Improving the models that can be used for macro-prudential analysis is an important priority at the ECB (and other central banks).

The research work is carried out under the Macro-prudential Research Network of EU central banks (MaRs).

Focus on:
- developing macrofinancial models with financial instability
- developing early warning indicators
- analysing contagion in Europe using the Target2 data
Some examples of the work carried out in the MaRs Network

- Boissay, Collard and Smets (2012)
  - RBC model with heterogeneous banks
  - Inter-bank market fragile due to asymmetric information
  - Systemic crisis: inter-bank shutdown which results in widespread illiquidity

- Aoki and Nikolov (2012) and (2013)
  - Model of systemic crisis caused by the collapse of asset price bubbles
  - Crisis large when bank exposures are large
  - Bank exposures are large due to moral hazard (AN 2012) and shadow banking activities (AN 2013)
This project

- Collaborative effort of several EU central banks
- Authors: Laurent Clerc (BdeF), Alexis Derviz (CNB), Caterina Mendicino (BdeP), Stephane Moyen (DB), Kalin Nikolov (ECB), Javier Suarez (CEMFI), Livio Stracca (ECB), Alex Vardoulakis (FRB)
- Objective: Produce a micro-founded model for macro-prudential analysis
- Main purpose is to have a welfare-justification for the use of regulatory tools
  - explicit modelling of financial intermediaries which can default
  - clear channels through which financial instability imposes costs on the real economy
  - amplification of shocks
Where does financial system risk come from?

- In our model bank risk arises from:
  - idiosyncratic borrower default risk due to imperfect diversification
  - aggregate borrower default risk due to aggregate (real and financial) shocks

Why are lending and defaults excessive?
- banks have insured liabilities \( \Rightarrow \) lend cheaply and leverage and borrower default are excessive
- costly because defaults have deadweight costs
- when leverage is high, amplification in response to shocks is greater

Welfare effects of bank capital
- capital requirements align banks’ incentives and prevent excessive risk taking (\(+ve\) effect)
- capital requirements tighten credit supply (\(-ve\) effect)
- at low capital requirements, the \(+ve\) effect dominates, otherwise the \(-ve\) effect dominates
Related Literature

- Occasionally binding constraints
  - Korinek (2008), Korinek and Jeanne (2011)
  - Bianchi and Mendoza (2011), Bianchi (2012)
  - Brunnermeier and Sannikov (2013)

- Choice of bad projects under high leverage
  - Martinez-Miera and Suarez (2012)
  - Collard, Dellas, Diba and Loisel (2012)
  - Gallo and Thomas (2012)
  - Christiano and Ikeda (2013)
Related Literature (cont’d)

- Collapse of asset price bubbles

- Asymmetric information
  - Martin (2008), Martin (2012)
  - Boissay, Collard and Smets (2012)
  - Bigio (2012)
The Model Structure

- Standard debt contracts for all borrowers
  - no state contingency

- Households
  - borrow to buy houses
  - default when the value of the house is less than the mortgage

- Firms
  - 2-period OLG with bequests
  - default when value of the firm less than debt

- Banks
  - 2-period OLG with bequests
  - default when value of loans falls below deposits
  - insured deposits
  - regulatory capital requirement
Patient Households

- The dynasty of patient households are the savers in the economy.
- They maximise the following objective function

\[
E_t \left[ \sum_{i=0}^{\infty} (\beta^s)^{t+i} \left[ \log (c^s_{t+i}) + v^s_{t+i} \log (h^s_{t+i}) - \frac{q^s_{t+i}}{1 + \eta} (l^s_{t+i})^{1+\eta} \right] \right]
\]

subject to the intertemporal budget constraint as follows

\[
c^s_t + q^H_t h^s_t + d_t \leq w_t l^s_t + q^H_t h^s_{t-1} + R^D_{t-1} d_{t-1} - T^s_t + \Pi_t
\]
Impatient Households

- The dynasty of impatient households are the borrowing households in the economy
- They maximise the following objective function

$$E_0 \sum_{t=0}^{\infty} (\beta^m)^t \left[ \log (c_t^m) + v_t^m \log (h_t^m) - \frac{\varrho_{t+1}^m}{1+\eta} \right]$$

subject to the intertemporal budget constraint as follows

$$c_t^m + q_t^H h_t^m - b_t^m$$

$$\leq w_t l_t^m + \int_0^{\infty} \max \left\{ \omega_t^m q_t^H h_{t-1}^m - R_{t-1}^m b_{t-1}^m, 0 \right\} dF^m(\omega^m) - T_t^m$$

$$\equiv n_t^m,$$
Household default

- Conventional (uncontingent) debt
- Households experience idiosyncratic (mean = 1) shocks $\omega_{mt}$ to their housing value: default whenever house value is less than required repayment
  \[ \omega_{mt} q_t^H h_{t-1}^m < R_{t-1}^m b_{t-1}^m \]
- Defines a critical value of $\omega_{mt}$
  \[ \omega_{mt} \leq \bar{\omega}_{mt} = x_{t-1}^m / R_t^H, \]
  where
  \[ R_t^H \equiv q_t^H / q_{t-1}^H \]
is the ex post aggregate realized gross return on housing, and
  \[ x_t^m \equiv \frac{R_t^m b_t^m}{q_t^H h_t^m} \]
is household leverage.
Credit Supply to Households

- Banks supply loans to households as long as the profits from these loans deliver the bank’s desired rate of return on equity:

\[ E_t \max \left[ \omega_{t+1}^H \tilde{R}_{t+1}^H b_t^m - R_t^D d_t, 0 \right] \geq \rho_t \phi_t^H b_t^m. \]  

(5)

where \( \omega_{t+1}^H \) is a mortgage-bank-specific loan quality shock and \( \tilde{R}_{t+1}^H \) is the loan return. Using the usual BGG notation we have:

\[ (1 - \Gamma^H(\bar{\omega}_{t+1}^H))\tilde{R}_{t+1}^H b_t^m \geq \rho_t \phi_t^H b_t^m. \]  

(6)

where

\[ \Gamma^m(\bar{\omega}_t^m) = \bar{\omega}_t^m \int_{\bar{\omega}_t^m}^{\infty} f(\omega^m) d\omega^m + \int_0^{\bar{\omega}_t^m} \omega^m f(\omega^m) d\omega^m \]

- Intuition: mortgage loan profits must deliver the bank’s required expected rate of return on equity \( \rho_t \)
- Limited liability distortions allow banks to meet rate of return benchmark with lower lending rates
Borrowers choose consumption \((c_t^m)\), housing \((h_t^m)\), labour supply \((l_t^m)\), leverage \((x_t^m = (R_t^m b_t^m) / (q_t^H h_t^m))\) and debt \((b_t^m)\) to maximise

\[
\max E_t \left[ \sum_{i=0}^{\infty} (\beta^m)^{t+i} \left[ \log (c_{t+i}^m) + v_{t+i}^m \log (h_{t+i}^m) - \frac{\varrho_{t+i}^m}{1 + \eta} (l_{t+i}^m)^{1+\eta} \right] \right]
\]

subject to the budget constraint of the dynasty,

\[
c_t^m + q_t^H h_t^m - b_t^m \leq w_t l_t^m + (1 - \Gamma^m (\bar{\omega}_t^m)) q_t^H h_{t-1}^m - T_t^m,
\]

and the participation constraint of the bank,

\[
E_t (1 - \Gamma^H (\bar{\omega}_t^H)) \tilde{R}_{t+1}^H b_t^m \geq \rho_t \phi_t^H b_t^m.
\]

which describes bank loan supply to the household sector and:

\[
\tilde{R}_{t+1}^H b_t^m \equiv \left[ (\Gamma^m (\bar{\omega}_t^m) - \mu^m G^m (\bar{\omega}_t^m)) q_{t+1}^H \right] h_t^m
\]

\[
\bar{\omega}_{t+1}^m = \frac{x_t^m}{q_t^H / q_{t+1}^H}
\]
Simplified version of BGG: Entrepreneurs live for two periods

In second period of life, maximise

$$\max_{c_{t+1}, n_{t+1}} \left( c_{t+1}^e \right)^{\chi^e} \left( n_{t+1}^e \right)^{1-\chi^e}$$

subject to:

$$c_{t+1}^e + n_{t+1}^e \leq W_{t+1}^e - T_t^e$$

Optimizing behavior yields

$$c_{t+1}^e = \chi^e W_{t+1}^e$$

$$n_{t+1}^e = (1 - \chi^e) W_{t+1}^e.$$
Hence in first period of life maximise:

\[
\max_{k_t, b_t^e, R_t^F} E_t(W_{t+1}^e)
\]  \hspace{1cm} (13)

subject to the period \( t \) resource constraint

\[
q_t^K k_t - b_t^e = n_t^e,
\]  \hspace{1cm} (14)

the definition

\[
W_{t+1}^e = \max \left[ \omega_{t+1} \left( r_{t+1}^k + (1 - \delta) q_{t+1}^K \right) k_t - R_t^F b_t^e, 0 \right],
\]  \hspace{1cm} (15)

and the bank’s participation constraint

\[
E_t (1 - \Gamma^F (\bar{\omega}_{t+1}^F)) \tilde{R}_{t+1}^F = \rho_t \phi_t^F,
\]  \hspace{1cm} (16)
The corporate contracting problem

- Again we use the BGG notation $\Gamma^e (\bar{w}_{t+1})$
- The corporate contracting problem chooses capital ($k_t$) and leverage ($x^e_t = (R^e_t b^e_t) / (q^K_t k_t)$) to maximise:

$$\max_{x^e_t, k_t} E_t \left[ (1 - \Gamma^e (\bar{w}_{t+1})) R^K_{t+1} q^K_t k_t \right]$$

subject to the participation constraint of the bank:

$$E_t (1 - \Gamma^F (\bar{w}^F_{t+1})) \tilde{R}^F_{t+1} = \rho_t \phi^F_t,$$

where

$$\tilde{R}^F_{t+1} = (\Gamma^e (\bar{w}^e_{t+1}) - \mu^e G^e (\bar{w}^e_{t+1})) R^K_{t+1} q^K_t k_t$$

$$\bar{w}^e_{t+1} = \frac{x^e_t}{R^K_{t+1}}$$
Bankers live for two periods. In second period of life, maximise

$$\max_{c_{t+1}^b, n_{t+1}^b} \left( c_{t+1}^b \right)^{\chi^b} \left( n_{t+1}^b \right)^{1-\chi^b}$$

subject to:

$$c_{t+1}^b + n_{t+1}^b \leq W_{t+1}^b.$$  

Optimizing behavior yields

$$c_{t+1}^b = \chi^b W_{t+1}^b$$

$$n_{t+1}^b = (1 - \chi^b) W_{t+1}^b.$$
Hence in first period of life, maximise:

$$\max_{e_t^F} E_t(W_t^{b+1}) = E_t(\bar{\rho}_{t+1}^F e_t^F + \bar{\rho}_{t+1}^M (n_t^{b} - e_t^F)).$$

(21)

First order condition wrt $e_t^F$:

$$E_t\bar{\rho}_{t+1}^F = E_t\bar{\rho}_{t+1}^M = \rho_t,$$

(22)

Aggregate evolution of banker net worth:

$$N_{t+1}^b = (1 - \chi^b) \left( \bar{\rho}_{t+1}^F E_t^F + \bar{\rho}_{t+1}^M \left( N_t^b - E_t^F \right) \right).$$

(23)
Banks

- Banks are one-period lived firms which raise equity from bankers and deposits from patient households.
- Banks specialise in either mortgage or corporate loans. Corporate banks’ profits are given by:

  \[ \pi^F_{t+1} = \max \left[ \omega_{t+1} \tilde{R}^F_{t+1} b^e_t - R^D_t d^F_t, 0 \right], \]

- Regulatory capital constraint:

  \[ e^F_t \geq \phi^F_t b^e_t, \quad (24) \]

- Bank default

  \[ \bar{\omega}^F_{t+1} = (1 - \phi^F_t) \frac{R^D_t}{\tilde{R}^F_{t+1}}, \quad (25) \]

- Ex post rate of return on equity:

  \[ \tilde{\rho}^F_{t+1} = \frac{(1 - \Gamma^F(\bar{\omega}^F_{t+1})) \tilde{R}^F_{t+1}}{\phi^F_t}. \quad (26) \]
Capital production firms

- Investment

\[ I_t = k_t - (1 - \delta) k_{t-1} \]

requires resources

\[ \left[ 1 + g \left( \frac{l_t}{l_{t-1}} \right) \right] l_t \]

where \( g \left( \frac{l_t}{l_{t-1}} \right) \) is the investment adjustment cost function.

- Firm is owned by the patient households \( \implies \) choose investment \( I_t \) in order to maximize

\[
E_t \sum_{t=\tau}^{\infty} \frac{\lambda_{t+s}^s}{\lambda_t^s} \left\{ q^K_t I_t - \left[ 1 + g \left( \frac{l_t}{l_{t-1}} \right) \right] l_t \right\},
\]

- FOC:

\[ q^K_t = 1 + g \left( \frac{l_t}{l_{t-1}} \right) + \frac{l_t}{l_{t-1}} g' \left( \frac{l_t}{l_{t-1}} \right) - E_t \varphi^{P}_{t,t+1} \left( \frac{l_{t+1}}{l_t} \right)^2 g' \left( \frac{l_{t+1}}{l_t} \right). \]
Market clearing conditions

- Aggregate bank capital constraint

\[(1 - \chi^b) W^b_t = \phi^F_t \left[ q^K_t k_t - (1 - \chi^e) W^e_t \right] + \phi^M_t \left( \frac{q^H_t h^m_t x^m_t}{R^m_t} \right).\]

- Deposit market

\[d_t = (1 - \phi^F_t) \left[ q^K_t k_t - (1 - \chi^e) W^e_t \right] + (1 - \phi^M_t) \left( \frac{q^H_t h^m_t x^m_t}{R^m_t} \right).\]

- Labour market

\[(1 - \alpha) \frac{y_t}{w_t} = l^s_t + l^m_t.\]

- Goods market: long and ugly expression

- Capital market: entrepreneur demand equals capital firm supply

\[q^K_t k_t = n^e_t + b^e_t.\]
### Household Preference parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Household discount factor</td>
<td>$\beta^s$</td>
<td>0.995</td>
</tr>
<tr>
<td>Impatient Household discount factor</td>
<td>$\beta^m$</td>
<td>0.96</td>
</tr>
<tr>
<td>Patient Household utility weight on housing</td>
<td>$\nu^s$</td>
<td>0.25</td>
</tr>
<tr>
<td>Impatient Household utility weight on housing</td>
<td>$\nu^m$</td>
<td>0.25</td>
</tr>
<tr>
<td>Patient Household marginal disutility of labour</td>
<td>$\varrho^s$</td>
<td>1.0</td>
</tr>
<tr>
<td>Impatient Household marginal disutility of labour</td>
<td>$\varrho^m$</td>
<td>1.0</td>
</tr>
<tr>
<td>Habit persistence parameter</td>
<td>$\psi$</td>
<td>0.0</td>
</tr>
<tr>
<td>Variance of household idiosyncratic shocks</td>
<td>$\sigma^2_m$</td>
<td>0.2</td>
</tr>
<tr>
<td>Household bankruptcy cost</td>
<td>$\mu^m$</td>
<td>0.3</td>
</tr>
</tbody>
</table>
## Baseline Calibration

### Entrepreneurial sector parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dividend payout ratio of entrepreneurs</td>
<td>$\chi^e$</td>
<td>0.1</td>
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<tr>
<td>Variance of entrepreneurial idiosyncratic shocks</td>
<td>$\sigma^2_e$</td>
<td>0.2</td>
</tr>
<tr>
<td>Entrepreneur bankruptcy cost</td>
<td>$\mu^e$</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Kalin Nikolov, (European Central Bank), Assessing Macroprudential Policies in a Macroeconomic Model with Three Layers of Defaults, 28th October 2013, 23/37
### Baseline Calibration

**Banking sector parameters**

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td><strong>Bankers</strong></td>
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</tr>
<tr>
<td>Dividend payout ratio of bankers</td>
<td>$\chi_e$</td>
<td>0.1</td>
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<tr>
<td>Variance of corporate bank idiosyncratic shocks</td>
<td>$\sigma^2_F$</td>
<td>0.05</td>
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<tr>
<td>Variance of mortgage bank idiosyncratic shocks</td>
<td>$\sigma^2_F$</td>
<td>0.05</td>
</tr>
<tr>
<td>Capital requirement for corporate loans</td>
<td>$\phi^F$</td>
<td>0.11</td>
</tr>
<tr>
<td>Capital requirement for mortgages</td>
<td>$\phi^M$</td>
<td>0.11</td>
</tr>
<tr>
<td>Corporate bank bankruptcy cost</td>
<td>$\mu^F$</td>
<td>0.3</td>
</tr>
<tr>
<td>Mortgage bank bankruptcy cost</td>
<td>$\mu^H$</td>
<td>0.3</td>
</tr>
</tbody>
</table>
## Baseline Calibration

### Production parameters and shock processes

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital share</td>
<td>$\alpha$</td>
<td>0.3</td>
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<tr>
<td>Capital depreciation rate</td>
<td>$\delta$</td>
<td>0.025</td>
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<tr>
<td>Capital adjustment cost parameter</td>
<td>$\zeta$</td>
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<tr>
<td><strong>Shock processes</strong></td>
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<tr>
<td>TFP shock persistence</td>
<td>$\rho^A$</td>
<td>0.85</td>
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<tr>
<td>Risk shock persistence</td>
<td>$\rho^\sigma$</td>
<td>0.85</td>
</tr>
<tr>
<td>Housing demand persistence</td>
<td>$\rho^D$</td>
<td>0.85</td>
</tr>
</tbody>
</table>
The bank’s required rate of return on equity is given by the following expression:

\[ E_t \tilde{\rho}_t^{F} = \frac{E_t \left[ 1 - \Gamma^F(\omega^F_t) \right] \tilde{R}_t^{F}}{\phi_t^F}. \]

Leverage does two things
- amplifies the rate of return on equity for given loan spreads (standard effect)
- increases the probability of bankruptcy - amplifies profits through higher limited liability subsidy
The limited liability subsidy and the rate of return on equity

- How much does the limited liability boost the rate of return on equity everything else equal?

- Without bankruptcy, the rate of return on equity is given by:

$$E_t \tilde{\rho}^F_{t+1} = E_t \frac{\tilde{R}^F_{t+1} - (1 - \phi^F_t) R^D_t}{\phi^F_t}$$

- Hence the limited liability subsidy is given by:

$$\frac{(1 - \phi^F_t) R^D_t - E_t (\Gamma^F (\omega^F_t) \tilde{R}^F_{t+1})}{\phi^F_t}$$
The limited liability subsidy and the rate of return on equity (cont’d)

![Graphs showing limited liability subsidy, net leveraged rate of return on equity, lending rate under limited liability, and probability of bank failure.](image-url)
Higher generalised capital ratios in the SS

- Welfare Gains Savers
- Welfare Gains Borrowers
- Welfare Gains Entrepreneurs
- Welfare Gains Bankers

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Higher generalised capital ratios in the SS (cont’d)

![Graph 1: Total Consumption](image1)

![Graph 2: Social Welfare Gains](image2)
Higher generalised capital ratios in the SS (cont’d)

TOTAL FISCAL COST TO OUTPUT

FISCAL COST BANK H

FISCAL COST BANK F
Higher generalised capital ratios in the SS (cont’d)
Higher generalised capital ratios in the SS (cont’d)

Def Rate Bank H

Def Rate Bank F

Def Rate Households

Def Rate Entrepreneurs
IRF to a TFP shock

Productivity Shock

OUTPUT

INVESTMENT

CONSUMPTION BORROWERS

CONSUMPTION SAVERS

Productivity Shock

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IRF to a TFP shock (cont’d)

Price of Capital

House Prices

NetWorth Entrepreneurs

NetWorth Banker

Leverage Entrepreneurs

Leverage Households

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IRF to a TFP shock (cont’d)

Productivity Shock

-8 -6 -4 -2 0 2
$10^{-3}$

DEFAULT BANK H

-1.5 -1 -0.5 0

DEFAULT BANK F

-0.25 -0.2 -0.15 -0.1 -0.05 0

DEFAULT ENTREPRENEURS

-0.25 -0.2 -0.15 -0.1 -0.05 0

DEFAULT HOUSEHOLDS

-1.5 -1 -0.5 0

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We build a model for macroprudential policy
- key objective is to have a clear channel through which financial instability places costs on the real economy
In our model
- banks take excessive risk due to limited liability/deposit insurance