EUROPEAN CENTRAL BANK

EUROSYSTEM

A "canonical" model for assessing macroprudential regulatory policies

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Outline of the presentation

1) Where do we stand

2) The Challenges we face

3) Next steps

Where do we stand? Purpose

- Cross-country project developed in the context of the Mars network
- Develop a "reference" model containing (i) a minimum set of building blocks (ii) rationales for macro-prudential policies
- Incorporate approaches on financial amplification and instability into a tractable dynamic macro model
- Focus on use in policy making rather than making a cutting edge contribution to the academic literature

Broad Objective

- The aim of the project is to study the main financial regulation suggested in the policy discussions:
  - Bank capital regulation
  - Bank liquidity regulation
  - LTV/DTI limits on borrowers
  - Sectoral capital buffers
  - Cyclical vs. structural regulation
  - Margins requirements

- The final objective is to assess the effectiveness and analyse the transmission mechanism of of macro-prudential policies. Our Model is to be calibrated and potentially estimated on euro area data and country data
- Codes to be made generally available in the Eurosystem

Current state of the model: building blocks

- Banking sector as in Goodhart *et. al* (2012): Optimizing financial institutions solving a portfolio problem and intermediating funds between savers and borrowers - Default by banks to be added

- Household sector as in Kioytaki-Moore (1997), Iacoviello (2005): Patient and Impatient households

- Mortgages can default as in Mendicino and Stracca (2012), Goodhart *et al.* (2010): default has an impact on the balance sheet of financial institutions, who experience a loss

- Corporate sector as in Derviz (2012): akin to Bernanke, Gertler, Gilchrist (1999)

- To be added later: Shadow banks as in Goodhart *et al.* (2012) to study margin requirements

Reference literature

- **Gertler and Karadi (2011), Gertler and Kioytaki (2011):**
  - Net worth of financial institutions ; Banks issue equity shares
- **Daracq-Paries, Kok-Sorensen, Rodriguez-Palenzuela (2011):**
  - Models households and different industrial sectors
  - Default in all sectors, but not in the banking sector which is relatively stylized
- **Kiley and Sim (2011):**
  - Models bank capital structure and liquidity shocks
- **Benes and Kumhof (2011):**
  - Extends BGG to allow for risky loans and losses accruing ex-post to banks.
  - Models the costs of violating the regulatory constraint on bank leverage

- The purpose of this growing literature is to put a non-trivial banking sector in General Equilibrium models, the balance sheet health of which affects credit and activity in the real economy

Focus on Default and Banking Structure

<u>Policy motivation</u>

- Bridge macro-prudential regulation with micro-prudential, which focuses on risk rather and loss absorbency rather than aggregate credit, GDP
- The policy focus of the paper, which requires the modelling of bank capital structure (capital regulation), liquidity shocks (liquidity regulation), household and firm defaults (LTV regulation)

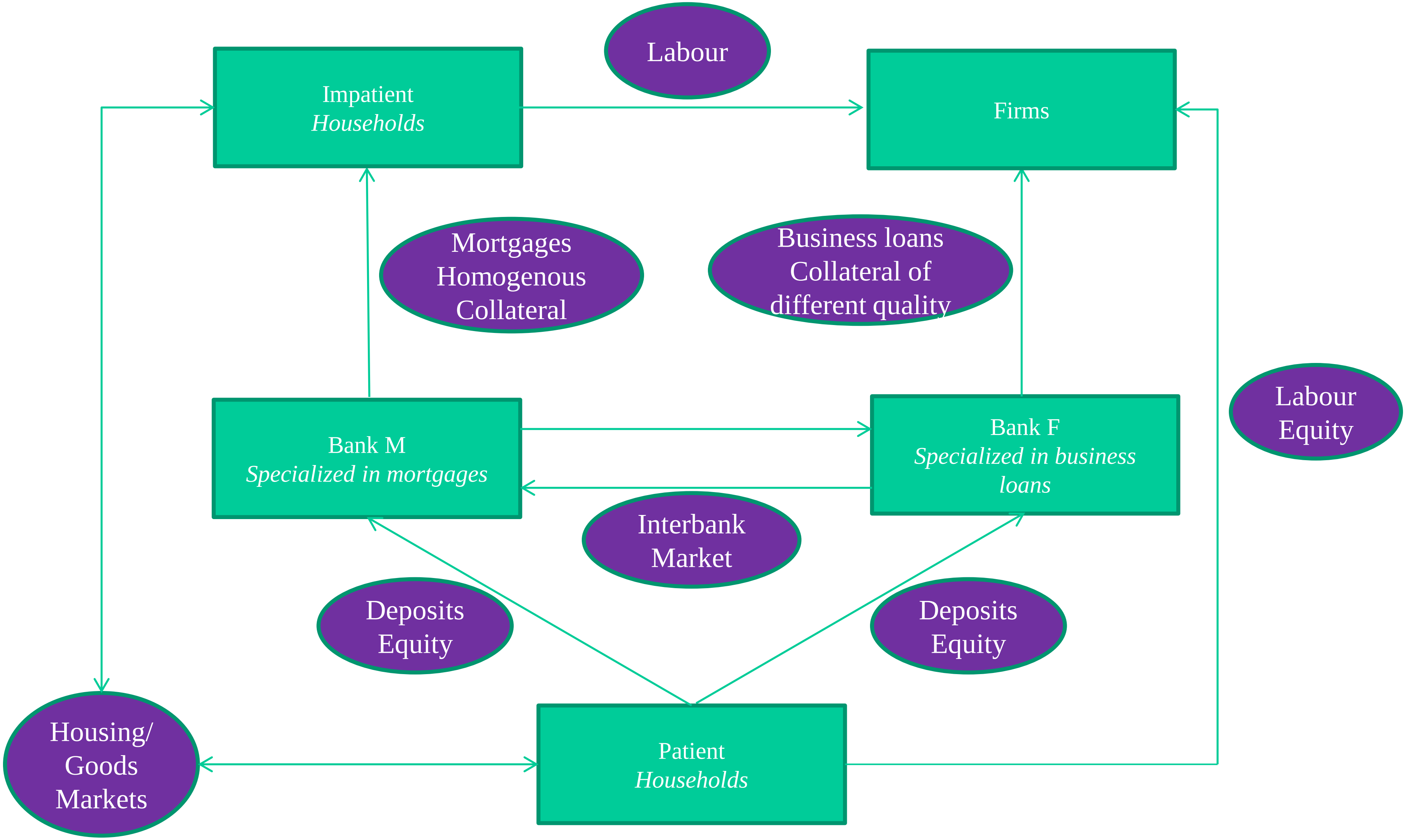
<u>Macroeconomic Implication</u>

- Default as a discontinuity can allow for bigger swings in the presence of adverse shocks

<u>Endogenous Leverage</u>

- Desire to incorporate default risk in the asset book of financial institutions and an active management of their liabilities (equity vs. deposits)
- Endogenous lending terms distinct from the interest rate
- Optimizing financial institutions solving an intertemporal portfolio problem and being subject to losses

Model's view


Labour
Impatient
Households
Firms
Mortgages
Homogenous
Collateral
Business loans
Collateral of
different quality
Labour
Equity
Bank M
Specialized in mortgages
Bank F
Specialized in business
loans
Interbank
Market
Deposits
Equity
Deposits
Equity
Housing/
Goods
Markets
Patient
Households

Mortgages and Business Loans

- **Mortgages** are collateralized by the housing purchases of impatient households
- Departures from the literature following Kiyotaki-Moore (1997) and Iacoviello (2005) in the modelling of mortgages in two ways:
  i. there is *aggregate risk* to which the contract is not contingent
  ii. a representative household can decide to *partially default* on the loan

- **Business loans** are collateralized by the physical capital as well as the realised production
- Both systemic and idiosyncratic shocks in production *a la* Bernanke, Gertler & Gilchrist (1999)
- The important departure is that business loans are risky, i.e. the interest rate is not state-contingent, and losses can accrue to lenders ex-post (see Benes & Kumhof, 2011)

Patient Households

Patient households maximize

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \left[\log(c_t^P) + v_{h,t}^P \log(h_t^P) - v_{l,t}^P f(l_t^P)\right]$$

c_t^P is the consumption of goods, h_t^P the amount of housing consumed, l_t^P the labour and $v_{h,t}^P, v_{h,t}^P$ preferences parameters

The intertemporal budget constraint is

$$c_t^P + p_t^h(h_t^P - h_{t-1}^P) + D_t + \sum_j \vartheta_{j,t}^P + \sum_a e_t^{P,a} P_t^{e,a}$$

$$\leq w_t l_t^P + R_{t-1}^D D_{t-1} + \sum_j \frac{\vartheta_{j,t-1}^P}{\vartheta_{j,t-1}^P + \vartheta_{j,t-1}^{P-}} \Pi_t^j + \sum_a e_{t-1}^{P,a}(P_t^{e,a} + DPS_t^a)$$

$\mathbf{p_t^h}$	Price of housing	$\mathbf{w_t}$	Wage	$\mathbf{e_t^{P,a}}$	Shares of bank a ∈ {M, F} purchased
$\mathbf{D_t}$	Deposits	$\boldsymbol{\vartheta_j^P}$	Equity invested in firm j	$\mathbf{P_t^{e,a}}$	Price per share of bank $a \in \{M, F\}$
$\mathbf{R_t^D}$	Return on deposits	$\mathbf{\Pi_t^j}$	Profits of firm j	$\mathbf{DPS_t^a}$	Dividends per share of bank $a \in \{M, F\}$

Impatient Households

Impatient households maximize

$$E_0 \sum_{t=0}^{\infty} \beta_I^t \left[\log(c_t^I) + v_{h,t}^I \log(h_t^I) - v_{l,t}^I f(l_t^I)\right]$$

The intertemporal budget constraint is

$$c_t^I + p_t^h h_t^I + (1 - \delta_t^I) R_{t-1}^M B_{t-1}^M \leq w_t l_t^I + B_t^M + \left(1 - \Omega(\delta_t^I)\right) p_t^h h_{t-1}^I$$

Function $\boldsymbol{\Omega}(\cdot)$

I. Linear Function $\Omega(\delta_t^I) = \delta_t^I$

$\Rightarrow \delta_t^I = 1$ if $p_t^h h_{t-1}^I < R_{t-1}^M B_{t-1}^M$, $\delta_t^I = 0$ otherwise (Geanakoplos, 2003, Goodhart et al. 2010,2012)

II. $\Omega(\delta_t^I) \rightarrow +\infty$ as $\delta_t^I \rightarrow 0 \Rightarrow$ Zero default in equilibrium, akin to collateral constraints excluding default

III. Interior default $0 < \delta_t^I < 1$:

- $\Omega(\delta_t^I) \rightarrow 0$ as $\delta_t^I \rightarrow 0$
- $\Omega\colon R_+ \rightarrow R_+$ has a fixed point in the closed interval $[0,1]$
- $\Omega(\delta_t^I) \rightarrow +\infty$ as $\delta_t^I \rightarrow 1$

$\mathbf{B_t^M}$	Mortgage	$\mathbf{0 \leq \delta_t^I \leq 1}$	Default level	$\boldsymbol{\Omega}(\cdot)$	Pecuniary cost of default function

Firms (I)

- Firm j combines labour and capital to produce the final good according to function

$$A_{t+1}f(k_t, m_t) = S_{t+1}L_{t+1}(k_t)^a(m_t)^{1-a}$$

where A_{t+1} is the TFP, S_{t+1} is an systemic shock in productivity affecting all firms and L_{t+1} is an idiosyncratic productivity shock, which is realised after investments and borrowing decisions take place

- Firm j raise equity, η_t^{qk}, and borrows from the bank, η_t^{Bk}, to invest in new capital, the price of which is p_t^z
- The capital purchased is transformed to firm-specific capital according to a function $J(\cdot)$

- The capital used for production in a surviving firm is the sum of depreciated plus newly acquired capital $$k_t = (1-d)k_{t-1} + J\left(\frac{\eta_t^{qk} + \eta_t^{Bk}}{p_t^z}\right)$$
- A surviving firm repays the interest on the business loan out of production and roles over the principal. The debt of a surviving firm evolves according to

$$B_t^F = B_{t-1}^F + \eta_t^m + \eta_t^{bk} = B_{t-1}^F + w_t m_t + \eta_t^{bk}$$

where $\eta_t^m = w_t m_t$, is the bank loan to pay for labour before production takes place

Firms (II)

- Firm j pays dividends $y_t = max\{S_t L_t f(k_{t-1}, m_{t-1}) - r^F_{t-1} B^F_{t-1}, 0\}$, where r^F_{t-1} is non-state contingent interest rate charged on business loans
- If $S_t L_t f(k_{t-1}, m_{t-1}) < r^F_{t-1} B^F_{t-1}$, the firm defaults and the bank seizes the collateral $S_t L_t f(k_{t-1}, m_{t-1}) + p^Z_t Z((1-d)k_{t-1})$, where $Z(\cdot)$ is the inverse of $J(\cdot)$
- Define the cut-off level for default by $A^d_t = \frac{r^F_t B^F_{t-1}}{f(k_{t-1}, m_{t-1})}$ or $L^d_t = \frac{r^F_t B^F_{t-1}}{S_t f(k_{t-1}, m_{t-1})}$
- After aggregation the total business loan extension is

$$B^F_t = \Phi^+_A(A^d) B^F_{t-1} + w_t M_t + \eta^{BK}_t, \quad \text{where } \Phi^+_A(A) = \int_A^{+\infty} \varphi_A(a) da$$

- Given the exogenous law of motion for physical capital $K_t = (1 + S_t g_t - d)K_{t-1}$ and the equilibrium price of capital given by $\theta_A(A^d_{t+1}) f_k((1-d)K_{t-1} + J_t, M_t) = p^Z_t Z'(J_t)$, new borrowing for capital investment is given by $K_t = (1-d)K_{t-1} + J\left(\frac{\eta^{qK}_t + \eta^{BK}_t}{p^Z_t}\right)$

Banks

- Bank $a \in \{M, F\}$ is owned by the patient household and wants to maximize a concave function of the expected flow of dividends. Also:
- This also introduces portfolio diversification since the bank will not only care about the expected payoff of its portfolio, but also about the underlying risk

$$maxE_0 \sum_{t=0}^{\infty} \beta_a^{t+1} f(Div_{t+1}^a)$$

- The intertemporal budget constraint is

$$Div_{t+1}^a + B_{t+1}^a + R_t^D D_t^a + R_t^{IB} B_t^{IB,a} \leq X_{t+1}^\alpha B_t^a + D_{t+1}^a + B_{t+1}^{IB,a} + E_{t+1}^a - E_t^a$$

$\mathbf{B_t^a}$	Mortgage or business loan	$\mathbf{B_t^{IB,a}}$	Interbank loan	$\mathbf{X_{t+1}^\alpha}$	Effective return on mortgages or business loan
$\mathbf{D_t^a}$	Deposits	R_t^{IB}	Interbank rate	$\mathbf{Div_{t+1}^a}$	Total dividends distributed
$\mathbf{R_t^D}$	Return on deposits	$\mathbf{E_{t+1}^a - E_t^a}$	Change in equity		

Equilibrium returns

- The effective return on mortgages is

$$X_{t+1}^{M} = (1-\delta_{t+1}^{I})R_t^M + \frac{\delta_{t+1}^{I} p_{t+1}^{h} h_t^I}{B_t^M}$$

where δ_{t+1}^{I} is given by $\Omega'(\delta_{t+1}^{I}) = \frac{R_t^M B_t^M}{p_{t+1}^{h} h_t^I}$

- The payoff per unit of business loans extended, X_{t+1}^{F}, conditional on the realisation of the aggregate productivity shock, S_{t+1}, is

$$X_{t+1}^{F} = \frac{\Psi_L^-(\hat{L}_{t+1}^{d}) S_{t+1} f(K_t, M_t) + \Phi_L(\hat{L}_{t+1}^{d})\left[p_{t+1}^{z} Z((1-d)K_t)\right]}{B_t^F} + $$
$$+ \left(1 - \Phi_L(\hat{L}_{t+1}^{d})\right)(1 + r_{t+1}^{F}).$$

where $\Phi_L^+(L) = \int_L^{+\infty} \varphi_L(l)dl$, $\Psi_L^+(L) = \int_L^{+\infty} l\varphi_L(l)dl$, $\Phi_L(L) = 1 - \Phi_L^+(L)$ and $\Psi_L^-(L) = \overline{L} - \Psi_L^+(L)$

Market Clearing

- Total housing purchases need to be equal to the total stock of housing

$$h_t^P + h_t^I = \overline{H}$$

- Equity raised by banks is equal to the price per share multiplied by the number of shares

$$E_t^a = e_t^{P,a} P_t^{e,a} = \overline{e}^a P_t^{e,a}$$

- Total equity invested in the production sector satisfies

$$\sum_j \vartheta_{j,t}^P = \eta_t^{qk}$$

- Given the aggregation, the patient household invests in a diversified portfolio of firms

$$\sum_j \vartheta_{j,t}^P = \vartheta_t^P \text{ and } \sum_j \Pi_t^j = S_t \theta_L\left(L^d\right)[f(K_{t-1}, L_{t-1}) - r_{t-1}^F B_{t-1}^F]$$

Extension of mortgages: Example

- The first order condition with respect to mortgage extension is

$$-\varphi_t^M + E_{t+1,t}(X_{t+1}^M \varphi_{t+1}^M) = 0$$

- But, $X_{t+1}^M = (1-\delta_{t+1}^I)R_t^M + \frac{\delta_{t+1}^I p_{t+1}^h h_t^I}{B_t^M}$
- The level of mortgages depends crucially on the mortgage rate given a downward sloping demand curve and the fact that the benefits from mortgage default are limited in the default state due to the pecuniary cost function
- All else equal a lower mortgage rate requires:
  i. A higher net-worth of the bank when the mortgage is extended
  ii. A higher net-worth in the states where default is harsher
  iii. Lower default which depends on the initial mortgage extension (point i) and the price of housing in the default state (point ii)
- The above can give rise to endogenous variations in leverage where lower housing prices result in bigger losses for banks, which cut credit extension and thus push prices lower, and so on

Introducing a Liquidity Mismatch

- Objective I: Introduce a demand for liquidity and a precautionary motive for savings
- Objective II: Capture a fire-sales externality due to costly liquidation
- Amend patient households' problem such that they face a liquidity shock before banking loans mature and deposits are repaid by the bank. Denote the liquidity shock by $\frac{1}{\varepsilon_{t+1}^{D}}\overline{L}$
- Deposits are demandable at any point, thus households will demand the fraction $\varepsilon_{t+1}^{D} D_t^a$
- Bank a can satisfy this with cash that it carries from the previous period or by liquidating early a fraction of its asset denoted by ω_{t+1}^{α}
- We assume that the liquidation price is exogenouly determined, but it is linear to the effective return on assets, i.e. $\omega_{t+1}^{\alpha} X_{t+1}^{\alpha} \lambda^a$ with $0 < \lambda^a < 1$
- The budget set of bank a becomes

$$\varepsilon_{t+1}^{D} D_t^a \leq \omega_{t+1}^{\alpha} X_{t+1}^{\alpha} B_t^{\alpha} \lambda^a + cash_t^a$$

$$Div_{t+1}^a + B_{t+1}^a + R_t^D D_t^a + R_t^{IB} B_t^{IB,a} + cash_{t+1}^a \leq (1-\omega_{t+1}^{\alpha}) X_{t+1}^{\alpha} B_t^a + D_{t+1}^a + B_{t+1}^{IB,a} + E_{t+1}^a - E_t^a$$

The challenges we face

Default is a discontinuity: The decision to default introduces a kink depending on the **relative value** of collateral to the loan

I. Ex-post idiosyncratic shocks on the value of the collateral are one way to deal with the issue, given that they result in a distribution of defaults
   - We take this approach for business loans: The bank faces a distribution of business loan defaults with a state-dependant cut-off level, while firms are risk-neutral and exit the economy once they default
   - Forlati and Lambertini (2011) consider idiosyncratic shocks in the value of housing collateral backing up mortgages. Also, they approach is equivalent to partial default
   - In our model, housing collateral is homogenous across agents and is not subject to ex-post idiosyncratic shocks

The Challenges we face

II. Ways to deal computationally with mortgage default:

a. Calibrate the steady state such there is partial default, i.e. the value of collateral is lower than the mortgage repayment and $\Omega(\delta_t^I) \rightarrow +\infty$ as $\delta_t^I \rightarrow 1$

b. Approximate the repayment decision $min\left[(1-\delta_t^I)R_{t-1}^M B_{t-1}^M, \left(1-\Omega(\delta_t^I)\right)p_t^h h_{t-1}^I\right]$ with a differentiable logistic function

c. Proceed without the approximation in (b) or default in the steady state in (a) and solve non-linearly for a deterministic path rather than stochastically as in (a) and (b)

Regulation

- Distinction can be drawn between cyclical and structural macro-prudential policies
- Cyclical macro-prudential policy aims to:
  - Lean against the buildup of risks over time, and
  - Create buffers and resilience against a potential future crisis
- Regulations to be considered:
  - Countercyclical capital buffers tied to aggregate credit growth
  - Sectoral buffers tied to macro-variables specific to the housing or business sectors
  - Restrictions on banking dividends to accumulate equity
  - Time-varying LTV regulation tied to the price of housing
- Structural macro-prudential policies aim at fixing market failures relating to infrastructures, externalities across institutions
- Regulations to be considered:
  - Minimum capital requirements: Standardized and IRB approach for calculation of risk-weights
  - Liquidity requirements defined either on the asset or the liability side of the balance sheet

Next steps

- Solve and calibrate the model to get a first assessment of macro-prudential policies to cope with shocks and externalities embedded in the models

- Develop a quantitative version of the model (monetary version + nominal frictions)

- Estimate / calibrate the model for a set of countries and analyze the effects and effectiveness of macro-prudential policies