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Stress Testing and Corporate Finance *

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Abstract

The article contributes to the literature on financial fragility, studying how macroeconomic shocks affect supply and demand in the corporate debt market. We take into account the effect of the competitive environment, as well as the risk level, measured by companies' default rate. The model is estimated using data from the Harmonised BACH database of corporate accounts for large euro area countries on the 1993-2005 period, in order to carry out an illustrative stress testing exercise. We measure the impact of large macroeconomic shocks (a severe recession and a sharp increase in oil prices) on the equilibrium in the debt market.

Key words : corporate finance, debt, financial fragility, stress tests, panel data

JEL : G3, C33, E44.

Résumé

L'article contribue à la littérature sur la fragilité financière, en étudiant comme les chocs macroéconomiques affectent l'offre et la demande sur le marché de la dette aux entreprises. Nous prenons en compte l'effet de l'environnement concurrentiel, ainsi que du niveau de risque, mesuré par le taux de défaillance des entreprises. Le modèle est estimé à partir de la base BACH de données harmonisées de comptes d'entreprises pour les grands pays de la zone euro sur la période 1993-2005, afin de mettre en oeuvre un exemple illustratif de *stress tests*. Nous mesurons les effets de grands chocs macroéconomiques (une forte récession et une augmentation importante des prix du pétrole) sur l'équilibre du marché de la dette.

Mots-clés : financement des entreprises, endettement, fragilité financière, *stress tests*, données de panel

Classification JEL : G3, C33, E44.

Non-technical summary

In the last few years, "stress tests" have been applied to an increasing number of countries in order to assess the resilience of the financial system to large macroeconomic shocks. The spirit of the exercise is to consider "large but realistic" shocks, i.e. that have a low -but non zero- probability of occurrence, typically a large increase in interest rates, a severe recession hitting the economy, a large oil price shock or a significant foreign exchange shock, etc. One drawback of these tests is that they are rather mechanistic, they focus on demand shocks to the financial sector and do not take into account of the effects of financial institutions on the real economy.

In the paper, we propose a way to improve upon the way stress tests are usually carried out, concentrating on the corporate segment of the debt market in the euro area (Germany, France, Italy and Spain), using the EU Commission BACH database of accounting data on corporate firms. We distinguish explicitly between the demand for debt by corporate firms, and the supply of debt, notably by financial institutions. This provides a new framework for implementing the response of the equilibrium in the corporate debt market (in terms of debt level and interest rate) to large macroecomic shocks. We extend the "balance sheet approach" (according to the Sorge and Virolainen's 2006 taxonomy), by assuming that risk is time-varying, even if it remains exogenous. By carefully distinguishing between supply and demand for debt, the analysis allows to improve upon the usual practice of stress tests. However, feedbacks effects remain contemporaneous and include only the reaction of banks' supply to firms' demand (there is no dynamic "second round" effects).

For illustrative purposes, we consider two scenarios : (i) a significant reduction in world demand (originating in the US), leading to a recession in the euro area; (ii) an increase in oil prices (+70%) with a monetary policy reaction to counteract "second round" effects on inflation.

The results indicate that the change in equilibrium largely depends on the change in the default rate. In particular, in the first scenario of recession, the suppliers of capital, and financial institutions among them, raise interest rates in order to take into account the increase in the default rate. Such an effect is both statistically and economically significant.

More precisely, scenario (i) of recession implies an increase in borrowing requirements due to lower profitability, which is more than offset by a lower turnover and higher risk for banks (with higher default rate), which decrease debt supply. The final effect is that real debt decreases by 2 to 4%, while the debt service increases by 25 to 50 basis points. In the second scenario, the oil price shock is associated with an increase in the short term interest rate by the Central Bank (by 70 basis points) in order to offset the "second round" effects on inflation which triggers a decrease in GDP growth by 0.15%. It leads to a slightly higher default rate, but the main factor behind the overall negative effect on debt (-0.2 to -3.2%) comes through the increase in short term interest rate by the Central Bank. It also largely explains the increase in the interest burden by 50 to 75 basis points.

Résumé non technique

Récemment des "*stress tests*" ont été mis en oeuvre dans un nombre croissant de pays afin d'apprécier la capacité de résistance du système financier a des chocs macroéconomiques de taille importante. L'objectif de ces exercices de simulation est de considérer l'effet sur le système financier de chocs "importants mais réalistes", au sens où ils ont une probabilité d'apparition faible mais non nulle. Typiquement, on étudie les effets d'une forte hausse des taux d'intérêt, une récession touchant l'économie, un choc pétrolier important, ou un décrochage du taux de change. Cependant ces tests ont de nombreuses limites qui résident dans leur caractère mécanique et dans l'accent mis sur les chocs de demande affectant le secteur financier, alors que les effets des institutions financières sur l'économie réelle ne sont généralement pas pris en compte.

Dans le papier, nous proposons un moyen d'améliorer la façon dont les *stress tests* sont mis en oeuvre, en mettant l'accent sur le marché de la dette des entreprises non financières de la zone euro (Allemagne, France, Italie et Espagne) en mobilisant la base BACH de données d'entreprises publiée par la Commission Européenne. Nous distinguons de façon explicite entre la demande d'endettement des entreprises et l'offre de dette, notamment par les institutions financières. Nous proposons ainsi un modèle permettant d'analyser comment l'équilibre sur le marché de la dette (en termes de niveau de dette et de taux d'intérêt) se modifie en réponse à des grands chocs macroéconomiques. Nous élargissons l'approche "en termes de bilan" (selon la taxonomie de Sorge and Virolainen, 2006), en intégrant un indicateur de risque variable dans le temps, même s'il demeure exogène. En distinguant clairement entre l'offre et la demande d'endettement, notre approche permet d'améliorer la pratique actuelle des *stress tests*. Cependant, les effets de retour du financier sur le réel demeurent contemporains et n'incluent que la réaction de l'offre des banques à le demande des entreprises (il n'y a pas d'effets de retour dynamiques).

A titre d'illustration, nous considérons deux types de scénarios : (i) une réduction significative de la demande mondiale (prenant sa source aux Etats-Unis), conduisant à une récession dans la zone euro; (ii) une hausse des prix du pétrole (+70%) incluant une réaction de la politique monétaire visant à éviter les effets de "second tour" sur l'inflation.

Les résulats indiquent que les modifications de l'équilibre dépendent fortement des variations du taux de défaillance. En particulier, dans le premier scénario de récession, les offreurs de capital, et parmi eux les institutions financières, augmentent les taux débiteurs afin de prendre en compte la hausse du taux de défaillance. Cet effet est à la fois statistiquement et économiquement significatif.

Plus précisement, le scénario (i) implique une hausse des besoins d'endettement face à la chute de la profitabilité, mais celle-ci est plus que compensée par la réduction de l'activité (mesurée par les ventes) et la hausse du risque de crédit pour les banques (avec la hausse du taux de défaillances), ce qui réduit l'offre de dette. L'effet final est une baisse de la dette de 2 à 4% en valeur réelle, alors que les charges d'intérêt de la dette augmentent de 25 à 50 points de base. Dans le deuxième scénario, le choc de prix du pétrole est associé à une hausse du taux d'intérêt à court terme de la Banque Centrale (de 70 points de base) afin d'empêcher les effets de "second tour" sur l'inflation, ce qui conduit un ralentissement du PIB de 0,15%. Cela conduit à une légère hausse du taux de défaillance, mais la cause principale de la baisse de la valeur réelle de dette (de 0.2 à 3.2%) est la hausse du taux d'intérêt à court terme par la Banque Centrale. Il contribue aussi largement à la hausse des charges d'intérêt de la dette de 50 à 75 points de base.

Introduction

In the last few years, "stress tests" have been applied to an increasing number of countries in order to assess the resilience of the financial system to large macroeconomic shocks (see Jones, Hilbers and Slack, 2004). The spirit of the exercise is to consider shocks that have a low -but non zero- probability of occurrence, typically a large increase in interest rates, a severe recession hitting the economy, a large oil price shock or a significant foreign exchange shock, etc. One drawback of these tests is that they are rather mechanistic, focus on demand shocks to the financial sector and do not take into account of the effects of financial institutions on the real economy.

In the paper, we propose a way to improve upon the way stress tests are usually carried out, concentrating on the corporate segment of the debt market in the euro area. Such a market is important in itself since loans by euro area financial institutions to non financial corporations amounted to 43% of euro area GDP in 2005. The innovation of the paper is to distinguish explicitly between the demand for debt by corporate firms, and the supply of debt, notably by financial institutions. Of course, such an analysis is useful to study the transmission mechanism of monetary policy to the corporate sector, through the effect on its financial structure. However, its relevance is more direct in the context of "stress tests". Indeed, the debt market is the major channel of transmission of macroeconomic shocks to the financial sector. We follow the "balance sheet approach" (Sorge and Virolainen, 2006), but this is an "extended portfolio approach" since we assume that risk is time-varying, even if it remains exogenous. By carefully distinguishing between supply and demand for debt, the analysis allows to improve upon the usual practice of stress tests. However, feedbacks effects remain contemporaneous and include only the reaction of banks' supply to firms' demand (there is no dynamic "second round" effects).

In the paper we derive the equilibrium in the corporate debt market in terms of the interest rate and the volume of debt by non financial corporations, estimating jointly a supply and a demand schedule for debt. Demand determinants (interest rates and activity variables) are rather standard -although they are derived from maximisation principles- but the modelling approach devotes significant attention to the supply side, with emphasis on the competitive conditions as well as on the risks faced by fund providers. Shocks to credit risks, by affecting the profitability of financial institutions may, as a consequence, also endanger financial stability (Davis and Stone, 2004, Ivaschenko, 2003).

To study the debt market, we rely on the EU Commission's Harmonised BACH database which provides detailed balance sheet and profit&loss accounts by sectors and size classes for several countries. Due to data availability, we concentrate on France, Germany, Italy and Spain on the 1993-2005 period.

The structure of the paper is the following. In section 1, we sketch the theoretical model which is used to motivate the variables that we use in order to derive the supply and the demand for debt by corporate firms. The data are presented in section 2. Section 3 discusses the empirical results. Section 4 illustrates how the model can be used for stress testing by considering the effect of a severe recession and an oil price shock. Section 5 concludes.

1 Basic model

In this section we briefly sketch a structural model for analysing the supply and demand for debt by non financial companies in order to determine the equilibrium debt and interest rate. The demand for debt is rather standard, although it results from optimizing behaviour on the part of the firm. We also derive precisely the supply of debt. Our analysis is based on the equilibrium between supply and demand based on market clearing, following work on the effect of monetary policy on firms' financing conditions (Friedman and Kuttner, 1993, Kashiap, Stein, Wilcox, 1993 and more recently Bougheas, Mizen, Yalcin, 2006). It is, however, useful to make reference to several other contributions to the literature that model the interactions between supply and demand in a disequilibrium framework. Ogawa and Suzuki (2000) for Japan model the "desired" level of debt by the ratio of debt to capital stock which depends positively on the ratio of sales to capital stock as well as the size of the firm, but negatively on the profit level, the access to the bond market, as well as the interest rate on debt. The maximum supply of debt depends on the availability of collateral. Atanasova and Wilson (2004) for the UK determine demand for bank loans as a positive function of size, activity -measured by sales- and as a negative function of the availability of substitutes to bank loans -measured by the level of internally generated cash flows, as well as trade credits- and the loan premium. On the other hand, supply depends positively on the level of collateral, and negatively on the tightness of monetary conditions. These variables will be used in our model.

1.1 Demand for debt by corporate firms

Our analysis concentrates on aggregate financial debt, which is the sum of bonds and bank loans, but we also take into account the existence of alternative sources of funds. Following Ogawa and Suzuki (2000) and Atanasova and Wilson (2004), demand for debt depends positively on activity and negatively on interest rates as well as alternative funds, which are mainly represented by retained earnings or current profits. The higher the current profitability, the lower the level of borrowing.[1]

More formally, the economy is made of firms of different types $i = 1, ...I$. Demand for debt from a representative firm of type i results from cost minimisation. Let firm of type i decide to finance an investment. For that purpose, it will rely on its own funds (retained earnings), complemented with debt. Net profits generate internal cash flow, hence reduce the demand for debt. Firms are therefore induced to rely on external capital if they do not have internal resources ("pecking order theory").

Firms' investment is therefore funded through a combination of debt D_i and retained earnings RE_i. Thus, investment x_i is such that $x_i = RE_i + D_i$. It is used to produced the final good.

The production function is $f_{\lambda_i}(x_i) = \lambda_i\sqrt{x_i}$, where $\lambda_i > 0$ is an indicator of the size of the company, which may be measured by the level of assets or the level of equities.

[1] In the model of Bougheas, Mizen, Yalcin (2006), it is rather future profitability that matters: if future profitability is too low, companies cannot fund projects through the capital markets and rely on debt and in particular bank loans.

We assume that the company repays its loan only if it does not go bankrupt. The company maximises profits that are defined as $(1-\pi_i^{fail})[\lambda_i\sqrt{D_i+RE_i}-r_i^D D_i]$. The probability of default is noted π_i^{fail}, so that $1-\pi_i^{fail}$ is the probability of success (the time index is omitted but all variables are time-varying). r_i^D is the cost of debt.

First order conditions with respect to D_i lead to $D_i+RE_i=\left(\frac{\lambda_i}{2r_i^D}\right)^2$. This yields the demand for debt:

$$D_i=\left(\frac{\lambda_i}{2r_i^D}\right)^2-RE_i. \tag{1}$$

Or equivalently : $D_i=g(\lambda_i,r_i^D,RE_i)$, with $\frac{\partial D_i}{\partial\lambda_i}>0$, $\frac{\partial D_i}{\partial r^D}<0$, $\frac{\partial D_i}{\partial RE_i}<0$.[2]

In order to estimate such a relationship, we assume that the variables are stationary around their steady state and express them in deviation from this state. We introduce $\widehat{X}=\log\left(\frac{X}{\overline{X}}\right)$, with $\overline{X}$ the steady state value of X, so that $X=\overline{X}\exp\left(\widehat{X}\right)$.

In particular, in the steady state, we have :

$$\overline{D}_i=\left(\frac{\overline{\lambda}_i}{2\overline{r}_i^D}\right)^2-\overline{RE}_i. \tag{2}$$

Assuming that the variables are close to their steady state[3], we get, after straightforward algebra:

$$\widehat{D}_i\simeq\frac{\overline{\lambda}_i^2}{2\left(\overline{r}_i^D\right)^2\overline{D}_i}\left(\widehat{\lambda}_i-\widehat{r}_i^D\right)-\frac{\overline{RE}_i}{\overline{D}_i}\widehat{RE}_i.$$

We can then replace $\widehat{D}_i$ and $\widehat{RE}_i$ by their value, namely $\log(D_i)-\log\left(\overline{D}_i\right)$ and $\log(RE_i)-\log\left(\overline{RE}_i\right)$ and $\widehat{r}_i^D$ by its approximation $\left(\frac{r_i^D}{\overline{r}_i^D}-1\right)$. One finally gets :

$$\log(D_i)\simeq\frac{\overline{\lambda}_i^2}{2\left(\overline{r}_i^D\right)^2\overline{D}_i}\widehat{\lambda}_i-\frac{\overline{\lambda}_i^2}{2\left(\overline{r}_i^D\right)^3\overline{D}_i}r_i^D-\frac{\overline{RE}_i}{\overline{D}_i}\log(RE_i)+\left[\frac{\overline{\lambda}_i^2}{2\left(\overline{r}_i^D\right)^2\overline{D}_i}+\frac{\overline{RE}_i}{\overline{D}_i}\log\left(\overline{RE}_i\right)+\log\left(\overline{D}_i\right)\right].$$

Or equivalently:

$$\log(D_i)\simeq\alpha_0 r_i^D+\alpha_1\widehat{\lambda}_i+\alpha_2\log(RE_i)+\mu_i, \tag{3}$$

with $\alpha_0<0,\alpha_1>0$ and $\alpha_2<0$.

[2] Notice that we assume that the price level is normalised to one. If one introduces the price level, the production function is then defined in terms of real investment or real financing, and profits are expressed as unit price times quantity sold. The equation would be almost unchanged but the real demand for debt would depend on real retained earnings.

[3] We use also the first order approximation: $\exp(z)\simeq 1+z$, for $z\ll 1$.

The demand for debt is finally a semi-log relationship between the logarithm of debt and interest rates, with a negative effect of retained earnings or past profitability. Size only appears in deviation from its steady state (this is equivalent to assuming that the steady state level of size is included in the intercept). We approximate $\widehat{\lambda}_i$ by the growth rate of sales S_i, that is $\Delta \log (S_i)$, and finally get the equation to estimate on the demand side:

$$\log (D_i) = \alpha_0 r_i^D + \alpha_1 \Delta \log (S_i) + \alpha_2 \log (RE_i) + \mu_i \tag{4}$$

Note that the probability of default vanishes in the first order conditions of this simple model, but it could be introduced in order to take into account the opportunistic behaviour by companies. This is reserved for future work.

1.2 Supply of debt

Regarding the supply of debt, one should, in principle, distinguish between bank loans and bonds. While the bond market is likely to be quite competitive, there is substantial evidence that bank credit markets may be characterised by some degree of imperfect competition, where banks compete in Cournot fashion (see Monti Klein, 1971, Freixas and Rochet, 1995, Neven and Röller, 1999, Corvoisier and Gropp, 2002). However, it is also clear that, depending on their size, corporate firms face different financial constraints. While small firms do not have access to the bond market, the competitive conditions are likely to be identical in the bond market and in the large company segment of the credit market. We assume therefore that the supply for debt differs across company size segments, i.e. that small and large firms do not experience similar competitive conditions.

Each firm of type i faces a supply schedule $L_i(r_i^L)$, which is derived from profit maximisation by the bank in the credit market for small and medium size firms that do not have access to the bond markets (r_i^L is the cost of credit). Note that for large companies, there exists also a $L_i(r_i^L)$ schedule. However, our assumption that bond and credit market face similar competitive conditions, implies that $L_i(r_i^L) = D_i(r_i^D)$. Nevertheless, we keep the distinction between loan L and debt D at this stage.

One single bank can serve different types of firms, but we assume separability of costs between the different segments. Under the assumption of imperfect competition among banks (i.e. banks offer differentiated services) in the credit market, let $P_i(L_i)$ be the expected profit of the bank serving segment i of the market, which is associated with the loan L_i:[4]

$$\mathbb{P}_i(L_i) = r_i^L (1 - \pi_i^{fail}) L_i - r^R L_i - C_i(L_i),$$

where r^R and $MC_i(L_i) \equiv \frac{dC_i(L_i)}{dL_i}$ are the short term refinancing cost[5] for banks (the short term interest rate) and the marginal cost, respectively. The probability of default is still

[4] The assumption of imperfect competition is not required to get an upward sloping supply curve for r_i^L as a function of L_i, which depends on the existence of convex costs.

[5] Normally the cost function of banks depends not only on loans but also on deposits. Indeed, as it is standard in the literature, we assume the separability of the cost function, so that deposits disappear from calculations.

noted π_i^{fail}. The optimality condition holds as:

$$\frac{\partial \mathbb{P}_i}{\partial L_i} = 0 \Longleftrightarrow r_i^L(1-\pi_i^{fail}) + \frac{\partial r_i^L}{\partial L_i} L_i(1-\pi_i^{fail}) - r^R - MC_i(L_i) = 0. \tag{5}$$

Banks are supposed to be symmetric, so that they have identical marginal cost schedules across markets they serve. Under the standard increasing and convex costs assumption, the first and second derivatives, respectively MC_L and MC_{LL} , are both positive.

One assumes that each bank faces a continuum of identical firms of a given type i, so that one can just consider the average loan L_i to firms of type i (nevertheless banks may have different supply schedules to different types of firms and discriminate between firms of different types), so that, for type i firms, the previous equation can be rewritten as:

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

and using the approximation $(1-\pi_i^{fail})^{-1} = (1+\pi_i^{fail})$ for π_i^{fail} small, one gets the supply equation:

$$r_i^L = -c_{isl} + (1+\pi_i^{fail})(r^R + MC_i(L_i)), \tag{6}$$

where $-c_{isl}$ is equal to $\frac{-\partial r_i^L}{\partial L_i} L_i = \frac{-\partial r_i^L}{\partial LogL_i} > 0$ which is constant in the semi-log specification.

1.3 Estimating the supply and demand equilibrium

We describe now the regression to be implemented and give some details on the estimation methods.

1.3.1 Supply and demand regressions

Using the arbitrage condition in the segment of debt to large companies, the demand for debt is estimated as (notice that in principle, all the coefficients may be individual specific, although depending on the empirical method used, one needs to put more constraints on the coefficients) :

$$Log(D_{it}/P_t) = \gamma_{10i} + \gamma_{11}\Delta Log(Turn_{it}) + \gamma_{12} Inv_{it} - \gamma_{13} Roa_{it} + \gamma_{14} r_{it}^D + \epsilon_{it}^d, \tag{7}$$

with D_{it}/P_t, $Turn_{it}$ and Roa_{it} are companies' real aggregate debt, sales growth and returns on assets (Roa), respectively. Roa has a negative effect on borrowing, as it determines the level of internal cash flow available to the firms for investment. Higher sales growth are likely to require more debt to finance the expanded activity level. We also introduce a indicator of investment structure, namely the investment ratio (investment/sales) Inv_{it}: a higher investment ratio is more likely to raise the demand for debt.

Concerning supply, we assume a parametric form for $MC_i(D_{it}) = \alpha + \beta Log(D_{it}/P_t)$, the form of which is indifferent as long as it is an increasing function of D_{it}.

Moreover, as indicated below, for lack of data we need to assume that the default probability does not depend on individual i; it only depends on time (and the country) : π_t^{fail}.

The supply function is therefore specified with the following non structural form:

$$r_{it}^D = \gamma_{20i} + \gamma_{21}\pi_t^{fail} + \gamma_{22}r_t^R + \gamma_{23}Log(D_{it}/P_t) + \epsilon_{it}^s. \tag{8}$$

The value of the intercept γ_{20i} cannot be directly interpreted as the interest margin since the coefficient also includes the average effect of the other variables. However, it may be interesting to compare its level across companies. It is expected to be decreasing with the size of the company, due to higher competition in the larger company segment of the debt market. Several functional form are possible to model the dependence of the margin on the size of the company. We assume a linear relationship as $\gamma_{20i} = \mu_i + \gamma Size_{it}$ and introduce directly the $Size$ variable in the supply equation. The coefficient γ_{23} is also positive because of the properties of the cost function.

To summarize the interest rate at which banks are willing to supply loans is an increasing function of the reference rate r_t^R. It is also increasing both in the debt volume D_{it} and the default probability π_t^{fail}.[6]

1.3.2 Estimation methods

Regarding estimation, our approach is only static at this stage. We also face two crucial econometric problems: (i) the existence of simultaneity in a supply/demand system and (ii) the need to take into account of heterogeneity in a panel context.

Regarding the issue of simultaneity, the estimation of a joint supply/demand system raises the classical problem of endogeneity. If endogenous variable are used as regressors, they are, in general, not independent of the error terms, so that OLS is biased. To avoid this problem, we use an instrumental variable method, where the estimates of the parameters are Two Stage Least Square (2SLS) estimates, obtained as follows:

- in a first step, one regresses the endogenous variables on all exogenous variables by OLS;
- in a second step, one estimates by a Least Square method the parameters of the regression after replacing the RHS endogenous variable by its estimate from the first step.

[6] The non availability of default probabilities at the individual level is not likely to affect the significance of the main variables if one assumes that default probabilities depend linearly on the size of the company: $\pi_{it}^{fail} = \pi_t^{fail} - \beta^f Size_{it}$ (empirically defaults are lower for larger companies). In that case, regressing on π_t^{fail} instead of π_{it}^{fail} only creates a bias on the size variable if it is introduced. Indeed, if one does introduce the size variable to measure the effect of competition and margin behavior we get: $\gamma_{20i} + \gamma_{21}\pi_t^{fail} = \mu_i + \gamma Size_{it} + \gamma_{21}(\pi_{it}^{fail} + \beta^f Size_{it}) = \mu_i + (\gamma + \gamma_{21}\beta^f)Size_{it} + \gamma_{21}\pi_{it}^{fail}$. This implies that the analysis of margin behaviour is more fragile, since it results from several effects (negative effect from default mismeasurement, positive effect from margins). The availability of data on default probability by type of companies would therefore help derive sharper conclusions on margin behaviour and competition.

We estimate the non-structural model of equations (7) and (8), where demand and supply are explained by the relevant fundamentals.

It is well known that 2SLS estimates are the best way to deal with the endogeneity problem when the system is just identified or overidentified. Notice that in our case, the system is overidentified. We provide therefore several specification tests.

In the presence of endogeneity, there is a trade-off between unbiasedness and efficiency, since OLS estimator are biased but there is a loss of efficiency with IV (the asymptotic variance is always larger than for OLS). Although there are theoretical reasons for such an endogeneous supply/demand system in our case, we check for endogeneity in our system using the Davidson and MacKinnon's (1993) test. We also verify the appropriateness of our instruments, by running overidentification tests which measure whether instruments are orthogonal to the error terms (test of overidentifying restrictions of Sargan-Hansen). Since the null hypothesis is that the instruments are not correlated with the error variables, deviation from the null implies that the instruments are not appropriate.[7] We also measure the information content of the instruments, providing the partial R^2 coefficient of the regression of the endogenous variables on the instruments, as well as joint F-test of significativity of the instruments.

Regarding the second econometric issue, namely the use of panel data, we consider both fixed effects and random effects models. We run Hausman tests to assess whether the heterogeneity across groups (i.e. our country-sector-size triplets of companies) rather comes from differences in average values (for which the fixed effect would be more appropriate) or from differences in the coefficients (hence leading to the choice of a random effect estimator).[8] In addition, for the fixed effect model, we test whether the different intercepts are significantly different from zero.

More precisely, for the fixed effects specification, we implement the Within-2SLS method (hereafter noted as W2SLS), while, for the random effects models, we compute the EC2SLS (Error Component 2SLS) and the G2SLS (Generalized 2SLS) estimates of the parameters.

The EC2SLS estimates are obtained as a weighted average of the "Within-2SLS" and the "Between-2SLS" estimates, with weights depending on the respective variance-covariance matrices of both estimates (Baltagi, 2001). The G2SLS estimates (Balestra and Varadharajan-Krishakumar, 1987) involve instrument variables optimally transformed according to the variance matrix of the residuals of the estimated equation. It differs from the EC2SLS by the choice of instrumental variables that are used, but both have the same asymptotic Variance-Covariance matrix[9].

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[7] For more details about Hansen-Sargan test, See Wooldridge (2000).

[8] The statistic of the Hausman test is distributed as $\chi^2(k)$ with k the number of variables, so that fixed effect is accepted when it is larger than the threshold value.

[9] Baltagi (2006) suggests a generalisation of such a test in the presence of endogeneity (FE2SLS *vs* RE2SLS, or in our case W2SLS *vs* EC2SLS).

2 Data

The analysis of the euro area corporate debt market is based on the EU Commission's Harmonised BACH database, which provides harmonised balance sheet and profit and loss accounts for different countries. The data are annual and available according to a breakdown by industrial sectors and three size classes (small/medium/large[10]). Due to data availability, only corporate firms in France, Germany, Italy and Spain are used on the 1993-2005 period. In the empirical analysis, each class i is therefore a country-sector-size triplet. The 12 sectors that are selected are manufacturing (excluding energy), construction, wholesale and retail trade.[11] It is important to note that the database does not provide individual data but aggregates, i.e. sums over the companies belonging to the class. Indicators in level are therefore expressed in terms of averages over the number of companies belonging to the class, while indicators in ratios are computed with aggregate items, which are the only information available (hence they are ratios of averages and not average ratios). While this may be seen as a drawback, it is actually one of the strengths of the BACH database, since entry/exit of individual companies are taken care of, through the availability of overlapping samples. Indicators in growth rates are therefore computed on samples that are constant over two successive years. All in all, the analysis is based on a sample of 144 triplets (i.e. $12 \times 3 \times 4$) observed over 12 years (we lose a year when computing growth rates), hence a total of 1728 observations. The following indicators are computed:

- **Det**, real aggregate financial debt (in logarithms, average value, divided by the GDP deflator);
- **Int**, interest burden in % of total financial debt (r^D in section 1);
- **Turn**, year-on-year growth of sales;
- **Inv**, investment ratio, measured as investment/sales;
- **Roa**, measured as net profits divided by total assets.

In addition, with respect to the model presented in equation (5), we include two other variables:

- **Gar(i),** indicator assessing the amount of collateral available to the company, measured by the ratio of "Collateral" to "total assets". Collateral is measured by the

[10] Small firms have an annual sales below 7 Million euros, medium firms are between 7 and 40 Million euros of annual sales, and large firms have sales above 40 Million euros.

[11] Manufacture of food products, beverages and tobacco; manufacture of textiles and textile products; manufacture of pulp, paper and paper products; manufacture of chemicals, chemical products and man-made fibres; manufacture of rubber and plastic products; manufacture of other non-metallic mineral products; manufacture of basic metals and fabricated metal products; manufacture of machinery and equipment not elsewhere classified ; manufacture of elecrical and optical equipment; manufacture of transport equipment; construction; wholesale and retail trade.

sum of Tangible fixed assets and stocks. This is a further risk factor that is often found in the empirical finance literature (see Kremp and Sauve, 1999): the amount of collateral -i.e. the garantees pledged by the borrower to the lender- is likely to have a positive effect on debt, or, equivalently, a negative effect on interest charges. Such a variable is more likely to affect small and medium sized firms and the variable is interacted with a size dummy for small companies ($Gar1$) or medium-sized companies ($Gar2$).[12] It is expected that the constraint on collateral effect is larger for small than for medium sized companies, so that the coefficient on $Gar1$ is negative and larger in absolute value than for $Gar2$.

- **Size,** measured by average total assets (in logarithms). Here, the variable is mainly designed to measure the impact of competition on the banks' margin -which should be decreasing with the size the borrower. If the market is more competitive for larger companies, the margin of debt suppliers should be smaller- we introduce the total size of the balance sheet as indicator of size. The coefficient associated with $Size$ is expected to be negative.

For lack of detailed data at the sector-size level on the corporate default rates π_{it}^{fail} for all countries over the whole sample,[13] we use aggregate data by country. For France, we rely on data from Insee, while data for the other countries are provided by a rating agency (see Euler-Hermes, 2006). The number of bankruptcies is divided by the number of companies as published by Eurostat. We also introduce the three month nominal interest rate, in annual average, to measure the refinancing cost or the opportunity cost for banks (r^R in the previous section).

Table 1 : Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Average real financial debt, logs (Det)	15.484	1.712	11.924	19.964
Interest burden (r^D)	0.068	0.025	0.009	0.290
Year on year sales growth ($Turn$)	0.059	0.064	-0.107	0.845
Investment ratio (Inv)	0.036	0.024	-0.012	0.494
Return on Assets (Roa)	0.043	0.024	-0.060	0.155
Short Term nominal interest rate (r^R)	0.042	0.021	0.021	0.104
Probability of default (π^{fail})	0.013	0.011	0.000	0.032
Average total assets, logs ($Size$)	16.868	1.771	14.026	21.373
Collateral /Total assets ($Gar1$)	0.153	0.223	0	0.736
Collateral /Total assets ($Gar2$)	0.145	0.210	0	0.619

[12] See above for the definition of the size classes.

[13] See Nahmias (2005) for data with a sector-size breakdown for France over the last part of the sample. The paper also deals with the delicate issue of computing default rates, ie due the difficulty of to find consistent data of number of bankruptcies and companies, due to the tendency of companies that are experiencing difficulties to stop reporting information.

3 Empirical results

We now proceed with the estimation of the model[14]. We consider the non structural model where all the relevant variables, motivated in section 1, enter in one of the two equations (7) and (8). We consider different estimation methods: W2SLS, EC2SLS and G2SLS.[15]

The results are the following:

- Davidson and MacKinnon tests confirm the existence of endogeneity in most cases, so that the use of IV methods is indeed appropriate. However, for the demand function only, the use of instruments is more pertinent in the presence of variables measuring collaterals (the p-value of the exogeneity test is lower in this case: 8.8% against 16.8%). The partial R^2 and the partial F indicate that the choice of instruments is all in all acceptable, even if the overidentification test has a low value for the demand equation.

- Hausman tests cannot distinguish between the fixed effect and the random effect model for the demand equation, while fixed effects are strongly accepted for the supply equation.

- Demand equation is consistent with the model described in section 1. Supply equation estimated by W2SLS exhibits coefficients of the correct sign and order of magnitude.

- Consistently across specifications and estimation methods, the empirical fit of the supply equation appears to be better than that of the demand equation.

- Fixed effects in the supply equation, which measure the interest margin of fund suppliers, notably financial institutions, indicate that the degree of competition is higher for large than for small companies.

We now go through the results in greater detail. We discuss the results of the estimation of two different demand and supply equations systems. They are actually rather similar, except for the introduction of the amount of collateral ($Gar1$ and $Gar2$) in the supply equation (Tables 1 and 2).

3.1 Model without collateral variables

As indicated in Table 2, the demand equation adequately exhibits in all cases a negative and significant coefficient on the regression of Det on interest rate r^D. The coefficient associated with r^D in the demand equation is around -2.8 (-2.789 for W2SLS, -2.934 for EC2SLS, -2.870 for G2SLS), so that an increase in the cost of debt by 100 basis points

[14]We applied five panel unit root tests (Levin, Lin & Chu, ADF, PP, IPS and Breitung) in order to determine the properties of our variables. All in all, we can reject the hypothesis of Unit Root (common or individual) for all variables (results are available upon request).

[15]Results were obtained with the help of STATA 9.1.

(bp) triggers a decrease in real debt by 2.8 %. All estimation methods find very similar estimates for the parameters of the demand equation. However, the EC2SLS model fails to exhibit a proper supply/demand system, since the coefficient associated with *Det* in the supply equation is negative instead of the expected positive sign.

Table 2: Model without collateral variables[a]

	Fixed effects model		*Random effects model*			
	W2SLS		*EC2SLS*		*G2SLS*	
	Det	r^D	*Det*	r^D	*Det*	r^D
r^D	-2.789^{**} (1.185)	—	-2.934^{***} (0.616)	—	-2.870^{***} (0.617)	—
Det	—	0.015^{**} (0.007)	—	-0.019^{***} (0.003)	—	0.007 (0.005)
Turn	0.436^{***} (0.108)	—	0.451^{***} (0.107)	—	0.447^{***} (0.107)	—
Inv	2.540^{***} (0.353)	—	2.525^{***} (0.262)	—	2.527^{***} (0.263)	—
Roa	-3.209^{***} (0.631)	—	-3.202^{***} (0.343)	—	-3.202^{***} (0.343)	—
r^R	—	0.816^{***} (0.040)	—	1.005^{***} (0.029)	—	0.940^{***} (0.032)
π^{fail}	—	0.621^{***} (0.158)	—	0.461^{***} (0.056)	—	0.344^{***} (0.062)
Size	—	-0.031^{***} (0.010)	—	0.016^{***} (0.003)	—	-0.009^{*} (0.004)
Const.	15.66^{***} (0.040)	0.320^{***} (0.048)	15.67^{***} (0.138)	0.047^{***} (0.007)	15.66^{***} (0.136)	0.065^{***} (0.008)
R^2	0.160	0.780	0.0145	0.722	0.0141	0.599
$H_{\chi^2(k)}$	—	—	0.000	81.89^{***}	0.000	42.63^{***}
$F_{(k-1,n-k)}$	837.71^{***}	9.17^{***}	—	—	—	—
Exog.test (*p−value*)	0.168	0.000	—	—	—	—
Overid.test (*p−value*)	0.869	0.497	0.000	0.000	0.764	0.256
Partial F	150.35^{***}	41.11^{***}	—	—	—	—
Partial R^2	0.344	0.131	—	—	—	—

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 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; *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.

The coefficient associated with the short term nominal interest rate r^R is close to one in the random effect models, while it is around 0.8 for the W2SLS, and, in the latter case, the equality of the coefficient to 1 is rejected given the low standard errors. Nevertheless, the interpretation of the supply equation in terms of interest margin behavior, i.e. $r^D - r^R$, implies that the margin is a decreasing function of the level of r^R, indicating that competition is more acute with higher nominal interest rates r^R. One observes rather similar coefficients in the supply equation except concerning the coefficients of π_t^{fail} which ranges from 0.621 (W2SLS), 0.461 (EC2SLS) and 0.344 (G2SLS), and also for the coefficient of the $Size$ variable, which is only negative for the W2SLS and G2SLS models. The fixed effect model appears therefore as the only one to be well specified. The appropriateness of such a model is also confirmed by the various specification tests.

3.2 Model with collateral variables

In Table 3, the collateral variables $Gar1$ and $Gar2$ are introduced in the supply equation as suggested by a large body of the literature. All estimation methods still find very similar estimates for the parameters of the demand equation. For the supply equation, the W2SLS and G2SLS methods identify a well specified positively sloped Marginal Cost function, with a positive coefficient associated with Det. However, this coefficient is not significantly different from zero in the EC2SLS case. One also continues to observe the same similarity of coefficients across methods for the supply equation except concerning the coefficients of π_t^{fail}, which varies from 0.636 (W2SLS), 0.361 (EC2SLS) and 0.184 (G2SLS). The $Size$ variable in the supply equation has now the appropriate negative sign for all three models (although it is not significant in the EC2SLS case), providing evidence in favour of greater competition in the larger company segment of the debt market.

The $Gar1$ and $Gar2$ variables, introduced as a additional measure of risk in the supply equation, have the correct sign and order of magnitude (respectively -0.076 and -0.041 for W2SLS, -0.039 and -0.035 for EC2SLS, -0.083 and -0.064 for G2SLS), since the collateral requirement is expected to be more severe for small than for medium sized firms. Regarding specification tests, the presence of endogeneity is now clearly indicated for both equations, with the null assumption of similarity between OLS and IV clearly rejected at the 8.8% and 0.0% level. However the absence of overidentification created by the instruments is less clearly rejected for the Det equation (p-value of 4.5% only).

All in all, these results could indicate that the condition of independence of the unobserved individual effects and the exogenous variables is not satisfied in all cases. Thus the Random effect estimates could be inconsistent. However, the "within" transformation leaves the W2SLS estimate consistent and unbiased so that we only retain the W2SLS estimation for the supply/demand system.

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)
*Gar*1	—	-0.076^{***} (0.038)	—	-0.039^{***} (0.011)	—	-0.083^{***} (0.015)
*Gar*2	—	-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.

Accordingly, we focus in the rest of the article on the results of the W2SLS estimations. Notice that in Table 1 and 2, the coefficient of the *Size* variable in the supply equation is negative with the W2SLS method, providing evidence that the degree of competition in the debt market is higher for large company than for small companies.

3.3 Differences across company sizes

As indicated above, the level of the intercept does not measure the interest margin directly.[16] However, it is interesting to quantify the differential effect of the variables that affect the interest margin, in particular the *Size* variable. The interest margin that can be derived from the supply side equation is expected to be decreasing with the size of the company, since competition is more acute for large companies than for small companies. To verify that it is indeed the case for our sample, we provide in Table 4 statistics on the distribution of the fixed effect by groups of companies. The μ_i coefficient is the fixed effect from the model estimated in Table 3 and we take averages across the three size classes (i.e. small/medium/large). As can be verified, the overall average across the three class sizes is exactly equal to zero.[17] Given the large standard errors, it appears that the size class averages of the μ_i coefficients are not significantly different from zero and from each other. More importantly, it should be remembered that this fixed effect is computed from a model where we include the $Size$ variable on the RHS, so that it does not provide the value of the interest margin γ_{20i} as defined in equation (5). Under the assumption that the $Size$ variable is uncorrelated with the other exogenous variables, one can compute the implied γ_{20i} as indicated in Annex A.

The mean and distribution of the $\gamma_{20}^{*(j)}$'s (namely the difference between $\gamma_{20}^{(j)}$'s and the intercept) is provided in the second row of Table 4 (first row is the fixed effect directly estimated by the model, while the second row factors in the effect of the $Size$ variable). It is clear from the second row that the interest margin is decreasing with the size class. Indeed the class average for small companies is 0.0568 while it is −0.0589 for large firms, when the collateral variable is included. Even taking into account the size of the standard deviations, the difference is statistically significant.

Table 4 : Distribution of fixed effects of the supply function (equ. 8)

	model without collateral			*model with collateral*		
Size category j	*Small*	*Medium*	*Large*	*Small*	*Medium*	*Large*
$\mu^{(j)}$	−0.0273 (0.0197)	−0.0068 (0.0150)	0.0341 (0.0194)	−0.0094 (0.0178)	−0.0066 (0.0137)	0.0160 (0.0201)
$\gamma_{20}^{*(j)}$	0.0338 (0.0167)	0.0012 (0.0133)	−0.0351 (0.0177)	0.0568 (0.0138)	0.0021 (0.0121)	−0.0589 (0.0190)
$\widetilde{\mu}^{(j)}$	0.0192 (0.0135)	−0.0005 (0.0113)	−0.0186 (0.0151)	0.0496 (0.0106)	−0.0056 (0.0106)	−0.0440 (0.0161)

Numbers in brackets denote standards deviations; $\widetilde{}$ correspond to model estimated without $Size$ variable
$\gamma_{20}^{*(j)}$ are modified fixed effect by j, specified as $\gamma_{20}^{*(j)} = \mu^{(j)} + \widehat{\gamma}(\overline{Size} - \overline{\overline{Size}})$, see Annex A.

Furthermore, in order to provide a robustness check, we perform the same exercise with a similar equation but without introducing explicitly the Size variable. It turns out

[16] The intercept includes any possible constant term in the model. Its level depends on the functional form chosen to measure the effect of the different variables on the interest rate. For example, the marginal cost part may also include a fixed component.

[17] The μ_i coefficients are the difference with respect to the overall average, which appears as "*Const*" in Tables 2 and 3.

that the class average of the fixed effect ($\widetilde{\mu}^{(j)}$ in bottom row of Table 4) is also decreasing from small to large companies. This provides evidence that the market for corporate debt is more competitive for the large companies.

4 Stress testing exercise

In order to illustrate how the model can be used for stress testing, we derive the equilibrium in the debt market and consider two "stress scenarios" that are used to shock the exogenous variables. As indicated in Figure 1 below, starting from an equilibrium (r_1,Q_1), a change in the exogenous variables triggers a shift in the supply and demand equations, so that the new equilibrium becomes (r_2,Q_2). The scenarios are calibrated with the Banque de France MASCOTTE macroeconometric model (see Baghli et *al.*, 2004, as well as Fagan and Morgan, 2006) and the NIESR's Nigem model. Based on the responses of the macroeconomic variables (real GDP and its deflator, companies investment/value added, growth of value added in nominal terms, gross operating surplus/capital stock) to the initial shocks, we use "bridge equations" to shock the exogenous variable of the reduced form of our structural model.[18]

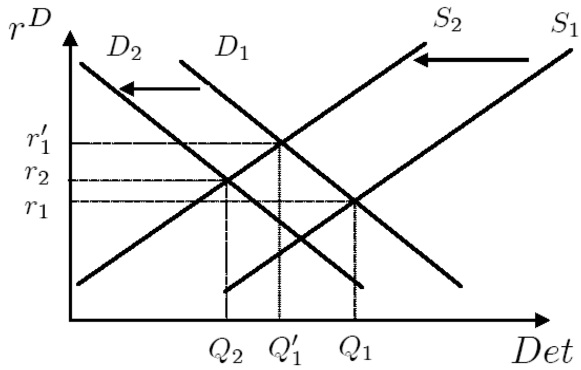

Figure 1 : Effect of an adverse macroeconomic shock on the equilibrium in the debt market

The two scenarios considered are as follows (see de Bandt and Oung, 2004, for details):

[18]Formally, the reduced form of the model is written as $\begin{pmatrix} Det_{it} \\ r_{it}^D \end{pmatrix} = AZ_{it}$, with Z_{it} the exogenous variables (sales, investment ratio, default rate, Roa). These variables are linked to macroeconomic variables through "bridge equations". For example, we would need to connect sales growth of firm i to nominal GDP growth. In our experiments, we carry out shocks of a "large but realistic size" so that we can use an aggregate linear relationship, namely $\frac{\Delta S_t}{S_{t-1}} = B_G \frac{\Delta GDP_t}{GDP_{t-1}}$, where we link *average* sales growth to nominal GDP growth. Indeed, as indicated in Tables 6 below, the shock on debt is lower than 10% so that the linear approximation is valid. However, as indicated in Annex B, our approach is flexible enough to accommodate a non linear relationship for the "bridge equations", as well as shocks that differ across individuals, or even shocks of larger size (see footnote 21). The coefficients of B_G for the different exogeneous variables are not reported here but available upon request, they link Inv to the ratio of companies investment/value added; $Turn$ to the growth of nominal value GDP (more precisely, growth of value added), Roa to the ratio Gross Operating Surplus/Capital stock, and π^{fail} to (inverted) real GDP growth.

- a significant reduction in world demand (originating in the US), leading to a recession in the euro area;

- an increase in oil prices (+70%) with a monetary policy reaction to counteract second round effects on inflation.

Technically, the exogenous variables are shocked from the level of the last observation available, assuming the shock is persistent and takes place at the beginning of the year (in the first quarter, since MASCOTTE and NIGEM are quarterly models).[19] The impact is measured in percentage change for Det (since it is expressed in logarithms) and basis point of Int. The impact elasticities are given by the coefficients of the reduced form model as indicated in table 5 and 6. These coefficients are non linear functions of the structural parameters of the supply and demand equations (they are also a non linear function of $(1+\pi^{fail})$ for the reduced form derived from the model in table 3). Standard errors on the impact can be computed with the "Delta method", using the variance-covariance of the coefficients in each structural equation.[20]

Here we only present aggregate stress scenarios, while it is possible to run scenarios that vary across size of sectors, if the exogenous variables have different sensitivities to the macroeconomic shocks.[21]

We use the model without collateral to compute the multipliers.

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

Applying these multipliers to the historical value of the exogenous variables (this constitutes the baseline scenario), one can derive stressed values of the exogenous variables, hence the new equilibrium values for Det and r^D. Table 6 provides the new values of

[19] The shock is considered as deviation from a macroeconomic baseline scenario for projections made for 2005. However, an update of such a baseline is available with the BACH database, where data for the full year are available with a 6-month lag.

[20] The 95% confidence bound is only computed in the case of the structural model (see section 4.2). This implies computing the reduced form coefficients r of the structural model. Since the reduced form coefficients (or the elasticity of debt and interest rate to the exogenous variables) are non linear functions of the structural coefficients s, the standard errors are computed as $C\Sigma C'$ with C the matrix $\partial r(s)/\partial s'$ and Σ is the covariance matrix of the structural coefficients, as available in Table 3. We only assume that the structural coefficients are uncorrelated between the supply and the demand equation, so that Σ is actually a block-diagonal matrix.

[21] If the shock affect companies differently across size or sector, this would imply estimating different "bridge equations": $\begin{pmatrix} Det_{i(j)t} \\ r^D_{i(j)t} \end{pmatrix} = A_{(j)} Z_{i(j)t}$ for the different companies i in categries (j). Our framework allows a convenient decomposition of the contribution of the different categories to the aggregate change in debt and interest. This is reserved for future work.

the exogenous variables in response to the stress (see line "scenario 1-stressed values" and "scenario 2-stressed values"). Summing up the contribution of the different exogenous variables one can determine the new equilibrium values.[22] Note that the $Size$ variable is unchanged and does not appear in the table for the non structural model.

Table 6: 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**	
Lower bound‡						-1.963	
Upper bound‡						-3.676	
Impact on r^D *(in basis points)*	-4.482	0.061	1.962	42.32			**39.861**
Lower bound‡							24.216
Upper bound‡							55.507
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**	
Lower bound‡						-3.203	
Upper bound‡						-0.118	
Impact on r^D *(in basis points)*	0.082	0.122	0	1.788	62.66		**64.652**
Lower bound‡							55.168
Upper bound‡							74.134

‡Confidence Intervals (upper and lower bound) as constructed using the DELTA Method.

From Table 6, it appears that the scenario 1 of recession implies an increase of borrowing requirements due to lower Roa, which is more than offset by a lower turnover and higher risk for banks (with higher default rate), which decrease supply. The final effect

[22] In Table 6, we provide the results of stresses on the equilibrium value of Det, r^D which are computed as:

$$Det(stressed) - Det(2005) = G(Z(stressed)) - G(\ Z(2005))$$
$$r^D(stressed) - r^D(2005) = F(Z(stressed)) - F(Z(2005)).$$

where Z are the exogenous variables and $F(.)$ and $G(.)$ are non linear functions of the coefficients of the estimated model.

is that real debt decreases by 2.8%, while the debt burden (r^D) increases by 39.9 basis points (bp). In the second scenario, the oil price shocks is associated with an increase in the short term interest rate r^R by the Central Bank (by 70 bp) in order to offset the second round effects on inflation which triggers, according to MASCOTTE and NIGEM a decrease in GDP growth by 0.15%. It leads to a slightly higher default rate, but the main negative effect on Det (-1.7%) comes through the increase in r^R. It induces an increase in the interest burden r^D by 64.6 bp.

5 Conclusion

In the paper we model the impact of macroeconomic shocks on the equilibrium in the corporate debt market, introducing the effect of competitive conditions (we provide evidence of a stronger competitive environment in the segment for large than small companies) as well as credit risk. Although risk is exogenous in our analysis, we explicitly measure how the equilibrium depends on time-varying risk in the economy. This provides a richer analysis of the debt market, as well as a way to improve upon the way stress tests are carried out. By measuring supply effects, one comes closer to an assessment of feedback effects from the financial sector to the real sector from shocks initiated in the real sector, although the analysis remains static. The results from the illustrative stress tests that we run in the last section, indicate that the equilibrium depends on the change in the default rate. In particular, in the first scenario of recession, the suppliers of capital, and financial institutions among them, raise interest rates in order to take into account the increase in the default rate. Such an effect is both statistically and economically significant.

However, as already mentioned, the risk factor remains exogenous to the financial sector, while it may, to some extent, depend on credit distribution (an increase in debt is likely to bring a more than proportional increase in risk). Further work should therefore attempt to determine jointly the evolution of debt and risk.

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A The fixed effects in the model and the size effect

In the structural model, there is no size variable, while we have introduced one in the regression. The point raised in section 3.3 is to use the estimated parameter γ_{20i} to measure differences across firm sizes.

Let us assume that, in the regression, we have a X_1 variable (for sake of simplicity, we suppose that it is unique) and a size variable X_2.

The Within estimates satisfy:

$$\widehat{\beta}_{0i} = \overline{y}_i - \widehat{\beta}_1 \overline{x}_{1i} - \widehat{\beta}_2 \overline{x}_{2i}, \tag{A1}$$

where $\overline{z}_i$ denotes the average value: $\overline{z}_i = \frac{1}{T} \sum\limits_t z_{it}$.

If variable X_2 were omitted in the regression, one would get:

$$\widehat{\alpha}_{0i} = \overline{y}_i - \widehat{\alpha}_1 \overline{x}_{1i}, \tag{A2}$$

so that the fixed effect $\widehat{\alpha}_{0i}$ in the simple model should obey:

$$\widehat{\alpha}_{0i} = \widehat{\beta}_{0i} + (\widehat{\beta}_1 - \widehat{\alpha}_1)\overline{x}_{1i} + \widehat{\beta}_2 \overline{x}_{2i}. \tag{A3}$$

Averaging the previous equations over the individuals gives:

$$\widehat{\alpha}_0 = \widehat{\beta}_0 + (\widehat{\beta}_1 - \widehat{\alpha}_1)\overline{\overline{x}}_1 + \widehat{\beta}_2 \overline{\overline{x}}_2, \tag{A4}$$

where $\overline{\overline{z}} = \frac{1}{N} \sum\limits_i \overline{z}_i$.

Accordingly, one can write that the structural parameter γ_{20i} should be estimated with $\widehat{\alpha}_{0i}$. Substracting A4 from A3:

$$\widehat{\gamma}_{20i} = \widehat{\alpha}_{0i} = \widehat{\alpha}_0 + \widehat{\mu}_i + (\widehat{\beta}_1 - \widehat{\alpha}_1)(\overline{x}_{1i} - \overline{\overline{x}}_1) + \widehat{\beta}_2(\overline{x}_{2i} - \overline{\overline{x}}_2), \tag{A5}$$

with $\widehat{\mu}_i = \widehat{\beta}_{0i} - \widehat{\beta}_0$.

One can neglect the term $(\widehat{\beta}_1 - \widehat{\alpha}_1)(\overline{x}_{1i} - \overline{\overline{x}}_1)$, if the regression is unaffected by the introduction of the X_2 variable; one can therefore compute (see Table 4 in the main text):

$$\begin{aligned} \widehat{\gamma}_{20i} &\simeq \widehat{\mu}_i + \widehat{\beta}_2(\overline{x}_{2i} - \overline{\overline{x}}_2) + \widehat{\alpha}_0, \\ &= \widehat{\gamma}^*_{20i} + \widehat{\alpha}_0. \end{aligned}$$

B Deriving the aggregate elasticity to macroeconomic shocks

We provide here more details on how, in our framework, one can compute the effect of macroeconomic shocks on debt and interest rates, using a model estimated on a panel of individual firms. Such a framework can also be used to assess the effect of shocks on different types of firms.

The model is written in logarithms for the debt equation:[23]

$$Log(Debt_i) = a_{0,i} + a_1 \frac{\Delta S_i}{S_{i,-1}} + u_i, \tag{A6}$$

where $\frac{\Delta S_i}{S_{i,-1}}$ is the growth rate of sales, and we omit for the ease of presentation the other variables.[24] We then use a "bridge equation" to connect, e. g. sales to macroeconomic variables. This bridge equation is of the form $\frac{\Delta S_i}{S_{i,-1}} = f_i(\frac{\Delta Y}{Y_{-1}})$, with f_i a possibly non linear function of Y, a macroeconomic variable (GDP, investment).[25]

1. First, one assumes a linear bridge equation between $\frac{\Delta S_i}{S_{i,-1}}$ and the growth rate of GDP $\frac{\Delta Y}{Y_{-1}}$:

$$\frac{\Delta S_i}{S_{i,-1}} = B_i \frac{\Delta Y}{Y_{-1}}. \tag{A7}$$

Let us refer to superscript B for the baseline and V for the stressed variant scenario. Assume that the economy's GDP is hit by a shock of size η measured on $\frac{\Delta Y}{Y_{-1}}$, so that:

$$\left(\frac{\Delta Y}{Y_{-1}}\right)^B \rightarrow \left(\frac{\Delta Y}{Y_{-1}}\right)^V = \left(\frac{\Delta Y}{Y_{-1}}\right)^B + \eta, \tag{A8}$$

so that the shock on $\frac{\Delta S_i}{S_i}$ is :

$$\left(\frac{\Delta S_i}{S_{i,-1}}\right)^B \rightarrow \left(\frac{\Delta S_i}{S_{i,-1}}\right)^V = \left(\frac{\Delta S_i}{S_{i,-1}}\right)^B + B_i\eta. \tag{A9}$$

Aggregating over all companies, noting $w_i = S_i / \sum_i S_i$:

$$\sum_i w_i \left(\frac{\Delta S_i}{S_{i,-1}}\right)^B \rightarrow \sum_i w_i \left(\frac{\Delta S_i}{S_{i,-1}}\right)^V = \sum_i w_i \left(\frac{\Delta S_i}{S_{i,-1}}\right)^B + \sum_i w_i B_i \eta. \tag{A10}$$

The effect of the shock on company i's debt, $Debt_{i,}$ is such that:

$$\frac{{Debt_i}^V - {Debt_i}^B}{{Debt_i}^B} = \exp(a_1 B_i \eta) - 1. \tag{A11}$$

[23] This is easily extendable to the interest equation which is linear, hence additivity is preserved.
[24] The procedure is identical for the other exogenous variables: π^{fail}, or the investment ratio.
[25] Relationships expressed in levels would not affect substantially the analysis.

This yields for the aggregate debt level (we assume here that $w_i \simeq D_i / \sum_i D_i$ consistently with equation (3) in the main text):

$$\frac{Debt^{\ V} - Debt^{\ B}}{Debt^{\ B}} = \sum_i w_i \left[\exp(a_1 B_i \eta) - 1\right]. \tag{A12}$$

a) If the shock is small, $\eta << 1$: the following approximation holds:

$$\frac{Debt^{\ V} - Debt^{\ B}}{Debt^{\ B}} \simeq \sum_i w_i a_1 B_i \eta = a_1 \sum_i w_i B_i \eta, \tag{A13}$$

where $\sum_i w_i B_i$ is the aggregate elasticity of sales to output that we note $B_G = \sum_i w_i B_i$. The causal chain is thus the following:

$$\begin{aligned} &\text{shock } \eta \text{ on } \tfrac{\Delta Y}{Y_{-1}} \quad \rightarrow \quad \text{shock } B_G \eta \text{ on } \left(\tfrac{\Delta S}{S_{-1}}\right)_G = \textstyle\sum_i w_i \tfrac{\Delta S_i}{S_{i,-1}} \\ &\Rightarrow \text{effect on debt } = \frac{Debt^{\ V} - Debt^{\ B}}{Debt^{\ B}} = a_1 B_G \eta. \end{aligned} \tag{A14}$$

If the elasticity B_i is the same across all firms i, the latter simply reduces to $B_G = B_i, \forall i$. In order to recover B_G, one needs to estimate it. In any case -whether the B_i's are the same or not- one needs to regress the aggregate variable $\left(\frac{\Delta S}{S_{-1}}\right)_G = \sum_i w_i \frac{\Delta S_i}{S_{i,-1}}$ onto $\frac{\Delta Y}{Y_{-1}}$.

b) If the shock is large*:*

- in the case where the B_i's are the same for all firms ($B_i = B_G, \forall i$), the effect of the shock, previously measured by (A14), is now given by:

$$\frac{Debt^{\ V} - Debt^{\ B}}{Debt^{\ B}} = \exp(a_1 B_G \eta) - 1, \tag{A15}$$

- in the case where the elasticities differ across companies, it is reasonable to consider that they remain homogeneous within classes (for example, small, medium and large companies). Noting these elasticities as $B_{(j)}$, (A14) becomes:

$$\frac{Debt^{\ V} - Debt^{\ B}}{Debt^{\ B}} = \sum_j w_{(j)} \left[\exp(a_1 B_{(j)} \eta) - 1\right]. \tag{A16}$$

In the latter case, one needs to regress the growth rate of sales per class (j), $\sum_{i \in (j)} w_{i(j)} \frac{\Delta S_i}{S_{i,-1}}$, onto $\frac{\Delta Y}{Y_{-1}}$ in order to estimate the different elasticities $B_{(j)}$.

The procedure is therefore very similar in case a) and b) and easily implemented with the BACH database. The only difference is the slightly more complicated formula when comparing (A14) and (A16). In most cases usually considered in stress tests the assumption of "small" shocks (i. e. less than 10%) is likely to hold.

2. Second, we suppose that the relationship between $\frac{\Delta S_i}{S_{i,-1}}$ and $\frac{\Delta Y}{Y_{-1}}$ is non-linear: For example, let us assume that (A7) becomes:

$$\frac{\Delta S_i}{S_{i,-1}} = B_{0,i} + B_{1,i}\frac{\Delta Y}{Y_{-1}} + B_{2,i}\left(\frac{\Delta Y}{Y_{-1}}\right)^2. \tag{A17}$$

Thus an (absolute) shock η onto $\frac{\Delta Y}{Y_{-1}}$ affects $\frac{\Delta S_i}{S_{i,-1}}$ according to:

$$\left(\frac{\Delta S_i}{S_{i,-1}}\right)^B \rightarrow \left(\frac{\Delta S_i}{S_{i,-1}}\right)^V = \left(\frac{\Delta S_i}{S_{i,-1}}\right)^B + B_{1,i}\eta + B_{2,i}(2\eta\frac{\Delta Y}{Y_{-1}} + \eta^2) \tag{A18}$$

a) Case of a small shock:

One can neglect the additional term $B_{2,i}(2\eta\frac{\Delta Y}{Y} + \eta^2)$ since $2\eta\frac{\Delta Y}{Y} + \eta^2 << \eta$. Thus to measure the aggregate impact on debt one is back to a linear relationship, as in (A14).

b) Case of a large shock:

The equivalent of (A16) is now given by :

$$\frac{Debt^{\ V} - Debt^{\ B}}{Debt^{\ B}} = \sum_j w_{(j)}\left[\exp\left\{a_1(B_{1,(j)}\eta + B_{2,(j)}(2\eta\frac{\Delta Y}{Y_{-1}} + \eta^2)\right\}) - 1\right], \tag{A19}$$

with $B_{1,(j)}$ and $B_{2,(j)}$denoting the coefficients B_1 and B_2 of $\frac{\Delta Y}{Y_{-1}}$ and $\left(\frac{\Delta Y}{Y_{-1}}\right)^2$, respectively for the different classes (j).These coefficients are estimated from regressions of $\left(\frac{\Delta S}{S_{-1}}\right)_{(j)}$ onto $\frac{\Delta Y}{Y_{-1}}$ and $\left(\frac{\Delta Y}{Y_{-1}}\right)^2$ for the different classes (j). The computation of (A19) is straightforward. It provides also a convenient decomposition of the overall effect into the contributions of the different types of companies.

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