The competitive effects of credit constraints in the global economy - Theory and structural estimation ‡

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Abstract

This paper studies the consequences of credit constraints for price setting, endogenous markups, and welfare in open economies. We use a model of heterogeneous firms which engage in Cournot competition and face a variable demand elasticity to formulate hypotheses with regard to the impact of credit constraints for the aforementioned outcomes. A structural stochastic version of the model is calibrated and estimated on data of 261,717 manufacturing firms in 12 European countries and 20 NACE 2-digit industries. We thereby obtain a parameter that indicates the effect of credit constraints on the industry's cost cutoff. Based on these estimates, we run a counterfactual experiment of abolishing credit constraints in all countries and industries. The estimated responses of prices, markups and product variety have countervailing effects for welfare. In sum, credit constraints have negligible welfare implications in our model.

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1 Introduction

Firms usually need to finance their operations at least to some extent externally. Among the many options, bank loans are one of the most prominent sources in many countries (Mishkin and Eakins, 2009). It is thus obvious that firm- and industry-specific outcomes are crucially determined by the credit conditions banks can offer.[1] These financing conditions, in turn, depend on institutional characteristics such as the efficiency of the banking system and also on firm-level variables such as collateral, the amount of demanded credit, or the predicted amortization time of investments.

There is a fairly large literature on financial constraints in the context of international trade. That literature hypothesizes and provides evidence for effects of financial constraints and financial market development on the structure of trade through comparative advantage (Kletzer and Bardhan, 1987; Baldwin, 1989; Egger and Keuschnigg, 2010), on trade volume (Beck, 2002; Chaney, 2005; Manova, 2008, 2011), and on international capital flows (Matsuyama, 2005; Antràs and Caballero, 2009; Ju and Wei, 2008). Yet, the implications of financial constraints for product market competition in the open economy received less attention. The present paper aims at filling this gap. We first use a model with heterogeneous firms to shed light on the role of credit constraints for product prices, endogenous markups, and welfare in closed and open economies.[2] In a second step, we quantify the theoretical hypotheses by calibrating and estimating a structural stochastic version of the open-economy model on firm-level data in 12 European countries and 20 manufacturing industries.

Credit constraints emerge from an interplay of collateral assets, the share of costs that have to be financed externally, and the development of financial markets affecting the probability of repayment. This approach closely follows Manova (2011) leading to country-industry specific measures of credit constraints. Although simple, the model captures the stylized fact that the least-productive firms are denied access to external finance and thus

[1]The recent financial crisis exerted a key impact on the real economy through changing credit conditions to firms – not only exporters (see Ahn, Amiti, and Weinstein, 2012; Amiti andWeinstein, 2012) but all types of businesses (see Hosono, 2009). Wong (2000) provides a discussion on and a theoretical analysis of the financial crisis in Korea in 1997.

[2]Peters and Schnitzer (2010) study the role of financial constraints in a model with variable markups for technological progress.

have to exit the market if credit constraints tighten.[3] We show that an increase in credit constraints leads to higher price-cost markups and fewer firms whereas average prices may rise or fall. This ambiguity roots in two countervailing effects: (i) The *competition effect* as fewer competitors allow each firm to exploit their increased market power to set higher prices, and (ii) the *productivity effect* as the more productive companies – those that charge lower prices on average – remain in the market. Thus, the welfare-reducing effects of credit constraints through less product variety (fewer firms) may be counteracted by a strong competition effect (lower prices).

The theoretical framework allows us to quantify credit constraints and their impact on firm-level and industry-level variables. We utilize cross-section data on sales, costs, and external finance for altogether 261,717 firms in 12 European countries and 20 manufacturing industries together with institutional data for those countries to estimate fundamental parameters of the model and calibrate it to the data. In particular, the data set allows us to estimate domestic cost-cutoff levels for each country and industry and other fundamental parameters and variables needed for comparative static analysis. We then use the model to shed light on the quantitative importance of financial constraints in Europe, not only for sales, exports, and markups, but also for firm entry and welfare.

We use the parameter estimates to simulate a counterfactual scenario where credit constraints are abolished. We find that the movement to a world without financial frictions reduces average productivity by 2.48% and price-cost markups by 5.70%. Firm entry is predicted to rise by 5.22% while average prices increase by about one percent. The latter finding indicates that the productivity effect dominates the price movement (due to entry of less-productive firms). In sum, this leads to negligible welfare effects close to zero.

The paper is organized as follows. The next section introduces the building blocks of the model. Section 3 discusses the effects of credit constraints in the closed economy, before we extend the analysis to the open economy in section 4. In section 5, we describe the data and estimation strategy to identify fundamental model parameters. These results are crucial ingredients for the counterfactual analysis in section 6. The last section offers concluding remarks.

[3]This implication is also present in the seminal model by Holmstrom and Tirole (1997) which builds on moral hazard and differences in asset endowments rather than productivities.

2 Model setup

To address the role of credit constraints for price-cost margins, we build our analysis on the heterogeneous-firms model of Melitz and Ottaviano (2008). In contrast to a CES-specification, a larger number of competing firms leads to a higher price elasticity of demand and thus lower markups in that model.

2.1 Households

Consider an economy that is populated by L consumers whose preferences are described by the following utility function

$$U = q_0^c + \alpha \int_{v \in V} q^c(v) dv - \frac{1}{2}\gamma \int_{v \in V} q^c(v)^2 dv - \frac{1}{2}\eta \left(\int_{v \in V} q^c(v) dv \right)^2. \tag{1}$$

The demanded quantities of the numéraire good and each variety v of the composite good are denoted by q_0^c and $q^c(v)$, respectively. Furthermore, (1) features a love of variety as long as $\gamma > 0$. A higher level of α and a lower level of η imply a stronger preference for the composite good compared to the numéraire. Assuming that the numéraire good is always consumed, (1) delivers the demand function for variety v

$$q(v) \equiv Lq^c(v) = \frac{\alpha L}{\eta N + \gamma} - \frac{L}{\gamma} p(v) + \frac{\eta N}{\eta N + \gamma} \frac{L}{\gamma} \bar{p}, \qquad \forall v \in V^*, \tag{2}$$

where N measures the number of consumed varieties with $\bar{p} = (1/N) \int_{v \in V^*} p(v) dv$ as their average price. As N is endogenously determined in this model, V^* is the largest subset of varieties that satisfies

$$p(v) \leq \frac{\gamma \alpha + \eta N \bar{p}}{\eta N + \gamma} \equiv p_{max}. \tag{3}$$

According to (3), a larger number of competing varieties reduces the maximum willingness to pay for variety v and increases the price elasticity of demand $\epsilon(v) = [(p_{max}/p(v)) - 1]^{-1}$. Hence, the preference specification (1) implies pro-competitive effects of larger markets which are absent from a Dixit-Stiglitz framework with a large number of firms and a constant elasticity of demand.[4]

[4] See Zhelobodko, Kokovin, Parenti and Thisse (2011) for a rigorous treatment of monopolistic competition models with large numbers of firms in a broad set of elasticity-of-demand contexts.

2.2 Firms

Turning to the production side of the economy, each consumer inelastically supplies one unit of labor in a perfectly-competitive labor market so that the number of both consumers and workers can be denoted by L. There are no frictions in the production of the homogeneous good and we assume one unit of labor to produce one unit of q_0. In the absence of fixed costs, this establishes a perfectly competitive environment where firms make zero profits. Setting the price of the homogeneous good to unity and assuming diversification of production, wages are pinned down to unity.

Entry in the differentiated goods sector requires an upfront investment f_e units of labor to learn about the firm-specific productivity level $1/c$. The parameter c denotes the unit labor input requirement that companies draw from a common and known distribution function $G(c)$. There are no per-period fixed production costs. To simplify the analysis and to obtain closed-form solutions, we follow the empirical literature on heterogeneous firms in assuming productivity and cost draws to follow a Pareto distribution $G(c) = c^k$ with $c \in [0, 1]$ and $k \geq 1$.[5] The shape parameter k provides information about the degree of firm heterogeneity. If $k = 1$, c is distributed uniformly. At higher levels of k, high-cost draws become more likely.

2.3 Credit constraint

Manufacturing firms are liquidity constrained and need to finance a share σ of their input costs through loans from a perfectly competitive banking sector.[6] The idea is that some bills have to be paid before the firm generates revenues from sales. As Rajan and Zingales (1998) have argued, the degree of external financial dependence is likely to be driven by technology as, for instance, the gestation and harvesting periods of projects vary.

In modeling credit constraints, we closely follow Manova (2011). Firms make a take-it-or-leave-it offer to a potential investor clarifying the amount to be borrowed, $\sigma c q(c)$, the repayment $R(c)$ and the share of the investment the creditor can use as collateral, β.

[5] We have set the scale parameter to unity without loss of generality. This implies that the highest unit cost c firms can draw is fixed at this level.

[6] Recent empirical work on credit constraints documents that deals between firms entail significant advance financing and a risk of contract repudiation (see Jindrichovska and Körner, 2008, in general; and Amiti and Weinstein, 2012, for exporters).

For the sake of simplicity, the amount of collateral can be expressed in relation to a firm's financial needs $\sigma cq(c)$. This captures the stylized fact that larger firms (those that have to finance a larger total cost of inputs) usually request a larger volume of credit and also tend to have more collateral to offer in absolute terms than smaller firms. Note that we have introduced the convenient notation of expressing firm-level variables in terms of c as these variables only differ in unit input requirements.

Bringing these ingredients together leads to the *participation constraint* of an investor,

$$-\sigma cq(c) + \lambda R(c) + \beta (1 - \lambda) \sigma cq(c) \geq 0, \tag{PC}$$

where λ denotes the probability of repayment and the outside option is normalized to zero. A lender would not grant a loan if she expected losses from the deal. Thus, the sum of expected repayment and expected collateral claim must not fall short of the credit volume.[7] Due to perfect competition among investors, every firm negotiates a repayment such that (PC) holds with equality. Rearranging (PC) yields

$$R(c) = \frac{1}{\lambda} [1 - \beta (1 - \lambda)] \sigma cq(c). \tag{4}$$

Further, every creditor is only willing to provide external finance to those firms that are able to repay in case the financial contract is enforced. This leads to the *liquidity constraint*

$$p(c)q(c) - (1 - \sigma)cq(c) \geq R(c), \tag{LC}$$

where the left-hand side denotes the net revenues of the firm. As external funds are more costly than internal funds, the firm that earns zero profits in the absence of credit constraints would now be unable to service the debt and hence it would be denied access to external funding and exit.

3 Autarky

Before we study the open-economy version of the model, we want to build intuition by analyzing the equilibrium in autarky. Firms in the manufacturing sector maximize expected profits

$$\pi(c) = p(c)q(c) - (1 - \sigma) cq(c) - \lambda R(c) - (1 - \lambda) \beta \sigma cq(c) \tag{5}$$

[7] Specifying the credit constraint purely in terms of variable costs can be interpreted as the long-run perspective (where fixed costs are also variable).

subject to demand (2), the participation constraint (PC) and the liquidity constraint (LC). Combining the participation constraint with the profit equation delivers the same first-order condition as in Melitz-Ottaviano (2008), namely

$$q(c) = \frac{L}{\gamma}\left[p(c) - c\right].$$

This implies that profit-maximizing quantities and prices are unaffected by credit constraints. However, credit constraints do play a role in the model. Instead of the zero-profit condition we need to apply the liquidity constraint (LC) to identify the marginal firm and thus the cost cutoff c_d.[8] As argued above, external funds are more expensive than internal funds such that the marginal firm in the unconstrained model would no longer be able to cover the repayment from its net revenues. Applying (LC) yields $p(c_d) = p_{max} = \theta c_d$, where θ measures the degree of credit constraints as a constant markup over production costs. It is given by

$$\theta \equiv 1 + \sigma\left[\frac{1-(1-\lambda)\beta}{\lambda} - 1\right] \geq 1. \tag{6}$$

Note that $\theta > 1$ whenever $\lambda < 1$. Further, it is immediate from (6) that a lower share of collateralizable investment, β, a lower cash flow to finance inputs internally as is captured by a higher degree of external dependence, σ, and a lower probability of repayment, λ, each increase the degree of credit constraints. Model solutions at $\theta = 1$ (i.e., in the absence of finance constraints) can be used as a benchmark to compare model solutions at estimated values of θ for assessing the consequences of credit constraints.

To study price-cost markups, we rely on the well-known Lerner Index which is given by $LI(c) = [p(c) - c]/p(c)$. Based on the insights above, we can express firm-level prices and markups as functions of the cost cutoff c_d, the firm-specific cost level c, and the financial constraint parameter θ:

$$p(c) = \frac{1}{2}\left(\theta c_d + c\right)$$

$$LI(c) = \frac{p(c) - c}{p(c)} = \frac{\theta c_d - c}{\theta c_d + c}.$$

To study the role of credit constraints, we need to solve the free-entry condition

$$\int_0^{c_d} \pi(c)dG(c) = \frac{L}{4\gamma}\int_0^{c_d}\left(\theta c_d - c\right)^2 dG(c) = f_e \tag{FEC}$$

[8]We assume that the cost cutoff is strictly smaller than one so that there are always firms that exit after participating in the productivity draw.

for the cost cutoff c_d. Taking advantage of the Pareto parametrization of technology, we obtain

$$c_d = \left[\frac{2(k+1)(k+2)\gamma f_e}{L\kappa}\right]^{1/(k+2)}, \tag{7}$$

where $\kappa = 0.5[(k+1)(k+2)\theta^2 - 2k(k+2)\theta + k(k+1)] > 1$ whenever $\theta > 1$. In the absence of credit constraints (i.e. $\theta = 1$), the model collapses to Melitz-Ottaviano (2008). Finally, we obtain the number of active firms from the price threshold (3),

$$N = \frac{2\gamma}{\eta}\frac{k\theta + \theta}{k\theta + \theta - k}\frac{\alpha - \theta c_d}{\theta c_d}. \tag{8}$$

The number of entrants is given by $N_e = N/G(c_d)$.

It is straightforward to show that a tougher credit constraint (a higher value of θ) reduces both the cost cutoff (c_d) and the number of competing firms (N).[9] Intuitively, an increase in θ leads to a higher required repayment $R(c)$ that only the more productive firms are able to guarantee. Hence, some of the least-productive companies are denied external finance although they would be profitable in the absence of financial frictions. With fewer firms surviving, each company receives a larger market share and exploits the gain in market power by setting higher prices and markups. This also implies higher revenues and profits for each company.

It is also of interest to analyze the role of credit constraints for industry averages of firm-level variables. In general, the average of performance measure $z(c)$ is given by $\bar{z} = \left[\int_0^{c_d} z(c)dG(c)\right]/G(c_d)$. Prices and markups are then given by

$$\bar{p} = \frac{(k+1)\theta + k}{2(k+1)}c_d$$

$$\bar{LI} = \frac{(k+1)\theta - k}{(k+1)\theta + k}.$$

Knowing the response of firm-level measures does not allow us to infer statements about industry averages because entry and exit alters the composition of firms. On the one hand, each firm raises prices as a response to an increase in credit constraints. This behavior roots in less competition because fewer firms are able to secure external finance. We thus refer to this channel as the *competition effect.* On the other hand, with the least-productive companies being pushed out of the market, average prices tend to decrease as high-productive firms charge lower prices. We refer to this channel as the *productivity*

[9] Appendix A summarizes all derivation details for the autarky version of the model.

effect. In sum, there are two countervailing effects. It turns out that the impact of θ for average prices is generally ambiguous and crucially depends on the relative prevalence of high-cost firms (indicated by a high value of the distributional shape parameter k). With many unproductive firms, a tightening of credit constraints precludes many firms from entering the market rendering the competition effect strong. Hence, a more unequal distribution of firm productivity tends to imply higher average prices when access to external funds becomes more costly. Despite this ambiguity, the average Lerner Index clearly increases in θ.

Let us finally discuss the role of credit constraints for welfare which we measure in terms of indirect utility:

$$W = 1 + \frac{1}{2\eta}(\alpha - \theta c_d)\left(\alpha - \frac{(k+1)(k+2)\theta + k(k+2) - \frac{k}{k\theta+\theta-k}}{2(k+1)(k+2)} c_d\right). \tag{9}$$

We know from Melitz-Ottaviano (2008) that welfare is decreasing in average prices and increasing in the number of firms (i.e. products due to love-of-variety) and the variance of prices. The latter is true as more variance allows each household to reallocate expenditures to products that are available at a lower price. Summarizing our results from above, we can conclude that there are positive and negative effects of credit constraints on welfare. On the one hand, tighter credit constraints reduce welfare as fewer firms operate and price variation declines. On the other hand, there might be a positive impact on welfare if the *productivity effect* dominates the average price movement. Hence, credit constraints may lead to a rise in welfare.

4 Open economy

Now consider two countries, labeled ℓ and ℓ^*, that may differ in size (as measured by labor endowments) and credit constraints. Both economies interact by trading both commodities. While the numéraire good can be transported at zero cost, firms have to ship $\tau > 1$ units of a manufactured variety to make sure that one unit arrives abroad. Provided that production is diversified in both countries and each produces one unit of the numéraire good with one unit of labor, wages are equated at unity in both locations. With identical preferences, we obtain the price threshold for country ℓ as

$$p^{\ell}_{max} = \frac{\alpha\gamma + \eta N^{\ell}\bar{p}^{\ell}}{\eta N^{\ell} + \gamma}, \tag{3'}$$

where N^ℓ summarizes both domestic sellers in country ℓ and exporters to country ℓ. Similarly, $\bar{p}^\ell$ denotes the average price of a manufactured variety in country ℓ including domestic and imported goods.

Denoting export variables with subscript x and domestic variables with subscript d, $p_x^\ell(c)$ and $p_d^\ell(c)$ are the prices of a firm in country ℓ with input coefficient c for the export and domestic market, respectively. Firms maximize profits for each market independently so that a firm would only export if sales to that market imply non-negative profits. The cost cutoffs for the domestic and export market thus have to satisfy $c_d^\ell = p_{max}^\ell/\theta^\ell$ and $c_x^\ell = p_{max}^{\ell^*}/\left(\theta^\ell\tau\right)$. Hence, we can link the export cutoff in ℓ with the domestic cutoff in ℓ^* according to $c_x^\ell = \left(\theta^{\ell^*}c_d^{\ell^*}\right)/\left(\theta^\ell\tau\right)$. Following a similar procedure as in the previous section, we express all firm-specific variables as functions of the cutoffs c_d^ℓ, c_x^ℓ and country-industry-specific credit constraints.

To derive the cost cutoff in the open economy, we need to combine the free-entry conditions of both countries, accounting for profits earned domestically and from exporting,

$$\pi_d^\ell(c) = \frac{L^\ell}{4\gamma}\left(\theta^\ell c_d^\ell - c\right)^2, \qquad \pi_x^\ell(c) = \frac{L^{\ell^*}}{4\gamma}\left(\tau\right)^2\left(\theta^\ell c_x^\ell - c\right)^2.$$

Plugging these expressions into the free-entry conditions

$$\int_0^{c_d^\ell}\pi_d^\ell(c)dG(c) + \int_0^{c_x^\ell}\pi_x^\ell(c)dG(c) = f_e, \qquad (FEC')$$

and substituting the export cutoff by the respective domestic cutoff delivers the domestic open-economy cost cutoff for country ℓ

$$c_d^\ell = \left[\frac{2(k+1)(k+2)\gamma f_e^\ell}{L^\ell\kappa^\ell}\frac{1-\tau^{-k}\frac{\kappa^\ell}{\kappa^{\ell^*}}\left(\frac{\theta^{\ell^*}}{\theta^\ell}\right)^{k+2}}{1-\tau^{-2k}}\right]^{1/(k+2)}. \qquad (7')$$

To ensure a positive cutoff level in both countries we assume that the numerator of the second fraction in (7′) is strictly positive.[10] Hence, at higher levels of trade costs, firms in either country may be relatively more credit constrained without being entirely pushed out of the market by foreign competitors.[11]

[10]The formal conditions for this are $\tau^{-k}\frac{\kappa^\ell}{\kappa^{\ell^*}}\left(\frac{\theta^{\ell^*}}{\theta^\ell}\right)^{k+2} < 1$ for country ℓ and $\tau^{-k}\frac{\kappa^{\ell^*}}{\kappa^\ell}\left(\frac{\theta^\ell}{\theta^{\ell^*}}\right)^{k+2} < 1$ for country ℓ^*.

[11]Together with the condition that households have positive demand for manufactured goods, these conditions ensure diversification of production.

To solve for the equilibrium number of operating firms in country ℓ, it is essential to compute the average price $\bar{p}^{\ell}$ reflecting both prices for domestic and imported goods. Since the effective costs (including trade costs) for domestic firms and foreign exporting firms selling to consumers in the same country follow the same Pareto distribution, we know that the price distributions must be identical across countries.[12] Hence, the export price distribution of country ℓ^* is identical to the domestic price distribution of firms in country ℓ and we have $\bar{p}^{\ell} = \{[(k+1)\theta + k]/(2k+2)\}c_d^{\ell}$. Together with the price bound p_{max}^{ℓ} from (3′) and similar expressions for country ℓ^*, the number of active firms, that is domestic producers and foreign exporters, in country ℓ is the open-economy counterpart to (8), given by

$$N^{\ell} = \frac{2\gamma}{\eta}\frac{k\theta^{\ell} + \theta^{\ell}}{k\theta^{\ell} + \theta^{\ell} - k}\frac{\alpha - \theta^{\ell}c_d^{\ell}}{\theta^{\ell}c_d^{\ell}}. \tag{8′}$$

Now, we can straightforwardly derive the number of entrants in country ℓ, $N_e^{\ell} = N^{\ell}/G\left(c_d^{\ell}\right)$, the number of domestic firms, $N_d^{\ell} = N_e^{\ell}\left(c_d^{\ell}\right)^k$, and the number of exporters, $N_x^{\ell} = N_e^{\ell}\left(c_x^{\ell}\right)^k$.

To obtain prices and Lerner Indices for the domestic and the export market, respectively, we simply have to substitute the open-economy cost cutoffs c_d^{ℓ} and c_x^{ℓ} in the closed-economy formulas and account for trade costs. For the sake of brevity, we report these expressions in Appendix B and dedicate more attention to interpreting the role of credit constraints in the open economy. Similarly to autarky, an increase in θ reduces the cost cutoff implying that the least-productive companies exit and the number of operating firms drops.[13] With regard to the pricing behavior, firms increase domestic prices, but reduce export prices when confronted with tighter credit constraints. Similarly to autarky, the effect on average prices is ambiguous and subject to the same two countervailing effects, the *competition effect* and the *productivity effect*. However, the average price for exports unambiguously declines in θ. Intuitively, as more domestic exporters are denied external finance to produce for the export market, foreign firms enter their domestic market and increase local competition. As a consequence, the remaining exporters reduce their prices to reach consumers.

Taking a look at the Lerner Index, firms choose a higher markup as a response to tighter credit constraints at home, but a lower one if foreign credit frictions increase. Again, these

[12]Note that any truncation of a Pareto distribution from above delivers the same distribution with shape parameter k again.

[13]We report comparative static results in Appendix B.

effects are driven by endogenous firm entry and exit affecting the degree of competition (in opposite directions) in each market. We conclude our analysis by highlighting that responses of average prices and Lerner Indices as well as welfare in the open economy are qualitatively identical to the ones in autarky. In the sequel of the paper, we (i) derive a model-based estimate of credit constraints and (ii) quantify the effects of these frictions for key industry variables like productivity, prices, or markups.

5 Structural estimation and model calibration

To estimate fundamental parameters, we use a structural stochastic version of the open-economy version of the above model. We employ firm-level data in manufacturing from Bureau van Dijk's *Amadeus Database.* This data-set provides information on balance sheet data of firms in more than 30 European countries. However, the sample coverage varies significantly across economies. While this may be less important for some studies, it may entail a problem for empirical work which aims at estimating features of a country's or a country-and-industry's distribution of firms. In the interest of a good representation of firms by country *and* industry, we base our analysis on only 12 European countries for which the representation of the population of firms appears acceptable.[14] In order to eliminate the role of data errors and outliers, we focus on averaged data for the period 1999-2007. In sum, we employ data of 261,717 firms in 20 NACE 2-digit manufacturing industries. For convenience, we will use superscript $\ell = 1, ..., 12$ to denote countries and subscript $j = 1, ..., 20$ to denote NACE 2-digit industries in what follows.

In particular, we employ two equations of the theoretical model to estimate the parameters. First, we use the cost cutoff equation ($7'$) to obtain the shape parameter of the distribution function, k_j, the love-of-variety measure γ_j, and the probability that firms repay their loans, λ_j. Second, we employ the equation for the number of active domestic firms in the local market, $N_d^\ell = N_e^\ell (c_d^\ell)^k$, to estimate the demand parameters α_j and η_j. These parameters are necessary to calculate the comparative-static effects of changes in

[14]These countries are Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Poland, Portugal, Slovak Republic, Spain, and Sweden. Notice that the sample of German firms appears to be the least representative among the considered ones due to an over-representation of large firms in the economy. However, it will turn out that the estimated parameters do not appear very sensitive to this so that we will ignore this issue subsequently.

credit constraints on the number of firms and welfare.

5.1 Measurement and descriptive statistics

Before going into the details of the estimation strategy, let us briefly describe the measurement of the key variables underlying the analysis. First of all, we need a measure for the domestic cost cutoff by country and industry, representing the dependent variable of the stochastic counterpart to the cost cutoff equation ($7'$). We define variable costs as the costs of employees plus material costs. These make up the lion's share of a company's variable cost positions. Relating these expenses to firm-level sales delivers a measure for the cost share based upon which we may identify the least productive firms per country and industry. According to the model, the lowest-cost firms charge the highest markups and should therefore have the lowest cost shares.

Further, we need measures of collateral, β_j^ℓ, and external financial dependence, σ_j^ℓ. We proxy β_j^ℓ by the share of tangible assets in production costs and σ_j^ℓ by the value of current liabilities relative to production costs for each firm in the sample. Such measures had been used by Almeida and Campello (2007) or Guariglia (2008), and they have been found to be robustly related to financial constraints (see Guariglia, Tsoukalas, and Tsoukas, 2010). In line with theory, we impose identical finance constraints, as measured by θ, on each firm per country-industry pair. We thus compute the median values of collateral and external financial dependence.

Population is measured in millions and taken from the World Bank's World Development Indicators 2010. Trade costs are estimated from average aggregate bilateral trade data for the countries and years covered. The annual bilateral export source data come from the United Nations' Comtrade Database. We obtain estimated log bilateral trade costs as the average of log bilateral exports minus exporter-year and importer-year fixed effects across all years. Moreover, we assume that trade costs are identical for all industries and symmetric such that $\tau^\ell = \tau^{\ell^*}$. Finally, we use private credit by deposit money banks relative to GDP as a proxy for institutional quality or financial contractibility. As argued by Manova (2011), this measure determines the probability of repayment, λ. We take this variable from the World Bank's Financial Structure Dataset (see Beck and Demirgüç-Kunt, 2009).

We will estimate the key parameters as averages by country and/or NACE 2-digit

Table 1: Descriptive statistics

Panel A: Firm averages by country

Country	Firms N_d^ℓ	Sales $\bar{r}^\ell$	Costs $\bar{c}^\ell \bar{q}^\ell$	Collateral β^ℓ	Fin. depend. σ^ℓ
Belgium	1,579	47,130	35,578	0.178	0.399
Czech Republic	2,478	12,626	8,899	0.280	0.331
Germany	10,658	53,731	41,134	0.128	0.146
Finland	6,680	8,427	6,463	0.233	0.253
France	59,214	10,803	7,440	0.123	0.446
Hungary	907	6,568	5,529	0.275	0.292
Italy	74,648	9,447	6,717	0.166	0.620
Poland	5,707	8,801	6,479	0.207	0.293
Portugal	12,418	2,278	1,539	0.243	0.529
Slovak Republic	504	5,684	3,957	0.279	0.368
Spain	71,848	4,899	3,773	0.187	0.420
Sweden	15,076	3,015	2,041	0.181	0.318
Unweighted average	21,810	9,648	6,998	0.170	0.463

Panel B: Firm averages by industry

Industry	Firms N_{dj}	Sales $\bar{r}_j$	Costs $\bar{c}_j \bar{q}_j$	Collateral β_j	Fin. depend. σ_j
Food & beverages	31,335	10,946	8,005	0.220	0.371
Textiles	10,113	5,867	3,936	0.179	0.515
Apparel	9,314	5,685	3,614	0.113	0.487
Leather	6,738	4,024	2,789	0.106	0.496
Wood	14,551	3,774	2,794	0.182	0.445
Pulp & paper	4,157	14,814	10,364	0.211	0.470
Publishing & printing	15,076	2,917	1,918	0.208	0.480
Chemicals	7,871	47,223	31,720	0.178	0.471
Rubber & plastic	13,055	10,564	7,679	0.212	0.459
Other non-metallic	13,481	6,971	4,631	0.239	0.508
Basic metals	4,347	35,585	27,105	0.198	0.452
Metal products	53,743	3,920	2,798	0.177	0.477
Machinery	32,675	9,333	6,920	0.114	0.481
Office machinery & computers	1,246	9,820	8,062	0.060	0.437
Electrical machinery	8,493	12,342	9,311	0.103	0.473
Radio & television	2,910	22,202	16,118	0.092	0.465
Instruments	6,986	6,887	4,783	0.112	0.424
Motor vehicles	4,107	70,154	57,144	0.149	0.417
Other transport	2,790	7,927	5,736	0.118	0.467
Furniture	18,711	3,638	2,612	0.149	0.476
Unweighted average	13,086	9,648	6,998	0.170	0.463

Notes: Sales and production costs are sample means and measured in thousands of Euros, while collateral and financial dependence refer to the median firm.

industry. Of course, variation of fundamental variables across country-industry cells and parameter estimates at the country or industry level will lead to a variation in comparative static effects on fundamental aggregate outcomes which are specific to country-industry cells. Certainly, with 12 countries and 20 industries, there are too many cells to shed light on. Therefore, let us report descriptive statistics of the key variables once by country and once by industry. Table 1 summarizes such statistics of fundamental variables to the analysis in the upper part per country and in the lower part per NACE 2-digit industry. In the first couple of columns of that table, we report numbers of firms in a country or industry, sales per firm, variable production costs per firm, the relative extent of collateral β_j^ℓ, and the relative extent of external financial dependence σ_j^ℓ.

Numbers of firms are measured within a country (but across all 20 NACE 2-digit industries) in Panel A and within a NACE 2-digit industry (but across all 12 countries) in Panel B of Table 1. Hence, Panel A provides some insight into the relative importance of countries and Panel B into the relative importance of industries in Europe. The figures in the first column suggest that Italy, Spain, and France are much better represented in the sample than Germany or Poland among the large countries. Notice that also many of the smaller economies are well represented in the data (regarding their firm populations). According to the entries in the fourth column, the richest countries in the sample do not have the highest share of collateral (those are the countries being relatively strong in research and innovation). However, these economies appear to depend on external finance more strongly on average than others (consistent with relatively more efficient capital market institutions there).

Notice that there is great variation in the relative importance across NACE 2-digit industries in Panel B of Table 1. If anything, the variability of sales and variable costs per firm is even bigger across industries than across countries. In particular, industries differ much more strongly in the extent of availability of collateral than countries do, while the reverse is true for external financial dependence. This is a reflection of collateral (and the degree of reliance on intangible assets in general and innovation in specific) to be an important industry-specific (much less so a country-specific) characteristic, but external financial dependence to be more pronouncedly driven by a country's institutional setting than by industry characteristics.

5.2 Estimation of fundamental parameters

In a first step, we estimate a constrained stochastic version of equation ($7'$) per country ℓ and NACE 2-digit industry j. In order to be able to identify parameters which vary across countries and industries, we assume homogeneity of parameters at deeper levels of aggregation (firms or NACE 3-digit industries). Using index h to denote NACE 3-digit industry variation, the stochastic counterpart of ($7'$) has the form

$$c_{dh}^{\ell} = \left[\frac{2(k_j+1)(k_j+2)\gamma_j f_{ej}}{L^{\ell}\left(\kappa_j^{\ell}\right)} \frac{1-(\hat{\tau}^{\ell})^{-k}\frac{\kappa^{\ell}}{\kappa^{\ell*}}\left(\frac{\theta_j^{\ell*}}{\theta_j^{\ell}}\right)^{k_j+2}}{1-(\hat{\tau}^{\ell})^{-2k_j}} \right]^{1/(k_j+2)} + u_h^{\ell}, \qquad (7'')$$

$$\theta_j^{\ell} = 1 + \sigma_j^{\ell}\left[\frac{1-(1-\lambda_j)\beta_j^{\ell}}{\lambda_j} - 1\right], \qquad (6')$$

where θ_j^{ℓ} reflects credit constraints in country ℓ and industry j, $\theta_j^{\ell*}$ is a measure of the (weighted) average credit constraint abroad from the viewpoint of firms in industry j and country ℓ, and u_h^{ℓ} is a stochastic term. We set the shape parameter of the Pareto distribution equal to two, as has been estimated by Del Gatto, Mion, and Ottaviano (2006). Since trade costs are estimated as explained above, we denote them by $\hat{\tau}^{\ell}$ in ($7''$). Furthermore, λ is estimated as an unknown parameter times the employed proxy for institutional quality, private credit relative to GDP, in ($7''$). We constrained the repayment probability λ to lie in the unit interval and, to achieve convergence of the nonlinear model to be larger than 0.9 (which is consistent with bankruptcy statistics). In general, we estimated standard errors of parameters from bootstraps with 200 replications.

Together with the measured collateral β_j^{ℓ} and financial dependence σ_j^{ℓ} in the data, the parameter estimates imply an estimate of the credit constraints measure $\hat{\theta}_j^{\ell}$ of in between 1.023 and 1.031 across countries and in between 1.009 and 1.058 across NACE 2-digit industries. The corresponding results are reported in the left section of Table 2 (to the left of the vertical line). Panel A provides an overview of average results by country while panel B refers to average results by industry, akin to Table 1.

Table 2: Parameter estimates and estimates of credit constraints

Panel A: Averages by country

Country	$\hat{\lambda}_j$	$\hat{\gamma}_j$	$\hat{\theta}^{\ell}_j$	$\hat{\alpha}_j$	$\hat{\eta}_j$
Belgium	0.929	4.045	1.024	1.952	0.412
Czech Republic	0.929	4.163	1.024	1.818	0.368
Germany	0.933	5.527	1.025	2.484	0.819
Finland	0.931	5.185	1.025	2.201	0.649
France	0.932	5.741	1.026	2.447	0.839
Hungary	0.914	2.438	1.028	1.259	0.018
Italy	0.932	5.741	1.027	2.511	0.839
Poland	0.930	5.509	1.027	2.379	0.685
Portugal	0.935	4.703	1.023	2.055	0.454
Slovak Republic	2.905	5.000	1.031	1.267	0.026
Spain	0.932	5.741	1.027	2.511	0.839
Sweden	0.931	5.830	1.026	2.512	0.881
Unweighted average	0.931	5.146	1.026	2.256	0.662

Panel B: Averages by industry

Industry	$\hat{\lambda}_j$	$\hat{\gamma}_j$	$\hat{\theta}^{\ell}_j$	$\hat{\alpha}_j$	$\hat{\eta}_j$
Food & beverages	0.906	2.162	1.024	1.021	0.003
Textiles	0.950	4.255	1.015	2.227	0.314
Apparel	0.916	2.243	1.037	1.174	0.007
Leather	0.950	4.045	1.025	1.446	0.046
Wood	0.950	4.972	1.011	1.849	0.153
Pulp & paper	0.950	6.335	1.09	2.901	0.726
Publishing & printing	0.924	2.598	1.025	1.059	0.004
Chemicals	0.950	7.631	1.019	3.700	1.419
Rubber & plastic	0.950	1.853	1.013	1.144	0.008
Other non-metallic	0.900	2.742	1.029	1.586	0.074
Basic metals	0.950	8.211	1.018	4.417	2.266
Metal products	0.900	3.259	1.034	1.223	0.015
Machinery	0.900	2.207	1.051	1.237	0.013
Office machinery & computers	0.900	11.967	1.059	4.782	2.663
Electrical machinery	0.950	8.519	1.019	3.728	1.464
Radio & television	0.950	11.611	1.018	5.792	4.415
Instruments	0.950	7.726	1.020	2.963	0.787
Motor vehicles	0.950	6.142	1.021	1.740	0.322
Other transport	0.900	11.296	1.058	4.233	1.993
Furniture	0.950	5.043	1.020	1.635	0.090
Unweighted average	0.931	5.146	1.026	2.256	0.662

Notes: Estimates of financial constraints are country specific because collateral and financial dependence are measured on the country level, see (6′).

While the parameters in the left block of Table 2 are elemental for comparative static analysis, they are not sufficient. In particular, if effects on the number of active firms and welfare are of interest, we need to estimate two additional parameters, α_j and η_j. While those parameters cannot be estimated from the model in ($7''$), we may formulate a stochastic counterpart to $N^{\ell}_{dh} = N^{\ell}_{eh}(c^{\ell}_{dh})^{k_j}$ to estimate them. However, we first need to derive the number of entrants in countries ℓ and ℓ^* at the NACE 3-digit industry level which we get from solving the set of equations $N^{\ell}_{eh}(c^{\ell}_{dh})^{k_j} + N^{\ell^*}_{eh}(c^{\ell^*}_{xh})^{k_j} = N^{\ell}_{dh}$. This delivers[15]

$$N^{\ell}_{dh} = \frac{2(\hat{k}_j+1)\hat{\gamma}_j}{\eta_j\left[1-(\hat{\tau}^{\ell})^{-2k}\right]}\left[\hat{\Theta}^{\ell}\frac{\alpha_j-\hat{\theta}^{\ell}_j\hat{c}^{\ell}_{dh}}{\left(\hat{\theta}^{\ell}_j\hat{c}^{\ell}_{dh}\right)^{\hat{k}_j+1}} - \left(\hat{\tau}^{\ell}\right)^{-k}\hat{\Theta}^{\ell^*}\frac{\alpha_j-\hat{\theta}^{\ell^*}_j\hat{c}^{\ell^*}_{dh}}{\left(\hat{\theta}^{\ell^*}_j\hat{c}^{\ell^*}_{dh}\right)^{\hat{k}_j+1}}\right]\left(\hat{\theta}^{\ell}_j\hat{c}^{\ell}_{dh}\right)^{\hat{k}_j} + \varepsilon^{\ell}_h, \tag{10}$$

where $\hat{\Theta}^{\ell} = (\hat{k}+1)\hat{\theta}^{\ell}/[(\hat{k}+1)\hat{\theta}^{\ell}-\hat{k}]$ and ε^{ℓ}_h represents a stochastic term. As with equation ($7''$), we exploit variation across NACE 3-digit industries in each country in order to estimate α_j and η_j from equation (10), as indicated by subscript h. Notice that the Pareto shape parameters, the cost cutoffs, and financial constraints as estimated from ($7''$) and summarized in Table 2 are now employed as known parameters and independent variables when estimating (10). The foreign cost cutoffs for firms in country ℓ and NACE 3-digit industry h, $\hat{c}^{\ell^*}_{dh}$, are computed as GDP-weighted averages of the remaining 11 (non-ℓ) countries in the same industry. The estimated NACE 2-digit industry-specific preference parameters $\hat{\alpha}_j$ and $\hat{\eta}_j$ are summarized in Table 2 as averages per country in the upper right panel and as averages per NACE 2-digit industry in the lower right panel.

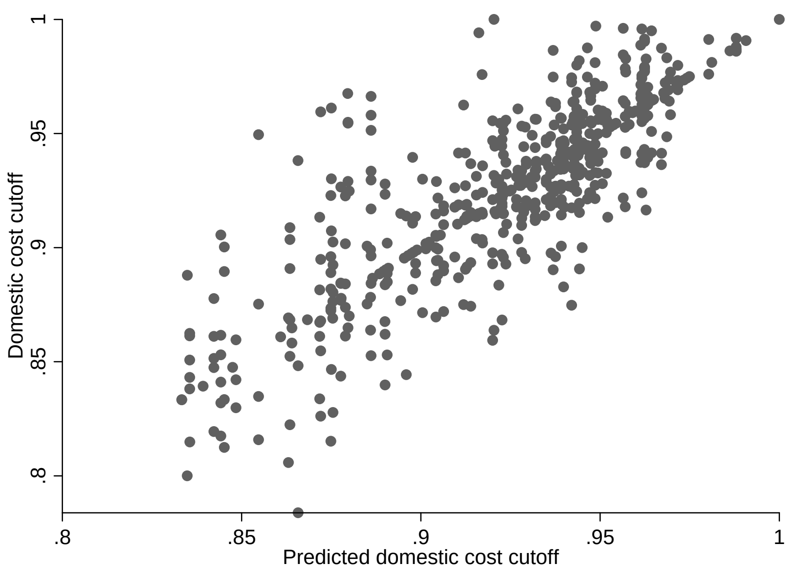
5.3 Illustrating the goodness of fit of the estimated and calibrated model

While we view the subsequent quantification based on comparative static analysis clearly as an exercise in *theory with numbers*, we would certainly feel more confident about outcomes, if the utilized theoretical model were able to capture key moments in the data.

In particular, we may assess the fit of the model when comparing model predictions about cost cutoff parameters with observable values thereof. For such an assessment, we could proceed as follows. Let us take predictions of all parameters in ($7''$). Then, we may determine country-industry-specific entry costs at the NACE 2-digit industry level, $\hat{f}^{\ell}_{ej}$,

[15] Note that we need to impose the constraint $\alpha_j > \hat{\theta}^{\ell}_j\hat{c}^{\ell}_{dh}$.

Figure 1: Observed and predicted domestic cutoffs for NACE 3-digit industries



as an ℓj-specific centered residual from the predicted domestic cost cutoff in comparison to the observed cutoff in (7″). Now, we may utilize this measure along with the other estimates and generate centered cost cutoff predictions at the NACE 3-digit level, $\hat{c}^{\ell}_{dh}$, and compare those with the centered observed values, c^{ℓ}_{dh}.

This comparison between observed and predicted values is illustrated in Figure 1. The corresponding data suggest that the underlying correlation coefficient between the two measures amounts to 0.8, pointing to a very good fit of the model.

6 Counterfactual analysis

Equipped with the parameter estimates and the observable variables, we are now ready to quantify comparative-static effects of credit constraints based on the model. To do this, we compare model outcomes based on estimated parameters with a counterfactual scenario where credit constraints are absent (i.e. $\theta = 1$). Based on comparative static results, we should expect average productivity ($1/\overline{c}$) and average markups ($\overline{LI}$) to decline while the number of operating firms (N) should increase when credit constraints vanish. Average prices ($\overline{p}$) and welfare (W) may increase or decrease. The corresponding results

Table 3: Abolishing credit constraints

Panel A: By country					
Country	$1/\overline{c}$	$\overline{p}$	$\overline{LI}$	N	W
Belgium	-2.30	0.93	-5.29	5.10	-0.07
Czech Republic	-2.29	0.93	-5.27	4.90	-0.06
Germany	-2.39	0.97	-5.50	5.07	-0.06
Spain	-2.60	1.06	-5.97	5.38	-0.06
Finland	-2.41	0.98	-5.54	5.12	-0.06
France	-2.49	1.03	-5.76	5.13	-0.05
Hungary	-2.71	1.10	-6.18	5.52	-0.09
Italy	-2.58	1.05	-5.93	5.31	-0.05
Poland	-2.61	1.06	-5.97	5.38	-0.06
Portugal	-2.27	0.91	-5.21	5.09	-0.06
Slovak Republic	-2.99	1.19	-6.72	6.01	-0.10
Sweden	-2.48	1.02	-5.73	5.12	-0.05
Sample average	-2.48	1.01	-5.70	5.22	-0.06

Panel B: By industry					
Industry	$1/\overline{c}$	$\overline{p}$	$\overline{LI}$	N	W
Food & beverages	-2.35	0.95	-5.38	4.72	-0.08
Textiles	-1.44	0.58	-3.37	2.89	-0.01
Apparel	-3.52	1.43	-7.91	7.09	-0.14
Leather	-2.41	0.97	-5.51	4.82	-0.04
Wood	-1.07	0.43	-2.50	2.13	-0.01
Pulp & paper	-0.92	0.37	-2.17	1.84	0.00
Publishing & printing	-2.47	1.00	-5.64	4.95	-0.08
Chemicals	-1.90	0.77	-4.40	3.80	-0.01
Rubber & plastic	-1.31	0.53	-3.06	2.62	-0.02
Other non-metallic	-2.83	1.14	-6.42	5.66	-0.05
Basic metals	-1.74	0.70	-4.04	3.48	0.00
Metal products	-3.25	1.33	-7.36	6.50	-0.10
Machinery	-4.81	1.95	-10.54	9.70	-0.20
Office machinery & computers	-5.54	2.25	-12.02	11.16	-0.03
Electrical machinery	-1.82	0.73	-4.22	3.64	-0.01
Radio & television	-1.78	0.72	-4.13	3.56	0.00
Instruments	-1.93	0.79	-4.49	3.86	-0.01
Motor vehicles	-2.05	0.83	-4.73	4.10	-0.01
Other transport	-5.48	2.23	-11.89	11.02	-0.03
Furniture	-1.92	0.77	-4.43	3.84	-0.02
Sample average	-2.48	1.10	-5.70	5.22	-0.06

Notes: This table reports percentage changes of average firm-level and aggregate variables in response to abolishing financial constraints in all countries and sectors, that is setting $\theta_j^\ell = 1$.

are summarized in Table 3. Akin to Tables 1 and 2, this table is organized in two blocks in a vertical dimension: Panel A reflects averages per country and Panel B averages per NACE 2-digit industry.

The key insights from Table 3 – where all figures represent changes of outcomes in percent – may be summarized as follows. First, abolishing credit constraints reduces average productivity by 2.48% on average. While some industries experience a mild reduction (e.g. Pulp & Paper, -0.93%), productivity drops quite substantially in others (e.g. Office Machinery & Computers, -5.54%). The average markup drops by 5.70% as firm entry has increased the number of competitors by 5.22% on average. Effects are particularly pronounced in the Office Machinery & Computers-industry (Lerner Index -12.02%, firm entry +11.16%), while the reduction of credit constraints has relatively minor effects in the Wood- and Pulp & Paper-industries (Lerner Index -2.17% to -2.50%, firm entry about +2%).

With regard to average prices and welfare (which are generally ambiguous in the theoretical model), our counterfactual analysis indicates that the *productivity effect* dominates the *competition effect* such that average prices increase despite lower credit constraints. As this price channel reduces welfare while the variety effect (+5.22%) increases it, we find that the overall implications for welfare are negligible (-0.06% on average).

7 Concluding remarks

This paper examined the role of credit constraints for product market competition. After deriving theoretical predictions in a heterogeneous-firms model with variable price-cost markups, we quantified the hypotheses by structurally estimating and calibrating the model to data. For the latter, we used information on about 261,717 manufacturing firms in 12 European countries and 20 industries. Based on the theoretical model, credit constraints induce a markup over marginal production costs of 2.5-3% on average in the data.

Several results stand out from this analysis. The theoretical model predicts that an increase in credit constraints precludes the least productive firms from securing external finance. Attenuated product market competition leads to higher price-cost margins, but the effects on average prices are ambiguous. This roots in two countervailing effects: On the one hand, fewer competitors allow every operating firm to exploit its stronger market power (*competition effect*); on the other hand, more productive firms remain in the market which tends to decrease average prices (*productivity effect*).

This ambiguity translates to implications for welfare. Tighter credit constraints unambiguously reduce the number of available varieties (firms) exerting a negative impact on welfare. However, if the productivity effect dominates the competition effect, tighter credit constraints may reduce average prices such that the price channel neutralizes the variety channel. In our counterfactual analysis, the implications of abolishing credit constraints on welfare are indeed negligible.

Appendix

A Autarky

$$\frac{\partial c_d}{\partial \theta} = -\frac{(k+1)\,\theta - k}{\kappa} c_d < 0$$

$$\frac{\partial \theta c_d}{\partial \theta} = \frac{k}{k+2}\frac{\kappa + k + 1}{\kappa} c_d > 0$$

With these insights at hand, it is straightforward to show that firm-level prices and markups increase in θ while the number of operating firms declines in θ.

Average prices respond ambiguously to a change in credit constraints. We have

$$\frac{\partial \overline{p}}{\partial \theta} = \frac{1}{2}\left[1 - \frac{(k+1)\,\theta + k}{(k+1)}\frac{(k+1)\,\theta - k}{\kappa}\right] c_d \gtreqless 0.$$

B Open economy

Firm-level prices and markups for each market are given by

$$p_d^\ell(c) = \frac{1}{2}\left(\theta^\ell c_d^\ell + c\right) \qquad LI_d^\ell = \frac{\theta^\ell c_d^\ell - c}{\theta^\ell c_d^\ell + c}$$

$$p_x^\ell(c) = \frac{\tau^{\ell *}}{2}\left(\theta^\ell c_x^l + c\right) \qquad LI_x^\ell = \frac{\theta^\ell c_x^\ell - c}{\theta^\ell c_x^\ell + c}$$

To obtain industry averages, we simply need to substitute the respective cutoff for the open economy into the autarky equation.

Let us now turn to comparative-static results. First, we show that the cost cutoff decreases θ^{ℓ}?

$$\frac{\partial c_d^{\ell}}{\partial \theta^{\ell}} = -\frac{1}{\theta^{\ell}} \frac{\theta^{\ell} \frac{(k+1)\theta^{\ell}-k}{\kappa^{\ell}} - \left(\tau^{\ell *}\right)^{-k} \frac{\kappa^{\ell}}{\kappa^{\ell *}} \left(\frac{\theta^{\ell *}}{\theta^{\ell}}\right)^{k+2}}{1-\left(\tau^{\ell *}\right)^{-k} \frac{\kappa^{\ell}}{\kappa^{\ell *}} \left(\frac{\theta^{\ell *}}{\theta^{\ell}}\right)^{k+2}} c_d^{\ell} < 0$$

To proof the result, we need to show that

$$\theta^{\ell} \frac{(k+1)\,\theta^{\ell}-k}{\kappa^{\ell}} \geq 1$$

At $\theta^{\ell}=1$, this expression is equal to one. Further, it is immediate that this expression is increasing in θ^{ℓ} which suffices to sign the derivative.

Next, the following derivative serves useful for further calculations.

$$\frac{\partial \theta^{\ell} c_d^{\ell}}{\partial \theta^{\ell}} = \frac{1-\frac{(k+1)\theta^{\ell}-k}{\kappa^{\ell}}}{1-\left(\tau^{\ell *}\right)^{-k} \frac{\kappa^{\ell}}{\kappa^{\ell *}} \left(\frac{\theta^{\ell *}}{\theta^{\ell}}\right)^{k+2}} c_d^{\ell} > 0$$

Further, the effect of an increase in credit constraints abroad on domestic cost cutoffs is clearly negative:

$$\frac{\partial c_d^{\ell}}{\partial \theta^{\ell *}} = -\left(k+1\right) c_d^{\ell} \frac{\left(\tau^{\ell *}\right)^{-k} \frac{\kappa^{\ell}}{\kappa^{\ell *}} \left(\frac{\theta^{\ell *}}{\theta^{\ell}}\right)^{k+2}}{1-\left(\tau^{\ell}\right)^{-k} \frac{\kappa^{\ell}}{\kappa^{\ell *}} \left(\frac{\theta^{\ell *}}{\theta^{\ell}}\right)^{k+2}} \frac{(k+1)\,\theta^{\ell *} - k\frac{2\theta^{\ell *}-1}{2\theta^{\ell *}}}{\kappa^{\ell *}} < 0$$

Based on these results, it is immediate that all firm-level variables for the domestic market increase in θ^{ℓ} while they respond negatively for the export market. As in autarky, the number of operating firms in country ℓ is decreasing in θ^{ℓ}. The average price may increase or decrease when credit constraints alter.

$$\frac{\partial \overline{p}}{\partial \theta^{\ell}} = \frac{1}{2}\left(1-\frac{(k+1)\,\theta^{\ell}+k}{(k+1)\,\theta^{\ell}} \frac{\theta^{\ell} \frac{(k+1)\theta^{\ell}-k}{\kappa^{\ell}} - \left(\tau^{\ell *}\right)^{-k} \frac{\kappa^{\ell}}{\kappa^{\ell *}} \left(\frac{\theta^{\ell *}}{\theta^{\ell}}\right)^{k+2}}{1-\left(\tau^{\ell *}\right)^{-k} \frac{\kappa^{\ell}}{\kappa^{\ell *}} \left(\frac{\theta^{\ell *}}{\theta^{\ell}}\right)^{k+2}}\right) c_d^{\ell} \gtreqless 0$$

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