Export Pricing and Credit Constraints:

Theory and Evidence from Greek Firms

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Abstract: We propose a partial-equilibrium model with endogenous quality, non-homothetic preferences and credit constraints. The model's main predictions are supported empirically by a unique data set of Greek manufacturing firms with firm-level exports, credit scores and financial variables. Specifically, we find that less credit-constrained Greek exporters enjoying higher credit scores charge higher export prices, sell greater export quantities, and face less price elastic export demand curves. The finding of a positive and significant correlation between less credit-constrained exporters and export prices contradicts the prediction of standard models of trade with heterogeneous firms and credit constraints. These models predict that less credit-constrained firms face lower marginal costs of production and charge lower export prices. Our analysis suggests that credit constraints affect exporter behavior through changes in product quality.

Keywords: Greece, international trade, financial constraints, export pricing, non-homothetic preferences, product quality.

JEL classification: F14, G32, L11, L15.

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1. Introduction

Financial constraints have important implications. In the context of international trade, credit availability affects the cost structure of trading firms and thus influences the extensive and intensive margins of exporters. Specifically, the supply of credit shapes the investment behavior of firms, impacts firm productivity, and thus affects the nature of export pricing and even the structure of firm heterogeneity.[1] When credit constraints operate mainly through limited external funding of fixed (sunk) costs, entry to foreign markets is affected, with only the most productive firms being able to generate enough cash flows to meet start-up exporting costs (Chaney, 2013). When financial constraints affect variable and especially marginal costs, export prices are affected as well, as more credit-constrained exporters face higher marginal costs (Manova (2013) and Feenstra et al. (2014)).

Although several papers have investigated the intensive margin of firm exporting, far less is known about the mechanisms through which credit constraints affect export *pricing* at the firm level. A notable implication of trade models with heterogeneous firms is that less constrained firms will tend to charge lower prices, driven by lower marginal costs and higher productivity. Melitz (2003) type models with a constant price elasticity of demand, stemming from CES preferences, imply that export price is proportional to marginal cost of production. As a result, less credit-constrained firms incurring lower effective marginal costs charge lower export prices.[2]

The main motivation for our paper is driven by a set of robust stylized facts from Greek exporters. In contrast to the main prediction of Melitz-type trade models, we document that less financially constrained Greek exporters charge *higher* prices and sell *higher* export quantities leading to higher export revenues. This result echoes the main findings of Manova and Zhang (2012) who investigate empirically the pattern of export prices using custom data on Chinese trade flows.[3] Based on their findings, the authors argue persuasively that empirically relevant trade models should feature endogenous product quality that may differ across export destinations.

Motivated by this empirical regularity and the view of Manova and Zhang, we propose a parsimonious partial-equilibrium model with endogenous product quality, variable price

[1] Initiated by the work of Melitz (2003) and Bernard et al. (2003), a large literature has emphasized the productivity and welfare gains from intra-industry trade in markets with heterogeneous firms. Bernard et al. (2007, 2012), Redding (2011), Melitz and Trefler (2012) and Melitz and Redding (2014) provide extensive surveys of related theoretical and empirical literature.

[2] See, for instance, Manova (2013) and Feenstra et al. (2014).

[3] The online Appendix offers a number of regressions that are directly comparable to those reported by Manova and Zhang (2012) and illustrates that the main features of the dataset on Greek firms are similar to theirs.

elasticity of demand, and credit constraints. Higher product quality leads to greater consumer willingness to pay and higher fixed and variable costs. Each firm faces an exogenous probability that it will not be able to serve the export market, as in Manova (2013) and Feenstra et al. (2014). Each firm finances an exogenous fraction of production costs by borrowing from a perfectly competitive banking sector. The remaining fraction of production costs is financed through retained earnings. Firms maximize expected profits by choosing export quantity and quality.

Our modeling approach rests on the well-known idea that credit, in addition to reducing production costs, can also be used to finance marketing, advertising, price-based promotions, higher-quality raw materials, R&D investments, and hiring of more productive workers. These activities enhance product quality, raise consumer willingness to pay, and thus expand the firm's market with an outward shift in demand. The quality-based 'demand-side channel' of credit constraints is particularly relevant for exporters, who operate in foreign markets and hence face extra costs due to information gathering, building distribution and sales systems, offering additional customer services and warranties, adjusting products to local legislation and tastes. Given the nature of these activities that precede sales and almost always involve upfront payments, the key feature of our model is that related outlays, which are jointly chosen with output in the firm's optimization problem, rely heavily on external financing.

Credit constraints are captured by the exogenous risk of default and measured by each firm's credit score. This score is reported on a ten-grade scale and expresses the credit quality of a firm with respect to the probability of bankruptcy over a year. Thus, it constitutes an ideal measure of the firm's theoretical default risk. In the theoretical model, a firm with a lower risk of default obtains a loan with a lower interest rate and enjoys higher expected export revenue. Empirically, firm-specific credit scores are used routinely by banks to decide whether a Greek firm will receive a loan and the terms of the loan including the lending rate.

We employ the model to derive predictions for the determinants of export prices, export quantities, and the price elasticity of export demand. The model predicts that less credit-constrained firms produce higher-quality products, charge higher prices, sell higher quantities abroad, and face lower price demand elasticities for their exports. The intuition behind these predictions is a follows. The assumption of a perfectly competitive banking sector implies that the interest rate charged to firms is inversely proportional to the survival rate (one minus the firm default rate). As a result, each firm's expected production costs are independent of the rate of default. Thus, an increase in firm survival probability increases expected total and marginal firm revenue inducing firms to engage in quality upgrading and to produce a higher level of

output. An increase in product quality raises the reservation price leading to a steeper inverse demand curve and less elastic demand function. In sum, quality-augmented models of trade introduce a novel demand-side mechanism that channels the effects of credit constraints on export prices, export quantities, and the price elasticity of demand.

The econometric analysis provides support for the empirical relevance of this demand-side mechanism. Our findings confirm the model predictions regarding the effects of credit constraints and are robust across a number of specifications, which include the potential endogeneity of credit constraints. Specifically, we find that less credit-constrained firms (i.e., firms with higher credit scores) charge higher export prices, sell greater quantities, and face less elastic demands. The economic magnitude of these effects is also significant: an increase in one standard deviation in a firm's credit score is associated, on average, with a 4.3% increase in export price and a 9.3% increase in exported quantity.

In addition to the effects of credit constraints, the model offers predictions on the effects of consumer income, trade costs and other market characteristics. According to the model, export price increases with consumer income and trade costs; and exported quantity increases with consumer income and decreases with trade costs. The price elasticity of demand is inversely related to exported quantity, as in Krugman (1979); and therefore decreases with consumer income and increases with trade costs. Finally the effects of market size, captured by the number of consumers, are ambiguous and depend on the presence or absence of scale economies in marketing, as in Arkolakis (2010). In the econometric analysis we use per-capita GDP to measure consumer income; geographic distance between Greece and the destination country to proxy trade costs; and aggregate GDP in the destination country to measure market size. The empirical analysis confirms these predictions by establishing that Greek exporters charge higher prices in richer and more distant markets; conditional on export price, they export greater quantities; and face less elastic demand functions in richer and less distant markets. In addition, Greek exporters face scale economies in marketing. The pattern of Greek export prices is consistent with the main findings of Manova and Zhang (2012) supporting their view that exporters choose optimally the quality of their products based on market characteristics in destination countries. Finally, the elasticity-related findings highlight the role of non-homothetic tastes as an essential feature of empirically relevant trade models.

Our paper is related and contributes to two main strands of the literature on exporter behavior. First, it belongs to the strand of literature investigating empirically the linkages between financial constraints and trade margins. Berman and Héricourt (2010) use a cross-country firm-level dataset of emerging and developing economies to establish that financial

factors, measured by liquidity and leverage ratios, do not have a significant effect on export quantities or export participation suggesting that financial factors affect only initial sunk cost of exporting. Greenaway et al. (2007) use a panel of UK manufacturing firms to establish empirically that leverage and liquidity constraints influence negatively the likelihood of exporting (extensive trade margin). Feenstra et al. (2014) propose a Melitz-type model where asymmetric information between a lender and heterogeneous borrowers creates credit constraints. They provide empirical support for the model by reporting that Chinese exporters face more severe credit constraints than non-exporters primarily because exporters face a longer time lag to ship and sell their products abroad. Minetti and Zhou (2011) use a sample of Italian firms and report that credit rationing, based on survey responses, affects adversely the amount of foreign sales and that this effect is substantially higher than the corresponding one for domestic sales. Muûls (2015) finds that less financially constrained firms in Belgium are more likely to export or import, export more products to more destinations, and also exhibit higher value of foreign sales per product-destination.

None of these studies analyzes the effects of credit constraints on exported product prices and none of them proposes a quality-based model of exporting. It should be mentioned that a positive correlation between less-credit constrained firms and higher export revenue is consistent with Melitz-type models. Since firms in these models face elastic demand curves, less financially-constrained firms that charge lower (as opposed to higher) export prices necessarily obtain higher export revenues. One significant contribution of our paper to the literature of credit constraints and trade margins is to establish that less credit-constrained firms charge *higher export prices* in addition to selling greater quantities indicating a demand-side effect. As said, this finding is inconsistent with Melitz-type models because they imply a negative correlation between less-credit constrained firms and export prices.

Second, our paper is related to the strand of trade literature investigating the role of quality in export pricing and its implications for the relationship between prices and market toughness, given by destination size and distance. Baldwin and Harrigan (2011) find that disaggregated export unit values are positively related to distance and negatively related to market size, and propose a quality-augmented Melitz-type model with CES preferences. The empirical findings are then explained as a composition effect: since only the best firms sell in these markets charging high prices, average prices at the product level will be increasing in smaller and more distant markets. Moreover, several empirical studies such as Hummels and Skiba (2004), Johnson (2012), Martin (2012), and Hallak and Sivadasan (2013) find that exports have higher unit values on average than domestic goods. Bastos and Silva (2010) and

Harrigan et al. (2015) establish that unit values are higher in shipments to larger and richer nations. Finally, Bastos and Silva (2010) show that these shipments are not characterized by lower quantities, suggesting that demand-side factors are an important driver of product quality.

We contribute to this strand of literature by proposing theoretically and establishing empirically a novel mechanism that relates financial frictions to export prices and quantities which operates through changes in product quality. Specifically, our empirical findings confirm the predictions of a simple model featuring non-homothetic preferences, endogenous quality, and credit constraints. Our theoretical model and empirical findings complement and extend existing results of studies on the 'quality sorting' of exporters, which have identified product quality through unit price, or quality-adjusted unit prices. One important extension is the link between credit constraints and the price elasticity of demand, based on the assumption of non-homothetic preferences. To our knowledge, our study is the first to document the impact of credit constraints on price elasticities of demand and relate them to destination-specific characteristics.

The paper by Arkolakis (2010) is closer in spirit to ours. This study puts forward the idea that marketing expenditures affect trade at the firm-level based on the concept that additional advertising leads to additional revenues. The key assumptions are that the cost to reach a certain number of consumers in a market decreases with the population size of the market and that, within a given market, the marginal cost of marketing increases with the number of consumers reached. We adopt this idea in the present paper by assuming that effective market size depends on the number of consumers and the degree of scale economies in marketing. Although our empirical findings are consistent with scale economies in marketing, our paper differs from Arkolakis (2010) in scope, focus, and issues addressed.

Our paper is partially motivated by the empirical work of Manova and Zhang (2012) which establishes that export prices are higher in richer, larger, and more distant destinations. These findings support the empirical relevance of trade models with endogenous product quality. Our paper confirms their empirical results and adds two more features, which are missing from their analysis: a formal model with endogenous quality, and additional empirical finding relating credit scores to export pricing and price elasticities.

We conclude by noting that a salient feature of our approach is that we do not require product-quality information in the data to test the model's predictions.[4] We rely on the

[4] Khandelwal (2010) discusses extensively the empirical implications of inferring product quality and shows

negative correlation of credit constraints with prices and quantities to argue that this and other empirical regularities can arise from the interplay between financial constraints and endogenous product quality. The current paper builds on this nexus to argue that our findings are *consistent* with our proposed model which features non-homothetic preferences and endogenous product quality.

The rest of the paper is structured as follows. In Section 2 we describe the dataset on Greek exporters and the main stylized facts related to credit constraints. Section 3 presents a model with heterogeneous firms that face credit-constrained marketing expenditures and derives testable implications. Sections 4 and 5 present the econometric analysis and results respectively, and Section 6 concludes.

2. Greek exporting firms: dataset and stylized facts

In this section we briefly describe the dataset on Greek exporters. We then present preliminary evidence suggesting that less financially constrained Greek firms charge higher export prices, export greater quantities and thus earn higher export revenues.

2.2. Dataset

The dataset on Greek exporting manufacturing firms merges data from two sources for the year 2007. Trade data are obtained from the Intrastat databank, available via Greek Statistical Agency (ELSTAT). Financial variables are obtained from the ICAP, the largest firm collecting balance sheet and financial information on Greek firms. More details on the construction of the dataset are given in sections A and B of the online Appendix.

The literature on exporting and financial frictions has used a variety of measures capturing credit constraints. For instance, Greenaway et al. (2007), Bellone et al. (2010), Berman and Héricourt (2010) use liquidity (cash flows) and leverage (total debt over total assets) as measures of financially binding constraints. Yet, these balance sheet measures capture a single dimension of the firm's fundamentals and access to financial markets. Minetti and Zhu (2011) use survey responses from Italian firms on credit rationing based on a self-declared binary classification indicating whether or not it is credit constraint. However, in markets with strong asymmetries typically associated with financially constrained firms, survey measures tend to simply assess qualitatively the demand for credit, rather than credit supply that matters for trade finance. In other words, balance sheet measures offer a partial

how it can be estimated from price and quantity information using disaggregated trade data.

assessment of credit access and survey data suffer from moral-hazard considerations.

We measure the degree of credit constraints for individual firms using the ICAP Credit Rating score from the ICAP database. This score expresses a firm-specific multivariate estimate of credit quality with respect to the probability of default and/or bankruptcy over a one–year time horizon. The credit score is a single indicator controlling for insolvency, excessive and/or bad debts, overdue accounts, and other typical commercial risks. The assessment is based on an analysis of commercial, financial and trading data derived from public sources and interviews with the rated firms, and it is measured on a ten-grade scale.

Importantly, the ICAP credit score is routinely used by Greek banks on their decisions to supply credit to firms. Hence, it is closely correlated to the degree of credit constraints faced by a Greek firm. A higher default risk does not only imply a higher probability of credit denial, but is also positively associated with interest payments for any given loan, acting in a similar manner to credit constraints since it affects the size of the loans that can be afforded by these firms (Feenstra et al., 2014). This credit score is also used by firms in assessing the credibility of their clients and suppliers and thus provides a form of extra liquidity through short-term financing from suppliers. Section B of the Online Appendix gives more details on the construction and classification of ICAP credit ratings.[5]

2.2. Stylized facts

We begin with a description of a few interesting patterns revealed by the Greek data which serve as stylized facts motivating our theoretical framework. The first column of Table 1 reports some key statistics for our full sample of exporters. The sample consists of 2,169 firms accounting for 1,811 exported products. The average number of products per firm is 7.2 and the average number of destinations per firm is 5.8. We note that exporters are larger firms with higher sales and profits than the rest of the firms in the sample (not reported here), a finding that is typical in related empirical literature.[6] We find marked differences between more or less credit-constrained Greek exporters based on their credit ratings, as indicated in the second and third column of Table 1. High-rated (less credit-constrained) exporters sell more products and serve more destinations, both in total and on average, compared to low-rated exporters.

Encouraged by the differences in main characteristics between more and less credit-

[5] See also Muûls (2015) who uses a credit score measure for Belgian exporters that combines financial variables, firm-specific characteristics, as well as industry-specific and macro-economic variables.

[6] See also Arkolakis and Muendler (2013) for a survey on the empirical properties and regularities of various country datasets (including the Greek dataset).

constrained Greek firms, we next explore the nexus among credit scores, export prices, quantities, and revenues through OLS regressions. Following Manova and Zhang (2012), we stress that the estimated coefficients reflect correlations, rather than causal effects. We address issues related to causality in Sections 4 and 5.

Table 2 reports OLS regressions of firm intensive margins on credit scores using firm-product-destination observations. Product fixed effects are included to control for systematic differences across goods in consumer appeal, comparative advantage, transportation costs, units of measurement (kilos versus physical units), and other product-specific characteristics. We also include destination fixed effects to account for destination-specific characteristics, such as consumer income, general demand conditions, transportation costs, as well as inflation and exchange rates.

Panel A of Table 2 reports the results on export revenues. The first two columns show that higher revenues are associated with higher quantities and lower prices. The third column confirms the finding established in Table 1, that less constrained exporters have higher revenues, a result also found by Minetti and Zhu (2011) for Italian firms. The same pattern is confirmed in the next two columns of Panel A, where in addition to financial ratings, quantities and prices are included as right-hand-side variables. Panels B and C respond the corresponding regressions with price and quantity as left-hand-side variables respectively. Panel B shows that higher prices are associated with lower revenues and quantities. The third column shows that firms with higher ratings charge higher prices and the coefficient becomes statistically significant and larger when we condition for revenues and quantities in the fourth and fifth columns of Panel B respectively. In Panel C we establish that higher ratings are associated with higher exports quantities, with the exception of column (4), in which the coefficient of ratings is negative and marginally significant when we control for firm revenues (size). We return to the relationship between quantities and credit constraints later, using detailed instrumented regressions with firm fixed effects.

To sum up, the stylized facts point out that less-constrained exporters sell higher quantities at higher prices. These findings are at odds with the standard prediction of models with heterogeneous exporters, which predict that credit constraints reduce marginal costs and hence prices. In the next section we build up a partial-equilibrium model with credit constraints and endogenous quality which is consistent with these stylized facts.

3. Theoretical framework

This section presents a partial-equilibrium model analyzing the impact of credit constraints on

export pricing, export revenue and price elasticity of demand. Motivated by the aforementioned stylized facts on Greek exporters, we focus on the behavior of an exporter producing a differentiated product with variable price elasticity of demand and endogenous quality. We treat quality as a choice variable raising the consumer willingness to pay and production costs.

We assume that each firm produces a single variety in two separate plants, or two distinct lines of production, with one devoted to exports and the other to domestic production, as in Verhoogen (2008).[7] Production, marketing and related activities occur before the product is sold abroad. Consequently, firms must finance an exogenous fraction of production and distribution costs as in Feenstra et al. (2014). The remaining fraction is financed through retained earnings. The typical exporter faces an exogenous probability of default raising the costs of borrowing above the costs of funds. Empirically, the probability of default is measured by the firm-specific credit rating. The supply of credit is provided by a competitive banking sector. We also assume that each exporter faces iceberg-type trade costs.

3.1. Demand structure

The foreign (export) market consists of *N* identical consumers and is served by n firms. Following the standard approach to partial-equilibrium modeling, we assume that the utility of each consumer is given by:

$$U = \sum_{i=1}^{n} \beta\lambda_i \ln(z_i + \theta) + z_0, \qquad (1)$$

where z_i is the quantity of product *i*, λ_i denotes product quality, and z_0 is the composite outside good. Parameter $\beta > 0$ captures the exogenous level of consumer willingness to pay, and parameter $\theta > 0$ introduces quasi-homothetic preferences leading to variable price elasticity of demand.

According to equation (1), consumer utility increases with product quality λ_i and with consumer willingness to pay β, which reflects higher consumer income in a partial-equilibrium setting with identical consumers. Parameter θ introduces the notion that a consumer gets utility from 'window shopping' or from having the option of consuming a variety.

Maximizing (1) subject to the standard budget constraint $I = \sum_{i=1}^{n} p_i z_i + p_0 z_0$ and setting

[7] This choice is based on data availability. Extending the model to multiple products is feasible but would complicate the algebra without offering additional significant insights to the empirical analysis.

the price of outside good equal to unity ($p_0 = 1$) yields the following inverse demand function for a typical product *i*

$$p_i = \frac{\beta \lambda_i}{z_i + \theta}. \tag{2}$$

Because consumer utility is symmetric across products, one can drop subscript i and can write the aggregate quantity demanded of a typical product as $x = Nz$, where the number of identical consumers *N* captures market size. For empirical purposes we assume that the consumer willingness to pay equals consumer income, that is, $\beta = I$. Substituting these expressions into (2) yields the market (as opposed to per-capita) inverse product demand

$$p = \frac{I\lambda}{xN^{-1} + \theta}. \tag{3}$$

The product price p increases with market size *N*, product quality λ, and consumer income I, and declines with firm output *x* and parameter θ. Equation (3) implies a finite reservation price equal to $I\lambda/\theta$ which increases with product quality and consumer income I, as expected. The reservation price decreases with parameter θ implying a flatter and thus more elastic inverse demand curve for higher values of θ: a higher value of θ increases the utility of "window shopping" and reduces the consumer reservation price. Where $\theta = 0$, the inverse demand function becomes Cobb-Douglas with an infinite reservation price.

Equation (3) leads to the following expression for the *price* elasticity of demand

$$\varepsilon = -\frac{\partial x}{\partial p}\frac{p}{x} = 1 + \frac{\theta N}{x} > 1. \tag{4}$$

According to (4), the price elasticity exceeds unity, declines with quantity demanded *x*, and increases with market size measured by the number of consumers *N*, as in Krugman (1979). As a result, quality-augmented, quasi-homothetic preferences represented by (1) generate an elastic demand function that admits unconstrained monopoly prices.

Equation (3) leads to the following *quality* elasticity of demand

$$\eta \equiv \frac{\partial x}{\partial \lambda}\frac{\lambda}{x} = \left(1 - \frac{p\theta}{\beta\lambda}\right)^{-1} > 1, \tag{5}$$

which is greater than unity for strictly positive prices and quantities. The quality elasticity of demand increases with price and declines with quality.

Export revenue is given by

$$R(x,\lambda) \equiv px = \frac{I\lambda x}{xN^{-1}+\theta} \tag{6}$$

and increases with the two choice variables, output *x* and product quality λ. Consequently, equation (6) generates the following marginal revenue functions

$$R_x \equiv \frac{\partial R(x,\lambda)}{\partial x} = p\left(1-\frac{1}{\varepsilon}\right) = \frac{I\theta\lambda}{\left(xN^{-1}+\theta\right)^2} > 0, \tag{7}$$

$$R_\lambda \equiv \frac{\partial R(x,\lambda)}{\partial \lambda} = \frac{Ix}{(xN^{-1}+\theta)} > 0. \tag{8}$$

Marginal revenue with respect to quantity R_x declines with output and increases with quality. In other words, product quality and output sold are strategic substitutes in the sense that $R_{x\lambda}(x,\lambda) = I\theta/(xN^{-1}+\theta)^2 > 0$. Marginal revenue with respect to quality R_λ increases with output and does not depend on quality.

3.2. Cost structure

We assume segmented domestic and export markets, and focus only on the latter. Firm costs consist of fixed and variable costs. The former increase with product quality λ and capture costs associated with establishing better product design, more effective distribution systems, better product-quality control, designing more effective advertising campaigns etc. For expositional convenience, we assume that fixed costs are quadratic in product quality and given by $\lambda^2/2$.

Variable costs depend on trade costs, marketing, and factor prices. We assume that the cost of delivering *z* units to each of *N* foreign consumers is given by $\tau z N^{1-\alpha}\mu\lambda$. Parameter $\tau > 1$ captures per-unit trade (transportation) costs: in order to deliver *z* units of output to a foreign consumer, the firm has to produce τz units of output. Term $N^{1-\alpha}$ captures, in a reduced form, marketing costs by transforming the actual number of consumers *N* into consumer "equivalents" $N^{1-\alpha}$, as in Arkolakis (2010). Parameter $\alpha < 1$ is associated with the degree of scale economies (or diseconomies) in marketing: if $\alpha = 0$, then marketing entails constant returns to scale; if $0 < \alpha < 1$, there are scale economies in marketing; and if $\alpha < 0$, then there are scale diseconomies in marketing.[8] Parameter $\mu > 0$ captures the dependence of variable costs on factor prices and firm productivity. Finally, we assume that variable costs increase

[8] This modeling of marketing costs follows the spirit of Arkolakis (2010) who uses a probabilistic framework leading to a more general specification of marketing costs within the context of a trade model with heterogeneous firms.

with product quality. The basic idea is that an exporter can use higher quality inputs (e.g. more skilled workers, better machines, higher quality raw materials or components) to upgrade product quality.

The above considerations can be incorporated in the following cost function

$$C(x,\lambda)=\frac{\lambda^2}{2}+\left(\frac{\tau\mu}{N^{\alpha}}\right)x\lambda, \tag{9}$$

where $z=x/N$ was used. This cost specification implies constant marginal costs with respect to output increasing linearly with quality.

3.3. Credit constraints

Following Feenstra et al. (2014), we assume that an exogenous fraction of production cost $0\le\delta\le1$ is financed through a loan whereas the remaining fraction of production costs $1-\delta$ is covered through retained earnings.[9] The exporting firm receives a loan from a competitive banking sector and faces an exogenous probability of default, $0<1-\psi<1$. If the firm defaults, it does not earn any revenue and the loan (principal plus interest payments) are not paid. If the firm does not default, it earns export revenue and pays back its loan. We abstract from issues associated with asymmetric information, incomplete insurance markets and the need for collateral payments. Consequently, the firm collects export revenue $R(x,\lambda)$ with probability ψ and pays back $(1+r)\delta C(x,\lambda)$, where *r* is the loan interest rate.

These assumptions lead to the following expression for expected profits from exporting

$$\pi=\psi R(x,\lambda)-(1-\delta)C(x,\lambda)-\psi(1+r)\delta C(x,\lambda), \tag{10}$$

where ψR is expected export revenue, $(1-\delta)C(x,\lambda)$ is the amount of production costs financed internally with certainty, and $\psi(1+r)\delta C(x,\lambda)$ is the expected cost of the loan. We assume that at equilibrium, expected profits must be non-negative, i.e., $\pi\ge0$. This assumption ensures that the cash flow constraint holds: if the firm does not default, then revenue generated from foreign sales exceeds the loan value $R(y,m)>(1+r)\delta C(x,\lambda)$.[10]

We assume that there is a perfectly competitive banking sector providing loans to exporters. Let $\rho>0$ denote the exogenous cost of funds. In other words, a loan of $\delta C(x,\lambda)$ costs the bank $(1+\rho)\delta C(x,\lambda)$ with certainty. By lending this amount to a firm the bank

[9] All results hold for the case where the firm finances through external borrowing all production costs, i.e. $\delta=1$.
[10] Manova (2013) provides an excellent discussion and exposition of the cash flow constraint in the context of a general-equilibrium model of trade with heterogeneous firms.

receives back $(1+r)\delta C(x,\lambda)$ from the firm with probability ψ. As a result bank expected profit from a loan is $\Pi = \psi(1+r)\delta C(x,\lambda) - (1+\rho)\delta C(x,\lambda)$. Free-entry into the banking sector implies $\Pi = 0$ and determines the interest rate charged to each firm

$$1+r = \frac{1+\rho}{\psi}. \tag{11}$$

Equation (11) implies that the interest rate charged to each firm *r* increases with the cost of funds ρ and declines with survival probability ψ. The latter will be measured with each firm's credit score.

3.4. Equilibrium

Each firm maximizes expected profit from exporting by choosing output and product quality and by taking the interest rate as given. Substituting equations (6), (9) and (11) in (10) leads to the following expression for profits from exporting

$$\pi = \psi \frac{\beta\lambda x}{xN^{-1}+\theta} - \phi(\tau\mu N^{-\alpha}\lambda x + \frac{\lambda^2}{2}) \ , \tag{12}$$

where $\phi = 1+\delta\rho > 1$. Setting $\tau = 1$ delivers the corresponding expression for domestic firm profits. Maximizing (12) with respect to output *x* and quality λ leads to the following first-order conditions:

$$\frac{\psi I\theta}{\left(xN^{-1}+\theta\right)^2} = \phi\tau\mu N^{-\alpha} \ , \tag{13}$$

$$\frac{\psi Ix}{\left(xN^{-1}+\theta\right)} = \phi(\tau\mu x N^{-\alpha} + \lambda) \ . \tag{14}$$

In words, the firm maximizes expected profits from exporting by setting expected marginal revenue equal to expected marginal costs.[11]

Solving (13) for exported output yields

$$x = \left[\left(\frac{\psi N^{\alpha} I\theta}{\tau\mu\phi}\right)^{1/2} - \theta\right] N \, , \tag{15}$$

and dividing the two first-order conditions generates the following positive relationship

[11] The second-order conditions for profit maximization are satisfied in the neighborhood of equilibrium. Standard calculations deliver $\pi_{xx} = -2\psi I\lambda\theta N^{-1}(xN^{-1}+\theta)^{-3} < 0$; $\pi_{\lambda\lambda} = -\phi < 0$; and $\pi_{\lambda x} = \psi I\theta(xN^{-1}+\theta)^{-2} - \phi\tau\mu = 0$, where π_{xx}, $\pi_{\lambda\lambda}$ and $\pi_{\lambda x}$ denote the second derivatives of (12) with respect to *x* and λ. Thus, $\pi_{xx}\pi_{\lambda\lambda} > (\pi_{x\lambda})^2 = 0$ ensuring that the solution to equations (13) and (14) corresponds to a maximum.

between output and product quality:

$$\lambda = \frac{\tau\mu x^2}{\theta N^{1+\alpha}}. \tag{16}$$

Substituting export quantity x from equation (15) in (16) yields a closed-form solution to equilibrium quality,

$$\lambda = \tau\mu N^{1-\alpha}\left[\left(\frac{\psi I N^{\alpha}}{\mu\phi\theta}\right)^{1/2} - 1\right]^2. \tag{17}$$

Equations (15) and (17) determine the equilibrium values of exported quantity and quality. By setting $\tau = 1$, these equations determine the corresponding domestic equilibrium with *N* and *I* denoting the number and per-capita income of domestic consumers.

3.5. Comparative statics

Data availability dictates the focus on empirically testable properties. Specifically we consider the effects of measurable parameters on product price *p*, product quantity *x*, and price elasticity *ε*.

In particular, substituting (15) and (17) into the inverse demand function (3) yields a closed-form solution to export price,

$$p = \frac{\lambda I}{xN^{-1} + \theta} = N^{1-\alpha}\left[\left(\frac{\tau\psi N^{\alpha} I\mu}{\theta\phi}\right)^{\frac{1}{4}} - \theta\left(\frac{\tau\psi N^{\alpha} I\mu}{\theta\phi}\right)^{-\frac{1}{4}}\right]^2. \tag{18}$$

Inspection of equation (18) lead to the following result.

Proposition 1. Export price p: increases with firm survival probability ψ; increases with trade costs τ; increases with consumer income I; and increases with market size measured by the number of consumers N, if there are no scale diseconomies in marketing ($0 \le \alpha \le 1$).

According to Proposition 1, firms exporting to countries with richer consumers and larger markets charge higher prices especially in the presence of scale economies in marketing. At first sight, the effect of demand-based parameters on price seems plausible and straightforward. An increase in consumer willingness to pay measured by per-capita income, I, shifts the demand curve upwards resulting in higher output and price. Notice though that an increase in output puts downward pressure on price and requires an increase in product quality to reverse the initial drop in price. This point is made clearer if one considers the

effects of an increase in ψ, which reduces marginal and average costs, raises output and quality, and thus has a seemingly ambiguous effect on export price. It turns out that the quality-based effect on the export price dominates the output-triggered effect leading to a price increase. As expected, higher trade costs are reflected in higher export prices.

What are the effects on export quantity *q*, which is another observable variable of interest? Equation (15), which provides a closed-form solution to product quantity, leads to the second empirically relevant result:

Proposition 2. Export output x: increases with firm survival probability ψ; decreases with trade costs τ; increases with consumer income I; and increases with market size measured by the number of consumers N if there are no scale diseconomies in marketing ($0 \leq \alpha \leq 1$).

The intuition behind the output effect of a higher firm survival probability is as follows. A higher value of ψ implies a higher chance of earning export (and domestic) revenue and thus a higher probability of paying back the loan. It also implies a lower interest rate *r*, according to (11), meaning that a firm with higher ψ receives a higher credit score and thus is less credit constrained. As a result, higher survival probability translates into lower marginal costs and higher export quantity. Similar considerations apply to the effects of income per capita, which raises consumer willingness to pay leading to a shift in the inverse demand curve and a higher quantity. Larger markets translate directly to more output especially in the case of scale economies in marketing. Finally, larger trade costs imply greater marginal costs and lower output.

Finally, substituting (15) in (4) delivers a closed-form solution to the variable price elasticity of demand

$$\varepsilon = 1 + \theta \left[\left(\frac{\psi N^{\alpha} I \theta}{\tau \mu \phi} \right)^{\frac{1}{2}} - \theta \right]^{-1} . \tag{19}$$

Equation (19) implies that virtually all model parameters affect the price elasticity of demand ε through export quantity x. Any parameter increasing export quantity leads to a less elastic demand. The following Proposition summarizes these testable effects.

Proposition 3. Export price elasticity of demand ε: decreases with firm survival probability ψ; increases with trade costs τ; decreases with consumer income I; and decreases with market size measured by the number of consumers N if there are scale economies in marketing (

$0 \leq \alpha \leq 1$*).*

The intuition behind Proposition 3 is closely related to non-homothetic preferences according to which the elasticity of demand declines with per-capita consumption $z = x/N$, as in Krugman (1979). In our quality augmented model, any parameter that increases export quantity leads to a lower price elasticity of demand. Thus firms with higher credit scores, exporting in larger markets with richer consumers, or facing lower trade costs export higher quantities and face less elastic demand functions.

More comparative statics results can be readily derived. However these results require measuring parameters for which data is not available and thus are not presented here. From a theoretical perspective, we complete the analysis by stating the determinants of product quality, derived from equation (17):

Proposition 4. Export quality λ *: increases with firm survival probability* ψ *; increases with trade costs* τ*; increases with consumer income I; and increases with market size measured by the number of consumers* N *if there are no scale diseconomies in marketing (*$0 \leq \alpha \leq 1$*).*

Product quality is not directly observable but its presence governs the effects of model parameters on other endogenous measurable variables such as export price and revenues. This point is made clearer by considering the effects of credit constraints in a model where quality is exogenous and the price elasticity of demand is constant. These are standard features of Melitz (2003) type models of trade with heterogeneous firms. In this case, the first-order condition yields equalization of expected marginal revenue to constant marginal cost and is given by $\psi p(1-1/\varepsilon) = \phi\tau\mu N^{-\alpha}\lambda$, where $R_x = p(1-1/\varepsilon)$ is marginal revenue. It is obvious then that a rise in the firm's credit rating, captured by higher ψ, leads to a lower export price p contrary to equation (21). In addition, the assumption of constant price elasticity of demand implies that the right-hand-side of equation (23) collapses to a constant. Manova and Zhang (2012) offer more details on this point and argue persuasively that the structure of export prices is inconsistent with models that treat export quality as an exogenous variable.

4. Empirical implementation

In this section we investigate the empirical implications of the proposed model. First, we discuss how the model can be tested empirically. Second, we describe our identification strategy by addressing the potential endogeneity of credit constraints, measured here by the

firm's financial rating.

4.1. Empirical implications

Taking the model to the data requires a strategy taking into account several considerations. We feel pretty confident that the firm-specific credit score is a good measure of firm survival probability, and thus reflects the degree of credit constraints; in addition, we are comfortable with our measures of export intensive margins, namely export revenue, export price (unit value) and quantity. We also feel confident with our assumptions that consumer willingness to pay is identical to consumer income ($\beta = I$), which naturally leads to use of GDP per capita as a proxy of consumer income, and the use of GDP and distance as proxies for parameters N (market size), and τ (per-unit trade costs), respectively.

The main caveat relates to the fact that product quality is not directly observable and several other parameters cannot be measured due to lack of available data. Keeping these limitations in mind, we test the empirical implications of the simple partial-equilibrium model and do not provide a structural estimation of parameters. As a result, we focus on the effects of credit constraints measured by firm-specific credit scores on export price, export quantity, and price elasticity of demand for exports. The effects of other variables of interest including per capita GDP, distance, degree of product differentiation, and GDP are related to the model's predictions and should be interpreted as suggestive. In other words, these additional variables play the role of controls rather than precise measures of model parameters.

Another caveat is related to the choice of functional forms. For instance, equation (1) implies that the inverse demand function is proportional to product quality and thus excluding the presence of diminishing returns. In addition, the cost structure takes the simplest possible functional form. These assumptions lead to explicit solutions but they also imply that testing the theoretical propositions corresponds to testing the functional forms of demand and costs structure.

Keeping these considerations in mind, the comparative statics properties of the model lead to the following empirical implications. The main determinants of firm export price are summarized in Proposition 1 and stated as

$$p = f(\overset{+}{\psi}, \overset{+}{\tau}, \overset{+}{I}, \overset{+}{N}), \tag{20}$$

where the sign over each parameter denotes its expected effect on the dependent variable. Variable p is measured by the export unit value; ψ is measured by the credit score; I is measured by per-capita GDP of the destination country; N by GDP of the destination country;

τ by the bilateral distance between home and destination countries.

Keeping the same notation, Proposition 2 identifies the main determinants of firm export quantity x

$$x = g(\overset{+}{\psi}, \overset{-}{\tau}, \overset{+}{I}, \overset{+}{N}), \tag{21}$$

where x is measured by the export quantity. Equation (21) is based on the assumption that the inverse demand is proportional to product quality, as indicated by equation (3). This means that, for given N and I, quantity rises only if λ / p increases. Even if less credit-constrained firms charge a higher price and export higher quality products, the effect on quantity is positive if higher credit scores lead to a higher increase in quality than price. In other words, the quality-induced increase in price dampens the effect of higher credit scores on export quantity.

We therefore proceed by testing the effects of credit constraints on product quantity conditional on export price. Specifically, substituting the solution to product quality λ from equation (17) into the inverse demand equation (3) yields the following determinants of firm export quantity x

$$x = G(\overset{-}{p}; \overset{+}{\psi}, \overset{+}{\tau}, \overset{+}{I}, \overset{+}{N}). \tag{22}$$

Equation (22) implies that a higher credit score leads to an upward shift in the demand curve and a higher quantity for a given export price.[12] More importantly, it implies that this shift is caused solely by quality upgrading thus providing an indirect test of Proposition 4 as well.

Finally, the main determinants of price elasticity of demand for exports, ε, are summarized by Proposition 3 as

$$\varepsilon = h(\overset{-}{\psi}, \overset{+}{\tau}, \overset{-}{I}, \overset{-}{N}). \tag{23}$$

We close this subsection by offering a few remarks on issues associated with product quality. Solving equation (4) for $\theta = N^{-1}x(\varepsilon + 1)$ and substituting this expression into equation (6) yields $\lambda = s\varepsilon$, where $s = R/NI = pz/I$ is the share of consumption expenditure. This implies that, product quality can be calculated if one had information on product-specific price elasticity of demand and share of consumption expenditure. Notice however that in our

[12] Formally, quantity demanded is given by $x = N\left\{p^{-1}N^{1-a}\tau\mu\left[\left(\frac{\psi IN^{a}}{\mu\phi\theta}\right)^{1/2} - 1\right]^{2} - \theta\right\}$. This expression yields partial derivatives whose signs are summarized by equation (22).

case the estimated price elasticity of demand $\hat{\varepsilon}$ depends upon credit constraints, ψ, and model parameters, as indicated by (23). In other words, and letting practical issues on the construction and/or aggregation of product quality aside, it would then make little sense to correlate estimated product quality, which would be obtained via $\hat{\varepsilon}$, to credit constraints ψ.[13]

4.2. Identification of credit constraints

A problem that is well recognized in the literature on the assessment of the effects of financial constraints on firm performance is the potential endogeneity of the particular measure of financial constraints used.[14] The ICAP financial rating for Greek firms can be affected by firm profitability, productivity, and other idiosyncratic structural characteristics, and also takes into account if a firm is an exporter. However, it is not directly affected by firm-specific exporting intensive margins (prices and quantities), because they are not publicly available. Since the credit score is based on information available at the end of each year, in our OLS regressions we employ the lagged rating that is relevant for credit supply. Furthermore, because we examine the intensive margins of exporting at the firm-product-destination level, our empirical results are less sensitive to how much firms export, or how they set prices, across product-destination pairs depending on their access to credit. For example, even if credit scores are given to firms according to their unobserved productivity characteristics that affect their exporting performance, within-firm sales and price differentials per product-destination pair should not be seriously affected.

Nevertheless, there can still be a potentially indirect problem of reverse causality. Suppose high firm prices are primarily due to high unobserved production costs, and lower credit scores are systematically given to firms with higher production costs. In this case, we might be attributing to the credit score what is actually driven by production characteristics.

[13] The model refers to a single firm and the theoretical measure of quality λ is product specific. Any empirical estimate of quality $\hat{\lambda}$ from the data would be firm-product-destination specific. Its association with a firm-specific measure, like credit constraints, would require aggregation across destinations and products per firm, which would be hardly interpretable as revenues and quantities differ inherently along these two dimensions. For instance, selling the same product in two markets implies endogenously-chosen differential qualities, and hence elasticities, due to the size-distance-wealth country-specific effect.

[14] Regarding related literature, Manova et al. (2015) identify the role of financial constraints for Chinese exporters looking at foreign direct and portfolio investments, rather than balance sheet variables, and find that they have affected both fixed costs related to participation in exporting decisions and variable costs influencing the scale of foreign sales. Amiti and Weinstein (2011) use Japanese matched firm-bank data to identify a bank-firm trade finance channel and find that it accounts for roughly one third of the decline in exports during the Japanese crisis in the 1990s. Minetti and Zhu (2011) tackle the issue of endogeneity between credit constraints and the probability of exporting by exploiting variations in the provincial supply of banking services through regulatory restrictions, which are closely related to the share of local credit-rationed firms.

One standard way to address this is to correct directly for productivity differentials, as reported above. Another way is through instrumentation, which allows us to disentangle the direction of causality.

Our main identification strategy to address this potential caveat is to model the firm's credit rating based on product-related, rather than firm-specific, characteristics. Our claim here is not to explain fully the credit score but to extract some (hopefully exogenous) information from the supply of credit in the specific product market that would be reasonable for instrumentation. The key idea is that the credit score of a single firm, which exports a particular product, is unlikely to drive the ratings of other firms that export the same product. In this vein, our instrumentation strategy relies on considerations that drive credit suppliers to give credit to a firm other than those related to a firm's intensive margins. Specifically, our instrument for a firm-product pair is based on the average credit score of the previous year of all firms that have exported the product in any market, excluding the firm under consideration. This empirical strategy rests on the well-known idea of network effects or externalities (see e.g. Golsbee and Klenow, 2002). Our instrument here proxies the financial reasons for credit supply and is plausibly orthogonal to credit availability that relates to the underlying economic situation of the firm. The instrumentation assumptions are therefore that the firm's credit rating is correlated with the average credit score of other firms that export a product, which in turn is exogenous to unexpected shifts in export prices or quantities for the firm-product-destination pairs. Our instrument is not firm-specific since it applies to each firm-product pair and hence raises fewer questions in terms of satisfying the exclusion restriction.[15]

5. Empirical specifications and results

The regressions reported in Table 2 reveal simple correlations between export margins and financial constraints. In this section we present the econometric analysis investigating the effects of financial constraints and discuss the empirical results.

5.1. Prices

We first examine the relationship between firms' export prices and financial ratings. The following general specification, based on (20), explores their co-movement:

[15] Since our regressions are cross-sectional, additional complications from the time persistence of credit scores are not introduced. It is possible that the association between a firm's credit score with the average credit score of firms that export a specific product does not apply equally to all firm-product pairs and might be affected, for instance, by the number of competitors in the product market or the number of products produced by the firm.

$$\ln p_{fd\omega} = \alpha_0 + \beta_1 \ln fr_f + \beta_2 \ln dist_d + \beta_3 \ln gdp\_pc_d + \beta_4 \ln gdp_d + \sum \gamma_j Z_j^p + \eta_{fd\omega} \quad (24)$$

where $p_{fd\omega}$ and $q_{fd\omega}$ denote the price (unit value) and physical output (quantity) respectively of product ω by firm f shipped to destination d, fr_f is firm's f credit score, $dist_d, gdp\_pc_d$, gdp_d, denote distance, income (proxied by gdp) per capita and income of destination d respectively, Z_j^p is a set of j control variables for prices, and η_{fdp} is a firm-product-destination specific disturbance term. Following Proposition 1, we expect that firms with higher credit ratings will charge higher prices ($\beta_1 > 0$). Firms serving more distant and richer destinations will also charge higher prices ($\beta_2, \beta_3 > 0$), whereas the effect of destination size on prices will be positive ($\beta_4 > 0$) if there are scale economies in marketing.

We investigate the impact of financial constraints on export prices by accounting for the impact of firm-specific characteristics captured by Z_i^p, like age, size and productivity, which according to existing empirical literature are likely to be important determinants of pricing, particularly in the presence of financial frictions.[16] For instance, Kugler and Verhoogen (2012) report a robust positive correlation between output prices and plant size (measured by sales or employment) for Colombian manufacturers. Yet, this effect might be reversed in the presence of financial constraints that are more likely to be faced by smaller exporters and thus are expected to benefit more and expand faster relative to large firms when liquidity constraints are relaxed.

Although an obvious measure of firm size is total sales, as pointed out by Kugler and Verhoogen (2012), sales represent quantities times prices. Hence any measurement error in prices may appear on both sides of the regression with export prices or quantities as the dependent variables, and generate a positive bias in OLS estimates. To address these concerns, we follow Kugler and Verhoogen (2012) and proxy plant size by employment, which has the advantage that any measurement error is likely to be less severe and, importantly, uncorrelated with a measurement error in output values and quantities of outputs and inputs. A standard feature of models with heterogeneous firms is that firms with higher productivity represent a disproportionate share of aggregate exports. The behavior of these firms will therefore heavily affect the aggregate impact of financial constraints. To this end, we control additionally for total factor productivity (*tfp*) at the firm level using the standard

[16] Forbes (2007) reports that during the period of increased taxes on capital inflows in Chile, smaller traded firms experienced significant financial constraints and these constraints decreased as firm size increased. Zia (2008) shows that the removal of subsidized credit causes a significant decline in the exports of small firms, while the exports of large firms and of group network firms are unaffected.

Olley-Pakes methodology.

Columns (1)-(4) in Table 3 contain some basic specifications with financial ratings and control variables, including product and destination fixed effects. In column (1) the coefficient on ratings is positive and statistically significant implying that less constrained firms charge higher prices, whereas the coefficients on age and employment are negative and significant. Column (2) augments the previous specification by including total factor productivity *tfp* as a independent variable. All coefficients retain their signs and significance, whereas productivity is found to have an insignificant effect. Columns (3) and (4) report the same specifications using the average rating of all other firms that export the same product as an instrument for the firm's financial rating. The 2SLS estimates are similar to the OLS estimates, consistent with the hypothesis that there is no endogeneity problem between prices and financial ratings at the firm level. The coefficient estimates are again highly statistically significant and indicate that prices are positively correlated with financial ratings, whereas the rest of the coefficients remain virtually unaffected. Based on the values of the F-test for single endogenous regressor and the minimum eigenvalue test, we reject the null hypothesis of weak instruments for all specifications considered in columns (3), (4), (13) and (14).

Columns (5)-(10) explore sequentially the effects of distance, income per capita and income of destination country. In accordance with our theoretical predictions, we find that firms charge higher prices in more distant, richer and bigger markets. Similar empirical patterns are also found by Manova and Zhang (2012, Table VII) and Harrigan et al. (2015). When we include all main determinants of export prices in line with equation (21), we find in columns (11)-(14) that the estimated coefficients obtain the signs predicted by the theoretical model. The firm's financial rating affects positively prices in all regressions, whereas the magnitudes of the coefficients are similar to those reported in columns (1)-(4). To gauge the economic significance of the effect of credit constraints on prices, consider a one standard deviation rise in the scaling of the firm's financial rating (ranging from 1 to 10), which amounts to 1.87. Assuming a coefficient estimate on financial ratings of 0.16 in line with our instrumented regressions, a one standard deviation increase of the average financial rating (amounting to 7 in our data) would be roughly associated with a 4.3% rise in the firm's export prices.

5.2. Quantities and price elasticities

In this subsection we estimate the effects of credit constraints on exported quantities and elasticities. Given the questions at hand raised by Propositions 2 and 3 and data availability,

we follow here a semi-structural approach to proxy the effect of credit constraints on quantities and elasticities. Specifically, rather than relying on a reduced-form empirical strategy as the one adopted in the previous subsection, we estimate variants of demand equations that assess the impact of the coefficients of interest on quantities conditional on prices. This approach is more robust on the choice of functional forms and allows us subsequently to obtain variable price elasticities by interacting prices with firm-specific (credit ratings) and destination-specific (distance, income, size) variables in the context of the estimated demand specifications.

5.2.a. Export quantities

The effects of credit constraints on quantities are explored by estimating the following specification based on equation (22):[17]

$$\ln q_{fd\omega} = \alpha_0 + \alpha_1(-\ln p_{fd\omega}) + \beta_1 \ln fr_f + \beta_2 \ln dist_d + \beta_3 \ln gdp\_pc_d + \beta_4 \ln gdp_d + \sum \gamma_i Z_k^q + \eta_{fd\omega} \quad (25)$$

where Z_k^q is a set of k control variables for quantities. Specification (25) yields the demand elasticity of exports, α_1, and accounts for the effects of credit constraints and other factors as dictated by Proposition 2. Specifically, we expect that firms that have higher ratings, and hence are less financially constrained, sell higher quantities ($\beta_1 > 0$). Firms serving more distant and richer destinations sell higher quantities ($\beta_2 > 0$, $\beta_3 > 0$). If there are scale economies in marketing, the effect of destination market size on quantities exported will be positive ($\beta_4 > 0$).

To eliminate the well-known endogeneity bias in plants' idiosyncratic demand levels, we follow Foster et al. (2008) and Khandelwal (2010) and instrument prices using firm-specific physical productivity, which will be correlated with prices, but uncorrelated with short-run demand shocks. In contrast to expenditure-based measures of productivity, firm-specific physical productivity is determined by physical quantities of outputs and inputs. More specifically, physical (labor) productivity (labeled *qtfp*) is calculated as the ratio of output quantity to employment and has the advantage that it does not confound technological efficiency with producer-specific demand or factor cost components. Given that most of our

[17] Estimating a specification based on equation (21), without controlling for export prices, yielded insignificant coefficients suggesting rejection of restrictive assumptions regarding functional forms. Specifically, this result suggests that higher prices induced by higher credit scores reduce export quantities to substantially dampen the magnitude of quantity increase due to quality upgrading. Details of the econometric results are not reported here and are available from the authors upon request.

sample consists of multi-product firms, we impose the restriction that at least 50% of the firm's revenues is obtained from a single product. Based on the values of the F-test for single endogenous regressor and on the minimum eigenvalue test for more endogenous regressors, we reject the null hypothesis of weak instruments for all relevant specifications in Tables 4-6. This suggests that similarly to average rating as an instrument for the financial rating, *qtfp*, is also a strong instrument for *price*.

Column (1) in Table 4 reports a benchmark regression in which only prices, instrumented by *qtfp*, are included in the specification. We find that the typical elasticity is 2.8, a value that is close to those reported by Imbsy and Méjean (2010) for Greece, which range between 3 and 3.5. Columns (2) augments the previous specification by including financial ratings as a dependent variable. As predicted by equation (20), the coefficient of interest on the financial rating enters with a positive and statistically significant sign after controlling for the effect of prices. This finding is confirmed in column (3), in which the rating is instrumented by the average rating of all other firms that export the same product in line with our identification strategy. The coefficient estimates on the financial rating from the instrumented regression corroborate the one obtained by OLS, indicating that the estimated positive impact of financial ratings on export quantities is not driven by the endogeneity of credit constraints.

Columns (4)-(6) then explore sequentially the effects of the three destination-specific characteristics, namely size, income and proximity. We find that the sign of their effects are in line with relationship (22) with the exception of the coefficient on distance, which is negative and significant. The signs of these partial correlations, though, say little about the impact of credit constraints on quantities. Column (7) includes all variables in a single specification. The firm's rating enters with a positive and statistically significant sign, whereas the coefficients on per-capita income and market size take the predicted signs and are statistically significant indicating that larger quantities are exported to larger, and richer destinations. The coefficient on distance remains negative and significant although its magnitude and level of significance are reduced substantially. Column (8) estimates the corresponding regression in which the financial rating is instrumented. The coefficient on the financial rating is again positive and statistically significant, though lower, whereas the rest of the coefficients are virtually unaffected.

In terms of economic magnitudes, the estimates on the effects of credit constraints on quantities sold have similar implications to those reported for prices. Assuming a conservative value of 0.35 for the coefficient on financial rating, which is the rough average from our instrumented regressions, an exporting firm with an average financial rating would increase its

quantities sold by 9.3% following a one standard deviation rise in its credit rating.

As a final step, we test the strength of our findings to another factor that might be related to a firm's performance in terms of quantities sold and is driven by the trading environment in the form of differences in competition (Mayer et al., 2014). Specifically, in our case less constrained firms that face tougher competition in certain product markets (e.g. in the form of lower markups) might sell *relatively* more than firms facing higher credit costs by skewing their production mix towards higher-quality goods. This behavior would result in a spurious negative correlation between credit constraints and export quantities that could interfere with the identification of our predictions on quantities exported. To address this potential caveat, in columns (9) and (10) we (partially) control for differences in market structure by including the numbers of firms per product and firms per product-destination as independent variables, with the latter variable measuring the degree of competition in a specific destination. The coefficients on these variables enter with a positive and a negative sign respectively, whereas the rest of the coefficients on the variables of interest, with the exception of the one on distance that is now insignificant, are very similar to the previous ones.

5.2.b. Price elasticities

We now turn to the factors that affect the price elasticity of demand according to (23) by estimating the following specification:

$$\ln q_{fd\omega} = \alpha_0 - \ln p_{fd\omega}\,[\alpha_1 + \beta_1 \ln fr_f + \beta_2 \ln dist_d + \beta_3 \ln gdp\_pc_d + \beta_4 \ln gdp_d\,] + \sum \gamma_i Z_k^q + \eta_{fd\omega} \quad (26)$$

We are interested whether the firm's price elasticity of demand,

$$\varepsilon \equiv -\frac{\partial \ln q_{fd\omega}}{\partial \ln p_{fd\omega}} = \alpha_1 + \beta_1 \ln fr_f + \beta_2 \ln dist_d + \beta_3 \ln gdp\_pc_d + \beta_4 \ln gdp_d\,,$$

is sensitive to (i) variations in firm's credit constraints, and (ii) distance, income per capita and income of destination *d*, through coefficients $\beta_1, \beta_2, \beta_3, \beta_4$. According to Proposition 3, we expect that firms with higher ratings will face less elastic demand $(\beta_1 < 0)$. Firms serving more distant destinations will face more elastic demand ($\beta_2 > 0$) and firms that serve richer destinations will face more inelastic demand ($\beta_3 < 0$). Finally, firms serving larger markets will face more inelastic demand ($\beta_4 < 0$) if there are scale economies in marketing.

Table 5 presents the benchmarks results in the context of specification (26). Column (1) introduces the price-rating interaction term, which is found to be positive and statistically significant: the less financially constrained a firm is, the lower the price elasticity it faces.

Columns (2)-(4) explore sequentially the effects of destination distance, income per capita, and aggregate income on the price elasticity of demand using interactions terms. The coefficients on the interaction terms enter with the predicted signs, though the one on income per capita is statistically insignificant. In column (5) all variables enter in a single specification and take the predicted signs, which are all statistically significant. A similar picture is obtained in column (6), which controls partially for market structure proxied by the numbers of firms per product and firms per product-destination. The general picture strongly implies that Greek exporters face binding financial constraints that affect the price elasticity of demand with less constrained exporters facing less elastic demand.

To allow for comparisons between groups of firms based on their financial ratings, we split the sample in high-rated and low-rated firms based on their credit rating. Specifically, we classify as high-rated, and consequently financially unconstrained, firms those that are rated 9 and 10 on the 10-scale range, which amount to roughly 25% of all firms. In a similar vein, we classify as low-rated, and consequently highly constrained, firms those that are rated 5 or below, which amount to roughly 20% of all firms. In columns (7)-(12) we test whether the price-rating interaction term is different between the two groups using the simple specification with the price-rating interaction term, the specification with all interactions and the full-fledged specification that controls for market structure. The estimated interaction terms of prices with financial ratings are substantially different between the two groups: in all specifications the coefficients are found to be positive and statistically significant for high-rated firms, whereas they are insignificant for low-rated firms.

We further investigate the robustness of our main findings to some plausible alternatives related to exporters and/or their products. For technological reasons innate to the nature of the manufacturing process, exporters in certain sectors incur higher up-front costs related to marketing and advertisement, and hence are relatively more financially dependent. Consequently, firms in these sectors are much more vulnerable to financial frictions. A relevant exercise is therefore to examine the elasticity responses for various firm groups, in which the elasticity is more likely to be differently affected based on their structural characteristics. As a first step, we distinguish between consumption and non-consumption goods. About 20% of the products that are exported by firms for which we have enough information in order to calculate firm-specific physical productivity (*qtfp*), are classified as consumption goods.[18] Overall we have 519 firms that produce 335 consumption goods. More

[18] We use the United Nations classification in Broad Economic Categories defined in terms of the Standard

than half of these firms (60%) have a high credit score and employ on average 173 employees compared to firms with low credit score that employ on average 34 employees. The results are reported in columns (1)-(3) of Table 6 and all hypothesized effects are again confirmed. Notably, the effect on the price-rating term is lower in magnitude, implying that the drop in the price elasticity of demand due to a decrease in financial constraints is smaller for consumption goods. This counterintuitive finding may be due to the inherently lower direct price elasticity of demand for consumption goods, as indicated by the lower values of the price coefficient relative to those obtained in Table 5. To further shed some light on this finding, in columns (4)-(6) we test whether the elasticities are differently affected by credit constraints in sectors with greater scope for quality differentiation using Rauch's (1999) classification index. The price-rating coefficients take values similar to the ones reported for consumption goods.

Finally, we test whether our results depend on the product mix of exporters. Several papers have analyzed the behavior of multi-product exporters and their implications for firm heterogeneity with emphasis placed on tougher competition (see e.g. Bernard et al., 2012; Arkolakis et al., 2014; Mayer et al., 2014). For simplicity of exposition, the theoretical model featured a single-product exporting firm; however, 89% of the firms used in the regressions are multiproduct firms. In the presence of financial constraints, a composition effect might arise on a firm's product mix that would then translate into differences in pricing: more financially constrained exporters might shift resources to the production of goods associated with lower perceived quality to counterbalance their comparative disadvantage. Thus, given input requirements, a less constrained firm producing a given set of products will export on average a larger share of higher-quality goods. This effect would skew the average firm price across products upwards and generate a spurious positive correlation between ratings and pricing at the firm level, which would in turn affect the elasticity estimates.

To address this potential caveat, we use only observations from firms that ship one product per destination. Our sample consists of 814 firms that export 881 goods in 171 unique destinations. About half of these firms (53%) have a high credit score and are on average larger (182 employees) than low-rating firms (37 employees). High credit score firms export 665 products to 161 destinations whereas low-rating firms export 537 products to 132 destinations. Columns (7)-(9) in the right panel of Tables 6 display the corresponding regressions, which show that the price-rating interaction term is negative as predicted but now

International Trade Classification (http://unstats.un.org/unsd/iiss/Classification-by-Broad-Economic-Categories-BEC.ashx).

takes a larger value compared to the previous specifications. This indicates that the reduction in the price elasticity for less constrained firms is substantially higher for single-product exporter establishing the robustness of our theoretical analysis and suggesting that multiproduct firms rely more on internal finance and/or are not affected by external finance as much due to product diversification.

6. Conclusions

This paper proposes a partial-equilibrium model with endogenous product quality, non-homothetic preferences, and credit constraints. We confirm the main prediction of the model using a unique data set with information on firm-specific credit scores and financial variables of Greek manufacturing exporters for the period 2007. Less credit-constrained Greek exporters charge higher export prices, sell larger export quantities, and face lower export price elasticities. Greek exporters also charge higher prices in richer, larger, and more distant markets.

The pricing behavior of Greek exporters is inconsistent with the main prediction of Melitz-type models of trade that do not incorporate endogenous product quality. These models imply that less credit-constrained exporters face lower marginal costs and thus charge lower prices. Our findings are also inconsistent with trade models where firms face export demand functions with constant price elasticity.

Our results bear several potentially important implications out of which two are outlined here. First, they suggest that public policies leading to a reduction in the probability of default that might take the form of loan guarantees have substantial effects on exports. For instance, a rise in the credit score of a Greek exporter with an average financial rating by one standard deviation is correlated with a 4.3% increase in export prices and a 9.3% in export quantities leading to higher export revenues by 14%. Our results also suggest that an increase in the probability of default, caused by the Greek financial crisis, which started in 2009, and the recently imposed capital controls can lead to a severe reduction in credit scores, export revenues, and international competitiveness.

Our analysis supports the empirical relevance of trade models with non-homothetic preferences and endogenous product quality. These features could be incorporated in a Melitz-type general-equilibrium model of trade with heterogeneous firms. Such a framework would allow researchers to analyze the extensive margin of trade, as well as evaluating the welfare implications of trade openness and policies. The development of such class of trade models lies outside the scope of the present paper and represents a fruitful avenue of research.

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TABLE 1. Greek exporting manufacturing firms, summary statistics (2007)

	All exporters	Financial ratings of exporters	
		High	Low
A. Exporting characteristics			
number of exporting firms	2169	542	459
value of exports	3279	8716	1217
number of products	1811	1434	908
number of destinations	173	144	119
average number of products per firm	7.2	11.7	4.4
average number of destinations per firm	5.8	8.2	4.1
average number of destinations per product	9	6.6	3.6
number of observations	33106	14793	4023
B. Firm characteristics			
employment	126	319	55
age	17	22	13
total sales	35696	107488	9923
total assets	47040	111651	47810
fixed assets	27113	64397	36560
gross profits	7698	22760	1737
operating costs	6133	16291	3069
liquidity ratio	0.189	0.264	0.111
leverage	5.360	2.44	10.29
cash flow	0.075	0.096	0.057

Notes: The classification of firms rating includes 10 categories from AA to H (see section B of the Appendix). *High* rating firms are those in the top 2 categories (about 25% of the firms) and *Low* rating firms are firms rated 5 or below (about 20% of all firms). Liquidity ratio is defined as the firm's current assets less current liabilities over total assets. Value of exports, total assets, fixed assets, gross profits and operating costs are reported in thousand Euros. Leverage ratio is defined as the firm's ratio of total liabilities to equity. Cash flow is calculated as profits net of tax expenditures plus depreciation and is normalized by total assets (see also Minetti and Zhou, 2011).

TABLE 2. Export performance and financial ratings

A. Dependent variable: revenues					
financial rating			0.221*** (5.14)	0.062*** (3.57)	0.226*** (5.27)
quantity	0.819*** (423.02)			0.819*** (422.91)	
price		-0.216*** (-16.21)			-0.217*** (-16.25)
N	33106	33106	33106	33106	33106
R^2	0.896	0.305	0.300	0.897	0.306
B. Dependent variable: price					
financial rating			0.027 (1.38)	0.036* (1.85)	0.062*** (3.57)
revenues	-0.041*** (-16.31)			-0.041*** (-16.35)	
quantity		-0.181*** (-93.62)			-0.181*** (-93.70)
N	33106	33106	33106	33106	33106
R^2	0.811	0.851	0.809	0.811	0.851
C. Dependent variable: quantity					
financial rating			0.194*** (4.05)	-0.036* (-1.85)	0.226*** (5.27)
revenues	1.041*** (414.96)			1.041*** (414.57)	
price		-1.216*** (-91.28)			-1.217*** (-91.30)
N	33106	33106	33106	33106	33106
R^2	0.928	0.622	0.516	0.928	0.622

Notes: All variables are in logs. The regressions include a constant term and *t* statistics based on robust standard errors clustered at product level are in parentheses (* denotes p<.10, ** denotes p<.05, *** denotes p<.01). All regressions include product and destination fixed effects.

TABLE 3. Export prices under financial constraints

	Dependent variable: export price													
	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) OLS	(6) OLS	(7) OLS	(8) OLS	(9) OLS	(10) OLS	(11) OLS	(12) OLS	(13) 2SLS	(14) 2SLS
financial rating	0.123***	0.263***	0.162***	0.201***							0.133***	0.280***	0.158***	0.162**
	(3.23)	(4.60)	(4.46)	(2.79)							(3.38)	(4.76)	(4.29)	(2.23)
distance					0.010	0.034***					-0.006	0.013	-0.005	0.013*
					(1.46)	(3.83)					(-0.82)	(1.55)	(-0.92)	(1.87)
gdp per capita							0.167***	0.148***			0.156***	0.128***	0.156***	0.128***
							(13.43)	(9.98)			(11.95)	(8.19)	(19.14)	(13.35)
gdp									0.036***	0.041***	0.010***	0.018***	0.010***	0.017***
									(9.63)	(9.00)	(2.75)	(3.71)	(3.18)	(4.16)
age	-0.035**	-0.054**	-0.037***	-0.049***	-0.017	-0.027	-0.019	-0.026	-0.016	-0.024	-0.026*	-0.050**	-0.028***	-0.040***
	(-2.51)	(-2.29)	(-4.31)	(-3.33)	(1.28)	(-1.14)	(-1.36)	(-1.12)	(-1.15)	(-1.03)	(-1.87)	(-2.07)	(-3.18)	(-2.65)
employment	-0.044***	-0.047***	-0.047***	-0.040***	-0.037***	-0.015	-0.037***	-0.017	-0.035**	-0.014	-0.047***	-0.046***	-0.049***	-0.033***
	(-5.51)	(-2.81)	(-8.85)	(-3.56)	(-5.06)	(-0.94)	(-5.08)	(-1.09)	(-4.78)	(-0.93)	(-5.83)	(-2.75)	(-9.20)	(-2.91)
tfp		-0.015		-0.008		0.025		0.019		0.019		-0.009		0.005
		(-0.48)		(-0.44)		(0.80)		(0.61)		(0.62)		(-0.29)		(0.26)
destination FE	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N	32343	17043	31934	16814	31021	16357	31106	16405	31106	16405	31021	16357	30626	16136
R^2	0.811	0.839	0.807	0.836	0.803	0.830	0.807	0.833	0.804	0.831	0.807	0.834	0.803	0.830
products (clusters)	1802	1468	1811	1458	1790	1457	1790	1457	1790	1457	1790	1457	1790	1457

Notes: The regressions include a constant term and *t* statistics based on robust standard errors clustered at product level are in parentheses (* denotes p<.10, ** denotes p<.05, *** denotes p<.01). All regressions include product fixed effects. 2SLS denotes Instrumental Variables estimation.

TABLE 4. Export quantities under financial constraints

Dependent variable: export quantity										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
price	2.813***	2.777***	2.788***	0.219***	0.211***	0.200***	2.716***	2.727***	2.786***	2.797***
	(24.82)	(24.96)	(24.90)	(13.67)	(11.42)	(10.62)	(24.43)	(24.34)	(24.27)	(24.19)
financial rating		0.538***	0.375***				0.506***	0.349***	0.539***	0.364***
		(7.16)	(3.17)				(6.59)	(2.91)	(6.92)	(3.01)
distance				-0.134***			-0.051***	-0.050**	-0.002	-0.001
				(-7.08)			(-2.59)	(-2.51)	(-0.11)	(-0.04)
gdp per capita					0.075***		0.259***	0.260***	0.244***	0.246***
					(3.30)		(8.52)	(8.48)	(7.95)	(7.92)
gdp						0.081***	0.128***	0.129***	0.156***	0.157***
						(7.99)	(10.77)	(10.74)	(12.47)	(12.42)
number of firms per product									-0.234***	-0.243***
									(-18.41)	(-18.44)
number of firms per product-destination									0.014***	0.014***
									(8.15)	(8.10)
destination FE	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO
firm FE	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO
N	17061	17061	16844	16314	16368	16368	16314	16103	16314	16103
R^2	0.492	0.501	0.493	0.685	0.684	0.684	0.503	0.495	0.492	0.484

Notes:
All variables are in logs. The regressions include a constant term and *t* statistics based on robust standard errors are in parentheses (* denotes p<.10, ** denotes p<.05, *** denotes p<.01). The coefficient on (the negative of) *price* is interpreted as the absolute value of the price elasticity of demand. All regressions include product fixed effects. *qtfp* has been used as instrument for *prices*. In Columns (3), (9) and (10), average rating has been used as instrument for *financial rating*.

TABLE 5. Export demand elasticities under financial constraints

Dependent variable: export quantity												
	all firms						high-rated firms			low-rated firms		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
price	3.272***	-0.671***	0.447***	0.568***	5.311***	5.808***	5.282***	7.577***	8.080***	2.505***	3.766***	4.084***
	(24.07)	(-3.26)	(3.50)	(2.86)	(19.13)	(19.44)	(7.21)	(8.28)	(8.61)	(4.88)	(4.78)	(5.03)
price x financial rating	-0.073***				-0.072***	-0.076***	-0.186**	-0.240***	-0.263***	-0.058	-0.051	-0.026
	(-8.66)				(-8.16)	(-8.48)	(-2.42)	(-3.00)	(-3.27)	(-0.72)	(-0.57)	(-0.29)
price x distance		0.089***			0.044***	0.010		0.108***	0.075**		0.051	0.014
		(6.91)			(3.26)	(0.66)		(3.72)	(2.41)		(1.24)	(0.32)
price x gdp per capita			-0.047		-0.145***	-0.140***		-0.177***	-0.169***		-0.069	-0.057
			(-0.48)		(-8.07)	(-7.71)		(-4.74)	(-4.50)		(-1.53)	(-1.27)
price x gdp				-0.052***	-0.082***	-0.097***		-0.075***	-0.086***		-0.089***	-0.107***
				(-4.00)	(-12.22)	(-13.58)		(-5.69)	(-6.39)		(-4.50)	(-5.05)
number of firms per product						-0.265***			-0.596***			-0.072
						(-14.21)			(-6.79)			(-1.34)
number of firms per product-destination						0.017***			0.016***			0.021***
						(8.74)			(3.86)			(4.19)
firm FE	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO
destination FE	YES	NO	NO	NO	NO	NO	YES	NO	NO	YES	NO	NO
N	17061	16314	16368	16368	16314	16314	6280	6012	6012	2378	2265	2265
R^2	0.485	0.664	0.665	0.657	0.462	0.442	0.453	0.404	0.394	0.706	0.678	0.674

Notes: All variables are in logs. The regressions include a constant term and *t* statistics based on robust standard errors are in parentheses (* denotes p<.10, ** denotes p<.05, *** denotes p<.01). The coefficients on (the negative of) *price* and its interaction terms yield the absolute value of the price elasticity of demand. All regressions include product fixed effects. *qtfp* has been used as instrument for prices.

TABLE 6. Export demand elasticities under financial constraints: sensitivity analysis

Dependent variable: export quantity									
	consumption goods			differentiated goods			one product per destination		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
price	2.778***	4.402***	4.954***	2.868***	4.190***	4.628***	3.545***	5.199***	5.888***
	(10.45)	(9.21)	(9.31)	(17.76)	(13.95)	(14.30)	(15.49)	(10.52)	(11.09)
price x financial rating	-0.043***	-0.037***	-0.044***	-0.046***	-0.046***	-0.051***	-0.112***	-0.114***	-0.125***
	(-3.60)	(-3.09)	(-3.48)	(-5.11)	(-4.83)	(-5.20)	(-5.61)	(-5.28)	(-5.52)
price x distance		0.083***	0.048**		0.036**	0.005		0.094***	0.050*
		(4.20)	(2.26)		(2.55)	(0.33)		(3.93)	(1.90)
price x gdp per capita		-0.169***	-0.161***		-0.093***	-0.087***		-0.150***	-0.143***
		(-6.00)	(-5.63)		(-4.86)	(-4.50)		(-5.16)	(-4.77)
price x gdp		-0.058***	-0.073***		-0.060***	-0.074***		-0.069***	-0.086***
		(-6.41)	(-7.48)		(-8.41)	(-9.69)		(-5.53)	(-6.43)
number of firms per product			0.015***			-0.230***			0.050***
			(11.68)			(-10.59)			(5.38)
number of firms per product-destination			0.017***			0.015***			0.024***
			(5.10)			(7.48)			(6.57)
destination FE	YES	NO	NO	YES	NO	NO	YES	NO	NO
N	3932	3782	3782	10338	9898	9898	5264	4972	4972
R^2	0.398	0.379	0.346	0.498	0.481	0.463	0.566	0.525	0.493

Notes: See Table 5.