Markups, Productivity and the Financial Capability of Firms

Carlo Altomonte (Bocconi University & Bruegel)
Domenico Favoino (Bocconi University & Bruegel)
Tommaso Sonno (U. Catholique de Louvain & LSE)

PRELIMINARY AND INCOMPLETE

Abstract

In this paper we introduce credit constraints as in Manova (2013) in a framework of monopolistically competitive firms with endogenous markups, as in Melitz and Ottaviano (2008). Before producing, firms need to invest in tangible fixed assets to be used as collateral in order to obtain credit. In addition to productivity, firms are also heterogeneous in their financial capability, so that a higher financial expertise would involve advantages in the negotiation of redeployable assets, which the literature recognizes as crucial in decreasing the cost of collateral. By introducing heterogeneity in financial capability, our theoretical model predicts that, conditional on productivity, a higher financial capability is associated to higher markups. This allows us to study the implications of changes in collateral requirements faced by firms in their external borrowing. Specifically, the model predicts that a tightening of collateral requirements produces two effects on markups: a market cleansing effect, through which a more competitive environment leads to lower markups, and a relative advantage of firms with higher financial capability, leading to relatively higher markups. The theoretical results are tested empirically capitalizing on a representative sample of manufacturing firms covering a subset of European countries during the financial crisis.

1 Introduction

[To be added...]

2 Theoretical Model

2.1 Demand Side

We consider an economy with L consumers, each supplying one unit of labour. Consumers can allocate their income over two goods: a homogeneous good, supplied by perfectly competitive firms, and a differentiated good. The market for the latter is characterized by monopolistic competition, with consumers exhibiting love for variety and horizontal product differentiation. Preferences are quasi-linear as, e.g., in Melitz and Ottaviano (2008):

$$U = q_0 + \alpha \int_{i\in\ \Omega} q_i^c \ di - \frac{1}{2}\gamma \int_{i\in\ \Omega} (q_i^c)^2 \ di - \frac{1}{2}\eta \left[\int_{i\in\ \Omega} q_i^c \ di \right]^2 \tag{1}$$

where the set Ω contains a continuum of differentiated varieties, each of which is indexed by i. q_0 represents the demand for the homogeneous good, taken as numeraire, while q_i^c corresponds to the individual consumption of variety i of the differentiated good. α and η are utility function parameters indexing the substitution pattern between the homogeneous and the differentiated good; γ represents the degree of differentiation of varieties $i \in \Omega$ instead.

By assuming that the demand for the homogenous good is positive, i.e. $q_0 > 0$, and solving the utility maximization problem of the individual consumer, it is possible to derive the inverse demand for each variety:

$$p_i = \alpha - \gamma q_i^c - \eta \int_{i\in\ \Omega} q_i^c \ di \ , \forall i \in \Omega \tag{2}$$

By inverting (2) we obtain the individual demand for variety i in the set of consumed varieties Ω^*, where the latter is a subset of Ω and retrieve the following linear market demand system:

$$q_i = L q_i^c = \frac{\alpha L}{\gamma + \eta N} - \frac{L}{\gamma} p_i + \frac{\eta N \overline{p} L}{\gamma(\gamma + \eta N)} \ , \forall i \in \Omega^* \tag{3}$$

N represents the number of consumed varieties, which also corresponds to the number of firms in the market since each firm is a monopolist in the production of its own variety; $\overline{p} = \frac{1}{N} \int_{i\in\ \Omega^*} p_i di$ is the average price charged by firms in the differentiated sector.

We can assume that the consumption of each variety is positive, i.e. $q_i^c > 0$, in order to obtain an expression for the maximum price that a consumer is willing to pay. Setting

$q_i = 0$ in the demand for variety i yields the following:

$$p_{max} = \frac{\alpha\gamma + \eta N \overline{p}}{\gamma + \eta N}$$

Therefore, prices for varieties of the differentiated good must be such that $p_i \leq p_{max}$, $\forall i \in \Omega^*$, which implies that Ω^* is the largest subset of Ω that satisfies the price condition above.

2.2 Technology

Firms use one factor of production, labour, inelastically supplied in a competitive market. The production of the homogeneous good requires one unit of labour, which implies a wage equal to one.
Both the differentiated and the homogeneous good are produced under constant returns to scale, but the entry in the former industry involves a sunk cost f_E, representing start-up investments which constitute the initial endowment of each firm

Firms are heterogeneous in productivity, having a firm-specific marginal cost of production $c \in [0, c_M]$ randomly drawn from a given distribution right after entry. Based on observation of their marginal production costs, firms then decide whether to stay in the market and produce a quantity $q(c)$ at a total production costs $cq(c)$, or exit.

2.3 Financing of firms and collateral

In our framework firms need to borrow money from banks in order to finance a share of their production costs $cq(c)$. Banks, which operate in a perfectly competitive banking sector, define contract details for loans and make a take-it or leave-it offer to firms, including the collateral needed against the loan. Tangible fixed assets are used as collateral.[1] In order to obtain credit and start producing, firms thus use (part of) their fixed entry cost f_E to invest into tangible assets that they can then pledge as collateral to banks.[2]

In line with recent empirical evidence emerging from the finance literature (Campello and Giambona, 2012)) firms can invest their initial fixed entry cost between two type of tangible assets: redeployable assets (R) constituted by land, plants and buildings; and non-redeployable assets (N), i.e. machinery and equipment. Redeployable assets are easier to resell on organized markets, and thus, being more liquid, can facilitate firms'

[1]The use of tangibles as collateral for loans is a standard practice for firms asking for loans and a common feature of the finance literature, as discussed among others by Graham (1998), Vig (2013) or Brumm et al. (2015).

[2]Manova (2013) assumes that fixed entry cost already constitute part of the collateral that firms can use, although she does not exclude that firms might invest in tangible assets to increase their capacity for raising outside finance.

borrowing; non-redeployable assets, being more firm-specific and with a value that deteriorates over time (because of technological obsolescence) are less easy to be employed as a guarantee for loans compared to the formers.

Larger firms, having to finance a larger total production cost, will require a larger volume of credit and thus would need more collateral, which is an empirical regularity detected in the data (Rampini and Viswanathan, 2013). As tangible assets are used as collateral, the latter also implies that larger firms will have more tangible asset, a well known stylized fact.

Hence, it is convenient to model the firm investment in tangible asset as the optimal allocation between redeployable and non-redeployable assets, given the 'endowment' of initial fixed entry costs the firm is ready to pay, expressed in terms of the amount of tangible asset per unit of output. Each firm thus faces the following maximization problem:

$$\max i(R, N) = R^{\alpha} N^{1-\alpha} \tag{4}$$

subject to the constraint:

$$f_E = (1 - \epsilon(\tau))R + N$$

The term $i(R, N)$ represent the amount of tangible asset per unit of output that the firm obtains when allocating its endowment f_E in redeployable and non-redeployable assets, given the price of the same assets, with α and $(1-\alpha)$ representing the marginal returns of the investment into assets of type R and N, respectively. While non-redeployable assets N are supplied in a perfectly competitive market at a price $p_N = 1$, we assume that the price of redeployable assets R varies across firms, being the result of a bargaining process between the supplier of the same asset and the firm.

The price of redeployable assets depends in particular on the financial capability of firms, which is a firm-specific parameter $\tau \in [0, 1]$ randomly drawn right after the entry of the firm.[3] Specifically, the price of redeployable assets R is $1 - \epsilon(\tau)$, with $\epsilon(\tau) \geq 0$ and itself increasing in τ. The intuition is that firms with better financial expertise can fetch a lower price on the market for their redeployable assets. This is in line with evidence provided by Guner et al. (2008), showing how the financial expertise of directors plays a positive role in finance and investment policies adopted by the firm.[4]

From the maximization of the investment function we obtain the following optimal amounts of R and N that a firm will buy:

$$R^* = \frac{\alpha}{(1 - \epsilon(\tau))} f_E$$

[3] The probability distributions $\tau \in [0, 1]$ and of $c \in [0, c_M]$ are assumed to be independent.

[4] Glode et al. (2012) model the financial expertise of firms as the ability in estimating the value of securities, and show how these characteristic increase the ability of firms of raising capital.

$$N^* = (1-\alpha)f_E$$

Note that, while the optimal N is the same for all firms, the amount of redeployable assets increases with the financial ability of firms. Hence, a greater financial expertise translates in a more efficient use of the initial endowment. By plugging R^* and N^* in (4), we obtain the optimal amount of tangible assets per unit of output $i^*(\tau)$ that a firm of type τ can obtain:

$$i^*(\tau) = \frac{\alpha^\alpha}{(1-\epsilon(\tau))^\alpha}(1-\alpha)^{1-\alpha} f_E \tag{5}$$

in which $i^*(\tau)$ is strictly increasing in the financial capability of the firm. Equation 5 also allows us to define the financial capability cutoff, i.e. the minimum amount of financial capability that firms need having to stay in the market. This corresponds to $\widetilde{\tau}$ such that $\epsilon(\widetilde{\tau}) = 0$, i.e. a firm characterized by the cutoff financial capability would not obtain any type of advantage in the price of redeployable assets. As a consequence, the τ-cutoff firm will obtain an amount of tangible asset per unit of output equal to:

$$\widetilde{i} = \frac{\alpha^\alpha}{(1-\epsilon(\widetilde{\tau}))^\alpha}(1-\alpha)^{1-\alpha} f_E = \alpha^\alpha (1-\alpha)^{1-\alpha} f_E \tag{6}$$

which represents the lower bound in the amount of tangible assets per unit of output that surviving firms are able to obtain on the market.

The implications of heterogeneity in financial capability can be seen considering the case of all firms having the same financial expertise $\bar{\tau}$. As firms in the industry have the same fixed entry cost f_E, in our setting they will end up with the same amount of tangible asset per unit of output $i(\bar{\tau})$. In this case, the total amount of tangible assets available to any firm $\bar{I}(c) = i(\bar{\tau})q(c)$ will just be a function of the firm's size, i.e. ultimately of its marginal costs. In other words, even introducing a financial sector in our framework, without heterogeneity in financial capability productivity will remain the only endogenous variable needed to characterize the entire equilibrium of the industry, as a given marginal cost c would determine the firm's size $q(c)$ and hence the volume of the loan as a share of production costs $cq(c)$, as well as the amount of tangible assets $\bar{I}(c)$ and hence the availability of collateral. Introducing heterogeneity also on financial capability τ, on top of productivity, allows instead to derive non-trivial implications for firms' behavior, especially when studying the implications of financial shocks.

Coming to the modeling of the banking sector, banks do not know the actual financial capability of firms, but can observe $\widetilde{\tau}$ and the resulting amount of tangible fixed assets of the lowest financially capable (cutoff) firm, which is given by $\widetilde{i}q(c)$.[5] Hence, they would

[5] The model leads to the same propositions if we assume that banks observe the average τ instead of $\widetilde{\tau}$. Results are available on request.

supply loans to all firms that are financially capable enough to stay in the market after the draw of their τ, i.e. those firms such that $\tau \geq \widetilde{\tau}$.

Following Egger and Seidel (2012) and Manova (2013), firms need to externally fund a share σ of their total production costs $cq(c)$ and have to repay $R(c)$ to banks. Repayment occurs with exogenous probability λ, with $\lambda \in (0, 1]$, which is determined by the strength of financial institutions, while with probability $(1 - \lambda)$ the financial contract is not enforced, the firm defaults, and the creditor seizes the collateral. In particular, a share β of all tangible fixed assets is taken as collateral by the lender and collected if the firm is not able to repay the debt. The parameter $\beta \in [0, 1]$ is sector-specific and decided by banks according to their financing needs, as in Manova (2013) and Peters and Schnitzer (2015). Combining the two sources of firm heterogeneity in marginal costs and financial capability (c, τ) we can write the participation constraint of a bank as follows:

$$-\sigma cq(c,\tau) + \lambda R(c,\tau) + (1-\lambda)\widetilde{\beta i}q(c,\tau) \geq 0 \tag{7}$$

As we can easily see, no interest rate is charged by banks because of perfect competition in the banking sector. For the same reason, the participation constraint holds with equality for all banks. Hence, it is possible to derive an expression for the repayment function:

$$R(c,\tau) = \frac{1}{\lambda}[\sigma c - (1-\lambda)\widetilde{\beta i}]q(c,\tau) \tag{8}$$

Although a financial capability larger than $\widetilde{\tau}$ is required in order to obtain a loan, such characteristic is not sufficient. In fact, firms must also satisfy the following liquidity constraint:

$$p(c,\tau)q(c,\tau) - (1-\sigma)cq(c,\tau) + \beta(i(\tau) - \widetilde{i})q(c,\tau) \geq R(c,\tau) \tag{9}$$

A firm for which the above inequality does not hold would not be able to obtain the loan because of its inability to reimburse the debt to the borrower. This firm would exit the market right after the entry, i.e. after the random draw of its τ and marginal cost of production c.

2.4 Profit maximization

Each firm in the differentiated sector maximizes the following profit function

$$\pi(c,\tau) = p(c,\tau)q(c,\tau) - (1-\sigma)cq(c,\tau) - \lambda R(c,\tau) - (1-\lambda)\widetilde{\beta i}q(c,\tau) + \beta(i(\tau) - \widetilde{i})q(c,\tau)$$

under three constraints: the participation constraint (7), the liquidity constraint (9) and the demand for the supplied variety (3). The term $\beta(i(\tau) - \widetilde{i})q(c,\tau)$ represents the cost advantage obtained by a firm with financial capability equal to τ on the cost of collateral. Such term is the difference between the actual investment in tangible fixed assets made by a firm and the required investment to be used as collateral. This term enters the profit function directly as it represents a decrease in the debt burden proportional to the financial expertise of the firm.

By plugging (8) in the profit function we obtain a much simpler form for firm's profits:

$$\pi(c,\tau) = p(c,\tau)q(c,\tau) - cq(c,\tau) + \beta(i(\tau) - \widetilde{i})q(c,\tau) \tag{10}$$

Solving the profit maximization problem and using the demand constraint to derive $\frac{\partial p}{\partial q} = -\frac{\gamma}{L}$ yields the FOC:

$$p(c,\tau) - \frac{\gamma}{L}q(c,\tau) - c + \beta(i(\tau) - \widetilde{i}) = 0$$

By rearranging the terms in the above equation, we finally obtain an expression for the supply of each firm:

$$q(c,\tau) = \frac{L}{\gamma}[p(c,\tau) - c + \beta(i(\tau) - \widetilde{i})] \tag{11}$$

We can now use the liquidity constraint in order to derive the marginal cost cutoff c_D. Knowing that firms that would not be able to repay the debt will directly exit the market, the liquidity constraint (9) must hold with equality for the cutoff firm. Moreover, since the cutoff firm corresponds to that firm that sets $p_i = p_{max}$, we can rewrite (9) as follows:

$$p_{max}q(c_D,\tau) - (1-\sigma)c_D q(c_D,\tau) + \beta(i(\tau) - \widetilde{i})q(c_D,\tau) = R(c_D,\tau)$$

Rearranging the terms in the equation above yields a simple expression for the p_{max} in function of the cost cutoff c_D:

$$p_{max} = \theta c_D - \frac{(1-\lambda)}{\lambda}\beta\widetilde{i} \tag{12}$$

where $\theta = \frac{1}{\lambda}[\sigma + \lambda - \sigma\lambda]$ is a constant. Note that, since $i(\tau)$ is increasing in τ, the maximum price charged by a firm corresponds to the price made by the least financially capable firm. For this reason, in correspondence of the p_{max} we have that $i(\tau) = i(\widetilde{\tau})$.

2.5 Equilibrium

At the equilibrium, the demand for each variety equals the supply:

$$\left[\frac{\alpha\gamma}{\gamma + \eta N} + \frac{\eta N \overline{p}}{\gamma + \eta N} - p(c,\tau)\right]\frac{L}{\gamma} = \frac{L}{\gamma}[p(c,\tau) - c + \beta(i(\tau) - \widetilde{i})]$$

Note that the first two terms on the left hand side are equal to the p_{max} previously derived; hence, by substituting it with its expression in (12) and rearranging we obtain the equilibrium price charged by a firm characterized by a certain pair (c,τ):

$$p(c,\tau) = \frac{1}{2}\left[\theta c_D + c + \frac{(2\lambda - 1)}{\lambda}\beta\widetilde{i} - \beta i(\tau)\right] \tag{13}$$

Furthermore, we can derive an expression for the equilibrium markup of a (c, τ)-firm by subtracting the marginal cost from the equilibrium price. Since the cost function has the following form:

$$\begin{aligned} C(c,\tau) &= (1-\sigma)cq(c,\tau) + \lambda R(c,\tau) + (1-\lambda)\beta\widetilde{i}q(c,\tau) - \beta(i(\tau) - \widetilde{i})q(c,\tau) \\ &= cq(c,\tau) - (i(\tau) - \widetilde{i})q(c,\tau) \end{aligned}$$

we have that

$$\mu(c,\tau) = p(c,\tau) - MC(c,\tau) = \frac{1}{2}\left[\theta c_D - c - \frac{1}{\lambda}\beta\widetilde{i} + \beta i(\tau)\right] \tag{14}$$

By looking at expression (14), it is easy to note that, as in the Melitz and Ottaviano (2008) model, the equilibrium markup charged by a (c, τ)-firm is increasing in the production cost cutoff c_D and decreasing in the firm-specific marginal cost of production c. Hence, the less a firm is productive, the lower would be its markup (holding constant the effects on the equilibrium cost cut-off c_D of the industry, herein discussed). Interestingly, the financial capability of firms also plays a role in this framework. We formalize this result in the following

Proposition I. *The equilibrium markup $\mu(c, \tau)$ of a firm characterized by a pair (c, τ) is an increasing function of the financial capability of the firm, τ.*

Considering that the function $i(\tau)$ is increasing in τ, the above result is straightforward. The intuition is that a higher financial expertise would not only result in larger advantages in capital accumulation and in contracting with banks, but also in a markup premium. Differently from Manova (2013) and Melitz and Ottaviano (2008), we thus have that productivity is not the only firm characteristic affecting the equilibrium outcomes of the economy.

Finally, it is possible to derive an expression for a firm's profits in equilibrium:

$$\pi(c,\tau) = \frac{L}{4\gamma}\left[\theta c_D - c - \frac{1}{\lambda}\beta\widetilde{i} + \beta i(\tau)\right]^2 \tag{15}$$

2.6 Parameterization

To fully characterize the industry equilibrium, we have to solve for the value of the cost cut-off c_D, taking into account both sources of heterogeneity (c, τ).[6] As in Melitz and Ottaviano (2008), we assume that the marginal cost of production c follows an Inverse Pareto distribution with a shape parameter $k \geq 1$ over the support $[0, c_M]$. Additionally, we assume that the financial capability τ follows a Uniform distribution in the interval

[6] Recall that the cut-off of τ is defined as $\epsilon(\widetilde{\tau}) = 0$.

[0,1]. As already stated, the two probability distributions are independent. The cumulative density functions of c and τ can then be written as:

$$G(c) = \left(\frac{c}{c_M}\right)^k \ , \ c \in [0, c_M]$$

$$F(\tau) = \tau \ , \ \tau \in [0,1]$$

respectively. To solve for the equilibrium we also need to specify the functional form of $\epsilon(\tau)$, i.e. the price advantage enjoyed by the τ firm in the purchase of the redeployable asset. We assume that $\epsilon(\tau) = \tau - a$, with $a \in [0,1)$ being a constant. It is easy to note that $\epsilon(\tau)$ increases in τ and the function equals 0 in correspondence of a, therefore implying that the financial capability cutoff is $\widetilde{\tau} = a$.

By applying the free-entry equilibrium condition, according to which firms would be willing to enter the market until expected profits are equal to the fixed cost of entry f_E, we have:

$$\pi^e = \int_0^{c_D} \int_a^1 \frac{L}{4\gamma} \left[\theta c_D - c - \frac{1}{\lambda}\beta\widetilde{i} + \beta i(\tau)\right]^2 \ dF(\tau) \ dG(c) = f_E \tag{16}$$

Since $dG(c) = g(c)dc$ and $dF(\tau) = f(\tau)d\tau$, we can solve the integral in the free entry condition as follows:

$$\begin{aligned}
\pi^e &= \frac{Lk}{4\gamma c_M^k} \int_0^{c_D} \int_a^1 \left[\theta c_D - c - \frac{1}{\lambda}\beta\widetilde{i} + \beta i(\tau)\right]^2 \ d\tau \ dc = \\
&= \frac{Lk}{4\gamma c_M^k} \left(\left[(1-a)\left(\frac{\theta^2}{k} + \frac{1}{k+2} - \frac{2\theta}{k+1}\right)\right] c_D^{k+2} + \left[2\delta\left(\frac{1}{k+1} - \frac{\theta}{k}\right)\left(\frac{1-a}{\lambda} - \frac{1-a^{\alpha-1}}{a^{\alpha-1}(\alpha-1)}\right)\right] c_D^{k+1} \right) \\
&+ \frac{Lk}{4\gamma c_M^k} \left[\frac{\delta^2}{k}\left(\frac{1-a^{2\alpha-1}}{a^{2\alpha-1}(2\alpha-1)} + \frac{1-a}{\lambda^2} - \frac{2(1-a^{\alpha-1})}{\lambda a^{\alpha-1}(\alpha-1)}\right)\right] c_D^k = f_E
\end{aligned}$$

where $\delta = \alpha^\alpha(1-\alpha)^{1-\alpha}\beta f_E$. For simplicity, we name the first, the second and the third term multiplying the powers of c in square brackets of the above equation as A, B and C, as these are all comprised of exogenous parameters. Therefore, the free entry condition can be rewritten as follows:

$$\frac{Lk}{4\gamma c_M^k} c_D^k \left[(A c_D^2 + B c_D + C\right] = f_E \tag{17}$$

By rearranging the terms in (17) we obtain an expression for the production cost cutoff c_D:

$$c_D = \left(\frac{4\gamma c_M^k f_E}{L}\right)^{1/k} \left[A c_D^2 + B c_D + C\right]^{-1/k} \tag{18}$$

As we can see by looking at expression (18), it is not possible to find an explicit solution for c_D. However, as shown in Appendix A, one can prove that a positive solution always exists, and is unique under the parameter restrictions of the model.

2.7 Shock to collateral requirements

Assume now that an exogeneous shock to the economy leads banks to pledge for a larger share of collateral, namely, β increases. We are interested in analysing the effect of such shock on markups charged by firms in the differentiated sector.

Taking the first derivative of $\mu(c,\tau)$ with respect to β yields:

$$\frac{\partial \mu(c,\tau)}{\partial \beta} = \frac{1}{2}\left[\theta \frac{\partial c_D}{\partial \beta} - \frac{1}{\lambda}\widetilde{i} + i(\tau)\right] \tag{19}$$

We separately analyze the sign of the three terms in square brackets on the left-hand side of (19). First, by applying Dini's Implicit Function Theorem, according to which $h'(x) = -\frac{H_x(x,h(x))}{H_y(x,h(x))}$, we have that:

$$\frac{\partial c_D}{\partial \beta} = -\frac{\partial \pi^e(\beta, c_D(\beta))/\partial \beta}{\partial \pi^e(\beta, c_D(\beta))/\partial c_D} < 0$$

The sign of the derivative of c_D w.r. to β is negative since, as shown in Appendix B, both the derivatives of π^e in the above formula are positive. The intuition is that when banks pledge for more collateral, some firms would not be able to satisfy the liquidity constraint since the minimum required amount of tangible fixed assets becomes larger. Hence, the least efficient firms in the market would not obtain the loan from banks and exit, generating a fall in the production cost cutoff c_D.

As far as the second and the third term in (19) are concerned, their derivative is equal to $\alpha^\alpha(1-\alpha)^{1-\alpha} f_E \left[\frac{1}{(1-\tau+a)^\alpha} - \frac{1}{\lambda}\right]$. It then follows that for the cutoff firm $\widetilde{\tau} = \alpha$, the term is negative. Therefore, this negative effect adds to the negative effect of the change in β on c_D described above. As the financial capability τ of the firm increases, the term becomes smaller and eventually the sign of the derivative becomes positive.

We can formalize this result in the following

Proposition II. *The equilibrium markup $\mu(c,\tau)$ of a firm characterized by a pair (c,τ) decreases with a shock to collateral requirements by banks, β. The negative effect is however mitigated for more financially healthy firms: firms with a relatively high τ will experience a relatively smaller decrease in $\mu(c,\tau)$.*

As a larger β can be associated to tighter credit constraints for firms, the model predicts that a negative shock to credit markets leads to the exit of least productive firms and to a general decrease in the level of markups. However, those firms that have been able to obtain a relatively lower cost in the generation of their tangible fixed assets, due to their high financial expertise, would experience a relatively milder shock.

Hence, differently from a model in which marginal costs/productivity are the only source of firm heterogeneity, and thus a tightening in credit constraints would only affect the cost cutoff c_D equally affecting all firms in the market, the introduction of different firm-level financial capabilities in our framework allows for an heterogeneous response of firms to a symmetric financial shock.

3 Data and markups estimation

3.1 Firm-level data

Our firm-level data derive from the first survey on European Firms in a Global Economy (Efige), a research project funded by the European Community's Seventh Framework Programme (FP7/2007-2013). The project aims at analyzing the competitive performance of European firms in a comparative perspective. This dataset is the first harmonized cross-country dataset containing quantitative as well as qualitative information on around 150 items for a representative sample of some 15,000 manufacturing firms in the following countries: Austria, France, Germany, Hungary, Italy, Spain, and the United Kingdom. These items cover international strategies, R&D, innovation, employment, financing and organizational activities of firms, before and after the financial crisis.

The survey was carried out between January and April 2010. Managers were asked to report information on the different questions for the period 2008-09, with specific questions requesting information on the reaction of firms to the crisis in 2009/10, while other questions tracked the persistency of some variables (e.g. exports or innovation activities) in the years before 2008. The questionnaire has been administered via either CATI (Computer Assisted Telephone Interview) or CAWI (Computer Assisted Web Interview) procedures. The complete questionnaire is available on the Efige web page, www.efige.org. A discussion of the dataset as well as its validation is available in Altomonte et al (2012), while Bekes et al. (2011) discuss explicitly the reaction of firms to the crisis as measured in the survey.

An interesting characteristic of the Efige dataset is that, on top of the unique and comparable cross-country firm-level information contained in the survey, data can be matched with balance sheet figures. More precisely, we have been able to integrate Efige data with balance-sheet information drawn from the Amadeus database managed by Bureau van Dijck, retrieving twelve years of usable balance-sheet information for each surveyed firm, from 2001 to 2013. This data in particular enable the calculation of firm-specific measures of productivity and markups over time.

The Efige dataset includes about 3,000 firms operating in Germany, France, Italy and Spain, some 2,200 firms in the United Kingdom, and about 500 firms for Austria and Hungary, as reported in Table 1 below.

Table 1: Efige sample size, by country

Country	Number of firms
Austria	443
France	2,973
Germany	2,935
Hungary	488
Italy	3,021
Spain	2,832
UK	2,067
Total	14,759

The sampling design follows a stratification by industry, region and firm size structure. Firms with less than 10 employees have been excluded from the survey, that instead presents an oversampling of larger firms with more than 250 employees to allow for adequate statistical inference for this size class. Detailed information on the distribution of firms by country/size class and industry can be retrieved on the Efige website (http://www.bruegel.org/datasets/efigedataset).[7]

3.2 Financial capability and descriptive statistics

We exploit two questions available in the Efige sample as proxies of the firm-specific financial capability. A first question asks whether the firm uses derivatives for its financial management strategy "*During the last year did your firm use any kind of derivatives products (e.g. forward operations, futures, swaps) for external financing needs or treasury management or foreign exchange risk protection?*". Around 46% of firms answer this question, and of those, around 10% report a positive answer.[8] A second question in the survey asks the firm's number of banks used. The question is answered by almost the entire sample and shows an average of three banks of two banks per firm (two for the median firm). We use these two variables variously combined as proxies of a firm's financial capability. The intuition is pretty straightforward: if in the firm there are people able to manage derivative products for financial hedging, this will imply a particularly high level of financial capability of the firm. The same intuition works for the number of banks: the higher the number of banks with which the firm interacts and has relations, the more sophisticated we expect the financial management strategy of the firm.

[7]In order to take into account the oversampling and to retrieve the sample representativeness of the firms' population, a weighting scheme (where weights are inversely proportional to the variance of an observation) is set up according to firm's industry and class size. All our regression results are thus computed by taking into account this weighting scheme, except where otherwise specified.

[8]The self-selection induced by the response rate is homogeneous in terms of the country-industry-size distribution of the original sample

From the Amadeus dataset linked with Efige we derive instead information on Tangible Fixed Assets, Sales as a proxy of output and the number of employees. We report in Table 2 their descriptive statistics for the year 2008, i.e. the year referred to in the questions related to financial capability.

Table 2: Descriptive statistics

	Obs.	Mean	Std. Dev.	Min	Max
Tangible Fixed Assets (2008)	12035	1903	4583	1	50204
Sales (2008)	10554	10986	24694	194	250215
Employees (2008)	9583	66	114	10	1062
Number of Banks	14571	2.99	2.0225	1	14
Financial Hedge	6872	9.58%	0.2943	0	1
Adequate Production Scale	14450	86.37%	0.3432	0	1
Exporter	14759	66.73%	0.4712	0	1
Product Innovation	14759	49.09%	0.4999	0	1
Quality Certification	14759	59.53%	0.4909	0	1
Manager Rewarded also by Financial Benefits	14237	34.73%	0.4761	0	1

Table 2 reports also the descriptive statistics of the variables used as additional controls in the empirical analysis. The variable 'Adequate Production Scale' is a dummy indicating if, compared to competitors, the firm's scale of production is perceived as adequate: we use the latter to capture in the cross-sectional dimension a potential heterogeneity of firms that are considering to upgrading their production scale through future investments. The dummy 'Exporter' indicates if the firm has exported any of its product in the year 2008, or has exported "always" or "sometimes" its products before 2008. The variable 'Product Innovation' shows if the firm carried out any product innovation in the years 2007-2009. Similarly the dummy 'Quality Certification' assumes value one if the firm has gone through any form of quality certification (e.g. ISO9000) during 2008. Finally, 'Manager Rewarded' indicates if executives/managers are rewarded with variable benefits based on their performance (including financial and non-financial benefits).

Finally, we also have information on whether firms have requested in the considered period a loan from a bank, as our theoretical model works through this channel. Not surprisingly, this condition is verified for 14,139 firms in our data (i.e. 96% of the sample).

3.3 Markup and Productivity Estimation

In order to estimate markups and productivity, we follow De Loecker and Warzynski (2012), which introduced a method to estimate markups by employing expenditure on inputs and elasticity of output to the use of inputs in production. This innovative algorithm for markup computation has a relevant advantage over other methods reported in the literature: it yields firm-specific and time-varying mark-ups, which enables the use of these estimates in panel data analysis.

The production function for firm i in logs has the form:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \epsilon_{it} \tag{20}$$

where y_{it}, l_{it} and k_{it} represent the log of output, labour and capital, respectively, ω_{it} stands for the technological shock, i.e. productivity, and ϵ_{it} is an error term. De Loecker and Warzynski (2012) estimate the production function coefficients by using the algorithm developed by Ackerberg, Caves and Fraser (2006, ACF henceforth), which is a two-step estimation procedure that allows to obtain consistent and unbiased estimates of β_l and β_k.

In each period firms minimize their costs, i.e. they solve the following problem:

$$\Lambda(L_{it}, K_{it}, \lambda_{it}) = w_{it}L_{it} + s_{it}K_{it} + \lambda_{it}(Y_{it} - Y_{it}(\cdot))$$

where λ_{it} is the Lagrange multiplier and w_{it} and s_{it} correspond to the wage and the price of capital, respectively. The first-order condition for the labour input can be written as

$$\frac{\partial \Lambda_{it}}{\partial L_{it}} = w_{it} - \lambda_{it}\frac{\partial Y_{it}(\cdot)}{\partial L_{it}} = 0$$

Rearranging terms and multiplying both sides by $\frac{L_{it}}{Y_{it}}$ we obtain:

$$\frac{\partial Y_{it}(\cdot)}{\partial L_{it}} = \frac{w_{it}}{\lambda_{it}}\frac{L_{it}}{Y_{it}}$$

Note that $\frac{\partial Y_{it}(\cdot)}{\partial L_{it}}$ is the output elasticity of labor, which corresponds to β_l under the assumption of Cobb-Douglas technology in production. Since λ_{it} can be interpreted as the marginal cost of production c_{it}, if we consider the definition of markup as the ratio between price and marginal cost and multiply both sides by P_{it}, we have that:

$$\beta_l = \mu_{it}\frac{w_{it}L_{it}}{P_{it}Y_{it}}$$

where the term $\frac{w_{it}L_{it}}{P_{it}Y_{it}}$ corresponds to the share of expenditure in labour of firm i in period t, denoted with α_{it}^L. Consequently, De Loecker and Warzynski (2012) can write a time-varying firm-specific markup as follows:

$$\mu_{it} = \frac{\beta_l}{\alpha_{it}^L} \tag{21}$$

An advantage of this method is that in order to obtain markup estimates we only need information about the share of expenditure in inputs, easily retrievable from balance sheets of companies, and the output elasticity of the labour input. The latter is obtained from the production function estimation, for which we mainly rely on Wooldridge (2009), which proposes the use of a GMM framework in order to obtain efficient estimates for β_l and β_k. For what concerns total factor productivity estimates (TFP, henceforth), they are obtained from the same estimation process.

As a robustness check, we have also estimated production function coefficients à la ACF (2009) as in De Loecker and Warzynski (2012), and then used the retrieved coefficients to construct alternative measures of markups and TFPs. Table 3 below reports median values and standard deviations of markups computed in our sample by using the two procedures.

Table 3: Markup estimates: median values and standard deviations

Estimation Method	Median	Standard deviation
Wooldridge	1.103	0.594
ACF	1.043	0.931

4 Empirical results

Our purpose is to analyze the relationship between markups and financial capability of firms and the effect of a credit crunch on markups in the economy as described in our theoretical model. Therefore, the empirical analysis is focused on the test of Propositions 1 and 2.

4.1 Test of Proposition I

The model predicts that, conditional on firm-level productivity, a higher financial capability τ is associated to higher markups. The channel of this effect takes place through the initial investment in tangible fixed assets needed by the firm in order to generate the collateral necessary for obtaining the bank loan. In our model, financially more capable firms are in fact able to generate redeployable assets (then primarily used as collateral) at cheaper costs, a gain then reflected in their markups. In this section we empirically test for this channel.

As discussed in the theoretical framework, our four main variables of interest are markups, productivity, financial capability and firms' investments in tangible fixed assets per unit of output. Recalling equation (14), we expect a positive correlation between markups and firm-specific productivity, as well as between markups and financial capability. In particular, financial capability τ is the our novel key variable influencing positively the investment allocation of each firm. We test a preliminary correlation between these four variables in the cross-section of 2008 through the following regression:

$$\ln \mu_i = \gamma_1 \ln TFP_i + \gamma_2 FH + \gamma_3 \ln(Banks) + \gamma_4 \ln i_i + Z + \epsilon_i \tag{22}$$

where μ_i is the firm-specific markup; TFP is the firm-specific productivity; FH and $\ln(Banks)$ are the variables proxying the firm-specific level of financial capability, respectively in terms of an active financial hedging strategy and as well as considering the (log) number of banks that the firm deals with; i_i is the variable indicating the firm-specific tangible fixed assets per unit of output; Z is a matrix of firm, country-industry effects discussed below; ϵ is the error term. The regression is run conditional on the fact that a firm has requested a bank loan in the considered period, a condition however satisfied by 96% of firms in our sample, as already discussed.

Table 4: Test of Proposition I

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	IV
Dependent variable	$\ln(\mu)_i$	$\ln(\mu)_i$	$\ln(\mu)_i$	$\ln(\mu)_i$
$\ln(\text{TFP})_i$	0.405***	0.401***	0.425***	0.559***
	(0.0259)	(0.0264)	(0.0317)	(0.0525)
Financial hedge$_i$	0.0671***	0.0485**	0.0419	
	(0.0240)	(0.0238)	(0.0256)	
$\ln(\text{Banks})_i$	0.134***	0.129***	0.111***	
	(0.0149)	(0.0156)	(0.0175)	
ln(Tangible fixed assets per output)$_i$			0.0753***	0.472***
			(0.00734)	(0.0961)
Adequate production scale$_i$		0.0725***	0.0675***	-0.0238
		(0.0202)	(0.0219)	(0.0439)
Exporter$_i$		0.0579***	0.0437**	0.00180
		(0.0166)	(0.0184)	(0.0337)
Product innovation$_i$		0.0214	0.0211	0.0115
		(0.0134)	(0.0146)	(0.0259)
Quality certification$_i$		0.0810***	0.0592***	-0.0914*
		(0.0151)	(0.0166)	(0.0496)
Manager rewarded also by financial benefits$_i$		0.0228	0.0181	0.0511
		(0.0177)	(0.0189)	(0.0329)
Obs.	3,269	3,092	2,442	2,442
R2	0.478	0.499	0.543	
Firm size and age controls	YES	YES	YES	YES
Country-Industry FE	YES	YES	YES	YES
Robust SE	YES	YES	YES	YES
	First-stage estimates and IV statis			
Financial hedge$_i$				0.166**
				(0.0854)
$\ln(\text{Banks})_i$				0.261***
				(0.0580)
F-statistic for weak identification				13
Hansen-J statistic				0.523

Table 4 presents the results of the cross-section, with markups and productivity both estimated with the Wooldridge's method.[9] As expected, column (1) confirms that markups are positively correlated with productivity and that, conditional on it, financially capable firms also display higher markups (for both proxies of financial capability), as predicted by the theoretical framework. The results hold also controlling for firm's size,[10] as well as the (logarithm of) a firm's age. We also include a full set of country*industry fixed effects to capture all possible spurious compositional effects beyond variation at the firm level.[11]

In column (2) we repeat the exercise taking into account the additional firm level characteristics previously discussed: the firm reporting an adequate production scale, the export and innovation activities, the presence of quality certification as well as the strategy of remuneration of managers. Results are robust for our variables of interest.

In column (3) we add to the previous specification the (log of) tangible fixed assets per unit of output (sales). If our theoretical model is correct, financial capability should positively influence the cost of generating tangible assets used as collateral, and thus tangible fixed assets per unit of output should be positively and significantly related to firm-level markups. In turn, financial capability should be mediated by the latter variable in term of its effect on mark-ups. This channel seems to be confirmed by our results. In fact, we can observe that when tangible assets are included in the estimation the coefficients associated to our proxies of financial capability decrease and lose some significance, while tangible assets per unit of out are positively and significantly associated to markups, always including the full set of country*industry and firm-level controls. The latter indicates on the one hand that financial capability and tangible assets are indeed related and influence markups, as postulated in our model; on the other hand, it is clear that there is a problem of endogeneity which we have to address.[12] For this, we go back to our theoretical model.

In section 2.3 we argued that the financial capability of manager(s) is associated with a higher efficiency (lower costs) in investing in tangible fixed assets before starting to produce, i.e. before asking loans to banks. This extra cost advantage of firms characterized by a high financial capability translates into higher level of markups during the production phase. The theoretical model thus suggests that financial capability could be used as an instrument for the unit investment in tangible fixed assets in the markup es-

[9]Robust results using the ACF algorithm are reported in Appendix C.

[10]The effects of firms' size on TFP and financial constraints have been widely discussed in the literature (see for example Hadlock and Pierce, 2010). We introduce this control in the form of a categorical variable, varying from 1 to 4 based on the firm having between 10-19, 20-49, 50-249 or more than 250 employees, respectively. The choice of a categorical variable is driven by the willingness of reducing the possible endogeneity with TFP and other firm-specific controls. All our results are confirmed if we substitute the natural log of the number of employee to the size categories.

[11]Industry fixed-effects are retrieved from Manova (2013) as measures of financial vulnerability (i.e. the extent to which a firm relies on outside capital for its investment).

[12]In Appendix C we use as a robustness check the ACF algorithm for markups and productivity, with similar results.

timation. The IV estimates are reported in column (4) of Table 4, where our two proxies of financial capability (Financial hedge and number of banks) are used as instruments for the tangible fixed assets per unit of output, which turns out to be positively and significantly associated to firm-level markups, always conditional on productivity and the usual set of firm-level as well as country*industry controls. The first-stage of the IV estimation (reported on the bottom of Table 4 for the two variables of interest) confirms the power of our instruments (the F-statistic is above the critical threshold of 10), while the Hansen-J statistic confirms the validity of our instruments.

Overall, these results seem to provide robust evidence that a firm's financial capability is associated to higher level of markups via the impact that the former characteristic has on the ability of the firm to efficiently generate tangible fixed assets, thus confirming our Proposition I.

4.2 Test of Proposition II

In order to test Proposition II we exploit the fact that, during the crisis years of 2008/09 the collateral requirements of banks have increased significantly. We retrieve this information from the ECB Bank Lending Survey (BLS). The survey, started in 2005, contains questions regarding the development of supply and demand of loans during the past quarter and the expected evolution during the next quarter. In particular, some questions of the BLS indicate if, in a specific quarter, collateral requirements of banks have tightened, eased or showed no changes. The information is reported as the share of respondents on a -100/+100 percentage scale for a given country in a given year. We have averaged the quarterly data in order to obtain a year-country variation for this variable, labeled 'Collateral requirement'.

Specifically, in the years 2008 and 2009, collateral requirements have tightened three fold, from a median value of .075 over the entire sample period to .21 for the two considered year. We have thus created a 'Crisis' dummy, taking value 1 for the years 2008-09 and 0 otherwise. We have hence tested Proposition II through the following specification

$$\begin{aligned} \ln \mu_{ict} =& \gamma_1 \ln TFP_{ict} + \gamma_2 FC_{ict} + \gamma_3 Collateral_{ct} + \gamma_4 Crisis_t + \gamma_5 FC * Crisis_{ict} + \\ &+ \gamma_6 FC * Collateral * Crisis_{ict} + Z + \epsilon_{ict} \end{aligned} \tag{23}$$

To achieve a parsimonious specification for our proxies of financial capability, we have combined them into one dummy variable, taking value of 1 if a firm both uses financial hedging strategies and has working relations with more than one bank (i.e. above the median of the variable), and zero otherwise. We have interacted this firm-level variable with the crisis dummy, in order to test, as postulated by Proposition II, financially capable firms suffer relatively less from a tightening of collateral requirements. As collateral requirements display some heterogeneity across countries and time in our sample, we have also interacted the latter variable with our main interaction variable (the coefficient γ_6), to check whether the overall average effect of the financial capability at times of crisis depends also on the extent to which collateral requirements have varied across countries in those years.

Table 5: Test of Proposition II

	(1) Years: 2006-2009	(2) Years: 2007-2010	(3) Years: 2006-2013
Dependent variable	$\ln(\mu)_{ict}$	$\ln(\mu)_{ict}$	$\ln(\mu)_{ict}$
$\ln(TFP)_{ict}$	0.407***	0.418***	0.452***
	(0.0118)	(0.0117)	(0.00828)
Financial capability$_{ict}$	0.0827***	0.0789***	0.0825***
	(0.0173)	(0.0187)	(0.0115)
Collateral requirements$_{ct}$	-0.245***	-0.248***	0.00195
	(0.0228)	(0.0232)	(0.0203)
Crisis$_t$	-0.0127	0.0128	-0.0199**
	(0.00997)	(0.00999)	(0.00821)
Financial capability$_{ict}$*Crisis$_t$	0.117***	0.118***	0.179***
	(0.0411)	(0.0413)	(0.0385)
Financial capability$_{ict}$*Collateral requirements$_{ct}$*Crisis$_t$	-0.227***	-0.212***	-0.439***
	(0.0795)	(0.0791)	(0.0787)
Financial capability marginal effect	0.118***	0.116***	0.114***
	(0.0154)	(0.0157)	(0.0114)
Obs.	13,284	13,166	23,975
R2	0.393	0.388	0.384
Firm size and age controls	YES	YES	YES
Industry vulnerability FE	YES	YES	YES
Robust SE	YES	YES	YES

Table 5 reports our results, tested over different time spans. Column (1) and (2) center the effect around the years of the crisis, including either the subsequent or the following years (2006-2009 and 2007-2010, respectively), while column (3) extends the analysis to the entire sample 2006-2013 for which data on collateral requirements are available. Results, robust across the various specifications (as well to the ACF algorithm for markups and productivity, as reported in Appendix), confirm indeed that financially capable firms have suffered relatively less from a tightening of collateral requirements in terms of markups, as confirmed by the relevant interaction. Overall, the marginal effect of financial capability is positive and significant across specifications, in line with Proposition II.

5 Conclusions

A Existence and Uniqueness of a positive c_D

In this section we want to show that a unique positive production cost cutoff c_D exists.Using the free entry condition, we set $\pi^e - f_E = 0 = h(c_D)$, where the function $h(c_D)$ has the following form:

$$h(c_D) = (1-a)\left(\frac{\theta^2}{k} + \frac{1}{k+2} - \frac{2\theta}{k+1}\right)c_D^{k+2} + \frac{2\delta}{\lambda}\left(\frac{1}{k+1} - \frac{\theta}{k}\right)\left((1-a) - \frac{(1-a^{\alpha-1})\lambda}{a^{\alpha-1}(\alpha-1)}\right)c_D^{k+1} + \\ + \frac{\delta^2}{k}\left(\frac{1-a^{2\alpha-1}}{a^{2\alpha-1}(2\alpha-1)} + \frac{1-a}{\lambda^2} - \frac{2(1-a^{\alpha-1})}{\lambda a^{\alpha-1}(\alpha-1)}\right)c_D^k - \frac{4\gamma c_M^k}{Lk} f_E = 0$$

Note that the function does not exists for values of $\alpha = 1/2, 1$. Taking the first derivative of $h(c_D)$ w.r. to c_D yields:

$$h'(c_D) = (1-a)(k+2)\left(\frac{\theta^2}{k} + \frac{1}{k+2} - \frac{2\theta}{k+1}\right)c_D^{k+1} + \frac{2\delta(k+1)}{\lambda}\left(\frac{1}{k+1} - \frac{\theta}{k}\right) \\ \left((1-a) - \frac{(1-a^{\alpha-1})\lambda}{a^{\alpha-1}(\alpha-1)}\right)c_D^k + \delta^2\left(\frac{1-a^{2\alpha-1}}{a^{2\alpha-1}(2\alpha-1)} + \frac{1-a}{\lambda^2} - \frac{2(1-a^{\alpha-1})}{\lambda a^{\alpha-1}(\alpha-1)}\right)c_D^{k-1} = 0$$

In order to define the signs of the solutions of $h'(c_D) = 0$ we study the sign of the three terms multiplying the powers of c_D. It is easy to note that the sign of the first term is always positive.
For what concerns the second term, we have that $\left(\frac{1}{k+1} - \frac{\theta}{k}\right) < 0$, while $\frac{2\delta(k+1)}{\lambda} > 0$. the remaining part of the second term can be either positive or negative. However, under the assumption that $\lambda(1-a^{\alpha-1}) + (1-\alpha)(1-a)a^{\alpha-1} > 0$, the sign is negative. Therefore, under such assumption, we would have

$$\frac{2\delta(k+1)}{\lambda}\left(\frac{1}{k+1} - \frac{\theta}{k}\right)\left((1-a) - \frac{(1-a^{\alpha-1})\lambda}{a^{\alpha-1}(\alpha-1)}\right) > 0$$

Finally, the third term is positive.
By applying Cartesio's Rule, we can say that the equation $h'(c_D) = 0$ has two negative solutions. Moreover, we know from Rolle's Theorem that between each two solutions of $h(c_D) = 0$ there is always a solution for $h'(c_D) = 0$. Since $h'(c_D) = 0$ has two negative solutions under the condition expressed above, we can be sure that $h(c_D) = 0$ can have at most one positive solution.
Now note that:

- $h(0) < 0$,
- $h(+\infty) \to +\infty$,

which imply that the function $h(c)$ must have a positive solution.
Hence, we can conclude that, under the condition $\lambda(1-a^{\alpha-1}) + (1-\alpha)(1-a)a^{\alpha-1} > 0$ there exists a unique positive cost cutoff c_D.

B Derivative of c_D w.r. to β (Proposition II)

In this section we want to show that:

$$\frac{\partial c_D}{\partial \beta} < 0$$

By applying the U. Dini's Implicit Function Theorem, we can rewrite the derivative as follows

$$\frac{\partial c_D}{\partial \beta} = -\frac{\partial \pi^e(\beta, c_D(\beta))/\partial \beta}{\partial \pi^e(\beta, c_D(\beta))/\partial c_D}$$

being π^e a differentiable function of c_D and β. We first compute the derivative of $\pi^e(\beta, c_D(\beta))$ w.r. to β and show that its sign is positive. Knowing that expected profits can be written as:

$$\pi^e(\beta, c_D(\beta)) = \frac{Lk}{4\gamma c_M^k} c_D^k \left[A c_D^2 + B c_D + C\right]$$

where B and C are function of β, taking the first derivative w.r. to β yields

$$\begin{aligned}
\frac{\partial \pi^e(\beta, c_D(\beta))}{\partial \beta} &= \frac{Lk}{4\gamma c_M^k} c_D^k \left[\frac{\partial B}{\partial \beta} c_D + \frac{\partial C}{\partial \beta}\right] \\
&= \frac{Lk}{4\gamma c_M^k} \frac{2}{\lambda} \frac{\partial \delta}{\partial \beta} \left(\frac{1}{k+1} - \frac{\theta}{k}\right) \left((1-a) - \frac{(1-a^{\alpha-1})\lambda}{a^{\alpha-1}(\alpha-1)}\right) c_D^{k+1} + \\
&+ \frac{L}{4\gamma c_M^k} \frac{\partial \delta^2}{\partial \beta} \left(\frac{1-a^{2\alpha-1}}{a^{2\alpha-1}(2\alpha-1)} + \frac{1-a}{\lambda^2} - \frac{2(1-a^{\alpha-1})}{\lambda a^{\alpha-1}(\alpha-1)}\right) c_D^k
\end{aligned}$$

The condition $\lambda(1-a^{\alpha-1}) + (1-\alpha)(1-a)a^{\alpha-1} > 0$, which guarantees the existence of a unique positive c_D, ensures us that:

- $\frac{2}{\lambda}\left(\frac{1}{k+1} - \frac{\theta}{k}\right)\left((1-a) - \frac{(1-a^{\alpha-1})\lambda}{a^{\alpha-1}(\alpha-1)}\right) > 0$
- $\left(\frac{1-a^{2\alpha-1}}{a^{2\alpha-1}(2\alpha-1)} + \frac{1-a}{\lambda^2} - \frac{2(1-a^{\alpha-1})}{\lambda a^{\alpha-1}(\alpha-1)}\right) > 0$

Since $\frac{\partial \delta}{\partial \beta} > 0$, we can conclude that $\frac{\partial \pi^e(\beta, c_D(\beta))}{\partial \beta} > 0$.
Now we turn to the derivative of the expected profit function w.r. to the cost cutoff c_D. Specifically, we have:

$$\frac{\partial \pi^e(\beta, c_D(\beta))}{\partial c_D} = \frac{Lk}{4\gamma c_M^k} c_D^{k-1}\left[(k+2)A c_D^2 + (k+1)B c_D + kC\right]$$

The condition $\lambda(1-a^{\alpha-1}) + (1-\alpha)(1-a)a^{\alpha-1} > 0$ ensures us that B is positive, being A and C always nonnegative. Therefore, the derivative has a positive sign.
To sum up, since both $\frac{\partial \pi^e(\beta, c_D(\beta))}{\partial \beta}$ and $\frac{\partial \pi^e(\beta, c_D(\beta))}{\partial c_D}$ are positive, we can conclude that the production cost cutoff c_D is decreasing in the collateral requirement chosen by banks, β.

C Additional robustness check

Table 6: Test of Proposition I

Markups and productivity estimated with Ackerberg, Caves and Fraser method

	(1) OLS	(2) OLS	(3) OLS	(4) IV
Dependent variable	$\ln(\mu)_i$	$\ln(\mu)_i$	$\ln(\mu)_i$	$\ln(\mu)_i$
$\ln(\text{TFP})_i$	0.891***	0.895***	0.915***	1.062***
	(0.0409)	(0.0422)	(0.0463)	(0.0648)
Financial hedge$_i$	0.0717**	0.0688**	0.0686**	
	(0.0311)	(0.0314)	(0.0335)	
$\ln(\text{Banks})_i$	0.0962***	0.0935***	0.0883***	
	(0.0214)	(0.0223)	(0.0239)	
ln(Tangible fixed assets per output)$_i$			0.0415***	0.404***
			(0.0105)	(0.112)
Adequate production scale$_i$		0.115***	0.108***	0.0182
		(0.0286)	(0.0303)	(0.0510)
Exporter$_i$		0.0578**	0.0444*	-0.000511
		(0.0247)	(0.0255)	(0.0378)
Product innovation$_i$		-0.00286	0.00246	-0.00541
		(0.0209)	(0.0216)	(0.0292)
Quality certification$_i$		0.0615***	0.0401*	-0.100*
		(0.0236)	(0.0242)	(0.0575)
Manager rewarded also by financial benefits$_i$		0.0537*	0.0563**	0.0870**
		(0.0275)	(0.0286)	(0.0376)
Obs.	2,750	2,605	2,369	2,369
R2	0.513	0.526	0.537	
Firm size and age controls	YES	YES	YES	YES
Country-Industry FE	YES	YES	YES	YES
Robust SE	YES	YES	YES	YES
	First-stage estimates and IV statis			
Financial hedge$_i$				0.151*
				(0.0876)
$\ln(\text{Banks})_i$				0.254***
				(0.0590)
F-statistic for weak identification				11.38
Hansen-J statistic				0.739

Table 7: Test of Proposition II

Markups and productivity estimated with Ackerberg, Caves and Fraser method

	(1) Years: 2006-2009	(2) Years: 2007-2010	(3) Years: 2006-2013
Dependent variable	$\ln(\mu)_{ict}$	$\ln(\mu)_{ict}$	$\ln(\mu)_{ict}$
$\ln(TFP)_{ict}$	0.407***	0.418***	0.452***
	(0.0118)	(0.0117)	(0.00828)
Financial capability_{ict}	0.0118	0.00476	0.0173
	(0.0227)	(0.0242)	(0.0158)
Collateral requirements_{ct}	-0.485***	-0.523***	-0.191***
	(0.0314)	(0.0318)	(0.0281)
Crisis_{t}	0.0435***	0.0488***	-0.00413
	(0.0144)	(0.0146)	(0.0121)
Financial capability_{ict}*Crisis_{t}	0.156***	0.152***	0.233***
	(0.0547)	(0.0554)	(0.0522)
Financial capability_{ict}*Collateral requirements_{ct}*Crisis_{t}	-0.244**	-0.205**	-0.507***
	(0.0975)	(0.0977)	(0.0975)
Financial capability marginal effect	0.118***	0.116***	0.114***
	(0.0154)	(0.0157)	(0.0114)
Obs.	13,284	13,166	23,975
R2	0.393	0.388	0.384
Firm size and age controls	YES	YES	YES
Industry vulnerability FE	YES	YES	YES
Robust SE	YES	YES	YES