FINANCIAL FRICTIONS, PRODUCT QUALITY, AND INTERNATIONAL TRADE

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Abstract

Product quality plays a key role in economics, but differs markedly across countries and industries. What are the determinants and implications of this pattern? In this paper, we test an explanation for the large heterogeneity in product quality that rests on the interplay between cross-country differences in financial frictions and cross-industry differences in financial vulnerability. To guide the empirical analysis, we rely on a simple trade model featuring heterogeneous firms, endogenous output quality, country heterogeneity in financial frictions, and industry heterogeneity in financial vulnerability. The model clearly illustrates how the interaction of financial frictions and financial vulnerability shapes the geographical and sectoral variation in product quality. We estimate the model using a novel data set, which contains proxies for export quality, financial development, and financial vulnerability for virtually all manufacturing industries and countries in the world, over a period that spans the last three decades. Our results show that the interplay between financial frictions and financial vulnerability is a main driver of the observed variation in product quality across countries and industries. The model also suggests that quality adjustments are an important mechanism through which financial development affects international trade and shapes countries' export structure. We find strong evidence consistent with this implication.

JEL Codes: F14, F36, G20.
Keywords: Credit Market Imperfections; Financial Vulnerability; Product Quality; Export Structure.

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1 Introduction

Product quality plays a central role in economics. Scholars have long argued that the production of high-quality goods influences key aspects of countries' economic performance, including international trade, employment and wages, growth, and development.[1] However, not all countries are able to produce high-quality goods. Rather, it is well documented that average product quality varies widely across countries; moreover, cross-country differences in product quality vary substantially across industries; see Schott (2004), Khandelwal (2010), Hallak and Schott (2011), Feenstra and Romalis (2014), and our own data presented below (Figure 1 and Table 1).[2] This evidence begs the important question of what may explain such a large heterogeneity in product quality. So far, the literature seems to agree on two main determinants: cross-country differences in skill and capital endowments (Schott, 2004) and economic development (e.g., Hummels and Klenow, 2005; Hallak, 2006, 2010).[3]

This paper makes two contributions to the literature. First and foremost, it tests an alternative explanation that rests on the interplay between country heterogeneity in *financial frictions* (King and Levine, 1993) and industry heterogeneity in *financial vulnerability* (Rajan and Zingales, 1998; Claessens and Laeven, 2003). We provide the first evidence that the interaction of these country and industry characteristics is a major determinant of the geographical and sectoral variation in average product quality. Second, the paper shows that quality adjustments are a key mechanism through which financial frictions affect specialization and trade (Beck, 2002; Manova, 2013). Thereby, we dig out a possible new explanation behind the long-run evolution of comparative advantage.

To motivate our analysis and illustrate the key patterns in our data, in Figure 1 we show the relationship between the average quality of countries' products and their financial development. The sample includes 171 countries over 1988-2011. Financial development is proxied by the average ratio of private credit to GDP, while quality is proxied using two standard measures: log export prices (unit values) in the first graph and a more precise indicator introduced by Khandelwal (2010) in the second.[4] Each graph plots the raw correlation between average quality and financial development (black circles), as well as the partial correlation after controlling for per capita GDP and the endowments of skill labor and capital (red circles). Average product quality is strongly positively correlated with financial development, independently of the proxy and even after accounting for the main alternative explanations considered in the literature. This suggests that cross-country differences in financial frictions may play an important role in explaining the large variation in product quality observed around the world.

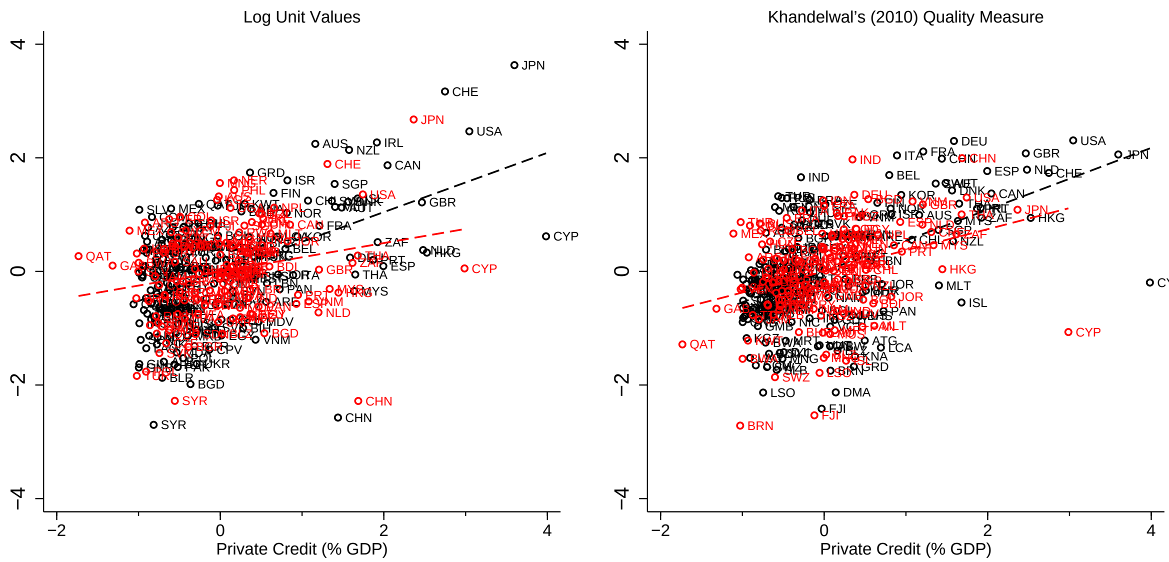
[1]Grossman and Helpman (1991) and Aghion and Howitt (1992) discuss the role of quality upgrading for growth; see Aghion and Howitt (2005) and Gancia and Zilibotti (2005) for comprehensive reviews of this literature. Flam and Helpman (1987) and Fajgelbaum et al. (2011) are representative of a strand of research pointing out the role of quality in international trade. Brooks (2006) and Verhoogen (2008) highlight the importance of quality for export success in developing countries. Feenstra and Romalis (2014) discuss the consequences of product quality for countries' terms of trade. Finally, Khandelwal (2010) and Verhoogen (2008) emphasize the implications of quality for employment and wages, and Hidalgo et al. (2007) those for development.

[2]These studies use highly disaggregated, product-level, export data to infer the average quality of goods produced in different countries and industries. In this paper we embrace the same approach. See Section 4 for details on the methodology to estimate quality, and the notes to Figure 1 and Table 1 for details on the data.

[3]We discuss other, less investigated, explanations later on in the paper.

[4]Khandelwal's (2010) measure attributes higher quality to products that display larger market shares conditional on prices. It thus relaxes the assumption, implicit in the first graph, that higher prices only reflect higher quality. Nowadays, this measure is widely used in the literature and is superseding unit values. It thus constitutes our preferred proxy.

Figure 1: Financial Development and Product Quality across Countries



β= 0.522, s.e.= 0.085, R^2= 0.27. β= 0.249, s.e.= 0.129, R^2= 0.44. β= 0.544, s.e.= 0.073, R^2= 0.30. β= 0.372, s.e.= 0.122, R^2= 0.39.

Notes: Each circle corresponds to a country (171 overall). Private credit is the amount of credit issued by commercial banks and other financial institutions to the private sector (source: *Global Financial Development Database*). It is averaged over 1988-2011 and standardized. Unit values and Khandelwal's (2010) measure are constructed using data on each country's exports to all the members of the European Union, at the 8-digit level of product disaggregation (source: *Comext*). Each proxy is calculated separately for each pair of countries (exporter and importer), year, and manufacturing industry (273 overall). Then, it is divided by its average within a given importer, industry, and time period. This yields a measure of the relative quality of each exporter's goods in the same destination market, industry, and year, and thereby ensures comparability. The figure plots the standardized value of the mean relative quality for each country. The black circles refer to the unconditional correlation between average quality and financial development, whereas the red circles refer to the partial correlation after controlling for log per capita GDP (source: *World Development Indicators*), log capital stock per worker, and log years of schooling (source: *Penn World Tables 8.0*).

At the same time, Table 1 shows that the cross-country relationship between financial frictions and average product quality varies systematically across industries, depending on their financial vulnerability. The table classifies the 171 countries into two groups, with high or low levels of financial development. Similarly, it classifies 273 manufacturing industries into two groups, with high or low levels of financial vulnerability. As customary, the latter is proxied by the share of capital expenditures not financed through cash flow ('external finance dependence'; Rajan and Zingales, 1998) and by the share of tangible—hence collateralizable—assets in total assets ('asset tangibility'; Claessens and Laeven, 2003). Each cell in the table reports a proxy for average quality across all countries and industries belonging to it. Note that, while average quality increases with financial development in all industries, it does especially so in financially more vulnerable ones, where firms rely more on outside capital and have less collateral.[5]

In Section 2, we start by illustrating a simple theory that will guide our empirical analysis and clarify the main insight behind our interpretation of the evidence. The theory rests on standard ingredients. In particular, it builds on the multi-country trade model with firm productivity heterogeneity (*a la* Melitz,

[5]Our empirical analysis will provide more systematic evidence on the differential impact of financial development across industries with different financial vulnerability. As explained below, we will use an approach that resembles a difference-in-differences, and is similar to the strategy used by Rajan and Zingales (1998) and Manova (2013) to study the effects of financial development on growth and exports, respectively. Compared to a naive cross-country regression like the one in Figure 1, this approach drastically allays concerns with omitted variables and improves the identification of the effect of financial frictions.

Table 1: Financial Development, Financial Vulnerability, and Product Quality

a) Log Unit Values	External Finance Dep.			Asset Tangibility		
Financial Development	Low	High	Diff.	Low	High	Diff.
Low	-0.15	-0.17	-0.02	-0.32	0.01	0.33
High	0.03	0.04	0.01	-0.05	0.11	0.16
Difference	0.18	0.21	0.03	0.27	0.10	-0.17
b) Khandelwal's (2010) Measure	External Finance Dep.			Asset Tangibility		
Financial Development	Low	High	Diff.	Low	High	Diff.
Low	0.30	0.07	-0.23	0.22	0.16	-0.06
High	0.39	0.23	-0.15	0.35	0.28	-0.06
Difference	0.09	0.16	0.07	0.13	0.12	-0.01

Notes: External finance dependence is the share of capital expenditures not financed with cash flow from operations. Asset tangibility is the share of net property, plant, and equipment in total assets. Both measures are computed as the median value across all US firms in *Compustat* between 1988 and 2012. The 273 manufacturing industries are divided into two groups, based on whether each measure is above or below the sample median. Similarly, the 171 countries are divided into two groups, based on whether average private credit is above or below the sample median. Each cell reports the median value of a quality measure (averaged over destination markets and years, and then standardized) across all countries and industries belonging to that cell.

2003) developed by Helpman et al. (2008), and subsequently extended by Manova (2013) to allow for country heterogeneity in financial frictions and for multiple industries heterogeneous in financial vulnerability.[6] In this framework, we embed the standard mechanism through which liquidity constraints influence the choice of output quality by firms, as originally introduced by Fan et al. (2013) and subsequently used by Ciani and Bartoli (2013) in one-sector models. To this purpose, different from the original formulation in Manova (2013) and in line with a well-established literature (e.g., Kugler and Verhoogen, 2012; Crinò and Epifani, 2012; Ciani and Bartoli, 2013; Fan et al., 2013; Hallak and Sivadasan, 2013), we assume that output quality is endogenous, and that firms choose it to optimize a trade-off between higher revenues and larger fixed costs of quality upgrading.[7] These costs reflect the fact that producing higher-quality goods requires investments in R&D, innovation, and marketing, which are mostly fixed outlays (Sutton, 2001, 2007). Firms cannot finance these investments entirely with internal funds, so they need to borrow from external investors.

The model clearly shows that, in equilibrium, the interplay between financial frictions and financial vulnerability is an important determinant of the geographical and sectoral variation in average product quality. Specifically, the model highlights two margins through which financial development affects the average quality of products sold by a country in a given destination and industry. First, financial development raises the quality of goods sold by incumbent firms, as better credit conditions loosen their liquidity constraint and allow them to finance higher fixed costs of quality upgrading (intensive margin). This effect is more pronounced in financially more vulnerable industries, where firms rely more on external financing and have fewer tangible assets to pledge as collateral. Second, financial development induces new firms to enter the market. This reduces the average quality of products sold therein by

[6] Chaney (2013) and Feenstra et al. (2014) are other leading examples of heterogeneous-firms trade models with financial frictions. These studies overcome the main limitation of earlier models with a representative firm (e.g., Kletzer and Bardhan, 1987; Beck, 2002; Matsuyama, 2005; Ju and Wei, 2011), namely, the fact that in those models either all or no producers export when the economy opens to trade.

[7] For related heterogeneous-firms trade models with endogenous quality, see Verhoogen (2008), Johnson (2012), and Feenstra and Romalis (2014). These models do not envisage fixed costs of quality upgrading. For models with exogenous quality, see instead Baldwin and Harrigan (2011) and Crozet et al. (2012).

the country, because the new entrants are less productive than the incumbents and thus produce lower-quality goods (extensive margin). Also this effect is generally stronger in financially more vulnerable industries.

We are not aware of any study that has tested the empirical relevance of these implications and quantified the importance of this explanation compared with more consolidated theories. In Section 3, we therefore present our empirical strategy for studying these issues. Quite naturally, the model delivers an equation that links the average quality of goods sold by a country in a given destination and industry to the financial variables. To bring this equation to the data, we use a standard parametrization for bilateral trade frictions and production costs, and derive an empirical specification that can be estimated using standard techniques. Importantly, we show that the model yields a specification that includes full sets of country and destination-industry fixed effects, and is therefore reminiscent of a difference-in-differences (DID) specification: it establishes causality by exploiting the combination of cross-country variation in financial development and cross-industry variation in financial vulnerability, while controlling for any country characteristic that could affect product quality uniformly across industries and destination markets. Next, we extend a two-step estimation procedure proposed by Helpman et al. (2008) and Manova (2013) to untangle and quantify the contributions of the extensive and intensive margins. The procedure also corrects for the sample selection bias originating from the fact that the quality equation is estimated on the sub-sample of observations with positive trade flows. Our technical contribution is to adapt the original procedure to cases in which the outcome variable is not bilateral trade (as in Helpman et al., 2008 and Manova, 2013), but an average quantity such as average product quality in our case.

To estimate the model, we use data on the exports of 171 countries to all the members of the European Union (EU) over 1988-2011. These data are described in Section 4. Unlike data on domestic production, the trade data are available and comparable for many countries and years. Moreover, they are reported at a higher level of product disaggregation (8-digit in our case). For these reasons, these data are commonly used in the literature to infer product quality.[8] Using Khandelwal's (2010) methodology, we construct time-varying estimates of the average quality of goods sold by each country in each EU member, within 273 manufacturing industries. This is the empirical counterpart of the average quality derived in the model, and serves as the dependent variable in our DID-like specification.

The empirical analysis unfolds in Section 5. We find strong evidence that the interplay between country heterogeneity in financial frictions and industry heterogeneity in financial vulnerability is an important predictor of quality variation across countries and industries. Specifically, our results show that financial development raises average product quality relatively more in industries where firms rely more on external financing and have fewer collateralizable assets. We show that this result is strikingly robust across alternative samples and many different ways of measuring product quality, financial development, and financial vulnerability. We also consider several competing explanations, and show that controlling for factor endowments, economic development, and many other forces of change does not overturn this result. Moreover, we extensively discuss remaining concerns with endogeneity. In this respect, we argue that the specific pattern of our coefficients cannot be easily generated by alternative stories based on reverse causality. To further substantiate this argument, we show that our evidence is

[8]See, in particular, Khandelwal (2010), Hallak and Schott (2011), Amiti and Khandelwal (2012), Colantone and Crinò (2014), and Feenstra and Romalis (2014).

unchanged when exploiting two sources of exogenous variation in the ability of the environment to provide credit: equity market liberalizations (Manova, 2008) and systemic banking crises (Kroszner et al., 2007).

Next, we study the two margins that, according to the model, could underlie the effect of financial frictions on average product quality. We find robust evidence that quality adjustments within incumbent firms (the intensive margin) explain 75-80% of the aggregate effect of financial frictions on average quality; the combination of firm selection (the extensive margin) and sample selection bias explains the remaining 20-25% of the effect. To the best of our knowledge, we are the first to point out the existence of these two margins, untangle them, and quantify their contributions. It is reassuring, therefore, that our results are in line with the evidence from other studies focusing on different effects of financial frictions. In particular, they are in line with recent findings by Midrigan and Xu (2014), who show that, in a sample of Korean firms, most of the TFP effect of financial frictions occurs within firms. Our results support their explanation that financial frictions induce severe within-firm distortions in the decision to upgrade technology. Moreover our findings, obtained with a semi-structural estimation procedure applied to cross-country data, are broadly consistent with a sparse micro-level research, based on reduced-form regressions for a few individual countries, providing evidence of a within-firm correlation between indicators of financial health or liquidity constraints and specific quality proxies for individual products, such as firms' self-assessed quality in Italy (Ciani and Bartoli, 2013) and export-based indicators in China and France (Fan et al., 2013; Bernini et al., 2013).

Finally, we discuss the economic significance and implications of our results. We start by quantifying the contribution of financial frictions and financial vulnerability to the observed heterogeneity in average quality across countries and industries. Using different exercises, we show that the financial variables have quantitatively similar effects to factor endowments and economic development, so far the most accredited explanations for the observed variation in product quality. Then we re-consider, through the lens of these results, the effects of financial frictions on specialization and trade, which have been the object of a vast and important empirical literature. The model has new implications for how financial frictions can affect trade flows and countries' export structure. In particular, it suggests that cross-industry differences in the sensitivity of average quality to financial frictions may be an important mechanism through which financial development shapes the industrial composition of countries' exports. In this regard, our empirical findings evoke a new explanation for the well-known evidence that financially more developed countries export relatively more in financially more vulnerable industries (Beck, 2002; Manova, 2013).[9] Namely, they suggest that this fact may be due to financial development giving a stronger boost to average product quality in those industries. Consistent with this argument, we find that quality adjustments explain a large portion (between 25% and more than 100%) of the overall impact of financial development on exports across sectors. To strengthen this conclusion, we provide evidence that the standard model with exogenous and homogeneous quality is largely inconsistent with other important features of the data, which instead line up closely with the predictions of a model in which quality is endogenous.

In addition to the work cited above, our paper is related to two other literatures. First, we brush

[9] See Beck (2003), Manova (2008), Chor (2010), Chor and Manova (2012), and Chan and Manova (2013) for other important studies on financial development and export structure. Nunn and Trefler (2015) provide an excellent review of the literature.

against the empirical literature on credit constraints and firms' exports.[10] We complement this literature by analyzing the macro-level relationships between finance, quality, specialization, and trade, which are out of the scope of these studies. Second, we make contact with the important macro literature on the real effects of financial frictions.[11] We weigh in on the debate by providing novel evidence that financial frictions affect dimensions of the real economy (i.e., the ability of countries to produce high-quality goods) that go beyond the ones traditionally considered in the literature.

2 Theoretical Framework

In this section we illustrate a static, partial equilibrium, theory that will guide our empirical analysis. The theory builds on the multi-country trade model with heterogeneous firms developed by Helpman et al. (2008), and subsequently extended by Manova (2013) to allow for country heterogeneity in financial frictions and for multiple industries heterogeneous in financial vulnerability. Different from the original model and in line with a well-established literature (e.g., Kugler and Verhoogen, 2012; Crinò and Epifani, 2012; Ciani and Bartoli, 2013; Fan et al., 2013; Hallak and Sivadasan, 2013), firms endogenously choose the quality of their products to optimize a trade-off between higher revenues and larger fixed costs of quality upgrading. Our main objective is to study how the interplay between financial frictions and financial vulnerability affects the average quality of goods sold by a given country in different destinations and industries.

2.1 Set-Up

Preferences and demand We consider a world with J countries, indexed by $i, j = 1, .., J$. In each country there are S industries, indexed by $s = 1, .., S$. Each industry consists of a continuum of differentiated products, labeled by l. The representative consumer in country j has the following Cobb-Douglas preferences:

$$U_j = \prod_s C_{js}^{\vartheta_s} , \quad \vartheta_s \in (0,1) , \tag{1}$$

where ϑ_s is the share of total spending R_j devoted to the goods produced in industry s, with $\sum_s \vartheta_s = 1$. The terms C_{js} are industry-specific CES aggregators of the following form:

$$C_{js} \equiv \left[\int_{l \in B_{js}} \left(q_{js} (l) \, x_{js} (l) \right)^{\alpha} dl \right]^{1/\alpha} , \quad \alpha \in (0,1) , \tag{2}$$

where B_{js} is the set of industry-s products available for consumption in country j, $x_{js}(l)$ is consumption of product l, $q_{js}(l) \geq 1$ is its quality, and $\varepsilon \equiv (1-\alpha)^{-1} > 1$ is the elasticity of substitution between any two products. As customary, we describe quality as a uni-dimensional metric translating physical units

[10] See, in particular, Greenaway et al. (2007), Minetti and Zhu (2011), Amiti and Weinstein (2011), Paravisini et al. (2011), Bricongne et al. (2012), and Behrens et al. (2013).

[11] See, e.g., King and Levine (1993) and Rajan and Zingales (1998) on growth effects; Erosa and Cabrillana (2008), Buera et al. (2011), Buera and Shin (2013), and Midrigan and Xu (2014) on TFP effects; Michelacci and Quadrini (2009), Bonhomme and Hospido (2012), Chodorow-Reich (2013), and Bentolila et al. (2013) on labor market effects; and Aghion et al. (2005), Antràs and Caballero (2009), Antràs et al. (2009), Aghion et al. (2010), Manova et al. (2011), Gorodnichenko and Schnitzer (2013), and Bilir et al. (2014) on investment effects. Matsuyama (2008) provides a comprehensive survey of this literature.

into utils: the higher is quality, the greater is the utility the consumer receives from one unit of the good.

Maximization of (1) subject to a budget constraint yields the following expression for the demand of good l in country j:

$$x_{js}(l) = \frac{q_{js}(l)^{\varepsilon-1} p_{js}(l)^{-\varepsilon} Y_{js}}{P_{js}^{1-\varepsilon}}, \tag{3}$$

where $Y_{js} \equiv \vartheta_s R_j$, $p_{js}(l)$ is the price of good l in country j, and

$$P_{js} = \left[\int_{l \in B_{js}} \left(\frac{p_{js}(l)}{q_{js}(l)} \right)^{1-\varepsilon} dl \right]^{1/(1-\varepsilon)}$$

is the ideal, quality-adjusted, price index associated to (2). Note that demand is decreasing in the price and increasing in the quality of the good.

Entry and production In a given country j and industry s, there is a measure N_{js} of active firms. Each firm produces a different product under monopolistic competition. To enter the industry, each firm pays a sunk cost equal to $c_{js} f_{ej}$, where f_{ej} is the number of units of an input bundle and c_{js} is the cost of each unit; this cost is specific to each country and industry. After paying the sunk entry cost, each firm discovers its productivity $1/a$, where a is the number of units of the input bundle used by the firm to produce one unit of output. We assume that the distribution of a across firms is described by a continuous c.d.f. $G(a)$ with support $[a_L, a_H]$, where $0 < a_L < a_H$. The density of $G(a)$ is denoted by $g(a)$. This distribution is the same across countries and industries.[12]

To produce a good for destination i, a country-j firm active in industry s incurs a marginal cost equal to:

$$MC_{ijs}(a) = \omega_{ijs}(a)\, q_{ijs}^{\delta}, \quad \omega_{ijs}(a) \equiv \tau_{ij} c_{js} a, \quad \delta \in [0,1), \tag{4}$$

where $\tau_{ij} > 1$ is an iceberg trade cost that needs to be paid for shipping goods from j to i, δ is the elasticity of marginal cost to product quality, and $\omega_{ijs}(a)$ can be interpreted as a measure of the marginal cost per unit of quality.[13] In (4), q is indexed by i because we assume that firms can sell goods of different quality in different destination markets. This assumption is common to most heterogeneous-firms models with endogenous quality (e.g., Verhoogen, 2008; Crinò and Epifani, 2012; Ciani and Bartoli, 2013; Fan et al., 2013; Feenstra and Romalis, 2014). It generates quality variation across destination markets for the same firm-product pair, consistent with an overwhelming amount of empirical evidence.[14]

Following Sutton (2001, 2007), we also assume that producing higher-quality products entails higher fixed costs. This captures the fact that quality upgrading requires investments in R&D, innovation, and marketing, which are mostly fixed outlays. We make use of the standard formulation in the recent heterogeneous-firms literature with endogenous quality (e.g., Crinò and Epifani, 2012; Kugler and Verhoogen, 2012; Ciani and Bartoli, 2013; Fan et al., 2013; Hallak and Sivadasan, 2013). Namely, we posit

[12] The a's capture productivity differences across active firms in the same country and industry. Aggregate differences across countries and industries are subsumed in the c_{js}'s.

[13] Marginal cost may be increasing in quality if, for instance, higher-quality products require better inputs (see, e.g., Verhoogen, 2008; Johnson, 2012; Kugler and Verhoogen, 2012).

[14] See Verhoogen (2008) for an interesting case study, and Bastos and Silva (2010) and Manova and Zhang (2012) for econometric evidence based on firm-product level data sets for different countries.

that producing a good of quality q_{ijs} requires a fixed cost equal to:

$$RD_{ijs} = c_{js} q_{ijs}^{\gamma}, \tag{5}$$

where $\gamma > 0$ is the elasticity of the fixed cost to product quality. Eq. (3) and (5) show that quality upgrading involves a trade-off between higher demand (hence revenues) and higher fixed costs. Finally, we make the standard assumption (Melitz, 2003) that entering a destination i involves a fixed cost equal to:

$$E_{ijs} = c_{js} f_{ij}. \tag{6}$$

Financial frictions and financial vulnerability Following Manova (2013) we assume that, while all variable costs can be funded internally, a fraction $d_s \in (0, 1)$ of the fixed costs must be borne up-front, before revenues are realized. Hence, a country-j firm producing in industry s needs to borrow $d_s \left(RD_{ijs} + E_{ijs}\right)$ from external investors to service destination i; see Ciani and Bartoli (2013) and Fan et al. (2013) for a similar formulation.[15] To be able to borrow, firms must pledge collateral. As in Manova (2013), we assume that a fraction $t_s \in (0, 1)$ of the sunk entry cost is invested in tangible assets, which can be used as collateral. The parameters d_s and t_s describe the financial vulnerability of an industry: the higher is d_s and the lower is t_s, the financially more vulnerable is industry s. As customary, we assume that d_s and t_s vary across industries due to innate technological factors (e.g., the nature of the production process or the cash harvest period), which are exogenous from the perspective of each firm.

Countries differ in their level of financial development, and thus in the strength of financial frictions facing domestic firms. To parsimoniously capture all factors that could influence the ability of the environment to facilitate transactions between investors and firms, we assume, as in Manova (2013), that each country has a different degree of financial contractibility. This means that an investor in country j can expect to be repaid with probability $\lambda_j \in (0, 1)$. Instead, with probability $1 - \lambda_j$, the contract is not enforced and the investor seizes the collateral

$$CO_{js} = t_s c_{js} f_{ej}. \tag{7}$$

In this case, the firm needs to replace the collateral to be able to borrow again in the future.[16]

At the beginning of the period, each firm signs a contract with an investor. The contract specifies: (*a*) how much the firm needs to borrow, (*b*) the amount F_{ijs} that will be paid to the investor if the contract is enforced, and (*c*) the value of the collateral that will be seized by the investor if the contract is not enforced. After that, revenues are realized, and the investor is paid at the end of the period.

[15] As discussed by Manova (2013), the underlying assumption is that firms cannot use the profits earned in previous periods to finance the fixed costs, for instance, because they have to distribute all profits to their shareholders. Alternatively, and equivalently, d_s can be interpreted as the fraction of the fixed costs that remains to be financed externally after having used all the past profits. The assumption that variable costs are financed internally squares well with the evidence in Sutton (2001, ch. 4) and Sutton (2007, ch. 5). Indeed, the investments firms make for upgrading quality are mostly fixed outlays, and part of these investments are faced well before the project pays off. Accordingly, it is realistic that most of the outside capital used by firms to produce higher-quality goods covers the fixed rather than the variable costs of quality upgrading.

[16] In reality, firms may also use letters of credit to borrow from investors located in the importing country. This form of international trade finance accounts for a small share of the total funding raised by firms, and still requires an active role by domestic credit institutions (Manova, 2013). In any case, given that our empirical specification includes a full set of importer-industry-year fixed effects (see Section 5), it fully controls for the role of financial frictions in the destination markets.

2.2 Firms' Problem

A country-j firm in industry s chooses a price p_{ijs}, quality q_{ijs}, and payment F_{ijs} to maximize profits in destination market i. In particular, the firm solves the following problem:

$$\max_{p,q,F} \left[\left(p_{ijs} - MC_{ijs}(a) \right) x_{ijs} - (1-d_s) \left(RD_{ijs} + E_{ijs} \right) \right] - \left[\lambda_j F_{ijs} + \left(1-\lambda_j\right) CO_{js} \right] \tag{8}$$

$$\text{subject to} \quad \left(p_{ijs} - MC_{ijs}(a) \right) x_{ijs} - (1-d_s) \left(RD_{ijs} + E_{ijs} \right) \geq F_{ijs} \tag{9}$$

$$\text{and to} \quad \lambda_j F_{ijs} + \left(1-\lambda_j\right) CO_{js} \geq d_s \left(RD_{ijs} + E_{ijs} \right), \tag{10}$$

where the demand x_{ijs}, the marginal cost $MC_{ijs}(a)$, the fixed costs RD_{ijs} and E_{ijs}, and the collateral CO_{js} are specified in eq. (3)-(7), respectively.[17] Intuitively, (8) shows that each firm maximizes the difference between the cash flow from operations in market i (the first square-bracketed term) and the expected cost of the loan (the second square-bracketed term). The cash flow is equal to the operating profits earned by the firm in country i minus the fraction of the fixed costs funded internally. The expected cost of the loan is instead equal to the probability-weighted average of the payment made to the investor if the contract is enforced and the collateral seized by the investor if the contract is not enforced. Firms' decisions are subject to two constraints. Eq. (9) is the liquidity constraint of the firm, which states that in case of repayment the firm can promise the investor at most its cash flow. Eq. (10) is instead the participation constraint of the investor, which states that the value of the loan cannot exceed the expected return from the investment.[18] With competitive credit markets, investors break even in expectation. Hence, firms adjust F_{ijs} so that (10) always holds as an equality.

2.3 Firms' Decisions

Benchmark case without financial frictions It is useful to start from a benchmark case without financial frictions. In this situation, $\lambda_j = 1$, and a country-j firm in industry s simply chooses p_{ijs} and q_{ijs} to maximize profits in destination i:

$$\max_{p,q} \left(p_{ijs} - MC_{ijs}(a) \right) x_{ijs} - \left(RD_{ijs} + E_{ijs} \right).$$

[17] The dependence of x_{ijs}, $MC_{ijs}(a)$, and RD_{ijs} on q_{ijs} is understood, and is thus left implicit to avoid excessive clutter in the notation.

[18] As discussed by Manova (2013), the model can be easily extended to allow for an exogenous interest rate ι. In this case, the right-hand side of (10) would become $(1+\iota)\, d_s \left(RD_{ijs} + E_{ijs} \right)$ and the qualitative predictions of the model would remain unchanged.

Using (3)-(6), the optimal price, quality, and revenues have the following expressions:

$$p_{ijs}(a) = \frac{\omega_{ijs}(a) \, q_{ijs}(a)^{\delta}}{\alpha}, \tag{11}$$

$$q_{ijs}(a) = q^{o}_{ijs}(a) = \left[\left(\frac{\omega_{ijs}(a)}{\alpha P_{is}} \right)^{1-\varepsilon} \frac{(\gamma - \tilde{\gamma}) \, Y_{is}}{\varepsilon \gamma c_{js}} \right]^{1/\tilde{\gamma}}, \tag{12}$$

$$r_{ijs}(a) = r^{o}_{ijs}(a) = \frac{\varepsilon \gamma c_{js}}{\gamma - \tilde{\gamma}} \left[\left(\frac{\omega_{ijs}(a)}{\alpha P_{is}} \right)^{1-\varepsilon} \frac{(\gamma - \tilde{\gamma}) \, Y_{is}}{\varepsilon \gamma c_{js}} \right]^{\gamma/\tilde{\gamma}}, \tag{13}$$

where $\tilde{\gamma} \equiv \gamma - (\varepsilon - 1)(1 - \delta) > 0$ by the second order condition for a maximum. Eq. (11) shows that the profit-maximizing price is a constant mark-up $1/\alpha$ over marginal cost. More interestingly, (12) shows that a given firm produces higher-quality goods for larger markets, and that more productive firms sell higher-quality products in all the destinations they serve. The reason is that, as shown by (13), firms' revenues are larger the greater is market size and the higher is firm productivity; in turn, with larger revenues, firms can afford paying higher fixed costs of quality upgrading. In (12) and (13), $q^{o}_{ijs}(a)$ and $r^{o}_{ijs}(a)$ denote the 'optimal' quality and revenues; we use this notation to distinguish these quantities from those arising when firms are liquidity constrained (see below). Finally note that, using (3) and (11), the quality-elasticity of revenues equals $(\varepsilon - 1)(1 - \delta)$. It follows that restricting δ to be smaller than 1 (see (4)) ensures revenues to be increasing in quality. Moreover, from (11), it also implies that quality-adjusted prices are decreasing in quality, consistent with empirical evidence (see, e.g., Baldwin and Harrigan, 2011).

Country-j firms enter destination i as long as their profits exceed the entry cost. This is the case for all firms with $a \leq a^{*}_{ijs}$, where a^{*}_{ijs} is defined by the following condition:

$$\frac{r^{o}_{ijs}\left(a^{*}_{ijs}\right)}{\varepsilon} - RD_{ijs}\left(a^{*}_{ijs}\right) = E_{ijs}.$$

Using (5), (6), (12), and (13), the solution for a^{*}_{ijs} is:

$$a^{*}_{ijs} = \left(\frac{\varepsilon c_{js} f_{ij}}{1 - \frac{\gamma - \tilde{\gamma}}{\gamma}} \right)^{\tilde{\gamma}/[\gamma(1-\varepsilon)]} \left(\frac{\gamma - \tilde{\gamma}}{\varepsilon \gamma c_{js}} \right)^{(1-\delta)/\gamma} Y_{is}^{1/(\varepsilon-1)} \frac{\alpha P_{is}}{\tau_{ij} c_{js}}. \tag{14}$$

It follows that only a fraction $G\left(a^{*}_{ijs}\right)$ of the N_{js} active firms sell in country i. This fraction may be zero, if no firm finds it profitable to enter country i. This is the case when $a^{*}_{ijs} < a_L$, i.e., when the least productive firm that can profitably sell in i has a coefficient a below the support of $G(a)$.

Firms' decisions with financial frictions When credit markets are imperfect, we need to distinguish two groups of firms among those exporting to a given destination: (a) firms for which the liquidity constraint is not binding and (b) liquidity-constrained firms. We now discuss the quality choice of each group of firms.

Consider first the firms for which the liquidity constraint is not binding. The cash flow of these firms is large enough to incentivize the creditor at financing the investment associated with the optimal quality.

Hence, these firms make the same decisions as in a model without financial frictions: their price, quality, and revenues are given by (11), (12), and (13), respectively. Since profits and cash flow are increasing in productivity, the liquidity-unconstrained firms are those with coefficient a below a certain threshold $\underline{a}_{ijs}$. Using (10)-(13) in the liquidity constraint (9) and evaluating the latter as an equality, $\underline{a}_{ijs}$ is defined by the following condition:

$$\frac{r^o_{ijs}\left(\underline{a}_{ijs}\right)}{\varepsilon}\left[1-\left(1-d_s+\frac{d_s}{\lambda_j}\right)\frac{\gamma-\tilde{\gamma}}{\gamma}\right]=c_{js}f_{ij}+\frac{1-\lambda_j}{\lambda_j}c_{js}\left(d_sf_{ij}-t_sf_{ej}\right), \tag{15}$$

and its solution reads as follows:

$$\underline{a}_{ijs}=\left\{\frac{\varepsilon\left[c_{js}f_{ij}+\frac{1-\lambda_j}{\lambda_j}c_{js}\left(d_sf_{ij}-t_sf_{ej}\right)\right]}{1-\left(1-d_s+\frac{d_s}{\lambda_j}\right)\frac{\gamma-\tilde{\gamma}}{\gamma}}\right\}^{\tilde{\gamma}/[\gamma(1-\varepsilon)]}\left(\frac{\gamma-\tilde{\gamma}}{\varepsilon\gamma c_{js}}\right)^{(1-\delta)/\gamma}Y_{is}^{1/(\varepsilon-1)}\frac{\alpha P_{is}}{\tau_{ij}c_{js}}. \tag{16}$$

By comparing (16) and (14), we see that $\underline{a}_{ijs}<a^*_{ijs}$ under the conventional assumption that $d_sf_{ij}>t_sf_{ej}$, which implies that firms' financing needs exceed their collateral.[19]

Note that, absent financial frictions, firms with $\underline{a}_{ijs}<a<a^*_{ijs}$ would enter market i with the optimal quality. But with imperfect credit markets, these firms are liquidity constrained and cannot achieve $q^o_{ijs}(a)$. Intuitively, the revenues of these firms are too low, so they cannot incentivize the creditor at financing the investment associated with the optimal quality: even if these firms offered the investor all of their revenues in case of repayment, the investor would not break even.

Then, what do these firms do? Some of them will have an incentive to choose quality below the first best. Recall that the fixed cost of quality upgrading, RD_{ijs}, is increasing in quality. Hence, by lowering quality, a firm reduces the value of the investment to be financed externally. While lower quality is also associated with lower revenues, the marginal reduction in revenues is initially smaller than that in the fixed cost.[20] For sufficiently productive firms, this extra cash flow is enough to satisfy the liquidity constraint. Obviously, because deviating from the optimal quality results in lower profits, each firm will deviate by just as much as is needed to make the constraint hold as an equality.

Formally, note that the assumption that all variable costs are funded internally implies that the optimal pricing rule of liquidity-constrained firms is also given by (11). Using this and (10) in (9), the liquidity constraint of these firms implies:

$$\frac{Y_{is}}{\varepsilon}\left(\frac{\omega_{ijs}(a)}{\alpha P_{is}}\right)^{1-\varepsilon}q_{ijs}(a)^{\gamma-\tilde{\gamma}}-\left(1-d_s+\frac{d_s}{\lambda_j}\right)c_{js}q_{ijs}(a)^{\gamma}\leq c_{js}f_{ij}+\frac{1-\lambda_j}{\lambda_j}c_{js}\left(d_sf_{ij}-t_sf_{ej}\right). \tag{17}$$

The right-hand side of (17) does not depend on quality (i.e., it is a constant). At the same time, it is easy to show that, for any given level of productivity $1/a$, a reduction in quality below $q^o_{ijs}(a)$ initially increases the left-hand side. This reflects the fact that, for small deviations from the optimal quality, the reduced funding needs exceed the loss in revenues, resulting in higher cash flow. At some point, however, the second effect starts dominating; at this point, further reductions in quality lower cash flow, reducing the

[19] Since $\lambda_j<1$, this is a sufficient, yet not necessary, condition for $\underline{a}_{ijs}<a^*_{ijs}$.

[20] Recall that, by the second-order condition for a maximum, the quality-elasticity of the fixed cost, γ, is greater than the quality-elasticity of revenues, $(\varepsilon-1)(1-\delta)$.

LHS of (17). To see this, differentiate the LHS with respect to $q_{ijs}(a)$ and write the resulting expression in terms of $q^o_{ijs}(a)$. The result is:

$$\frac{\partial LHS}{\partial q_{ijs}(a)} = q_{ijs}(a)^{\gamma-1}\,\gamma c_{js}\left[\left(\frac{q^o_{ijs}(a)}{q_{ijs}(a)}\right)^{\tilde{\gamma}} - \left(1 - d_s + \frac{d_s}{\lambda_j}\right)\right]. \tag{18}$$

Note that the second term in square brackets is a constant greater than 1, since $\lambda_j < 1$. Hence, there exists a range of quality levels below $q^o_{ijs}(a)$ for which (18) is negative, i.e., for which the LHS of (17) is decreasing in quality. Specifically, this is the case for all $q_{ijs}(a)$ between $q^c_{ijs}(a)$ and $q^o_{ijs}(a)$, where

$$q^c_{ijs}(a) = \left(1 - d_s + \frac{d_s}{\lambda_j}\right)^{-1/\tilde{\gamma}}\left[\left(\frac{\omega_{ijs}(a)}{\alpha P_{is}}\right)^{1-\varepsilon}\frac{(\gamma-\tilde{\gamma})\,Y_{is}}{\varepsilon\gamma c_{js}}\right]^{1/\tilde{\gamma}} \tag{19}$$

is the quality level at which (18) is equal to zero, i.e., the quality level that maximizes the LHS of (17).

Hence, a liquidity-constrained firm with coefficient a chooses the quality level between $q^c_{ijs}(a)$ and $q^o_{ijs}(a)$ that makes (17) hold as an equality. Because less productive firms realize lower revenues, they need to deviate more from the optimal quality to achieve this goal. In fact, there exists a firm with coefficient $\bar{a}_{ijs}$ that barely meets the liquidity constraint by setting quality at exactly $q^c_{ijs}(\bar{a}_{ijs})$. The cut-off $\bar{a}_{ijs}$ is therefore defined by the following condition, obtained by using (19) in (17) and evaluating the latter expression as an equality:

$$\frac{\tilde{\gamma} r^c_{ijs}(\bar{a}_{ijs})}{\gamma\varepsilon} = c_{js}f_{ij} + \frac{1-\lambda_j}{\lambda_j}c_{js}\left(d_s f_{ij} - t_s f_{ej}\right) \tag{20}$$

with

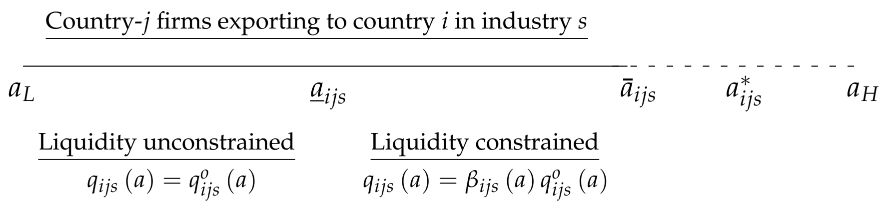
$$r^c_{ijs}(\bar{a}_{ijs}) = \left(1 - d_s + \frac{d_s}{\lambda_j}\right)^{-(\gamma-\tilde{\gamma})/\tilde{\gamma}}\frac{\varepsilon\gamma c_{js}}{\gamma-\tilde{\gamma}}\left[\left(\frac{\omega_{ijs}(\bar{a}_{ijs})}{\alpha P_{is}}\right)^{1-\varepsilon}\frac{(\gamma-\tilde{\gamma})\,Y_{is}}{\varepsilon\gamma c_{js}}\right]^{\gamma/\tilde{\gamma}}. \tag{21}$$

Finally, firms with $a > \bar{a}_{ijs}$ cannot profitably sell in destination i. Intuitively, these firms are very unproductive, so their revenues are too low for an investor to break even.[21]

Figure 2 summarizes the discussion so far. Firms with $a_L < a < \underline{a}_{ijs}$ are liquidity unconstrained, and choose the optimal quality $q^o_{ijs}(a)$. Firms with $\underline{a}_{ijs} < a < \bar{a}_{ijs}$ are liquidity constrained, and choose quality below the first best (written in the figure as a fraction $\beta_{ijs}(a) \in (0,1)$ of $q^o_{ijs}(a)$). Finally, firms with $a > \bar{a}_{ijs}$ are not productive enough to enter market i.

[21] It is easy to see that $\bar{a}_{ijs} < a^*_{ijs}$. To this purpose, re-write (17) for the firm with coefficient $\bar{a}_{ijs}$ as follows: $\frac{Y_{is}}{\varepsilon}\left(\frac{\omega_{ijs}(\bar{a}_{ijs})}{\alpha P_{is}}\right)^{1-\varepsilon} q^c_{ijs}(\bar{a}_{ijs})^{\gamma-\tilde{\gamma}} - c_{js}\left(q^c_{ijs}(\bar{a}_{ijs})^{\gamma} + f_{ij}\right) = \frac{1-\lambda_j}{\lambda_j}c_{js}\left[d_s\left(q^c_{ijs}(\bar{a}_{ijs})^{\gamma} + f_{ij}\right) - t_s f_{ej}\right]$. The LHS of this expression are the profits of this firm, which are strictly positive since the RHS>0. It follows that the least productive firm that can enter destination i is more productive than the marginal exporter in the absence of financial frictions.

Figure 2: Firms' Decisions with Financial Frictions



2.4 Average Quality

Aggregating across firms, the average quality of goods exported by j to i in industry s is given by:

$$\begin{aligned}\tilde{Q}_{ijs} &\equiv \int_{a_L}^{\underline{a}_{ijs}} q^o_{ijs}(a) \frac{g(a)}{G(\bar{a}_{ijs})} da + \int_{\underline{a}_{ijs}}^{\bar{a}_{ijs}} \beta_{ijs}(a)\, q^o_{ijs}(a) \frac{g(a)}{G(\bar{a}_{ijs})} da \\ &= \left[\left(\frac{\tau_{ij} c_{js}}{\alpha P_{is}} \right)^{1-\varepsilon} \frac{(\gamma - \tilde{\gamma})\, Y_{is}}{\varepsilon \gamma c_{js}} \right]^{1/\tilde{\gamma}} \left(\int_{a_L}^{\underline{a}_{ijs}} a^{(1-\varepsilon)/\tilde{\gamma}} \frac{g(a)}{G(\bar{a}_{ijs})} da + \int_{\underline{a}_{ijs}}^{\bar{a}_{ijs}} \beta_{ijs}(a)\, a^{(1-\varepsilon)/\tilde{\gamma}} \frac{g(a)}{G(\bar{a}_{ijs})} da \right). \quad (22)\end{aligned}$$

Eq. (22) shows that $\tilde{Q}_{ijs}$ responds both to the selection of firms into market i (governed by $\bar{a}_{ijs}$) and to the average quality of these firms' products (governed by $\underline{a}_{ijs}$ and $\beta_{ijs}(a)$). In particular, $\tilde{Q}_{ijs}$ is ceteris paribus increasing in $\underline{a}_{ijs}$ and $\beta_{ijs}(a)$, and decreasing in $\bar{a}_{ijs}$. The intuition is that a higher $\underline{a}_{ijs}$ or a higher $\beta_{ijs}(a)$ imply that some of the firms selling in i choose a higher quality level. This raises $\tilde{Q}_{ijs}$ other things equal ('intensive margin'). In contrast, a higher $\bar{a}_{ijs}$ implies that more firms sell in i. Because the new entrants are less productive than the incumbents, they produce lower-quality goods. This reduces $\tilde{Q}_{ijs}$ other things equal ('extensive margin'). In the next section, we discuss how each margin responds to the interplay between financial frictions and financial vulnerability.

2.5 Comparative Statics

We now study how $\underline{a}_{ijs}$, $\beta_{ijs}(a)$, and $\bar{a}_{ijs}$ depend on the degree of financial frictions in each country (proxied by λ_j) and financial vulnerability in each industry (proxied by d_s and t_s). Starting from $\underline{a}_{ijs}$ and $\beta_{ijs}(a)$, these quantities are defined by (15) and (17), respectively. The comparative-statics results are summarized in the following two propositions.

Proposition 1 *(Intensive margin, $\underline{a}_{ijs}$) The threshold $\underline{a}_{ijs}$ below which firms choose the optimal quality is ceteris paribus increasing in financial development ($\partial \underline{a}_{ijs}/\partial \lambda_j > 0$), the more so in financially more vulnerable industries ($\partial^2 \underline{a}_{ijs}/\partial \lambda_j \partial d_s > 0$ and $\partial^2 \underline{a}_{ijs}/\partial \lambda_j \partial t_s < 0$).*

Proof. See Appendix A. ■

Proposition 2 *(Intensive margin, $\beta_{ijs}(a)$) The quality of liquidity-constrained firms is ceteris paribus increasing in financial development ($\partial \beta_{ijs}(a)/\partial \lambda_j > 0$), the more so in financially more vulnerable industries ($\partial^2 \beta_{ijs}(a)/\partial \lambda_j \partial d_s > 0$ and $\partial^2 \beta_{ijs}(a)/\partial \lambda_j \partial t_s < 0$).*

Proof. See Appendix A. ■

The intuition behind these results is the following. Less harsh financial frictions correspond to a higher probability λ_j that the contract is enforced. Firms can thus promise the investor a lower payment F_{ijs}, while still guaranteeing that the investor breaks even in expectation. As a result, the share of firms that are liquidity unconstrained and achieve the optimal quality increases (higher $\underline{a}_{ijs}$). At the same time, the liquidity-constrained firms can raise quality closer to the first best (higher $\beta_{ijs}(a)$). Both effects are stronger in industries that rely more on external financing (higher d_s), as firms in these industries cover a larger fraction of their investments with outside capital. Similarly, both effects are stronger in industries with lower asset tangibility (lower t_s), as firms in these industries have less collateral.

Turning to $\bar{a}_{ijs}$, the latter is determined by (20). The comparative-statics results are summarized in the following proposition.

Proposition 3 *(Extensive margin, $\bar{a}_{ijs}$) The entry threshold $\bar{a}_{ijs}$ is ceteris paribus increasing in financial development ($\partial \bar{a}_{ijs}/\partial \lambda_j > 0$), the more so in industries with lower asset tangibility ($\partial^2 \bar{a}_{ijs}/\partial \lambda_j \partial t_s < 0$). The effect of financial development on $\bar{a}_{ijs}$ across industries with different external finance dependence is theoretically ambiguous ($\partial^2 \bar{a}_{ijs}/\partial \lambda_j \partial d_s \lesseqgtr 0$).*

Proof. See Appendix A. ■

The intuition for the first part of Proposition 3 follows the same argument as in the previous paragraph. The indeterminacy about the effect of d_s has to do with the fact that less productive firms produce lower-quality goods and can thus offer the investor smaller revenues in case of repayment, but they also rely less on outside capital. As shown in Appendix A, depending on which effect prevails, $\partial^2 \bar{a}_{ijs}/\partial \lambda_j \partial d_s$ can be either negative or positive. The empirical analysis will say which case is more consistent with our data.[22]

3 Estimation

Our estimation strategy builds on Helpman et al. (2008) and Manova (2013). In a nutshell, we use the model, along with distributional assumptions on productivity and bilateral trade costs, to derive an estimable version of (22), the equation that links $\tilde{Q}_{ijs}$ to the financial variables (*quality equation*). We also derive a term that can be used to control for firm selection when estimating the quality equation, thereby separating the intensive-margin (Propositions 1 and 2) and extensive-margin contributions (Proposition 3) of financial frictions. This term is constructed using predicted components from a first-stage equation (*selection equation*) that specifies the probability of observing trade between two countries in a given industry as a function of the financial variables and bilateral trade costs. As discussed by Helpman et al. (2008) and Manova (2013), despite the fact that the two margins arise in the model due to the presence of heterogeneous firms, they can be separated using the information contained in aggregate trade data. The reason is that, according to the model, the characteristics of the marginal exporter to a given destination can be identified from the observed variation in trade costs, as well as in other country and industry characteristics including the financial variables (see eq. (20) and (21)).

[22] A similar indeterminacy emerges also in some extension of the model in Manova (2013).

3.1 The Quality Equation

We start by rearranging (22) to express $\tilde{Q}_{ijs}$ as follows:

$$\tilde{Q}_{ijs} = q^o_{ijs}(a_L) V_{ijs} E_{ijs}, \tag{23}$$

where

$$V_{ijs} \equiv \frac{1}{G(\bar{a}_{ijs})} \int_{a_L}^{\bar{a}_{ijs}} \left(\frac{a}{a_L}\right)^{(1-\varepsilon)/\tilde{\gamma}} g(a)\, da,$$

$$E_{ijs} \equiv \frac{\int_{a_L}^{\underline{a}_{ijs}} \left(\frac{a}{a_L}\right)^{(1-\varepsilon)/\tilde{\gamma}} g(a)\, da + \int_{\underline{a}_{ijs}}^{\bar{a}_{ijs}} \beta_{ijs}(a) \left(\frac{a}{a_L}\right)^{(1-\varepsilon)/\tilde{\gamma}} g(a)\, da}{\int_{a_L}^{\bar{a}_{ijs}} \left(\frac{a}{a_L}\right)^{(1-\varepsilon)/\tilde{\gamma}} g(a)\, da},$$

and

$$q^o_{ijs}(a_L) = \left[\left(\frac{\omega_{ijs}(a_L)}{\alpha P_{is}}\right)^{1-\varepsilon} \frac{(\gamma - \tilde{\gamma}) Y_{is}}{\varepsilon \gamma c_{js}}\right]^{1/\tilde{\gamma}}$$

is the quality of the most efficient firm (with coefficient a_L).

Eq. (23) shows that $\tilde{Q}_{ijs}$ is proportional to the quality of the most productive firm, with factors of proportionality given by V_{ijs} and E_{ijs}. If all firms were endowed with the same coefficient a_L, then $\tilde{Q}_{ijs} = q^o_{ijs}(a_L)$. V_{ijs} and E_{ijs} scale down $\tilde{Q}_{ijs}$ to account for the extensive- and intensive-margin contributions of financial frictions in the presence of firm heterogeneity. Specifically, V_{ijs} accounts for 'firm selection' (the extensive margin). When firms are heterogeneous in productivity, financial frictions imply that only firms with $a < \bar{a}_{ijs}$ can profitably export from j to i in industry s. Because these firms are less efficient than the most productive firm, $V_{ijs} < 1$. When $\bar{a}_{ijs} < a_L$, no firm can profitably export, so V_{ijs} and $\tilde{Q}_{ijs}$ are not defined; otherwise, V_{ijs} is a decreasing function of $\bar{a}_{ijs}$. Instead, E_{ijs} accounts for 'average firm-level quality' (the intensive margin). Financial frictions imply that some of the firms exporting from j to i in industry s do not achieve the optimal quality. Hence, $\underline{a}_{ijs} < \bar{a}_{ijs}$ and $\beta_{ijs}(a) < 1$, implying that $E_{ijs} < 1$. E_{ijs} is ceteris paribus increasing in $\underline{a}_{ijs}$ and $\beta_{ijs}(a)$.

Following Helpman et al. (2008), we assume that productivity $1/a$ follows a Pareto distribution, truncated over the support $[a_L, a_H]$. Hence, we assume that $G(a) = \frac{(a^k - a_L^k)}{(a_H^k - a_L^k)}$, with $k > (\varepsilon - 1)/\tilde{\gamma}$. Under this assumption, we can re-write V_{ijs} as follows:

$$V_{ijs} = \frac{\tilde{\gamma} k}{\tilde{\gamma} k - \varepsilon + 1} W_{ijs}, \tag{24}$$

where

$$W_{ijs} \equiv \frac{\left(\frac{\bar{a}_{ijs}}{a_L}\right)^{k-(\varepsilon-1)/\tilde{\gamma}} - 1}{\left(\frac{\bar{a}_{ijs}}{a_L}\right)^{k} - 1}. \tag{25}$$

Using these expressions and recalling that $\omega_{ijs}(a_L) \equiv \tau_{ij} c_{js} a_L$, we can re-write (23) in log-linear form as follows:

$$\tilde{q}_{ijs} = \theta_0 + \frac{1}{\tilde{\gamma}} y_{is} - \frac{\varepsilon}{\tilde{\gamma}} \ln c_{js} + \frac{\varepsilon - 1}{\tilde{\gamma}} p_{is} - \frac{\varepsilon - 1}{\tilde{\gamma}} \ln \tau_{ij} + w_{ijs} + e_{ijs}, \tag{26}$$

where lowercase letters denote the natural logarithms of the corresponding uppercase variables.[23]

Next, we use a similar parametrization for the variable trade costs as in Helpman et al. (2008):

$$\frac{\varepsilon-1}{\tilde{\gamma}}\ln\tau_{ij}\equiv\zeta d_{ij}-u_{ij}, \tag{27}$$

where d_{ij} is the log of the bilateral distance between i and j, and u_{ij} is an unobserved, country-pair specific, i.i.d. trade friction, with $u_{ij}\sim N\left(0,\sigma_u^2\right)$. Following Manova (2013), we also assume that c_{js} is decomposable into a country-specific term c_j and an industry-specific term c_s:[24]

$$c_{js}\equiv c_j c_s. \tag{28}$$

Then, using (27) and (28), we can write (26) as follows:

$$\tilde{q}_{ijs}=\theta_0+\theta_{is}+\theta_j-\zeta d_{ij}+w_{ijs}+e_{ijs}+u_{ij}, \tag{29}$$

where $\theta_{is}\equiv\tilde{\gamma}^{-1}\left[y_{is}+(\varepsilon-1)\,p_{is}-\varepsilon\ln c_s\right]$ is an importer-industry fixed effect and $\theta_j\equiv-\left(\varepsilon/\tilde{\gamma}\right)\ln c_j$ is an exporter fixed effect. As explained above, the interplay between financial frictions and financial vulnerability influences both w_{ijs} and e_{ijs}, by affecting $\underline{a}_{ijs}$, $\beta_{ijs}\left(a\right)$, and $\bar{a}_{ijs}$. Importantly, note that θ_j absorbs all characteristics specific to each exporting country that affect $\tilde{q}_{ijs}$ uniformly across destination markets and industries. Similarly, θ_{is} absorbs all characteristics specific to each importer and industry that influence $\tilde{q}_{ijs}$ uniformly across exporters. Hence, (29) resembles a DID specification, which identifies the effect of financial frictions by exploiting their differential importance across industries with different financial vulnerability. This drastically limits concerns with omitted variables, and allows establishing a causal impact of financial frictions on average quality.

In Section 5, we will start by regressing $\tilde{q}_{ijs}$ on interactions between proxies for financial development (FD_j), external financial dependence (EF_s), and asset tangibility (AT_s), plus all variables in (29) except for w_{ijs} and e_{ijs}. This specification will inform us about the overall effect of financial frictions on average quality. Next, we will re-estimate the same specification including also w_{ijs}. Because this term controls for firm selection, any remaining effect of financial frictions on $\tilde{q}_{ijs}$ will reflect their influence on average firm-level quality. This will allow us to quantify the relative contribution of the intensive and extensive margins. We now use the model to derive a consistent estimate for w_{ijs}.

3.2 The Selection Equation

Following Manova (2013), we define a latent variable Z_{ijs} as a function of the productivity of the most efficient firm, $1/a_L$, relative to the exporting productivity cut-off, $1/\bar{a}_{ijs}$. Dividing (13) by (21) and using

[23] In (26), θ_0 is a constant that bundles a number of parameters: $\theta_0\equiv\ln\left\{\frac{\tilde{\gamma}k}{\tilde{\gamma}k-\varepsilon+1}\left[\left(\frac{a_L}{\alpha}\right)^{1-\varepsilon}\left(\frac{\gamma-\tilde{\gamma}}{\varepsilon\gamma}\right)\right]^{1/\tilde{\gamma}}\right\}$.

[24] Section 5.3.1 allows for a more general formulation, which also includes exporter-industry determinants of c_{js}, such as endowment-based comparative advantage. Our main conclusions will remain unchanged.

(20), we can write Z_{ijs} as follows:

$$Z_{ijs} \equiv \left(\frac{\bar{a}_{ijs}}{a_L}\right)^{(\varepsilon-1)\gamma/\tilde{\gamma}} = \frac{\left(1-d_s+\frac{d_s}{\lambda_j}\right)^{(\tilde{\gamma}-\gamma)/\tilde{\gamma}}}{\left(1-d_s+\frac{d_s}{\lambda_j}\right)f_{ij}-\frac{1-\lambda_j}{\lambda_j}t_s f_{ej}} \frac{\tilde{\gamma}\left[\left(\frac{\omega_{ijs}(a_L)}{\alpha P_{is}}\right)^{1-\varepsilon}\left(\frac{\gamma-\tilde{\gamma}}{\gamma\varepsilon c_{js}}\right)Y_{is}\right]^{\gamma/\tilde{\gamma}}}{\gamma-\tilde{\gamma}}. \quad (30)$$

Positive exports from j to i in industry s are observed if $Z_{ijs} > 1$. Moreover, Z_{ijs} is increasing in $\bar{a}_{ijs}$, and thus in the proportion of the N_{js} active firms selling in i. Using (30), we can re-write (25) as follows:

$$W_{ijs} = \frac{Z_{ijs}^{(\tilde{\gamma}k-\varepsilon+1)/\gamma(\varepsilon-1)}-1}{Z_{ijs}^{\tilde{\gamma}k/\gamma(\varepsilon-1)}-1}. \quad (31)$$

Importantly, W_{ijs} is decreasing in Z_{ijs}, since $\varepsilon > 1$ implies that the exponent of Z_{ijs} at the numerator of (31) is smaller than that at the denominator. Hence, the more firms export to i, the higher is the latent variable Z_{ijs}, and the smaller is the factor W_{ijs} that scales down $\tilde{Q}_{ijs}$ to account for firm selection.

Next, we parametrize the fixed entry cost as in Helpman et al. (2008):

$$f_{ij} \equiv \exp\left(\varphi_i + \varphi_j + \xi_1\varphi_{ij} - \nu_{ij}\right).$$

This specification decomposes f_{ij} into a term measuring the trade barrier imposed by the importing country on all exporters (φ_i), a term measuring a common fixed cost faced by the exporting country in all destination markets (φ_j), a term measuring any additional fixed entry cost specific to the country pair (φ_{ij}), and some unmeasured, country-pair specific, i.i.d. trade friction ν_{ij}, with $\nu_{ij} \sim N\left(0, \sigma_\nu^2\right)$. We also assume, as in Manova (2013), that the first term in the RHS of (30) can be expressed as a function of our proxies for financial development and financial vulnerability:

$$\frac{\left(1-d_s+\frac{d_s}{\lambda_j}\right)^{(\tilde{\gamma}-\gamma)/\tilde{\gamma}}}{\left(1-d_s+\frac{d_s}{\lambda_j}\right)f_{ij}-\frac{1-\lambda_j}{\lambda_j}t_s f_{ej}} = \exp\left(\chi_{is}+\chi_j-\xi_1\varphi_{ij}+\xi_2 FD_j\cdot EF_s-\xi_3 FD_j\cdot AT_s+\nu_{ij}\right), \quad (32)$$

where χ_j is an exporter fixed effect that captures: (*i*) φ_j; (*ii*) the sunk entry cost f_{ej}; and (*iii*) the main effect of FD_j. Similarly, χ_{is} is an importer-industry fixed effect that captures: (*i*) φ_i; and (*ii*) variation in EF_s and AT_s across industries. Using (27), (28), and (32), we can write (30) in log-linear form as follows:

$$z_{ijs} = \xi_0 + \xi_{is} + \xi_j - \gamma\zeta d_{ij} - \xi_1\varphi_{ij} + \xi_2 FD_j\cdot EF_s - \xi_3 FD_j\cdot AT_s + \eta_{ij}, \quad (33)$$

where $\xi_{is} \equiv \chi_{is} + (\gamma/\tilde{\gamma})\left[y_{is} + (\varepsilon-1)\,p_{is} - \varepsilon\ln c_s\right]$ is an importer-industry fixed effect, $\xi_j \equiv \chi_j - (\varepsilon\gamma/\tilde{\gamma})\ln c_j$ is an exporter fixed effect, and $\eta_{ij} \equiv \nu_{ij} + \gamma u_{ij} \sim N\left(0, \sigma_\nu^2 + \gamma^2\sigma_u^2\right)$.[25]

Although z_{ijs} is unobserved, we do observe the existence of trade flows. Let T_{ijs} be a dummy equal to 1 when j exports to i in industry s, and 0 otherwise. Because $z_{ijs} > 0$ when $T_{ijs} = 1$ and $z_{ijs} = 0$ when $T_{ijs} = 0$, we can estimate (33) by Probit. In particular, we specify the following Probit model for the

[25] ξ_0 is a constant that bundles a number of parameters: $\xi_0 \equiv \ln\left\{\frac{\tilde{\gamma}}{\gamma-\tilde{\gamma}}\left[\frac{\gamma-\tilde{\gamma}}{\varepsilon\gamma}\left(\frac{a_L}{\alpha}\right)^{1-\varepsilon}\right]^{\gamma/\tilde{\gamma}}\right\}$.

conditional probability ρ_{ijs} of observing positive trade between j and i in industry s:

$$\begin{aligned} \rho_{ijs} &\equiv \Pr\left[T_{ijs} = 1|\text{covariates}\right] \\ &= \Phi\left[\xi_0^* + \xi_{is}^* + \xi_j^* - (\gamma\zeta)^* d_{ij} - \xi_1^* \varphi_{ij} + \xi_2^* FD_j \cdot EF_s - \xi_3^* FD_j \cdot AT_s\right], \end{aligned} \tag{34}$$

where the stars indicate that the variables have been divided by σ_η, implying that Φ is the c.d.f. of the standard normal distribution and that the error term $\eta_{ij}^* \equiv \eta_{ij}/\sigma_\eta$ is distributed unit normal.

Using the estimates from (34), we can construct the predicted probability $\hat{\rho}_{ijs}$. The latter can be used to compute $\hat{z}_{ijs}^* = \Phi^{-1}\left(\hat{\rho}_{ijs}\right)$, the predicted value of the latent variable $z_{ijs}^* \equiv z_{ijs}/\sigma_\eta$. Then, a consistent estimate for W_{ijs} can be obtained from:

$$W_{ijs} = \frac{\left(Z_{ijs}^*\right)^{\kappa_1} - 1}{\left(Z_{ijs}^*\right)^{\kappa_2} - 1},$$

where $\kappa_1 \equiv \sigma_\eta\left(\tilde{\gamma}k - \varepsilon + 1\right)/\gamma\left(\varepsilon - 1\right)$ and $\kappa_2 \equiv \sigma_\eta \tilde{\gamma}k/\gamma\left(\varepsilon - 1\right)$.

$\tilde{Q}_{ijs}$ is only defined in the sub-sample of observations with positive trade flows. Thus, we need an estimate for w_{ijs} conditional on observing positive trade, i.e., $E\left[w_{ijs}|., T_{ijs} = 1\right]$. Since η_{ij}^* is distributed unit normal, the inverse Mills ratio $\widehat{\overline{\eta}}_{ijs}^* \equiv \phi\left(\hat{z}_{ijs}^*\right)/\Phi\left(\hat{z}_{ijs}^*\right)$ provides a consistent estimate for $\bar{\eta}_{ijs}^* \equiv E\left[\eta_{ij}^*|., T_{ijs} = 1\right]$. Then, using the fact that $\widehat{\overline{z}}_{ijs}^* \equiv \hat{z}_{ijs}^* + \widehat{\overline{\eta}}_{ijs}^*$ is a consistent estimate for $E\left[z_{ijs}^*|., T_{ijs} = 1\right]$, we can obtain an estimate for $E\left[w_{ijs}|., T_{ijs} = 1\right]$ as follows:

$$\widehat{\overline{w}}_{ijs}^* = \ln\left\{\frac{\exp\left[\kappa_1\left(\hat{z}_{ijs}^* + \widehat{\overline{\eta}}_{ijs}^*\right)\right] - 1}{\exp\left[\kappa_2\left(\hat{z}_{ijs}^* + \widehat{\overline{\eta}}_{ijs}^*\right)\right] - 1}\right\}.$$

Finally, using the sub-sample of observations with positive trade flows may also induce sample selection bias. This can be controlled for by including $\widehat{\overline{\eta}}_{ijs}^*$ as an additional regressor when estimating (29) (Heckman (1979)).[26]

4 Data and Variables

We now describe our measures of product quality (Section 4.1), financial development (Section 4.2), and financial vulnerability (Section 4.3).

4.1 Measures of Product Quality

The quality of a product depends on several attributes, both tangible and intangible, that influence the way in which consumers perceive the good and thus their willingness to pay for it. As such, quality

[26]Note that $\widehat{\overline{\eta}}_{ijs}^*$ controls for sample selection bias induced by unobservables. In the absence of firm heterogeneity, this would be the only correction needed. Intuitively, in this situation, all firms would be equally affected by observed country characteristics such as the financial variables. In the presence of firm heterogeneity, however, one also needs to account for the influence that these observables exert on $\tilde{q}_{ijs}$ by determining the selection of exporting firms (i.e., by affecting the export cut-off $\bar{a}_{ijs}$). This effect is captured by the additional control $\widehat{\overline{w}}_{ijs}^*$.

is hardly observable. In an influential paper, Khandelwal (2010) introduces a simple methodology for inferring quality from the information on prices and quantity contained in the trade data. As explained below, the methodology requires comparable time-series of bilateral trade, at the finest possible level of product disaggregation. In this paper, we implement this methodology using data on imports into the EU. These data are sourced from *Comext*, a database administered by Eurostat. Two unique features make them particularly suited to estimate quality using Khandelwal's (2010) approach. First, they are readily comparable across importing and exporting countries. Second, their level of product disaggregation (8-digit) is higher than the one available for most other countries in public databases (6-digit).[27] We observe 6713 products, but following Khandelwal (2010) we restrict to manufacturing goods (5689 products).[28] For each product, we have information on the value (in Euros) and quantity (in tons) of imports into 26 EU members from all the countries in the world between 1988 and 2012.[29] To match these data with our measures of financial vulnerability, we assign each product to a 4-digit SIC industry (273 overall) using a converter provided by the World Bank *World Integrated Trade Solution*.

The basic intuition behind Khandelwal's (2010) approach is that, conditional on prices, higher-quality products should command higher market shares in a given destination. Building on this intuition, he derives quality by estimating a system of demand functions, which reflect preferences for both the vertical and the horizontal attributes of the goods. Quality is the vertical component of the model. It represents the mean valuation that consumers in country i assign to a particular product l exported by country j at time t.

As in Khandelwal (2010), we specify the following empirical version of the demand functions (the subscripts s and i are omitted, because eq. (35) will be estimated separately for each 4-digit industry and importing country):[30]

$$\ln s_{ljt} - \ln s_{0t} = \beta_{lj} + \beta_t + \beta_1 p_{ljt} + \beta_2 \ln ns_{ljt} + \beta_3 \ln pop_{jt} + \epsilon_{ljt}. \tag{35}$$

In (35), s_{0t} is the market share of an outside variety (domestic product), which is computed as 1 minus import penetration in the industry.[31] $s_{ljt} \equiv x_{ljt}/MKT_t$ is the quantity market share of the product in the

[27] Eurostat employs the Combined Nomenclature (CN) classification. Up to the sixth digit, it coincides with the Harmonized System (HS) classification used by most countries.

[28] The CN classification has undergone several changes over the period of analysis; see Colantone and Crinò (2014) for a detailed discussion of this point. Hence, we use a procedure developed by Van Beveren et al. (2012) to convert the original data into a consistent product classification. The original procedure covers the years 1988-2010, so we extend it to account for classification changes occurred in more recent years. This leaves us with 6713 products (of which 5689 are manufacturing goods) consistently defined between 1988 and 2013.

[29] Eurostat aggregates Belgium and Luxemburg into a single unit, so our data include 26 rather than 27 EU members. For Austria, Finland, and Sweden, the data are available since 1995; for the 12 countries that joined the EU in 2004 or 2007, they are available since 1999. Given that, as explained in the next section, our preferred measure of financial development (private credit) is available up to 2011, our main estimation sample spans the period 1988-2011. However, in some specifications using alternative proxies, we will be able to also include the data for 2012.

[30] Eq. (35) is derived from the nested logit framework introduced by Berry (1994). As shown, e.g., by Anderson et al. (1987), this framework nests the CES preference system that we use. Indeed, CES demand functions also have the property that higher-quality goods display larger market shares conditional on prices, as can be seen using (3). Empirically, (35) is a more general (hence preferable) formulation, as it also controls for horizontal attributes of the good (see below) that would bias the quality estimates if omitted. We estimate (35) separately for each 4-digit industry because products would not be comparable within more aggregated sectors, and the quality estimates would then be meaningless.

[31] To measure import penetration, we use production data at the 2-digit industry level from three sources: *Euklems* (O'Mahony and Timmer, 2009) and the *World Input Output Database* (Timmer, 2012) for 1995-2007, and Eurostat for more recent years. We combine these data with trade data from the OECD (*Stan Database for Industrial Analysis*). To have complete time

corresponding 4-digit industry, with $MKT_t \equiv \sum_l \sum_j x_{ljt}/(1-s_{0t})$. p_{ljt} is the price of the good, proxied by the c.i.f. (cost, insurance, and freight) unit value. $ns_{ljt} \equiv x_{ljt}/\sum_j x_{ljt}$ is country j's share in the total imported quantity of product l ('nest share'). As discussed by Khandelwal (2010), different versions of the same good sold by different countries may be more substitutable than completely distinct products: controlling for ns_{ljt} prevents the quality estimates from being influenced by this different pattern of substitutability. Finally, pop_{jt} is country j's population.[32] It accounts for the fact that larger countries tend to export more varieties of the same product, a feature that may artificially inflate their quality estimates. Together, ns_{ljt} and pop_{jt} therefore accommodate differences in horizontal characteristics across products.

Log quality is given by $\ln q_{ljt} = \beta_{lj} + \beta_t + \epsilon_{ljt}$, where the fixed effect β_{lj} captures the time-invariant valuation of product l exported by country j, the year fixed effect β_t captures a secular time trend common to all products, and the residual ϵ_{ljt} captures shocks to the valuation of the product in year t. Note that, by conditioning on prices, the methodology accounts for many factors unrelated to quality that may affect market shares. For instance, a product may have a high market share simply because it comes from a nearby country. However, given that prices include transportation costs, they account for the effect of distance. A similar argument can be made regarding the influence of policy-related trade barriers such as tariffs, because the c.i.f. unit values include them. Finally, market shares may reflect heterogeneity in mark-ups across exporters. Conditioning on prices, however, also controls for this confounding factor.

Because unit values are notoriously noisy, to estimate (35) we follow Khandelwal (2010) and exclude observations with unit values in the extreme 5% tails of the distribution, within each importer and industry. We also exclude importer-industry combinations with less than 50 available observations. Estimation is performed by 2-Stage Least Squares (2SLS), to account for possible correlation between p_{ljt} and ns_{ljt} on the one hand, and ϵ_{ljt} on the other. We use the same instruments as in Khandelwal (2010): bilateral exchange rates, the interactions of bilateral distance with oil prices and product-specific transportation costs, the number of countries exporting product l to destination i, and the number of products exported by country j to i.[33]

Table 2 contains summary statistics on the estimation results. Column (1) refers to the 2SLS estimates. For comparison, column (2) reports the results obtained by estimating (35) using OLS. We perform 8257 separate regressions using almost 22 million observations. The median 2SLS regression uses 1384 observations, corresponding to 225 'varieties' (exporter-product combinations). As expected, the median price elasticity is negative and the median coefficient on the nest share positive. Reassuringly, the price elasticity estimated by 2SLS is more negative than its OLS counterpart, implying that the instruments move the price coefficient in the expected direction. Moreover, the 2SLS estimates are remarkably close to those obtained by Khandelwal (2010), who uses import data for the US. In particular, he reports a

series on import penetration for all industries and countries, we impute the missing values (6% of observations) through linear interpolation. As shown in Section 5, the imputation has no implications for our main results.

[32]We use population data from the *World Development Indicators*.

[33]Bilateral exchange rates are sourced from Eurostat and the *International Financial Statistics*. Bilateral distance is the population-weighted number of kilometers between the capital cities of i and j, sourced from CEPII. Oil prices are Brent prices from *FRED* (Federal Reserve Bank of St. Louis). To compute the product-specific transportation costs, we follow the same procedure as in Colantone and Crinò (2014). We start by sourcing data on bilateral transportation costs for the US; these data come from Schott (2008) and are available at the 6-digit level of the HS classification. We regress these transportation costs on partner fixed effects, to remove the influence of distance from the US. Then, we average the residuals of this regression within each 6-digit product, across all trading partners of the US. Finally, we attribute the same transportation cost to all 8-digit products belonging to the same 6-digit code, and use the procedure of Van Beveren et al. (2012) to convert the resulting data in a consistent product classification.

Table 2: Descriptive Statistics on the Quality Estimates

	(1)	(2)
Coefficient on price (median)	-0.056	-0.010
Price elasticity (median)	-0.782	-0.128
Coefficient on nest share (median)	0.513	0.883
Observations per estimation (median)	1384	1397
Varieties per estimation (median)	225	231
R^2 (median)	0.15	0.85
Total estimations	8257	8257
Total observations	21,739,232	21,985,524
Hansen J-statistic (p-value, median)	0.157	-
F-statistic for excl. instr., price (p-value, median)	0.025	-
F-statistic for excl. instr., nest share (p-value, median)	0.000	-
Estimator	2SLS	OLS

median price elasticity of -0.58 and a median coefficient on the nest share of 0.46, while in our data these quantities equal -0.78 and 0.51, respectively.

The estimation procedure delivers quality estimates that vary by product, exporting country, destination market, industry, and year. We use these estimates to construct the empirical counterpart of $\tilde{q}_{ijs}$ in the model. To this purpose, we first take the exponential of the individual estimates, and then compute their average within each exporter-importer-industry-year cell. Taking the log of this measure we arrive at an estimate for $\tilde{q}_{ijst}$.

4.2 Measures of Financial Development

In the model, countries are heterogeneous in terms of financial contractibility. This gives rise to heterogeneity in the extent to which the environment is able to provide credit to domestic firms. Empirically, this heterogeneity gets reflected in the different size of financial systems across countries. Accordingly, our main measure of financial development (FD_{jt}) is 'private credit', the amount of credit issued by commercial banks and other financial institutions to the private sector. This measure excludes credit issued by central banks, as well as loans to the government and public firms. As such, it is a close proxy for the ability of the financial system to facilitate transactions between private investors and firms, and to channel savings from the former to the latter. Private credit is indeed the standard measure of financial development used in the literature on finance, growth, and exports (e.g., King and Levine, 1993; Manova, 2013).

We source data on private credit for 171 countries between 1988 and 2011 from the World Bank *Global Financial Development Database* (Cihak et al., 2012). Table 3a reports the mean and standard deviation of private credit, both for the cross-section of country-level averages (column 1) and for the country-year panel (column 2). Private credit varies substantially across countries and over time. In the cross-section, it has a mean of 43.1% and a standard deviation of 39.3%, and ranges from a minimum of 1.3% (Democratic Republic of Congo) to a maximum of 195.1% (Cyprus). In the panel, private credit has a mean of 44.9% and a standard deviation of 44.1%, and ranges from a minimum of 0.01% (Zambia in 2010) to a maximum of 284.6% (Cyprus in 2011).

Table 3: Descriptive Statistics on Financial Development and Financial Vulnerability, %

	a) Financial Development (FD_j)		b) Financial Vulnerability	
	Cross Section	Panel	Ext. Fin. Dep. (EF_s)	Asset Tangibility (AT_s)
	(1)	(2)	(3)	(4)
Mean	43.1	44.9	2.9	25.7
Standard deviation	39.3	44.1	65.4	11.2

Notes: Columns (1) and (2) report summary statistics on private credit, for the cross-section of country-level averages and for the country-year panel, respectively. External finance dependence and asset tangibility are constructed as explained in the note to Table 1.

4.3 Measures of Financial Vulnerability

Our empirical measures of external finance dependence and asset tangibility are nowadays standard in the literature. Following Rajan and Zingales (1998) and Manova (2013), we measure an industry's external finance dependence (EF_s) using the share of capital expenditures not financed with cash flow from operations. Following Claessens and Laeven (2003) and Manova (2013), we instead measure an industry's degree of asset tangibility (AT_s) using the share of net property, plant, and equipment in total assets. As customary, both measures are constructed using *Compustat* data on all publicly-listed firms in the US. For each of the 273 manufacturing industries in our sample, we use the median value of asset tangibility and average external finance dependence across all firms in the industry over 1988-2012.[34]

As discussed in previous papers, the use of US data is imposed by lack of similar data for other countries. Yet, it also has two advantages, which we now briefly recall. First, the US has one of the most advanced financial systems in the world. This makes it plausible that these measures reflect the true amount of outside capital and tangible assets desired by firms (Rajan and Zingales, 1998). Second, using US data mitigates the concern that these measures may endogenously respond to countries' financial development; in a robustness check, we will also exclude the US from the sample to further alleviate endogeneity concerns. Note that, even if financial vulnerability is not the same in all countries, this does not endanger identification, as long as the ranking of industries in terms of both measures is similar across countries. This assumption is common to all the studies using these measures. It rests on the consideration that most of the differences in the use of outside capital and tangible assets across industries depend on technological factors that are likely to persist across countries. Indeed, we will show that our results are robust when using the rankings of EF_s and AT_s instead of their actual values.

Table 3b reports descriptive statistics on EF_s and AT_s. Consistent with previous studies, both measures vary substantially across industries. EF_s has a mean of 2.9% and a standard deviation of 65.4%, while AT_s has a mean of 25.7% and a standard deviation of 11.2%. The industries with the lowest levels of EF_s and AT_s are 'cigarettes' (SIC 2111) and 'X-ray apparatus and tubes' (SIC 3844), respectively. Those with the highest levels are 'electromedical equipment' (SIC 3845) and 'sawmills and planing mills' (SIC 2421). EF_s and AT_s are only weakly correlated (-0.02).

[34] *Compustat* reports information on the 4-digit SIC industry to which a firm belongs. For 4-digit industries with no firm in *Compustat*, we follow the conventional approach of using the value of each measure in the corresponding 3- or 2-digit industry.

Table 4: Baseline Estimates

	(1)	(2)	(3)	(4)	(5)
FD_{jt}	1.267***				
	(0.082)				
$FD_{jt} \cdot EF_s$	0.316***	0.317***	0.319***		0.313***
	(0.025)	(0.024)	(0.024)		(0.024)
$FD_{jt} \cdot AT_s$	-0.256*	-0.476***		-0.530***	-0.475***
	(0.146)	(0.147)		(0.147)	(0.147)
d_{ij}					-0.529***
					(0.036)
Obs.	3,144,866	3,144,866	3,144,866	3,144,866	3,144,866
R^2	0.98	0.98	0.98	0.98	0.98
Imp-ind-year (*i-s-t*) FE	yes	yes	yes	yes	yes
Exp-year (*j-t*) FE	no	yes	yes	yes	yes
N. of exporters (*j*)	171	171	171	171	171
N. of industries (*s*)	273	273	273	273	273
N. of clusters (*i-j*)	4099	4099	4099	4099	4099

Notes: The dependent variable is $\tilde{q}_{ijst}$, the average quality of goods exported by country j to country i in industry s at time t. d_{ij} is the distance between countries i and j. Standard errors are corrected for clustering within exporter-importer pairs. ***, **, and *: indicate significance at the 1%, 5%, and 10% level, respectively. See also notes to previous tables.

5 Results

In this section, we present the empirical results. Using the equation for $\tilde{q}_{ijs}$ (eq. (29)), we first provide extensive evidence that financial frictions reduce the average quality of countries' products, especially in industries that are financially more vulnerable. Then, we use the two-step estimation procedure laid out above to untangle the contributions of the intensive and extensive margins. Finally, we quantify the effect of the financial variables on average quality and discuss the implications of quality adjustments for the impact of financial frictions on trade flows.

5.1 Baseline Estimates

Table 4 contains the baseline estimates. In column (1), we regress $\tilde{q}_{ijst}$ only on FD_{jt} and its interactions with EF_s and AT_s. We control for a full set of importer-industry-year effects (the equivalent of θ_{is} in the model) to compare the average quality of goods sold by different countries in the same destination market, industry, and time period.[35] We correct the standard errors for clustering within exporter-importer pairs, to account for the correlation induced in the error term of (29) by the unobserved component of the bilateral trade costs. Note that the coefficient on FD_{jt} is positive and very precisely estimated. At the same time, the coefficient on $FD_{jt} \cdot EF_s$ is positive and that on $FD_{jt} \cdot AT_s$ negative, and both are statistically significant at conventional levels. Consistent with Figure 1 and Table 1, these results imply that average product quality increases with financial development relatively more in industries where firms rely more on outside capital and have less collateral. Hence, the interplay between financial frictions and financial vulnerability has explanatory power for predicting variation in product quality across countries and industries.

[35]Given that (35) is estimated separately for each importer-industry pair, the quality estimates are comparable only across the exporters selling in the same industry and destination: the fixed effects ensure that we only exploit this source of variation. The linear terms in EF_s and AT_s are subsumed in the fixed effects.

In column (2), we add a full set of exporter-year effects (the equivalent of θ_j in the model), which subsume the linear term in FD_{jt}. The coefficients on $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$ are now only identified from the combination of cross-country variation in FD_{jt} and cross-industry variation in EF_s and AT_s. The results are similar to those obtained in column (1), and the coefficients are now even larger and more precisely estimated. In columns (3) and (4), we re-estimate the last specification including the two interactions one at a time. The coefficients are close to those in column (2), consistent with the fact that EF_s and AT_s are only weakly correlated and thus capture distinct aspects of financial vulnerability. Finally, in column (5) we add the log of bilateral distance d_{ij}, thereby obtaining a specification that matches (29). The coefficient on distance is negative and significant, as implied by the model, but those on $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$ remain unchanged.

5.2 Robustness Checks

We now perform a series of checks to verify the robustness of the baseline estimates. The results are reported in Table 5.

Outliers In panel a), we show that our evidence is not driven by a handful of influential observations. In rows (1) and (2) we trim and winsorize, respectively, the extreme 1% of observations for $\tilde{q}_{ijst}$. In rows (3) and (4), we instead exclude the countries with the extreme values of FD_{jt} (Democratic Republic of Congo and Cyprus) or the industries with the extreme values of EF_s and AT_s (SIC 2111, 2421, 3844, and 3845). The coefficients are always similar to the baseline estimates.

Alternative quality measures In panel b), we show that our evidence is preserved when using alternative ways for constructing $\tilde{q}_{ijst}$. In row (5), we compute the product-specific quality estimates excluding the residuals ϵ_{ljt}, which may add some noise. In row (6), we construct $\tilde{q}_{ijst}$ as the value-weighted average of the product-specific quality estimates. This constitutes a slight departure from the theoretical definition of $\tilde{q}_{ijst}$, but allows giving less weight to products with smaller import values, for which the quality estimates may be more noisy. In row (7), we re-estimate quality after excluding the observations for which the outside variety s_{0t} is based on interpolated import penetration. This reduces sample size but ensures that the results are not driven by the interpolation. Finally, in row (8) we exclude the years 2008-2011, to ensure that the quality estimates are not influenced by the sharp drop in trade volumes during the recent financial crisis. The results always confirm the baseline estimates.

Alternative measures of financial vulnerability In panel c), we show that the results are robust to using alternative measures of financial vulnerability. In row (9), we re-compute EF_s and AT_s using *Compustat* data for the period 1980-1987, the decade prior to the beginning of our sample. This serves two purposes. First, if our results were lost, it would mean that the US industrial structure of financial vulnerability is not persistent over time. It would then be unrealistic to expect the same structure to extend to different countries. Second, the US data for an earlier decade may be a better benchmark for countries at lower levels of development. In row (10), we use instead the rankings of industries in terms of EF_s and AT_s.[36] This implies some loss of information, but mitigates concerns with the stability of these measures

[36] To ease the interpretation of the results, we normalize the rankings to range between zero and one.

Table 5: Robustness Checks

	$FD_{jt} \cdot EF_s$		$FD_{jt} \cdot AT_s$		d_{ij}			
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Obs.	R^2
a) Outliers								
1) Trimming $\tilde{q}_{ijst}$ (1%)	0.271***	(0.021)	-0.284**	(0.139)	-0.508***	(0.035)	2,986,149	0.98
2) Winsorizing $\tilde{q}_{ijst}$ (1%)	0.291***	(0.022)	-0.375***	(0.132)	-0.511***	(0.034)	3,144,866	0.99
3) No extreme FD_{jt}	0.332***	(0.023)	-0.552***	(0.147)	-0.519***	(0.036)	3,126,446	0.98
4) No extreme EF_s and AT_s	0.396***	(0.027)	-0.442***	(0.150)	-0.528***	(0.037)	3,106,871	0.98
b) Alternative quality measures								
5) No residuals ϵ_{ljt}	0.189***	(0.021)	-0.512***	(0.143)	-0.341***	(0.032)	3,141,432	0.99
6) Value-weighted estimates	0.312***	(0.024)	-0.707***	(0.147)	-0.637***	(0.038)	3,145,065	0.98
7) No interpolated s_{0t}	0.315***	(0.024)	-0.425***	(0.150)	-0.544***	(0.036)	3,081,919	0.98
8) No 2008-2011	0.350***	(0.026)	-0.592***	(0.163)	-0.511***	(0.037)	2,477,070	0.98
c) Altern. measures of fin. vulner.								
9) Prior decade (1980-1987)	0.110***	(0.020)	-0.894***	(0.158)	-0.532***	(0.037)	2,943,862	0.98
10) Rankings of EF_s and AT_s	0.630***	(0.056)	-0.149***	(0.055)	-0.529***	(0.036)	3,144,866	0.98
11) No US	0.300***	(0.023)	-0.526***	(0.146)	-0.533***	(0.035)	3,056,163	0.98
d) Altern. measures of fin. frict.								
12) Liquid liabilities	0.202***	(0.026)	-0.790***	(0.188)	-0.536***	(0.037)	3,179,775	0.98
13) Banks assets	0.297***	(0.023)	-0.565***	(0.144)	-0.529***	(0.036)	3,141,767	0.98
14) Comm./centr. banks assets	1.189***	(0.106)	-2.875***	(0.561)	-0.538***	(0.036)	3,053,545	0.98
15) Domestic credit	0.311***	(0.022)	-0.513***	(0.140)	-0.534***	(0.035)	3,328,136	0.98
16) Capitalization ratio	0.114***	(0.012)	-0.188**	(0.074)	-0.519***	(0.037)	3,051,715	0.98
17) Investors protection	0.284***	(0.053)	-0.474*	(0.292)	-0.533***	(0.035)	3,394,836	0.98
18) Contracts enforcement	0.572***	(0.058)	-0.631*	(0.369)	-0.532***	(0.035)	3,394,836	0.98
19) Insolvencies resolution	0.789***	(0.055)	-0.666**	(0.339)	-0.531***	(0.035)	3,394,836	0.98
20) Getting credit	0.492***	(0.061)	-0.924**	(0.365)	-0.533***	(0.035)	3,394,836	0.98
21) Lending rate	-0.236***	(0.015)	0.273***	(0.084)	-0.539***	(0.035)	3,129,328	0.98

Notes: The dependent variable is $\tilde{q}_{ijst}$, the average quality of goods exported by country j to country i in industry s at time t. All specifications include full sets of exporter-year and importer-industry-year effects. Standard errors are corrected for clustering within exporter-importer pairs. ***, **, and *: indicate significance at the 1%, 5%, and 10% level, respectively. See also notes to previous tables.

across countries, because the rankings are more likely to be preserved than the actual values. Finally, in row (11) we exclude the US. In all cases, our main evidence is preserved.

Alternative measures of financial frictions In panel d), we show that the results hold when using different proxies for financial frictions. We start by considering the most common alternatives to private credit for measuring the size of the financial system. Following King and Levine (1993), Beck (2003), and Aghion et al. (2005), we use liquid liabilities (row 12), banks assets (row 13), and the commercial-to-central banks assets ratio (row 14). Following Rajan and Zingales (1998), we use instead domestic credit (row 15) and the capitalization ratio (row 16).[37] Reassuringly, all measures yield the same message as private credit.

So far, following a well-established empirical literature, we have used measures of size to proxy

[37]Liquid liabilities is total liabilities by banks and other financial intermediaries as a share of GDP. This variable may include liabilities backed by credit to public institutions, and may entail some double counting. Banks assets is total assets of commercial banks as a share of GDP. It is a more comprehensive, yet imprecise, measure of size, because it also includes credit to the public sector and banks assets other than credit. The commercial-to-central banks assets ratio is commercial banks assets divided by the sum of commercial banks plus central banks assets. It is commonly viewed as a proxy for the relative importance of private financial intermediaries. Domestic credit is a broader, but possibly less precise, measure of size, because it may include credit issued by, and granted to, public institutions. Finally, the capitalization ratio is the sum of domestic credit and stock market capitalization. Unlike the other measures, it accounts for the role of equities; yet, it may be an imprecise measure of size, because stock market capitalization also reflects factors other than equity issuance, such as investors' expectations about firms' growth potential. All variables are sourced from the *Global Financial Development Database*.

for λ_j. These variables give an objective and outcome-based indication of the ability of the financial system to provide funds (Manova, 2013). Moreover, they are all well measured, and comparable both across countries and over time. Next, we show that our results are preserved when using proxies for the effectiveness of institutions that may facilitate transactions between investors and firms. In particular, we use countries' ratings in terms of: investors protection (row 17), strength of contracts enforcement (row 18), and effectiveness at resolving insolvencies (row 19). We also use an index for the ease of getting credit, which exploits information on the strength of legal rights protection for borrowers and investors (row 20).[38] These indices are similar to some of the alternative measures used by Rajan and Zingales (1998) and Manova (2013), but are available for more countries; none of them varies over time. Note that the coefficients maintain the same sign as in the baseline specification, and remain significant at conventional levels.

Finally, in the model, worse financial frictions raise the cost of borrowing, because they increase the payment F_{ijs} that firms have to promise the investors to make them break even. Accordingly, in row (21) we use the log of the lending rate as an inverse proxy for λ_j.[39] We expect the opposite pattern of signs compared to when using private credit. Strikingly, the coefficient on $FD_{jt} \cdot EF_s$ is indeed negative and very precisely estimated, whereas that on $FD_{jt} \cdot AT_s$ is positive and highly significant.

5.3 Discussion

Having shown that our evidence is robust to possible measurement issues, we devote this section to discussing two important aspects related to the interpretation of the coefficients: competing explanations (Section 5.3.1) and endogeneity (Section 5.3.2).

5.3.1 Competing Explanations

The first aspect is the role of alternative explanations. Given that we always control for exporter-year and importer-industry-year effects, we only need to consider factors that vary across exporters and may have a differential impact across industries. We extend the specification by adding proxies for these factors, and study how our main coefficients respond. The results are reported in Table 6.

Factor endowments and economic development Schott (2004) shows that capital- and skill-abundant countries produce higher-quality versions of the same product, the more so the higher is the capital and skill intensity of production. If skill- and capital-abundant countries have more developed financial systems, and if skill- and capital-intensive industries are financially more vulnerable, then our results may be picking up the effect of endowment-based comparative advantage. In column (1), we therefore add the interactions between the skill and capital intensity of each industry (SI_s and KI_s) and the relative endowment of skill labor and capital in each exporting country (SE_{jt} and KE_{jt}).[40] Both interactions are

[38]These indices are sourced from the World Bank *Doing Business Database*. We normalize them to range between zero and one, and so that higher values indicate a better position in the ranking.

[39]The lending rate is the average interest rate charged for loans to the private sector. It is a commonly-used measure of the cost of borrowing in a country (e.g., Chor and Manova, 2012). We use data from the *International Financial Statistics* and the OECD over 1988-2012.

[40]Capital intensity is measured by the log capital-labor ratio, skill intensity by the log ratio of non-production to production workers employment. Both variables are constructed using US data from the *NBER Productivity Database* and are averaged over

Table 6: Competing Explanations

	Factor Endowm. (1)	Economic Develop. (2)	Import Compet. (3)	Institut. Quality (4)	Exchange Rate (5)	R&D Expend. (6)	Quality Ladder (7)	Industry Growth (8)	All Controls (9)
$FD_{jt} \cdot EF_s$	0.264***	0.153***	0.314***	0.142***	0.163***	0.166***	0.252***	0.334***	0.075**
	(0.024)	(0.029)	(0.024)	(0.031)	(0.029)	(0.025)	(0.023)	(0.024)	(0.031)
$FD_{jt} \cdot AT_s$	-0.963***	-0.732***	-0.472***	-0.790***	-0.789***	-0.600***	-0.736***	-0.310**	-0.833***
	(0.149)	(0.196)	(0.147)	(0.212)	(0.193)	(0.166)	(0.151)	(0.147)	(0.219)
$KE_{jt} \cdot KI_s$	0.228***								0.256***
	(0.015)								(0.017)
$SE_{jt} \cdot SI_s$	0.744***								0.780***
	(0.123)								(0.137)
$GDP_{jt} \cdot EF_s$		0.106***							0.014
		(0.013)							(0.028)
$GDP_{jt} \cdot AT_s$		0.162*							-0.645***
		(0.093)							(0.181)
$IMP_{jt} \cdot EF_s$			-0.056						-0.006
			(0.039)						(0.040)
$IMP_{jt} \cdot AT_s$			0.207						-0.146
			(0.304)						(0.324)
$RL_j \cdot EF_s$				0.153***					-0.027
				(0.019)					(0.039)
$RL_j \cdot AT_s$				0.258**					0.556**
				(0.129)					(0.241)
$RER_{jt} \cdot EF_s$					0.279***				0.146***
					(0.035)				(0.056)
$RER_{jt} \cdot AT_s$					0.600**				0.247
					(0.239)				(0.332)
$RD_j \cdot EF_s$						14.067***			9.148***
						(1.298)			(1.671)
$RD_j \cdot AT_s$						16.674*			4.317
						(8.810)			(11.472)
$FD_{jt} \cdot QLAD_s$							0.558***		0.517***
							(0.055)		(0.057)
$FD_{jt} \cdot TFPG_s$								-7.670***	-9.596***
								(0.837)	(0.890)
d_{ij}	-0.514***	-0.527***	-0.529***	-0.528***	-0.530***	-0.525***	-0.529***	-0.529***	-0.512***
	(0.037)	(0.037)	(0.036)	(0.036)	(0.037)	(0.037)	(0.036)	(0.036)	(0.038)
Obs.	3,055,041	3,114,484	3,143,168	3,144,866	3,124,840	3,064,918	3,144,866	3,144,866	2,962,528
R^2	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98

Notes: The dependent variable is $\tilde{q}_{ijst}$, the average quality of goods exported by country j to country i in industry s at time t. SE_{jt} and KE_{jt} are endowments of skill labor and capital. SI_s and KI_s are skill and capital intensity. GDP_{jt} is per capita GDP. IMP_{jt} is import penetration. RL_j is rule of law. RER_{jt} is real exchange rate. RD_j is R&D expenditures. $QLAD_s$ is quality ladder. $TFPG_s$ is TFP growth. All specifications include full sets of exporter-year and importer-industry-year effects. Standard errors are corrected for clustering within exporter-importer pairs. ***, **, and *: indicate significance at the 1%, 5%, and 10% level, respectively. See also notes to previous tables.

positive and very precisely estimated, in line with Schott's (2004) findings. However, the inclusion of these variables does not overturn our main results. More generally, previous studies have shown that richer countries produce goods of higher quality (see, e.g., Hummels and Klenow, 2005; Hallak, 2006, 2010). To account for the effect of economic development, in column (2) we follow Manova (2013) and add the interactions between our measures of financial vulnerability and the log of each country's real per capita GDP (GDP_{jt}).[41] Reassuringly, our main findings are qualitatively unchanged.

the period of analysis. The relative endowments of skill labor and capital are defined as the endowment of each factor in the exporting country relative to the importing country: the capital endowment is measured by the log capital stock per worker, the skill endowment by the log number of years of schooling; the data come from the *Penn World Tables 8.0* (Feenstra et al., 2013).

[41] GDP data are sourced from the *World Development Indicators*.

Import competition In a recent paper, Amiti and Khandelwal (2012) find that import tariffs reductions raise the quality of a country's products, because firms respond to tougher competition from abroad by producing higher-quality goods.[42] If financially more vulnerable industries were systematically more exposed to the competition of foreign countries, then our results could be contaminated by the effect of import competition on product quality. Lacking comprehensive tariffs data for most of the countries in our sample, we control for this explanation using import penetration as an inverse proxy for import tariffs. Thus, in column (3) we include the interactions between our measures of financial vulnerability and each country's import penetration ratio (IMP_{jt}), defined as merchandise imports over apparent consumption.[43] The new interactions enter with small and insignificant coefficients, suggesting the effects of import competition to be independent of industry characteristics. At the same time, our coefficients of interest are essentially identical to the baseline estimates.

Institutional quality A recent literature points to the quality of a country's legal institutions as an important source of comparative advantage. As discussed by Nunn and Trefler (2015), these institutions may affect not only specialization across industries, but also within-industry specialization in terms of quality. To check that our results are not picking up the effect of institutional quality, in column (4) we add the interactions between our measures of financial vulnerability and each country's rule of law (RL_j), the most common proxy for the quality of legal institutions.[44] The coefficients on the new interactions are positive and precisely estimated, but controlling for institutional quality does not hinder our main evidence on financial frictions.

Real exchange rate Recent papers show that financial development is correlated with a country's real exchange rate (e.g., Russ and Valderrama, 2009), which in turn affects exports. To control for this, in column (5) we include the interactions between our measures of financial vulnerability and the log of each exporter's real exchange rate (RER_{jt}).[45] The new interactions enter with positive and significant coefficients, but our main evidence is preserved.

R&D expenditures Countries differ substantially in the amount of resources devoted to R&D. In our data, R&D expenditures are positively correlated with private credit, and industries with higher (lower) values of EF_s (AT_s) are more R&D intensive.[46] Since quality upgrading entails investments in R&D and other innovation activities (Sutton, 2001, 2007), countries with higher R&D expenditures may have an advantage at producing high-quality goods in R&D-intensive industries. To ensure that our results are not contaminated by this mechanism, in column (6) we add the interactions between our measures

[42] Fan et al. (2014) and Martin and Mejean (2014) find similar evidence using firm-level data for China and France, respectively.

[43] We construct this variable using data from the *World Development Indicators*. Apparent consumption is GDP plus imports minus export.

[44] Data on rule of law come from the *Worldwide Governance Indicators Database* (Kaufmann et al., 2011). Since the index is very stable over time for most countries, we use country-specific averages over all available years (1996-2012).

[45] We use data from the *Penn World Tables 8.0*.

[46] Across 124 countries over 1988-2012, the average ratio of R&D expenditures to GDP ranges from 0.02% (Bosnia and Herzegovina) to 4.1% (Israel), and its correlation with private credit is 0.58; source: *World Development Indicators*. Across 172 industries (a small sub-sample for which *Compustat* has also data on R&D investments), the correlation of R&D/sales with EF_s (AT_s) is 0.39 (-0.48).

of financial vulnerability and the average ratio of R&D expenditures to GDP in each country (RD_j). Both interactions have positive and statistically significant coefficients, but controlling for them does not overturn our main results.

Quality ladder For technological reasons, the scope for quality differentiation varies widely across industries (see, e.g., Sutton, 2001, 2007). If financially more vulnerable industries have a greater scope for quality differentiation, then our results may pick up this characteristic instead of financial vulnerability. To control for this, in column (7) we add the interaction between private credit and Khandelwal's (2010) measure of each industry's quality ladder ($QLAD_s$), the standard proxy for the scope for quality differentiation.[47] As expected, this variable enters with a positive and significant coefficient, but controlling for it leaves our main estimates largely unchanged.

Industry growth Financial frictions may be more important for rapidly-growing industries, where firms have higher investment rates to finance (Claessens and Laeven, 2003). To ensure that our results are not reflecting industry heterogeneity in growth rates, in column (8) we add the interaction between private credit and each industry's average growth rate of TFP over the sample period ($TFPG_s$).[48] Including this variable has no noteworthy implications for our main results.

Wrap-up Finally, in column (9) we include all variables discussed in this section in the same specification. Strikingly, our evidence is preserved also in this extremely demanding exercise.

5.3.2 Endogeneity

We now discuss concerns with endogeneity. As already mentioned, important features of the analysis make our estimates unlikely to be biased by omitted variables. In particular, our DID-like approach allows us to control for a comprehensive set of fixed effects, which absorb all time-varying characteristics of each exporter and importer-industry pair. While it may still be the case that our estimates pick up factors specific to each exporter-industry combination, the extensive sensitivity analysis in the previous section has shown that the results are robust to controlling for the main ones.

Other features of the analysis significantly allay concerns with reverse causality. The latter requires that firms upgrade product quality for factors other than finance, and this, in turn, affects the financial variables in a way that explains our specific pattern of coefficients. Let us consider first the financial vulnerability measures. A possible story is that, once firms in an industry have decided to improve quality, they start accumulating intangible assets such as blueprints; as a result, the value of AT_s in the industry goes down. Firms may also become more dependent on outside capital, as they need to cover higher fixed outlays; as a result, the value of EF_s in the industry increases. In principle, this mechanism could explain the pattern of our coefficients. Recall, however, that EF_s and AT_s are kept constant over

[47] Using data on imports into the US, Khandelwal (2010) estimates the quality ladder of each product as the difference between its maximum and minimum quality across all exporting countries in the year 1989. Then, he constructs an aggregate ladder for each 4-digit SIC industry as the weighted average of the product-specific ladders, using products' import shares as weights. We use the normalized ranking of industries in terms of Khandelwal's (2010) estimates, estimating missing ladders for 4-digit industries with the median ladder in the corresponding 3- or 2-digit industry.

[48] This variable is constructed using data from the *NBER Productivity Database*.

time, so they are little affected by yearly variation in average quality. Moreover, we have shown that the results are unchanged when using the rankings of EF_s and AT_s, which are even less sensitive to annual changes in quality. Also, because EF_s and AT_s are constructed using US data, they do not reflect firms' decisions in other countries; while the results might be entirely driven by the US, we have shown that excluding it from the sample makes no difference. Finally, the results also hold when using pre-sample values of EF_s and AT_s, which are not influenced by firms' decisions over the period of analysis.

Consider now the measure of financial development. A possible concern is that unobserved shocks to industries intensive in external finance raise their average quality, as well as the amount of borrowing in the economy. This mechanism can explain the positive coefficient on $FD_{jt} \cdot EF_s$, even in the absence of financial frictions. As argued by Manova (2013), however, it cannot explain the negative and significant coefficient on $FD_{jt} \cdot AT_s$. The reason is that, if financial markets were frictionless, the amount of collateralizable assets should not affect firms' ability to borrow. Hence, the negative coefficient on $FD_{jt} \cdot AT_s$ provides strong support for the role of financial frictions. Furthermore, we have shown that our results hold when replacing private credit with time-invariant indices of financial development, which are less likely to respond to industry-specific shocks to average quality. Finally, we now show that our results continue to hold when exploiting two distinct sources of exogenous variation in the ability of the environment to provide credit: equity market liberalizations and systemic banking crises.

Equity market liberalizations In a recent paper on the implications of financial frictions for the industrial composition of countries' exports, Manova (2008) uses episodes of equity market liberalizations (EML) to circumvent concerns with the endogeneity of private credit. She convincingly argues that EML, by suddenly allowing foreign capital to flow into the economy, raise the ability of firms to obtain external financing. She also asserts that EML, being the outcome of complex political processes, represent exogenous and unanticipated shocks from the perspective of individual firms or industries.[49]

We source from Manova (2008) data on EML for 90 countries between 1988 and 1997. As in Manova (2008), we define a dummy equal to 1 for a country in the official year of the liberalization, as well as in all subsequent periods (EML_{jt}). We then interact this dummy with EF_s and AT_s, and re-estimate the baseline specification using the new interactions in place of $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$. In an Instrumental Variables framework, this regression would illustrate the reduced-form relationship between the dependent variable ($\tilde{q}_{ijst}$) and the instrument (EML_{jt}). The results are in column (1) of Table 7. Strikingly, the coefficient on $EML_{jt} \cdot EF_s$ is positive and highly significant, whereas that on $EML_{jt} \cdot AT_s$ is negative and very precisely estimated. Hence, the exogenous credit shock induced by EML has the same implications for average quality as an increase in private credit.

Banking crises Kroszner et al. (2007) revisit the seminal paper of Rajan and Zingales (1998) using banking crises (BC) as an exogenous, negative, shock to the ability of the financial system to provide credit. The argument is intuitive. BC undermine the correct functioning of financial intermediaries, limiting their ability to channel savings from investors to firms. Moreover, BC are systemic events triggered by major shocks at the national or international level, so their occurrence is arguably exogenous from the

[49] In any case, if firms were able to anticipate the date of the EML, they would likely raise quality prior to it, in the expectation of easier financing in the future. If anything, this would bias the coefficients downwards.

Table 7: Endogeneity

	Equity Market Liberalizations	Banking Crises	
	(1)	(2)	(3)
$EML_{jt} \cdot EF_s$	0.321***		
	(0.063)		
$EML_{jt} \cdot AT_s$	-1.158***		
	(0.298)		
$BC_{jt} \cdot EF_s$		-0.206***	-0.201***
		(0.028)	(0.029)
$BC_{jt} \cdot AT_s$		0.349**	0.311**
		(0.152)	(0.155)
$CC_{jt} \cdot EF_s$			-0.138***
			(0.045)
$CC_{jt} \cdot AT_s$			0.531**
			(0.209)
$SC_{jt} \cdot EF_s$			-0.117**
			(0.050)
$SC_{jt} \cdot AT_s$			-0.152
			(0.308)
$RE_{jt} \cdot EF_s$			-0.017
			(0.011)
$RE_{jt} \cdot AT_s$			0.147**
			(0.058)
d_{ij}	-0.195***	-0.524***	-0.500***
	(0.066)	(0.036)	(0.036)
Obs.	583,097	2,922,117	2,838,060
R^2	0.98	0.99	0.99

Notes: The dependent variable is $\tilde{q}_{ijst}$, the average quality of goods exported by country j to country i in industry s at time t. EML_{jt}, BC_{jt}, CC_{jt}, SC_{jt}, and RE_{jt} are dummies for equity market liberalizations, banking crises, currency crises, sovereign debt crises, and recessions, respectively. All specifications include full sets of exporter-year and importer-industry-year effects. Standard errors are corrected for clustering within exporter-importer pairs. ***, **, and *: indicate significance at the 1%, 5%, and 10% level, respectively. See also notes to previous tables.

perspective of individual firms or industries.

Building on this argument, we now revisit our evidence by exploiting the negative shock induced by BC on countries' financial systems. We source data on systemic BC from Laeven and Valencia (2012); we have information for 113 countries over 1988-2011.[50] We construct a dummy equal to 1 for a country in the aftermath of a crisis (BC_{jt}) and interact it with our measures of financial vulnerability. Then, we re-estimate the baseline specification using the new interactions in place of $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$. As before, this regression can be interpreted as describing the reduced-form relationship between $\tilde{q}_{ijst}$ and the BC_{jt} instrument. The results are in column (2) of Table 7. Remarkably, the coefficient on $BC_{jt} \cdot EF_s$ is negative and that on $BC_{jt} \cdot AT_s$ positive, and both are precisely estimated at the 5% level or better.

A possible concern is that BC often occur in periods of economic turmoil, and are accompanied by other systemic events such as currency and sovereign debt crises (e.g., Gennaioli et al., 2014). To ensure that our coefficients are picking up the effects of the financial shock induced by BC, rather than the effects of other contemporaneous shocks, we extend the specification by adding interactions between our measures of financial vulnerability and three dummy variables, which equal 1 for a country during

[50] A banking crisis is defined as systemic if the following two conditions are met: (*i*) there are significant signs of financial distress in the banking system, as indicated by significant bank runs, losses in the banking system, and/or bank liquidations; and (*ii*) significant banking policy intervention measures are put in place in response to significant losses in the banking system; see Laeven and Valencia (2012, p. 4) for more details.

a currency crisis (CC_{jt}), a sovereign debt crisis (SC_{jt}), and a recession (RE_{jt}).[51] The results are reported in column (3). While the coefficients on the new controls are generally significant, those on $BC_{jt} \cdot EF_s$ and $BC_{jt} \cdot AT_s$ are reassuringly close to the baseline estimates. Hence, the negative credit shock induced by BC has similar effects on average quality as a reduction in private credit.

5.4 Margins

So far, our results show that financial development raises average quality relatively more in financially more vulnerable industries. According to the model, this suggests that the effect on average firm-level quality (the intensive margin, as per Propositions 1 and 2) dominates the effect on firm selection (the extensive margin, as per Proposition 3). Arguably, this is the most policy-relevant scenario. But how strong is the role of each margin? In this section, we implement the two-step estimation of the quality equation to untangle the two margins and quantify their contributions.

In practice, this task requires that we first estimate the selection equation (34), and then retrieve the predicted probability $\hat{\rho}_{ijst}$ and the terms $\widehat{\overline{w}}^*_{ijst}$ and $\widehat{\overline{\eta}}^*_{ijst}$. To avoid the identification of the second-stage coefficients to rely on the joint normality assumption for the unobserved trade costs, we need a variable that enters the selection equation but is excluded from the quality equation. In this respect, (29) and (34) show that φ_{ij} (the country-pair specific component of the fixed entry cost) affects ρ_{ijs} but has no direct effect on $\tilde{q}_{ijs}$. Hence, φ_{ij} satisfies the exclusion restriction and can be used to identify the second-stage coefficients.

Building on Helpman et al. (2008) and Manova (2013), we proxy for φ_{ij} using measures of the regulatory costs associated with doing business in a country. In particular, we use two variables: (1) the number of procedures for registering a business property and (2) the costs of the official procedures for shipping a standardized cargo to/from the country.[52] For each variable, we compute the log average of its value in the importing and exporting country ($regprop_{ij}$ and $procs_{ij}$), to capture the fact that these costs are magnified when both trading partners impose high regulatory barriers. Because these variables reflect the fixed cost of doing business in a country, they satisfy the exclusion restriction of no direct effect on product quality.[53]

The selection equation is estimated in column (1) of Table 8. Note that the excluded variables enter with the expected negative sign, implying that higher regulatory costs lower the probability that two countries trade with each other in a given industry. The coefficients are estimated with extremely high precision. This shows that regulatory costs have strong explanatory power in predicting the formation of

[51] Data on currency and sovereign debt crises come from Laeven and Valencia (2012). A currency crisis is defined as 'a nominal depreciation of the currency vis-à-vis the US dollar of at least 30% that is also at least 10 percentage points higher than the rate of depreciation in the year before' (Laeven and Valencia, 2012, p. 11). A sovereign debt crisis is defined as a sovereign debt default or restructuring episode. To identify the recessions, we first detrend the series of log nominal GDP from the *World Development Indicators*, using the Hodrick-Prescott filter with a smoothing parameter of 100 (as in Kroszner et al., 2007). Then, we define a recession as the period between a peak and the following trough in the cyclical component of the series.

[52] We use the ratings of countries in terms of each measure, sourced from the World Bank *Doing Business Database*. These ratings are time invariant.

[53] In unreported regressions (available upon request), we have used lagged participation in bilateral trade ($T_{ijst\text{-}1}$) as an alternative excluded variable, similar to Johnson (2012). The argument is that past participation is a strong predictor of current participation, implying the existence of substantial fixed entry costs (Roberts and Tybout, 1997). None of our conclusions changed when using this variable. However, a concern with lagged participation is that it may be correlated with some unobserved determinants of the variable trade cost, u_{ijt}, and thus with average quality. Hence, we prefer to focus on the results using regulatory costs, which are not subject to this concern.

Table 8: Margins

	Selection Equation	Quality Equation (dep. var.: $\tilde{q}_{ijst}$)					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Probit				Dummies for Bins of $\hat{\rho}_{ijst}$		
	(dep. var.: T_{ijst})	No Controls	NLS	Polynomial in $\hat{\bar{z}}^*_{ijst}$	100	500	1000
$FD_{jt} \cdot EF_s$	-0.087***	0.312***	0.248***	0.249***	0.249***	0.249***	0.249***
	(0.002)	(0.024)	(0.012)	(0.013)	(0.011)	(0.011)	(0.011)
$FD_{jt} \cdot AT_s$	-1.184***	-0.474***	-0.352***	-0.364***	-0.362***	-0.364***	-0.364***
	(0.056)	(0.147)	(0.077)	(0.080)	(0.093)	(0.083)	(0.072)
d_{ij}	-0.737***	-0.529***	-0.780***	-0.774***	-0.773***	-0.774***	-0.774***
	(0.011)	(0.036)	(0.005)	(0.016)	(0.016)	(0.015)	(0.013)
$procs_{ij}$	-0.115***						
	(0.015)						
$regprop_{ij}$	-0.136***						
	(0.018)						
$\hat{\bar{\eta}}^*_{ijst}$			1.695***	1.504***			
			(0.023)	(0.195)			
$\kappa_1 - \kappa_2$ (from $\hat{\bar{w}}^*_{ijst}$)			-0.057**				
			(0.028)				
Obs.	27,452,622	3,144,311	3,144,311	3,144,311	3,144,311	3,144,311	3,144,311
R^2		0.98	0.98	0.98	0.98	0.98	0.98

Notes: $procs_{ij}$ is the cost of the official procedures for shipping a standardized cargo to/from the country (average between i and j). $regprop_{ij}$ is the number of procedures for registering a business property in the country (average between i and j). $\hat{\bar{\eta}}^*_{ijst}$ is the inverse Mills ratio. $\hat{\bar{w}}^*_{ijst}$ is a term accounting for firm selection. Both $\hat{\bar{\eta}}^*_{ijst}$ and $\hat{\bar{w}}^*_{ijst}$ are constructed using the predicted probability $\hat{\rho}_{ijst}$ from column (1). All specifications include full sets of exporter-year and importer-industry-year effects. The specification in column (3) is estimated by non-linear least squares (NLS). Column (4) includes a sixth-order polynomial in $\hat{\bar{z}}^*_{ijst}$ (coefficients unreported). Columns (5)-(7) include full sets of dummies for bins of $\hat{\rho}_{ijst}$ (100, 500, and 1000 bins, respectively; coefficients unreported). Standard errors are corrected for clustering within exporter-importer pairs in columns (1) and (2), and bootstrapped (100 replications) in columns (3)-(7). ***, **, and *: indicate significance at the 1%, 5%, and 10% level, respectively. See also notes to previous tables.

bilateral trade relationships. The other coefficients also have the expected sign and are highly significant. In particular, the probability to trade decreases with distance. Moreover, it increases relatively more with financial development in industries with lower asset tangibility and external finance dependence. The latter result implies that our data are consistent with $\partial^2\bar{a}_{ijs}/\partial\lambda_j\partial d_s < 0$ (see Proposition 3).

Using the coefficients reported in column (1), we compute $\hat{\rho}_{ijst}$ and construct $\hat{\bar{w}}^*_{ijst}$ and $\hat{\bar{\eta}}^*_{ijst}$.[54] Then, we re-estimate (29) including these two terms among the regressors. As already mentioned, the resulting coefficients on $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$ measure the effect of financial frictions on 'average firm-level quality', after netting out firm and sample selection. Note that, according to the estimates of the selection equation reported in column (1), firm and sample selection should have opposite effects on the coefficients. In particular, controlling for firm selection should lower both coefficients, because worse financial frictions reduce the probability to trade (and thus the export cut-off $\bar{a}_{ijs}$) relatively more in industries with lower EF_s and AT_s. For the same reason, controlling for sample selection should increase both coefficients. Intuitively, if we observe positive trade when financial conditions are weak and EF_s or AT_s are low, the unobserved component of trade costs is likely to be small (i.e., u_{ijt} is likely to be large). Hence, excluding observations with zero trade flows induces a negative correlation between $FD_{jt} \cdot EF_s$ or $FD_{jt} \cdot AT_s$ and the error term of (29), biasing the coefficients downwards. Ultimately, the relative

[54]For a minor share (0.04%) of observations, $\hat{\rho}_{ijst}$ is indistinguishable from 0 or 1. In order to infer $\hat{z}^*_{ijst} = \Phi^{-1}\left(\hat{\rho}_{ijst}\right)$, we follow Helpman et al. (2008) and Manova (2013) and set $\hat{\rho}_{ijst} = 0.9999999$ ($\hat{\rho}_{ijst} = 0.0000001$) for all observations with $\hat{\rho}_{ijst}$ above (below) this value.

strength of firm and sample selection depends on how strongly $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$ are correlated with $\widehat{\overline{w}}^*_{ijst}$ and $\widehat{\overline{\eta}}^*_{ijst}$.

The results are reported in columns (2)-(7). In column (2), we simply re-estimate the baseline specification on the sub-sample of observations for which we can construct $\hat{\rho}_{ijst}$. The coefficients are essentially identical to those in column (5) of Table 4. In column (3), we add $\widehat{\overline{w}}^*_{ijst}$ and $\widehat{\overline{\eta}}^*_{ijst}$. Since $\widehat{\overline{w}}^*_{ijst}$ is a non-linear function of the parameters κ_1 and κ_2, we estimate the model by non-linear least squares (NLS). To account for the fact that $\widehat{\overline{w}}^*_{ijst}$ and $\widehat{\overline{\eta}}^*_{ijst}$ are based on an estimated variable ($\hat{\rho}_{ijst}$), we report bootstrapped standard errors based on 100 replications, re-sampling observations within clusters defined by exporter-importer pairs. As expected, the coefficient on $\widehat{\overline{\eta}}^*_{ijst}$ is positive and precisely estimated, pointing to the existence of sample selection bias.[55] Moreover, $\kappa_1 < \kappa_2$, which implies, consistent with the model, that the term W_{ijs} that scales down $\tilde{Q}_{ijs}$ to account for firm selection is decreasing in the latent variable Z_{ijs}, and thus in the proportion of exporting firms (see eq. (31)).[56] Turning to our main coefficients, they have the same sign as before, and are very precisely estimated. The point estimates are smaller in absolute value than those in column (2), implying that quality adjustments within firms exporting to a given destination account for 75-80% of the overall effect of financial frictions on average quality. Firm and sample selection explain the remaining 20-25% of the effect.

We close this section with some sensitivity checks, which confirm the robustness of the previous results. In particular, note that the functional forms of $\widehat{\overline{w}}^*_{ijst}$ and $\widehat{\overline{\eta}}^*_{ijst}$ hinge on our assumptions about the distributions of firm productivity and unobserved trade costs. These assumptions allowed us to derive and estimate a fully parametric model, which serves as our benchmark. However, they also induced non linearity, which implies that κ_1 and κ_2 are identified out of functional form. This may raise concerns with the robustness and stability of the results. Hence, we now progressively relax these assumptions, starting from the Pareto formulation for $G(a)$. This implies that we can no longer derive a closed-form expression for the term V_{ijs} in eq. (23).[57] Rather, V_{ijs} is now an arbitrary decreasing function of the export cut-off $\overline{a}_{ijs}$, and thus of the latent variable Z_{ijs}. Accordingly, we approximate $v_{ijs} \equiv \ln V_{ijs}$ using a flexible function of $\widehat{\overline{z}}^*_{ijst}$. We choose a sixth-order polynomial, although this choice is irrelevant for our conclusions. The resulting model is semi-parametric and linear, and can thus be estimated by OLS. The results, reported in column (4), are remarkably close to those of the non-linear specification.

Finally, we also relax the joint normality of the unobserved trade costs. This implies that we can no longer have two separate controls for firm and sample selection, because $\widehat{\overline{z}}^*_{ijst}$ and $\widehat{\overline{\eta}}^*_{ijst}$ were both constructed using the c.d.f. and density of the standard normal distribution. However, given that both terms depend on $\hat{\rho}_{ijst}$, we can still jointly account for firm and sample selection using an arbitrary function of this predicted probability.[58] To approximate this function as flexibly as possible, we divide $\hat{\rho}_{ijst}$ into bins of equal size, and add a dummy for each of these bins. This yields a linear, fully non-parametric, model, which is estimated in columns (5)-(7) using 100, 500, and 1000 bins of $\hat{\rho}_{ijst}$, respectively. The results are similar across the board.

[55]Note that this coefficient is equal to $corr\left(u_{ijt}, \eta_{ijt}\right)(\sigma_u/\sigma_\eta)$.

[56]$\kappa_1 - \kappa_2$ is tightly identified in our data, while the level of each coefficient is more difficult to pin down due to the functional form of $\widehat{\overline{w}}^*_{ijst}$. Below, we show that the results are robust to relaxing our distributional assumptions, which determine the specific form of the controls for firm and sample selection.

[57]Recall that, under Pareto, V_{ijs} and W_{ijs} differ only by a constant term (see (24)).

[58]In principle, $\hat{\rho}_{ijst}$ could now be estimated using any c.d.f. at the first stage. In practice, using, e.g., a logistic distribution yields similar results. Hence, we keep on using the same $\hat{\rho}_{ijst}$ as before, estimated by Probit.

Table 9: Variation in Average Quality, Comparative Statics, %

One-standard-deviation increase in country characteristic:	FD_j		SE_j	KE_j	GDP_j	
Differential effect across industries at different levels of:	EF_s	AT_s	SI_s	KI_s	EF_s	AT_s
	(1)	(2)	(3)	(4)	(5)	(6)
	12	11	9	23	19	17
One-standard-deviation increase in country characteristic:	RL_j		RER_j		RD_j	
Differential effect across industries at different levels of:	EF_s	AT_s	EF_s	AT_s	EF_s	AT_s
	(7)	(8)	(9)	(10)	(11)	(12)
	-12	-10	1	1	4	3

Notes: Columns labeled by EF_s show the differential change in average quality between the industry at the 75th percentile of the distribution by external finance dependence and the industry at the 25th percentile, following a one-standard-deviation increase in the country characteristic indicated at the top. Columns labeled by SI_s and KI_s do the same exercise, using the distributions by skill and capital intensity, respectively. Finally, columns labeled by AT_s compare the industry at the 25th percentile of the distribution by asset tangibility with the industry at the 75th percentile. The results are based on the estimates in column (9) of Table 6.

5.5 Economic Significance and Implications of the Results

We now discuss the economic significance and implications of our results. First, we study the quantitative relevance of financial frictions and financial vulnerability for explaining variation in average quality across countries and industries, and compare their contribution with that of the main alternative explanations considered in the literature (Section 5.5.1). Then, we analyze how adjustments in average quality contribute to the overall effect of financial development on the industrial structure of countries' exports (Section 5.5.2).

5.5.1 Financial Frictions and Variation in Average Quality

We start with a simple comparative-statics exercise. In particular, we compute the differential change in average quality induced by a one-standard-deviation increase in private credit, across industries with different financial vulnerability. To perform this exercise, we use the coefficients from our richest specification (column 9 of Table 6) and report the results in columns (1) and (2) of Table 9. We find that average quality would increase by 12% more in the industry at the third quartile of the distribution by EF_s, relative to the industry at the first quartile. Similarly, it would increase by 11% more in the industry at the first quartile of the distribution by AT_s, relative to the industry at the third quartile. For comparison, the table shows the results of similar exercises conducted for the other country characteristics considered in Table 6.[59] In particular, columns (3) and (4) show that a one-standard-deviation increase in the endowment of skill labor (capital) would raise average quality by 9% (23%) more in the industry at the 75th percentile of the distribution by skill intensity (capital intensity), relative to the industry at the 25th percentile. Column (5) shows that a commensurate increase in per capita GDP would raise average quality by 19% more in the industry at the third quartile of the distribution by EF_s, relative to the industry at the first quartile. The differential increase in average quality between the industries at the 25th and 75th percentile of the distribution by AT_s would instead be 17% (column 6). The other variables have smaller effects, as shown in columns (7)-(12). Hence, the impact of financial frictions falls within the range of those of the main alternative determinants of product quality.

[59] We disregard import competition because the coefficients on this variable are always small and insignificant.

Table 10: Variation in Average Quality, Counterfactuals

	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\tilde{q}}^{Fin.\ Dev.}_{ijs2011}$	0.448***			0.434***	0.233**	0.260***
	(0.005)			(0.009)	(0.094)	(0.100)
$\hat{\tilde{q}}^{Fact.\ End.}_{ijs2011}$		0.359***		0.017**		0.013
		(0.004)		(0.008)		(0.009)
$\hat{\tilde{q}}^{Econ.\ Dev.}_{ijs2011}$			0.431***		0.210**	0.172*
			(0.004)		(0.092)	(0.100)
Obs.	39,461	53,069	52,929	39,461	39,394	39,394
R^2	0.19	0.13	0.19	0.19	0.19	0.19

Notes: The dependent variable is $\tilde{q}_{ijs2011}$, the average quality of goods exported by country j to country i in industry s, at the end of 2011. $\hat{\tilde{q}}^{Fin.\ Dev.}_{ijs2011}$ is the counterfactual value of quality that would arise only due to the observed change in financial development. This variable is constructed using the coefficients in column (9) of Table 6 and the change in FD_{jt} over the sample period, assuming that all other variables in the specification had remained constant at their initial levels. $\hat{\tilde{q}}^{Fact.\ End.}_{ijs2011}$ and $\hat{\tilde{q}}^{Econ.\ Dev.}_{ijs2011}$ have a similar interpretation and are constructed analogously. All coefficients are beta coefficients. All specifications refer to the partial correlation after netting out the exporter and importer-industry effects. Standard errors are robust to heteroskedasticity. ***, **, and *: indicate significance at the 1%, 5%, and 10% level, respectively. See also notes to previous tables.

Next, we assess the power of the financial variables in explaining the actual variation in average quality observed in the data. Using our estimates (column 9 of Table 6) and the actual change in FD_{jt} over the period of analysis, we predict the average quality of exports from j to i in industry s at the end of 2011, assuming that all other variables entering the specification had remained constant at their initial levels. We label this counterfactual quality $\hat{\tilde{q}}^{Fin.\ Dev.}_{ijs2011}$. Then, we regress the actual value of average quality in 2011 ($\tilde{q}_{ijs2011}$) on $\hat{\tilde{q}}^{Fin.\ Dev.}_{ijs2011}$, absorbing the exporter and importer-industry effects. The beta coefficient and R^2 from this regression are reported in column (1) of Table 10. The interaction of financial development and financial vulnerability explains, alone, 19% of the residual variation in average quality. For comparison, columns (2) and (3) perform similar exercises, using the counterfactual quality implied by the observed changes in factor endowments, $\hat{\tilde{q}}^{Fact.\ End.}_{ijs2011}$, and per capita GDP, $\hat{\tilde{q}}^{Econ.\ Dev.}_{ijs2011}$. Note that factor endowments explain a smaller fraction of the observed variation in average quality (13%), while the explanatory power of economic development is similar to that of financial frictions (19%). When the counterfactual qualities are jointly included in the same specification (columns 4-6), the coefficient on $\hat{\tilde{q}}^{Fin.\ Dev.}_{ijs2011}$ is only slightly reduced, and remains larger and more precisely estimated than those on $\hat{\tilde{q}}^{Fact.\ End.}_{ijs2011}$ and $\hat{\tilde{q}}^{Econ.\ Dev.}_{ijs2011}$. We conclude that the interplay between financial frictions and financial vulnerability is an important driver of the geographical and sectoral variation in product quality. Its effect is empirically no less relevant than those of the main alternative explanations considered in the literature until now.

5.5.2 Financial Frictions, Average Quality, and Export Structure

An important example of the real effects of financial frictions is their influence on international trade and countries' export structure. In particular, previous studies unambiguously show that financially more developed countries export relatively more in financially more vulnerable industries (see, especially, Beck, 2002; Manova, 2013). According to our model, firms' export revenues are increasing in product quality. At the same time, our empirical results show that financial development raises average quality relatively more in financially more vulnerable industries. It follows that these cross-industry differences in the response of average quality to financial frictions provide a mechanism through which financial development could shape the industrial composition of countries' exports. In this section, we provide evidence on this mechanism.

We start by showing that our data replicate the standard results about the effects of financial development on countries' export structure. To this purpose, we derive and estimate a gravity-like equation implied by the model. Aggregating revenues across firms and using $\beta^r_{ijs}(a) \in (0,1)$ to express the reduced sales of liquidity-constrained producers, total exports from j to i in industry s are given by:

$$\begin{aligned} M_{ijs} &\equiv N_{js}\left(\int_{a_L}^{\underline{a}_{ijs}} r^o_{ijs}(a)\, g(a)\, da + \int_{\underline{a}_{ijs}}^{\bar{a}_{ijs}} \beta^r_{ijs}(a)\, r^o_{ijs}(a)\, g(a)\, da\right) \\ &= N_{js} r^o_{ijs}(a_L)\, V^r_{ijs} E^r_{ijs}, \end{aligned} \tag{36}$$

where

$$\begin{aligned} V^r_{ijs} &\equiv \int_{a_L}^{\bar{a}_{ijs}} \left(\frac{a}{a_L}\right)^{(1-\varepsilon)\gamma/\tilde{\gamma}} g(a)\, da, \\ E^r_{ijs} &\equiv \frac{\int_{a_L}^{\underline{a}_{ijs}} \left(\frac{a}{a_L}\right)^{(1-\varepsilon)\gamma/\tilde{\gamma}} g(a)\, da + \int_{\underline{a}_{ijs}}^{\bar{a}_{ijs}} \beta^r_{ijs}(a) \left(\frac{a}{a_L}\right)^{(1-\varepsilon)\gamma/\tilde{\gamma}} g(a)\, da}{\int_{a_L}^{\bar{a}_{ijs}} \left(\frac{a}{a_L}\right)^{(1-\varepsilon)\gamma/\tilde{\gamma}} g(a)\, da}, \end{aligned}$$

and

$$r^o_{ijs}(a_L) = \frac{\varepsilon\gamma c_{js}}{\gamma - \tilde{\gamma}} \left[\left(\frac{\omega_{ijs}(a_L)}{\alpha P_{is}}\right)^{1-\varepsilon} \frac{(\gamma - \tilde{\gamma})\, Y_{is}}{\varepsilon\gamma c_{js}}\right]^{\gamma/\tilde{\gamma}}$$

is the revenue of the most efficient firm. As in the quality equation (23), E^r_{ijs} and V^r_{ijs} adjust $r^o_{ijs}(a_L)$ to account for the intensive- and extensive-margin contributions of financial frictions in the presence of firm heterogeneity. Note, in particular, that V^r_{ijs} is increasing in $\bar{a}_{ijs}$, as a higher proportion of exporting firms raises total exports *ceteris paribus*.

To derive an estimable version of (36), we proceed as in Section 3.1. In particular, we take logs of (36), use the parametrization for τ_{ij} and c_{js} in (27) and (28), and now also assume that $N_{js} = \varkappa_s N_j$, where $\varkappa_s$ is the share of industry s in the total number N_j of active firms in country j.[60] This yields the following empirical specification of the gravity equation:

$$m_{ijs} = \mu_0 + \mu_{is} + \mu_j - \gamma\zeta d_{ij} + v^r_{ijs} + e^r_{ijs} + \tilde{u}_{ij}, \tag{37}$$

where $\mu_{is} \equiv (\gamma/\tilde{\gamma})\left[(\varepsilon - 1)\, p_{is} + y_{is}\right] + \left[(\tilde{\gamma} - \varepsilon\gamma)/\tilde{\gamma}\right] \ln c_s + \varkappa_s$ is an importer-industry fixed effect, $\mu_j \equiv \left[(\tilde{\gamma} - \varepsilon\gamma)/\tilde{\gamma}\right] \ln c_j + n_j$ is an exporter fixed effect, and $\tilde{u}_{ij} \equiv \gamma u_{ij} \sim N\left(0, \gamma^2\sigma^2_u\right)$.[61]

In column (1) of Table 11, we regress m_{ijst} on $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$, plus all variables in (37) except for v^r_{ijs} and e^r_{ijs}. This regression yields the overall effect of financial development on the industrial structure of countries' exports. The coefficient on $FD_{jt} \cdot EF_s$ is positive and highly significant, whereas

[60] A more flexible approach would be to directly control for the number of firms in each country and industry. At the level of industry disaggregation at which we work, these data are unavailable for most countries and years.

[61] In (37), μ_0 is a constant that bundles a number of parameters: $\mu_0 \equiv \ln\left[\left(\frac{\gamma-\tilde{\gamma}}{\varepsilon\gamma}\right)^{(\gamma-\tilde{\gamma})/\gamma} \left(\frac{a_L}{\alpha}\right)^{(1-\varepsilon)\gamma/\tilde{\gamma}}\right]$.

Table 11: Average Quality and Export Structure

	Total Exports m_{ijst} (1)	Total Exports m_{ijst} (2)	Average Quality $\tilde{q}_{ijst}$ (3)	Total Quantity x_{ijst} (4)	Average Qual.-Adj. Prices $\tilde{p}_{ijst}$ (5)	Average Raw Prices $\bar{p}_{ijst}$ (6)
$FD_{jt} \cdot EF_s$	0.027***	0.031***	0.310***	0.030***	-0.313***	-0.003**
	(0.003)	(0.002)	(0.007)	(0.004)	(0.007)	(0.001)
$FD_{jt} \cdot AT_s$	-1.695***	-1.611***	-0.472***	-1.543***	0.320***	-0.152***
	(0.022)	(0.008)	(0.044)	(0.024)	(0.044)	(0.008)
d_{ij}	-1.519***	-1.477***	-0.529***	-1.688***	0.698***	0.169***
	(0.003)	(0.002)	(0.006)	(0.003)	(0.006)	(0.001)
$\widehat{\eta}^*_{ijst}$		1.265***				
		(0.034)				
Obs.	3,139,124	3,139,124	3,139,124	3,139,124	3,139,124	3,139,124
R^2	0.52	0.53	0.98	0.54	0.98	0.76

Notes: The dependent variables are indicated in the columns' headings and are all expressed in logs. Column (2) includes a sixth-order polynomial in $\widehat{z}^*_{ijst}$ (coefficients unreported). All specifications include full sets of exporter-year and importer-industry-year effects. Standard errors are corrected for clustering within exporter-importer pairs. ***, **, and *: indicate significance at the 1%, 5%, and 10% level, respectively. See also notes to previous tables.

that on $FD_{jt} \cdot AT_s$ is negative and very precisely estimated. Hence, our data confirm that financially more developed countries export relatively more in industries where firms rely more on outside capital and have less collateral (Manova, 2013). In column (2), we control for the term v^r_{ijst}, which accounts for firm selection; for brevity, we use a linear semi-parametric model, proxing for v^r_{ijst} with a sixth-order polynomial in $\widehat{z}^*_{ijst}$. We also control for sample selection bias by including the inverse Mills ratio $\widehat{\eta}^*_{ijst}$ as an additional regressor. Our coefficients of interest have the same sign and approximately the same size as in column (1). Hence, in our data, changes in firm-level sales (the intensive margin) account for most of the effect of financial development on exports. This is broadly consistent with the evidence in Manova (2013), who finds the intensive margin to be predominant also in her data.

Having shown that our data are not special in any respect, we turn to the question of how adjustments in average quality contribute to the effect of financial development on countries' export structure. Note that bilateral industry-level exports can be decomposed as follows:

$$m_{ijs} = \tilde{q}_{ijs} + x_{ijs} + \tilde{p}_{ijs}, \tag{38}$$

where $\tilde{q}_{ijs}$ is the log of average quality, $x_{ijs} \equiv \ln X_{ijs}$ is the log of total exported quantity, and $\tilde{p}_{ijs} \equiv \ln\left(M_{ijs}/X_{ijs}\tilde{Q}_{ijs}\right)$ is the log of the average quality-adjusted price. The properties of OLS imply that the coefficients obtained by regressing $\tilde{q}_{ijs}$, x_{ijs}, and $\tilde{p}_{ijs}$ on the RHS variables of (37) will add up to those for aggregate exports. Hence, these coefficients can be used to gauge the *ceteris paribus* contribution of each term to the overall effect of financial development on exports.

The results of these regressions are reported in columns (3)-(5). Remarkably, the coefficients on $FD_{jt} \cdot EF_s$ and $FD_{jt} \cdot AT_s$ from the quality regression (column 3) are both large compared to the estimates in column (1). In particular, the point estimates imply that adjustments in average quality account, alone, for 25% of the overall coefficient on $FD_{jt} \cdot AT_s$ and for more that 100% of the overall coefficient on $FD_{jt} \cdot EF_s$.

As shown in columns (4) and (5), the remainder of the effect passes through changes in total quantity and average quality-adjusted prices. According to the model, these variables respond to financial development because firms adjust their output quality. The estimated coefficients are in line with the theoretical predictions. In particular, they imply that financial development increases quantity and decreases quality-adjusted prices relatively more in financially more vulnerable industries. This is consistent with the fact that firms raise quality more in these industries when credit conditions improve.

Quantity and prices could respond to changes in financial frictions also in the traditional model with exogenous and homogeneous quality, provided that firms borrow from outside investors to finance also their variable costs (see Manova, 2013). In such a framework, liquidity-constrained firms would produce less than the optimal amount, and would charge a price above the first best. The reason is that, by reducing quantity, these firms would lower their funding needs, and would thus be able to meet the liquidity constraint. Then, financial development would lead these firms to raise quantity and decrease prices, which would result in higher revenues; these effects would be stronger in financially more vulnerable industries. Importantly, this mechanism would provide an alternative explanation, unrelated to quality, for the intensive-margin contribution of financial frictions documented in column (2).

We now evaluate the performance of a model with exogenous and homogeneous quality, and compare it with that of a model in which quality is endogenous. To this purpose, note that, if quality were homogeneous, $\tilde{Q}_{ijs} = 1$ and (38) would become:

$$m_{ijs} = x_{ijs} + \bar{p}_{ijs},$$

where $\bar{p}_{ijs} \equiv \ln\left(M_{ijs}/X_{ijs}\right)$ is now the log of the average raw price. Column (4) reports the results of the quantity regression, which are the same as before. The results of the price regression are shown in column (6). Note that the quantity regression is uninformative to discriminate the two models, because both would imply the same pattern of coefficients. Instead, the price regression contains useful information: as mentioned above, in a model with exogenous and homogeneous quality, financial development would lead to a stronger reduction in prices in financially more vulnerable industries. This would imply a positive coefficient on $FD_{jt} \cdot AT_s$ and a negative coefficient on $FD_{jt} \cdot EF_s$. In practice, the former coefficient is wrongly signed and the latter is essentially zero. Hence, changes in raw prices are inconsistent with the predictions of a model featuring exogenous and homogeneous quality. As shown before, instead, changes in average quality and quality-adjusted prices are in line with the predictions of a model in which quality is endogenously chosen by firms. It follows that a theoretical explanation that neglected the role of product quality could lead to erroneous conclusions regarding the mechanisms through which financial development affects specialization and trade.

6 Conclusion

In this paper, we do two things. First and foremost, we investigate how the interplay between country heterogeneity in financial frictions and industry heterogeneity in financial vulnerability affects the geographical and sectoral variation in average product quality. Second, we study how quality adjustments contribute to explaining the effects of financial frictions on international trade and countries' export structure. To discipline our empirical analysis, we use a standard trade model featuring heterogeneous firms, endogenous output quality, cross-country differences in financial frictions, and cross-industry differences in financial vulnerability. We estimate the model using a rich panel data set, which covers virtually all manufacturing industries and countries in the world, and contains reliable measures of export quality, financial development, and financial vulnerability over the last three decades. Our results show that the interaction of financial frictions and financial vulnerability is a crucial driver of the observed variation in average quality across countries and industries. Moreover, they suggest that changes in average quality are a key mechanism through which financial development shapes the industrial composition of countries' exports.

Our findings offers a new lens through which to interpret other important facts about the real effects of financial frictions. For instance, they may provide an alternative explanation for why credit market imperfections have strong effects on TFP, and for why these effects are highly heterogeneous across countries and industries (Buera et al., 2011). We view this analysis as a promising avenue for future research.

A Proofs of Theoretical Propositions

Proposition 1 The cut-off $\underline{a}_{ijs}$ is defined by eq. (15). Differentiating both sides of this equation with respect to λ_j, $\lambda_j d_s$, and $\lambda_j t_s$ yields:

$$\begin{aligned}
&\frac{\partial LHS}{\partial \lambda_j} = \frac{r_{ijs}\left(\underline{a}_{ijs}\right) d_s}{\varepsilon \lambda_j^2}\frac{\gamma-\tilde{\gamma}}{\gamma} > 0 \quad \text{and} \quad \frac{\partial RHS}{\partial \lambda_j} = -\frac{c_{js}\left(d_s f_{ij} - t_s f_{ej}\right)}{\lambda_j^2} < 0;\\
&\frac{\partial^2 LHS}{\partial \lambda_j \partial d_s} = \frac{r_{ijs}\left(\underline{a}_{ijs}\right)}{\varepsilon \lambda_j^2}\frac{\gamma-\tilde{\gamma}}{\gamma} > 0 \quad \text{and} \quad \frac{\partial^2 RHS}{\partial \lambda_j \partial d_s} = -\frac{c_{js} f_{ij}}{\lambda_j^2} < 0;\\
&\frac{\partial^2 LHS}{\partial \lambda_j \partial t_s} = 0 \quad \text{and} \quad \frac{\partial^2 RHS}{\partial \lambda_j \partial t_s} = \frac{c_{js} f_{ej}}{\lambda_j^2} > 0.
\end{aligned}$$

Since the LHS of (15) is decreasing in $\underline{a}_{ijs}$, it follows that:

$$\frac{\partial \underline{a}_{ijs}}{\partial \lambda_j} > 0, \frac{\partial^2 \underline{a}_{ijs}}{\partial \lambda_j \partial d_s} > 0, \text{and } \frac{\partial^2 \underline{a}_{ijs}}{\partial \lambda_j \partial t_s} < 0.$$

Proposition 2 For liquidity-constrained firms, eq. (17) holds as an equality. Because the RHS is the same as in (15), its derivatives are the same as in the previous proof. The derivatives of the LHS are instead equal to:

$$\frac{\partial LHS}{\partial \lambda_j} = \frac{d_s c_{js} q_{ijs}(a)^{\gamma}}{\lambda_j^2} > 0, \frac{\partial^2 LHS}{\partial \lambda_j \partial d_s} = \frac{c_{js} q_{ijs}(a)^{\gamma}}{\lambda_j^2} > 0, \text{and } \frac{\partial^2 LHS}{\partial \lambda_j \partial t_s} = 0.$$

Recalling that the LHS is decreasing in quality for $q_{ijs}(a) \in \left[q_{ijs}^c(a), q_{ijs}^o(a)\right]$ and that we have expressed the quality of liquidity-constrained firms as a fraction $\beta_{ijs}(a)$ of the optimal quality $q_{ijs}^o(a)$, it follows that:

$$\frac{\partial \beta_{ijs}(a)}{\partial \lambda_j} > 0, \frac{\partial^2 \beta_{ijs}(a)}{\partial \lambda_j \partial d_s} > 0, \text{and } \frac{\partial^2 \beta_{ijs}(a)}{\partial \lambda_j \partial t_s} < 0.$$

Proposition 3 The cut-off $\bar{a}_{ijs}$ is defined by eq. (20). The RHS is the same as in (15) and (17), so its derivatives are the same as in the previous proofs. Differentiating the LHS with respect to λ_j, $\lambda_j d_s$, and $\lambda_j t_s$ yields:

$$\frac{\partial LHS}{\partial \lambda_j} = \frac{r_{ijs}\left(\bar{a}_{ijs}\right) d_s \left(\gamma - \tilde{\gamma}\right)}{\varepsilon \gamma \lambda_j^2 \left(1 - d_s + \frac{d_s}{\lambda_j}\right)} > 0, \; \frac{\partial^2 LHS}{\partial \lambda_j \partial t_s} = 0, \text{ and}$$

$$\frac{\partial^2 LHS}{\partial \lambda_j \partial d_s} = \frac{r_{ijs}\left(\bar{a}_{ijs}\right) (\varepsilon - 1)(1 - \delta) \left[\lambda_j \tilde{\gamma} - \left(1 - \lambda_j\right)(\varepsilon - 1)(1 - \delta) d_s\right]}{\varepsilon \gamma \lambda_j^3 \tilde{\gamma} \left(1 - d_s + \frac{d_s}{\lambda_j}\right)^2} \lesseqgtr 0.$$

Since the LHS is decreasing in $\bar{a}_{ijs}$, it follows that:

$$\frac{\partial \bar{a}_{ijs}}{\partial \lambda_j} > 0, \; \frac{\partial^2 \bar{a}_{ijs}}{\partial \lambda_j \partial t_s} < 0, \text{ and } \frac{\partial^2 \bar{a}_{ijs}}{\partial \lambda_j \partial d_s} \lesseqgtr 0.$$

Recalling that $\tilde{\gamma} \equiv \gamma - (\varepsilon - 1)(1 - \delta)$, $\partial^2 LHS / \partial \lambda_j \partial d_s$ is more likely to be negative the smaller is γ relative to $(\varepsilon - 1)(1 - \delta)$, i.e., the smaller is the quality-elasticity of the fixed cost compared to the quality-elasticity of revenues.

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