Markups, Productivity and the Financial Capability of Firms*

Carlo Altomonte[†,a], Domenico Favoino[b], and Tommaso Sonno[c]

[a] *Bocconi University*
[b] *Tinbergen Institute*
[c] *Université Catholique de Louvain and F.R.S.-FNRS*

Abstract

We extend a framework of monopolistically competitive firms heterogeneous in productivity and with endogenous markups (as in Melitz and Ottaviano, 2008) to incorporate the presence of financial frictions. Before producing, firms need to obtain a loan necessary to cover part of production costs, for which they have to pledge collateral in the form of tangible assets. In addition to productivity, firms are also heterogeneous in their financial capability: some firms have access to collateral at lower costs. As a result, financial capability and collateral requirements enter together with productivity in the expression of the equilibrium firm-level markup. At the aggregate level, the model shows that tighter credit constraints in the form of higher collateral requirements mitigate the pro-competitive effect of trade. We validate our theoretical results capitalizing on a representative sample of manufacturing firms surveyed across a subset of European countries during the financial crisis. Guided by theory, we estimate for each firm financial capability, TFP and markups. We then employ those estimates to structurally retrieve from the model a firm-specific measure of collateral requirements (a proxy of credit constraint), and test our main propositions.

Keywords: Credit constraints, heterogeneous firms, markups, international trade

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†Corresponding author: PAM - Bocconi University, Via Rontgen 1, Milano, Italy, *carlo.altomonte@unibocconi.it*

1 Introduction

A large and growing literature shows how financial market imperfections affect economic outcomes through their interplay with firms' characteristics. In particular, credit constraints have been recognized as an important determinant of export and innovation activity, on top of firms' productivity.[1] In addition, there seems to be high within-industry heterogeneity of firms with respect to access to external finance, even after controlling for firm characteristics such as size and productivity.[2]

Motivated by these findings, this paper extends a framework of monopolistically competitive firms heterogeneous in productivity and with endogenous markups (as in Melitz and Ottaviano, 2008) to incorporate the presence of financial frictions. Before producing, firms pay a fixed entry cost but also need to access collateral in the form of tangible assets. Collateral is required by banks in order to provide a loan necessary to cover part of the firm's production costs. Once the loan is obtained, firms maximize profits, given individual productivity. To account for the heterogeneous access of firms to external finance, firms differ in their financial capability, i.e. different firms access collateral at different costs.

The main implication of this extended framework is that financial capability (the cost of collateral for firms) and collateral requirements (the quantity of collateral requested by banks) enter, together with productivity, in all our equilibrium expressions. Looking in particular at firm-level markups we find that, for a given level of collateral requirement, more financially capable firms do not transfer all the cost advantage they have in generating the requested amount of collateral into lower prices, but rather retain relatively higher margins. Moreover we also find that higher collateral requirements mitigate the pro-competitive effects (average lower markups) generally observed in standard models of trade and firm heterogeneity. Hence, our result support the view that the presence of financial frictions affects the strength of reallocation within an industry after a trade shock.

The insights derived from the theoretical model are tested empirically on a representative sample of manufacturing firms surveyed across a subset of European countries during the financial crisis (the Efige dataset).[3] For each firm in the sample we obtain balance-sheet

[1]See among others Minetti and Zhu (2011); Gorodnichenko and Schnitzer (2013); Manova (2013); Peters and Schnitzer (2015); Muuls (2015); Chaney (2016); Bonfiglioli et al. (2017).

[2]Irlacher and Unger (2016) use World Bank firm-level data across countries to decompose the total variation of access to credit (proxied as tangible over total assets) into within- and between-industry variation, finding that roughly 80% of the variation is within (narrowly defined) industries, also after controlling for firm-level characteristics. We retrieve a similar feature in our data. Bottazzi et al. (2008) are able to correlate a formal bank-based measure of credit rating in Italy to different measures of firm-level profitability, observing a large variation of firms' performances within the different rating classes in the same sector-year.

[3]The European Firms in the Global Economy (Efige) dataset is a harmonized cross-country dataset con-

information from 2002 to 2013 using the Amadeus database managed by Bureau van Dijk. Following the intuitions of the model, we retrieve from balance sheet data a non-parametric measure of the (ex-ante unobserved) firm-specific financial capability. We then estimate a measure of firm-specific total factor productivity (TFP) purged from the effect of financial capability, and retrieve firm-level markups following the methodology proposed by De Loecker and Warzynski (2012).[4] Finally, we use the estimated financial capability, TFP and markups to back out from the model a firm-specific measure of collateral requirements (a proxy of credit constraint), and test our theoretical propositions. The construction of a structural measure of firm-level credit constraint is another result of this paper.

Empirical estimates confirm the theoretical insights of the model, and are robust to a battery of sensitivity and robustness checks. The retrieved firm-level measure of credit constraints also performs well if compared to other proxies existing in the literature.

Our paper speaks to the literature on firm heterogeneity and international trade under credit constraints. Manova (2013) incorporates financial frictions in a CES framework à la Melitz (2003), thus with constant firm-level markups. In her model, firms need collateral to obtain loans that cover part of fixed exports costs. As a result, credit constraints affect both the extensive and intensive margin of exports, as companies face binding constraints in the financing of both their fixed and variable export costs. Peters and Schnitzer (2015) incorporate financial frictions in a variable markup framework as in Melitz and Ottaviano (2008). They build a model of endogenous technology adoption, in which the cost of purchasing the advanced technology has to be financed externally. In their framework, however, they assume that technology adoption results in an increase of the price margin by a fixed amount, and hence do not work out the implications of credit constraints for markups and the pro-competitive effects of trade. Egger and Seidel (2012) discuss the implications of credit constraints for prices and markups introducing the use of collateral proportional to a firm's production cost. Differently from our approach, however, they do not take into account the heterogeneity of firms in access to external finance. As a result, their profit-maximizing quantities and prices are affected by credit constraints only through the cost

taining quantitative as well as qualitative information on around 150 variables for a representative sample of some 15,000 manufacturing firms surveyed in 2010 across the following countries: Austria, France, Germany, Hungary, Italy, Spain, and the United Kingdom.

[4]The routine for markup estimation proposed by De Loecker and Warzynski (2012) relies on a control for unobserved productivity and allows for flexible production technologies, being able to accommodate a different range of (dynamic or fixed) inputs of production. As in our model more financially capable firms are able to obtain fixed assets at cheaper costs, we have to incorporate a control for the effects of financial capability in the standard algorithms used to estimate productivity at the firm level (Woolridge, 2009 or Ackerberg et al., 2015).

cutoff parameter.

Another strand of literature to which our paper is related looks at the implications of financial frictions for resource misallocation. Gopinath et al. (2015) in particular calibrate a small open economy model with heterogeneous firms, capital adjustment costs and, crucially, size-dependent borrowing constraints in order to assess the importance of capital allocation in affecting productivity growth. They show how a model with financial frictions depending on firm size is better able to replicate firm behavior in the data, leading to capital inflows potentially misallocated toward firms that have higher net worth, but are not necessarily more productive. While we do not look directly at resource misallocation in our paper, our results show that the pro-competitive effects of trade taking place through selection and reallocation are indeed hindered by higher collateral requirements. We do also find evidence that our structural measure of firm-level financial constraint is significantly correlated with firm size: firms with larger assets or turnover display systematically lower constraints in our data.

Finally, our theoretical model borrows a number of insights from the financial literature. From Vig (2013) and Brumm et al. (2015) we take the idea that the amount and quality of tangible assets collected by firms influence the measure of collateral that banks require as a guarantee against loans. Specifically, tangible assets differ in terms of "redeployability" (see Berger et al., 2011; Campello and Giambona, 2013; Cerqueiro et al., 2016). More redeployable tangible assets (eg. land) are less firm-specific, but can be more easily sold and thus are more easily accepted as collateral. We also exploit evidence existing in the literature (e.g. Rampini and Viswanathan, 2013) that larger firm size is typically associated to higher (need of) loans, and thus collateral. In our model, more financially capable firms obtain redeployable assets at lower prices and thus benefit from lower costs. In turn, more productive firms have a larger size, but also require higher loans and collateral. As a result, productivity and financial capability jointly affect profits and markups in equilibrium.

The paper is organized as follows. We present our theoretical framework in Section II. Section III describes our data and introduces our estimation routines for financial capability, productivity and markups. In section IV we discuss the empirical strategy used to test our predictions, including our estimate of firm-level collateral requirements, and present our main results together with robustness checks. The final section concludes.

2 Theoretical Model

2.1 Setup and identification

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, produced under monopolistic competition. In order to produce, liquidity constrained firms need to finance a share of their production costs through loans from a perfectly competitive banking sector. To provide a loan, banks require firms to pledge an amount of tangible assets to be used as collateral. Specifically, there are two types of tangible assets: redeployable (land, buildings) and non-redeployable (machinery). Redeployable assets are easier to collateralize. Firms are heterogeneous in financial capability: more financially capable firms have a lower cost of obtaining redeployable assets. Firms are also heterogeneous in marginal costs, and learn about their specific level of financial capability and productivity after having incurred a sunk entry cost. Once endowed with information on their financial capability and marginal costs, firms that can cover production costs and satisfy the liquidity constraint (net revenues at least equal to the repayment of the loan) stay in the market.

The two sources of heterogeneity, marginal costs of production and financial capability, are ex-ante uncorrelated as these are drawn from two independent probability distributions. Still, they jointly influence firm behavior: more productive firms end up in equilibrium with higher output for which they require larger loans, and thus are requested a higher amount of collateral. In turn, a firm with a higher level of financial capability will face lower costs for obtaining the required amount of collateral, which will influence her overall cost structure and thus optimal production levels.

To disentangle the effects of these two sources of heterogeneity and identify the model, we exploit an empirical regularity in our data, i.e. the proportionality between firms' output and collateral (as in Rampini and Viswanathan, 2013, see infra for more detail). From this observation we can posit that firms are required by banks to collect a fixed amount of collateral per unit of output, a parameter that is exogenous from the perspective of individual firms and varies across sectors for technological reasons (as in Manova, 2013).[5] We derive from the model an expression for the cost advantage that a firm characterized by a given level of financial capability has in creating the (exogenous) required amount of collateral per unit of output. This cost advantage is in principle independent of the optimal firm size,

[5]In the last part of the paper we also introduce a firm-level collateral requirement.

driven by productivity. The latter is confirmed in our data: our non-parametric measure of the firm-specific financial capability is uncorrelated with a standard proxy of firm-level productivity (value added per employee), as well as with the computed TFP (see Appendix C). We can then rewrite firms' profits with this separable cost advantage term, and solve the model.

2.2 Demand and Production Technology

Consumers exhibit love for variety with horizontal product differentiation and quasi-linear preferences (and thus variable markups), as 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. The term 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. The parameters α and η index the substitution pattern between the homogeneous and the differentiated good; γ represents the degree of differentiation of varieties $i \in \Omega$.

Conditional on the demand for the homogeneous good being 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 for which $q_i^c > 0$, and retrieve the following linear market demand system:

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

In the above expression 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. In order to obtain an expression for the maximum price that a consumer is willing to pay, we set $q_i = 0$ in the demand for variety i and obtain the following:

$$p_{max} = \frac{\alpha\gamma + \eta N\overline{p}}{\gamma + \eta N} \tag{4}$$

Therefore, as in Melitz and Ottaviano (2008), prices for varieties of the differentiated good must be such that $p_i \leq p_{max}$ for every variety $i \in \Omega^*$, which implies that Ω^* is the largest subset of Ω that satisfies the price condition above.

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 normalized to one. Both the homogeneous and the differentiated goods are produced under constant returns to scale, but entry in the latter industry involves a sunk cost f_E. Firms are heterogeneous in productivity, having a firm-specific marginal cost of production $c \in [0, c_M]$ randomly drawn from a given distribution. In equilibrium the output level $q(c)$ of a firm with cost c will thus be equal to the total demand for its own variety.

2.3 Financing of firms

In our framework, liquidity constrained firms need to borrow money from banks in order to finance a fixed share $\rho \in [0, 1]$ of their production costs $cq(c)$.[6] 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, specifying the collateral needed against the loan. Firms with larger output $q(c)$, having to finance a higher production cost, will require a larger loan and thus would need more collateral. The latter is an empirical regularity detected in the literature (Rampini and Viswanathan, 2013) and confirmed in our data: regressing (log) turnover on firm's bank liabilities yields a positive and significant coefficient, i.e. larger firms require more bank loans. In turn, regressing firms' bank liabilities on tangible assets, a proxy for collateral (as in Vig, 2013 or Brumm et al., 2015), also yields a positive and significant coefficient, supporting the existence of a proportional relation between output and the amount of collateral pledged.[7]

[6] In the trade literature with credit constraints, Manova (2013) or Chaney (2016), among others, assume that firms require loans to finance part of the fixed export costs; in the innovation literature, external finance is typically needed for investments that increase productivity/lower marginal costs (e.g. Peters and Schnitzer, 2015; Gorodnichenko and Schnitzer, 2014; Mayneris, 2010). In the corporate finance literature, the external financing choice of the firm relates to the q-theory and the sensitivity of investment to cash flow (see Chen and Chen, 2012 for a summary).

[7] We use the item 'Loans' reported in balance sheet data to test for this stylized fact, which incorporates firms' liabilities to credit institutions. The relation is robust to the inclusion of firm fixed effects. More details are available on request.

Specifically, firms will be required by banks to pledge an amount of collateral equal to $\beta q(c)$, with $\beta > 0$ representing the amount of collateral that banks require for each unit of output so that a loan can be disbursed to firms. As in Manova (2013), the unit requirement β is chosen by the bank and varies across sectors for technological reasons: it is therefore exogenous from the perspective of individual firms.[8]

Firms can pledge different types of tangible assets as collateral: redeployable assets (Re) constituted by land, plants and buildings; and non-redeployable assets (NRe), e.g. machinery and equipment. Redeployable assets are easier to resell on organized markets: being more liquid, they can be easily used as collateral and thus facilitate firms' borrowing. Non-redeployable assets are more firm-specific and with a value that deteriorates over time (because of technological obsolescence): as such, they are less easy to be used as collateral.[9]

Firms are heterogeneous in their financial capability of negotiating the price of redeployable assets, with each firm having a specific level of financial capability $\tau \in [0, 1]$ randomly drawn from a probability distribution and independent of $c \in [0, c_M]$. The price of redeployable assets Re is $1 - \epsilon(\tau)$, with $\epsilon(\tau) \geq 0$ and strictly increasing in τ: firms with higher financial capability τ can thus fetch a lower price on the market for their redeployable assets then used as collateral.[10]

Firms allocate between redeployable and non-redeployable assets under the constraint on the required unit amount of collateral β, using a generic CES function:

[8]We do not need to impose ex-ante an upper bound to β, because collateral will enter into the firm's profit as a cost and thus, if the unit requirement β is too high with respect to the firm's optimal size, the firm would simply decide not to produce (free exit). The only implicit assumption we need to make, given the imperfect nature of credit markets in our model, is that the firm, if she decides to produce, has a positive initial endowment out of which she can finance the sunk entry costs and the provision of collateral. This cash-in-advance expenses are in any case incorporated in the industry equilibrium via the free entry condition on expected profits (see infra). More in general, our results hold with different specifications of a functional form for collateral requirement, as long as it is exogenous to firms. In the last part of the paper we also model a firm-specific collateral requirement.

[9]The use of tangible assets as collateral for loans is a standard practice for firms and a common feature of the finance literature, as discussed among others by Vig (2013) or Brumm et al. (2015). Campello and Giambona (2012) discuss the distinction between redeployable and non-redeployable assets. More in general, under asset-based lending, collateralizable assets include inventory, accounts receivable, machinery and equipment, real estate or the cash flow. In Manova (2013) a fraction of the sunk entry cost into export paid by firms goes towards tangible assets that can be used as collateral.

[10]Guner et al. (2008) show how the financial expertise of directors can play a positive role in the investment policies adopted by the firm. Glode et al. (2012) model the financial expertise of firms as the ability in estimating the value of securities, and show how this characteristic increases the ability of firms of raising capital. Alternatively, one can think at the relationship lending literature, studying how the relations of managers with banks increase funds availability and reduce loan rates (see Elyasiani and Goldberg, 2004, for a review of the literature): more financially capable managers might be more skilled in bargaining with banks, thus reducing the overall cost of collateral. More in general the channels through which bank-managers relations can have an impact on a firm's borrowing are fund availability and quantity, or prices and collateral (see Berger and Udell, 1995 and 1998; Cole et al., 2004; Petersen and Rajan, 1995).

$$\min C(Re, NRe) = (1 - \epsilon(\tau))\, Re + NRe \tag{5}$$

s.t.

$$\left(\delta Re^{\frac{\sigma-1}{\sigma}} + (1-\delta) NRe^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} = \beta$$

The term $C(Re, NRe)$ represents the cost of tangible asset per unit of output as resulting from the allocation between redeployable (Re) and non-redeployable (NRe) assets, with $\delta \in (0,1)$ and $\sigma > 1$ being respectively the input share and elasticity of substitution between (Re) and (NRe).[11] From the minimization of the cost function (5) we obtain

$$C(\tau) = \frac{\beta\,(1-\epsilon(\tau))}{\left[\delta^{\sigma} + (1-\delta)^{\sigma}\,(1-\epsilon(\tau))^{\sigma-1}\right]^{\frac{1}{\sigma-1}}} \tag{6}$$

which is the expenditure function computed in the optimal amount of redeployable and non-redeployable assets for a firm with financial capability τ and a β unit requirement for collateral. As such, $C(\tau)$ is the marginal cost of collateral and is strictly decreasing in τ.[12]

From Equation (6) it is possible to define the financial capability cutoff $\widetilde{\tau}$ such that $\epsilon(\widetilde{\tau}) = 0$: a firm characterized by the (cutoff) financial capability $\widetilde{\tau}$ would not obtain any type of advantage in the price of redeployable assets. The latter represents the upper bound in the marginal cost of collateral and is equal to:

$$C(\widetilde{\tau}) = \beta\,[\delta^{\sigma} + (1-\delta)^{\sigma}]^{-\frac{1}{\sigma-1}} \tag{7}$$

By substracting (6) from (7) we get:

$$\theta(\tau) = C(\widetilde{\tau}) - C(\tau) = \beta[\nu(1-\eta(\tau))] \tag{8}$$

with $\eta(\tau) = [(1-\epsilon(\tau))^{\sigma-1}]^{-\frac{1}{\sigma-1}}$ and $\nu = [\delta^{\sigma} + (1-\delta)^{\sigma}]^{-\frac{1}{\sigma-1}}$ both a constant. Equation (8) is increasing in τ and describes the cost advantage in terms of raising collateral that a firm characterized by financial capability τ will have with respect to the cutoff firm. As it can be easily seen, the financial capability cutoff firm characterized by $\epsilon(\widetilde{\tau}) = 0$ will have no cost advantage, i.e. $\theta(\widetilde{\tau}) = 0$.

The implications of heterogeneity in financial capability can be seen considering the case of all firms having the same financial capability $\bar{\tau}$. As firms in the industry have the same

[11] The price of non-redeployable assets is normalized at unity.

[12] Our results hold with a more general specification of a functional form for the cost of collateral, as long as $\partial C(\tau)/\partial\tau < 0$.

unit requirement β and no specific advantage, in our setting they will end up with the same marginal cost of collateral $C(\bar{\tau})$. As a result, productivity would remain the only firm-specific variable characterizing the industry equilibrium: a given marginal cost c would in fact determine the firm's size, and from here the volume of the required loan as a share of total production costs, as well as the total cost of the collateral to pledge (via the parameter β) against this loan. Introducing heterogeneity also on financial capability τ, on top of productivity, allows instead to derive a more complex interaction between productivity and financial constraints in the industry equilibrium.

2.4 Banking sector

Firms that fund a share $\rho > 0$ of their total production costs $cq(c)$ have to repay $R(c)$ to banks. Repayment occurs with exogenous probability $\lambda \in (0,1)$; with probability $(1-\lambda)$ the financial contract is not enforced, the firm defaults, and the bank seizes the collateral $\beta q(c)$. To close the deal, the participation constraint of a bank is then:

$$-\rho cq(c) + \lambda R(c) + (1-\lambda)\beta q(c) \geq 0 \tag{9}$$

that is, the value of the disbursed loan $\rho cq(c)$ has to be equal to its expected reimbursement either as a repayment or through the seizing of the collateral in case of default. Because of perfect competition in the banking sector, the participation constraint holds with equality for all banks.

Firms will apply for a loan if a liquidity constraint is satisfied, such that net revenues are at least equal to the repayment of the loan $R(c)$ to the bank (see e.g. Manova, 2013). Specifically, the liquidity constraint incorporates the two sources of firm heterogeneity in marginal costs and financial capability (c, τ) as follows:

$$p(c,\tau)q(c,\tau) - (1-\rho)cq(c,\tau) + \theta(\tau)q(c,\tau) \geq R(c,\tau) \tag{10}$$

that is, the difference between revenues and the internally financed fraction of the costs, net of the cost advantage that a firm with financial capability τ has in generating the required amount of collateral, is larger or equal then the repayment of the loan necessary for production. A firm for which the above inequality does not hold would exit the market.

2.5 Profit maximization

Each firm in the differentiated sector maximizes the following profit function

$$\Pi(c,\tau) = p(c,\tau)q(c,\tau) - (1-\rho)cq(c,\tau) + \theta(\tau)q(c,\tau) - \lambda R(c,\tau) - (1-\lambda)\beta q(c,\tau)$$

As there are two sources of heterogeneity (c and τ), in order to solve the model we have to consider the cutoff level of marginal (production) costs at which profits are zero (the free exit condition, as in Melitz and Ottaviano, 2008) under the participation constraint (9), the demand for the supplied variety (3) and the liquidity constraint (10), given the cost advantage in collateral (8).

From equation (9) it is possible to derive an expression for the repayment function:

$$R(c) = \frac{1}{\lambda}[\rho c - (1-\lambda)\beta]q(c)$$

Plugging the expression above in the profit function, and solving the profit maximization problem using the demand constraint (3) yields the FOC:

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

Rearranging the terms above, we obtain the supply equation:

$$q(c,\tau) = \frac{L}{\gamma}\left[p(c,\tau) - c + \theta(\tau)\right] \tag{11}$$

We can now use the liquidity constraint (10) in order to impose a free exit condition and derive an expression for the production cost cutoff c_D. Knowing that firms that would not be able to repay the debt will exit the market, the liquidity constraint must hold with equality for the cutoff firm characterized by marginal production costs c_D. Moreover, since this cutoff firm corresponds to that firm that sets $p_i = p_{max}$, we can rewrite (10) as follows:

$$p_{max}q(c_D,\tau) - (1-\rho)c_D q(c_D,\tau) + \theta(\tau)q(c_D,\tau) = R(c_D,\tau)$$

Rearranging the terms in the equation above yields a simple expression for p_{max} as a function of the cost cutoff c_D and the cost advantage $\theta(\tau)$:

$$p_{max}(c_D,\tau) = \omega c_D - \phi - \theta(\tau)$$

where $\omega = \frac{\rho}{\lambda} + 1 - \rho$ and $\phi = \frac{1-\lambda}{\lambda}\beta$ are constants.

Our results are still conditional on the financial capability cutoff $\widetilde{\tau}$ with respect to which the cost advantage is calculated. In order to endogeneize the latter, from expression (8) we have that $\theta(\tau)$ is increasing in τ. Hence, the maximum price charged by a firm corresponds to the price of the least financially capable firm $\widetilde{\tau}$ having marginal production costs c_D. As $\theta(\widetilde{\tau})$ is the lower bound of $\theta(\tau)$ and is equal to 0, it then follows that the expression for p_{max} incorporating both the production and the financial capability cutoffs is simply

$$p_{max} = \omega c_D - \phi \tag{12}$$

We are now ready to solve for our firm-level equilibrium.

2.6 Equilibrium

At equilibrium, the demand for each variety equals supply:

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

Recalling our definition of p_{max} in (4), by substituting it with its expression (12) in the above equation and rearranging, we obtain the equilibrium price charged by a firm characterized by a given set of (c, τ)

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

From here, by subtracting the marginal cost from the equilibrium price we can derive an expression for the equilibrium markup of a (c, τ)-firm :

$$\mu(c,\tau) = p(c,\tau) - c = \frac{1}{2}\left[\omega c_D - c - \phi + \theta(\tau)\right] \tag{14}$$

By looking at expression (14), it is easy to note that, as in Melitz and Ottaviano (2008), 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. However in our model the introduction of collateral requirements as well as the heterogeneity of firms in their ability of raising collateral at different costs both affect the expression of the markup, as summarized in the following

Proposition #1. *The equilibrium markup $\mu(c,\tau)$ of a firm characterized by a pair (c,τ) and a given level of collateral requirement β is ceteris paribus an increasing function of its cost advantage $\theta(\tau)$ in raising collateral.*

Similar to productivity, more financially capable firms do not transfer all the cost advantage they have in generating the required amount of collateral into lower prices, but rather retain relatively higher margins. Moreover, the markup is also affected by the collateral requirement β, as the latter enters in the expression of the parameter ϕ, the cutoff c_D and the same cost advantage $\theta(\tau)$. To understand how a change in collateral requirement affects firm behavior in our model, we need to solve for the industry equilibrium.

2.7 Parameterization

In order to characterize the industry equilibrium, we have to solve for the value of the cutoffs c_D and $\widetilde{\tau}$. As we have no ex-ante prior on the distribution of financial capability of firms, we assume that τ follows a uniform distribution in the interval [0,1].[13] Recall that the financial capability cutoff $\widetilde{\tau}$ implies $\epsilon(\widetilde{\tau}) = 0$, i.e. no price advantage enjoyed by the cutoff firm in the purchase of the redeployable asset. Assuming that $\epsilon(\tau) = \tau - a$, with $a \in [0, 1)$ being a constant, the value of the financial capability cutoff is thus $\widetilde{\tau} = a$. The distribution of surviving firms, once financial capability has been drawn, is still uniform with density equal to $f(\tau) = \frac{1}{1-a}$.

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 $[0, c_M]$. The cumulative density functions can then be written as:

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

The density functions is $g(c) = \frac{kc^{k-1}}{c_M^k}$ while the distribution of surviving firms, once produc-

[13] The assumption of a uniform distribution of τ together with its independence from marginal costs c (as the allocation problem of tangible assets is not related to productivity) implies that the financial capability cutoff $\widetilde{\tau}$ does not depend on market characteristics but rather is a constant, whereas the cost cutoff c_D remains endogenous like in Melitz and Ottaviano (2008). This simplification allows to introduce a second source of heterogeneity in the firm-level equilibrium equations, while maintaining the model tractable at the level of industry aggregates. These distributional assumptions do not entail however a loss of generality, as it can be shown that relevant shocks (e.g. a change in market size) have similar effects on both the cost and financial capability cutoffs, and thus on the industry equilibrium.

tivity has been drawn, is still an inverse Pareto with density equal to $g(c) = \frac{kc^{k-1}}{c_D^k}$.

From the equations of demand and supply we can derive an expression for a firm's profits in equilibrium:

$$\pi(c,\tau) = \frac{L}{4\gamma}\left[\omega c_D - c - \phi + \theta(\tau)\right]^2 \tag{15}$$

A (c,τ)-firm would be willing to enter the market until expected profits are equal to the fixed cost of entry f_E, i.e.:

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

Since $dG(c) = g(c)dc$ and $dF(\tau) = f(\tau)d\tau$, we can rewrite the integral as:

$$\pi^e = \frac{Lk}{4\gamma c_M^k}\int_0^{c_D}\int_a^1 \left[\omega c_D - c - \phi + \theta(\tau)\right]^2 c^{k-1}\; d\tau\; dc = f_E \tag{17}$$

As shown in Appendix A, one can prove that a positive solution always exists for c_D and it is unique conditional on a choice of c_M. The parametrization then allows us to find an expression for the equilibrium number of firms in the market and derive average performance measures as a function of c_D.[14]

By equating both expressions (4) and (12) for p_{max} and solving N, we obtain

$$N = \frac{\gamma}{\eta}\frac{(\alpha - \omega c_D + \phi)}{(\omega c_D - \phi - \overline{p})} \tag{18}$$

which corresponds to the number of firms, and therefore varieties of the differentiated good, active in the market in equilibrium. From here we can derive an expression for the average price for the differentiated good and obtain a parameterized expression also for N.

Average prices and markups are a function of the average marginal cost c and financial capability. Following Melitz and Ottaviano (2008), we define average marginal costs as:

$$\overline{c} = \frac{\int_0^{c_D} cg(c)dc}{G(c_D)} = \frac{kc_D}{k+1} \tag{19}$$

Since τ is distributed as a uniform over the interval $(0, 1)$, we also have that average financial capability is:

[14] In our setup the effect of the variable of interest (e.g. market size) on a given performance measure (e.g. average industry markup) cannot be solved numerically, but has to be assessed by taking into account the sign of the effect of the variable of interest on c_D.

$$\overline{\tau} = \frac{\int_a^1 \tau f(\tau) d\tau}{F(1-a)} = \frac{1+a}{2} \tag{20}$$

Now we can derive an expression for the average markup charged by firms active in the market, which corresponds to:

$$\overline{\mu} = \frac{1}{2} \frac{\int_0^{c_D} \int_a^1 \left[\omega c_D - c - \phi + \theta(\tau)\right] f(\tau) g(c) dc d\tau}{G(c_D) F(1-a)}$$

Solving the integral yields:

$$\overline{\mu} = \frac{1}{2} \left[\frac{\omega k + \omega - k}{k+1} c_D - \beta \psi \right] \tag{21}$$

with the constant $\psi > 0$, implying a direct negative effect of collateral requirements β on the average markup.

2.8 Trade shock and the role of financial constraints

Our setup allows, among others, to analyze the effects of an increase in the market size L on the industry equilibrium, which is analogous to a symmetric opening of the economy to trade as in Melitz and Ottaviano (2008). Differentiating equation (21) yields

$$\frac{\partial \overline{\mu}}{\partial L} = \frac{1}{2} \left[\frac{\omega k + \omega - k}{k+1} \frac{\partial c_D}{\partial L} \right] < 0$$

To explore the implications of a trade shock we have to look at the effect of an increase in L on the cost cutoff c_D. As shown in Appendix B, we have that $\frac{\partial c_D}{\partial L} < 0$, i.e. an increase in market size tends to reduce the average industry markup by lowering the cost cutoff, in line with the pro-competitive effect of trade identified in the literature.

Collateral requirements, however, play a role in the reaction of the economy to a trade shock, as the magnitude of the derivative of the cost cutoff with respect to L depends, among others, on the amount of collateral requirements β (see Appendix B for a discussion). In particular, when β is relatively large, i.e. when banks require more collateral for the same loan, *ceteris paribus* the effect of a change in L on the cost cutoff is relatively low, that is:

Proposition #2. *An increase in the market size L lowers the average markup $\overline{\mu}$. Tighter credit constraints in the form of higher collateral requirements (higher β) mitigate the pro-competitive effect of trade.*

3 Data and estimations

3.1 Firm-level data

Our firm-level data derive from the 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 dataset collects around 150 variables for a representative sample of some 15,000 manufacturing firms in the following countries: Austria, France, Germany, Hungary, Italy, Spain, and the United Kingdom, as reported in in Table 1.[15]

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 firm-level information present in the Efige dataset has been matched with balance sheet data drawn from the Amadeus database managed by Bureau van Dijck, and collected from 2002 to 2013.

3.2 Estimation of financial capability

From the theoretical model we can back out an estimate of the cost advantage $\theta(\tau)$ accruing to each firm from her (unobserved) financial capability τ, using simple balance sheet information. As firms are able to collect collateral at different costs, and collateral is constituted by tangible assets, it then follows that the nominal value of a firm's tangible assets (TA) observed in a firm's balance sheet should be decreasing in τ, once controlling for firm size. The intuition here is that all firms are required to collect the same amount β of TA per unit

[15] The complete questionnaire is available on the Efige web page, www.efige.org. The sampling design follows a stratification by industry, region and firm size. Firms with less than 10 employees have been excluded from the survey, that instead presents an oversampling of firms with more than 250 employees to allow for adequate statistical inference for this size class. Descriptive statistics are reported in Appendix C. Detailed information on the distribution of firms by country/size class and industry, as well as a validation of the data vs. official statistics and the weighting scheme are available in Altomonte and Aquilante (2012).

of output, but firms with higher τ will obtain that required amount at a lower cost (lower nominal value of TA). Also, for the same reason, the cutoff firm $\tilde{\tau}$ would have the highest nominal value of tangible assets across firms of that specific size.

From here we can estimate $\theta(\tau)$ non-parametrically in three stages. First, we create size ranges of firms, by industry (deciles of turnover, with quintiles and twentiles used as robustness). Second, for each size range within each industry, we identify the upper bound level of (nominal) tangible assets recorded by firms (the average value of the top 5% largest TA of firms, robustness with 1%): this value represents the level of tangible assets of the cutoff firm(s). Finally, we compute the firm-specific $\theta(\tau)$ by taking the ratio between the TA level of the cutoff firm in each size/industry partition and the firm-specific value of nominal TA of firms in the same size/industry. We retrieve from here an index ≥ 1 which we then bound between 0 (cutoff firms) and 1 (maximum financial capability).[16]

Considering all combinations of size ranges (quintiles, deciles, twentiles), of cutoff levels of tangible assets (1%, 5%), as well as different industry aggregations (at the 2 or 3-digit level) we can obtain several versions of our firm-specific cost advantage measure, which we will use as sensitivity checks in testing our Propositions.

3.3 Estimation of productivity and markups

In order to estimate markups and productivity at the firm level we start from De Loecker and Warzynski (2012, henceforth DLW), who estimate markups combining the output elasticity on a input, as obtained from the estimation of a production function, with the share of the same input's expenditure on total sales. The DLW methodology is particularly suited for our estimation strategy for two reasons. First, it allows for flexible production technologies that can accommodate in principle different sources of firm heterogeneity. Second, the DLW estimate of the correlation between markups and firm-level characteristics is not affected by the availability of real vs. nominal output (revenue) data. The latter allows us to test our Propositions using the same balance sheet information from which we have retrieved our measure of financial capability.[17]

[16] Our identification strategy crucially relies on the fact that financial capability and productivity / marginal costs are independent, as a correlation would result in biased measures. While we will explicitly purge total factor productivity estimates from the effects of financial capability, the firm-level measure of $\theta(\tau)$ retrieved here is in any case uncorrelated (.03) with the firm-level labor productivity (value added per employee) measured in the sample, as reported in Appendix C.

[17] De Loecker and Warzynski (2012) discuss how, under a Cobb-Douglas technology, the output elasticity reduces to a constant, and thus the bias induced by unobserved output prices impacts only the estimate level of the markup, not its correlation with firm characteristics.

Although robust to the output price bias, additional problems arise when estimating our equilibrium equations in a setting in which financial capability is heterogeneous across firms. The reason is twofold. On the one hand, financial capability $\theta(\tau)$ is likely to be correlated to the (unobserved) firm-specific price of capital. If the latter is unaccounted for, this input price variation typically leads to a negative bias in the estimated coefficients of the production function from which markups are calculated.[18] Moreover, if unaccounted for, input prices would remain in the error term of the production function, thus ending up in our TFP estimates. The latter induces a potential problem of multicollinearity between TFP and financial capability when structurally estimating Equation (14). For these reasons, we have included financial capability as an additional variable in the control function through which we estimate TFP.

Technically, we have estimated our production function coefficients relying on Wooldridge (2009), which proposes to improve on the Ackerberg, Caves and Frazer (2015, henceforth ACF) algorithm originally employed in De Loecker and Warzynski (2012) through the use of a GMM framework. In our baseline measure, we have computed estimates of the production function as in Woolridge (2009), augmenting the set of regressors with financial capability. We have then used the estimated coefficients in order to compute both firm level markups and TFP. As a robustness check, we have estimated the production function through the standard Woolridge (2009) algorithm, as well as through the ACF approach, both in its standard version and correcting the control function with financial capability.

Table 2 below reports the median values and standard deviations of four different firm-level markups, while Appendix C reports, among others, the correlation between our different measures of productivity and financial capability. The first two measures of Table 2 are markups estimated through the Woolridge (2009) algorithm, both in the standard and corrected version discussed above. The third measure of markups is computed using production function coefficients estimated through the standard ACF routine, thus replicating De Loecker and Warzynski (2012). The fourth estimate reports markups estimated via the ACF algorithm in which the control function has been corrected for financial capability. These different measures provide additional robustness checks in the test of our Propositions.

[18] De Loecker and Goldberg (2014) discuss in detail the problem of the input price bias.

Table 2: Markup estimates: median values and standard deviations

Estimation method	Median	Standard deviation
Wooldridge (no correction)	1.2063	0.7543
Wooldridge (correction)	1.2152	0.7066
ACF (no correction)	1.0668	0.4016
ACF (correction)	1.0886	0.6267

4 Empirical analysis

4.1 Financial capability, productivity and markups

The model predicts that, conditional on firm-level productivity, a higher financial capability τ is associated to higher firm-level markups, as financially more capable firms, ceteris paribus, are able to obtain redeployable assets (primarily used as collateral) at cheaper costs, a gain then reflected in their markups. Specifically, recalling our markup equation (14)

$$\mu(c, \tau) = \frac{1}{2}\left[\omega c_D - \phi - c + \theta(\tau)\right]$$

we structurally estimate the latter at the firm-year level, with the dependent variable $\mu(c, \tau)$ being the markup estimated through DLW (2012), as previously discussed. In terms of covariates, ωc_D and ϕ are fixed effects or controls (depending on specification), c is (the inverse of) our TFP measure, corrected for τ and previously estimated, while $\theta(\tau)$ is the cost advantage term retrieved as described in section 3.2.

We test our markup equation for the years 2002-2013 under various specifications plus a number of sensitivity and robustness checks. In addition, as heterogeneity in financial capability is relevant only for liquidity constrained firms, we always condition our estimates on firms that have requested a loan from a bank.[19]

Table 3 presents our benchmark results, in which firm-specific financial capability is estimated by deciles of sales, and the cutoff level of tangible assets is calculated on the top 5% of the distribution for each size decile within each NACE-2 digits and year. Productivity and markups are estimated through the Woolridge (2009) algorithm, corrected for financial capability. In column (1), we employ a full set of firm fixed effects to wipe out any unobserved heterogeneity at the firm level that can drive the results, as well as year

[19] A total of 14,139 firms in our data, i.e. 96% of the sample, have requested a bank loan.

fixed effects.[20] Results confirm that markups are positively correlated with productivity and that, even controlling for productivity, more financially capable firms display significantly higher markups as predicted by the theoretical framework. In column (2) we control for the possibility that some financial/price shock happening over time across some firms (and thus not picked up by our firm FE) might drive the results, introducing as an additional control a country-time change in collateral requirement as retrieved from the ECB Bank Lending Survey.[21] While the latter is negative and significant, our main results are confirmed.

Table 3: Test of Proposition 1

	(1) Within estimator	(2) Within estimator	(3) Between estimator	(4) OLS
	decile of sales, top 5% TA cutoff	decile of sales, top 5% TA cutoff	decile of sales, top 5% TA cutoff	decile of sales, top 5% TA cutoff
	all years	all years	all years	only 2008
Dependent variable	$\ln(\mu)_i$	$\ln(\mu)_i$	$\ln(\mu)_i$	$\ln(\mu)_i$
$\ln(TFP)_i$	1.547***	1.594***	1.363***	1.462***
	(0.0109)	(0.0139)	(0.0123)	(0.0191)
Financial capability$_i$	0.437***	0.484***	0.205***	0.280***
	(0.0189)	(0.0231)	(0.0237)	(0.0375)
Change in collateral requirement		-0.0152*	-0.173*	
		(0.00778)	(0.101)	
Obs.	53,698	35,525	32,149	4,548
R2	0.807	0.836	0.726	0.769
Number of marks	7,873	7,249	6,544	
Firm size and age controls	NO	NO	YES	YES
Firm FE	YES	YES	NO	NO
Country-Industry FE	NO	NO	YES	YES
Year FE	YES	YES	YES	NO
Robust SE	YES	YES	NO	YES

***,**,* = indicate significance at the 1, 5, and 10% level, respectively. The dependent variable is the (log of) markups estimated as in De Loecker and Warzynski (2012), using production function coefficients estimated as in Wooldridge (2009). The financial capability variable is computed across deciles of sales, with firms having the top 5% of TA considered as the cutoff firms. TFP is computed through a modified version of Wooldridge (2009), cleaning production function estimates for firm-level financial capability. Change in collateral requirements indicates the percentage increase/decrease in the collateral requirements by banks. All specifications estimated with robust standard errors.

Insofar we have identified the effects of productivity and financial capability through the

[20] In terms of our structural estimation, firm-level fixed effects subsume the parameters ωc_D and ϕ.

[21] The ECB Bank Lending Survey reports a large variation in collateral requirements by banks across euro area countries around the years 2008 and 2009: requirements tightened threefold on average in the euro area, but these effects have not been all similar across countries.

within variation in the data, thus implying that firms can adjust their allocation of tangible assets, productivity and, consequently, markups over time. If our theory is valid, however, our results should also hold when we identify through the between variation in the data.

In columns (3) and (4) we thus replicate our analysis reported in column (2) without firm fixed effects. We include a set of country*industry fixed effects to capture all possible spurious compositional effects beyond variation at the firm level. We also control for additional firms' characteristics that might be correlated with both productivity and financial capability, notably the (logarithm of) firm's age as well as firm size (employment), variables that are known to exert an impact on on TFP and financial constraints (see for example Hadlock and Pierce, 2010).[22] Specifically, in column (3) we keep the panel dimension through a between estimator, while in column (4) we focus on the cross-section for the year 2008. In both cases the coefficient of financial capability decreases by around a third with respect to the within-estimation, but remains positive and highly significant.

In Table (4) we proceed with some sensitivity and robustness checks, reporting the results of the estimated coefficients of the two key variables of our model, productivity and financial capability, in different specifications of the markup regression, while always controlling for firm fixed effects (unless differently specified). In a first battery of tests (1 to 5), we change the estimation procedure of $\theta(\tau)$. Namely, in row (1) we estimate the latter by shrinking the size ranges of firms' sales to quintiles, and widening the cutoff level threshold of tangible assets to the top 10% of firms in each NACE-2 digit industry and year. In row (2) we do the opposite, broadening the size ranges of firms within which we estimate $\theta(\tau)$ to twentiles, and narrowing the cutoff level of tangible assets to the top 1% of the distribution in each industry-year. In rows from (3) to (5) we replicate the three different estimation methods of our benchmark Table 3 (FE, BE and cross-section) with financial capability now measured within each NACE-3 digits industry and year, i.e. for a total of around 100 industries. The sign and significance of our key parameters is always confirmed, with little changes in magnitude with respect to our benchmark results.

In a second group of sensitivity checks (rows 6 to 8), we revert to our benchmark measures of financial capability and TFP used in Table 3, but we experiment with the methods through which markups have been estimated. This, in order to avoid picking up some spurious cor-

[22]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). Firm size is controlled as 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 employees to the size categories.

relation deriving from the markup estimation method itself. In row (6) we employ markups retrieved from production function coefficients estimated with the ACF (2015) method and corrected for financial capability; in row (7) we replicate the results with markups estimated from production function coefficients calculated through the standard Woolridge (2009) algorithm, i.e. not corrected for financial capability; in row (8) we repeat the exercise using standard ACF (2015) estimates, thus replicating the original De Loecker and Warzynski (2012) measure of markups. Once again the sign and significance of our key parameters is confirmed.

Table 4: Test of Proposition 1 - Sensitivity

	TFP		Financial Capability			
	Coeff	Std. Err.	Coeff	Std. Err.	Obs.	R2
Baseline	1.594***	(0.0139)	0.484***	(0.0231)	35,525	0.836
Different measures of Financial Capability						
(1) Quintile of sales, top 10% TA cutoff	1.587***	(0.0137)	0.390***	(0.0212)	35,525	0.835
(2) Twentiles of sales, top 1% TA cutoff	1.588***	(0.0138)	0.466***	(0.0256)	35,393	0.834
(3) Disaggregation at Nace 3 digits - FE	1.584***	(0.0142)	0.297***	(0.0190)	34,528	0.833
(4) Disaggregation at Nace 3 digits - BE	1.363***	(0.0123)	0.180***	(0.0198)	31,470	0.726
(5) Disaggregation at Nace 3 digits - Cross Section	1.450***	(0.0192)	0.223***	(0.0300)	4,459	0.769
Alternative estimates of Markups						
(6) Markups ACF (corrected)	0.707***	(0.00922)	0.458***	(0.0201)	40,034	0.645
(7) Markups Wooldridge (not corrected)	1.575***	(0.0137)	1.283***	(0.0260)	35,565	0.825
(8) Markups ACF (not corrected)	1.585***	(0.0129)	0.655***	(0.0231)	39,777	0.836
Omitted variables (Cross Section)						
(9) Number of Banks	1.459***	(0.0188)	0.296***	(0.0367)	4,500	0.777
(10) R&D Investments	1.461***	(0.0191)	0.281***	(0.0375)	4,548	0.770
(11) Exporter Status	1.459***	(0.0191)	0.284***	(0.0372)	4,548	0.771
(12) N. of Banks, R&D Inv., and Exporter	1.457***	(0.0188)	0.299***	(0.0365)	4,500	0.778

***,**,* = indicate significance at the 1, 5, and 10% level, respectively. The model specification follows column (2) of Table 3 (column (4) for the cross-section). All estimates with robust standard errors.

Finally, rows (9) to (12) of Table 4 present a number of robustness checks on the cross-section specification. The purpose is to assess whether our specification remains significant also when controlling for additional firm-level variables potentially correlated with both financial capability and markups. To that extent, we use three questions available in the Efige survey for the year 2008. A first question inquires on the number of banks used by the firm. The question is answered by almost the entire sample and shows an average of three banks per firm (two for the median firm). The intuition is that a firm better connected to a relatively high number of banks might have access to financial conditions that entail both a lower cost of collateral (thus a higher $\theta(\tau)$) and the possibility to charge relatively higher markups (as losses would be covered by an extension of the credit lines). In this case, the relation between financial capability and markups might be spuriously driven by this omitted variable. The second question we use relates to the R&D investments incurred by the firm. The idea is that a firm could exploit its higher financial cost advantage to invest in R&D and innovation, thus increasing either her physical productivity or the quality of her products. Both elements end up into a higher revenue TFP and higher markups, again generating a spurious correlation with financial capability. The third characteristic that we observe in the data and we control for in our cross-sectional estimates is whether a firm has been consistently exporting over time part of its production. De Loecker and Warzynski (2012) show that markups differ dramatically between exporters and non-exporters, being statistically higher for exporting firms; at the same time, exporting firms might be better able to raise collateral at cheaper costs. We control for each of these three characteristics in rows (9) to (11), respectively, while in row (12) we run our benchmark specification considering banks, R&D and export status together. Our main results remain unchanged.

4.2 Firm-level collateral requirements and average markups

Our second theoretical result points at the fact that a trade shock leads, on average, to pro-competitive effects of trade mediated by credit constraints, with larger collateral requirements leading *ceteris paribus* to lower reductions in average industry markups. To test this channel, we estimate our markup equation augmented with a trade shock measured at the country, industry and year level interacted with a proxy of firm specific collateral requirements β_i that we can structurally back out from the model.

We start from equation (8) describing the cost advantage of a firm with financial capability τ. With firm-specific collateral requirements β_i, the latter expression becomes

$$\theta(\tau, \beta) = \beta_i[\nu(1 - \eta(\tau))]$$

as we do not posit ex-ante a specific collateral requirement for the cutoff firm $(\widetilde{\tau}, c_D)$.[23] It then follows that our markup equation (14) incorporates an additional source of heterogeneity related to the firm-specific collateral requirement

$$\mu(c, \tau, \beta) = \frac{1}{2}\left[\omega c_D - c - \phi(\beta) + \theta(\tau, \beta)\right] \tag{22}$$

The latter can again be estimated in its structural form, with the residual now a function

[23]Banks might be unable to identify the cutoff firm, or might base their firm-specific collateral requirement decisions on financial variables unrelated to financial capability or productivity.

of the firm-specific collateral requirements. In particular, our proxy for β_i is derived as the normalized residuals of the estimation of the above equation, run separately for each industry and including both firm and year fixed effects to wipe out any unobserved characteristic otherwise affecting the estimation. Appendix C shows the low level of correlation of our proxy with other regressors of the model, notably financial capability and TFP. In Appendix D we perform a plausibility check, testing our firm-specific collateral requirements against other standard measures of credit constraints at the firm-level existing in the literature.

To measure the trade shock, we exploit the sudden, ample and symmetric trade collapse incurred by European countries during the credit crisis of 2008/09 (Baldwin, 2009). Starting from BACI trade data at the country-industry-year level, we create a dummy variable $T_{zjt} = 1$ if the yearly growth of a given zj trade flow in each country-industry pair in year t is in the bottom 25% of the overall growth rate distribution of trade flows.

Our theoretical model predicts on average a positive sign of the trade shock dummy in the augmented markup equation, as lower trade (higher trade shock) leads to higher markups. It also points at a negative sign of the firm-specific collateral requirement: with higher collateral requirements some firms would not be able to satisfy the liquidity constraint, as the repayment function $R(c)$ becomes larger. Hence, the least efficient firms in the market (in terms of production) would exit, generating a fall in the production cost cutoff c_D, and thus a reduction of markups. Finally, we should also observe a negative sign of the interaction between the trade shock and the collateral requirement, as Proposition 2 states that, on average across firms, the effect of the trade shock should be smaller the higher is the collateral requirement.

Table 5 reports the results of our estimation for the time window 2006-2009, i.e. around the trade shock of the end of 2008.[24] Since we are testing for an effect on the average industry markup across firms, the model is estimated as a pooled OLS. We add controls for the evolution of credit markets in a given country*year (share of bank credit/GDP and amount of Non-performing loans in the bank sector/GDP, as retrieved from Eurostat), industry and year fixed effects, as well as individual time-varying firms' characteristics (age and size). Moreover we always employ bootstrapped standard errors, as we use an estimated proxy for firm-specific collateral requirements.

In column (1), markups, TFP and financial capability are defined as in our benchmark specification. Results are in line with our prediction: on top of the standard sign and significance of TFP and financial capability, a negative trade shock leads to significantly higher

[24] We obtain similar results with the time window 2007-2010.

markups, while tighter firm-specific collateral requirements lower them. Most importantly, the interaction between the trade shock and the collateral requirement is negative and significant, in line with Proposition 2.

Table 5: Test of Proposition 2

	(1)	(2)	(3)	(4)	(5)
	decile of sales, top 5% TA cutoff	decile of sales, top 5% TA cutoff, Nace 3 digits	quintile of sales, top 10% TA cutoff	decile of sales, top 5% TA cutoff	decile of sales, top 5% TA cutoff
	Firm-specific CR	Firm-specific CR	Firm-specific CR	Firm-specific CR	CR above/below median
Dependent variable	ln(μ)i Wooldridge (correction)	ln(μ)i Wooldridge (correction)	ln(μ)i Wooldridge (correction)	ln(μ)i ACF (correction)	ln(μ)i Wooldridge (correction)
ln(TFP)i	1.362***	1.360***	1.361***	1.205***	1.366***
	(0.0137)	(0.0138)	(0.0132)	(0.0176)	(0.0132)
Financial capabilityi	0.222***	0.188***	0.209***	0.204***	0.224***
	(0.0278)	(0.0229)	(0.0252)	(0.0300)	(0.0287)
Collateral requirement (CR)i	-0.585***	-0.593***	-0.585***	-0.338***	-0.143***
	(0.0467)	(0.0503)	(0.0477)	(0.0552)	(0.0113)
Negative trade shock (NTS)	0.422***	0.415***	0.421***	0.518***	0.408***
	(0.0793)	(0.0870)	(0.0858)	(0.0897)	(0.0741)
CR*NTS	-0.192**	-0.168*	-0.195**	-0.443***	-0.114***
	(0.0947)	(0.101)	(0.0936)	(0.101)	(0.0279)
Obs.	13,126	12,853	13,126	12,466	13,126
R2	0.757	0.757	0.757	0.672	0.754
Number of marks	5,794	5,681	5,794	5,516	5,794
Firm size and age controls	YES	YES	YES	YES	YES
Country-Year controls	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Bootstrapped (1000) SE	YES	YES	YES	YES	YES

***,**,* = indicate significance at the 1, 5, and 10% level, respectively. The dependent variable is the log of markups estimated as in De Loecker and Warzynski (2012). Financial capability is computed by decile of sales, assuming firms having the top 5% of TA to be the cutoff firms in columns 1, 2, 3, 5, and 10% in column 4. TFP is computed through a modified version of Wooldridge (2009), cleaning production function estimates for firm-level financial capability in columns 1, 2, 3, 5, and a modified version of Ackerberg, Caves and Frazer (2015) in columns 4. The negative trade shock is a dummy=1 if the yearly growth of a given trade flow in a country*industry*year is in the bottom 25% of the overall growth rate distribution of trade flows. Collateral requirement is the variable β_i estimated from equation (22). All specifications are estimated with bootstrapped standard errors (1,000 reps).

In columns (2) to (5) we provide a number of robustness checks of this result. In column (2) we use the measure of financial capability estimated at the NACE-3 digits level. In column (3) financial capability is retrieved by shrinking the size ranges of firms' sales to quintiles, and widening the cutoff level threshold of tangible assets to the top 10% of firms in each NACE-2 digit industry and year. In column (4), we employ as dependent variable markups estimated through the ACF (2015) algorithm. Finally, in column (5) we use as a measure of firm-level collateral requirement a dummy taking value 1 if a firm is above the median estimated β_i. All our results hold.

5 Conclusions

In this paper we have introduced financial frictions in a framework of monopolistically competitive firms with endogenous markups and heterogeneous productivity. Before producing, firms need to obtain a loan necessary to cover part of production costs, for which they have to pledge collateral in the form of tangible fixed assets. In addition to productivity, firms are also heterogeneous in their financial capability: some firms have access to collateral at lower costs. As a result, both financial capability and collateral requirements enter together with productivity in the expression of the equilibrium firm-level markup.

Looking in particular at firm-level markups we find that, for a given level of collateral requirement, more financially capable firms do not transfer all the cost advantage they have in generating the required amount of collateral into lower prices, but rather retain relatively higher margins. The latter is an interesting finding, as it might explain part of the high variation of firm-level markups across a given level of productivity typically observed in the data. Moreover we also find that higher collateral requirements mitigate the pro-competitive effects (average lower markups) generally observed in standard models of trade and firm heterogeneity. Hence, our result support the view that the presence of financial frictions affects the strength of reallocation within an industry after a trade shock.

Our theoretical results are validated exploiting a representative sample of manufacturing firms surveyed across a subset of European countries during the financial crisis. Guided by theory, we estimate for each firm financial capability, TFP and markups. We then employ those estimates to structurally retrieve from the model a firm-specific measure of collateral requirements (a proxy of credit constraint) useful to test our main propositions.

The latter measure can be easily retrieved from balance sheet figures, and performs reasonably well if compared to other standard proxies of firm-level financial constraints existing in the literature. As such, capitalizing on the data already available to us, in future research we plan to extend its application to different instances in which financial frictions are likely to affect firm-level outcomes, in particular in terms of reallocation of economic activities.

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Appendix

A Existence and uniqueness of cost cutoff

Equation (17) sets the expected profits of a firm facing the choice of entering the market as:

$$\pi^e = \frac{Lk}{4\gamma c_M^k} \int_0^{c_D} \int_a^1 \left[\omega c_D - c - \phi + \theta(\tau)\right]^2 c^{k-1}\, d\tau\, dc = f_E$$

Solving the integral yields

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

with the terms A, B and C being respectively equal to:

$$A = (1-a)\left[\frac{1}{2+k} - \frac{2\omega}{1+k} + \frac{\omega^2}{k}\right]$$

$$B = \frac{2(\omega + k\omega - k)\left[(a-1)(\delta-1)^2(\phi(1+2\delta^2-2\delta)-\beta) + \beta(1+2\delta^2-2\delta)ln\left(\frac{\delta^2+a(\delta-1)^2}{1+2\delta^2-2\delta}\right)\right]}{k(1+k)(\delta-1)^2(1+2\delta^2-2\delta)}$$

$$C = \frac{1}{k}\frac{\beta^2(\delta-1)^4}{(1+2\delta^2-2\delta)^2}\left[\frac{(1-a)(1+a-2\delta(1+a)+(3+a)\delta^2)}{(\delta-1)^4(\delta^2+a(\delta-1)^2)} - \frac{2(1+2\delta^2-2\delta)ln\left(\frac{1+2\delta^2-2\delta}{\delta^2+a(\delta-1)^2}\right)}{(\delta-1)^6}\right] + \frac{\phi^2(1-a)}{k} + \frac{2\beta\phi ln\left(\frac{1+2\delta^2-2\delta}{\delta^2+a(\delta-1)^2}\right)}{k(\delta-1)^2} - \frac{2(1-a)\beta\phi}{k(1+2\delta^2-2\delta)}$$

Now define $f(c_D)$ as:

$$f(c_D) = \pi^e - f_E = A c_D^{k+2} + B c_D^{k+1} + C c_D^k - \frac{4 f_E \gamma c_M^k}{Lk}$$

By Rolle's Theorem, between two solutions of $f(c_D) = 0$ there is always a solution of $f'(c_D)$. Hence, if $f'(c_D) = 0$ at least two positive values of the cost cutoff exist. Moreover, as long as the second positive cost cutoff is $> c_M$, the latter also implies the uniqueness of c_D.
By taking the first derivative of $f(c_D)$ we obtain

$$f'(c_D) = (k+2)A c_D^{k+1} + (k+1)B c_D^k + kC c_D^{k-1}$$

where $A > 0$ and $C > 0$ always, while $B < 0$. Hence, by Cartesio's Rule, $f'(c_D) = 0$ has at least two positive solutions, i.e. there is a solution to $f(c_D) = 0$.

B Derivative of cost cutoff with respect to L

By applying Dini's implicit function theorem, we obtain:

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

The derivative of the expected profit function with respect to L (the numerator of the above expression) is equal to:

$$\frac{\partial \pi^e(L, c_D(L))}{\partial L} = \frac{k c_D^k}{4\gamma c_M^k}(A c_D^2 + B c_D + C) > 0$$

with A, B and C having been defined in Appendix A. The denominator is instead equal to:

$$\frac{\partial \pi^e(L, c_D(\beta))}{\partial c_D} = \frac{L k c_D^{k-1}}{4\gamma c_M^k}[(k+2)A c_D^2 + (k+1)B c_D + kC] > 0$$

Hence, we have that:

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

Looking at how collateral requirements affect the above derivative, i.e. how changes in β affect the terms B and C, we have that a higher β will translate *ceteris paribus* into a lower value of $\frac{\partial c_D}{\partial L}$ for a very broad range of our exogenous parameters.

C Descriptive statistics

Table 6 reports descriptive statistics for the year 2008, i.e. the year referred to in the questions related to financial capability and investment in R&D. Table 7 reports instead the correlations among our retrieved right-hand side variables, namely financial capability $\theta(\tau)$, total factor productivity (estimated with the Wooldridge, 2009 algorithm), both in the standard format and including a correction for financial capability, our firm-level proxy of credit constraints β_i, as well as labor productivity (value added per employee) as robustness.

Table 6: Descriptive statistics

	Obs.	Mean	Std. Dev.	Min	Max
Tangible Fixed Assets (2008)	12035	1903	4582.88	1,002	50204
Sales (2008)	10554	10986	24694.42	194	250214
Employees (2008)	9583	66	113.94	10	1062
Number of Banks	14571	2.99	2.02	1	14
Investments in R&D	14759	59.90%	0.49	0	1

Table 7: Correlations of right-hand side variables

	Cost advantage $\theta(\tau)$	TFP Wooldridge not corrected	TFP Wooldridge corrected	Firm-level collateral requirement β_i	Value added per employee	Total asset
Cost advantage $\theta(\tau)$	1					
TFP Wooldridge not corrected	0.0316	1				
TFP Wooldridge corrected	-0.0651	0.4674	1			
Firm-level collateral requirement β_i	-0.0086	-0.0001	0.013	1		
Value added per employee	0.0307	0.3215	0.265	-0.0464	1	
Total asset	-0.2342	0.1099	0.1488	-0.0191	0.2871	1

D Firm-level collateral requirement

In this section we offer a plausibility check for our firm-level measure of collateral requirement. Since the literature has not reached an agreement on this topic yet (Farre-Mensa and Ljungqvist, 2016), we correlate our measure to a well-known proxy of firm-level financial constraints as derived from balance sheet data existing in the literature. Specifically, we use a firm-specific index of financial constraints developed by Whited and Wu (2006) and comprising information on firm-level cash-flow, dividends, long-term debt, firm sales and industry sales and their growth and total assets. The original index was estimated with a GMM estimation using firm-level data from quarterly COMPUSTAT data over the period 1975 to 2001. The higher the index, the more difficult (or costly) is for a firm to obtain external financing, thus in line with the interpretation of our β_i.

The WW measure retrieved from our balance sheet data is positively and significantly correlated with our estimated proxy of firm-level collateral requirements. Moreover, replicating the Whited and Wu (2006) original equation using our estimated firm-level collateral requirements as dependent variables yields similar results in terms of sign and significance of the right-hand side variables, as reported in the Table below.

Table 8: Replication of Whited and Wu (2006) with β_i

Dependent variable	Firm-level collateral requirement
Cash flow / Total assets	-0.329***
	(0.0196)
Payment of dividends	-0.0194***
	(0.00286)
Long term debt / Total assets	-0.0139
	(0.0135)
ln(Total assets)	-0.122***
	(0.00600)
Industry sales growth	0.0900***
	(0.0205)
Firm sales growth	-0.0841***
	(0.00491)
Obs.	45,256
R2	0.094
Number of marks	6,971
Firm FE	YES
Year FE	YES
Robust SE	YES

Note: The specification of the original Whited and Wu (2006) index is reported below:

$$WW = -.091CF/TA - .062DivPos + .021LTD/TA - .044ln(TA) + .102ISG - .035SG$$

where CF is Cash Flow/Total Assets, DivPos=1 if paid cash dividends, LTD/TA is long term Debt/Total Assets, TA is Total Assets, ISG is the industry sales growth while SG is a firms sales growth.