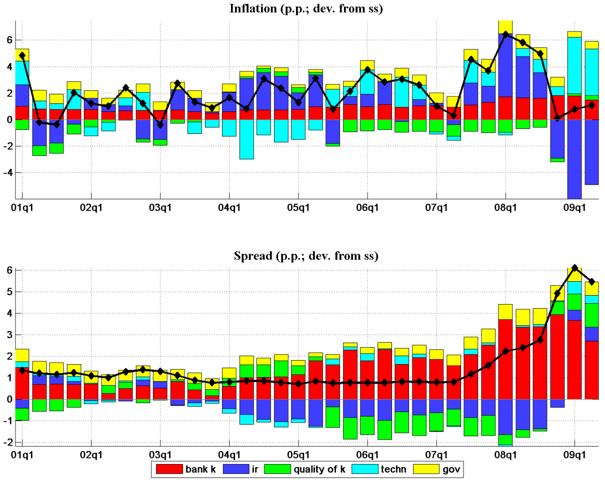
IRFs with/without credit policy: shock to **bank capital**



Historical decomposition (1)



Historical decomposition (2)



Conclusions and future research

- The fit of the baseline GK model is satisfactory for the observables; more checks (RMSE)
- The data favour a model with financial frictions
- Credit policy moderates the contraction
- zero lower bound scenario
- government intervention

State space representation

$$y_t = Z_t s_t + \epsilon_t \qquad \text{(observation)}$$
$$s_{t+1} = T_t x_t + v_t \qquad \text{(state)}$$

where $\epsilon_t \sim N(0, \Omega)$ and $v_t \sim N(0, \Phi)$

- The Kalman filter estimates the state recursively using information available up time t.
- The estimate of the final state uses all available information.

Basic mechanics of Bayesian estimation

- Let θ be the vector that collects the parameters of the model and y_T the data.
- All the information about the parameters is summarized by the posterior distribution

$$p(\theta|y_T) = \frac{p(y_T|\theta)p(\theta)}{p(y_T)} \tag{A1}$$

where $p(\theta|y_T)$ is the posterior density, $p(y_T|\theta)$ is the likelihood, $p(\theta)$ is the prior and $p(y_T)$ is the marginal distribution.

- Use the RW Metropolis-Hastings algorithm to generate draws from the posterior and the Kalman filter to recursively evaluate the likelihood.

RWMH algorithm

It is a numerical method to approximate the posterior distribution.

1. The aim is to draw samples from the following distribution, $\pi(\Theta)$, where a direct approach is not feasible.
2. Draw a candidate value Θ^{G+1} from a candidate density $q(\Theta^{G+1}|\Theta^{G})$ as:$\Theta^{G+1} = \Theta^{G} + e_t$, where $e_t \sim N(0, \Sigma)$.
3. Accept this candidate value with the probability:

$$\alpha = \min[\frac{\pi(\Theta^{G+1})}{\pi(\Theta^{G})}, 1]$$

   That is, compute α and draw one number u from the uniform (0,1). If $u < \alpha$ accept Θ^{G+1} otherwise keep Θ^{G}.

4. Repeat steps 2 and 3 many times until converge

Intermediate goods firms

- At the end of period t, firms acquire capital for use in the subsequent period.
- Each firm finances K_{t+1} by obtaining funds from the FI. The firm issues S_t state-contingent claims equal to the number of units of capital acquired and prices each claim at the price of a unit of capital Q_t:

$$Q_t K_{t+1} = Q_t S_t \tag{6}$$

- It maximises profits by choosing capital, labour and the utilization rate.