Export Growth and Credit Constraints*

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Abstract

We investigate the effect of credit constraints on the growth of exports at the micro level. We develop a stylized dynamic model showing credit constraints play a key role in early stages of exporting, but not in later stages. Our empirical results using product level data on exports to twelve European Union members and the U.S. support the model's predictions: exports from more credit constrained and riskier exporters grow faster. Export growth rates decrease with duration and converge across countries. While an important force in early stages, credit constraints affect export growth much less as the duration of exports increases.

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1 Introduction

Firms have two basic sources of financing their activities: internally from retained earnings and externally by borrowing from banks and other financial institutions. The ease with which firms are able to access financial assets has a great effect on their actions. Credit constraints have been shown to be an important determinant of international trade flows (Beck 2002, Manova 2008, 2013). However, their dynamic role and the persistence of these effects, important factors for policy makers, are yet to be examined rigorously. An exception are Amiti and Weinstein (2011) who show that deteriorating health of banks during a crisis is an important factor explaining the growth of a firm's exports relative to domestic sales. We build a model which allows us to examine the role of credit constraints in a dynamic setting and find that they play an important role in the beginning of exporting, but a diminishing one as exporting continues.

The lack of attention paid to the dynamic importance of credit constraints is a consequence of the modeling strategy adopted in many papers. Credit constraints are usually set exogenously for a given country. At best they are endogenized on the efficiency of a country's financial system or capital abundance. Since these factors tend to be relatively stable over time, the non-changing effect of of credit constraints is implicitly built into such models. The impact of credit constraints would be constant if their severity did not vary with time. In this paper we focus on the dynamic implications of credit constraints by examining their role in continuously successful exporters from the point when they begin to export.

While average credit constraints in a given country might indeed be robust over time, they need not be from a firm's perspective. A firm's credit constraints may vary dramatically even in the short run, depending on its performance. A new exporter might face unfavorable financing terms due to skepticism of lenders toward a first-time exporter.[1] Once the exporter proves to be successful, it can improve the terms of financing. As long as the early success is positively related to future performance, the perceived riskiness of the firm's exporting activity will decrease. The successful firm will have an easier time financing its activities either through its current lender, and be reevaluated as less risky, or by finding new sources, domestic or possibly international, which become available because of its success.

[1] Greenaway, Guariglia, and Kneller (2007) show that new exporters in the UK are deemed riskier than incumbent exporters.

For instance, a new Chilean wine exporter to the U.S. might initially borrow at a higher interest rate than a new French exporter because of its higher risk. Its initial footprint in the U.S. will be smaller, other things being equal. For exporting firms that successfully establish their presence, the country of origin plays a much lesser role when assessing risk. Success opens other financing avenues, allowing them to no longer be bound by their home country credit conditions. Established French and Chilean exporters will have access to similar sources of credit and will borrow under similar conditions. The Chilean exporter then has an opportunity to potentially catch up to the French exporter by growing faster, since it had a smaller initial footprint. As the duration of exporting increases domestic credit constraints will matter to a lesser degree, if at all.

We capture this idea by building a stylized dynamic model in which the rigidity of credit constraints is a function of the level of risk associated with the activity requiring external financing. The level of risk affects both the size and the cost of a loan, with less risky activities resulting in larger and cheaper loans for new exporters. We conjecture that after becoming a successful exporter, a firm can improve the terms of credit by greatly reducing the perceived risk of exporting. A firm which starts with worse initial terms of credit, but manages to succeed, will then see its exports grow at a higher rate. At the product level this effect will be more pronounced for countries with a shorter history of exports, since they will have a higher share of firms transitioning from being new and unproven to becoming experienced and successful.[2] As the duration of exporting increases, financial constraints the exporter faces in its home country will matter less for export growth, resulting in a convergence of export growth rates across exporters.

We find empirical support for our model using annual product-level exports to twelve European Union members and the United States. The growth of exports is increasing in the interest rate banks charge. Riskier exports grow faster as they are initially more constrained as their greater riskiness forces them to start exporting at lower initial volumes. Exports of products more reliant on external financing grow faster as do those produced by sectors with more tangible assets. While initially credit constraints have a great impact on growth rates, over time their role diminishes. We find that growth rates converge across all exporters over time. Our results are robust to product code changes, calculating growth rates using the midpoint formula, various timing issues, and

[2] The actual number of new exporters in a given year depends on multiple country and industry specific characteristics (e.g., productivity, factor endowments, international competition). Focusing on export growth and the share of new exporters rather than on the volume itself, allows us to abstract from these factors.

aggregation to industry level data.

While the recent literature on credit constraints in international trade (Muûls 2008; Chaney 2013; Feenstra, Li, and Yu 2013; and Manova 2013) examine credit constraints in static models, we focus on the dynamic effects of credit constraints. The earlier efforts examine the effects of credit constraints on intensive and extensive margins of exports, finding that credit constraints have a significant negative effect on both margins (Manova 2013). Given the dynamic nature of our effort, we focus on the role of credit constraints on the growth of exports, or changes in the intensive margin. Our contribution to this literature is in endogenizing the credit constraints on the risk of exporting which allows us to develop a dynamic model and show the effect of financial constraints on growth rates.

We add another element to our understanding of the effect of credit constraints. We show that while the effect of credit constraints on levels of exports might persist, their effect on the growth of exports is short lived. Credit constrained exporters will commence exporting at lower volumes due to their higher project risk, but if successful will grow faster as they can expand their exports at a faster rate. Our results are complementary to Muûls (2008), offering a more nuanced view of the role of credit constraints in the growth of exports. Muûls (2008) showed that credit constraints affect the extensive margin and the ability of the firm to begin exporting, but once a firm starts to export, credit constraints have no effect on the intensive margin or its growth. Our effort also stands out by taking into account the complete history of an export relationship from its inception.[3]

We make a contribution to the literature shedding light on the role of risk in international trade (Rauch and Watson 2003; Besedeš 2008; Segura-Cayuela and Vilarrubia 2008; Nguyen 2012; and Albornoz et al. 2012) and use estimated hazard of exports ceasing as a measure of risk. We use the uncertainty framework to provide micro-foundations for why financial constraints might change over time for exporting firms. In particular, we conjecture that the degree of financial constraints is endogenous to uncertain success, which, as in Albornoz et al. (2012), is lower for experienced exporters. Linking the two literatures allows us to derive new predictions. For example, we predict that in a country with the higher initial uncertainty (and thus higher interest rate) the product level exports will grow faster and that, in a given country, an industry with higher dependency on

[3] Jaud, Kukenova, and Strieborny (2009) focus on the role of credit constraints on duration of exports and take into account the entire history of an export relationship.

external credit and/or higher share of tangible assets will experience faster export growth. While the country-level predictions can potentially be derived from the framework of Albornoz et al. (2012), predicting the differences in the export growth rates across industry requires an explicit modeling of the financial constraints faced by firms including modeling of external financial dependence and the availability of tangible assets suitable for collateral.

Complementary to our work, Araujo, Mion, and Ornelas (2012) find that countries with weaker institutions experience higher rates of import growth from a given exporter. Their main intuitive point is similar to ours: export growth is larger after early barriers associated with weak institutions are overcome. While they study an exporter's growth from the viewpoint of the importing country's contract enforcement, we explore it from the exporter's initial stage of obtaining credit. Similar to our effort, they pay attention to the complete history of an exporting spell.

2 Theoretical Framework

In this section we provide a stylized dynamic model of credit constrained exporting firms to analyze how credit constraints affect export growth. The key assumption which distinguished us from other models with credit constrained exporters (see, e.g., Feenstra, Li, and Yu 2013; and Manova 2013) is that project risk and financial constraints become lower for exporting firms as they gain experience,[4] with the effect being stronger for firms which initially face higher risk. In other words, we believe that succeeding in exporting resolves more uncertainty for firms which start with a higher level of uncertainty. The direct implication of this assumption is that, conditionally on being successful, these firms grow faster than firms which initially face lower risk.

Formally, we consider a world consisting of $e = 1, 2, ..., E$ countries each of which exports differentiated varieties produced by monopolistically competitive firms to all other countries. Without loss of generality, we arbitrarily pick one country which we name Home (h), and consider exports to Home from all other countries. For simplicity, we propose a one-sector model in each country.[5]

[4] This part of the assumption builds on Albornoz et al. (2012) who assume that successful exporters face a lower probability of default than new exporters: "the need for new knowledge and competencies makes export success uncertain at the time of entry, but also implies that uncertainty is resolved through export experience" (Albornoz et al. 2012, p. 19). See Albornoz et al. (2012) for a corresponding empirical literature review supporting this assumption.

[5] Given the quasi-linear preferences, we can extend the model to a multi-sector version with sector-specific parameters.

2.1 Preferences

Home is populated by L symmetric consumers. At time 0 a representative consumer in Home maximizes lifetime utility given by $U_0 = \sum_{t\geq 0} \beta^t u_t$, where $\beta \in (0,1]$ is a discount factor and u_t is utility derived at period t. Specifically, u_t is defined over a numeraire z_t and many differentiated varieties x_{vt}:

$$u_t = z_t + \lambda_t \sum_{e\geq 1} \sum_{d\geq 0} \left(\sum_{v\in \nu_{ed}} x_{vt}^{\frac{\sigma-1}{\sigma}} \right) \qquad \sigma > 1 \tag{1}$$

where x_{vt} is an individual consumption of differentiated variety v in period t, and λ_t is a period-specific demand shifter. An exported variety v belongs to the set of varieties ν_{ed}: a pair of subscripts 'ed' defines a cohort of firms producing differentiated varieties in country $e \in \{1, \cdots, E\}$ and having export age (duration) $d \in \{0, 1, \cdots, D\}$. For example, suppose that for a given variety v some Japanese firm(s) started exporting to the U.S. in 2001 and additionally new Japanese exporting firms emerged in subsequent years 2002 and 2003. Then, as of 2003 there are three distinct sets of varieties available to the U.S. consumers: from the same source country Japan, but varieties are differentiated by duration, $d \in \{0, 1, 2\}$. We assume away the inter-temporal substitution over periods. Thus, the budget constraint of a representative consumer in period t is given by

$$z_t + \sum_e \sum_d \left(\sum_{v\in \nu_{ed}} p_{vt} x_{vt} \right) = I_t,$$

where the price of the numeraire is normalized to one, p_{vt} denotes the price of variety v in period t, and I_t is the total income of period t which consists of wage and share of firms' profits distributed to consumers.

As in Melitz and Ottaviano (2008) we assume that in equilibrium the demand for the numeraire is positive, $z_t > 0$.[6] In each period t, the marginal rate of substitution between the variety vt and the numerarie z is equal to the ratio of their prices:

$$\lambda_t \frac{\sigma - 1}{\sigma} x_{vt}^{-1/\sigma} = p_{vt},$$

[6]To ensure $z_t > 0$, we assume that the individual income, I_t, is higher than the per-consumer market value of all differentiated varieties sold in Home's market in period t. We provide the necessary and sufficient conditions for this assumption in Appendix B.1.

from which the individual demand for variety v in period t is derived as

$$x_{vt} = \left(\frac{\sigma - 1}{\sigma} \frac{\lambda_t}{p_{vt}} \right)^{\sigma} . \tag{2}$$

2.2 Financing for Exporting Firms

Labor is the only factor of production. Each country e is populated with L_e units of labor which are supplied inelastically in each period t.[7] The numeraire sector is characterized by perfect competition and constant returns to scale. One unit of labor can produce w_e units of the numeraire good, which is traded at zero cost. We assume that every country produces a strictly positive amount of the numeraire so that the wage in country e is equal to w_e.

All differentiated goods are produced with the same cost function. Each firm produces a single differentiated variety, which results in the same identity for a firm and its variety. Production of the differentiated variety v in country e incurs a fixed cost f_e and a marginal cost c_e (both in terms of units of labor). As in Manova (2013), active firms finance their domestic activities, including the fixed cost of production, with cash flow from operations. In contrast, each exporter incurs an additional fixed cost of F_e units of labor for each exporting destination to cover exports-related costs such as advertising and operations of distribution networks. As usual, we assume a Samuelson iceberg transportation cost: the exporter has to ship $\tau_e > 1$ units to deliver one unit of variety v from country e to Home. Following empirical evidence provided by Iacovone and Javorcik (2010), we assume that only a fraction of varieties sold domestically are suitable for exports, and that producers enter export markets in relatively small cohorts each period. This is formally captured by our assumption that each new cohort consists of n_e firms in each period.[8]

Different from domestic production, we assume that exporters face liquidity constraints in that a fraction $b \in (0, 1)$ of export-related costs has to be borrowed from external sources because most of the costs are borne up-front. We assume no carry-over of profits from one period to the next, which implies that both new and established exporters need to borrow the same share b of their exporting costs. This assumption is not uncommon to heterogeneous firms models (see e.g., Melitz 2003, Manova 2013) in which consumers collectively own all firms, and profits/losses are

[7] Parameters defined in this section without subscript t are time-period-invariant and are valid for each period t.

[8] Our main results remain valid even if the number of new exporters is either increasing or decreasing over time (see Proposition 5) below.

distributed among consumers in each period.[9] Exporting firms must pledge collateral with all of their export-related tangible assets to make the lending contract complete: the amount of tangible assets is denoted by a fraction $s \in (0,1)$ of export-related costs. That is, as in Manova (2012), b and s are set as exogenous technology-related parameters and thus firms cannot change the extent of collateral or external finance to affect the interest rate on the loan.[10]

Following Feenstra, Li, and Yu (2013), we define 'project risk' as the probability of failing to collect export revenue. Importantly, we assume that project risk is the only reason why a firm may default on a loan, which is different from Manova (2013) where a firm can exploit the lack of contract enforcement by not repaying the loan even when making profits from exporting.[11]

Following Albornoz et al. (2012), we assume that project risk is firm-specific and that a significant part of it is resolved by experienced firms which exported successfully at least once (unsuccessful exporters do not attempt exporting again). Thus, experienced exporters face lower risk than the first-time exporters. For the new exporters we allow for project risk to vary across countries, while for the experienced exporters we assume the risk to be symmetric across countries.

Assumption 1 *Let $\phi_e(d)$ denote the project risk of a firm with export duration d in country e. We assume that the project risk is lower for experienced exporters than it is for new exporters, and that it is symmetric for all experienced exporters from all countries, i.e.,*

$$\phi_e(0) > \phi_e(d \geq 1) = \widetilde{\phi} \qquad \forall e = 1, 2, ..., E.$$

As in Manova (2013), we assume competitive credit markets in all countries with an outside option of a world-market net interest rate $r \geq 0$. $R_e(d)$ denotes the interest rate set by the financial sector of country e for an exporter with duration d. Due to free entry into exporting, a firm would

[9] Our main results also hold if successful exporters can transfer their profits to the next period and thus become less dependent on external borrowing (see Proposition 4) below.

[10] That is, we deviate from the literature on optimal financial contracts, since in our model firms do not choose the amount of the collateral. Intuitively, this assumption is in line with Bester (1985, 1987) who assumes that if a firm becomes bankrupt, the bank becomes an owner of the investment project and its returns. Following this logic, the bank will try to liquidate the project in order to recapture some of its losses. The parameter s then is not the amount of collateral the firm chooses to pledge, but instead the share of the project value which can be liquidated by the bank, that is, the share of tangible assets. Moreover, this assumption is also consistent with the empirical proxy for the collateral used in this literature – asset tangibility – calculated at the industry level.

[11] While not labeling it as project risk, Amiti and Weinstein (2009) also empathize the risk of exporting operations as an important source of default risk on loan payments by exporting firms. Feenstra, Li, and Yu (2013) consider both types of default risk.

only apply for a loan if the expected profit is non-negative, which implies that a profit for successful exporters is strictly positive.[12] By Assumption 1, the lender will then face a default on its loan with the probability $\phi_e(0)$ when lending to a new exporter and with a lower default probability $\widetilde{\phi}$ when lending to an established exporter. In the event of a default, the firm loses its collateral $s \in (0,1)$ for each dollar borrowed (e.g., Bester 1985, 1987).

Following the finance literature on collateral liquidation, and similarly to Besanko and Thakor (1987, p. 673) and DellAriccia and Marquez (2006, p. 2526), we assume an asymmetry in the valuation of tangible assets between firms and lenders:

Assumption 2 *Collateral liquidation is costly. In the case of a default, the bank receives only* $\eta \in (0,1)$ *for each dollar of collateral; the remaining* $(1-\eta)$ *is used to cover the cost of the collateral liquidation.*

The importance and size of the collateral liquidation costs are widely discussed in economics and finance literatures, and can be traced back to Barro (1976). One explanation of the liquidation cost is the transactions costs of taking possession of and liquidating collateral (Besanko and Thakor 1987). Alternatively, the collateral can be more valuable to the entrepreneur than to the financier since the entrepreneur has superior skill to utilize collateral so that the lender who takes it over generates less value from it (see, e.g., Diamond and Rajan 2001, DellAriccia and Marquez 2006).

Empirically, the statistics reported in the Enterprise Survey by the World Bank Enterprise Analysis Unit[13] also provide an indirect evidence of the costly collateral liquidation: in most countries participating in the survey (including Greece, Germany, Portugal, and Spain), the average value of collateral needed for a loan exceeds the amount of the loan. Benmelech and Bergman (2009) introduce the redeployability of collateral in the airline industry and show that it decreases the cost of external financing. This evidence is consistent with the notion of asymmetric valuation of the collateral by the borrower and lender, where the asymmetry decreases in the cost of collateral liquidation (redeployability).

For any competitive bank, the present value of each dollar loaned must be equal to its expected

[12] In our model successful firms will always repay the loan.
[13] See `http://www.enterprisesurveys.org/Data/ExploreTopics/finance#2`.

revenue so that the following equality must hold:

$$1 + r = (1 - \phi_e(d))\,(1 + R_e(d)) + \phi_e(d)s\eta. \tag{3}$$

Equation (3) can be rearranged for the equilibrium interest rate $R_e(d)$ as

$$1 + R_e(d) = \frac{1 + r - \phi_e(d)s\eta}{1 - \phi_e(d)}, \tag{4}$$

from which we can tell that the interest rate $R_e(d)$ is increasing in project risk $\phi_e(d)$, i.e., $\frac{\partial}{\partial \phi_e}\left(\frac{1+r-\phi_e(d)s\eta}{1-\phi_e(d)}\right) = \frac{1+r-s\eta}{[1-\phi_e(d)]^2} > 0$.

The expected cost of exporting variety $v \in \nu_{ed}$ in period t is given by

$$\mathbb{E}\left[C_{vt}(d)\right] = w_e\left[c_e Q_{vt}(d) + F_e\right]\Big[\underbrace{1-b}_{\substack{\text{financed from}\\\text{firm's own resources}}} + \underbrace{b\,(1 - \phi_e(d))\,(1 + R_e(d)) + bs\phi_e(d)}_{\text{financed with the loan}}\Big].$$

Using equation (4), we can derive a simplified expression of the expected cost:

$$\mathbb{E}\left[C_{vt}(d)\right] = w_e\left[c_e Q_{vt}(d) + F_e\right]\left[1 + br + \phi_e(d)bs(1-\eta)\right]. \tag{5}$$

Note that the project risk $\phi_e(d)$ increases the expected cost of exporting, but only if banks value the collateral less than firms do – that is only if Assumption 2 holds (if $\eta = 1$, $\phi_e(d)$ disappears from equation (5)).

Next, the expected profit from exporting variety $v \in \nu_{ed}$ in period t is given by

$$\mathbb{E}[\pi_{vt}(d)] = \left[1 - \phi_e(d)\right]\frac{p_{vt}(d)Q_{vt}(d)}{\tau_e} - w_e\left[c_e Q_{vt}(d) + F_e\right]\left[1 + br + \phi_e(d)bs(1-\eta)\right]. \tag{6}$$

We assume that the parameters of the model are such that the demand for its variety is sufficient to guarantee a non-negative profit from exporting in any period t unless the firm fails in exporting due to project risk. In general, firms maximize an expected life-time profit, $\sum_{t\geq 0}\rho^t\mathbb{E}[\pi_{vt}(d)]$, where $\rho \in (0, 1]$ is a discount factor. This will not affect their per-period profit maximization, however, since we assume profit re-distribution at the end of each period. Section 2.7.1 shows that our results are also valid in the case of relaxed credit constraints for mature exporters consistent with the inter-temporal profit accumulation.

2.3 Market Equilibrium

We start by using the profit equation (5) to find the equilibrium delivered price of variety $v \in \nu_{ed}$ in period t. From the first order condition with respect to the price (note that from equation (2), the price elasticity of demand is $= \frac{dx_{vt}}{dp_{vt}}\frac{p_{vt}}{x_{vt}} = -\sigma$), we derive the profit-maximizing price:

$$p_{vt}(d) = \frac{\sigma c_e w_e \tau_e}{\sigma - 1} \times \frac{1 + br + \phi_e(d)bs(1-\eta)}{1 - \phi_e(d)}, \tag{7}$$

which turns into the standard expression for price, $p_v = \frac{\sigma c_e w_e \tau_e}{\sigma - 1}$, in the absence of project risk, $\phi_{ed} = 0$, and zero outside value for lenders, $r = 0$.[14] From the equilibrium price (7), we can derive the credit constraint measure Φ_{vt}, defined by Feenstra, Li, and Yu (2013) as the ratio of expected marginal revenue to marginal cost:

$$\Phi_{vt}(d) \equiv \frac{(1-\phi_e(d))p_{vt}(d)\frac{\sigma-1}{\sigma\tau_e}}{c_e} = 1 + br + \phi_e(d)bs(1-\eta) \geq 1. \tag{8}$$

As in Feenstra, Li, and Yu (2013), if an exporting firm does not need a loan (b=0), it will produce at $\Phi_{vt}(d) = 1$, even given a positive default probability $\phi_e(d) > 0$. Moreover, the magnitude of the credit constraint increases in the firm's project risk $\phi_e(d)$, share of external finance b, asset tangibility s, and cost of collateral liquidation $(1-\eta)$. Note from equation (7) that the credit constraint enters the price multiplicatively, and thus all of the parameters which increase the credit constraint increase the price as well.

Recall that the production function and credit market parameters are equal and t-invariant for all varieties belonging to the same origin-duration cohort. As a result, prices and credit constraints are also equal and t-invariant for all varieties in a given origin e and duration d cohort:

$$p_{vt}(d) = p_e(d) \qquad \Phi_{vt}(d) = \Phi_e(d) \qquad\qquad \forall v \in \{\nu_{ed}\}, t. \tag{9}$$

From equation (8) – and since the probability of default is the same for all experienced exporters

[14] Under the quasi-concave utility function and constant marginal cost, the price obtained in (7) is a unique local profit maximizer for any positive level of output.

(Assumption 1) – the financial constraint $\Phi_{vt}(d)$ is also equal for all established exporters:

$$\Phi_{vt}(d \geq 1) = \widetilde{\Phi} \qquad \forall v \in \{\nu_{ed}\}, t. \tag{10}$$

Finally we note that, from equations (2) and (9), the individual demands are also symmetric across varieties of a given cohort, and so are the per-firm exports, which are the summations of individual demands across all consumers in importer:

$$x_{vt}(d) = x_{et}(d) \qquad Q_{vt}(d) \equiv L x_{vt}(d) = Q_{et}(d) \qquad \forall v \in \nu_{ed}. \tag{11}$$

2.4 Aggregate Exports and Exports Growth Rate

We start by deriving the aggregate value of exports of all new varieties. Recall that the number of new entrants in each period is given by n_e, out of which only $(1 - \phi_e(0))$ will succeed in exporting. The price and quantity of a new exporting firm v are given by equations (7) and (11) (individual demand for variety v is given by equation (2)), and from equations (9) and (11), we know that prices and quantities are symmetric across all varieties of a given origin-duration cohort. Thus, the aggregate value of exports of all new varieties exported by country e in period t are given by:

$$V_{et}(0) \equiv n_e \left[1 - \phi_e(0)\right] p_e(0) Q_{et}(0) = n_e \left[1 - \phi_e(0)\right] L_e \left(\frac{c_e w_e \tau_e \Phi_e(0)}{1 - \phi_e(0)}\right)^{1-\sigma} \lambda_t^{\sigma} \left(\frac{\sigma - 1}{\sigma}\right)^{2\sigma - 1}. \tag{12}$$

In order to derive the aggregate value of exports by experienced exporters, we first need to derive the number of experienced firms with a given duration d. Since in every period a fraction of firms drops out due to project risk, the number of firms with duration d is given by

$$N_e(d) = n_e \left[1 - \phi_e(0)\right] \left(1 - \widetilde{\phi}\right)^d. \tag{13}$$

It is convenient to express the value of exports by all firms with duration d as a function of exports by new exporters, $V_{et}(0)$ (given by equation (12)):

$$V_{et}(d) \equiv N_e(d) p_e(d) Q_{et}(d) = V_{et}(0) \left(\frac{\Phi_e(d)}{\Phi_e(0)} \frac{1 - \phi_e(0)}{1 - \phi_e(d)}\right)^{1-\sigma} (1 - \widetilde{\phi})^d. \tag{14}$$

This result allows us to derive the value of exporters by all firms from country e with 'exporting age'[15] $D \geq 1$ as a function of exports by new exporters, $V_{et}(0)$:

$$\sum_{d=0}^{D} V_{et}(d) = V_{et}(0)\left[1 + \sum_{d=1}^{D}\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{1-\sigma}(1-\widetilde{\phi})^d\right], \tag{15}$$

Lastly, from (15), the exports growth for country e with exporting age $D \geq 1$ can be derived as:

$$G_{et}(D) \equiv \frac{\sum_{d=0}^{D} V_{et}(d)}{\sum_{d=0}^{D-1} V_{e(t-1)}(d)} = \frac{V_{et}(0)}{V_{e(t-1)}(0)}\left\{1 + \frac{\left(1-\widetilde{\phi}\right)^D}{\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} + \sum_{d=1}^{D-1}\left(1-\widetilde{\phi}\right)^d}\right\}, \tag{16}$$

which can be simplified to

$$G_{et}(D) = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma}\left\{1 + \left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^{-1}\right\}. \tag{17}$$

Note that due to the variation in the time specific shock λ, the growth rate in any particular period t can be either above or below one, or to put it differently it can be either positive or negative.

2.5 A Numerical Example

In this section we provide a numerical example to illustrate the mechanics of our model. We consider three arbitrarily chosen countries, Argentina, Bolivia, and Germany (indexed by A, B, and G, respectively), exporting from initial period 0 to period 15. To highlight a key result, we consider different initial project risks across countries (we set $\phi_A = 0.5$, $\phi_B = 0.67$, and $\phi_G = 0.34$), but a common lower project risk for experienced firms (we set $\widetilde{\phi} = 0.2$). In addition, to demonstrate a convergence in growth rates over time despite other differences, we allow for asymmetry in marginal costs ($c_A = 1.5$; $c_B = 2$; $c_G = 1$) and in the number of new firm-exporters ($n_A = 200$; $n_B = 100$; $n_G = 300$). The rest of the parameters are symmetric across countries.[16]

We start by calculating firm-level exports for new and experienced firms by plugging the chosen parameters into equation (2). In the top-left panel of Figure 1 we see that the proportional increase

[15] Export age of a given country is determined by the duration of its oldest exporting firm.

[16] In particular, for all countries we set $w = 1$ $\tau = 1$, $\sigma = 2$, $b = 0.5$, $\lambda_t = 1$ $\forall t$, $r = 0$, $\eta = 0.1$, $s = 0.4$, $L = 100$.

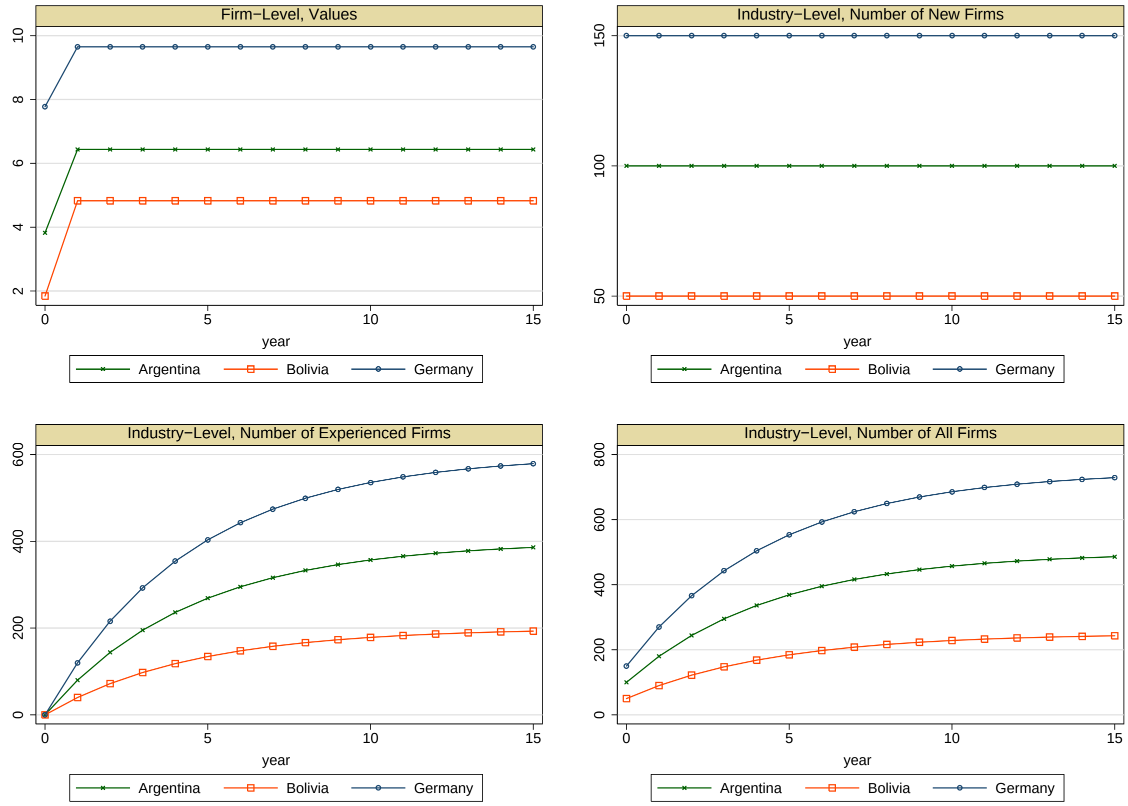

Figure 1: Dynamics of Firm-Level Exports and Number of Firms at Industry-Level

in export values due to experience is the highest for Bolivia, the country with the highest initial project risk, and the lowest for Germany, the country with the lowest initial project risk. This asymmetry in export value increases at firm-level is a key mechanic to the convergence in the growth rates at the industry level. The other three panels of Figure 1 show the dynamics of the number of firms over time. The number of new entrants stays constant over time while the number of experienced firms and all firms increase at a decreasing rate for all countries.

Figure 2 shows aggregated industry-level exports by new, experienced, and all firms as well as growth rates of exports by all firms. From the top-left panel of Figure 2 we can see that aggregate exports by new firms stay stable over time as is expected because the number of new firms remains constant over time and each new firm exports the same volume. Exports by experienced firms, in contrast, increase over time. This is because the number of experienced firms increases over time though each experienced firm exports the same volume each period. Exports by all firms are then a parallel shift up of the exports by experienced firms; the magnitude of the shift is equal to exports

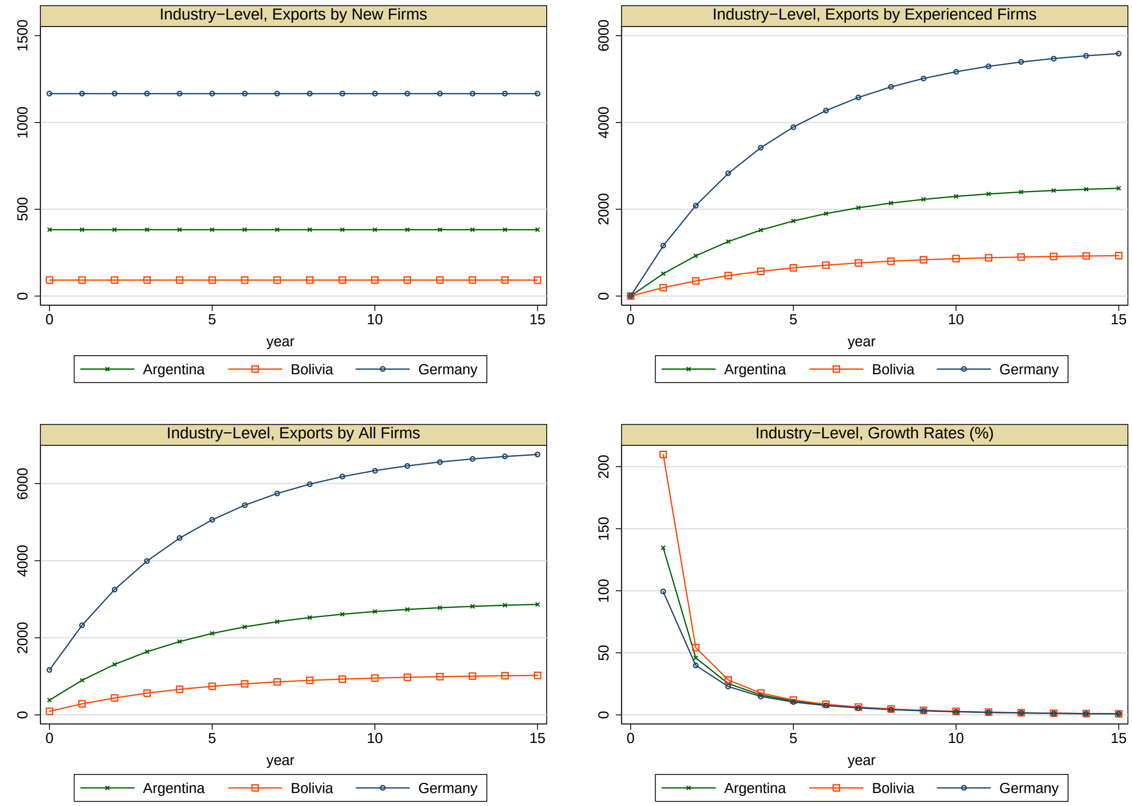

Figure 2: Dynamics of Industry-Level Exports and Growth Rates

by new firms. The bottom-right panel of Figure 2 is the most interesting and important one as it shows the dynamics of industry level growth rates. The decreasing speed of export growth is fastest for Bolivia in which new exporters faced the highest project risk; the decreases in the export growth rates for Germany are most moderate, and Argentina is between the two. The cause for this order is traced back to the top-left panel in Figure 1 as we explained. In what follows we will derive this result formally in Proposition 1 (a). Furthermore, we show that Proposition 1 (a) can sustain deviations from Assumptions 1 and 2 (in Propositions 4 and 5).

Note also that while the growth rates converge, the corresponding levels of exports do not converge across countries. Thus, while there is catch-up of sorts in growth rate (and more precisely convergence to a zero growth rate), there is no catch-up in the level of exports across identical durations.

2.6 Predictions

In this section we formulate testable predictions based on our model. Note that we do not analyze the dynamics of export prices, since we believe that without explicit modeling of quality upgrading over time our analysis of prices will be incomplete and potentially misleading.[17]

Our first proposition ties export growth to financial market parameters.

Proposition 1 *The growth rate of exports from country e, ceteris paribus, increases in*

(a) the country-specific project risk parameter, i.e., $\frac{\partial G_{et}(D)}{\partial \phi_e(0)} > 0$*;*

(b) share of external finance, i.e., $\frac{\partial G_{et}(D)}{\partial b} > 0$*;*

(c) asset tangibility of exporters, i.e., $\frac{\partial G_{et}(D)}{\partial s} > 0$*.*

In our model, project risk increases expected costs, but decreases expected revenue. Both channels increase the price, which in turn decreases the quantity. Since demand is elastic ($\sigma > 1$), the quantity effect is stronger than the price effect. Consequently, exporters facing higher risk will start with smaller revenues but they have more to gain from resolving initial uncertainty and, once successful, will grow faster. This is the intuition behind Proposition 1-(a).

Proposition 1-(b) predicts that the growth rate of exports will be higher when exporters in a given country relied more on external finance to cover export-related costs. Intuitively (and as is clearly seen in equations 5 and 8), the credit constraints are more relevant for firms which rely more on external borrowing. Thus, it is not surprising that firms with a higher share of external borrowing gain more and grow faster as credit constraints become less stringent due to firms gaining experience and facing lower project risk in the future.

Proposition 1-(c) predicts a positive relationship between asset tangibility and the growth rate. The intuition can be explained as follows. Higher asset tangibility lowers the interest rate, which is seen in (4) since the interest rate $R_e(d)$ is a decreasing function in s. It reduces the financing cost when an exporter would pay the borrowed amount back upon its export success. However, the exporter may lose the entire s in the event of its default, which is reflected in the expression for

[17] Fan, Lai, and Li (2013), using an extensive Chinese firm-level dataset, find that credit constrains force firms to produce sub-optimal quality, and that, controlling for their size and productivity, firms facing lower credit constraints produces higher quality goods. If one allows for credit constrains to decrease with duration, the quality effect will drive prices up over time, while the lower risk effect would decrease prices. The net effect is thus potentially ambiguous.

expected costs. The latter outweighs the former; the net effect of higher asset tangibility leads to the higher expected cost of financing as is seen in (5).

We note that Assumption 2 is critical for both (b) and (c) in that, if η were one, the expected cost and thus export growth would be independent of external finance dependence and asset tangibility. This is consistent with Manova (2013), who in Section 3.3 claims the same result (with prices and quantities at the optimal level) for the subset of firms for which the revenue is sufficient to repay the loan in full.

Our Proposition 2 describes the relationship between the growth rate and export duration for a given exporter and how it changes across all exporters.

Proposition 2 *Ceteris paribus, export growth rates*

(a) decrease with duration, i.e., $\frac{\partial G_{et}(D)}{\partial D} < 0$*;*

(b) converge across exporters as export durations increase.

At each period we have a constant stream of newly entering cohorts of exporters, but their share in the entire population of exporters diminishes. Thus, for a given country, the growth rate decreases over the duration. Related to this, we predict that export growth rates across different countries will converge as export duration increases.

Lastly, our model yields a prediction on the persistence of the effect of credit constraints. As the duration of exports from country e increases, the share of new firms in the total mass of exporters decreases, and so does the effect of credit constraints on export growth. Since established exporters face less strict constraints, over time the growth rate of exports depends less and less on the country of origin's initial credit constraints.[18] So, we have the following prediction:

Proposition 3 *Ceteris paribus, the longer is the duration of exports from country e, the smaller is the dependence of the growth rate on the probability of success of new varieties from country e,* $\left(\frac{\partial^2 G_{et}(D)}{\partial \phi_e(0) \partial D} < 0\right)$*, asset tangibility* $\left(\frac{\partial^2 G_{et}(D)}{\partial s \partial D} < 0\right)$*, and external financing* $\left(\frac{\partial^2 G_{et}(D)}{\partial b \partial D} < 0\right)$.

2.7 Robustness of Theoretical Results

In this section we relax several assumptions of our baseline model to show that our predictions remain robust to such extensions.

[18] Note that credit constraints always matter for new exporters.

2.7.1 Lesser Dependence of Mature Exporters on External Financing

Existing empirical literature indicates that more experienced firms depend less on external financing. For instance, Rajan and Zingales (1998) document an unambiguously sharp decline in the need for external borrowing by mature firms in the vast majority of sectors. In particular, external dependence[19] for mature firms is less than 0.2 for 80% of sectors while for young firms it is the case for only 11% of sectors. More specifically, external dependence for young versus mature firms is given by 2.06 versus 0.03 in Drugs, 1.52 versus 0.03 in Glass, and 1.05 versus 0.04 in Ships. In a more recent study, Cabral and Mata (2003) also find empirical evidence consistent with the hypothesis that financing constraints are binding for young firms but not for mature ones.

To reflect this feature, we may consider the case in which successful exporters rely less on external borrowing (e.g., due to inter-temporal profit accumulation). Formally, we assume that if b is the share of borrowing for new exporters it is kb for established exporters, with $0 \leq k \leq 1$. As we claim in Proposition 4 (and provide the in Appendix B.2), we find that the results shown in Proposition 1 are robust to this extension:

Proposition 4 *Even if experienced exporters have to borrow a smaller share than inexperienced exporters, our predictions of Proposition 1 are unchanged. That is, the growth rate of exports from country e increases in*

(a) the country-specific project risk parameter, ϕ_e*;*

(b) share of external finance, b*; and*

(c) asset tangibility of exporters, s*.*

Moreover, now we can establish results (b) and (c) even without Assumption 1.

2.7.2 Non-Constant Number of New Entrants

In the baseline model we assumed that the number of new exporters is constant over time for a given country. But, our results remain robust even if we allow the number of new exporters to either be increasing or decreasing over time.

[19] Rajan and Zingales (1998) define external dependence as the fraction of capital expenditures not financed with cash flow from operations.

Proposition 5 *The predictions of Proposition 1 are robust to allowing the number of new exporters in a given country to be either increasing or decreasing over time.*

While the mathematical proof for this result is somewhat mechanical and tedious, the underlying intuition is clear and simple: since our results are concerning the growth rates, the same proportional level changes would not affect the comparative statics for growth rates.

2.7.3 Spillovers and Learning-by-Doing

According to empirical findings in Alvarez et al. (2013), the probability of failure for new exporters is lower in the presence of existing exporters (from the same country). Our qualitative predictions are robust to possible extensions allowing for three classes of firms: initial exporters, new exporters who follow successful initial exporters, and incumbents.[20]

It is possible that learning-by-doing may generate similar predictions to our Proposition 2. Albornoz et al. (2012) model learning-by-doing cost savings and the decreasing probability of failure, but do not model the impact of credit constraints. For discussion purposes, let us set up a hypothetical assumption for the former conduit: the marginal cost of established exporters across all countries decreases by the same rate $\zeta > 1$ compared to the marginal cost of new exporters: $c_e(t \geq 1) = \frac{c_e(0)}{\zeta}$. The new growth rate expression with learning-by-doing is given by

$$G_e(D) = 1 + \left[\left(\frac{1}{\zeta} \frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}} \right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}} \right]^{-1}$$

If we set the credit constraints parameters b and s to zero, the growth rate will simplify to

$$G_e(D) = 1 + \left[\left(\frac{1}{\zeta} \frac{1-\phi_e(0)}{1-\widetilde{\phi}} \right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}} \right]^{-1}.$$

Such a model will still be able to explain differences in country-specific growth rates, but not differences in sector-specific growth rates consistent with sector-specific variation in credit constraints. That is, parts (b) and (c) of Proposition 1 cannot be produced when one attempts to explain our predictions on the growth rates with only the learning-by-doing (without the effects of credit constraints).

[20]The proof is available upon request.

3 Data and Empirical Approach

We use two data sets in our investigation. The main data set are exports to the United States and twelve members of the European Union between 1989 and 2007. Exports to the United States come from the U.S. Census Bureau and are recorded using the 10-digit Harmonized System (HS). European Union data come from EUROSTAT and are recorded using the 8-digit Common Nomenclature (CN). The unit of account is an export relationship, an exporter-product pair, recording exports of a product by one of 236 exporting countries to one of the thirteen destination countries. We examine our model empirically by estimating the reduced form of equation (B.5). We regress the log of the gross growth rate on the components of equation (B.5): project risk ϕ_e, reliance on external finance, asset tangibility, and duration of exporting. As discussed below we also include the lending rate in our estimation.

The second data set we use are annual exports at the 6-digit HS level of all countries as reported by the UN Comtrade database. We use data imports reported in Comtrade given that imports data tend to be of higher quality. As we discuss below, we use these data to estimate the project risk that we then use in growth regressions.

3.1 Export Growth Rates

Our main data set consists of 28,095,762 annual observations. Since our model pays particular attention to the entire history of an export relationship, we convert annual data to spells—episodes with two or more continuous years of positive exports. There are a total of 8,408,156 exporting spells for 5,047,210 relationships, allowing us to calculate a total of 19,687,606 growth rates.

Our investigation imposes three limits on our data. Our predictions hinge on observing a relationship from its inception forcing us to drop all observations on spells active in 1989, as they could have started in 1989 or any prior year. The second limitation is the availability of credit constraint variables. The third limitation is imposed by our use of UN Comtrade data to estimate the project risk, limiting our analysis to countries for which have their data reported in the database. Both limitations reduce the sample to 6,866,811 annual observations on 723,089 spells giving rise to a total of 6,866,811 growth rates.[21] Descriptive statistics on all gross growth rates as well as those used in our analysis are collected in Table 1.[22]

	All data						
	Average Growth Rate	Standard deviation	Median Growth Rate	Number of: Growth rates	Annual observations	Countries	Products
Belgium-Lux	15.39	2,165	1.02	1,550,434	2,166,817	198	16,048
Denmark	9.67	606	1.02	1,094,382	1,582,830	199	15,730
France	10.88	1,111	1.02	2,016,644	2,816,204	199	16,041
Germany	5.44	138	1.02	2,499,798	3,446,780	199	15,960
Greece	10.97	440	0.99	875,327	1,318,355	195	15,602
Ireland	16.36	3,735	1.02	671,624	1,038,877	196	15,642
Italy	11.11	731	1.01	1,824,334	2,612,677	199	16,006
Netherlands	37.53	13,746	1.01	1,660,985	2,411,801	199	15,764
Portugal	20.17	3,293	1.00	1,000,351	1,434,509	197	15,721
Spain	18.21	1,168	1.03	1,413,751	2,013,941	199	15,964
United Kingdom	14.23	1,750	1.00	2,020,386	2,913,137	198	15,932
United States	5.10	97	1.05	3,059,590	4,339,834	236	22,395

	Data used in regressions						
	Average Growth Rate	Standard deviation	Median Growth Rate	Number of: Growth rates	Annual observations	Countries	Products
Belgium-Lux	25.02	2,576	1.05	518,036	662,144	161	10,555
Denmark	14.34	484	1.06	418,638	544,338	146	9,950
France	20.30	1,809	1.07	606,148	776,059	165	10,623
Germany	8.18	198	1.07	739,178	942,285	166	10,558
Greece	14.69	310	1.05	386,838	499,990	145	9,697
Ireland	16.79	992	1.04	312,102	409,897	151	9,669
Italy	17.99	1,000	1.06	689,368	873,993	163	10,508
Netherlands	31.19	1,736	1.05	578,220	749,846	167	10,250
Portugal	36.02	5,255	1.04	335,394	438,080	151	9,927
Spain	28.85	1,612	1.08	486,260	625,364	158	10,383
United Kingdom	21.45	1,347	1.05	698,023	899,716	165	10,454
United States	7.45	128	1.11	1,098,606	1,414,278	166	17,109

Table 1: **Descriptive Statistics**

The distribution of gross growth rates is very skewed for every destination country. Looking at the bottom panel of Table 1, the average growth rate is the lowest for exports to the U.S. at 645%, while exports to Portugal have the largest average growth rate of 3,390%. In all cases the average growth rate is around the 90^{th} percentile. Median growth rates are more reasonable in magnitude, with exports to the U.S. having the largest median growth rate of 9% and exports to Portugal

[21] We also drop all instances of lending rates above 100% as outliers. At the country level there are 49 such instances, with the average lending rate of 2,906%. In the case of exports to the U.S. this reduces our sample by 2,679 out of almost one million growth rates.

[22] The net growth rate is calculated as $g = (\text{exports}_{t+1} - \text{exports}_t)/\text{exports}_t$.

and Ireland having the lowest one at 3%. Skewed distributions are not uncommon in product-level trade data.[23] Given the skewness of the distribution of growth rates, we use the natural logarithm of the growth rate in all regressions.

The last two columns of Table 1 show the number of countries reported to be exporting along with the number of products exported to each of the thirteen destinations.[24] Differences between the upper and lower panels of the table are due to the three limitations imposed on our data: availability of credit constraint variables, the need to clearly observe the beginning of a spell, and available countries in UN Comtrade database. On average across all destinations, some 30% of countries and product codes are dropped from data used in regressions. Note, however that the omitted data tends to involve slower growing exporters as both the mean and median growth rates are higher in the estimation sample (with the exception of mean in the case of the Netherlands).

3.2 Project Risk

Our model predicts that firms which are perceived to be riskier will commence their exports with smaller shipments. According to Proposition 1 export growth depends positively on exporter's project risk. Obtaining data on the perceived riskiness of an exporter is difficult. Instead, we estimate project risk using our secondary data set. We estimate a simple hazard of exports ceasing. The hazard rate is the probability of a spell of exports ceasing at a given point in time given that it has survived continuously until that point. Our choice of UN Comtrade data was dictated by our desire to measure project risk using exports to as many countries as possible so that our estimates are based on as much information as possible. Using just exports to the U.S. and the EU, the focus of our investigation, may bias the results as some exporters may not target those markets.

Following Besedeš and Prusa (2013) we estimate a simple hazard model where the hazard is a function of the log of duration, the initial volume of exports, GDP of the importer and the exporter, distance between the importer and the exporter, common border, and common language.[25] These variables are usually used as explanatory variables when estimating a hazard model using country-

[23] Besedeš (2008) shows that the distribution of initial export volumes to the U.S. is similarly skewed.

[24] The difference between the number of countries exporting to EU members and the U.S. has to do with the U.S. Census Bureau reporting trade with a larger number of very small countries, while the difference between the number of products exported to EU members and the U.S. has to do with the U.S. data reported for more precisely defined products.

[25] All gravity related variables come from CEPII's gravity data set, while GDP is from World Bank's World Development Indicators.

product level data. We estimate the following specification

$$h_{veD} = \Phi\left(\mathbf{X}_{veD}\beta + \tau_n + \nu_{ve}\right) \tag{18}$$

where Φ is the standard normal cumulative distribution function, $\mathbf{X}_{veD}$ is the vector of covariates, τ_n are spell number fixed effects, and ν_{ve} is a country-product random effect. Our estimates from the random effects probit model are shown in Table 2.[26] All coefficients are qualitatively similar to results usually obtained in the duration of trade literature: initial exports, both GDPs, common border, and common language reduce the hazard, while distance makes it more likely exports will cease increasing the hazard. As is usually the case, the longer the spell, the lower the likelihood it will fail.

Duration (ln)	-0.457***
	(0.000)
Initial exports (ln)	-0.122***
	(0.000)
Importer GDP (ln)	-0.024***
	(0.000)
Exporter (GDP)	-0.135***
	(0.000)
Distance (ln)	0.165***
	(0.000)
Common border (ln)	-0.140***
	(0.001)
Common language	-0.071***
	(0.001)
Constant	1.831***
	(0.004)
Observations	57,921,094
Number of spells	20,882,189
Log-Likelihood	-27,204,049
ρ	0.304***

Standard errors in parentheses with *, **, *** denoting significance at 10%, 5%, and 1%.

Table 2: **Hazard Model Estimates**

To obtain estimates of project risk we fit thed estimate hazard model at means of all variables used in estimation. We combine two sets of fitted estimates. We fit the estimates separately for each 6-digit HS product category (where the means of all variables vary by each product category) and then separately for each exporter-product pair. Consistent with Assumption 1 in the first year

[26]In the interest of space we refer the interested reader to Besedešš and Prusa (2013) for more information on estimating hazard models in trade.

a 6-digit product is exported, project risk is equal to the hazard fitted for each country-product pair. In every subsequent year, project risk is identical across exporters and is equal to the hazard fitted for each 6-digit HS code and common to every exporter.

3.3 Credit Constraints Data

In the absence of direct measures of credit constraints at the product level, we use several proxy variables. We use two industry level measures constructed by Chor and Manova (2012): asset tangibility and external finance dependence. Both correspond to elements in our model, measured at the sectoral level, and are expected to have a positive effect. Asset tangibility is the share of net property, plant, and equipment in total book-value assets. External finance dependence measures the share of capital expenditures not financed with cash flows from operations. Industries more dependent on external finance have smaller initial export volumes as they are evaluated as riskier borrowers.

We use one country-level variable that captures characteristics of the financial environment in which the exporter is initially operating. Average lending rates charged by a country's banking system are available from World Bank's *World Development Indicators* on an annual basis. Lending rates for European Union members were taken from EUROSTAT. The country-level lending rate corresponds to the interest rate banks charge firms in our model. Equilibrium lending rate is an endogenous variable in our model (see equation (4)) and thus we do not perform comparative statics with respect to lending rate. However, we include it in estimation for two reasons. One has to do with the fact that were we not to include it, our credit constraints measures would only vary at the industry level as we discussed in the preceding paragraph. Thus, lending rates provide us with country and time variation in credit constraints. The second reason is that lending rates may capture unobservable characteristics orthogonal to other variables, project risk and the two industry level measures.

Since a higher lending rate indicates a more expensive and smaller initial loan, resulting in a higher growth rate should the exporter prove successful, we expect the lending rate to have a positive effect on the growth of exports.

3.4 Duration

The rate at which an export relationship grows decreases the older the relationship becomes. We include a spell's current duration (or age) in our regressions to reflect how long a relationship has been active for. As an example, for a four year long relationship, there would be three observations in our data, for the growth into years two, three, and four. The value of the duration variable in each of these three observations would be two, three, and four.

4 Results

Our empirical investigation proceeds in several steps. We first examine the role of credit constraints as outlined by Proposition 1, followed by the dynamics of export growth as outlined by Proposition 2. We end with the persistence of credit constraints as outlined by Proposition 3.

In every regression we include calendar year, spell number, overall spell length, and industry fixed effects implemented at the 3-digit SITC level. Calendar year fixed effects control for unobserved annual macroeconomic shocks, λ_t in our model. Spell number fixed effects control for differences that may exist across multiple spells for a particular relationship as there may be unobserved differences, for example, between the first and second instance of Australian exports of wool to Germany. Overall spell length fixed effects control for any potential differences that may exist between spells of various total lengths, for example, between growth rates in a spell which lasts five years and one which lasts eleven years. This may especially be the case at the end of shorter spells as the growth rate in the fifth year of a five-year long spell may be fundamentally different than the growth rate in the fifth year of an eleven-year long spell. In addition, shorter spells may not be long enough for all dynamic examined in our model to play out. Finally, industry level fixed effects control for any unobserved differences across industries.

4.1 Export Growth

Proposition 1 states that the growth rate of exports is higher the more restrictive are the credit constraints. The growth rate should be increasing in project risk, lending rate, external finance dependence, and asset tangibility. We estimate the following regression using OLS

$$\begin{aligned}\ln(1+G_{vetDjn\Delta}) = \alpha_0 + \alpha_1 ln(\text{Project Risk}_{veDjn\Delta}) + \alpha_2 \ln(\text{LendRate}_{et}) \\ + \alpha_3 \text{ExtFinDep}_i + \alpha_4 \text{AssetTang}_i + \alpha_5 \text{Duration}_{vetDjn\Delta} \\ + \xi_t + \xi_j + \xi_n + \xi_\Delta + \epsilon_{vetDjn\Delta}\end{aligned} \tag{19}$$

We regress the log of the gross growth rate of product v on the part of exporter e in calendar year t in the year in spell D[27] belonging to 3-digit SITC industry j in the n^{th} spell of total duration of Δ years[28] on exporter's project risk, average lending rate charged by banks in exporting country e in calendar year t, external finance dependence and asset tangibility of sector j, and the year in spell D which reflects the current duration of the exporting spell. We also include calendar year, ξ_t, 3-digit SITC industry, ξ_j, multiple spell instance, ξ_n, and total spell length, ξ_d, fixed effects, while $\epsilon_{vetDjn\Delta}$ is the error term. Our model predicts $\alpha_1 > 0$, $\alpha_2 > 0$, $\alpha_3 > 0$, $\alpha_4 > 0$, and $\alpha_5 < 0$. We collect results in Table 3. Rather than report estimates for each EU member, we pool our data for all EU destinations and estimate a pooled regression including destination fixed effects in the estimated specification. We partly do this out of concern for space and partly since firms which ship their products to, for example, Germany might face much lower entry barriers to other EU markets than firms which do not export to the EU at all.[29]

The first two columns contain estimates on all spells in the data. Except for the lending rate for exports destined to the U.S., all estimated coefficients are as expected. The higher the project risk, the faster the growth as these exporters benefit the most from demonstrating they are successful ($\alpha_1 > 0$). For exports to both the U.S. and the EU a 1% higher project risk implies a 0.4% faster growth. In the case of exports to the EU, a 1% higher lending rate increase the growth rate by 0.006%, a small effect, but highly statistically significant. Exporters more dependent on external finance ($\alpha_3 > 0$) and with more tangible assets ($\alpha_4 > 0$) also grow faster.[30] The growth rate decreases with duration of exporting ($\alpha_5 < 0$).

[27] As in our notation in Section 2, D captures the current length of a country e's exports of product v. When the country starts exporting $D = 0$, while in the second year of successful exporting in the same spell $D = 1$.

[28] The total length of an exporting spell.

[29] EU destination specific results are qualitatively similar and are available on request.

[30] Since external finance dependence and asset tangibility are sector specific and constant over time, the direction of their effect is of greater interest than the magnitude, as is customary in the literature. Both variables can be thought of as providing a ranking of sectors along these two dimensions, in which case the magnitude of their effects are not as meaningful as the sign of the effect. See Manova (2013) for a discussion.

	All spells		Spells longer than 3 years		Spells longer than 6 years	
	U.S.	EU-12	U.S.	EU-12	U.S.	EU-12
Project risk (ln)	0.421***	0.426***	0.406***	0.415***	0.300***	0.301***
	(0.007)	(0.003)	(0.007)	(0.003)	(0.007)	(0.004)
Lending rate (ln)	0.001	0.006***	0.002	0.006***	0.006***	0.011***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
External finance dependence	0.007***	0.014***	0.010***	0.013***	0.007***	0.009***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)
Asset tangibility	0.132***	0.146***	0.144***	0.147***	0.084***	0.101***
	(0.030)	(0.014)	(0.028)	(0.013)	(0.030)	(0.014)
Duration	-0.016***	-0.011***	-0.020***	-0.013***	-0.037***	-0.028***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.764***	0.682***	0.853***	0.854***	0.848***	0.789***
	(0.078)	(0.019)	(0.079)	(0.020)	(0.120)	(0.022)
Observations	1,098,606	5,768,205	854,961	4,499,711	589,231	3,098,154
Spells	230,683	492,406	120,192	369,838	61,206	236,760
R^2	0.015	0.011	0.017	0.013	0.018	0.013

The dependent variable is the log of the gross growth rate, $1 + (\text{exports}_{t+1} - \text{exports}_t)/\text{exports}_t$. Calendar year, spell number, overall spell length, and industry level fixed effects included, robust standard errors clustered on relationship in parenthesis with *, **, *** denoting significance at 10%, 5%, and 1%. Observations report the number of annual exporter-product observations and spells report the total number of spells with positive exports of various length used in the analysis.

Table 3: **Export Growth and Credit Constraints**

The only departure from expected coefficient is the lending rate faced by exporters to the U.S. – it has a positive, but imprecisely estimated effect. One possible explanation for this departure is that it is possible that our model is better suited to examining longer lived exports, those with longer spells. Our model is designed to capture the dynamics of export growth as it is affected by credit constraints and project risk. It is quite possible that in very short spells, such as those less than 4 years in length, there is not enough time for the dynamics to fully play out. In the extreme case of two-year long spells, we observe only one growth rate. There are no dynamics to speak of in such spells. We examine this possibility in the remaining columns of Table 3.

We first drop all spells less than four years in length, and then all spells less than seven years in length. This naturally progressively reduces our sample size, but our results are qualitatively unchanged, except that when spells shorter than 7 years are dropped, the lending rate in the case of exports to the U.S. becomes statistically significant. Note that the magnitude of the effect of project risk decreases for both the U.S. and the EU, while that of lending rate and duration increases. The effect of the two sectoral variables, external finance dependence and asset tangibility, first increases (dropping spells less than 4 year long) and then decreases.

Our results may seem inconsistent with Albornoz et al. (2012) who concluded that credit constraints do not play a role in the growth of exports of Argentinean firms. When restricting their sample to firms deemed not to be credit constrained, those in sectors with asset tangibility above the median for the whole manufacturing sector, they found those firms grow faster. This is equivalent of finding that asset tangibility itself has a positive effect, were it included as a variable in regressions. This is identical to our results. The key difference is that our model predicts that firms with more tangible assets are expected to grow faster since a greater amount of tangible assets increases their costs (as we explain in section 2.6) and makes them start exporting with smaller volumes and larger prices.

4.2 Dynamics of Export Growth Rates

Proposition 2 states that growth rates decrease as the spell survives and that they converge across exporters as duration increases. The estimated coefficient on duration in Table 3 confirms the first part of the proposition, that growth rates decrease with duration ($\alpha_5 < 0$) with the effect ranging between a 0.011 (EU) and 0.016 (U.S.) log-point reduction in the growth of exports for every additional year of export duration when all spells are used and between 0.028 and 0.037 when only spells longer than 6 years are used. We now offer evidence on the second part of the proposition.

One approach to examining convergence is to regress the standard deviation of growth rates on duration. However, it does not control for the nominal size of growth rates. This is particularly problematic given the first part of proposition 2. When comparing all spells it implies that the average growth rate across all exporters is decreasing as spells survive. It is reasonable to expect that the standard deviation is decreasing as well. We instead calculate the coefficient of variation, dividing the standard deviation with the average growth rate, across all exporters at every duration for each product for all spells of equal length and separately for multiple spell cases. We only include products with at least five exporters at every duration and estimate the following specification

$$\text{COV}(1 + G_{veDjn\Delta})_{vDjn\Delta} = \beta_0 + \beta_1 \text{Duration}_{vDjn\Delta} + \kappa_j + \kappa_n + \kappa_d + u_{vDjn\Delta}.$$

where we regress the coefficient of variation for a product v in industry j across all exporters e in year D of total duration Δ of the same multiple spell instance n on the duration of exports and include spell number (κ_n), spell length (κ_Δ), and industry (κ_j) fixed effects at the 3-digit SITC level, and the error term $u_{vDjn\Delta}$. We expect to find $\beta_1 < 0$. Table 4 collects our results. The estimated negative coefficient on duration indicates that the coefficient of variation decreases with duration providing strong evidence of convergence of growth rates. Note that unlike our results on Proposition 1, the convergence of growth rates is not affected in an appreciable way by the exclusion of shorter spells.

	All spells		Spells longer than			
			4 years		7 years	
	U.S.	EU-12	U.S.	EU-12	U.S.	EU-12
Duration	-0.017***	-0.016***	-0.017***	-0.016***	-0.017***	-0.016***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Constant	1.055***	1.830***	0.901***	1.177***	0.749***	0.912***
	(0.032)	(0.029)	(0.064)	(0.028)	(0.058)	(0.028)
Observations	209,516	1,262,148	138,548	1,133,560	77,111	823,006
No. Subjects	15,776	12,956	9,954	11,630	4,992	9,159
R^2	0.078	0.228	0.047	0.121	0.046	0.062

The dependent variable is the coefficient of variation of growth rates at the product level. Industry (3-digit SITC), spell number, and spell length fixed effects included, robust standard errors clustered by products in parentheses with *, **, *** denoting significance at 10%, 5%, and 1%. Observations report the number of annual product observations, while products report the number of products analyzed.

Table 4: **Convergence of Export Growth Rates**

4.3 Persistence of Credit Constraints

Our final investigation focuses on Proposition 3 which predicts that credit constraints play a crucial role in the first year of growth, but become progressively less important in subsequent years as successful firms obtain access to cheaper financing and outweigh new entrants in terms of volume. We expect to find a decreasing role of credit constraints as duration increases. We estimate

$$\begin{aligned}
\ln(1 + G_{vetDjn\Delta}) = {} & \gamma_1 ln(\text{Project Risk}_{vejDn\Delta}) + \delta_1 ln(\text{Project Risk}_{veDjn\Delta}) \times \text{Dur}_{vetDjn\Delta} \\
& + \gamma_2 \ln(\text{LendRate}_{et}) + \delta_2 \ln(\text{LenRate}_{et}) \times \text{Dur}_{vetDjn\Delta} \\
& + \gamma_3 \text{ExtFinDep}_i + \delta_3 \text{ExtFinDep}_i \times \text{Dur}_{vetDjn\Delta} \\
& + \gamma_4 \text{AssetTang}_i + \delta_4 \text{AssetTang}_i \times \text{Dur}_{vetDjn\Delta} \\
& + \zeta_0 + \zeta_1 \text{Dur}_{vetDjn\Delta} + \xi_t + \xi_j + \xi_n + \xi_d + \epsilon_{vetDjn\Delta},
\end{aligned} \tag{20}$$

where we interact every key variable from specification (19) with duration, except for duration itself, and include calendar year (ξ_t), industry (ξ_j), spell number (ξ_n), and total duration (ξ_Δ) fixed effects, alongside the error term $\epsilon_{vetDjn\Delta}$. If the effect of project risk and credit constraints diminishes with duration, we should find coefficients of variables interacted with duration to be

	All spells		Spells longer than 3 years		Spells longer than 6 years	
	U.S.	EU-12	U.S.	EU-12	U.S.	EU-12
Project risk (ln)	0.501***	0.506***	0.481***	0.494***	0.387***	0.386***
	(0.007)	(0.004)	(0.007)	(0.004)	(0.008)	(0.004)
Project risk (ln) x Duration	-0.049***	-0.047***	-0.045***	-0.044***	-0.034***	-0.031***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Lending rate (ln)	0.037***	0.021***	0.050***	0.023***	0.071***	0.041***
	(0.004)	(0.002)	(0.004)	(0.002)	(0.005)	(0.003)
Lending rate (ln) x Duration	-0.007***	-0.003***	-0.008***	-0.003***	-0.010***	-0.004***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
External finance dependence	0.022***	0.028***	0.026***	0.028***	0.019***	0.022***
	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)
External finance dependence x Duration	-0.004***	-0.004***	-0.003***	-0.003***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Asset tangibility	0.234***	0.361***	0.228***	0.381***	0.093**	0.303***
	(0.035)	(0.017)	(0.035)	(0.017)	(0.041)	(0.019)
Asset tangibility x Duration	-0.033***	-0.055***	-0.027***	-0.053***	-0.010***	-0.038***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Duration	-0.135***	-0.128***	-0.128***	-0.123***	-0.109***	-0.096***
	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)
Constant	0.830***	0.729***	0.886***	0.887***	0.844***	0.801***
	(0.077)	(0.019)	(0.077)	(0.020)	(0.116)	(0.023)
Observations	1,098,606	5,768,205	854,961	4,499,711	589,231	3,098,154
Spells	230,683	492,406	120,192	369,838	61,206	236,760
R^2	0.017	0.013	0.02	0.015	0.02	0.014

The dependent variable is the log of the gross growth rate, $1+(\text{exports}_{t+1}-\text{exports}_t)/\text{exports}_t$. Calendar year, spell number, overall spell length, and industry level fixed effects included, robust standard errors clustered on relationship in parenthesis with *, **, *** denoting significance at 10%, 5%, and 1%. Observations report the number of annual exporter-product observations and spells report the total number of spells with positive exports of various length used in the analysis.

Table 5: **Credit Constraints Interacted with Duration**

of the opposite sign of the non-interacted variables, so that estimated coefficients γ_i and δ_i are of opposite signs, with γ_i positive. This is precisely what we find in Table 5—the longer the exports the smaller the effect of uncertainty and credit constraints.

One interesting aspect of these results is that unlike in Table 3 lending rates for exporters to the U.S. are now statistically significant and positive. This suggests that the dynamics of the effect of credit constraints, which are model predicts to be decreasing with duration are very important. As we drop progressively longer short spells (first those under 4 years in length and then those under 7 years in length) the magnitude of the effect of our variables changes in the same patterns as in Table 3: project risk and duration decrease, lending rate increases, while external finance dependence and asset tangibility first increase and then decrease. As a coefficient increases in value for a variable, so does the coefficient of its interaction with duration, and vice versa if the coefficient decreases.[31]

[31] By taking the absolute value of the ratio of the coefficient of a variable and its interaction with duration we can calculate how many years it takes for that effect to disappear. When all spells are used, it takes 5–7 years for the effect of credit constraint variables to be driven to zero and about 10 years for the effect of project risk. As we drop shorter spells the time needed for the effect to be driven to zero increases.

	Cumulative growth from start to			
	Year 7	Year 10	Year 7	Year 10
	U.S.		EU-12	
Project risk (ln)	0.068	0.122	0.222***	0.400***
	(0.065)	(0.086)	(0.031)	(0.039)
Lending rate (ln)	0.170***	0.207***	0.132***	0.169***
	(0.015)	(0.023)	(0.008)	(0.012)
External finance dependence	0.019	0.021	0.022**	0.014
	(0.022)	(0.031)	(0.009)	(0.013)
Asset tangibility	0.126	-0.008	-0.036	-0.217
	(0.264)	(0.371)	(0.120)	(0.166)
Constant	0.352	2.283**	0.196	0.688***
	(0.600)	(0.927)	(0.162)	(0.222)
Observations	61,829	33,067	323,973	174,978
Spells	59,404	32,053	231,943	143,394
R^2	0.064	0.07	0.045	0.053

The dependent variable is the log of the cumulative growth rate, $(\text{exports}_D - \text{exports}_0)/\text{exports}_0$, where D is a particular year in a spell. Calendar year, spell number, overall spell length, and industry level fixed effects included, robust standard errors clustered on relationship in parenthesis with *, **, *** denoting significance at 10%, 5%, and 1%. Observations report the number of annual exporter-product observations and spells report the total number of spells with positive exports of various length used in the analysis.

Table 6: **Credit Constraints and Cumulative Growth**

4.4 Cumulative growth

While we do not derive a specific proposition addressing cumulative growth, note that dividing equation (15) by initial exports, $V_{et}(0)$, provides an expression for cumulative growth from the start to a given year in spell D. Note that Proposition 1 should hold for cumulative growth as it does for year-to-year growth. We empirically examine whether this holds in Table 6 where we show estimates for cumulative growth to years 7 and 10 for spells longer than six years. Applying our model to cumulative growth provides us with mixed results. Project risk is significant and positive only in the case of EU data (increasing in magnitude the longer the period of cumulative growth), while in the case of exports to the U.S. it is never significant. Lending rate is the only variable which always has a significantly estimated coefficient consistent with predictions. External finance dependence and asset tangibility are never significant for exports to the U.S., while external finance dependence is sometimes significant and positive for exports to the EU. The mixed results we obtain are likely a consequence of important dynamics which exist in year-to-year data and are glossed over in cumulative growth data.

5 Robustness

Before concluding we perform several robustness exercises. Our results could be affected by product code changes, which we can account for in the case of exports to the U.S. only. For the sake of brevity we report our robustness results only for spells longer than six years. We examine whether results are robust to: two alternatives to lending rates, using the mid-point formula to calculate growth rates, exclusion of data on spells active in 1989, and aggregation of data to the industry level. These results are collected in Table 8. As one can see most of our results are consistent with our benchmark results. Below we discuss the most important departures.

5.1 Product Code Redefinitions

Product codes are revised periodically by administrative bodies which maintain them. In the case of the U.S., codes are adjusted on at least an annual basis.[32] One approach to code changes is to use the Pierce and Schott (2012) algorithm to concord U.S. HS codes across time. An alternative is to exclude all product codes affected by revisions. We follow both and estimate specification 19 for the U.S. and present results in Table 7 along with corresponding results from Table 3. Product code changes do not affect our results in any notable way.

5.2 Alternatives to Lending Rates

Rather than using the lending rate as a measure of the interest rate banks charge on loans, in the first column of Table 8 we use the net interest margin while in the second column we use overhead costs. Both measures come from the Financial Structure Database (Beck et al. 2000). Net interest margin measures the accounting value of a bank's net interest revenue as a share of its total earning assets capturing the difference between lending and deposit interest rates. Overhead costs equal the accounting value of a bank's overhead costs as a share of its total assets. Both variables reflect the efficiency of a banking sector and are constructed from bank-level data. Only in the case of net interest margin for exports to the EU do we obtain results consistent with the model. This may be a result of these two variables reflecting more the efficiency of the banking system than the cost of

[32] Changes come in three flavors: a product has declined in volume partially or completely so that a separate code is no longer warranted, a product has grown in volume or is brand new where a separate or new code is needed, or a product's code is revised for consistency reasons. See Pierce and Schott (2012) for a complete discussion.

	All spells			Spells longer than 6 years		
	Benchmark	Pierce-Schott concordance	Unchanged HS codes	Benchmark	Pierce-Schott concordance	Unchanged HS codes
Project risk (ln)	0.421***	0.404***	0.394***	0.300***	0.298***	0.289***
	(0.007)	(0.008)	(0.009)	(0.007)	(0.008)	(0.010)
Lending rate (ln)	0.001	-0.001	0.001	0.006***	0.005**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ext. fin. dep.	0.007***	0.007**	0.001	0.007***	0.010***	0.006*
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Asset tangibility	0.132***	0.147***	0.078*	0.084***	0.143***	0.088**
	(0.030)	(0.033)	(0.040)	(0.030)	(0.033)	(0.039)
Duration	-0.016***	-0.018***	-0.018***	-0.037***	-0.036***	-0.039***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Constant	0.764***	0.732***	0.526***	0.848***	0.806***	0.581***
	(0.078)	(0.080)	(0.050)	(0.120)	(0.105)	(0.058)
Observations	1,098,606	1,071,058	766,381	589,231	619,137	440,830
Spells	230,683	191,259	135,687	61,206	59,035	41,546
R^2	0.015	0.015	0.015	0.018	0.017	0.017

The dependent variable is the log of the gross growth rate, $1 + (\text{exports}_{t+1} - \text{exports}_t)/\text{exports}_t$. Calendar year, spell number, total spell length, and industry level fixed effects included, robust standard errors clustered on relationship in parenthesis with *, **, *** denoting significance at 10%, 5%, and 1%.

Table 7: **The Effect of U.S. HS Product Code Changes**

borrowing.

5.3 Calculating Growth Rates using the Midpoint Formula

We calculated all growth rates using the previous year as the base. As Bernard et al. (2013) show a good amount of growth identified between years one and two of an exporting spell may be a statistical anomaly. Since our data are recorded on an annual basis, it is possible that the first year volume is based on shipments during a fraction of the calendar year, while the second year volume is based on a full year's worth of shipments. The year two growth rate may then be exaggerated. An alternative approach with annual data is to use the midpoint formula, which smooths out any extreme annual changes. In addition, it addresses a potential bias in calculation of the year two growth rate. Using the midpoint formula has no qualitative effect on our results (column 3 of Table 8).

5.4 Export Spells with Unobserved Beginning

We have argued in Section 3 that our model requires us to restrict data to include only spells for which we can clearly determine the first year. This required us to drop information on all export spells observed in 1989 as that is the first observed year, but not necessarily the first year of those

	Net Interest Margin (1)	Overhead Costs (2)	Midpoint Growth Rates (3)	1989 Spells Only (4)	All Spells (5)	5-digit SITC Aggregation (6)
			United States			
Project risk (ln)	0.309***	0.308***	0.191***	0.018***	0.107***	0.275***
	(0.007)	(0.007)	(0.005)	(0.005)	(0.009)	(0.019)
Lending rate (ln)	-0.010***	-0.031***	0.004***	0.023***	0.014**	-0.004
	(0.002)	(0.002)	(0.001)	(0.001)	(0.006)	(0.006)
External finance dependence	0.006**	0.006***	0.005***	0.008***	0.005	0.011**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.005)
Asset tangibility	0.090***	0.094***	0.061***	0.023	0.141***	0.145*
	(0.029)	(0.029)	(0.021)	(0.019)	(0.051)	(0.075)
Duration	-0.036***	-0.036***	-0.026***	-0.004***	-0.033***	-0.040***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)
Constant	0.818***	0.847***	0.538***	-0.029	-0.044	0.886***
	(0.125)	(0.125)	(0.109)	(0.023)	(0.177)	(0.182)
Observations	598,555	598,800	570,993	807,633	218,535	63,003
Spells	63,094	63,097	61,206	60,008	48,866	6,361
R^2	0.018	0.018	0.019	0.007	0.008	0.022
			European Union			
Project risk (ln)	0.310***	0.310***	0.191***	0.128***	0.121***	0.232***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.004)	(0.007)
Lending rate (ln)	0.005***	-0.010***	0.010***	0.026***	0.023***	0.006**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)
External finance dependence	0.010***	0.010***	0.006***	0.004***	0.005***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Asset tangibility	0.108***	0.110***	0.068***	0.037***	0.089***	0.090***
	(0.013)	(0.013)	(0.009)	(0.007)	(0.024)	(0.031)
Duration	-0.027***	-0.027***	-0.019***	-0.010***	-0.034***	-0.038***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.002)
Constant	0.820***	0.834***	0.490***	0.102***	0.243***	0.705***
	(0.023)	(0.023)	(0.014)	(0.009)	(0.032)	(0.048)
Observations	3,172,371	3,174,371	2,987,042	7,137,164	1,254,473	504,308
Spells	331,956	331,963	319,670	581,129	346,031	50,599
R^2	0.013	0.013	0.015	0.006	0.007	0.013

The dependent variable is the log of the gross growth rate, $1+(\text{exports}_{t+1}-\text{exports}_t)/\text{exports}_t$. Lending rate is substituted by net interest margin in column (1) and by overhead costs in column (2). Calendar year, spell number, total spell length, and industry level fixed effects included, robust standard errors clustered on relationship, with *, **, *** denoting significance at 10%, 5%, and 1%.

Table 8: **Select Robustness Results**

spells. Including such spells would introduce a bias as we would treat all such spells as if 1989 was their first year. We examine such spells in columns 4 and 5 of Table 8.

In column 4 we only use spells which are active in 1989, while in column 5 we use all data available to us. All coefficients are estimated with the expected sign, and all but two are statistically significant (both in the case of exports to the U.S.) suggesting that perhaps the bias from including all data is not too large. We point out, however, that the magnitude of the project risk variable is much lower than in our benchmark specification, especially for the U.S. where it is an order of magnitude smaller (for the EU it is roughly a third of the benchmark size). Another problem with these data is how to properly calculate project risk. We estimate project risk as hazard of exports ceasing. For hazard estimation, spells observed in 1989 are problematic as their starting point is unobserved. The usual approach is to drop such data. In our estimates in columns 4 and 5 as project risk we use estimates obtained in such a way. But this likely results in a certain number of errors as we are assigning first year project risk to all spells observed for the first time in 1989 even though 1989 may not be their actual first year.

5.5 Aggregation of Trade Flows

Our model was developed with multiple exporters of the same product in mind. It is possible that in our highly disaggregated product-level data many products are exported by a single firm. To address this issue we aggregate our data to the 5-digit SITC level and examine the validity of our model in column 6 of Table 8. To estimate project risk at the 5-digit SITC level we first aggregated the 6-digit HS data from UN Comtrade to the 5-digit SITC level and then estimated the hazard model. Our results are qualitatively identical to those at the product level, except for the lending rate in the case of exports to the U.S. which is not significant.

6 Conclusion

The role of credit constraints in international trade is not relevant only for the volume of trade and various aspects of extensive and intensive margins. They play an important role in determining the growth of exports at the product level as we have modeled and documented. Using a stylized dynamic model we derive several testable predictions. Exports from more credit constrained firms grow faster, while the growth rate of all exporters decreases with time. Growth rates converge across all exporters of the same variety. Finally, the impact of credit constraints on the growth rate of exports diminishes over time: as an export relationship survives, their constraining effect on growth decreases. We test and confirm these predictions using highly disaggregated export data to the United States and the twelve members of the European Union.

The reduced role of credit constraints over time points to their large role at the margin for new export relationships. Credit constraints are an important and debilitating initial barrier. They reduce the initial volume by limiting the ability of constrained firms to finance their activities. However, as our results show, the debilitating effect disappears relatively quickly, within the first three years of an export relationship. The disappearance of credit constraint related barriers is conditional on the ability of the exporter to survive, which is not a straightforward proposition for developing countries as documented by Besedeš and Prusa (2011).

Our paper adds a new dimension to the assessment and design of export promotion policies, for we study how long financial barriers to exporting persist. The immediate policy implication of this result is that subsidizing credit for first-time exporters may allow them to overcome the initial barrier imposed by credit constraints. In addition, such assistance should be short lived given that the effect of credit constraints greatly diminishes over time. However, as documented by OECD (2008), while many countries have policies to help firms overcome credit constraints, none of them focus primarily on new exporters and only Singapore limits its assistance to the first two or three years of exporting. The design of such export promotion policies has to overcome mixed results of such policies as discussed in Bernard and Jensen (2004), Görg, Henry, and Strobl (2008), and Lederman, Olarreaga, and Payton (2010) for example.

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A Data Appendix

Data used in this paper are available from public sources.

Data	Source
Exports to the U.S. at the 10–digit HS level	U.S. Census Bureau, U.S. Imports CDs and DVDs
Exports to the EU at the 8–digit CN level	EUROSTAT, http://epp.eurostat.ec.europa.eu
Financial development, net interest margin, and overhead costs	Financial Structure Database
Lending rates	World Bank's *World Development Indicators* and EUROSTAT
External finance dependence and asset tangibility	Chor and Manova (2012)
GDP	World Bank's *World Development Indicators*
Distance, common border, common language	CEPII's gravity data set

B Theoretical Framework Appendix

B.1 Deriving Sufficient Conditions for the Interior Equilibrium

Our equilibrium derivations are based on the assumption of positive demand for the numeraire good in Home, $z > 0$. We need to ensure that each consumer in Home spends less than his income, w, on differentiated goods:

$$w > \frac{1}{L}\sum_{e}\sum_{d} V_{et}(d)\tau_e \qquad \forall t,$$

which is the total market value of all available differentiated varieties in Home in period t, normalized by the number of consumers L. Note that the net of trade barriers value of all varieties exported to Home in period t from country e, $\sum_d V_{et}(d)$ is defined by equation (15), which allows us to modify the above inequality as:

$$w > \frac{1}{L}\sum_{e} \tau_e V_{et}(0)\left[1 + \sum_{d=1}^{D}\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{1-\sigma}(1-\widetilde{\phi})^d\right], \tag{21}$$

where the total exports of new varieties from e in period t, $V_{et}(0)$, are given by equation (12), and the financial constraints for new and established exporters, $\Phi_e(0)$ and $\widetilde{\Phi}$, are defined by equation (8) (all remaining variables are parameters of the model defined in Sections 2.1 and 2.2).

B.2 Proof of Proposition 1

Proof. Using the results for the growth rate and the financial constraint, given by equations (17) and (8), we can show that the export growth rate

(a) increases in the project risk parameter $\phi_e(0)$:

$$\frac{\partial G_{et}(D)}{\partial \phi_e(0)} = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma} \frac{(\sigma-1)\left(\frac{1-\phi_e(0)}{\Phi_e(0)}\right)^{\sigma-2} \frac{1+br+bs(1-\eta)}{\Phi_e^2(0)} \left(\frac{\widetilde{\Phi}}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^2} > 0; \tag{22}$$

(b) increases in the share of external finance b:

$$\frac{\partial G_{et}(D)}{\partial b} = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma} \frac{(\sigma-1)\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\right)^{\sigma-2} \frac{s(1-\eta)(\phi_e(0)-\widetilde{\phi})}{\Phi_e^2(0)} \left(\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^2} > 0; \tag{23}$$

(c) increases in asset tangibility of exporters, s:

$$\frac{\partial G_{et}(D)}{\partial s} = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma} \frac{(\sigma-1)\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\right)^{\sigma-2} \frac{b(1-\eta)(\phi_e(0)-\widetilde{\phi})(1+br)}{\Phi_e^2(0)} \left(\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^2} > 0. \tag{24}$$

■

B.3 Proof of Proposition 2

Proof. From equations (17) and (8), we can show that

(a) export growth rates decrease with duration

$$\frac{\partial G_{et}(D)}{\partial D} = \frac{\lambda_t^\sigma \ln\left(1-\widetilde{\phi}\right)}{\lambda_{t-1}^\sigma} \frac{\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}}{\widetilde{\phi}}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^2} < 0,$$

because $\ln\left(1-\widetilde{\phi}\right) < 0$. To derive the partial derivative, we used the fact $\frac{d(a^x)}{dx} = (\ln a)a^x$;

(b) export growth rates converge across exporters as relationships age, since from equation (17)

$$\lim_{D\to\infty} G_{et}(D) = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma},$$

which is invariant across countries.

■

B.4 Proof of Proposition 3

Ceteris paribus, the longer is the duration of exports from country e, the smaller is the dependence of the growth rate on the probability of success of new varieties from country e, $\left(\frac{\partial^2 G_{et}(D)}{\partial \phi_e(0) \partial D} < 0\right)$, asset tangibility $\left(\frac{\partial^2 G_{et}(D)}{\partial s \partial D} < 0\right)$, and external financing $\left(\frac{\partial^2 G_{et}(D)}{\partial b \partial D} < 0\right)$.

Proof. From equations (31) the derivative of the growth rate with respect to the project risk parameter $\phi_e(0)$ can be simplified to:

$$\frac{\partial G_{et}(D)}{\partial \phi_e(0)} = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma} \frac{(\sigma-1)\left(\frac{1-\phi_e(0)}{\Phi_e(0)}\right)^{\sigma-2} \frac{1+br+bs(1-\eta)}{\Phi_e^2(0)} \left(\frac{\widetilde{\Phi}}{1-\widetilde{\phi}}\right)^{\sigma-1}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D/2} + \frac{(1-\widetilde{\phi})^{1-D/2}-(1-\widetilde{\phi})^{D/2}}{\widetilde{\phi}}\right]^2} > 0.$$

The only part of the equation above which depends on the duration is the expression in square brackets in the denominator – let us denote it with K. Note that

$$\frac{\partial K(D)}{\partial D} = -\frac{\ln(1-\widetilde{\phi})}{2} \left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D/2} + \frac{(1-\widetilde{\phi})^{1-D/2}-(1-\widetilde{\phi})^{D/2}}{\widetilde{\phi}}\right] > 0,$$

since $\ln(1-\widetilde{\phi}) < 0$. Thus, since the denominator of equation (31) increases in duration, the derivative $\frac{\partial G_{et}(D)}{\partial \phi_e(0)}$ decreases in duration: $\frac{\partial^2 G_{et}(D)}{\partial \phi_e(0) \partial D} < 0$. The same logic applies to the external financing and asset tangibility with starting equations (32) and (33), respectively. ■

B.5 Proof of Proposition 4

Proof.

Consider the case when experienced exporters need to borrow a fraction $k \in [0, 1)$ of what the inexperienced exporters have to borrow. Then, the financial constraint for experienced exporters will change to: $\widetilde{\Phi}_k = 1 + kbr + kbs\widetilde{\phi}(1-\eta)$, while other parts of the growth rate equation (17) remain unchanged. Then, it is possible to show that the growth rate of exports from country e still increases

(a) in the export risk parameter $\phi_e(0)$:

$$\frac{\partial G_{et}(D)}{\partial \phi_e(0)} = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma} \frac{(\sigma-1)\left(\frac{1-\phi_e(0)}{\Phi_e(0)}\right)^{\sigma-2} \frac{1+br+bs(1-\eta)}{\Phi_e^2(0)} \left(\frac{\widetilde{\Phi}_k}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}_k}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^2} > 0;$$

(b) in the share of external finance b:

$$\frac{\partial G_{et}(D)}{\partial b} = \frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma} \frac{(\sigma-1)\left(\frac{\widetilde{\Phi}_k}{\Phi_e(0)}\right)^{\sigma-2} \frac{r(1-k)+s(1-\eta)(\phi_e(0)-\widetilde{\phi}k)}{\Phi_e^2(0)} \left(\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}_k}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(1-\widetilde{\phi}\right)^{-D} + \frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^2} > 0;$$

(c) in the asset tangibility of exporters s:

$$\frac{\partial G_{et}(D)}{\partial s}=\frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma}\frac{(\sigma-1)\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\right)^{\sigma-2}\frac{b(1-\eta)[\phi_e(0)-k\widetilde{\phi}+brk(\phi_e(0)-\widetilde{\phi})]}{\Phi_e^2(0)}\left(\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(1-\widetilde{\phi}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(1-\widetilde{\phi}\right)^{-D}+\frac{(1-\widetilde{\phi})^{1-D}-1}{\widetilde{\phi}}\right]^2}>0.$$

Note that if in addition to defining the fraction of borrowing by experienced exporters as $bk<b$, we also relax Assumption 1, the growth rate defined by equation (17) will be modified to:

$$G_{et}(D)=\frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma}\left\{1+\left[\left(\frac{1+kbr+kbs\phi_e(1-\eta)}{1+br+bs\phi_e(1-\eta)}\right)^{\sigma-1}(1-\phi_e)^{-D}+\frac{(1-\phi_e)^{1-D}-1}{\phi_e}\right]^{-1}\right\}.$$

where ϕ_e is a country-specific project risk parameter which does not depend on duration. We can show that results (b) and (c) of Proposition 4 still hold in this case:

$$\frac{\partial G_{et}(D)}{\partial b}=\frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma}\frac{(\sigma-1)\left(\frac{\Phi_e(D)}{\Phi_e(0)}\right)^{\sigma-2}\frac{(1-k)(r+s\phi_e(1-\eta))}{\Phi_e^2(0)}(1-\phi_e)^{-D}}{\left[\left(\frac{1+kbr+kbs\phi_e(1-\eta)}{1+br+bs\phi_e(1-\eta)}\right)^{\sigma-1}(1-\phi_e)^{-D}+\frac{(1-\phi_e)^{1-D}-1}{\phi_e}\right]^2}>0;$$

$$\frac{\partial G_{et}(D)}{\partial s}=\frac{\lambda_t^\sigma}{\lambda_{t-1}^\sigma}\frac{(\sigma-1)\left(\frac{\Phi_e(D)}{\Phi_e(0)}\right)^{\sigma-2}\frac{b\phi_e(1-\eta)(1-k)}{\Phi_e^2(0)}(1-\phi_e)^{-D}}{\left[\left(\frac{\Phi_e(D)}{\Phi_e(0)}\right)^{\sigma-1}(1-\phi_e)^{-D}+\frac{(1-\phi_e)^{1-D}-1}{\phi_e}\right]^2}>0,$$

where $\Phi_e(0)=1+br+bs\phi_e(1-\eta)$ and $\Phi_e(D)=1+kbr+kbs\phi_e(1-\eta)$. ■

B.6 Proof of Proposition 5

Proof. Previously we assumed that the number of new entrants is unchanged for a given country, i.e., n_e does not change from period to period. Let us relax this assumption and allow the number of new firms to be non-constant. In particular, we assume that the number of new entrants in country e is n_e in the very first year of country's exports and then is either increasing or decreasing at the constant proportion θ, so that if the country's duration of exporting is D the number of new entrants is given by $n_e\theta^D$. The corresponding value of new aggregate exports in period t can then be calculated as:

$$V_{et}(0,D)=n_e\theta^D\left[1-\phi_e(0)\right]L_e\left(\frac{c_e w_e\tau_e\Phi_e(0)}{1-\phi_e(0)}\right)^{1-\sigma}\lambda_t^\sigma\left(\frac{\sigma-1}{\sigma}\right)^{2\sigma-1}. \tag{25}$$

The corresponding number of active firms with duration d is:

$$N_e(d,D)=n_e\theta^{D-d}(1-\phi_e(0))(1-\widetilde{\phi})^d, \tag{26}$$

while total exports by these firms in period t are:

$$V_{et}(d,D) \equiv N_e(d,D)p_e(d)Q_{et}(d) = \frac{V_{et}(0,D)}{\theta^d}\left(\frac{\Phi_e(d)}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\phi_e(d)}\right)^{1-\sigma}(1-\widetilde{\phi})^d. \tag{27}$$

For country e with the total duration $D \geq 1$ in period t, the aggregate exports of differentiated goods are given by

$$\sum_{d=0}^{D} V_{et}(d,D) = V_{et}(0,D)\left[1+\sum_{d=1}^{D}\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{1-\sigma}\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{d}\right]. \tag{28}$$

From equation (28), we can derive the growth rate of exports from country e between periods $t-1$ and t with the oldest exporters from country e having duration D in period t:

$$G_{et}(D) \equiv \frac{\sum_{d=0}^{D} V_{et}(d)}{\sum_{d=0}^{D-1} V_{e(t-1)}(d)} = \frac{V_{et}(0)}{V_{e(t-1)}(0)}\left\{1+\frac{\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{D}}{\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}+\sum_{d=1}^{D-1}\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{d}}\right\}, \tag{29}$$

which can be simplified to

$$G_{et}(D) = \frac{\lambda_t^{\sigma}}{\lambda_{t-1}^{\sigma}}\left\{1+\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{-D}+\frac{\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{1-D}-1}{1-\frac{1-\widetilde{\phi}}{\theta}}\right]^{-1}\right\}. \tag{30}$$

Next we can prove that:

Using the results for the growth rate and financial constraint, given by equations (30) and (8), we can show that the export growth rate

(a) increases in the project risk parameter $\phi_e(0)$:

$$\frac{\partial G_{et}(D)}{\partial \phi_e(0)} = \frac{\lambda_t^{\sigma}}{\lambda_{t-1}^{\sigma}}\frac{(\sigma-1)\left(\frac{1-\phi_e(0)}{\Phi_e(0)}\right)^{\sigma-2}\frac{1+br+bs(1-\eta)}{\Phi_e^2(0)}\left(\frac{\widetilde{\Phi}}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{-D}+\frac{\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{1-D}-1}{1-\frac{1-\widetilde{\phi}}{\theta}}\right]^{2}} > 0; \tag{31}$$

(b) increases in the share of external finance b:

$$\frac{\partial G_{et}(D)}{\partial b} = \frac{\lambda_t^{\sigma}}{\lambda_{t-1}^{\sigma}}\frac{(\sigma-1)\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\right)^{\sigma-2}\frac{s(1-\eta)(\phi_e(0)-\widetilde{\phi})}{\Phi_e^2(0)}\left(\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1}\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{-D}+\frac{\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{1-D}-1}{1-\frac{1-\widetilde{\phi}}{\theta}}\right]^{2}} > 0; \tag{32}$$

(c) increases in asset tangibility of exporters, s:

$$\frac{\partial G_{et}(D)}{\partial s} = \frac{\lambda_t^{\sigma}}{\lambda_{t-1}^{\sigma}} \frac{(\sigma-1)\left(\frac{\widetilde{\Phi}}{\Phi_e(0)}\right)^{\sigma-2} \frac{b(1-\eta)(\phi_e(0)-\widetilde{\phi})(1+br)}{\Phi_e^2(0)} \left(\frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(\frac{1-\widetilde{\phi}}{\theta}\right)^{-D}}{\left[\left(\frac{\widetilde{\Phi}}{\Phi_e(0)} \frac{1-\phi_e(0)}{1-\widetilde{\phi}}\right)^{\sigma-1} \left(\frac{1-\widetilde{\phi}}{\theta}\right)^{-D} + \frac{\left(\frac{1-\widetilde{\phi}}{\theta}\right)^{1-D}-1}{1-\frac{1-\widetilde{\phi}}{\theta}}\right]^2} > 0. \quad (33)$$

■