The Impact of Financial Development on Innovation-Based Exports: Do All Firms Benefit Equally? *

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Abstract

In a heterogeneous firms model with credit constraints and quality choice, I show that the benefits of easier and cheaper access to external finance to exporting firms increase in their productivity. More productive firms specialize in higher quality products and thus stand to gain more from cheaper credit, which is required for quality upgrading. This implies that the quality and export gaps between more and less productive exporters increase as the financial system improves. An empirical analysis using Taiwanese firm-level data for the period 1990–2015 supports my predictions, showing that less stringent credit constraints translate into higher export price and value of more productive firms.

JEL classification: F10, F14, G20, O14, O16
Keywords: Financial development, Productivity, Innovation, Quality, Heterogeneous firms

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1 Introduction

There is a substantial body of research on the link between financial development, economic growth and income inequality (Beck et al., 2007; Christopoulos and Tsionas, 2004; Greenwood and Jovanovic, 1990; King and Levine, 1993a,b; Levine, 1997; Merton and Bodie, 1995). It is believed that a well-functioning financial system reduces the cost of capital, promotes the efficient allocation of capital, and encourages economic growth. This implies that financial development can be a potentially important mechanism for persistent income inequality. However, the effect of financial development on income inequality is inconclusive. While several studies including Banerjee and Newman (1993), Beck et al. (2007) and Galor and Moav (2004) suggest that financial sector development reduces income inequality, Greenwood and Jovanovic (1990) show that financial development can increase income inequality and therefore, may decrease the rate of economic growth. Chen and Kinkyo (2016) find that financial development will reduce inequality in the long run, while it can increase inequality in the short run. This suggests that the relationship between financial development and inequality is complex and depends on whether the increase in inequality is large enough to outweigh the positive impact of financial development. This must be answered by comparing the results of studies in many different areas, including international trade. Yet, there has been relatively little empirical investigation of the impact of financial development on the inequality of export prices and values across firms or products.

This paper broadly contributes to the conflicting views about the impact of financial development on inequality. However, rather than re-examining the finance-growth link, I focus on the impact of financial development on exports given that trade is strongly associated with growth. Specifically, the objective of this study is to examine the asymmetric effects of financial sector development on export quality, price, and value across firms with different productivity levels. Since firms incur large costs when participating in export markets, it is natural to think that the effect of financial development on export performance particularly depends on a firm's productivity because of its effect on the cost structure. Although there are some papers dealing with trade and financial constraints at the firm level,[1] Alvarez and

[1]Other papers dealing with trade and financial constraints at the firm-level include Feenstra et al. (2014) and Forlani (2008). Feenstra et al. (2014) mainly show that the tighter credit constraint on exporting firms comes from the greater export share of the firm, the longer time-lag between production and sales of goods, and the greater information incompleteness and that the credit constraint negatively affects the intensive and

López (2013) and Berman and Héricourt (2010) are the only papers of which I am aware that focus on the differential effects of financial development across firms with different levels of productivity. They find empirical evidence that financial development disproportionately increases the probability of exporting for more productive firms. In particular, using firm-level data for several developing and emerging economies, Berman and Héricourt (2010) find that in the presence of fixed costs, financial constraints affect the extensive margin only: the quantity exported is not affected by financial constraints, but by the productivity of firms in the export market. While it is not the main focus of the paper, Manova (2013) implicitly shows asymmetry in the effect of financial development on the level of firms' exports, which depends on their productivity levels. Yet, these studies do not consider the product quality dimension.

When quality choice is absent, one may expect to find that more productive firms are less dependent on financial development, since they have lower production costs and generate higher profits, and therefore easier and cheaper access to external finance becomes less important with increasing firm productivity. This paper shows that when quality dimension is incorporated, this conclusion is no longer valid. Namely, my model predicts that more productive firms benefit more from relaxed financial constraints in terms of absolute export value. I therefore argue that a model, which simultaneously considers firm heterogeneity and endogenous innovation-based quality choice, can help explain the mechanism of the asymmetric effect observed in the data. As the quality and trade literature suggests, quality heterogeneity must be taken into account when studying the effect on exporters' behavior, because the differences in product quality provide an important source of firms' competitiveness. Further, this paper extends the previous literature and provides interesting, testable implications that the impact of financial development on exports is not concentrated at the extensive margin when a firm's cost structure is associated with product quality, and that the magnitude of the effect depends on the firm's level of productivity.

To motivate the empirical analysis, I discuss a simple theoretical model explaining the mechanism between financial constraints and exports, which draws heavily from the work of Fan et al. (2015). Fan et al. (2015) was the first to link credit constraints to firm characteristics and actions, such as productivity, and the choice of product quality and optimal

extensive margins of exports. Forlani (2008) finds the negative relationship between exporting probability and financial constraints.

prices. This paper builds on the model by providing a micro-foundation for the lending and borrowing decisions in which the interest rate endogenously changes according to the level of financial development. It shows that in the presence of financial constraints, more productive firms endogenously choose to increase product quality and prices. Moreover, I examine the interaction effect of financial development and firm productivity not only on export prices but also on export values, while Fan et al. (2015) focus on their separate effects on the unit value price, and therefore the quality. Thus, this paper contributes to advancing the understanding of the intensive margin of trade.

A significant distinction of my model from the previous work is its ability to demonstrate, consistent with empirical evidence, that the price differences across firms increase with the development of financial institutions. In other words, more productive firms start charging even higher prices as the financial system develops. In contrast, the opposite is true for Manova (2013): the export price decreases in the degree of financial development in the source country, and more productive firms charge even lower prices. Importantly, when considering input-based exports, Baldwin and Harrigan (2011), Manova and Zhang (2012), and Verhoogen (2008) also show that improvements in the financial system will reduce the prices of the existing firms. My model with innovation-based exports reveals, however, that financial development results in a positive, and moreover, differential effect on the prices that more and less productive firms charge.

I test the empirical implications of the model by focusing on the setting of Taiwan, which is ranked among the 20 largest exporters of merchandise in the world but still has a relatively underdeveloped bank-based financial system. I exploit a large dataset on Taiwanese firms for the period 1990–2015.[2] To see whether it is indeed the case that the effect of easier and cheaper access to outside financing is stronger for more productive firms, I include an interaction term between financial development and firm productivity. The results support the theoretical prediction: product quality, export price and value increase in productivity. The significant interaction coefficients indicate that this effect becomes stronger as financial systems improve. In addition, I find that the impact of country-level financial system development is more pronounced, of more relevance and can be better observed than that of firm-level financial constraints in explaining variation of export price and value. The robustness of the results is checked by the use of different financial development indicators.

[2] Fan et al. (2015) use the Chinese firm-level data for the period 2000–2006.

Overall, without questioning the benefits of financial development, this study suggests that it may have the unintended consequence of raising inequality.

The remainder of the paper is organized as follows. Section 2 provides a review of the literature. Section 3 presents a simple model featuring endogenous product quality, credit constraints, and heterogeneous productivity to illustrate the impact of financial development on the optimal quality and exports for firms at different levels of productivity. Section 4 describes the data and presents the strategy of the empirical analysis. Section 5 presents the main empirical results. Section 6 presents the conclusion.

2 Literature Review

This paper contributes to the growing literature on the role of financial constraints for exports in the heterogeneous firms model. An implication of these studies is that financial development contributes to reducing financial constraints at the firm level, thereby promoting exports. For example, Chaney (2016) extends the work of Melitz (2003) to a heterogeneous firms model in which firms with sufficient liquidity are able to export. The author argues that firms' productivity and liquidity matter regarding the decision to participate in the export market: more liquid and more productive firms are more likely to export than others. On the other hand, the intensive margin of exports is not affected by liquidity constraints, and only the level of productivity affects the exported volumes. As Chaney (2016) acknowledges, whether and how much trade is impeded by financial constraints depends on the distribution of productivity and liquidity across firms. Therefore, the question of whether financial constraints matter for international trade boils down to an empirical question. There are some further empirical studies that deal with the effect of financial factors on exports, but the results are mixed. Analyzing firms in Belgium, Muûls (2008) finds that financial constraints are crucial for the extensive margin of exports, but have no impact on the intensive margin once a firm starts to export. On the other hand, Greenaway et al. (2007) find that firms that start exporting in the UK over the period 1993–2003 are not characterized by higher liquidity than other firms. Using a large panel dataset of French manufacturing firms, Stiebale (2011) also argues that there is no evidence that financial constraints matter for export decisions. In this paper, I theoretically and empirically investigate the role of financial constraints on the intensive margin of exports when product quality upgrading influences the firm's cost

structure.

This paper also adds to the literature on the differential impacts of financial development on trade across countries, industries, and firms. For instance, Berthou (2010) shows theoretically and empirically that the effect of financial development on trade is reduced in countries that have initially a low or high initial level of financial development. Beck (2003) and Manova (2013) find that better financial markets lead industries with higher external finance dependence to export relatively more. Aghion et al. (2007) suggest that financial development matters most for the entry of small firms in sectors using more external finance. The present paper focuses on the heterogeneous response of export price and value across firms.

The models presented in the above papers exclude the quality dimension. This may help explain the conflict between their findings and the recent empirical evidence (Baldwin and Harrigan, 2011; Verhoogen, 2008). Fan et al. (2015) extend the Melitz (2003) model of heterogeneous firms by including endogenous quality choice and financial constraints. They theoretically examine the effects of credit constraints on a firm's choice of optimal quality and price. They predict that the effects of credit constraints on prices depend on two opposing effects: the quality adjustment effect, which lowers product quality and therefore reduces prices, and the price distortion effect, which is induced by reduced output and the consequent excess demand. The optimal prices decrease with more stringent credit constraints when the quality adjustment effect dominates the price distortion effect. While Fan et al. (2015) estimate the separate effects of credit access and firm productivity on the unit value price, the present paper focuses on their interaction effect on the export value, as well as that on the optimal quality and price, and emphasizes increasing inequality between firms.

Crozet et al. (2012) also incorporate endogenous quality choice into the Melitz (2003) model. They match firm-level export data with expert assessments of the quality of French champagne producers and show that firms choosing to produce higher-quality products are more likely to export and sell more at higher export prices than those producing lower-quality products. This result is somewhat contradictory to those presented in the previous papers on trade and heterogeneous firms; in the Melitz-type model, more productive and successful firms charge lower export prices. The positive relationship between export prices and a firm's productivity can be explained by the idea that the firm's productivity is positively related to its ability to produce higher-quality goods. This is the underlying idea of this paper.

I conclude, based on this survey, that this paper provides the novel micro-level evidence on the interaction effect of country-level financial development and firm productivity on the intensive margin of trade.

3 Model

My model is closely related to the heterogeneous firms trade model developed by Fan et al. (2015), which incorporates innovation-based endogenous product quality, credit constraints, and heterogeneous productivity. In order to arrive at a closed form solution, I restrict my analysis to a partial equilibrium model with a fixed number of exporters.[3]

The model in this paper improves the way in which financial constraints are represented. To emphasize the role of financial development that reduces the cost of enforcing the financial contracts and the interest rate, it follows the approach of Galor and Zeira (1993), which has not been previously applied in the trade-finance literature. As an example of conventional approaches, Manova (2013) measures the degree of financial development by the probability that the financial contract is enforced. The probability is exogenous to the model and is simply assumed to be determined by the strength of the country's financial institutions. In contrast, this paper captures the idea that the improvement in the financial system reduces the enforcement costs that banks incur and the interest rate that they charge, leading to easier and cheaper access to external finance for firms.[4]

3.1 Demand

I denote the source country by i, the destination country by j, and the sector by s, where $i, j \in 1, ..., N$ and $s \in 1, ..., S$. Consumers in country j have access to a set of varieties Ω_{js}. As in Fan et al. (2015), I assume that a representative consumer cares about a product's quality. The consumer's quality-augmented utility of country j is[5]

$$U_j = \sum_{s=1}^{S} \sum_{i=1}^{N} \left(\int_{\omega \in \Omega_{js}} [q_{is}(\omega) x_{ijs}(\omega)]^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

[3] I only consider exporting firms. Bernard and Jensen (2004) find that the U.S.' export growth is mostly explained by an increase in exports of existing exporters rather than by entry by new exporters.

[4] Modeling financial development as in Manova (2013) can bring the qualitatively same outcome, but requires an additional assumption. See Appendix for details.

[5] This paper assumes CES preferences, and therefore does not address market size effects.

where $q_{is}(\omega)$ is the quality of variety ω in sector s, originated from country i; $x_{ijs}(\omega)$ is country j's quantity consumed of variety ω in sector s, originated from country i; and $\sigma > 1$ is the elasticity of substitution between varieties. Product quality increases the consumer's willingness to pay, and therefore operates as a demand shifter. It also indicates the need for quality innovation. Consumers derive the optimal demand for each good, maximizing their utility subject to the budget constraint. The demand function for each variety is

$$x_{ijs}(p_{ijs}(\omega), q_{is}(\omega)) = [q_{is}(\omega)]^{\sigma-1} \frac{[p_{ijs}(\omega)]^{-\sigma}}{P_j^{1-\sigma}} Y_j \tag{2}$$

where $p_{ijs}(\omega)$ is the price of variety ω; $P_j = \sum_{s=1}^{S} \sum_{i=1}^{N} (\int_{\omega \in \Omega_{js}} [p_{ijs}(\omega)/q_{is}(\omega)]^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$ is the quality-adjusted aggregate price index; and Y_j represents the total expenditure of country j. Note that higher-quality products generate more demand, given the same price. For brevity, the subscripts for countries, as well as the index for variety, are omitted hereafter.

3.2 Production

Each industry has a continuum of firms, each producing a differentiated variety within its industry using labor as the only input. The firms are heterogeneous in two dimensions: productivity and product quality. In this framework, each firm endogenously chooses its optimal product quality, given its own productivity. Put differently, the firms with higher productivity endogenously choose to produce better-quality goods and become more competitive.

Production involves both fixed and variable costs. The general form of the total cost function is the same as in the Melitz (2003) model, but it is allowed to depend on quality. Similar to Fan et al. (2015), I assume that the marginal cost of production is positively correlated with quality and negatively correlated with a firm's productivity. It is a reasonable assumption in that producing a higher-quality product requires higher costs, and more productive firms, by definition, produce at lower marginal production costs. As also mentioned by Fan et al. (2015), the positive relationship between quality and marginal cost is common to the current quality and trade literature including Antoniades (2015), Johnson (2012), Khandelwal (2010), and Verhoogen (2008). Let the marginal cost be $MC(\phi, q) = q^{\alpha}/\phi$, where ϕ is firm-level productivity and $\alpha \in [0, 1]$ is the elasticity of marginal cost with respect to quality, which is common across firms and countries. As in Melitz (2003), each firm

draws random productivity upon entry. Iceberg trade costs are modeled in the standard fashion: τx units of each variety need to be exported, so that x units are finally consumed in the foreign country. A firm faces no trade costs in selling in its home market.

Besides the variable cost, as in Antoniades (2015), each firm pays a fixed cost for producing and exporting goods fq^2, where f is a constant. It captures the idea that a firm's fixed investment in production and export associated with quality improvement is dependent on the product quality. The total cost of firms with productivity ϕ is

$$TC(\phi, q) = \frac{\tau q^{\alpha}}{\phi} q^{\sigma-1} \frac{p^{-\sigma}}{P^{1-\sigma}} Y + fq^2. \tag{3}$$

Each price is expressed in terms of units of labor, used as the numeraire. Without a loss of generality, the wage rate is normalized to one.

3.3 Liquidity-Constrained Exporters

Now, I introduce financial constraints. In this paper, I suppose that all exporting firms are subject to possible financial constraints in paying total costs, including variable costs and fixed costs. A share of $d(\phi)$ of a firm's total costs must be financed by external funds. This share is assumed to be negatively associated with firm productivity (i.e., $d'(\phi) < 0$), since more productive firms tend to have more internal funds but receive fewer external funds.[6] This assumption fits well with the data showing that the share of external finance in total operating expenses decreases with firm productivity (See Figure 2).

As in Galor and Zeira (1993), an investor (or a lender) must have positive enforcement costs $e(B)$ that prevent the borrower from defaulting, and the costs are shown below to be proportional to a firm's financial needs B. A firm that borrows an amount of B pays an interest rate r, which covers the lender's interest rate r_0 and lender's cost $e(B)$. As all investors break even because of perfect competition,

$$B \cdot r = B \cdot r_0 + e(B). \tag{4}$$

[6] Manova (2013) assumes that firms in the same industry have to borrow the same share of their exporting costs for industry-specific, presumably technological reasons.

Lenders choose $e(B)$ to be high enough to make defaulting costly:

$$B(1+r) = \nu \cdot e(B) \tag{5}$$

where $\nu > 1$. The right hand side of (5) is the borrower's punishment, measured as the cost of defaulting. Parameter ν increases as financial institutions become stronger. Indeed, a higher ν implies a lower enforcement cost, other things equal. This is the *incentive compatibility constraint*, similar to Galor and Zeira (1993). Combining (4) and (5) yields

$$\begin{aligned} \nu \cdot e(B) - B &= B \cdot r_0 + e(B) \\ e(B) &= \frac{1+r_0}{\nu - 1} B. \end{aligned} \tag{6}$$

The enforcement costs of getting the principal and interest back, $e(B)$, indeed decrease with financial development.

Substituting (6) into (4) gives the following:

$$r = \frac{\nu r_0 + 1}{\nu - 1} > r_0. \tag{7}$$

Higher financial development leads to a lower interest rate r. The interest rate is independent of the amount of borrowing, B, as enforcement costs also increase with B.

3.4 Equilibrium and Predictions

Given the financial constraints, firms maximize profits

$$pq^{\sigma-1}\frac{p^{-\sigma}}{P^{1-\sigma}}Y - (1-d)\left[\frac{\tau q^{\alpha}}{\phi}q^{\sigma-1}\frac{p^{-\sigma}}{P^{1-\sigma}}Y + fq^2\right] - (1+r)d\left[\frac{\tau q^{\alpha}}{\phi}q^{\sigma-1}\frac{p^{-\sigma}}{P^{1-\sigma}}Y + fq^2\right] \tag{8}$$

where $r = (\nu r_0 + 1)/(\nu - 1)$.

Solving this optimization problem yields the following:

$$p = \left(1 + \frac{\nu r_0 + 1}{\nu - 1} d\right) \frac{\sigma}{\sigma - 1} \frac{\tau q^{\alpha}}{\phi} \tag{9}$$

$$x = q^{\sigma-1} \frac{p^{-\sigma}}{P^{1-\sigma}} Y = \frac{2}{(1-\alpha)\frac{\tau q^{\alpha}}{\phi}} f q^2 \tag{10}$$

$$R = q^{\sigma-1} \frac{p^{1-\sigma}}{P^{1-\sigma}} Y = \frac{2\sigma}{(1-\alpha)(\sigma-1)} \left(1 + \frac{\nu r_0 + 1}{\nu - 1} d\right) f q^2 \tag{11}$$

where R is the export values. Let $\Delta \equiv 1 + (\nu r_0 + 1)d/(\nu - 1)$, which reflects the price distortion in equation (9). This means that lower financial development (lower ν) or higher external finance dependence (higher d), which tightens the firm's credit constraints, increases the extent to which the price is distorted, given product quality.

Equations (9) – (11) illustrate how higher quality translates into higher price and export performance for each variety. A firm producing relatively higher-quality goods obtains a favorable demand shift, and can export more and charge a higher price. The maximization problem also gives the optimal quality endogenously chosen by firms with productivity ϕ:

$$q = \left[\frac{\tau(1-\alpha)}{2f} \left(\frac{\tau\sigma}{\sigma-1}\right)^{-\sigma} \Delta^{-\sigma} \frac{Y}{P^{1-\sigma}}\right]^{\frac{1}{2-(1-\alpha)(\sigma-1)}} \phi^{\frac{\sigma-1}{2-(1-\alpha)(\sigma-1)}}. \tag{12}$$

I impose the following condition:

Condition (i): $2 > (1-\alpha)(\sigma-1)$.

Under this condition, a firm's product quality q is positively correlated with its productivity ϕ.[7] In other words, more productive firms choose higher quality. This condition captures the fact that improving quality is costly (recall that fq^2 is the fixed production cost), and hence prevents a firm from increasing its quality without bounds. It also implies that a product is relatively highly differentiated because it is subject to a relatively low elasticity of substitution ($\sigma < (3-\alpha)/(1-\alpha)$).

The optimal pricing rule (9), combined with (12), yields the following:

$$p = \left[\frac{\tau(1-\alpha)}{2f} \frac{Y}{P^{1-\sigma}}\right]^{\frac{\alpha}{2-(1-\alpha)(\sigma-1)}} \left(\frac{\tau\sigma}{\sigma-1}\Delta\right)^{1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}} \phi^{\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)}-1}. \tag{13}$$

I now introduce the following condition:

[7] This is the same assumption as in Fan et al. (2015).

Condition (ii): $\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)} - 1 > 0$, or equivalently, $\sigma > 3$.

If Conditions (i) and (ii) hold, a firm's optimal price is positively correlated with its productivity.[8] If the fixed investment is not sufficiently effective to improve product quality—i.e., if Condition (ii) is not satisfied—it would be difficult for the firm to flexibly adjust its product quality and choose higher-quality products.

The model generates the following theoretical predictions, and it is noteworthy that they are made under fairly standard assumptions of existent models. Henceforth, unless otherwise noted, the following predictions are based on Conditions (i) and (ii).

Proposition 1. *More productive firms choose to export higher-quality products at higher prices* $\left(\frac{\partial q}{\partial \phi} > 0, \frac{\partial p}{\partial \phi} > 0\right)$.

Proof. *See Appendix.* □

When a product is highly differentiated ($\sigma < (3-\alpha)/(1-\alpha)$), competition is lower, and hence more innovation is expected to occur, since it is more likely that firms will obtain higher returns on the innovation that they implement (Schumpeter, 1942). In this case, more productive firms that can produce at lower variable costs (given a quality level) will try to innovate product quality and increase the gains from quality improvement. As marginal costs rise in quality, the price of a good is positively related to its quality.

Proposition 2. *High quality products are exported more* $\left(\frac{dx}{dq} > 0, \frac{dR}{dq} > 0\right)$. *This effect becomes stronger with higher financial development* $\left(\frac{\partial^2 x}{\partial q \partial \nu} > 0, \frac{\partial^2 R}{\partial q \partial \nu} > 0\right)$.

Proof. *See Appendix.* □

More productive, higher-quality firms are better able to serve markets with unfavorable business conditions, and thereby enjoy overall superior export performance. An increase in product quality increases both variable and fixed costs. Therefore, financial development (increase in ν), which enhances firms' ability to finance the increased costs, will also boost innovation, and magnify the impact of product quality on exports.

[8] Fan et al. (2015) made the similar assumption.

Proposition 3. *The improvement of the financial system induces more productive firms to raise their product quality relatively more and, as a result, exports increase by a higher magnitude for more productive firms* $\left(\frac{\partial^2 q}{\partial\phi\partial\nu} > 0, \frac{\partial^2 p}{\partial\phi\partial\nu} > 0, \frac{\partial^2 x}{\partial\phi\partial\nu} > 0, \frac{\partial^2 R}{\partial\phi\partial\nu} > 0\right)$ *if* $\frac{2-(1-\alpha)(\sigma-1)}{\alpha\sigma-2+(1-\alpha)(\sigma-1)}\frac{\nu-1}{\nu r_0+1} < d(\phi)$*, implying that the quality and export gaps between more and less productive firms increase as financial systems improve.*

Proof. *See Appendix.* □

Proposition 3 emphasizes that relieving financial constraints results in an uneven increase in product quality and the price and value of exports. More productive firms producing high quality goods require relatively more fixed investment for quality improvement because it is more costly to improve quality on already high quality products. However, they will continue to innovate in order to maintain their leadership position. Therefore, easier and cheaper access to external finance will have a stronger effect for those firms, and it will allow them to produce even higher-quality products. In other words, financial development increases product quality and prices $\left(\frac{\partial q}{\partial\nu} > 0, \frac{\partial p}{\partial\nu} > 0\right)$, the volume of exports $\left(\frac{\partial x}{\partial\nu} = \frac{\partial x}{\partial q}\frac{\partial q}{\partial\nu} > 0\right)$, and export values $\left(\frac{\partial R}{\partial\nu} = \frac{\partial R}{\partial q}\frac{\partial q}{\partial\nu} > 0\right)$, and these effects are stronger for more productive firms.

4 Empirical Strategy and Data

4.1 Data

For the first set of regressions, the dependent variable is the (log) price of exported goods and services, which can be potentially a measure of product quality. Antoniades (2015) and Baldwin and Harrigan (2011) show that price is a good proxy for quality. This is particularly true when the scope for quality differentiation is high (Antoniades, 2015; Khandelwal, 2010). Although there have been recent debates on the validity of using prices to proxy product quality, and some works, such as Khandelwal (2010) and Hallak and Schott (2011), oppose the large body of literature associating the export unit values with product quality, price is the most comprehensive measure of product quality available for empirical research (Bastos and Silva, 2010; Feenstra and Romalis, 2014; Hallak, 2006; Iacovone and Javorcik, 2008; Kugler and Verhogen, 2008; Schott, 2004). For the second set of regressions, the dependent variable is the (log) export value. Export price and value data are available from the Taiwan Economic Journal (TEJ) database.

One of the primary variables of interest is the level of financial system development. In this study, I use four variables to proxy for financial development.[9] First, a measure of country-level financial system development is the ratio of domestic private credit by deposit money banks to GDP.[10] While the private credit ratio does not directly measure the amelioration of information and transaction costs, a higher ratio of private credit to GDP indicates a higher level of financial services and greater financial intermediary development. Second, I use the ratio of financial institutions' assets to GDP as another measure of financial deepening. Third, financial development is often proxied by liquid liabilities of the financial system (M2/GDP), that is, currency plus demand and interest bearing liabilities of banks and non-financial intermediaries divided by GDP. It is considered the broadest measure of financial intermediation and includes three types of financial institutions: the central bank, deposit money bank, and other financial institutions. Finally, I use the lending-deposits spread of domestic banks. It is a measure of the efficiency with which the banking sector intermediates funds (Sharma, 2007). A narrower interest rate spread indicates a higher level of financial development. Given that the largest shares of the external funds of private corporate funds in Taiwan are loans from financial institutions (Shen and Wang, 2005), the financial structure in Taiwan is much like a bank-based financial system and the bank development is crucial for Taiwan's firms. The data for financial institutions-related variables and GDP are obtained from the Central Bank of the Republic of China (Taiwan) and the National Statistics of Taiwan, respectively.

The finance data of the TEJ database also include total assets, total liabilities, cash flow from operations, and revenue per worker. Firm productivity is measured as the (log) revenue per worker.[11] Following Berman and Héricourt (2010), to control the borrowing needs and ability of firms, I control the firm-level ratio of cash flow from operations to total assets and the ratio of total liabilities to total assets. The ratio of cash flow to total assets indicates the volume of funds that can be mobilized on a short-term basis by the firm. The more short-term liquidity the firm has, the less likely it will be financially constrained. The ratio

[9]The present study is different from Fan et al. (2015) in that in order to measure credit access, the latter collect data on the balances of total bank credits, long-term bank loans, and short-term bank loans and calculate the average bank loans to GDP ratio over the sample period (2000–2006) at the provincial level.

[10]It excludes credit issued to governments, government agencies, and public enterprises. Governmental use of credit can be contaminated by political considerations that would not necessarily lead to optimal allocation of resources.

[11]Since value added data are not available, the operating revenue is the most satisfactory basis for measuring firm productivity.

of total liabilities to total assets measures the firm's current demand for borrowing relative to its capacity to borrow. Firms with a higher ratio of total liabilities to total assets would have more difficulty obtaining additional capital through borrowing, indicating that they are more likely to be financially constrained. As in Berman and Héricourt (2010), I use the inverse of the ratio of total liabilities to total assets, so that its increase represents a decrease in firm-level financial constraints. Finally, based on previous firm-level studies on trade, I also include the firm's size (measured as the log of total assets) and the number of workers as control variables. It is often argued that firm size is correlated with firms' ability to raise external finance at low costs (Carpenter and Petersen, 2002; Stiebale, 2011).

A few observations are dropped because of implausible values such as zero or negative values of export values and quantities. Further, I trim the data by removing the varieties with extreme unit values that fall below the 5th percentile or above the 95th percentile within the year and product.[12] After the data cleaning process, the data used for the analysis comprise information on 1,253 publicly listed, exporting firms and 5,970 exported products for the period 1990–2015. Table B.1 presents descriptive statistics for the sample. The firms included in this study are primarily large-sized enterprises.[13] The maximum number of products per firm is 44 and 78% of firms export less than 10 products. Taiwanese export flows can be characterized by few multi-product firms exporting many products, in line with existing evidence for Portugal (Bastos and Silva, 2010) and Brazil (Arkolakis and Muendler, 2010). The distribution of the average revenue per worker is highly skewed with a long right tail.

4.2 Estimation Strategy

To test the predictions that more productive firms choose to produce higher-quality goods, which tend to be exported more, and that greater financial development magnifies

[12] Khandelwal (2010) drops varieties with extreme unit values that fall below the 5th percentile or above the 95th percentile within the SITC industry.

[13] According to Article 2 in the Standards for Identifying Small and Medium-sized Enterprises, an enterprise is classified as a SME if (1) the enterprise is an enterprise in the manufacturing, construction, mining or quarrying industry with either paid-in capital of NT$80 million or less, or less than 200 regular employees; (2) the enterprise is an enterprise in the industry other than any of those mentioned above and either had its sales revenue of NT$100 million or less in the previous year, or has less than 100 regular employees.

the positive effect, I estimate linear models with multi-way fixed effects of the form

$$\begin{aligned}\ln Y_{i,g,t} =& \beta_0 + \beta_1 \ln Productivity_{i,t} + \beta_2 (\ln Productivity_{i,t} \cdot FD_t) \\ &+ \zeta K_{i,t} + \varphi_{i,g} + \varphi_t + \varepsilon_{i,g,t}\end{aligned} \tag{14}$$

where i denotes firm, g denotes product, and t denotes time. The dependent variable, $\ln Y_{i,g,t}$, is the log of export price of product g exported by firm i in year t, and the log of export value of product g exported by firm i in year t; $\ln Productivity_{i,t}$ is the log of revenue per worker; and FD_t is a proxy for country-level financial development that varies on the annual level. I include the interaction term of financial development and productivity variables to analyze the differential effects of financial system development across firms. I do not include macroeconomic control variables (e.g., country-level financial development) because they are subsumed by year fixed effects. $K_{i,t}$ is a vector of additional control variables, including firms' size, the number of employees, and firm-level measures of financial constraints. Moreover, $\varphi_{i,g}$ and φ_t are fixed effect terms of firm-product and year, respectively. Firm-product fixed effects help control for differences between ordinary and processing firms (Bas and Strauss-Kahn, 2015). ε is the error term that includes all unobserved factors that may affect the dependent variables.

Based upon the model, we can make the empirical predictions. First, higher productivity increases product quality and, therefore, price. Second, easier and cheaper access to external finance is particularly important if the productivity level is higher. I expect $\beta_1 + \beta_2 FD_t > 0$ and $\beta_2 > 0$. The exception is the case where the interest spread is used. In this case, β_2 is expected to be negative.

5 Results

I begin by estimating the impacts of firm productivity and financial variables on export prices. I do not include any variable for financial development in the first regression. In column (1) of Table 1, the coefficient on the productivity proxy is positive and significant at the 1% level, in support of Proposition 1. The estimates reported in column (1) indicate that a one percent increase in productivity increases export prices by 0.09 percent. In columns (2)–(13), while the direct effect of productivity can be either positive, negative, or not significantly different from zero, the total effect is positive. Columns (2)–(13) show a

0.08–0.1 percent increase.[14]

While firm productivity has the potential to affect exports through a host of channels, in columns (2)–(13) I examine one specific link between productivity and export price (thus product quality), specifically that working through financial markets. The hypothesis to test is whether financial system development positively affects the impact of firm productivity on export price. To this end, I interact the productivity variable with an indicator of financial development and test for the significance of the interacted coefficient. A positive coefficient (negative coefficient for the interaction with interest spread) indicates that firm productivity is more effective in increasing product quality and prices in countries with better financial systems. In other words, a positive interaction provides evidence of complementarity between firm productivity and financial instruments. As regards the marginal effect of financial development, export prices are estimated to increase by 3.08 percent if the private credit to GDP ratio increases by 1 percentage point (column (2) of Table 1). This effect is not very sensitive to different financial development variables. This analysis provides results consistent with the predictions about productivity and the role of financial development. This provides broad evidence of the importance of financial development for quality innovation and inequality between firms.

In columns (3)–(4), (6)–(7), (9)–(10), and (12)–(13) of Table 1, I add the interactions between productivity and firm-level finance variables such as the ratio of cash flow to total assets and the ratio of total assets to total liabilities. Interestingly, firm-level borrowing needs and ability are not found to play a consistently significant role in determining export prices, possibly because of small variations in firm-level liquidity and leverage. The estimates for their interaction terms with productivity are not consistently significant. This provides further support to the hypothesis that country-level financial system development matters for firm export performance.[15]

I briefly discuss the other determinants that are included in the regressions. Export prices are not found to be positively correlated with firm size and the number of employees. This result is inconsistent with the result in Melitz and Redding (2012), where they find that the correlation between prices and firm size is strong.

[14]The marginal effect is calculated at the sample averages of the control variables.

[15]Harford et al. (2012) show that country-level corporate governance mechanism is more important than firm-level governance in influencing firm behavior, although not directly related to this study.

Table 1: Effect of productivity and financial development on export prices

Dependent variable: ln(export price)													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Productivity (ln)	0.091***	-0.294***	-0.280***	-0.268***	-0.117**	-0.104*	-0.078	-0.228***	-0.216**	-0.201**	0.179***	0.191***	0.240***
	(0.020)	(0.100)	(0.100)	(0.100)	(0.053)	(0.053)	(0.055)	(0.084)	(0.085)	(0.085)	(0.031)	(0.032)	(0.038)
Productivity (ln)		0.348***	0.347***	0.373***									
× Private credit/GDP		(0.089)	(0.089)	(0.089)									
Productivity (ln)					0.066***	0.066***	0.071***						
× FIA/GDP					(0.016)	(0.016)	(0.016)						
Productivity (ln)								0.152***	0.153***	0.166***			
× M2/GDP								(0.040)	(0.040)	(0.040)			
Productivity (ln)											-0.045***	-0.044***	-0.049***
× Interest spread											(0.013)	(0.013)	(0.013)
Size (ln)	0.039	0.040*	0.032	0.038	0.038	0.031	0.037	0.040*	0.032	0.038	0.039	0.032	0.037
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Employees (ln)	0.021	0.022	0.034	0.021	0.024	0.036	0.023	0.023	0.034	0.022	0.022	0.033	0.021
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
CF/TA			-0.420			-0.400			-0.411			-0.414	
			(0.426)			(0.426)			(0.426)			(0.426)	
Productivity (ln)			0.025			0.023			0.024			0.025	
× CF/TA			(0.046)			(0.046)			(0.046)			(0.046)	
TA/TL (ln)				0.410***			0.422***			0.417***			0.410***
				(0.154)			(0.155)			(0.155)			(0.155)
Productivity (ln)				-0.052***			-0.053***			-0.053***			-0.052***
× TA/TL (ln)				(0.018)			(0.018)			(0.018)			(0.018)
No. obs.	55,503	55,503	55,481	55,503	55,503	55,481	55,503	55,503	55,481	55,503	55,503	55,481	55,503
Firm × Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.861	0.861	0.861	0.861	0.861	0.861	0.861	0.861	0.861	0.861	0.861	0.861	0.861

Notes: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2: Effect of productivity and financial development on export values

Dependent variable: ln(export value)													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Productivity (ln)	0.863***	0.360***	0.345***	0.380***	0.630***	0.617***	0.658***	0.437***	0.424***	0.459***	0.982***	0.973***	1.024***
	(0.023)	(0.112)	(0.112)	(0.112)	(0.060)	(0.060)	(0.061)	(0.095)	(0.095)	(0.095)	(0.034)	(0.035)	(0.042)
Productivity (ln)		0.455***	0.459***	0.470***									
× Private credit/GDP		(0.098)	(0.098)	(0.098)									
Productivity (ln)					0.074***	0.075***	0.077***						
× FIA/GDP					(0.017)	(0.017)	(0.017)						
Productivity (ln)								0.204***	0.205***	0.211***			
× M2/GDP								(0.043)	(0.043)	(0.044)			
Productivity (ln)											-0.061***	-0.061***	-0.063***
× Interest spread											(0.014)	(0.014)	(0.014)
Size (ln)	0.129***	0.130***	0.134***	0.124***	0.128***	0.133***	0.123***	0.129***	0.134***	0.124***	0.129***	0.134***	0.124***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Employees (ln)	0.952***	0.954***	0.945***	0.959***	0.956***	0.947***	0.961***	0.954***	0.945***	0.960***	0.953***	0.944***	0.958***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
CF/TA			0.776			0.790			0.789			0.786	
			(0.521)			(0.521)			(0.521)			(0.521)	
Productivity (ln)			-0.071			-0.072			-0.072			-0.072	
× CF/TA			(0.057)			(0.057)			(0.057)			(0.057)	
TA/TL (ln)				0.291*			0.296*			0.301*			0.293*
				(0.173)			(0.174)			(0.173)			(0.173)
Productivity (ln)				-0.031			-0.032			-0.032			-0.031
× TA/TL (ln)				(0.020)			(0.020)			(0.020)			(0.020)
No. obs.	55,503	55,503	55,481	55,503	55,503	55,481	55,503	55,503	55,481	55,503	55,503	55,481	55,503
Firm × Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806

Notes: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

I previously argued that more productive firms producing higher quality products export more, and that this effect is stronger with cheaper access to external finance. I investigate the influence of financial development and productivity on export values. The coefficients in column (1) of Table B.2 indicate that a one percent increase in productivity is associated with an increase of 0.86 percent in export values. In columns (2)–(13), productivity appears to have positive effects (a 0.84–0.86 percent increase). With regard to the effect of financial development, the coefficients in column (2) show that if the private credit to GDP ratio increases by 1 percentage point, export values increase by 4.03 percent. More importantly, I find evidence suggesting that the role of financial development in increasing exports is larger for firms with higher productivity. Since financial needs are higher for firms with the ability to produce high quality products, better and cheaper access to external finance becomes increasingly important for exporting firms as productivity increases.

Again, firm-level finance variables do not play a consistently significant role in determining export values. The estimates for their interaction terms with productivity are not significant. Firm size and the number of employees have significantly positive impacts on export values of individual firms.

Some believe that Small- and Medium-sized Enterprises (SMEs) have played an important role in Taiwan's economic development. Many industry case studies show that Taiwan's export industry relies on a network of SMEs to undertake export production (e.g., Levy, 1990). Tables 3 and 4 present the results of fixed effects regressions for SMEs and large firms. I find that it is indeed large, productive firms that benefit more from financial development. More productive SMEs are more likely to be successful exporters, in line with my expectation. However, the interaction between financial development and firm productivity is not significant for SMEs. One possible explanation for why financial development is not favorable to SMEs is that SMEs tend to rely on the informal financial sector or government export assistance and thus the development of the formal financial sector does not contribute to their export performance. Even if they have access to formal credit from banks, SMEs engaging in a transaction with small banks are not likely to continue to obtain loans from them as the size of banks increases.[16] This result is somewhat contrary to the common perception that easier and cheaper access to external finance is more effective for SMEs.

To summarize, the estimation results confirm that higher productivity has a positive in-

[16]See Sapienza (2002) for a similar argument.

Table 3: Effect of productivity and financial development on export prices and values: large firms

Dependent variable:	ln(product price)				ln(export value)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Productivity (ln)	0.132***	-0.354***	-0.342***	-0.353***	0.957***	0.485***	0.481***	0.494***
	(0.028)	(0.122)	(0.122)	(0.123)	(0.033)	(0.135)	(0.136)	(0.137)
Productivity (ln)		0.436***	0.441***	0.441***		0.423***	0.422***	0.429***
× Private credit/GDP		(0.108)	(0.108)	(0.108)		(0.117)	(0.117)	(0.117)
Size (ln)	0.021	0.028	0.017	0.025	0.022	0.029	0.034	0.027
	(0.031)	(0.031)	(0.031)	(0.031)	(0.035)	(0.035)	(0.036)	(0.035)
Employees (ln)	0.020	0.020	0.030	0.025	0.965***	0.964***	0.958***	0.966***
	(0.038)	(0.038)	(0.039)	(0.038)	(0.042)	(0.042)	(0.043)	(0.042)
CF/TA			0.464				0.114	
			(0.521)				(0.675)	
Productivity (ln)			-0.075				-0.004	
× CF/TA			(0.056)				(0.072)	
TA/TL (ln)				0.082				0.147
				(0.204)				(0.240)
Productivity (ln)				-0.002				-0.014
× TA/TL (ln)				(0.024)				(0.028)
No. obs.	37,598	37,598	37,582	37,598	37,598	37,598	37,582	37,598
Firm × Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.869	0.869	0.869	0.869	0.820	0.820	0.820	0.820

Notes: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4: Effect of productivity and financial development on export prices and values: SMEs

Dependent variable:	ln(product price)				ln(export value)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Productivity (ln)	0.057*	-0.026	-0.011	-0.043	0.814***	0.618***	0.596**	0.632***
	(0.032)	(0.192)	(0.193)	(0.192)	(0.038)	(0.232)	(0.231)	(0.232)
Productivity (ln)		0.075	0.072	0.118		0.177	0.190	0.196
× Private credit/GDP		(0.173)	(0.173)	(0.172)		(0.204)	(0.204)	(0.205)
Size (ln)	0.048	0.048	0.048	0.055	0.114**	0.113**	0.109**	0.106**
	(0.046)	(0.046)	(0.046)	(0.046)	(0.047)	(0.047)	(0.047)	(0.047)
Employees (ln)	0.073	0.073	0.085*	0.057	1.104***	1.105***	1.101***	1.111***
	(0.051)	(0.051)	(0.051)	(0.051)	(0.054)	(0.054)	(0.055)	(0.054)
CF/TA			-1.101				0.839	
			(0.707)				(0.825)	
Productivity (ln)			0.106				-0.084	
× CF/TA			(0.076)				(0.091)	
TA/TL (ln)				0.177				0.236
				(0.211)				(0.250)
Productivity (ln)				-0.037				-0.025
× TA/TL (ln)				(0.024)				(0.029)
No. obs.	17,163	17,163	17,157	17,163	17,163	17,163	17,157	17,163
Firm × Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.854	0.854	0.854	0.854	0.780	0.780	0.780	0.780

Notes: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

fluence on export prices and values. More importantly, productivity interacts positively with financial development: easier and cheaper access to external funding induces more productive firms to increase their product quality and export more as compared to less productive firms. These results present strong support for this paper's theoretical predictions. This conclusion may appear somewhat contradictory to previous works that show that the role of finance with respect to trade is mainly concentrated at the time of entry (Berman and Héricourt, 2010; Chaney, 2016). One potential explanation is the existence of quality improvement, which is important to the performance and survival of firms.

Moreover, financial development is generally expected to alleviate the financial constraints faced by less productive firms, which, in turn, reduce the export gaps between more and less productive firms. However, this paper finds that better and cheaper access to external financial sources helps the more productive firms more than the less productive ones, leading to greater quality and export gaps. The results of this paper highlight the importance of financial development in the source country in determining gaps in export prices and values.

6 Conclusion

The recent literature presents rich evidence of the role of financial constraints in international trade at the macroeconomic level (Beck, 2002; Becker et al., 2012). However, despite their importance, the mechanisms through which improvements in financial systems affect product quality and exports at the micro level have received adequate attention only recently. This paper examines the effects of a country's financial development on firms' product quality and their export prices and values, taking into account the possible interaction between a firm's productivity and financial development.

In particular, this paper finds that firms with high productivity choose to produce high quality goods. In addition, highly productive firms tend to export greater quantities at higher prices, which leads to higher export values. The novel finding of this paper is that financial sector policies that reduce credit constraints disproportionately help more productive firms that incur higher costs for investing in quality upgrading, and lead to increased gaps in the export prices and values.

I believe that the findings in this paper can be informative for policy makers interested in

the link between financial system development and exports. Understanding the dynamics of introducing financial constraints and endogenous innovation-based quality choice at the firm level constitutes a critical step in understanding how a country can promote exports, and the policies that can stimulate this process. To improve export performance, it is important to enhance firms' innovation activities or productivity-enhancing investments and to improve financial system. This paper also suggests that government should support especially less productive firms through well-articulated policies to improve their performance and bridge the gap between more productive and less productive firms.

For future research, it would be interesting to further investigate why country-level financial factors are more important than firm-level financial factors in explaining firms' exports, especially in less developed countries.

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Appendix A. Proofs

A.1 Comparison with the result of Manova (2013)

A.1.1 Only fixed costs are externally financed

As in Manova (2013), assume that exporters need to raise outside capital for a fraction $d \in (0,1)$ of fixed costs. An investor can expect to be repaid with probability $\lambda \in (0,1)$ which is exogenous to the model and determined by the strength of the country's financial institutions. With probability $(1-\lambda)$, the financial contract is not enforced, the firm defaults, and the creditor seizes the collateral tfq^2.

Firms choose their export price and quality to maximize profits

$$\begin{aligned} &\max \left(p - \frac{\tau q^\alpha}{\phi}\right) x - (1-d) f q^2 - \lambda F\left(\frac{1}{\phi}\right) - (1-\lambda) t f q^2 \\ \text{subject to} \quad & x = q^{\sigma-1} \frac{p^{-\sigma}}{P^{1-\sigma}} Y \\ & \left(p - \frac{\tau q^\alpha}{\phi}\right) x - (1-d) f q^2 \geq F\left(\frac{1}{\phi}\right) \\ & - d f q^2 + \lambda F\left(\frac{1}{\phi}\right) + (1-\lambda) t f q^2 \geq 0 \end{aligned}$$

Solving this optimization problem yields

$$\begin{aligned} p &= \frac{\sigma}{\sigma-1} \frac{\tau q^\alpha}{\phi} \\ x &= \frac{2fq^2}{(1-\alpha)\frac{\tau q^\alpha}{\phi}} \\ R &= \frac{2f\sigma}{(1-\alpha)(\sigma-1)} q^2 \\ q &= \left[\frac{\tau}{f(\sigma-1)} \left(\frac{\tau\sigma}{\sigma-1}\right)^{-\sigma} \frac{\lambda}{(1-\lambda)(d-t)+\lambda} \frac{Y}{P^{1-\sigma}}\right]^{\frac{1}{2-(1-\alpha)(\sigma-1)}} \phi^{\frac{\sigma-1}{2-(1-\alpha)(\sigma-1)}} \end{aligned}$$

Under the condition (i) $2 > (1-\alpha)(\sigma-1)$, a firm's product quality q is positively correlated with its productivity. We also need to assume (ii) $(1-\lambda)(d-t)+\lambda > 0$ (i.e. $d-t > -\lambda/(1-\lambda)$) to ensure $q > 0$.

The impact of financial development on the link between product quality and exports is

$$\frac{\partial^2 R}{\partial q \partial \lambda} = \frac{4f\sigma}{(1-\alpha)(\sigma-1)} \frac{\partial q}{\partial \lambda}$$

where the impact of financial development on the optimal quality is

$$\frac{\partial q}{\partial \lambda} = \frac{1}{2-(1-\alpha)(\sigma-1)} \frac{q}{\lambda} \frac{d-t}{(1-\lambda)(d-t)+\lambda}.$$

Under the conditions (i) $2 > (1-\alpha)(\sigma-1)$ and (iii) $d-t>0$, financial development is more important for firms producing high quality goods.

A.1.2 Both fixed and variable costs are externally financed

Firms choose their export price and quality to maximize profits

$$\begin{aligned}
&\max \left(p - \frac{\tau q^\alpha}{\phi}\right) x - (1-d)\left[\frac{\tau q^\alpha}{\phi} x + f q^2\right] - \lambda F\left(\frac{1}{\phi}\right) - (1-\lambda) t \left[\frac{\tau q^\alpha}{\phi} x + f q^2\right] \\
\text{subject to} \quad & x = q^{\sigma-1} \frac{p^{-\sigma}}{P^{1-\sigma}} Y \\
& \left(p - \frac{\tau q^\alpha}{\phi}\right) x - (1-d)\left[\frac{\tau q^\alpha}{\phi} x + f q^2\right] \geq F\left(\frac{1}{\phi}\right) \\
& - d\left[\frac{\tau q^\alpha}{\phi} x + f q^2\right] + \lambda F\left(\frac{1}{\phi}\right) + (1-\lambda) t \left[\frac{\tau q^\alpha}{\phi} x + f q^2\right] \geq 0
\end{aligned}$$

Solving this optimization problem yields

$$\begin{aligned}
p &= \frac{2\sigma}{\sigma-1} \frac{\tau q^\alpha}{\phi} \\
x &= \frac{f q^2}{(1-\alpha)\frac{\tau q^\alpha}{\phi}} \\
R &= \frac{2f\sigma}{(1-\alpha)(\sigma-1)} q^2 \\
q &= \left[\frac{\tau}{f}\left(\frac{2\tau\sigma}{\sigma-1}\right)^{-\sigma}\left(\frac{\sigma+1}{\sigma-1}\frac{\lambda}{(1-\lambda)(d-t)+\lambda} - 1\right)\frac{Y}{P^{1-\sigma}}\right]^{\frac{1}{2-(1-\alpha)(\sigma-1)}} \phi^{\frac{\sigma-1}{2-(1-\alpha)(\sigma-1)}}
\end{aligned}$$

We need to assume (iv) $2\lambda/[(\sigma-1)(1-\lambda)] > d-t > 0$ to ensure $q>0$.

The impact of financial development on the optimal quality is

$$\frac{\partial q}{\partial \lambda} = \frac{1}{2-(1-\alpha)(\sigma-1)} \frac{q}{\frac{\sigma+1}{\sigma-1}\frac{\lambda}{(1-\lambda)(d-t)+\lambda}-1} \frac{\sigma+1}{\sigma-1} \frac{d-t}{\{(1-\lambda)(d-t)+\lambda\}^2}.$$

Again, under the conditions (i) $2 > (1-\alpha)(\sigma-1)$ and (iii) $d-t > 0$, the model shows that financial development and product quality improvement have a positive interaction effect on exports.

A.2 Proof of Proposition 1

The impact of firm's productivity on product quality is

$$\frac{\partial q}{\partial \phi} = \frac{q}{2-(1-\alpha)(\sigma-1)} \left[\frac{(-\sigma)\frac{\nu r_0+1}{\nu-1} d'(\phi)}{1+\frac{\nu r_0+1}{\nu-1} d(\phi)} + \frac{\sigma-1}{\phi} \right]$$

which is positive under Condition (i) $2 > (1-\alpha)(\sigma-1)$.

$$\begin{aligned}\frac{\partial p}{\partial \phi} = & \left[\frac{\tau(1-\alpha)}{2f}\frac{Y}{P^{1-\sigma}}\right]^{\frac{\alpha}{2-(1-\alpha)(\sigma-1)}} \left(\frac{\tau\sigma}{\sigma-1}\right)^{1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}} \\ & \left[\left(1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}\right)\left(1+\frac{\nu r_0+1}{\nu-1}d(\phi)\right)^{-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}} \frac{\nu r_0+1}{\nu-1} d'(\phi)\phi^{\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)}-1}\right. \\ & \left. + \left(1+\frac{\nu r_0+1}{\nu-1}d(\phi)\right)^{1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}} \left(\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)}-1\right)\phi^{\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)}-2}\right]\end{aligned}$$

which is positive under Condition (ii), which also means $1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)} < -\frac{\alpha}{2-(1-\alpha)(\sigma-1)} < 0$.

A.3 Proof of Proposition 2

The impact of product quality on exports is

$$\frac{\partial x}{\partial q} = \frac{2f}{\frac{\tau}{\phi}(1-\alpha)}(2-\alpha)q^{1-\alpha}$$

which is positive.

$$\frac{\partial R}{\partial q} = \frac{4f\sigma}{(1-\alpha)(\sigma-1)}\Delta q$$

which is positive.

The impact of financial development on the optimal quality is

$$\frac{\partial q}{\partial \nu} = \frac{1}{2-(1-\alpha)(\sigma-1)} \left[\frac{\tau(1-\alpha)}{2f} \left(\frac{\tau\sigma}{\sigma-1} \right)^{-\sigma} \frac{Y}{P^{1-\sigma}} \right]^{\frac{1}{2-(1-\alpha)(\sigma-1)}} \phi^{\frac{\sigma-1}{2-(1-\alpha)(\sigma-1)}} \Delta^{-\frac{\sigma}{2-(1-\alpha)(\sigma-1)}-1} \frac{\sigma(1+r_0)}{(\nu-1)^2} d$$

which is positive under Condition (i) $2 > (1-\alpha)(\sigma-1)$. The unconstrained exporter achieves higher quality levels than the constrained one.

The impact of financial development on the link between product quality and exports is

$$\frac{\partial^2 x}{\partial q \partial \nu} = \frac{2f}{\frac{\tau}{\phi}} (2-\alpha) q^{-\alpha} \frac{\partial q}{\partial \nu}$$

which is positive.

$$\frac{\partial^2 R}{\partial q \partial \nu} = \frac{4f\sigma}{(1-\alpha)(\sigma-1)} \frac{1+r_0}{(\nu-1)^2} dq \left(\frac{\sigma}{2-(1-\alpha)(\sigma-1)} - 1 \right)$$

which is positive if $\sigma/[2-(1-\alpha)(\sigma-1)] - 1 > 0$. This condition automatically holds under Condition (ii) because $\sigma/[2-(1-\alpha)(\sigma-1)] - 1 > \alpha(\sigma-1)/[2-(1-\alpha)(\sigma-1)] - 1$. Thus, financial development magnifies the effect of product quality on exports. □

A.4 Proof of Proposition 3

The effect of firm's productivity on the interaction between financial development and quality is

$$\frac{\partial^2 q}{\partial \nu \partial \phi} = \frac{1}{2-(1-\alpha)(\sigma-1)} \frac{\frac{\sigma(r_0+1)}{(\nu-1)^2} \left[\frac{\partial q}{\partial \phi} d(\phi) \left(1 + \frac{\nu r_0+1}{\nu-1} d(\phi) \right) + q d'(\phi) \right]}{\left(1 + \frac{\nu r_0+1}{\nu-1} d(\phi) \right)^2}$$

which is positive if $\frac{\partial q}{\partial \phi} d(\phi) \left(1 + \frac{\nu r_0+1}{\nu-1} d(\phi) \right) + q d'(\phi) > 0$, i.e., $\left[-\frac{1}{2-(1-\alpha)(\sigma-1)} \frac{\sigma(\nu r_0+1)}{\nu-1} d(\phi) + 1 \right] q d'(\phi) + \frac{q}{\phi} \frac{\sigma-1}{2-(1-\alpha)(\sigma-1)} d(\phi) \left(1 + \frac{\nu r_0+1}{\nu-1} d(\phi) \right) > 0$. This condition holds because $\frac{2-(1-\alpha)(\sigma-1)}{\sigma} \frac{\nu-1}{\nu r_0+1} < \frac{2-(1-\alpha)(\sigma-1)}{\alpha\sigma-2+(1-\alpha)(\sigma-1)} \frac{\nu-1}{\nu r_0+1} < d(\phi)$.

$$\frac{\partial^2 p}{\partial\nu\partial\phi} = \left[\frac{\tau(1-\alpha)}{2f}\frac{Y}{P^{1-\sigma}}\right]^{\frac{\alpha}{2-(1-\alpha)(\sigma-1)}} \left(\frac{\tau\sigma}{\sigma-1}\right)^{1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}}$$
$$\left[\left(1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}\right)\phi^{\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)}-1}\left(1+\frac{\nu r_0+1}{\nu-1}d(\phi)\right)^{-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}-1}\left(-\frac{r_0+1}{(\nu-1)^2}\right)\right.$$
$$\left\{-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}d(\phi)\frac{\nu r_0+1}{\nu-1}d'(\phi)+\left(1+\frac{\nu r_0+1}{\nu-1}d(\phi)\right)d'(\phi)\right\}$$
$$+\left(1-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}\right)\left(1+\frac{\nu r_0+1}{\nu-1}d(\phi)\right)^{-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}}\left(-\frac{r_0+1}{(\nu-1)^2}d(\phi)\right)$$
$$\left.\left(\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)}-1\right)\phi^{\frac{\alpha(\sigma-1)}{2-(1-\alpha)(\sigma-1)}-2}\right]$$

which is positive if $-\frac{\alpha\sigma}{2-(1-\alpha)(\sigma-1)}d(\phi)\frac{\nu r_0+1}{\nu-1}d'(\phi)+\left(1+\frac{\nu r_0+1}{\nu-1}d(\phi)\right)d'(\phi)>0$, i.e, $\frac{2-(1-\alpha)(\sigma-1)}{\alpha\sigma-2+(1-\alpha)(\sigma-1)}\frac{\nu-1}{\nu r_0+1}<d(\phi)$.

The effect of firm's productivity on the link between financial development and exports is

$$\frac{\partial^2 x}{\partial\nu\partial\phi} = \frac{2f}{(1-\alpha)\tau}(2-\alpha)q^{1-\alpha}\frac{\partial q}{\partial\nu}\left(1+\frac{\phi(2-\alpha)}{2-(1-\alpha)(\sigma-1)}\frac{\sigma-1}{\phi}\right)$$
$$+\frac{2f}{(1-\alpha)\tau}q^{2-\alpha}\frac{\phi(2-\alpha)}{2-(1-\alpha)(\sigma-1)}\frac{\frac{\sigma(r_0+1)}{(\nu-1)^2}d'(\phi)}{(1+\frac{\nu r_0+1}{\nu-1}d(\phi))^2}\left(-\frac{2-\alpha}{2-(1-\alpha)(\sigma-1)}d(\phi)\frac{\sigma(\nu r_0+1)}{\nu-1}+1\right)$$

which is positive because $\frac{2-(1-\alpha)(\sigma-1)}{\sigma(2-\alpha)}\frac{\nu-1}{\nu r_0+1}<\frac{2-(1-\alpha)(\sigma-1)}{\alpha\sigma-2+(1-\alpha)(\sigma-1)}\frac{\nu-1}{\nu r_0+1}<d(\phi)$. □

Appendix B. Data

Table B.1: Descriptive statistics

Variables	Mean	Standard deviation
Dependent variables:		
Export price (1000 NTD)	555.61	7,128.73
Export value (1000 NTD)	2,373,026	38,100,000
Financial development:		
Private credit/GDP	1.08	0.10
Financial institutions' assets/GDP	3.05	0.59
M2/GDP	2.05	0.23
Interest spread	2.11	0.68
Firm characteristics:		
Revenue per worker (NTD)	12,195.91	21,613.53
Total assets (NTD)	15,300,000	58,100,000
Number of workers	843.48	2,002.93
Cash flow from operation/Total assets	0.06	0.11
Total assets/Total liabilities	3.71	41.75

Notes: NTD denotes New Taiwan Dollar.

Figure 1: Financial sector development indicators

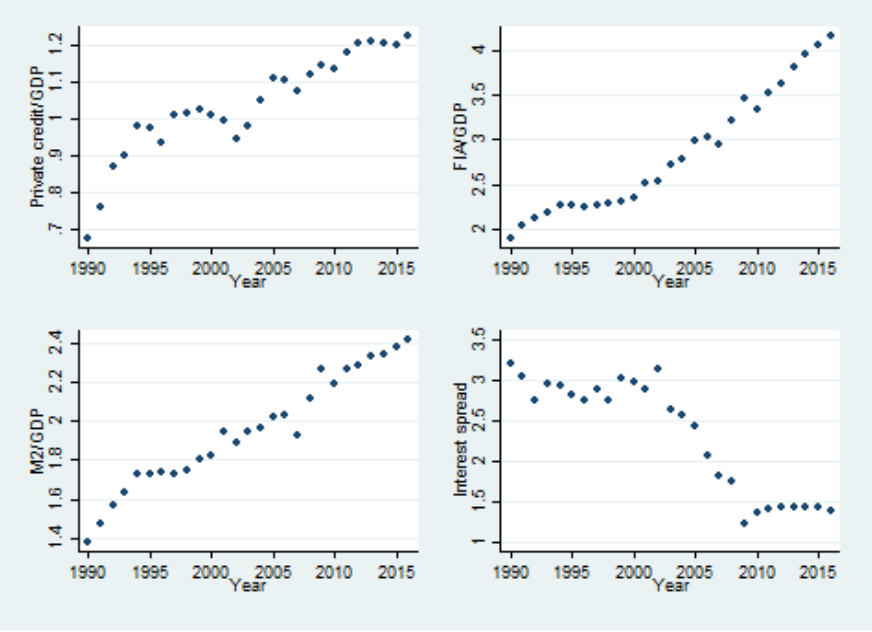
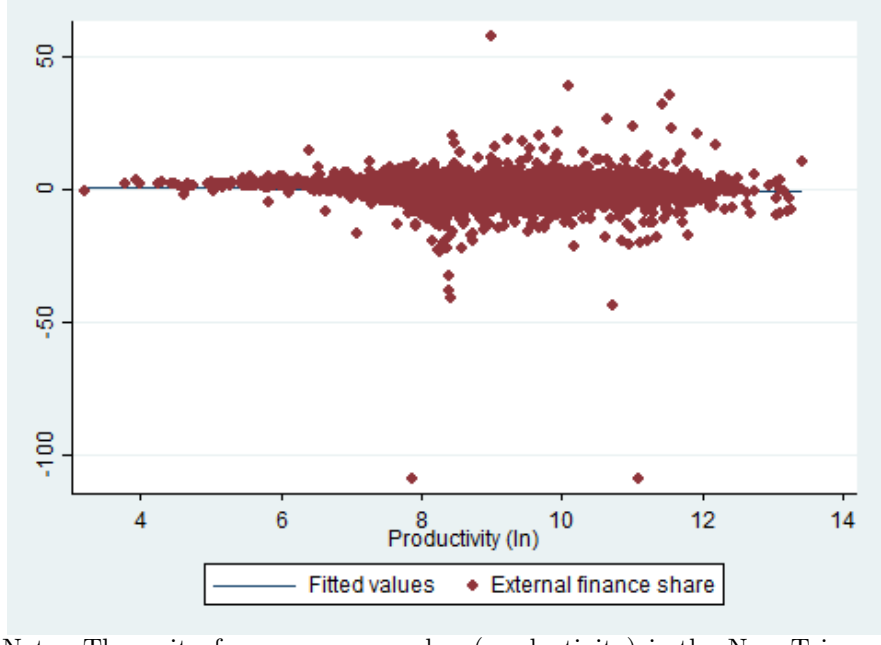


Figure 2: Revenue per worker and external finance share



Note: The unit of revenue per worker (productivity) is the New Taiwan Dollar. The correlation between the log revenue per worker and the share of external finance (total operating expenses minus cash flow from operations) in total operating expenses is -0.05, which is significant at the 1% level.

Table B.2: Effect of productivity and financial development on export quantity

Dependent variable: ln(export quantity)													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Productivity (ln)	0.786***	0.400***	0.376**	0.401***	0.628***	0.606***	0.626***	0.468***	0.446***	0.469***	0.862***	0.843***	0.853***
	(0.030)	(0.147)	(0.147)	(0.147)	(0.078)	(0.078)	(0.080)	(0.124)	(0.124)	(0.124)	(0.046)	(0.047)	(0.056)
Productivity (ln)		0.349***	0.352***	0.343***									
× Private credit/GDP		(0.130)	(0.130)	(0.130)									
Productivity (ln)					0.050**	0.051**	0.049**						
× FIA/GDP					(0.023)	(0.023)	(0.023)						
Productivity (ln)								0.152***	0.153***	0.149**			
× M2/GDP								(0.058)	(0.058)	(0.058)			
Productivity (ln)											-0.039**	-0.040**	-0.038**
× Interest spread											(0.018)	(0.018)	(0.019)
Size (ln)	0.143***	0.144***	0.155***	0.139***	0.143***	0.154***	0.138***	0.144***	0.155***	0.139***	0.143***	0.155***	0.138***
	(0.037)	(0.037)	(0.038)	(0.037)	(0.037)	(0.038)	(0.037)	(0.037)	(0.038)	(0.037)	(0.037)	(0.038)	(0.037)
Employees (ln)	0.921***	0.923***	0.904***	0.930***	0.924***	0.905***	0.931***	0.923***	0.905***	0.930***	0.922***	0.903***	0.929***
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
CF/TA			0.958			0.962			0.967			0.958	
			(0.681)			(0.682)			(0.682)			(0.682)	
Productivity (ln)			-0.073			-0.073			-0.074			-0.073	
× CF/TA			(0.074)			(0.074)			(0.074)			(0.074)	
TA/TL (ln)				-0.031			-0.034			-0.026			-0.039
				(0.215)			(0.216)			(0.215)			(0.215)
Productivity (ln)				0.011			0.012			0.011			0.012
× TA/TL (ln)				(0.025)			(0.025)			(0.025)			(0.025)
No. obs.	55,176	55,176	55,154	55,176	55,176	55,154	55,176	55,176	55,154	55,176	55,176	55,154	55,176
Firm × Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.885	0.885	0.885	0.885	0.885	0.885	0.885	0.885	0.885	0.885	0.885	0.885	0.885

Notes: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.