Stress Testing and Corporate Finance

O. de Bandt, C. Bruneau & W. El Amri

Topics

- Panel investigation of the European corporate debt market (supply&demand)
- 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

Plan of the paper

- Section 1: Structural (economic) references to derive the supply&demand equations
- Section 2: presentation of the data and the econometric tools
- Section 3: discussion of the empirical results regarding the market equilibrium
- Section 4: illustration of stress testing exercises: the case of a severe recession and an oil shock

I. Basic model

- 1 Demand for debt by corporate firms
  - Bank loans
  - Own funds
  - Equities

  (inter company loans are excluded)
- Here we concentrate on aggregate financial debt

I.1. Demand equation

obtained by minimizing the cost
of financial ressources

$$Min_{\{D_i,E_i\}}(r_i^D D_i + r_i^E E_i)$$

$$under \quad Y_i = D_i^{\alpha} E_i^{1-\alpha}$$

- Equities E_i (cost: r_i^E)

- Debt D_i (cost: r_i^D)

to, finance Y_i (investment–own funds)

One finds: $D_i = k\left(\frac{r_i^E}{r_i^D}\right)^{1-\alpha} Y_i$

Log-log specification

$$Log(D_i) = \alpha_0 Log(\frac{r_i^E}{r_i^D}) + Log(Y_i) + c$$

(with $\alpha_0 = 1-\alpha$)

Semi-log specification

$$Log(D_i) = \alpha_0 (\frac{r_i^E}{r_i^D}) + Log(Y_i) + c$$

I.2 Supply equation

Expected Profit of the bank serving segment i:

$$P_i(L_i) = r_i^L(1-\pi_i^{fail})L_i - r^R L_i - C_i(L_i)$$

where $L_i(r_i^L)$ denotes the supplied loan (average loan to firms of type i)

r_i^L the offered rate (cost of credit to the firms)

r^R is the short term refinancing cost for the bank

The cost function (for the bank) $C_i(L_i)$ is supposed to be convex
The marginal cost $MC_i(L_i)$ is therefore supposed to be an increasing function of L_i

π_i^{fail} denotes the default probability (for segment i)

- The optimality condition (Profit maximisation by lenders) holds as:

$$\frac{\partial P_i(L_i)}{\partial L_i} = 0 \Leftrightarrow$$

$$r_i^L(1-\pi_i^{fail}) + \frac{\partial r_i^L}{\partial L_i} L_i(1-\pi_i^{fail}) r^R L_i - r^R - MC(L_i) = 0$$

- Nota: The marginal costs of the banks are supposed to be identical across the markets they serve.

- The optimality condition can be rewritten as

$$r_i^L = -\frac{\partial r_i^L}{\partial L_i} L_i + \frac{r^R + MC(L_i)}{(1 - \pi_i^{fail)})}$$

- Using the approximation for small π_i^{fail}

$$\left(1 - \pi_i^{fail}\right)^{-1} \approx 1 + \pi_i^{fail}$$

one gets: $$r_i^L \approx -c_{isl} + (1 + \pi_i^{fail)})(r^R + MC(L_i))$$

where $$c_{isl} = \frac{\partial r_i^L}{\partial L_i} L_i = \frac{\partial r_i^L}{\partial Log L_i} < 0$$

is constant in the semi-log demand specification

II. **Empirical investigation**

II.1 Supply and demand regressions

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 net profits

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

$$r_i^D = \gamma_{20i} + \gamma_{21}(1+\pi_i^{fail)}) r_t^R + \gamma_{22}(1+\pi_i^{fail)}) + \gamma_{23}(1+\pi_i^{fail)}) Log(D_{it} / P_t) + \varepsilon_{it}^s$$

where $\gamma_{20i} = -c_{isl}$ is the interest margin which is expected to be >0

- In a simultaneous equation system, one should impose the cross-equation constraint:

$$\frac{\partial r_i^D}{\partial LogD_{it}} = (\gamma_{14})^{-1} = c_{sl} = -\gamma_{20<0}$$

II.2 Estimation methods

- At this stage, the estimation is static (we neglect the existence of possible serial correlations: left for further research)
- We have to account for heterogeneity in a panel context
- We have to face an endogeneity problem

(usual in estimating supply/demand equations) : this problem is avoided by implementing a 2SLS (Two stage least square) estimation method

- Two empirical investigations
  - 1) a non structural one, where the basic model is just used to justify the inclusion of the regressors retained in the demand and supply regression
  - 2) a (more) structural one where the supply equation of the basic model is estimated

- Regarding the use of panel data, we consider both fixed and random effects models
  - for the fixed effects approach, we implement the Within-2SLS
  - For the random effects approach, we use the EC2SLS (Error component 2SLS) and the G2SLS (generalized 2SLS)

The Hausman test allows to distinguish between both approaches

The use of panel data

- The regression is $y_{it} = \alpha + X'_{it}\beta + u_{it}; i = 1,\ldots,N \quad t = 1,\ldots,T$

$$u_{it} = \mu_i + v_{it}$$

- μ_i is the unobservable individual specific effect and v_{it} denotes the error component
- The X_{it} are supposed to be independent from the v_{it} for all i and t.
- μ_i can be supposed to be fixed parameters to be estimated and the remaining stochastic disturbance with v_{it} IID(0, σ_u^2)

- 1) The fixed effects specification

Thus, one implements the Within estimation method: one performs OLS on the transformed model :

$$y_{it} - \overline{y}_{i.} = (X_{it} - \overline{X}_{i.})'\beta + (v_{it} - \overline{v}_{i.})$$

$$\Leftrightarrow$$

$$Qy = QX'\beta + Qv$$

which gives :

$$\tilde{\beta}_{within} = (X'QX)^{-1} X'QY$$

$$\tilde{\alpha}_{within} = \overline{y}_{..} - \overline{X}_{..}'\tilde{\beta}_{within}$$

$$\tilde{\mu}_{i,within} = \overline{y}_{i.} - \tilde{\alpha}_{withn} - \overline{X}_{i.}'\tilde{\beta}_{withi}$$

- 1) The random effects specification (justified for example when one is drawing individuals randomly from a large population)

Thus, one performs a GLS estimation

by supposing that:

$$
\begin{aligned}
\operatorname{cov}(u_{it}, u_{js}) &= \sigma_\mu^2 + \sigma_\nu^2 \quad && for \;\; i = j, t = s \\
&= \sigma_\mu^2 && for \;\; i = j, t \neq s \\
&= 0 && otherwise
\end{aligned}
$$

One can prove that the GLS estimate is a linear combination of the within and the between estimates $\tilde{\beta}_{GLS} = W_1 \tilde{\beta}_{within} + W_2 \tilde{\beta}_{between}$

The Hausman specification test

. A critical assumption in the error component regression model is that: $E(u_{it} / X_{it}) = 0$

It is not satisfied if the unobservable (stochastic) individual effect μ_i is correlated with one of the regressors X_{it}
In that case the GLS estimator $\tilde{\beta}_{GLS}$ becomes biased and inconsistent . However, the Within Transformation wipes out the μ_i and leaves the Within estimator $\tilde{\beta}_{Within}$ unbiased and consistent.
Hausman proposes to compare $\tilde{\beta}_{GLS}$ and $\tilde{\beta}_{Within}$

Problem of endogeneity due to the simultaneity of the demand and supply equations

- In that case the OLS estimates are inconsistent and one has to implement instrumental variable methods like the two-stage least squares (2SLS)
- Depending on the specification which is retained to account for individual heterogenity, one is led to perform the W2SLS (Within 2SLS) or the EC2SLS (Error Component 2SLS) or the G2SLS (generalized 2SLS) (the difference between the G2SLS and the EC2SLS comes from the choice of instruments)
- In all cases, the two stages are the following:
  - First one approximates the endogenous variable of one of the two equations (for example the demand equation) by its OLS estimate
  - This estimate becomes a regressor of the other equation (the supply equation)

II.3 The data

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 period

We have selected 12 sectors (that are manufacturing (excluding energy),construction, wholesale and retail trade)

For the panel analysis, we have therefore N=144 (12 sectors x 3 sizes x 4 countries) and T=12

The variables are the following:

Det=log(total financial debt, divided by the GDP deflator)

Int = interest burden in % of total financial debt (r^D)

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

estimates of 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)

III Empirical results: main results

- The random effects specification is rejected for the supply equation according to Hausman's test but not for the demand equation
- 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
- The empirical fit of the supply equation to the data is better than the one of the demand equation
- W2SLS Estimation of the (structural) 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

Different investigations

- 1. a non structural one
  - Without collateral variables (Table 1)
  - With collateral variables (Table 2)

  Different estimations (W2SLS, EC2SLS, G2SLS)
- 2. a structural one
  - (W2SLS estimation)
  - In the supply equation, regressors like

$$(1+\pi_t^{fail})r_t^R, \quad (1+\pi_t^{fail}), \quad (1+\pi_t^{fail})Log(D_{it}/P_t)$$

Non structural model

Table 1: Non structural Model[a]

	Fixed effects model		Random effects model			
	W2SLS		EC2SLS		G2SLS	
	Det	r^D	*Det*	r^D	*Det*	r^D
r^D	−2.771*** (0.544)	—	−2.857*** (0.509)	—	−2.798*** (0.511)	—
Det	—	0.012** (0.005)	—	−0.018*** (0.003)	—	0.004 (0.004)
Turn	0.464*** (0.107)	—	0.472*** (0.093)	—	0.470*** (0.094)	—
Inv	2.049*** (0.437)	—	2.030*** (0.263)	—	2.038*** (0.263)	—
Roa	−4.219*** (0.402)	—	−4.211*** (0.278)	—	−4.210*** (0.278)	—
r^R	—	0.817*** (0.03)	—	1.016*** (0.018)	—	0.958*** (0.021)
π^{fail}	—	0.916*** (0.098)	—	0.575*** (0.054)	—	0.497*** (0.056)
Size	—	−0.029*** (0.006)	—	0.015*** (0.003)	—	0.002 (0.004)
Const.	15.874*** (0.054)	0.321*** (0.041)	15.882*** (0.145)	0.041*** (0.007)	15.877*** (0.143)	0.052*** (0.007)
R^2	0.259	0.764	0.259	0.773	0.259	0.770
$H_{\chi^2(k)}$	—	—	0.000	97.43***	0.000	101.06***
$F_{(k-1,n-k)}$	1038***	9.28***	—	—	—	—

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 (White's robust std err. for W2SLS);

W2SLS: within two-stage least squares method; EC2SLS:error-component two-stage least squares method; G2SLS: generalized two-stage least squares method;

$H_{\chi^2(k)}$ denotes the Hausman test 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.

Non structural model with collaterals

Table 2 : Non structural 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	−2.802*** (0.544)	—	−2.890*** (0.508)	—	−2.865*** (0.510)	—
Det	—	0.016*** (0.005)	—	−0.005 (0.004)	—	0.015*** (0.005)
Turn	0.465*** (0.107)	—	0.474*** (0.093)	—	0.473*** (0.093)	—
Inv	2.046*** (0.436)	—	2.026*** (0.263)	—	2.029*** (0.263)	—
Roa	−4.220*** (0.402)	—	−4.211*** (0.278)	—	−4.210*** (0.278)	—
r^R	—	0.805*** (0.030)	—	0.960*** (0.022)	—	0.869*** (0.028)
π^{fail}	—	0.934*** (0.062)	—	0.450*** (0.060)	—	0.284*** (0.069)
Size	—	−0.033*** (0.006)	—	−0.001 (0.005)	—	−0.024*** (0.006)
*Gar*1	—	−0.066*** (0.021)	—	−0.038*** (0.010)	—	−0.075*** (0.012)
*Gar*2	—	−0.044* (0.026)	—	−0.034*** (0.007)	—	−0.059*** (0.009)
Const.	15.877*** (0.054)	0.340*** (0.042)	15.886*** (0.144)	0.128*** (0.023)	15.883*** (0.143)	0.218*** (0.028)
R^2	0.259	0.759	0.259	0.773	0.259	0.751
$H_{\chi^2(k)}$	—	—	0.000	91.19***	0.000	1433***
$F_{(k-1,n-k)}$	1038***	8.72***	—	—	—	—

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 (White's robust std err. for W2SLS).
W2SLS: within two-stage least squares method; EC2SLS:error-component two-stage least squares method; G2SLS: generalized two-stage least squares method.
$H_{\chi^2(k)}$ denotes the Hausman test 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.

Fixed effects estimation of the structural model

Table 3 : Fixed effects estimation of structural Models ($W2SLS$)[a]

	without collateral variables		*with collateral variables*	
	Det	r^D	Det	r^D
r^D	-2.805^{***} (0.545)	—	-2.838^{***} (0.545)	—
$\widetilde{Det}$	—	0.012^{**} (0.005)	—	0.016^{***} (0.005)
$Turn$	0.466^{***} (0.106)	—	0.467^{***} (0.107)	—
Inv	2.045^{***} (0.437)	—	2.041^{***} (0.436)	—
Roa	-4.220^{***} (0.402)	—	-4.221^{***} (0.402)	—
$\widetilde{r}^R$	—	0.811^{***} (0.030)	—	0.800^{***} (0.030)
$\widetilde{\pi}^{fail}$	—	0.70^{**} (0.144)	—	0.655^{***} (0.143)
$Size$	—	-0.028^{***} (0.006)	—	-0.033^{***} (0.006)
$Gar1$	—	—	—	-0.065^{***} (0.021)
$Gar2$	—	—	—	-0.044^{*} (0.026)
$Const.$	15.878^{***} (0.054)	-0.371^{**} (0.156)	15.881^{***} (0.054)	-0.308^{*} (0.159)
R^2	0.259	0.763	0.259	0.758
$F_{(k-1,n-k)}$	1038^{***}	9.20^{***}	1038^{***}	8.67^{***}

Notes : *** indicates significance at 1% level; ** at 5% and * at 10%;

Numbers in brackets denote White's robust standards errors.

[a] Firm and time effects are not reported here.

W2SLS: within two-stage least squares method.

$F_{(k-1,n-k)}$ denotes the Fisher test that all fixed effects are equal to 0.

$\widetilde{Det} = (1+\pi^{fail})Det$; $\widetilde{r}^R = (1+\pi^{fail}) \times r^R$ and $\widetilde{\pi}^{fail} = (1+\pi^{fail})$.

Discussion on the size effect….

- Decomposition of the error term to measure the impact of competition : size variables → lower margin for larger companies

Discussion on the size effect

Introduction of the size variable in the supply regression

$$\beta_{0i}^{*} = \overline{y_i} - \beta_1^{*}\overline{x_{1i}} - \beta_2^{*}\overline{x_{2i}} \quad \textit{with the size variable } X_2$$

$$\alpha_{0i}^{*} = \overline{y_i} - \alpha_1^{*}\overline{x_{1i}} \quad \textit{without the size variable } X_2$$

accordingly,

$$\alpha_{0i}^{*} = \beta_{0i}^{*} + (\beta_1^{*} - \alpha_1^{*})\overline{x_{1i}} + \beta_2^{*}\overline{x_{2i}}$$

By averaging over individuals, one gets: $\alpha_0^{*} = \beta_0^{*} + (\beta_1^{*} - \alpha_1^{*})\overline{\overline{x_1}} + \beta_2^{*}\overline{\overline{x_2}}$

Finally, by substracting the two latter equations, one gets the interest margin $\gamma^{*}{}_{0i}$ as:

$$\alpha_{0i}^{*} = \gamma^{*}{}_{0i} = \alpha_0^{*} + \beta_{0i}^{*} - \beta_0^{*} + (\beta_1^{*} - \alpha_1^{*})(\overline{x_{1i}} - \overline{\overline{x_1}}) + \beta_2^{*}(\overline{x_{2i}} - \overline{\overline{x_2}})$$

$$\Leftrightarrow \gamma^{*}{}_{0i} \approx \alpha_0^{*} + \mu_i^{*} + \beta_2^{*}(\overline{x_{2i}} - \overline{\overline{x_2}})$$

One finds $\beta_2^{*} < 0$ with $\mu_i = \beta_{0i}^{*} - \beta_0^{*}$ not significantly different from zero for i=1,2,3 corresponding to the three size classes, which indicates a higher concurrence for the segment of the large companies

Table 4 : Distribution of fixed effects (Supply function)

Size category	*model without collateral*			*model with collateral*		
	Small	*Medium*	*Large*	*Small*	*Medium*	*Large*
μ_i	−0.0290	−0.0070	0.0360	−0.0155	−0.0040	0.0195
	(0.0211)	(0.0157)	(0.0205)	(0.0201)	(0.0148)	(0.0215)
γ_{20i}	−0.4593	−0.4859	−0.5138	−0.5044	−0.5481	−0.6051
	(0.0160)	(0.0134)	(0.0187)	(0.0144)	(0.0124)	(0.0205)

Numbers in brackets denote standards deviations.

γ_{20i} are fixed effects defined in (4) with $\gamma_{20i} = \mu_i + \gamma Size_{i.}$.

IV. Stess testing exercise (1)

- Why stress tests ? impact of large macro shocks on the stability of the financial system
- Loans to corporate firms are a large component of total assets of euro area financial institutions
- Take into account feedback effects of large shocks on banks' portfolio

  - Supply effects and not only demand (shifts in both dimensions)
  - Risk : impact of macro shocks on bankruptcy in the corporate sector

  (→ impact on supply by financial institutions)

- In practice (the recipe!):
  - Macro shocks
  - Effect on equilibrium interest rate and debt
  - Impact on domestic (euro area) portfolio, based on share of corporate loans in total portfolio

IV. Stess testing exercise (2)

- 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 secound 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:

Inv is linked to the ratio of companies investment/value added; turn to the growth of nominal value added , etc…

IV-A Coefficients of the reduced form model derived from the non structural model =elasticities of debt and interest rates to the exogenous variables

Table 5 : Coefficients of the reduced form of non structural model

	$Turn$	Inv	Roa	r^R	π^{fail}	$Size$	$Const.$
Det	0.449	1.983	-4.083	-2.191	-2.456	7.78×10^{-2}	14.503
r^D	5.39×10^{-3}	2.38×10^{-2}	-4.90×10^{-2}	0.791	0.886	-2.81×10^{-2}	0.495

Non structural model: impact of the shocks on the exogenous variables and total impact on Det and r^D

Table 6: Non structural model - 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	16.96	0.050
Scenario 1: stressed values	-0.031	0.031	0.041	0.019	–	–	
Impact on *Det* (in % points)	-3.206	0.033	1.734	-1.744		**-3.183**	
Impact on r^D (in basis points)	-3.847	0.040	2.081	62.942			**61.216**
Scenario 2: stressed values	0.042	0.031	0.046	0.012	0.030		
Impact on *Det* (in % points)	0.058	0.067	0	-0.077	-1.753	**-1.701**	
Impact on r^D (in basis points)	0.070	0.080	0	2.659	63.26		**66.066**

Non Structural Model

- **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) :

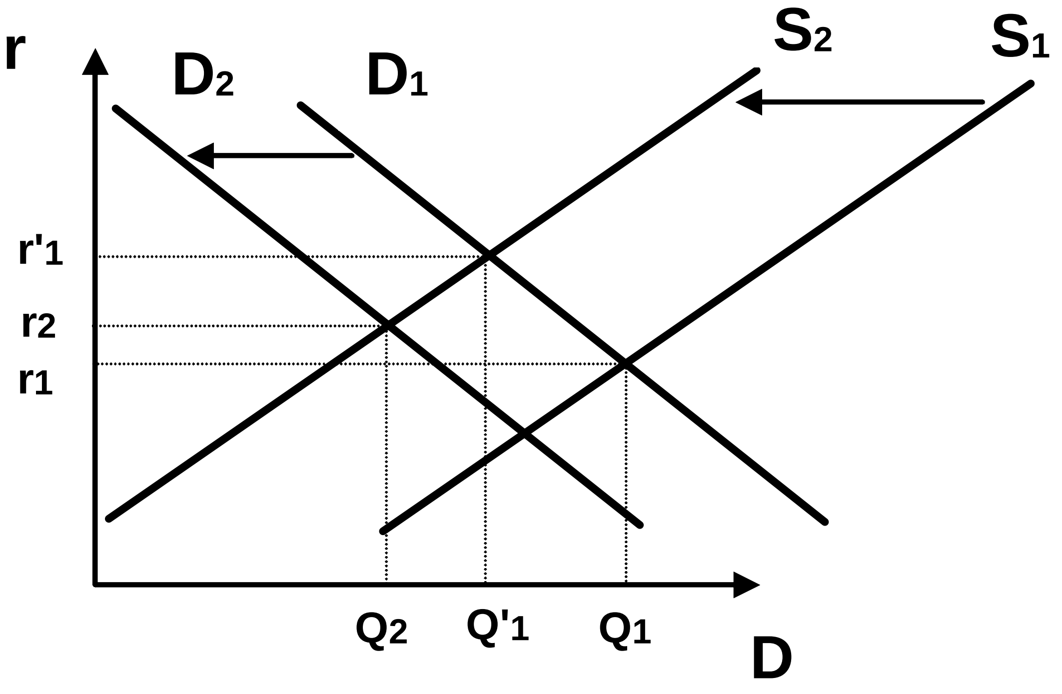
  → **Det -3.2%**
  - Impact on lending rate is positive: significant contribution from jigher bankruptcy (supply)

  → **r^D +61.2 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_-1.7%**
  - Impact on lending rate is positive: from higher refinancing rate and bankruptcy

  → **r^D +66.1 bp**

Supply shifts to the right, as well as demand→ lower debt level (Q1 to Q2) and higher interest rate (r1 to r2)



IV-B Structural model: impact of shocks on the exogeneous variables

- As in the non structural case, solve for the reduced form model,

→ Non linear structure of elasticities due to the presence of

$$(1+\pi_t^{fail})Log(D_{it}/P_t)$$

→ Elasticities depend on bankruptcy rates, with interaction effects with many variables

- Apply the same shocks as in the non structural case → impact of same order of magnitude as in the non structural case

Deriving of the reduced form model

- Estimated demand and supply equations:

$$Det = 15.90 - 2.80 r^{D} + 0.47 Turn + 2.04 Inv - 4.22 Roa$$

$$r^{D} = -0.37 + 0.01(1+\pi^{fail}) r^{R} + 0.70(1+\pi^{fail}) - 0.028 Size$$

- Reduced form

$$Det = \frac{1}{1+0.03(1+\pi^{fail})}[0.078 Size - 4.22 Roa + 0.47 Turn$$

$$- 2.27(1+\pi^{fail}) r^{R} - 1.96(1+\pi^{fail}) + 2.04 Inv + 16.92]$$

$$r^{D} = \frac{1}{1+0.03(1+\pi^{fail})}[-0.89(1+\pi^{fail}) - 0.03 Size + 0.02(1+\pi^{fail}) Inv$$

$$+ 0.05(1+\pi^{fail}) Roa + 0.81(1+\pi^{fail}) r^{R} + 0.0056(1+\pi^{fail}) Turn - 0.37]$$

- Effects of the shocks on the equilibrium value of Det and r^D

$$Det(stressed) - Det(2005)$$
$$= G(\pi^{fail}(stressed), Z(stressed)) - G(\pi^{fail}_{2005}, Z(2005))$$
$$with \quad Z = (Size, Roa, r^R, Inv, Turn)$$
$$G(\pi^{fail}, Z) = \frac{1}{1+0.03(1+\pi^{fail})}[0.078 Size - 4.22 Roa + 0.47 Turn$$
$$-2.27(1+\pi^{fail})r^R - 1.96(1+\pi^{fail}) + 2.04 Inv + 16.92]$$
$$r^D(stressed) - r^D(2005)$$
$$= F(\pi^{fail}(stressed), Z(stressed)) - F(\pi^{fail}_{2005}, Z(2005))$$
$$F(\pi^{fail}, Z) = \frac{1}{1+0.03(1+\pi^{fail})}[-0.89(1+\pi^{fail}) - 0.03 Size + 0.02(1+\pi^{fail}) Inv$$
$$+0.05(1+\pi^{fail}) Roa + 0.81(1+\pi^{fail}) r^R + 0.0056(1+\pi^{fail}) Turn - 0.37]$$

Structural model: impact of shocks on the exogeneous variables

Table 7*a* : Structural model - impact of the stress scenarios on exogenous variables

	$Turn$	Inv	Roa	π^{fail}	r^R	$Size$	$Cst.$
Value in 2005	0.040	0.030	0.045	0.012	0.022	16.96	1
Scenario 1: stressed values	-0.031	0.037	0.041	0.019	0.022	16.96	1
Impact on Det (in % points)	-3.217	0.032	1.736	-1.303	-0.033	-0.029	-0.378
Impact on r^D (in basis points)	-3.918	0.090	1.964	0.829	1.176	1.061	59.12
Scenario 2: stressed values	0.042	0.031	0.046	0.0121	0.0298	16.96	1
Impact on Det (in % points)	0.0585	0.066	0.000	-0.055	-1.783	-0.001	-0.016
Impact on r^D (in basis points)	0.072	0.083	-0.006	0.035	63.55	0.045	2.498

Total impact of the shocks on Det and r^D as well as confidence bands around total impact → statistically and economically significant effect

Table 7b : Structural model - total impact of stress scenarios on Det and r^D

	Impact on Det (in % points)	Impact on r^D (in basis points)
Scenario 1:	**-3.160**	**60.320**
Confidence Intervals[1]		
Lower bounds	-4.160	29.269
Upper bounds	-2.160	91.375
Scenario 2:	**-1.730**	**66.277**
Confidence Intervals[1]		
Lower bounds	-2.510	60.747
Upper bounds	-0.949	71.736

[1] Confidence Intervals was constructed using the DELTA Method.

Conclusion

- Structural model with supply and demand effects
- Better response of debt market to macro-economic shocks in stress test exercices→ economically and statistically significant response through risk factors
- Future work: more dynamics