INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Financial Frictions in DSGE Models

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November 8, 2011

Outline of the Talk

Brief Introduction to DSGE Models (i)

- DSGE models are powerful tools for macroeconomic analysis and practical forecasting.
  - They eliminate logical inconsistencies (as other models).
  - They are useful for explaining the behavior of an economy (initial conditions, forecasting).
  - But they cannot anticipate shocks (ex-post forecasting errors).
- DSGE models have several advantages:
  - Derivation from optimization problems (w.r.t. older Keynesian models).
  - Based on economic theory (w.r.t. non-structural models like VARs).
  - More-detailed story (w.r.t. gap models).

Brief Introduction to DSGE Models (ii)

- Dynamic stochastic general equilibrium models.
  - GE theory: describes the behavior of the whole economy (interaction of many markets - demands, supplies, prices, policies etc.)
  - Stochastic: the model economy is hit by various shocks.
  - Dynamic: the model shows the interactions among markets and variables over time.
- DSGE models are widely used today.
  - Tools for macro research (laboratories).
  - Tools for policymakers to conduct their policies.

Brief Introduction to DSGE Models (iii)

- Models derived from micro principles.
  - Optimizations of various agents on basis of their tastes, preferences, production capacities etc.
  - $\Rightarrow$ Parameters of these models are structural (supported from economic theory).
    - Non-structural models exploit reduced-form correlations in observed data (VAR, Box-Jenkins etc.).
- Model-consistent forward-looking rational expectations.
  - But: some critics today for ”ideal rational world” (no learning, herding behavior, asymmetric information etc.).

Building Blocks of DSGE Models

- Many agents (sectors) in the economy.
  - Households, firms, central bank, government, bundlers etc.
- Private agents solve optimization problems.
  - Households are maximizing utility.
  - Firms are maximizing profits or minimizing costs.
- Policy agents are not optimizing ... (e.g. a ”prescribed” monetary policy rule).
  - But sometimes optimal policy rules.

Features of Modern DSGE Models

- Apart from RBC features...
  - Intertemporal optimization, rational expectations, ”tastes and technologies”.
- ...these models contain some features to fit the data.
  - Real rigidities (habit formation, capital adjustment costs, imperfect substitutions between inputs etc.).
  - Monopolistic competition, markups.
  - Nominal rigidities.
  - Features for country-specific data.
    - Core models of central banks should be tailor-made.
    - Sector-specific features (technologies).
- Credible monetary policy is important for the real activity.
  - MP matters because of price and wage stickiness.

Some Current Issues of DSGE Models

- Financial frictions
  - Models for monetary policy and financial stability.
- Fiscal policy
- Unemployment etc.

Monetary Transmission Channels

- How MP instruments affect the real economic activity.
- Policy rate setting affects
  - $\Rightarrow$ short-term nominal rates and inflation expectations.
  - $\Rightarrow$ short-term real rates (prices are sticky in short-run) and lending rates (long-term and client rates).
- Usually two groups:
  - Traditional (focused by majority of DSGE models).
  - Asset price channels (focused by models with financial frictions).

Traditional Channels (i)

Real interest rate channel

- Nominal rigidities $\Rightarrow$ nominal interest rate changes imply real interest rate changes
  - $\downarrow$ real interest rate $\rightarrow \uparrow$ investment
- Works also with nominal interest rate near the zero floor (money expansion raises expected inflation).

Nominal interest rate channel

- Effects due to credit-debt structure of an economy.
  - $\uparrow$ nominal interest rate $\rightarrow$ worsening the cash-flow of indebted agents.

Traditional Channels (ii)

Exchange rate channels

1. Direct channel via import prices
   - Depreciation $\rightarrow \uparrow$ import prices $\rightarrow \uparrow$ CPI.
2. Indirect channel via terms of trade
   - Depreciation $\rightarrow \downarrow$ relative price of domestic goods $\rightarrow \uparrow$ net export.
3. Balance of payments
   - Depreciation $\rightarrow$ worsening a financial position of net foreign liabilities holders (higher payments in domestic currency).

Inflation expectations channel

- Public declaration of inflation target anchors inflation expectations $\rightarrow$ price- and wage-setting.

Asset Prices Channels

- Work through wealth effects, balance sheets positions, bank lending etc.
- Captured by financial frictions models.
- Asset prices determine the value against agents can borrow.
  - Net worth (financial accelerator approach).
  - Value of collateral (collateral constraints approach).
- Two main groups
  - Balance sheets channels.
  - Lending channels.

Balance Sheets Channels

- Net worth is one of banks' indicators for extending loans.
- MP expansion $\rightarrow \uparrow$ equity prices $\rightarrow \uparrow$ firms' net worth $\rightarrow \uparrow$ bank loans.
  - $\downarrow$ interest rate $\rightarrow$ bonds are less attractive relative to equities $\rightarrow \uparrow$ equity prices.
  - Monetary expansion $\rightarrow$ people have more money than demanded $\rightarrow \uparrow$ equity purchases $\rightarrow \uparrow$ equity prices.
- Unanticipated price level movements affect financial position of indebted agents.
  - $\uparrow$ price level $\rightarrow \downarrow$ value of firms' liabilities in real terms $\rightarrow \downarrow$ debt burden $\rightarrow \uparrow$ net worth.
- Also for households' expenditures
  - $\uparrow$ asset prices $\rightarrow \uparrow$ net worth $\rightarrow \uparrow$ consumption.
  - Also, higher housing value increases construction.

Bank Lending Channel

- Bank credit is important source of firms' funding.
- Bank lending depend on net worth of borrowers.
  - Banks monitor the financial situation of borrowers.
  - Loans can be collateralized by net worth.
- $\uparrow$ policy rates $\rightarrow \uparrow$ interbank and lending rates $\rightarrow \downarrow$ volume of credit.
- Lending channel crucial for smaller firms as large firms have usually access to funding from stock and bond markets.

Objectives of Financial Frictions Modeling

- Understanding interactions between real and financial sectors.
- Implementation for policy purposes.

Understanding Interactions between Real and Financial Sectors

- ”The deteriorating of credit market conditions is not simply a passive reflection of a declining real economy but is itself a major factor depressing the economic activity.” (Bernanke et al., 1999).
- Assessing the role of asset prices transmission channels.
- Amplification (acceleration) effects of shocks during financial crises.
- ”New types” of shocks during financial crises - riskiness, bubbles etc.
- Different behavior during financial crises - non-linearities due to significant shocks.

Implementation for Policy Purposes

- Satellite models vs. core models.
- Simulations for monetary policy and financial stability purposes (sensitivity scenarios, forecasting).
- Implementation into core models for countries where asset prices matter continually (e.g. New Zealand).
- During financial crises, the policymaking process is more complex and a central bank should ”have” appropriate tools for evaluating the current state of an economy and forecasting.

Approaches of Financial Frictions Modeling (i)

- Financial frictions modeling is not a new issue.
  - Papers before the mid-2008-2009 crisis.
  - After the crisis, the interest has intensified and turned to more practical questions.

Approaches of Financial Frictions Modeling (ii)

1. Financial accelerator (e.g. Bernanke et al., 1999).
   - Costly state verification and default risk.
2. Collateral constraints (e.g. Kiyotaki and Moore, 1999; Iacoviello, 2005).
   - Limited contracts enforcement and collateralized debt.
3. Banking sector modeling (e.g. Edwards and Végh, 1997).
   - Banking services as costly activities.

- (1),(2) - focus on ”essence” of asset prices channels (costly state verification, limited contracts enforcement)
- (3) - rather stylized description of stylized facts
- Some models combine assumptions $\rightarrow$ (probably) sometimes to large to control (black boxes)

Incorporating Financial Frictions (i)

Standard DSGE models

- Complete financial markets with perfect information for all agents.
  - $\Rightarrow$ Risk-averse representative household which trades only government (risk-free) bonds to smooth consumption.
  - $\Rightarrow$ No borrowing/lending among agents.
  - $\Rightarrow$ One interest rate (for risk-free bonds).
- Modigliani-Miller theorem holds
  - The market value of a firm is independent of its capital structure and is given by capitalizing its expected return.
  - The real economic activity is independent of the financial structure and it does not matter how a firm is financed.

Incorporating Financial Frictions (ii)

Information asymmetries in financial markets.

- Motivates incorporation of financial frictions.
- Affect the behavior between borrowers and lenders.
- $\Rightarrow$ Interactions between real and financial sectors matter as the Modigliani-Miller theorem does not hold.
- E.g. entrepreneurs have better knowledge about their projects than lenders.
  - $\Rightarrow$ Investors prefer projects where entrepreneurs are engaged in or provide sufficient collateral.

Incorporating Financial Frictions (iii)

- The introduction of borrowing/lending.
  - Requires heterogenous agents with different preferences (FA and CC approaches).
  - Costly banking assumption
- Financial accelerator
  - Risk-averse households.
  - Risk-neutral entrepreneurs (linear utility in consumption).
- Collateral constraints
  - Patient households.
  - Impatient households - (i) different value of the discount parameter and (ii) liquidity constrained.

Financial Accelerator

- BGG - (Bernanke, Gertler and Gilchrist 1999).
- Currently the most used approach.
- Focus on balance sheets effects.
  - How an endogenous development in balance sheet positions of borrowers can significantly amplify (accelerate) shocks.
- Model for understanding the role of credit market frictions within business cycles.
  - Accelerator can transform small shocks into significant fluctuations in real economic activity.
- Friction is placed on a non-financial side of the economy (entrepreneurs).

Financial Accelerator - Mechanism

- Link between net worth of entrepreneurs and the external finance premium (EFP).
  - EFP - the difference between external and internal costs of funds (alternatively, additional costs above a risk-free interest rate).
- EFP depends inversely on the borrowers' net worth.
  - Net worth of borrowers is procyclical (profits, asset prices etc.) $\Rightarrow$ EFP varies endogenously and countercyclically within business cycles.
  - E.g. if a shock lowers net worth $\Rightarrow$ EFP will increase $\Rightarrow$ lower internal funding (lower profits) and lower demand for external funding (higher EFP).

Financial Accelerator - Sectors

- Risk-averse households.
- Risk-neutral entrepreneurs.
  - Purchase capital from capital good producers at the beginning of t, rent it to firms, and sell it back at the end of t.
  - Entrepreneurs' net worth is not sufficient. $\Rightarrow$ They must combine their net worth with bank lending.
  - They cannot accumulate enough equity for internal financing.
- Capital goods producers.
  - To simplify the model (households and entrepreneurs cannot store the capital).
- Bank (financial intermediary).
  - Transfers deposits from households to entrepreneurs.

Financial Accelerator - Debt Contracts

- The costly state verification (CSV) assumption.
  - Information asymmetry between borrowers and lenders.
    - Entrepreneurs observe the realized return on capital costlessly.
    - Bank must pay fixed monitoring costs to observe entrepreneurs' returns.
  - Given the possibility of default and monitoring costs, lenders charge the external finance premium over the riskless rate.
  - EFP is increasing with the leverage ratio of entrepreneurs (debt to net worth).
- $\Rightarrow$ Optimal (not collateralized) contracts where
  - The positive EFP (and monitoring costs) limits tho borrowing.
  - The bank receives the expected return which is equal to the opportunity cost of its funds (the riskless rate).

Collateral Constraints

- Similar approach to the financial accelerator.
- Based on the limited contract enforcement assumption.
  - Repayment is secured by restricting the amount of loans to borrowers' collateral.
  - Lender requires a collateral when extending a loan (a bank expects possible problems of repayments when entrepreneurs declare default and secures the loan).
  - Lender does not need to care about the borrower's willingness to pay since the loan is secured by debtor's assets (lower moral hazard).
- $\Rightarrow$ Some durable assets serve as (i) production factors and (ii) collateral for loans (capital, housing, land).

Collateral Constraints - Mechanism (i)

- Supply of durable assets is limited $\Rightarrow$ Variation of asset prices. $\Rightarrow$ Investment expenditures are sensitive to the net worth of credit-constrained agents.
- The interaction between credit limits and assets prices.
  - $\Rightarrow$ Amplification of shocks.
  - $\Rightarrow$ Shocks are more persistent.

Collateral Constraints - Mechanism (ii)

- Acceleration for demand shocks (implying higher consumer and asset prices)
  - Higher consumer prices $\rightarrow \downarrow$ real value of debt obligations $\rightarrow \uparrow$ net worth of indebted agents.
  - Higher asset prices $\rightarrow \uparrow$ possible collateral of credit-constrained agents (higher borrowing capacity).
  - Higher consumption and investment further increase the borrowing capacity.
  - $\Rightarrow$ Given assumption that borrowers have higher propensity to spend than lenders, the demand shock amplifies responses of real variables relatively to the frictionless case.

Collateral Constraints - Mechanism (iii)

- Decelerator mechanism for supply shocks (shocks with negative correlation between output and inflation)
  - A negative supply shock increases debtors' net worth (for debt obligations in nominal terms).
- MP shock (higher interest rate)
  - Standard real interest rate channel.
  - Decrease of assets prices which leads to lower borrowing.
  - Moreover, a deflation raises the cost of debt service.

Collateral Constraints - Sectors

- Patient households.
- Credit-constrained sectors.
  - Impatient households.
    - Lower discount parameter - they discount the future more heavily (with higher discount rate).
    - (The more heavily discounting means that they demand higher returns from their investment to save instead of consuming today.)
    - Net borrowers.
  - Entrepreneurs - similar assumptions as impatient households.
- Note that credit-constrained agents are more productive comparing to unconstrained agents as they do not hold optimal level of assets for production purposes.

FA and CC Models - Similarities

- Both stress the balance sheet channel.
- Mechanisms through the net worth and asset prices.
- No explicit need for the financial intermediary.

FA and CC Models - Differences

- CC models assume the limited availability of funds: Loans must be collateralized by the net worth of debtors. FA models assume increasing EFP with no explicit upper bound.
- CC models assumes constant EFP (lending rate moves identically with the riskless rate).
- CC borrowers do not face idiosyncratic risks (no default).
- FA - the borrowers' net wealth is influenced by current (and past) conditions. CC - the value of collateral also reflects expected future values via varying asset prices.

Banking Sector Modeling

- Banking sector does not have an important role in canonical financial accelerator and collateral constraints models.
  - Frictions are on households' or non-financial firms' side.
  - Bank transfers funds from depositors to lenders.
- Several approaches for the incorporation of the banking sector into DSGE models.
  - Perfectly competitive banking sector.
  - Monopolistic banking sector.

Costly Banking (i)

- The perfectly competitive representative bank collects deposits from households and extends loans to borrowers.
- Banking services must be costly activities for achieving non-trivial role in the model.
  - In a model: A bank must use resources to produce deposits and loans.
  - In reality: Managing assets and liabilities, monitoring creditors, maintaining building etc.
- The costs of banking services are increasing functions of volume of provided services.

Costly Banking (ii)

- The bank's optimization problem results in first order conditions of the form $R_t^D = R_t - f_D'(\cdot)$ and $R_t^L = R_t + f_L'(\cdot)$.
  - $R^L \geq R$ as bank can always lend to the rest of the world at R.
  - $R^D \leq R$ as bank can always borrow from the rest of the world.
- Costless banking $\Rightarrow$ Both functions are zero (zero costs and zero profits by perfect competition).
- Costly banking $\Rightarrow$ Marginal costs of taking deposits and extending loans are positive $\Rightarrow$ Time-varying deposit and lending spreads.
- Procyclical lending spread (higher demand for loans during booms).
- Costly banking stabilizes an economy (higher costs during booms which lowers the lending).

Uncertainties of Financial Frictions (i)

- Financial sector and frictions cover a wide variety of mechanisms.
  - Several frictions in a single model $\Rightarrow$ hardly feasible and probably black box.
  - Different initial assumptions of frictions.
  - $\Rightarrow$ Usually focus on a single friction (accelerator on firms, constraints on households etc.).
- No workhorse model.
  - Various approaches (based on various assumptions) with different effects of FF for the real economic activity.
  - Moreover, combinations of frictions imply strengthening or weakening of the former effects (e.g. adding banking sector into a FA model can stabilizes accelerator's effects).

Uncertainties of Financial Frictions (ii)

- Financial crises have serious consequences for the real economic activity.
  - Their frequency is rare.
  - Crises might have different behavior and effects.
  - $\Rightarrow$ Calibration uncertainties, regular using of the model more uncertain.
- Unavailability of some time series and seeking proxy variables.
  - E.g. different housing indices with different correlation with business cycles.
  - Short series for the Czech economy (lending rates etc).

State Contingent Contracts

- (Bernanke et al., 1999)
- Risk-neutral entrepreneurs and risk-averse banks
  - Banks run zero profits and simply transfer funds from households to entrepreneurs.
  - Lending rates are adjusting ex post in response to aggregate shocks to compensate for the defaulted entrepreneurs and the monitoring costs.
  - $\Rightarrow$ different lending rates R^L_{t+1} for each the next-period possible future aggregate return on capital R^K_{t+1}. The bank always receives $R_t L_t$ in the $t+1$ whatever R^K_{t+1}.

State Non-Contingent Contracts

- (Beneš-Kumhof, 2011).
- Risk-neutral entrepreneurs and risk-neutral banks (banks also bear the risk of the contracts).
- Lending rate fixed ex ante.
- Banks run profits or looses.
  - Bank capital needed.
  - Or assumption that households receive profits and compensate for looses.

Entrepreneurs - Timing at t

- Entrepreneurs (who survived from $t-1$) purchase physical capital combining internal funds (net worth) and external funds (borrowing). The amount of loans is chosen

$$L_t = P_t^K K_t - E_t$$

- Banks intermediate funds from households to entrepreneurs.

Entrepreneurs - Timing at $t+1$ (i)

- The aggregate return on capital R^K_{t+1} is observed which determines the application of an appropriate lending rate R^L_{t+1}.
- Each entrepreneur observes his own return on capital $\omega R^K_{t+1} P^K_t K_t$ affected by idiosyncratic productivity ω.

Entrepreneurs - Timing at $t+1$ (ii)

- There is a cutoff productivity level which divides entrepreneurs into defaulting and surviving.
  - Defaulting entrepreneurs with insufficient return: $\omega R^K_{t+1} P^K_t K_t < R^L_{t+1} L_t \Rightarrow$

$$\bar{\omega} \equiv \frac{R^L_{t+1} L_t}{R^K_{t+1} P^K_t K_t}$$

  - Surviving entrepreneurs with sufficient return: Repay the loan to the financial intermediary and keep the difference as their net worth.
- Banks receive payments
  - From defaulting: The bank pays the monitoring costs and receives $(1-\mu)\omega R^K_{t+1} P^K_t K_t$. The entrepreneur receives nothing.
  - From surviving: The bank receives $R^L_{t+1} L_t = \bar{\omega} R^K_{t+1} P^K_t K_t$.

Entrepreneurs - Aggregate Return on Capital (i)

The aggregate return on capital is

$$R_{t+1}^K P_t^K K_t \int_0^\infty \omega f(\omega) d\omega$$

where $E(\omega) \equiv \int_0^\infty \omega f(\omega) d\omega = 1$

Entrepreneurs - Aggregate Return on Capital (ii)

The return of defaulting entrepreneurs

$$R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega =$$

$$\underbrace{\mu R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{Private loss in the model}} + \underbrace{(1-\mu) R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{bank's payoff}}$$

The return of surviving entrepreneurs

$$R^K_{t+1} P^K_t K_t \int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega =$$

$$\underbrace{\bar{\omega} R^K_{t+1} P^K_t K_t \int_{\bar{\omega}}^{\infty} f(\omega) d\omega}_{\text{bank's payoff}} + \underbrace{R^K_{t+1} P^K_t K_t \left[\int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega - \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega \right]}_{\text{entrepreneur's payoff}}$$

Entrepreneurs - Profit Maximization (i)

The expected profit of entrepreneur is maximized

$$\max_{K_t, R^L_{t+1}} E_{R^K_{t+1}} \left[\underbrace{R^K_{t+1} P^K_t K_t}_{\text{ag. return on K}} - \underbrace{R^L_{t+1} L_t \int_{\bar{\omega}}^{\infty} f(\omega) d\omega}_{\text{payment from surv. to B}} - \underbrace{R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{loss from def.}} \right]$$

s.t. a continuum of banks' constraints for each R^K_{t+1}

$$\underbrace{R^L_{t+1} L_t \int_{\bar{\omega}}^{\infty} f(\omega) d\omega}_{\text{from surviving entr.}} + \underbrace{(1-\mu) R^K_{t+1} P^K_t K_t \int_0^{\bar{\omega}} \omega f(\omega) d\omega}_{\text{from defaulting entr. less monitoring}} = R_t L_t$$

where $L_t = P^K_t K_t - E_t$ and $\bar{\omega} \equiv \frac{R^L_{t+1} L_t}{R^K_{t+1} P^K_t K_t}$

Entrepreneurs - Profit Maximization (ii)

After substitution

$$\max_{K_t,\bar{\omega}_t} E_{R^K_{t+1}} \left[R^K_{t+1} P^K_t K_t (1 - \Gamma(\bar{\omega})) \right]$$

s.t.

$$R^K_{t+1} P^K_t K_t [\Gamma(\bar{\omega}) - \mu G(\bar{\omega})] = R_t (P^K_t K_t - E_t)$$

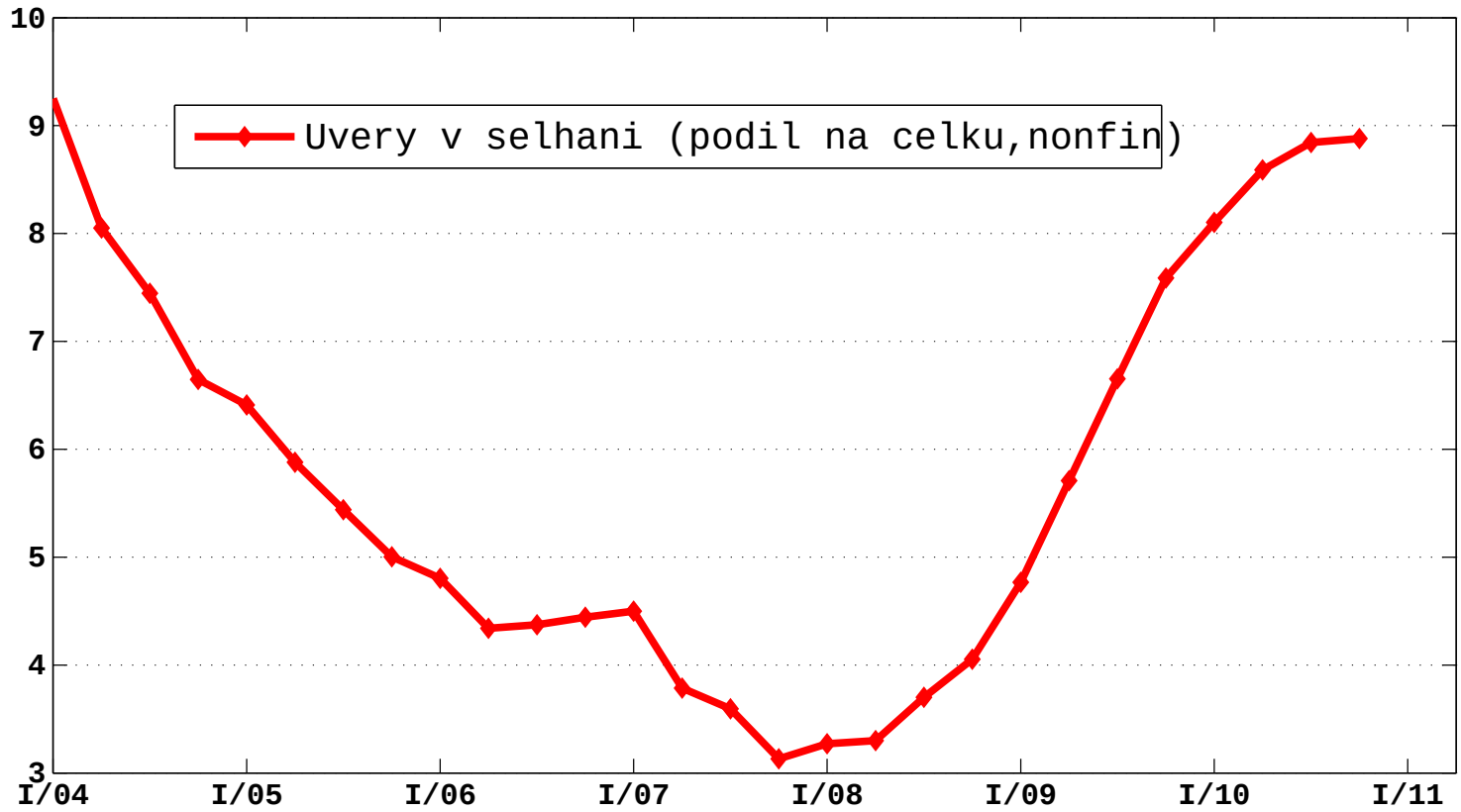
where the expected gross share of profits going to the lender is

$$\Gamma(\bar{\omega}) \equiv \int_0^{\bar{\omega}} \omega f(\omega) d\omega + \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega$$

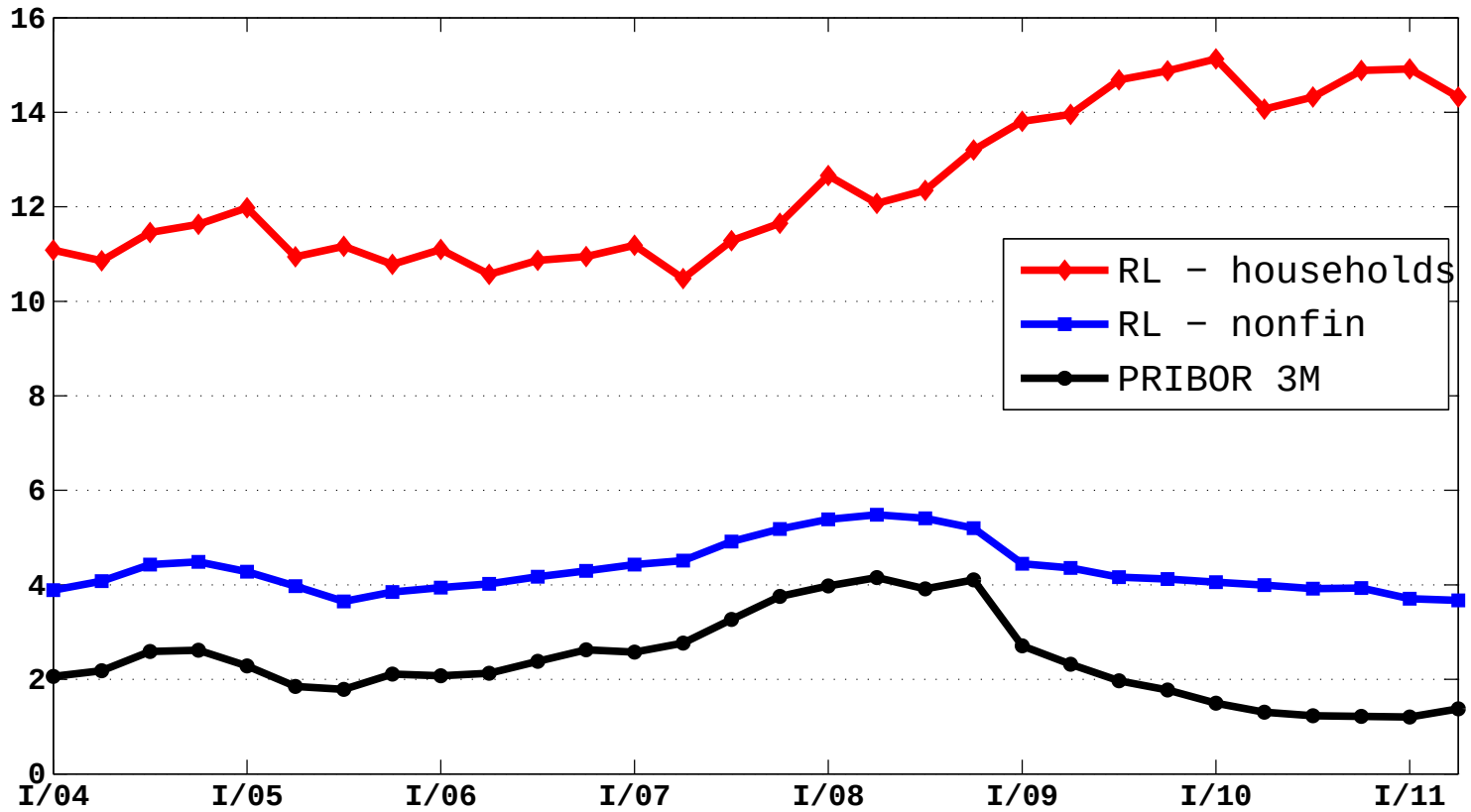
and the expected monitoring costs

$$\mu G(\bar{\omega}) \equiv \mu \int_0^{\bar{\omega}} \omega f(\omega) d\omega$$

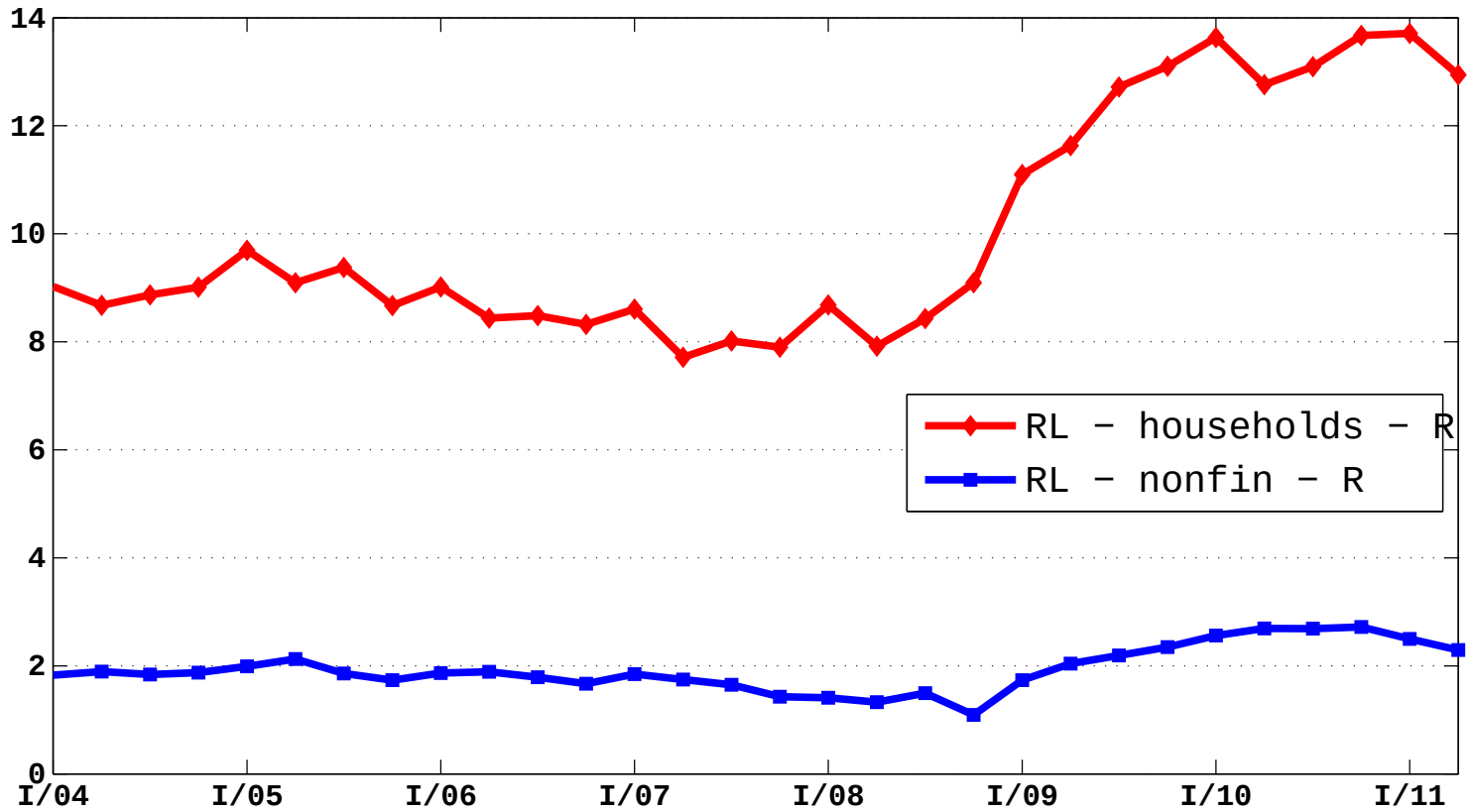
Data (i) - Non-Performing Loans



Data (ii) - Interest Rates



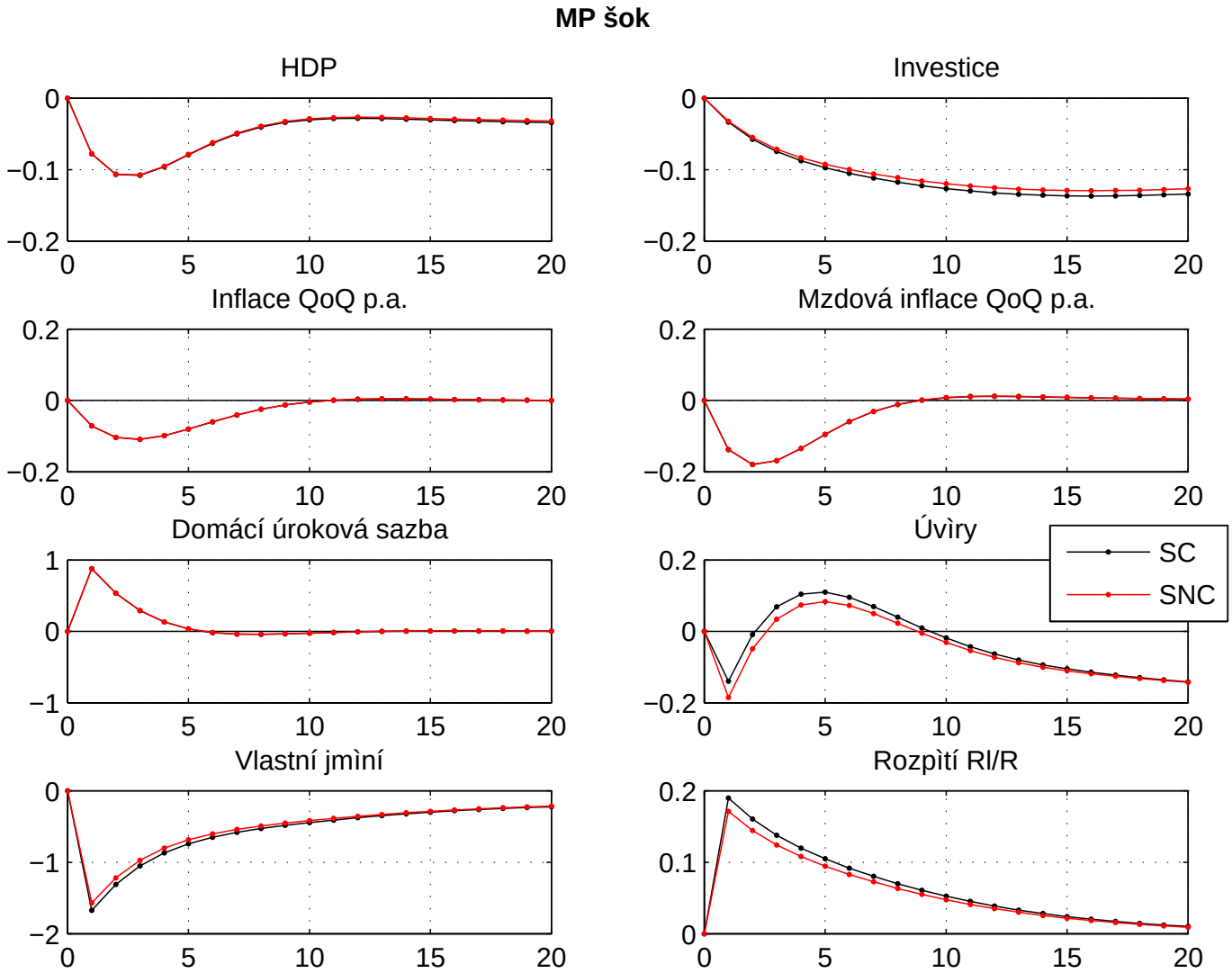
Data (iii) - Spreads



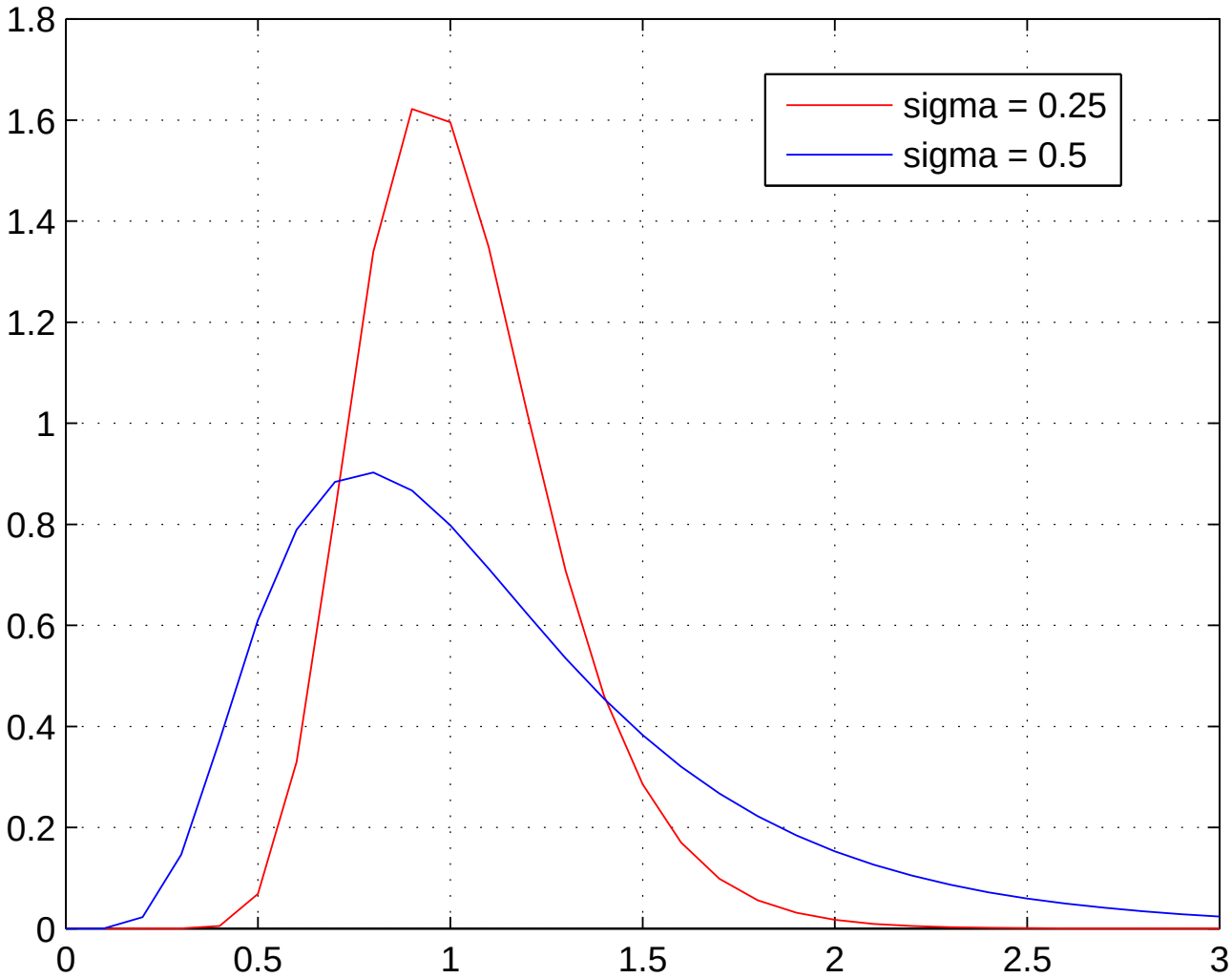
Shocks in the Model

- Standard shocks.
- Specific shocks (fin.crises, bubbles, significant cycles).
  - Focus on ”true exogenous” shocks (e.g. no direct shock to lending rate but shock which increases the lending rate).
  - One of model’s objectives.
  - E.g. higher riskiness during crises (temporarily increased standard deviation of the log-normal distribution of the idiosyncratic shock $\rightarrow$ high number of defaulting entrepreneurs).

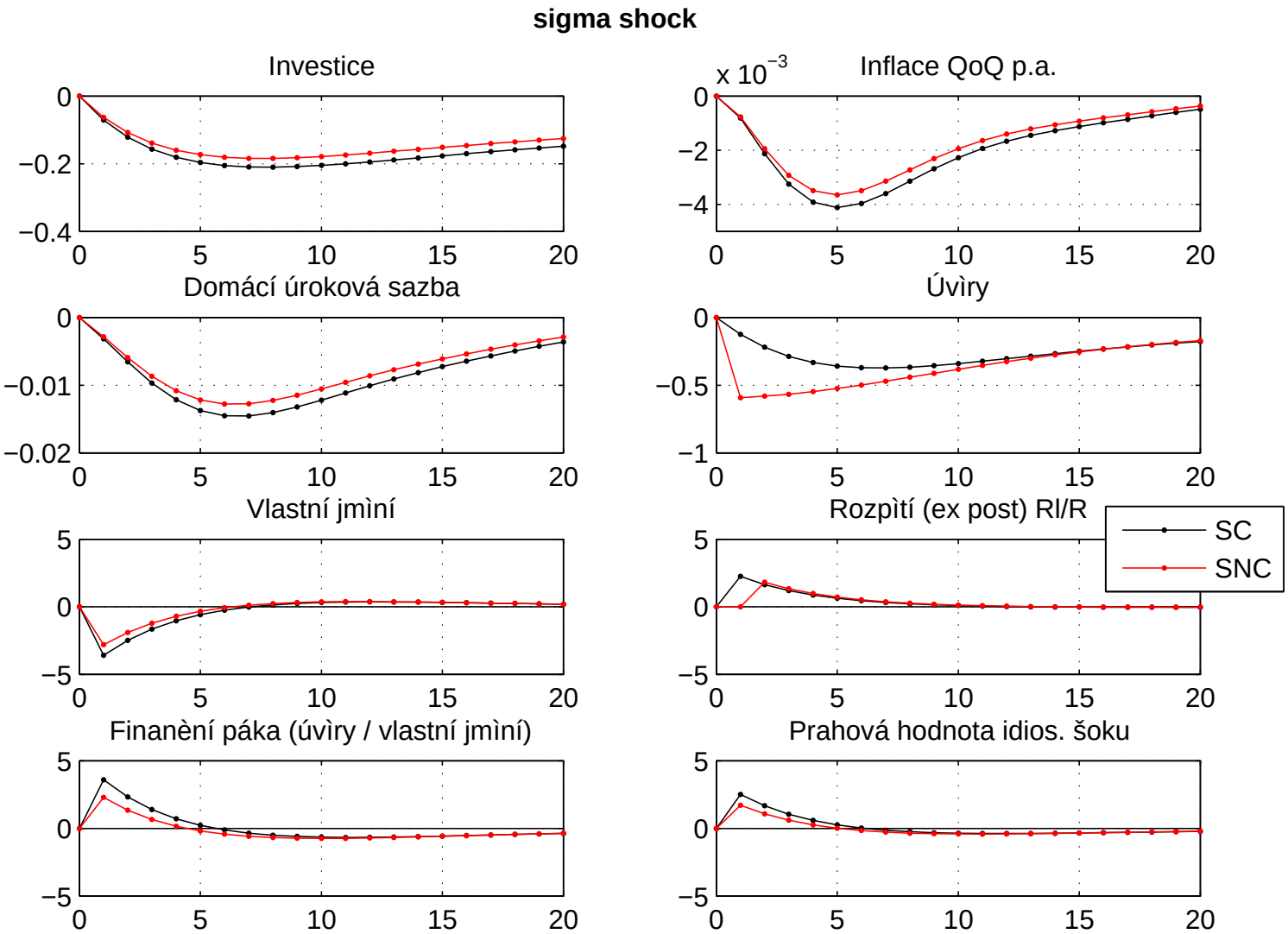
MP Shock


MP šok
HDP
Investice
Inflace QoQ p.a.
Mzdová inflace QoQ p.a.
Domácí úroková sazba
Úvìry
Vlastní jmìní
Rozpìtí Rl/R
SC
SNC

Sigma Shock (i)



Sigma Shock (ii)



Thank you for your attention

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