Stress Testing at Banque de France

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Plan

- Current framework

  A. Modelling the impact of macroeconomic stress scenarios on different outcomes of bank's loan portfolios (interest margin, PDs) and extrapolate effect on banks' solvency.

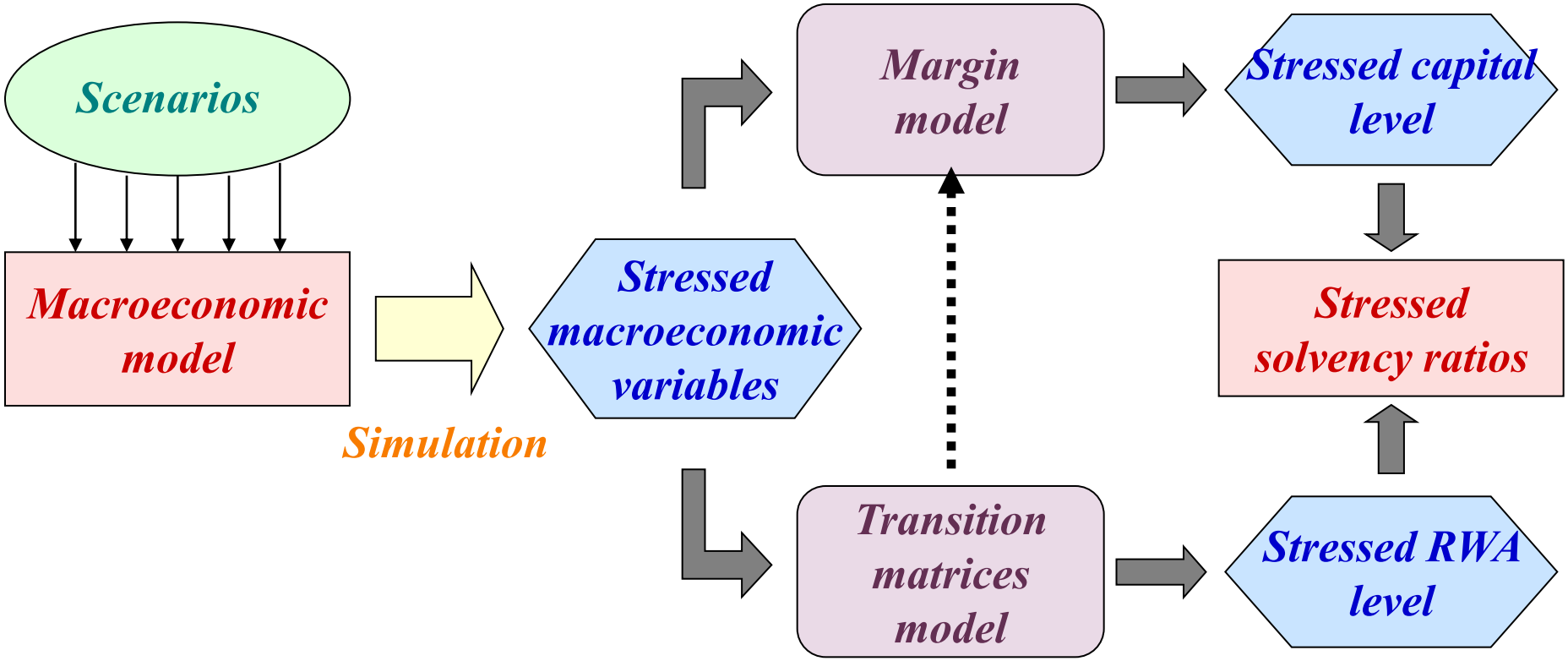
  B. Ad hoc shocks on the corporate credit portfolio of major French banks (sensitivity analysis)

  C. Ad hoc shocks on the EL of a single bank

- New instruments
  - *Loan Loss Provisions and the Macroeconomy*
  - Equilibrium in the corporate debt market

I – Current framework

I-A Macroeconomic stress testing exercises



I – Current framework

I-A- Macro stress testing

1- Analysis of intermediation Margin

- Estimated on the basis of panel data analysis (GMM estimation) of banks' net interest margin, period: 1993-2002.
- Dynamic approach (persistence)
- Main explanatory factors: yield curve, credit volumes and credit quality

$$M_{i,t} = 0.64 + \underset{(17.99)}{0.68} M_{i,t-1} + \underset{(10.19)}{0.35} r_t^* - \underset{(-4.96)}{0.59} \sigma_{p,t}^{*\,2} + \underset{15.34}{0.29} r_t^* \Delta L_{i,t} - \underset{-0.65}{0.20} \pi_{i,t} + \varepsilon_t$$

adjusted $R^2 = 0.83$

$M_{i,t}$ = credit margin for bank i at time t

r_t^* = 5y-3m risk free interest rate slope

$\sigma_{p,t}^*$ = volatility of 5y-3m risk free interest rate slope

$\Delta L_{i,t}$ = loan growth for bank i

$\pi_{i,t}$ = cost of risk expected by bank i at time t = $PD_{i,t}.LGD_{i,t}$

I – Current framework

I-A Macro stress testing

2- Capital requirements model (Risk-weighted assets)

- Estimates of risk weighted asset are computed using the probability of migration from one rating to another, in banks' corporate portfolios (***transition matrix***)
- Markovian approach : logistic function/ dynamic approach

$$M_t = \left[\Pr(rating_t = j \mid rating_{t-1} = i)\right]_{ij}$$

$$z_{ijt} = \log\left(\frac{\Pr(rating_t \le j \mid rating_{t-1} = i)}{\Pr(rating_t > j \mid rating_{t-1} = i)}\right)$$

$$z_{ijt} = \theta_{ij} z_{ij,t-1} + \alpha_{ij} + \beta_{ij} X_t + \varepsilon_{ijt}^{p}$$

$$X_t = macroeconomic\ variables\ (GDP, interest\ rate, etc.)$$

- A stressed loan portfolio P_t is then calculated with:

$$P_{t+1} = P_t M_{t+1}$$

I – Current framework

I-A Macro stress testing

3-Capital requirements model

- The increase in capital requirements due to a change in the credit ratings after a shock is then computed from the stressed portfolio, using Basel II formulae:

$$\theta_t = \Omega(P_t)$$

θ_t = capital requirements

Ω = Basel II function for credit risk computation

- The initial credit portfolio is obtained from :
  - Banks' resident individual exposures on corporates (credit register)
  - A breakdown of these exposure by risk classes (BDF internal ratings)
  - Initial (before the shock) risk weighted assets can be computed, using Basel II hypotheses on LGDs and asset correlation.

I – Current framework

I-A Macro stress testing

4- Stress scenario design (1/2)

Scenarios are either ***"severe" or more "realistic"***

- Partly inspired by initial FSAP scenarios (2003/2004):
  - 20 % drop in world demand for French goods
  - Decrease in consumption growth or in investment growth such as triggering a recession for the French economy.
  - Rise in oil price (100 USD)
  - Depreciation of USD/EUR
  - 200 BP parallel shift of interest rate curve
  - Flattening and Inversion of the yield rate curve (+200bp ST / +100bp LT)

I – Current framework

I-A Macro stress testing

4- Stress scenario design (2/2)

2 types of shocks simulated:

- ***Transitory shocks (macroeconomic),*** that are implemented progressively over the period. After 2 years, shocked variables return to their initial level

- ***Permanent shocks (markets),*** whose impact is entirely taken into account at the start of the stress period and maintained throughout the period: interest rates, exchanges rates, Brent oil prices etc.

•**Stressed exogenous factors** (inputs in the stress testing banking models) come from BDF internally used macroeconometric models (Mascotte, Nigem).

- GDP growth
- Outstanding loans to the private sector
- Interest rates and yield curve

I – Current framework

I-A Macro stress testing

5- Stress scenario results (1/4)

- Final results provide us with an estimate of stressed solvency ratios for the banking sector represented by its main large and complex financial institutions
  - The new level (after the shock) of own funds is computed taking account of the change in banks' operating income ➔ ***numerator of the ratio is impacted***

$$RWA_t = (1+\Delta\theta_t)\cdot(1+\Delta\upsilon_t)\cdot RWA_{t-1}$$
$$\Delta\theta_t = \text{risk effect}$$
$$\Delta\upsilon_t = \text{volumeeffect}$$

  - The transition matrices model provides an estimate of "stressed" RWA, according to both a volume effect (change in credit volumes) and a risk effect (change in the rating of credit counterparts) ➔ ***denominator is impacted***

$$FP_t = (1+\Delta M_t)\cdot\Pi_t + FP_{t-1}$$
$$FP_t = \text{capital}$$
$$\Delta M_t = \text{banks'margin growth}$$
$$\Pi_t = \text{Operatingincomefor the7 FrenchLCFIs}$$

- The stressed solvency ratio (Basel II type) is then compared to a benchmark (actual ratio for the large French banks)

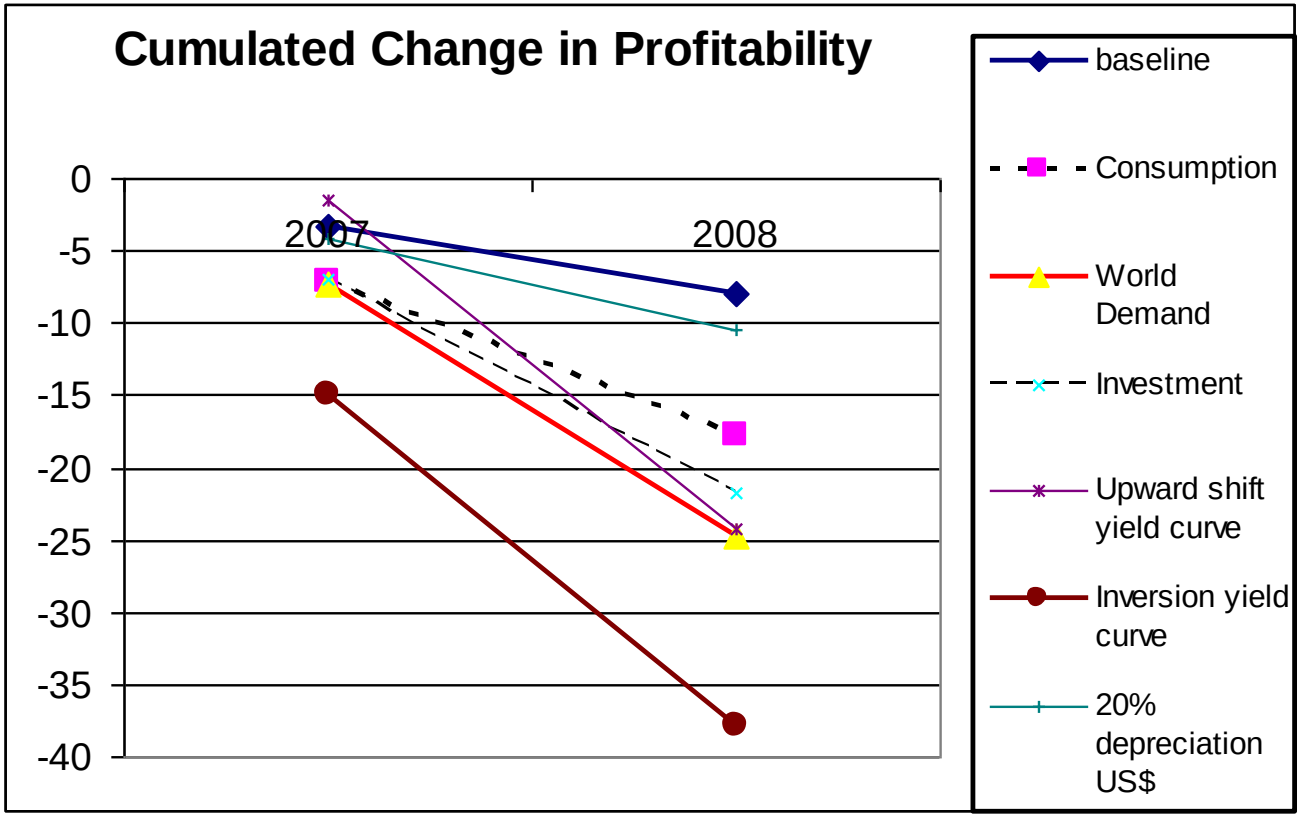
$$stress = FP_t^{BS} / RWA_t^{BS} - FP_t^{S} / RWA_t^{S}$$

I – Current framework

I-A Macro stress testing

5- Stress scenario results (2/4)

Impact of the shocks on banks' profitability (cumulated effect, %)

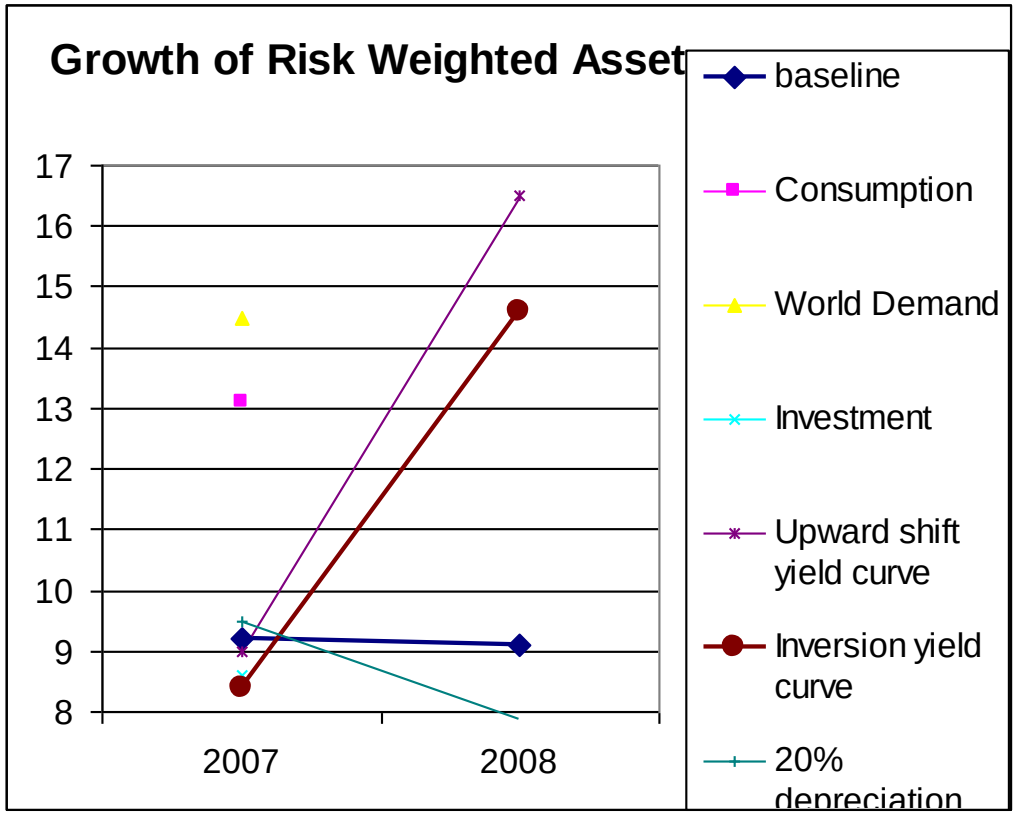


I – Current framework

I-A Macro stress testing

5- Stress scenario results (3/4)

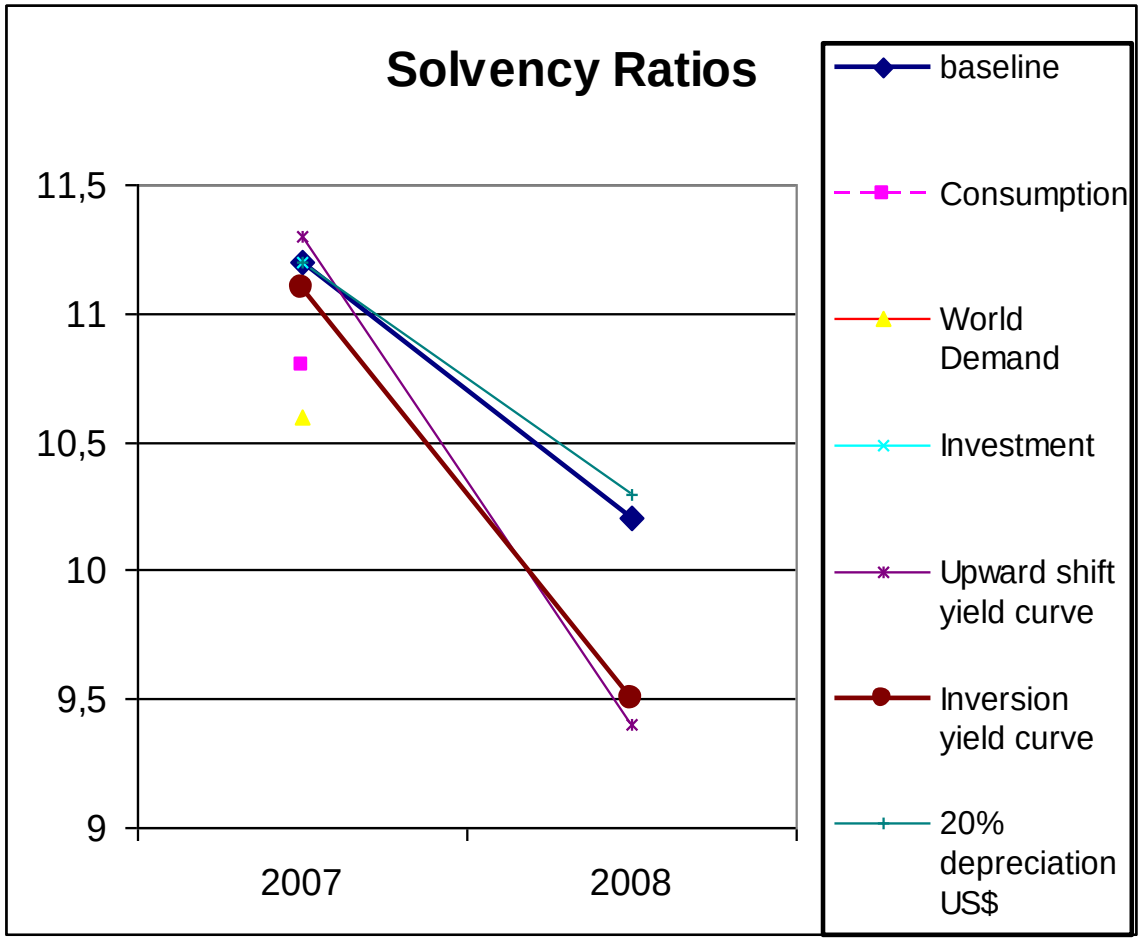
Scenarios impact on RWA



I – Current framework

I-A Macro stress testing

5- Stress scenario results (4/4)



I - Current framework

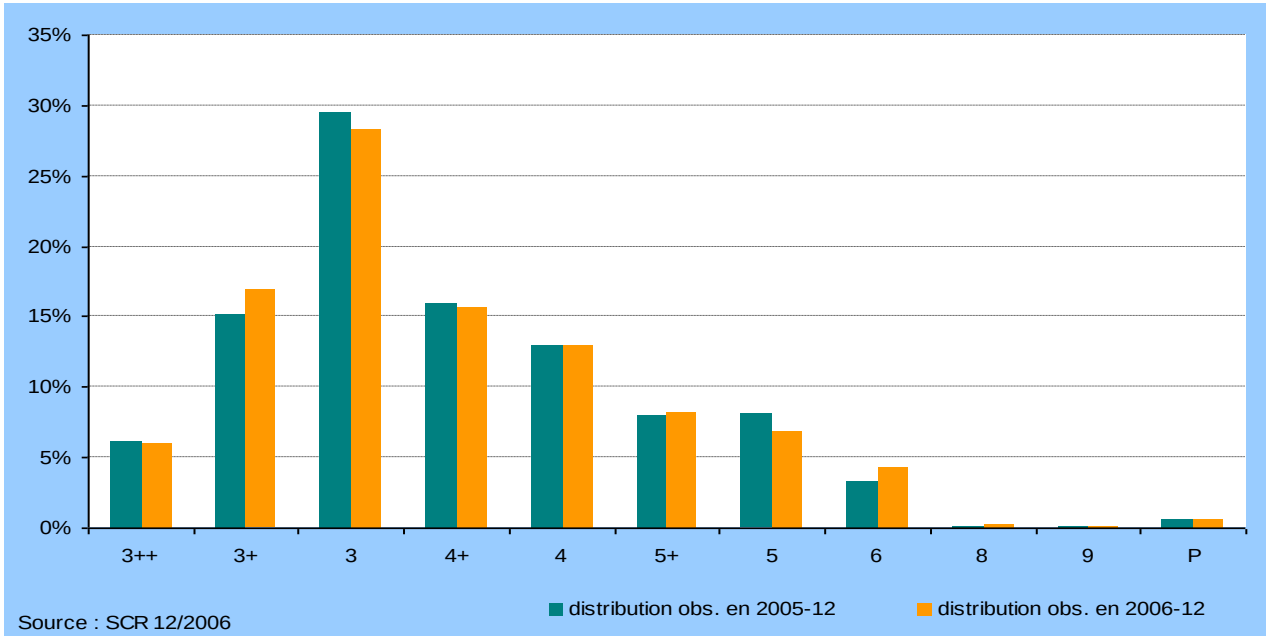
I-B. Ad hoc shocks on a credit portfolio

- Overall or sector-specific downgrade of credit ratings :
  - One notch for all ratings
  - Or two notches for specific sectors/countries and one notch for the others
- Using Banque de France data base :
  - For rated companies
  - For exposures (credit register)

I - Current framework

I-B Ad hoc shocks on a credit portfolio

- Risk distribution of the banks' exposures on rated enterprises



I- Current framework

I-B Ad hoc shocks on a credit portfolio

- A simulated overall-system stressed solvency ratio is calculated
- This stressed simulated ratio is compared to the benchmark solvency ratio

I - Current framework

I-C Ad hoc shocks on the EL of a single bank

- For an individual bank, a banking analysis tool, named SAABA 2:
  - Stress instantaneously the individual expected losses
  - Get the resulting stressed solvency ratio for the selected bank

II – New approaches

- Improvements desired:
  - Ad hoc nature of the link between macro and banking sector (credit demand equation)
  - Absence of feedback effects on the macroeconomy (independence between volumes and risk)
- Model the supply and demand equilibrium in one component of credit market : corporate debt

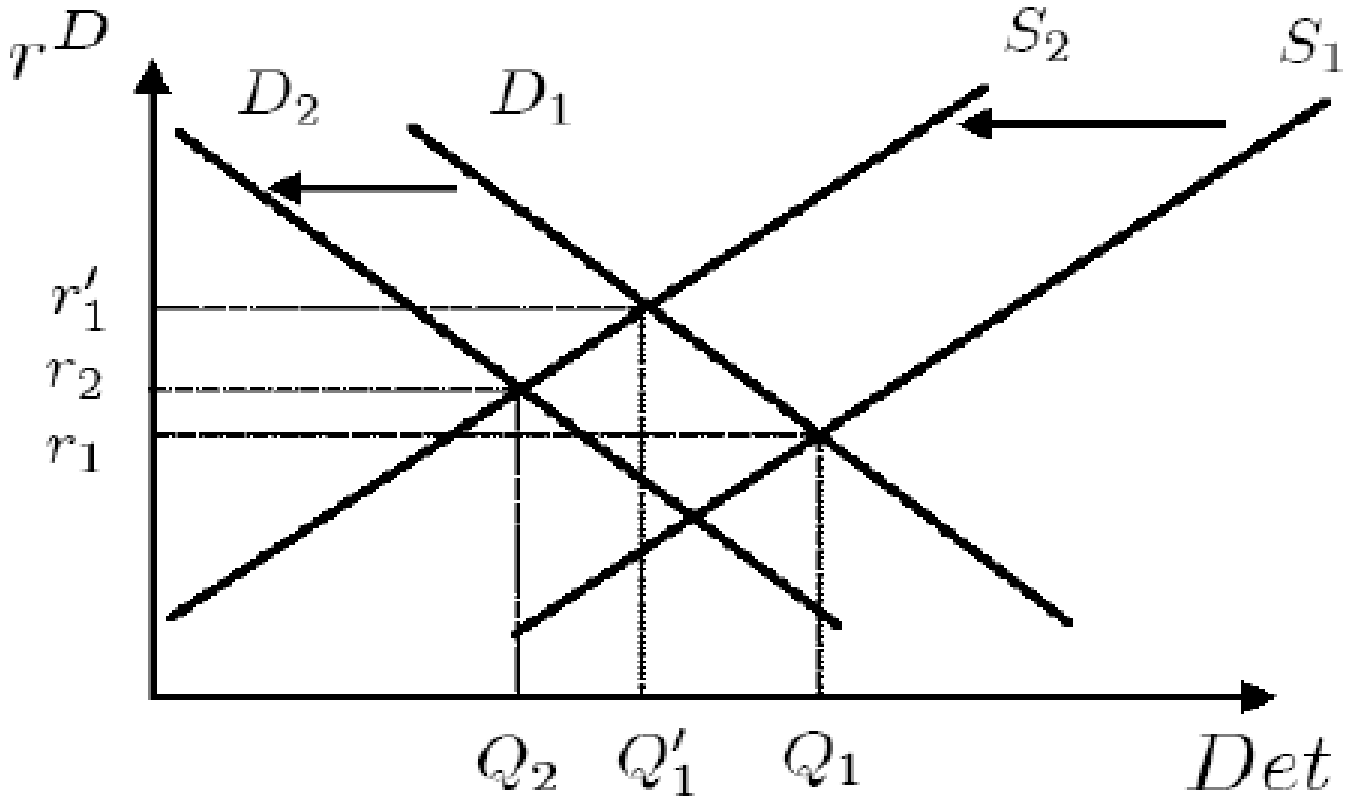
=> Panel investigation of the European corporate debt market (S&Dd)→ extension possible to HH

- Stress testing exercises:

  measures of the effects of large macroeconomic shocks (increase in interest rates, severe recession, large oil shocks, …) on the equilibrium in the corporate debt market → include feedback effects from shifts in both supply and demand schedules

II – New approaches

An example in response to an adverse macro shock : debt supply shifts to the right, as well as demand→ lower debt level (Q1 to Q2) and higher interest rate (r1 to r2)



II – New approaches

II-A Supply and demand schedules

The demand equation is derived from the demand equation but

additional indicators are introduced:

$$Log(\frac{D_{it}}{P_t}) = \gamma_{10i} + \gamma_{11} Log(Turn_{it}) + \gamma_{12} Inv_{it} - \gamma_{13} Roa_{it} - \gamma_{14} r_i^D + \varepsilon_{it}^d$$

where Inv_{it}, $Turn_{it}$ and Roa_{it} are companies' investment, sales growth and returns on assets

The supply equation ($r_i^L = r_i^D$ at equilibrium)

$$r_i^D = \gamma_{20i} + \gamma_{21} r_t^R + \gamma_{22} \pi_i^{fail)} + \gamma_{23} Log(D_{it} / P_t) + \varepsilon_{it}^s$$

where γ_{20i} is a function the interest margin, can be compared across companies, although its absolute level is not determined

II – New approaches

II-B Estimation methods

- At this stage, the estimation is static
- We have to account for heterogeneity in a panel context
- We have to face an endogeneity problem, usual in estimating supply/demand equations (**simultaneity bias**)
- this problem is avoided by implementing a 2SLS (Two stage least square) estimation method : W2SLS is preferred method

II – New approaches

II-C Data (1/2)

We use the EU Commission's Harmonized BACH database which provides harmonized balance sheet, profits and loss accounts for different countries: we have retained France, Germany, Spain and Italy

The data are annual and available according to a breakdown by industrial sectors and three size classes (small/medium/large): the individual index *i* is therefore a country-sector-size triplet and the time index *t* denotes a year

We focus on the 1993-2005 (T=12 periods) and N=144 (12 sectors x 3 sizes x 4 countries), selecting 12 sectors (manufacturing (excluding energy),construction, wholesale and retail trade)

II – New approaches

II-C Data (2/2)

The variables are the following:

Det = log(total financial debt, divided by the GDP deflator)
Int = interest burden in % of total financial debt (rD)
Turn = year-on year growth of sales
Inv = investment ratio= investment/sales
Roa = net profits divided by total assets
Gar(i)= amount of collateral available to the company
Gar(1) for the small companies and Gar(2) for the medium size companies
Size = total assets in logarithm

- The default probabilites are just available for countries
- The data are aggregates (sum over the companies of a same class)
- Indicators in level are averages over the number of companies of the class
- Ratios are computed as (weighted) average ratios (ratios of aggregates)

II – New approaches

II-D Empirical results : main results (1/3)

- Davidson and MacKinnon tests confirm the existence of endogeneity in most cases.

- The partial R^2 and the partial F indicate that the choice of instruments is all in all acceptable.

- All estimation methods provide very similar estimates for the parameters of the supply equation; with the collateral variables included, it is the same for the demand equation

II – New approaches

II-D Empirical results : main results (2/3)

- The empirical fit of the supply equation to the data is better than the one of the demand equation

- W2SLS Estimation of the supply equation provides coefficients of the correct sign and order of magnitude

- Fixed effects in the supply equation indicates that the degree of competition (for fund suppliers) is higher for large than for small companies

II – New approaches

II-D Empirical results : main results (3/3)

Model with collaterals

Table 3: Model with collateral variables[a]

	Fixed effects model		*Random effects model*			
	W2SLS		*EC2SLS*		*G2SLS*	
	Det	r^D	*Det*	r^D	*Det*	r^D
r^D	-2.946^{**} (1.183)	——	-3.084^{***} (0.615)	——	-2.897^{***} (0.616)	——
Det	——	0.0185^{**} (0.008)	——	-0.005 (0.005)	——	0.0187^{**} (0.006)
Turn	0.444^{***} (0.108)	——	0.459^{***} (0.107)	——	0.449^{***} (0.107)	——
Inv	2.534^{***} (0.348)	——	2.518^{***} (0.262)	——	2.526^{***} (0.263)	——
Roa	-3.210^{***} (0.628)	——	-3.202^{***} (0.343)	——	-3.202^{***} (0.344)	——
r^R	——	0.797^{***} (0.043)	——	0.941^{***} (0.033)	——	0.853^{***} (0.039)
π^{fail}	——	0.636^{***} (0.157)	——	0.361^{***} (0.066)	——	0.184^{**} (0.079)
Size	——	-0.034^{***} (0.010)	——	-0.001 (0.005)	——	-0.028^{***} (0.007)
Gar1	——	-0.076^{***} (0.038)	——	-0.039^{***} (0.011)	——	-0.083^{***} (0.015)
Gar2	——	-0.041 (0.033)	——	-0.035^{***} (0.008)	——	-0.064^{***} (0.010)
Const.	15.67^{***} (0.04)	0.337^{***} (0.049)	15.68^{***} (0.138)	0.139^{***} (0.026)	15.66^{***} (0.136)	0.242^{***} (0.034)
R^2	0.160	0.770	0.016	0.722	0.014	0.599
$H_{\chi^2(k)}$	——	——	0.000	40.22^{***}	0.000	102.88^{***}
$F_{(k-1,n-k)}$	836.25^{***}	8.66^{***}	——	——	——	——
Exog.test (*p−value*)	0.088	0.000	——	——	——	——
Overid.test (*p−value*)	0.045	0.432	0.000	0.000	0.000	0.168
Partial F	97.61^{***}	36.86^{***}	——	——	——	——
Partial R^2	0.346	0.124	——	——	——	——

Notes :***indicates significance at 1% level; ** at 5% and * at 10%; [a] Firm and time effects are not reported here; Numbers in brackets denote standards errors (robust to heteroskedasticity and autocorrelation for W2SLS); W2SLS: within two-stage least squares method; EC2SLS: error-component method; G2SLS: generalized two-stage least squares method; $H_{\chi^2(k)}$ denotes the Hausman test two-stage least squares fixed effects (W2SLS) *vs* Random effects (EC2SLS or G2SLS); $F_{(k-1,n-k)}$ denotes the Fisher test that all fixed effects are equal to 0; *Exog. test* : Davidson-MacKinnon test of exogeneity; *Overid. test* : Sargan-Hansen test of overidentifying restrictions; *Partial F* denotes the first-stage F-statistic that coefficients are null in the regression of the endogenous regressor on the instruments; *Partial* R^2 denotes the first-stage R^2 measure.

II – New approaches

II-E Implementing stress testing exercises (1/5)

- Loans to corporate firms are a large component of total assets of euro area financial institutions

- In practice:
  - Macro shocks
  - Effect on equilibrium interest rate and debt
  - Impact on banks' portfolio, based on share of corporate loans in banks' total portfolio

II – New approaches

II-E Implementing stress testing exercises (2/5)

- Two macro scenarios are considered:
  - **A significant reduction in world demand (originating in the US) leading to a recession in Europe**
  - **An increase in oil price (+70%) with a reaction of monetary policy to counteract the second round effects on inflation**
- We refer to macroeconomic models to calibrate the stress scenarios:

- we get the responses of macroeconomic variables (real GDP, GDP deflator, companies's investment/value added, growth of value added in nominal terms, gross operating surplus/capital stock) to the initial shocks

- **we** use bridge equations which link the exogeneous variables included in the corporate model to the macroeconomic aggregates:

for exemple : Inv is linked to the ratio of companies investment/value added, default to (inverse) GDP growth.

II – New approaches

II-E Implementing stress testing exercises (3/5)

Coefficients of the reduced form model
= Elasticities of debt and interest rates to the exogenous variables

Table 5 : Coefficients of the reduced form of the model without collateral variables

	$Turn$	Inv	Roa	r^R	π^{fail}	$Size$	$Const.$
Det	0.418	2.438	-3.080	-2.191	-1.662	8.299×10^{-2}	14.175
r^D	6.277×10^{-3}	0.0366	-4.620×10^{-2}	0.783	0.596	-2.975×10^{-2}	0.532

II – New approaches

II-E Implementing stress testing exercises (4/5)

Impact of the shocks on the exogenous variables and total impact on *Det* and r^D

Table 6a: Impact of the stress scenarios on equilibrium *Det* and r^D

	Turn	*Inv*	*Roa*	π^{fail}	r^R	*Det*	r^D
Value in 2005	0.040	0.030	0.045	0.012	0.022	15.42	0.048
Scenario 1: stressed values	-0.031	0.031	0.041	0.019	–	–	
Impact on Det (*in % points*)	-2.988	0.041	1.308	-1.180		**-2.819**	
Impact on r^D (*in basis points*)	-4.482	0.061	1.962	42.32			**39.861**
Scenario 2: stressed values	0.042	0.031	0.046	0.012	0.030		
Impact on Det (*in % points*)	0.054	0.082	0	-0.050	-1.747	**-1.661**	
Impact on r^D (*in basis points*)	0.082	0.122	0	1.788	62.66		**64.652**

II – New approaches

II-E Implementing stress testing exercises (5/5)

Stress Testing Results :

- **Scenario 1 : recession following a reduction in foreign demand**
  - Shock : negative growth in sales (turnover), lower RoA, higher bankruptcy rates
  - Equilibrium on the corporate debt market : lower demand from negative growth in sales, partially offset by positive effect from lower Roa + lower supply from higher bankruptcy rates
  - Impact on corporate debt volume is negative (equal contribution from supply and demand) :

  → **Det -2.819%**
  - Impact on lending rate is positive: significant contribution from higher bankruptcy (supply)

  → **r^D +39.861 bp**
- **Scenario 2 : An increase in oil price (+70%) with a reaction of monetary policy to counteract the secound round effects on inflation**
  - Shock : slight acceleration in sales (turnover), slightly higher bankruptcy rates, higher interest rates following ECB reaction
  - Equilibrium on the corporate debt market : slightly higher demand + significantly lower supply from higher bankruptcy rates, but mainly from higher refinancing rates
  - Impact on corporate debt volume is negative, mainly from higher refinancing rates :

  → **Det -1.661%**
  - Impact on lending rate is positive: from higher refinancing rate and bankruptcy

  → **r^D +64.652 bp**

Perspectives for future work

- Dynamics in debt market
- Liquidity shocks
- Non linearity
- Impact of macroeconomic shocks on (expected) corporate defaults and effect on banks
- Enrich macro models with real variables (house price shock through wealth effects or other channels)
- Analysis of contagion in interbank market