Information Spillovers in Export Destinations

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Abstract

How do information spillovers across export destinations affect the geography of exports? We refer to information spillovers to the fact that when firms have uncertainty on their profitability but learn about market conditions through exporting, firms not only learn about the destination of their exports but also about other similar destinations. This paper provides empirical evidence on the existence of these spillovers and builds a model of export supply and learning in which entry into a destination is influenced by its informativeness and a firm's past export experience in similar markets. Using Mexican customs data, we structurally estimate the model and perform counterfactual exercises to evaluate how information spillovers contribute to the geographical spread of exports, and how an FTA aimed at increasing bilateral trade between member countries, could result in the diversification of export destinations by allowing firms to learn about their profitability in third-markets.

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1 Introduction

Several distinct factors determine a firm's export supply, such as its productivity or the trade costs it faces. Moreover, in a world with imperfect information one could also consider a firm's perceived profitability in export destinations as an important factor. This is because uncertainty in demand could lead a firm not to enter a destination when it was actually profitable to do so, or on the contrary, lead a firm to enter a destination only to exit after discovering it was actually not profitable to export there, that is, an exporting failure. If uncertainty is present in export markets and therefore firms learn while exporting, one could also ask if learning about a destination is only possible when exporting there or if learning occurs not only when exporting to that destination but also when exporting to other similar export markets. This is precisely the main question of this paper, how do information spillovers affect firm's entry and exit decisions from export markets.

The literature on the geographic expansion of a firm's exports considers two mechanisms: the first is that exporting tenure lowers costs of exporting and thus increases the profitability of entering other export destinations. The second is that there are information spillovers across potential destinations and thus previous experience may lead a firm to enter new markets. This paper follows the second mechanism. On one hand, I provide empirical evidence of information spillovers affecting firm dynamics in export markets. On the other, using this empirical evidence as motivation, I build a structural model of export supply with learning in order to explore the mechanisms behind the geographical spread of a firm exports. To my knowledge, there is not enough work on how export destinations shape the pattern of entry into other destinations and on building empirical models that allow us to ask interesting questions regarding firms' export choices under uncertainty.

For example, assume a Mexican firm is considering exporting to Germany and Switzerland, but has uncertainty on its profitability. Given some prior beliefs, the exporter chooses to enter Germany and while exporting there, starts to learn about its true profitability in that country. However, the firm not only learns about Germany but also learns about Switzerland because of the similarity between these two countries. Therefore it could be the case that the experience of exporting to Germany leads the firm to export to Switzerland as well. This is what I call information spillovers, the fact that when exporting to a certain destination, a firm not only learns about that particular destination but also about other similar potential export destinations. If this mechanism is true, then these information spillovers could in part be generating the geographic spread of a firm's exports.

This paper contributes to the literature on uncertainty and entry choices such as the work by Das et al. (2007), Impullitti et al. (2013) and Dickstein and Morales (2018), to the literature on extended gravity such as the work by Morales et al. (2019) which remarks the importance of export experience when trying to explain exporter dynamics and to the literature on firm's destination choices such as the work by Nguyen (2012) where it is assumed that there is demand uncertainty across potential destinations -which is immediately resolved once a firm enters a market-, but only explores a two country static model. In contrast, I am proposing a dynamic framework in which demand shocks are imperfectly correlated across destinations and firms do not immediately discover their profitability but rather start a learning process, which seems more akin to the stylized facts for new exporters identified in the data as in Ruhl and Willis (2017). Another key difference is that the author only performs numerical simulations to evaluate on average how many destinations are entered by a firm, in contrast this paper structurally estimates a model and conducts counterfactual simulations to evaluate the effect of information spillovers.

In Albornoz et al. (2012), the authors consider a two-period, two-country model with perfectly correlated demand shocks and immediate learning. In contrast, this paper explores an environment with multiple potential destinations where demand is imperfectly correlated across these. Defever et al. (2015) provide reduced-form evidence of how it is more likely a firm will enter a destination geographically close to another destination the firm has previously exported to. Another paper in this line is that of Evenett and Venables (2002) but they consider that past export experience only affects the cost side of firms and that firms are not forward-looking i.e. when a firm is deciding whether to enter a new destination, it is not taking into account that the new location will provide information on other destinations as well.

The work by Schmeiser (2012) also considers the geographic expansion of a firm's exports but rather than being a story of demand uncertainty, it is a story about learning to export in which the fixed costs of entry into a destination are decreasing in the number of destinations previously served. Because of this, a destination that previously was not profitable to export to, might become profitable once sufficient experience is acquired thus generating geographical expansion. This is different to the framework I present since her work is more about firms getting the know-how of exporting -through reduced fixed costs of doing so- rather than firms acquiring more information while exporting to a given market.

2 Empirical Evidence

The most prominent empirical work regarding how past destination choices affect entry into new export markets is that of Defever et al. (2015), which tests if having previously exported to a given country increases the probability of entering a similar destination e.g. if a firm has exported to Germany, the firm is more likely to start exporting to Switzerland given that Germany and Switzerland are similar countries. This approach seems to be somewhat standard in the literature and even though it is intuitive, it is not the one I take in this paper.

While the sign of the coefficient for the effect of export experience on entry is positive in the work above mentioned, I am silent about it. The reason for this is that having previously exported to a destination may not necessarily lead to entry into a similar destination, but rather it should allow the firm to make more informed and better decisions. For example, if a firm while exporting to Germany learns that exporting to Switzerland would not be profitable, then export experience actually decreases the probability of a firm entering Switzerland after having entered Germany. Under this argument, all that exporting to Germany does is giving the firm more information about Switzerland, where more information could either be that exporting to Switzerland would be profitable or not. Moreover, if destinations provide information about other export markets, then the amount of information a destination provides might act as an incentive for firms to enter that particular export market.

Using customs data for Mexico on the universe of exporting firms, I compute a similarity index between export destinations and present reduced-form evidence on the existence of information spillovers and how they affect firm behavior in export markets. The drawback of this data I use is that it does not contain any exporter characteristics, which would indeed be useful for my empirical analysis.

2.1 Data

The data used in this paper comes from the Exporter Dynamics Database published by the World Bank and constructed by Fernandes et al. (2015). For the case of Mexico, firm-level data is available and contains yearly information on export destination, value of sales, year, product -at the HS 6-digit disaggregation level- and for some observations, quantity. As shown in Table 1, data is for the period between the years 2000 and 2012 and covers 203,869 distinct firms exporting to 226 destinations and 2,879 unique markets. A market is defined as a unique destination-product combination by aggregating products into a 2-digit disaggregation level.

Table 1 also provides a brief overview of some exporter characteristics relevant to this paper. The average number of destinations exported to by a firm in a single period is 2.08 destinations -standard deviation of 3.63-, while the average number of exported destinations but for all years in the sample is 2.54 -standard deviation of 4.57-. These low values for the mean number of destination countries reflects the small diversity in terms of export destinations for Mexico. Mexican exports are concentrated in a small number of destinations e.g. exports to the United States account for 82.63% of total export value during this period. This fact is only reinforced by the medians shown in parenthesis, which indicate that half of all Mexican firms only export to one country in their tenure as exporters.

As for the number of periods a firm exports to a particular destination, which I refer as tenure in an export market, the average firm exports only for 1.93 years -with a standard deviation of 1.60-. This points out to the fact that most firms experience exporting failures since they only enter an export market for a couple of periods and then exit from it. Meanwhile, the average tenure as an exporter is 2.36 years -with a standard deviation of 1.99 years-, which again shows that most firms only engage in international trade for a small number of periods, a fact that has been well documented in the literature. As for why this behavior persists in the data, it seems that, rather than a story of demand shocks driving firms out of export markets, it is one of uncertainty when engaging into international trade, which further motivates this paper.

2.2 Similarity of Destinations

To calculate a similarity index between export destinations, I follow the work by Finger and Kreinin (1979) in which the authors develop an export similarity index. Their index measures the similarity of two countries regarding their exports to a common third country and is defined as:

$$S_X(i,j;k) = \left[\sum_l \min\left(\frac{X_{ik}^l}{X_{ik}}, \frac{X_{jk}^l}{X_{jk}}\right)\right] \times 100 \tag{1}$$

where i and j are the two origin countries in consideration, k is the third country that is exported to, l represents some trade classification system and X represents the value of exports. For the purposes of this work, rather than using this export similarity index, I define and calculate an import-based similarity index. I am using imports rather than exports since Mexican firms serving a particular destination care about how similar is that destination to others in terms of their exports to those countries, which can be seen as imports from their perspective. The import-based similarity index is thus defined as:

$$S(i,j;k) = \left[\sum_l \min\left(\frac{M_{ik}^l}{M_{ik}}, \frac{M_{jk}^l}{M_{jk}}\right)\right] \times 100 \tag{2}$$

Statistic	**Value**
Years	2000 - 2012
# of firms	201,739
# of destinations	226
# of markets	2,879
Average # of destinations served per period	2.04
	(1.00)
Average # of markets served per period	3.38
	(1.00)
Average # of destinations served in total	2.47
	(1.00)
Average # of markets served in total	4.57
	(2.00)
Average tenure of a firm in an export destination	1.87
	(1.00)
Average tenure of a firm in an export market	1.67
	(1.00)
Average tenure of a firm as an exporter	2.25
	(1.00)

Table 1: Descriptive Statistics.

The index takes values such that $S \in [0, 100]$, where higher values of S represent a higher degree of similarity between countries i and j with respect to their imports from k. If the index is equal to 0, then i's and j's import patterns from k are totally dissimilar and if the index is equal to 100, then the commodity distribution of i's and j's imports from country k is identical. To calculate the import-based similarity index, I use my customs data as firm exports can be aggregated at the product-destination level and thus, I can calculate the value of imports of a certain country coming from Mexico for every product category in my data. Products are defined following the HS classification system at a 2-digit disaggregation level.

Part of the results of this calculation are shown in Figure 1, were I show as an example how similar are the United States to the rest of the world in terms of their imports coming from Mexico. The index appear to do a good job in predicting intuitive results such as the similarity between the USA and Canada or Commonwealth countries such as the United Kingdom, Australia, South Africa, etc. The complete end-product of this exercise is a

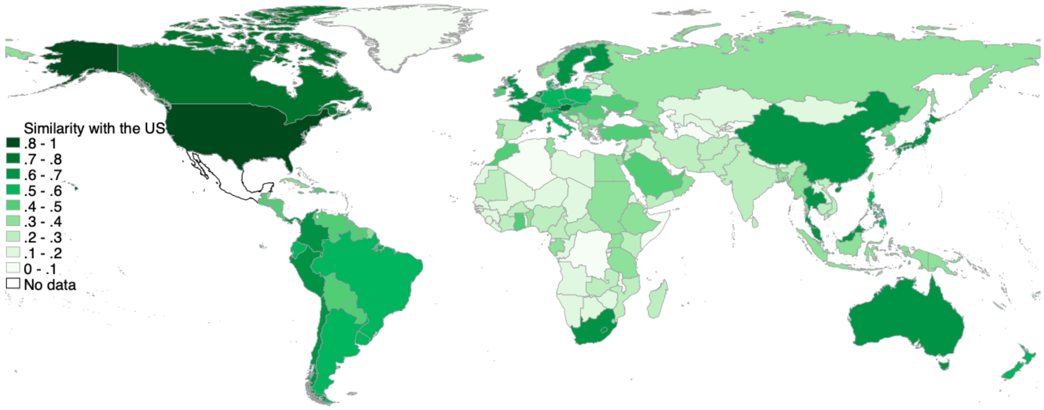

Figure 1: The US compared to the ROW in terms of their imports from Mexico.

symmetric matrix that shows how similar every country-pair is for the destinations to which Mexican firms exported to between the years 2000 and 2012. The index is calculated at a yearly level but then averaged out over all periods in my data in order to be used in my reduced-form regressions.

2.3 Identification Strategy

The goal of this section is to provide empirical evidence on the existence of information spillovers and whether these affect firms' choices in export markets. If destinations contain information about other potential destinations, then the following testable implications should follow:

Implication 1: *If destinations provide information about other similar destinations, then a firm that has previously exported to countries similar to i should be less likely to make a bad decision regarding entry into i.*

Assuming there is uncertainty on destination-specific profitability and there are information spillovers across similar destinations, then a firm that has higher export experience relevant to a certain destination is less likely to make a bad decision with respect to entry into that destination.

Implication 2: *If destinations provide information about other similar destinations, then destinations are valuable for how much information about other countries they provide. Destinations that are more informative should be more likely to be entered.*

In the presence of information spillovers and assuming both that firms are aware of these spillovers and that firms are forward-looking, then destinations are valuable not only because of their expected profitability but also because of how informative they are about destinations that firms have not previously exported to. A firm might enter a destination even when expecting non-positive profits if the destination will lead to lower uncertainty with respect to other destinations and thus, higher profits or at least better decisions in the future.

The rest of the section will describe in detail the identification strategy used to empirically test whether these implications hold in the data and thus, give validity to the structural model presented in this paper.

2.3.1 Relevant Export Experience and Bad Decisions

The ideal identification strategy would be regressing the probability of making a "bad decision" with respect to entry into a destination on a measure of how much information a firm has about this destination, where I use export experience as a proxy for the amount of information a firm has. However, estimating or even defining what making a bad decision means is challenging and even more so when the only available data I have is customs data without any firm characteristics.

Testing this implication first requires me to define what do I mean by a bad decision. I will consider as such the case in which a firm enters a certain market, realizes it is actually not profitable to export there and thus decides to exit. That is, entry when entry was not profitable. This requires me to define what do I consider to be an exit from a market and how to proxy for the firm actually being profitable or unprofitable. For the case of exit, I will consider two distinct cases:

- An exit is when a firm enters a market and exits from it in the next period.
- An exit is when I observe entry and the firm exits at some point before the last year in the data.

Measuring when a firm was profitable or not in an export market poses a greater challenge. Given the lack of firm characteristics in my data, the best I can do is to proxy for it using whether a firm exited -continued- the market when demand was increasing -decreasing-. That is:

- The firm was profitable: the firm did not exit the market despite a negative demand shock.

- The firm was not profitable: the firm exited the market despite a positive demand shock.

The reasoning behind this is if the firm exited the market even with a positive demand shock, it could indicate that the firm was not profitable in that market and thus exited. On the contrary, if I observe that a firm did not exit the market even with a negative demand shock, then it might be the case that the firm was being profitable, that is, if the firm was able to withstand a negative demand shock then it is likely that the firm was actually profitable in that market.

Lastly, I define a positive/negative demand shock using changes in demand. Even though the analysis is conducted at the market-level, a product-destination combination, I define demand shocks at the destination-level to account for the fact that a market might be served by a few firms and thus a firm's exit would be generating the negative market shock, which would cause a problem of reverse causality. I propose two measures of what a positive demand shock is:

- The growth rate of demand is positive.
- The growth rate of demand is above its average growth rate.

And equivalently for a negative demand shock. With these definitions in hand, Table 2 shows how my dependent variable is constructed. I ignore the cases in which the firm exited with a negative demand shock and when it continued with a positive demand shock, since it is less clear if the firm was or was not profitable in these cases. If the firm exited the market but there was a negative demand shock, I can not really say that the firm was not profitable since its exit might be driven precisely because of a negative demand shock and not the firm's profitability in that export market. The same intuition applies for the case in which a firm continued and there was a positive demand shock.

	Positive demand shock	**Negative demand shock**
Exit	Bad decision	-
Continue	-	Right decision

Table 2: Definition of a bad decision.

Now I turn my attention to the independent variable of this analysis, the measure of relevant export experience. I emphasize the word relevant to acknowledge the fact that not all previously exported to destinations provide the same amount of information about a particular destination, but rather it depends on how similar those destinations are to the one in consideration. If the destinations to which a firm has previously exported are more similar to the one in consideration, the firm should have more information about this destination and thus be more likely to make a better decision with respect to entry.

The measure of relevant export experience should be a function of two things: which destinations firm i has exported before period t and the similarity of each of these destinations with market m. Defining z_{imt} to be the amount of export experience that firm i has with respect to market m at time t, then:

$$z_{imt} = \sum_{j \in V_{i,t-1}} S(m, j) \tag{3}$$

where I sum across all destinations j in set $V_{i,t-1}$, which is the set of destinations to which firm i has exported up to period $t-1$. Clearly z_{imt} is increasing in the size of V_{it-1} as long as its elements are such that $S(m, j) > 0$, that is, if firm i has previously exported to countries somewhat similar to m. Having defined my main two variables, the specification in order to test whether having more information leads to better decision-making regarding entry into a destination is:

$$\mathbb{P}_{imt} = \alpha_0 + \alpha_1 z_{imt} + \epsilon_{imt} \tag{4}$$

where $\mathbb{P}_{imt}$ represents the probability of firm i having made a bad decision with respect to entry into market m at time t, where bad decision is defined according to one of the criteria above. That is, I am estimating a linear probability model of how relevant export experience affects the likelihood of making a bad decision regarding entry into an export market.

Specification 4 is not without its problems, as there could be other factors affecting entry into export markets. In particular, two issues are of concern. The first one is the fact that a positive demand shock could be driving entry into a destination and thus threatening identification of the effect of export experience on entry. For example, imagine a demand shock affecting both Germany and Switzerland, perhaps with different timing. The shock could lead to entry into Germany and then, as the shock hits Switzerland, lead to entry into Switzerland as well. If this is the case, the estimated coefficient for export experience would have an upward bias and thus, yield an incorrect estimate for the effect of export experience on how the firm makes entry decisions.

The second issue is that of firms learning how to export. The literature has found evidence that the more a firm has exported in the past, the better it is at exporting. If this is the case, profitability of export destinations would be increasing in export experience and thus, again threaten identification of the effect of increased information on a firm's entry choices. An example of this could be that a firm does not start exporting to Switzerland because by exporting to Germany it has learnt that it is profitable to do so, but rather because by exporting to Germany it becomes more efficient in exporting which later drives entry into Switzerland.

In order to control for both of these concerns, I propose the following specification:

$$\mathbb{P}_{imt} = \alpha_0 + \alpha_1 z_{imt} + \eta_1 \%\Delta x_{dt} + \eta_2 \%\Delta x_{it} + \phi_{f,m,t} + \epsilon_{imt} \tag{5}$$

where $\%\Delta x_{dt}$ represents the percentage change in demand from destination d and time t and $\%\Delta x_{it}$ represents firm i's aggregate exports in time t. I also include product, market and time fixed effects to capture any unobservables that might not be captured by my explanatory variables. On one hand, variable $\%\Delta x_{dt}$ controls for demand shocks driving entry. If there is a demand shock in destination d at time t, this will affect all other firms in that destination and thus will be picked up by this variable. On the other, variable $\%\Delta x_{it}$ controls for learning how to export effects and quality upgrading. If export experience is making the firm more efficient at exporting, this should increase exports to all other destinations the firm serves and thus will be picked up by the firm's aggregate exports.

Results for a random sample of firms are shown in Table 3. In it, each column represents a different definition of what a bad decision is. In here, dependent variable $\mathbb{P}_{x,y}$ should be read as the probability of making a bad decision according to criteria x, y, where x represents when did the firm exit the market and y how is a positive demand shock measured. The case in which $x = inm$ is when a firm exited the market immediately. The case in which $y = pdg$ is when a positive demand shock is defined as positive demand growth and $y = dgaa$ is when demand growth is above average. Other combinations for these definitions can be explored and would serve as robustness checks.

Table 3 shows results both for the specification in 4, without any controls or fixed effects, and for the full specification according to 5. The coefficient for my measure of relevant export experience indeed seems to be biased if I do not control for other factors that might be affecting a firm's entry behavior. Columns (2) and (3) are the same full specification but they differ on what definition of a bad decision I use. Comparing them, it seems the coefficient for export experience is robust to changes in this definition.

As can be seen, the coefficient for relevant export experience is significant and has the expected sign, indicating that higher relevant export experience results in a lower likelihood of a firm making a bad decision regarding entry into an unprofitable export market. Moreover, the magnitude of the coefficient is also reasonable, as it implies that if relevant export experience increases by one standard deviation -5.4 points- then a firm is 6.4% less likely to

	(1) $\mathbb{P}_{inm,pdg}$	(2) $\mathbb{P}_{inm,pdg}$	(3) $\mathbb{P}_{inm,dgaa}$
Export Experience	-0.00527***	-0.0118***	-0.0120***
	(-18.41)	(-5.78)	(-5.34)
$\%\Delta x_{dt}$		-1.85e-08	-7.93e-08
		(-0.79)	(-1.46)
$\%\Delta x_{it}$		1.22e-09*	1.87e-09**
		(2.84)	(3.23)
Constant	0.187***	0.216***	0.435***
	(81.78)	(21.79)	(51.05)
Fixed Effects		✓	✓
Observations	40,984	25,561	17,922

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Relevant Export Experience.

make a bad decision. In the last two specifications, standard errors are clustered at the firm, market and time level in order to capture any correlation on unobservables among these groups. It should also be noted that the decrease in observations when including controls is because some destinations are not exported to in contiguous years combined with a large number of firms not exporting two years in a row. Additionally, the size of the estimated coefficients on the control variables is the result of having very large growth rates of demand again because of the high turnover rates in some export markets.

In summary, there seems to be evidence of firms not only acquiring information about other potential destinations when exporting, but also of firms using that information in order to make better decisions regarding their entry into export markets. This supports the hypothesis claimed in **Implication I**.

2.3.2 Informativeness of Destinations and Entry

The objective of this section is to provide evidence for the fact that if destinations provide information about other potential destinations, then forward-looking firms might enter destinations in order to acquire information about other destinations. That is, testing whether informativeness of a destination affects the probability of entry into it. In order to do this, Equation 6 defines my measure of informativeness of an export destination. The index represents how informative destination d is for firm i at period t, this by taking into account the destinations to which firm i has not exported before and the similarity of those destinations to the destination in consideration. It is defined as:

$$I_{idt} = \sum_{j \notin V_{i,t-1} \cup \{d\}} S(d,j) \tag{6}$$

With the same notation as in Section 2.3.1 except that now I am summing over destinations that firm i has not exported before. The relationship I want to test is the following:

$$\mathbb{P}[\text{entry}_{idt}] = \beta_0 + \beta_1 I_{idt} + \epsilon_{idt} \tag{7}$$

I would expect for the sign of the coefficient for informativeness to be positive, representing that the more informative a destination is for a firm, the higher the probability the firm will enter that destination given that it would allow it to learn about other potential markets. As with the analysis for the effect of relevant export experience, the specification in 7 could be misleading as other factors can potentially affect the probability of entry into a destination. One of these factors, as discussed in the Section 2.3.1, is demand shocks driving entry into a destination i.e. if a firm entered a given destination it might be just because of a positive destination demand shock which now made the destination profitable.

With this issue in mind, I propose the specification in 8. If profitability of a destination is increasing -proxying profitability with positive demand shocks- it should be captured by variable $\%\Delta x_{dt}$. Further, I add destination and time fixed effects in order to account for any other unobserved source of variation in entry choices.

$$\mathbb{P}[\text{entry}_{idt}] = \beta_0 + \beta_1 I_{imt} + \eta_1 \%\Delta x_{dt} + \phi_{d,t} + \epsilon_{idt} \tag{8}$$

Results for these specifications are shown in Table 4 for a random sample of firms. The first column represents the specification stated in 7, the second column includes my control variable but does not account for fixed effects and lastly, the third column is the full specification as stated in 8.

Focusing on the results for the third specification, the estimated coefficient associated to my measure of informativeness is positive, which supports the hypothesis that if destinations contain information about other potential export markets, then destinations that are more informative are more likely to be entered. Moreover, the magnitude of the estimated coefficient is reasonable; it implies that if the informativeness of a destination increases by one standard deviation -20.06 points- then a firm is 6.8% more likely to enter that destination. One important thing to note here is that looking at the standard errors for the first and second columns, there is evidence of the need to cluster my standard errors since it seems

	(1) $\mathbb{P}(entry)$	(2) $\mathbb{P}(entry)$	(3) $\mathbb{P}(entry)$
Informativeness	0.0000577***	0.0000782***	0.00338***
	(166.70)	(160.07)	(10.93)
$\%\Delta x_{dt}$		7.67e-10***	2.52e-09*
		(124.68)	(2.37)
Constant	-0.00152***	-0.00265***	-0.163***
	(-151.87)	(-145.95)	(-10.85)
Fixed Effects			✓
Observations	33,132,504	27,671,505	27,671,505

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Informativeness Index.

there is correlation on unobservables. I do this for the third column, the full specification, by clustering my standard errors at the firm and destination level. As in Section 2.3.1, there is a loss in the number of observations because some destinations do not have observations in contiguous years given my random sample and the high turnover rates in export markets.

In summary, there is evidence in favor of **Implication II**, that is, if destinations are informative about other potential destinations and assuming firms are forward-looking, destinations that are more informative are more likely to be entered since firms value this information as it can lead them to make better choices in terms of their entry into export market choices.

3 A Model of Export Supply and Information Spillovers

The most prominent papers that develop models of information spillovers and firm entry into export markets are that of Nguyen (2012), Albornoz et al. (2012) and Morales et al. (2018). In terms of the general setup, I will follow the model developed in Cebreros (2016) but generalize it to multiple export destinations and allow for information spillovers across destinations while placing several simplifying assumptions in order to structurally estimate this augmented model.

The model builds on the standard heterogeneous firms framework by Melitz (2003) but adding uncertainty in terms of destination-specific demand shocks. Exporters can discretely choose to which destination to export based on their prior beliefs, which they update according to Bayes' Rule.

3.1 Demand

For the demand side, I assume that utility in export destination j is described by CES preferences:

$$U_j = \left(\int_{\Omega} \epsilon_j(\omega) q_j(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{9}$$

where $\sigma > 1$ is the elasticity of substitution across varieties, $q_j(\omega)$ is consumption of variety ω and $\epsilon_j(\omega)$ is a demand shifter. Given aggregate expenditure X_j, the demand function firm ω faces from country j is:

$$q_j(\omega) = \epsilon_j(\omega)^{\sigma} p_j(\omega)^{-\sigma} X_j P_j^{\sigma-1} \tag{10}$$

where P_j is the Dixit-Stiglitz price index:

$$P_j \equiv \left(\int_{\Omega} \epsilon_j(\omega)^{\sigma} p_j(\omega)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{11}$$

Using the fact that revenue is given by $r(\omega) \equiv p_j(\omega) q_j(\omega)$, I can use the expression for demand to rewrite an exporter's revenue in market j as:

$$r(q_j) = \epsilon_j(\omega) X_j^{\frac{1}{\sigma}} P_j^{\frac{\sigma-1}{\sigma}} q_j^{\frac{\sigma-1}{\sigma}} \tag{12}$$

I assume that all uncertainty in export market j depends on underlying export profitability θ_{jt} which is unknown to the firm. This allows me to rewrite the demand shifter a firm faces in export market j as $h(\theta_{jt})$, which captures both aggregate $X_j^{\frac{1}{\sigma}} P_j^{\frac{\sigma-1}{\sigma}}$ and idiosyncratic $\epsilon_j(\omega)$ determinants of demand. For simplicity, I assume a firm faces no uncertainty in the domestic market and normalize its demand shifter to unity. Given these assumptions, a firm faces the following revenue functions:

$$\text{Domestic Revenue: } r(q_j) = q_j^{\frac{\sigma-1}{\sigma}} \tag{13}$$

$$\text{Export Revenue: } r(q_j) = h(\theta_{jt}) q_j^{\frac{\sigma-1}{\sigma}} \tag{14}$$

3.2 Firms' Static Optimization Problem

For now, I will describe firm's static profit maximization problem, that is, without firms realizing the dynamic implications or their entry choices. Conditional on vector θ_t, a firm's total revenue is the sum of revenue in every market:

$$r_t = q_{ht}^{\frac{\sigma-1}{\sigma}} + \sum_{j \in D} d_{jt} h(\theta_{jt}) q_{jt}^{\frac{\sigma-1}{\sigma}} \tag{15}$$

where:

$$d_{jt} = \begin{cases} 1 & \text{if the firm exports to destination } j \text{ in period } t, \\ 0 & \text{otherwise.} \end{cases}$$

with q_{ht} and q_{jt} being quantities sold at home and at export market j respectively. Conditional on export status $d_t \in \mathbb{R}^D$, profit-maximizing firms will equate marginal revenue at home and every export destination:

$$q_{jt} = d_{jt} h(\theta_{jt})^{\sigma} q_{ht} \quad \forall j \in D \tag{16}$$

And thus I can define a firm's total output as:

$$q_t = \Big(1 + \sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma}\Big) q_{ht} \tag{17}$$

Equations 16 and 17 allow me to rewrite a firm's total revenue as:

$$\begin{aligned} r_t &= q_{ht}^{\frac{\sigma-1}{\sigma}} + \sum_{j \in D} d_{jt} h(\theta_{jt}) [d_{jt} h(\theta_{jt})^{\sigma} q_{ht}]^{\frac{\sigma-1}{\sigma}} = q_{ht}^{\frac{\sigma-1}{\sigma}} + \sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma} q_{ht}^{\frac{\sigma-1}{\sigma}} \\ &= \Big(1 + \sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma}\Big) q_{ht}^{\frac{\sigma-1}{\sigma}} = \Big(1 + \sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma}\Big) \Big[\Big(1 + \sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma}\Big)^{-1} q_t\Big]^{\frac{\sigma-1}{\sigma}} \\ &= \Big(1 + \sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma}\Big)^{\frac{1}{\sigma}} q_t^{\frac{\sigma-1}{\sigma}} \end{aligned} \tag{18}$$

Let f_j denote the fixed costs of exporting to destination j, which I assume that a firm has to pay every period it is in the market. Conditional on θ_t and the firm's export status d_t, firms choose their total quantity in order to maximize profits:

$$\max_{q_t} \left\{ \Big(1+\sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma}\Big)^{\frac{1}{\sigma}} q_t^{\frac{\sigma-1}{\sigma}} - \Big(f + \sum_{j \in D} d_{jt} f_j\Big) - \Big(1+\sum_{j \in D} \tau_{jt} d_{jt} h(\theta_{jt})^{\sigma}\Big)\Big(1+\sum_{j \in D} d_{jt} h(\theta_{jt})^{\sigma}\Big)^{-1} q_t \right\} \tag{19}$$

where the first term in parenthesis are total revenues, the second term are the fixed costs of serving the domestic and export markets and the third term represents the firm's variable costs. I am assuming that the only source of heterogeneity between firms comes from differences in their export profitability. I normalize the marginal cost of serving the domestic market to unity and thus, the marginal cost of serving export market j is equal to τ_{jt}.

Solving the firm's maximization problem, the optimal scale of operation for a firm is given by:

$$q_t = \Big(\frac{\sigma-1}{\sigma}\Big)^{\sigma}\Big(1+\sum_{j\in D}\tau_{jt}d_{jt}h(\theta_{jt})^{\sigma}\Big)^{-\sigma}\Big(1+\sum_{j\in D}d_{jt}h(\theta_{jt})^{\sigma}\Big)^{1+\sigma} \tag{20}$$

From which I can obtain an expression for profits as a function of export status d_t conditional on export profitability:

$$\Pi(d_t|\theta_t) = \frac{1}{\sigma}\Big(\frac{\sigma-1}{\sigma}\Big)^{\sigma-1}\Big(1+\sum_{j\in D}\tau_j d_{jt}h(\theta_{jt})^{\sigma}\Big)^{1-\sigma}\Big(1+\sum_{j\in D}d_{jt}h(\theta_{jt})^{\sigma}\Big)^{\sigma} - \Big(f+\sum_{j\in D}d_{jt}f_j\Big) \tag{21}$$

Notice that in the case in which there are no trade costs, this last expression collapses to:

$$\Pi(d_t|\theta_t) = \Big\{\frac{1}{\sigma}\Big(\frac{\sigma-1}{\sigma}\Big)^{\sigma-1} - f\Big\} + \sum_{j\in D}d_{jt}\Big\{\frac{1}{\sigma}\Big(\frac{\sigma-1}{\sigma}\Big)^{\sigma-1}h(\theta_{jt})^{\sigma} - f_j\Big\} \tag{22}$$

That is, profits are separable between home profits -the first term in brackets- and profits from exporting -the terms in the second bracket-. Going back to the case in which trade costs are present, given that the firm has uncertainty with respect to its export profitability θ_t, the firm's expected profits are given by:

$$\tilde{\Pi}(d_t|\Gamma_t) = \frac{1}{\sigma}\Big(\frac{\sigma-1}{\sigma}\Big)^{\sigma-1}\mathbb{E}_{\theta_t}\Big[\Big(1+\sum_{j\in D}\tau_j d_{jt}h(\theta_{jt})^{\sigma}\Big)^{1-\sigma}\Big(1+\sum_{j\in D}d_{jt}h(\theta_{jt})^{\sigma}\Big)^{\sigma}|\Gamma_t\Big] - \Big(f+\sum_{j\in D}d_{jt}f_j\Big) \tag{23}$$

where Γ_t represents the firm's information set at period t, which is a function of its export experience up until that point. Equation 23 is a key object as it represents a firm's expected profits as a function of its export status d_t given information set Γ_t. That is, in every period a firm is going to choose its export status $d_t = [d_{1t}, ..., d_{Dt}]$ such that the expression in 23 is maximized given information set Γ_t, which is a function of its export experience. Defining:

$$A_t(d_t|\Gamma_t) \equiv \mathbb{E}_{\theta_t}\Big[\Big(1+\sum_{j\in D}\tau_j d_{jt}h(\theta_{jt})^{\sigma}\Big)^{1-\sigma}\Big(1+\sum_{j\in D}d_{jt}h(\theta_{jt})^{\sigma}\Big)^{\sigma}|\Gamma_t\Big]^{\frac{1}{\sigma}} \tag{24}$$

Results in the final expression for a firm's expected profits given d_t:

$$\tilde{\Pi}(d_t|\Gamma_t) = \frac{1}{\sigma}\Big(\frac{\sigma-1}{\sigma}\Big)^{\sigma-1} A_t(d_t)^{\sigma} - \Big(f + \sum_{j\in D} d_{jt} f_j\Big) \tag{25}$$

where $A_t(d_t)$ captures all possible uncertainty regarding a firm's export profitability in export markets. Notice that this expression represents a static optimization problem for the firm, that is, it is not taking into account the dynamic implications of its entry choices. Dynamics have to be taken into account because if information spillovers are present and firms are forward-looking, then a firm might choose to enter a destination not only because of its expected profits but also because of the information content the destination has.

3.3 Learning and Information Spillovers

The objective of this section is to show how firms acquire information and update their beliefs according to Bayes' Rule. Assuming that firms know the exact functional form of $h(\cdot)$, once a firm chooses to export to destination j and observes realized demand in t, it receives a signal of its export profitability in destination j:

$$\theta_{jt} = \theta_j + \epsilon_{jt} \quad \text{where } \epsilon_{jt} \overset{\text{i.i.d.}}{\sim} \mathbb{N}(0, \sigma_\epsilon^2) \tag{26}$$

where the vector of a firm's true export profitability $\theta \in \mathbb{R}^D$ follows by assumption a multivariate normal distribution $\mathbb{N}(\mu_\theta, \Sigma_\theta)$. Firms knows both μ_θ and Σ_θ, as well as the distribution of ϵ_{jt}.

True export profitability is constant through time but is subject to random shocks which are unobservable to firms. In every period a firm exports to destination $j \in D$ it receives signal θ_{jt} and uses it to update its beliefs on the entire distribution of θ. If there were no information spillovers among export destinations, then the only belief that would be updated is precisely that for θ_j since exporting to j would give no information on the profitability of exporting to any other destination. The way I introduce information spillovers among export destinations is assuming that true export profitabilities $\{\theta_j\}_{j\in D}$ are correlated between each other, that is, covariance Σ_θ is a symmetric and non-diagonal matrix. In particular, the covariance between θ_j and θ_k is a function of the similarity between destinations j and k.

How learning works in the model is as follows. At $t = 0$ every firm gets a random draw of their θ from distribution $\mathbb{N}(\mu_\theta, \Sigma_\theta)$. Firms know this distribution and thus, it represents firms' prior beliefs about their export profitability. At $t = 1$ and based on these prior beliefs, firms choose export status d_1 in order to maximize Equation 24. For any $t > 1$, firms will choose to which destinations to export in that particular period but according to their updated beliefs on their export profitability, which are a function of their export history up to that point. The derivation of a firm's learning process for any export history $d^t = (d_1, ..., d_t)$ is as follows.

Bayes' Rule states that the distribution of θ conditional on observing signals z_t is proportional to the likelihood of observing those signals times the prior distribution of θ:

$$\pi(\theta|z_t) \propto L(z_t|\theta)\pi(\theta) \tag{27}$$

where $z_t \equiv d_t \odot \theta_t$ is the vector of signals observed during period t and $\pi(\theta)$ is the distribution of θ, which is common knowledge. Define $\Phi_t = \{j|d_{jt} = 1\}$ as the set of destinations a firm exported to in period t, then:

$$z_{jt} = \theta_j + \epsilon_{jt} \;\; \forall j \in \Phi_t \tag{28}$$

$$\Rightarrow z_{jt}|\theta_j \sim \mathbb{N}(\theta_j, \sigma_\epsilon^2) \tag{29}$$

Conditional on θ, realizations of z_t are i.i.d. due to the distribution of error term ϵ_{jt} and therefore I can express the likelihood of z_t conditional on θ as follows:

$$\begin{aligned} L(z_t|\theta) &= \prod_{j\in\Phi_t} \mathbb{N}(\theta_j, \sigma_\epsilon^2) \\ &\propto \exp\Big(-\frac{1}{2}\sum_{j\in\Phi_t} \Big(\frac{z_{jt}-\theta_j}{\sigma_\epsilon}\Big)^2\Big) \end{aligned} \tag{30}$$

Define $\Omega_t \equiv \text{diag}((1/\sigma_\epsilon^2)d_t)$ which is a diagonal and therefore symmetrical matrix such that $\Omega_{t_{jj}} = 0$ if $d_{jt} = 0$. The fact that $z_{jt} = \theta_{jt} \;\; \forall j \in \Phi_t$ allows me to rewrite the likelihood as:

$$L(z_t|\theta) \propto \exp\Big(-\frac{1}{2}(\theta_t - \theta)'\Omega_t(\theta_t - \theta)\Big) \tag{31}$$

Beliefs are updated after a firm has chosen its export status and those are the beliefs it carries into the next period. By Equation 27, the posterior distribution of a firm's export profitability given any export history d^{t-1} can be expressed as:

$$\pi(\theta|d^{t-1}) = \pi(\theta)\prod_{i=1}^{t-1} L(z_i|\theta) \tag{32}$$

where $\pi(\theta)$ is common knowledge and thus acts as firms' prior beliefs at the beginning of the learning process. Conditional on θ, the z_i terms are i.i.d. which allows me to express the above as the product of likelihood functions and therefore:

$$\begin{aligned}
\pi(\theta|d^{t-1}) &\propto \pi(\theta)\prod_{i=1}^{t-1}\exp\Big(-\frac{1}{2}(\theta_i-\theta)^{'}\Omega_i(\theta_i-\theta)\Big) \\
&\propto \exp\Big(-\frac{1}{2}(\theta-\mu_\theta)^{'}\Sigma_\theta^{-1}(\theta-\mu_\theta)\Big)\times\prod_{i=1}^{t-1}\exp\Big(-\frac{1}{2}(\theta_i-\theta)^{'}\Omega_i(\theta_i-\theta)\Big) \\
&\propto \exp\Big(-\frac{1}{2}(\theta-\mu_\theta)^{'}\Sigma_\theta^{-1}(\theta-\mu_\theta)-\frac{1}{2}\sum_{i=1}^{t-1}(\theta_i-\theta)^{'}\Omega_i(\theta_i-\theta)\Big)
\end{aligned} \tag{33}$$

For the sake of convenience, I take the natural logarithm of the whole expression and multiply both quadratic terms:

$$\begin{aligned}
\ln\pi(\theta|d^{t-1}) &\propto -\frac{1}{2}(\theta-\mu_\theta)^{'}\Sigma_\theta^{-1}(\theta-\mu_\theta)-\frac{1}{2}\sum_{i=1}^{t-1}(\theta_i-\theta)^{'}\Omega_i(\theta_i-\theta) \\
&= -\frac{1}{2}\Big[\theta^{'}\Sigma_\theta^{-1}\theta-\theta^{'}\Sigma_\theta^{-1}\mu_\theta-\mu_\theta^{'}\Sigma_\theta^{-1}\theta+\mu_\theta^{'}\Sigma_\theta^{-1}\mu_\theta \\
&+\sum_{i=1}^{t-1}\theta_i^{'}\Omega_i\theta_i-\sum_{i=1}^{t-1}\theta_i^{'}\Omega_i\theta-\sum_{i=1}^{t-1}\theta^{'}\Omega_i\theta_i+\sum_{i=1}^{t-1}\theta^{'}\Omega_i\theta\Big] \\
&= -\frac{1}{2}\theta^{'}\Big(\Sigma_\theta^{-1}+\sum_{i=1}^{t-1}\theta_i^{'}\Omega_i\Big)\theta+\frac{1}{2}\Big(\sum_{i=1}^{t-1}\theta_i^{'}\Omega_i\theta+\sum_{i=1}^{t-1}\theta^{'}\Omega_i\theta_i\Big) \\
&+\frac{1}{2}\Big(\theta^{'}\Sigma_\theta^{-1}\mu_\theta+\mu_\theta^{'}\Sigma_\theta^{-1}\theta\Big)-\frac{1}{2}\Big(\mu_\theta^{'}\Sigma_\theta^{-1}\mu_\theta+\sum_{i=1}^{t-1}\theta_i^{'}\Omega_i\theta_i\Big)
\end{aligned} \tag{34}$$

Since μ_θ, Σ_θ, Ω_i and θ_i are either observed or known by the firm, I can ignore the last term in parenthesis. Moreover, because of the dimensions of these matrices, I have that $\theta_i^{'}\Omega_i\theta=\theta^{'}\Omega_i\theta_i$ and $\mu_\theta^{'}\Sigma_\theta^{-1}\theta=\theta^{'}\Sigma_\theta^{-1}\mu_\theta$ and therefore:

$$\begin{aligned}
&\propto -\frac{1}{2}\theta^{'}\Big(\Sigma_\theta^{-1}+\sum_{i=1}^{t-1}\theta_i^{'}\Omega_i\Big)\theta+\sum_{i=1}^{t-1}\theta^{'}\Omega_i\theta_i+\theta^{'}\Sigma_\theta^{-1}\mu_\theta \\
&= -\frac{1}{2}\theta^{'}\Big(\Sigma_\theta^{-1}+\sum_{i=1}^{t-1}\theta_i^{'}\Omega_i\Big)\theta+\theta^{'}\Big(\Sigma_\theta^{-1}\mu_\theta+\sum_{i=1}^{t-1}\Omega_i\theta_i\Big)
\end{aligned} \tag{35}$$

which yields the following proportional expression:

$$\propto -\frac{1}{2}\Big(\theta - \mu_\theta^p\Big)^{'}\Big(\Sigma_\theta^{-1} + \sum_{i=1}^{t-1}\Omega_i\Big)\Big(\theta - \mu_\theta^p\Big)$$

$$\text{with } \mu_\theta^p = \Big(\Sigma_\theta^{-1} + \sum_{i=1}^{t-1}\Omega_i\Big)^{-1}\Big(\Sigma_\theta^{-1}\mu_\theta + \sum_{i=1}^{t-1}\Omega_i\theta_i\Big) \tag{36}$$

All of this results in the firm's posterior beliefs for its export profitability at the beginning of period t given export history d^{t-1} being:

$$\theta|d^{t-1} \sim \mathbb{N}\bigg(\Big(\Sigma_\theta^{-1} + \sum_{i=1}^{t-1}\Omega_i\Big)^{-1}\Big(\Sigma_\theta^{-1}\mu_\theta + \sum_{i=1}^{t-1}\Omega_i\theta_i\Big), \Big(\Sigma_\theta^{-1} + \sum_{i=1}^{t-1}\Omega_i\Big)^{-1}\bigg) \tag{37}$$

The posterior distribution in 37 holds for any $t > 0$. In particular, note from the mean and covariance matrix that in period $t = 1$, when the firm has not had any export experience before, the beliefs a firm has on its export profitability collapse to:

$$\begin{aligned} \theta|d^0 &\sim \mathbb{N}\bigg(\Big(\Sigma_\theta^{-1}\Big)^{-1}\Big(\Sigma_\theta^{-1}\mu_\theta\Big), \Big(\Sigma_\theta^{-1}\Big)^{-1}\bigg) \\ &= \mathbb{N}\Big(\mu_\theta, \Sigma_\theta\Big) \end{aligned} \tag{38}$$

That is, as discussed earlier, a firm's beliefs when it has not had any export experience are precisely the distribution of θ, which by assumption is common knowledge to all firms. As a summary, a firm's beliefs at period t on its export profitability as a function of its export history d^{t-1} are as follows:

$$\Gamma_t(d^{t-1}) = \begin{cases} (\mu_\theta, \Sigma_\theta) & \text{if } t = 1 \\ (\mu_\theta^p, \Sigma_\theta^p) & \text{if } t > 1 \end{cases} \tag{39}$$

where:

$$\Omega_i = \text{diag}((1/\sigma_\epsilon^2)d_i) \tag{40}$$

$$\mu_\theta^p = \Big(\Sigma_\theta^{-1} + \sum_{i=1}^{t-1}\Omega_i\Big)^{-1}\Big(\Sigma_\theta^{-1}\mu_\theta + \sum_{i=1}^{t-1}\Omega_i\theta_i\Big) \tag{41}$$

$$\Sigma_\theta^p = \Big(\Sigma_\theta^{-1} + \sum_{i=1}^{t-1}\Omega_i\Big)^{-1} \tag{42}$$

Note that I use Γ_t to refer to the firm's learning process as in Equation 24 because I assume that the information set that a firm has in period t is precisely its updated beliefs on the distribution of its true export profitability given its export history up until that period. This is where the learning process ties to the firm's discrete choice problem. At period t a firm is going to choose export status d_t such that the expression in 25 is maximized. To compute the expected value shown in 24, the firm is simply going to use its posterior posterior beliefs which evolve according to 39 as a function of its export history d^{t-1}.

3.4 Firms' Dynamic Optimization Problem

Up until this point, I have only discussed the firm's problem as static in nature but this is clearly not the case. As the learning process shows, there are dynamic implications to export decisions since once a firm decides to enter an export market it will affect its beliefs about its profitability in every export market and thus, affect future entry and exit decisions.

Data shows that some firms reenter an export market after having exited from it. Since the precision that a firm has with respect to its true export profitability θ is non-decreasing in tenure, the only way to rationalize this behavior is to assume the fixed costs a firm has to pay when exporting to a destination are subject to random shocks. As in Cebreros (2016), I will assume that the true fixed costs a firm has to incur in to export to market j at time t are given by:

$$f_{jt} = f_j + \xi\eta_{jt} \quad \text{where } \xi > 0 \text{ and } \eta_{jt} \overset{\text{i.i.d.}}{\sim} \mathbb{N}(0, \sigma_\eta^2) \tag{43}$$

Using Expression 25 and the above, expected profits in t given export status d_t will now be given by:

$$\tilde{\Pi}(d_t|\Gamma_t) + \sum_{j\in D} d_{jt}\xi\eta_{jt} \tag{44}$$

where η_{jt} is observed $\forall j \in D$ by a firm before choosing export status d_t. A firm's recursive problem regarding its entry and exit choices from export markets is characterized by the following Bellman equation:

$$\mathbb{V}_\Psi(\mu_\theta^p, \Sigma_\theta^p; \eta) = \max_{d\in\Xi}\{\tilde{\Pi}(d|\mu_\theta^p, \Sigma_\theta^p) + \sum_{j\in D} d_j\xi\eta_j + \beta\mathbb{E}_{\theta',\eta'}[\mathbb{V}_\Psi(\mu_\theta^{p'}, \Sigma_\theta^{p'}; \eta')]\} \tag{45}$$

subject to the evolution of a firm's beliefs about its profitability in export markets, as described in Section 3.3. In this recursive formulation, Ξ is the set of all possible combinations of export status d, β represents a discount factor and Ψ stands for the vector of parameters of the model.

As discussed in Section 2.3.2, firms are forward-looking and thus exporting to a certain destination is not only valuable because of the effect it has on expected profits $\tilde{\Pi}(d|\mu_\theta^p, \Sigma_\theta^p)$ but also because of the information it provides about other potential destinations; this is contained in the continuation value of the Bellman equation. Since entry into j will update a firm's beliefs on its export profitability in every potential destination, it therefore affects a firm's choice to enter export market j.

4 Estimation of the Model

In order to be able to estimate the model, several simplifying assumptions have to be in place. As the model is, a firm each period has $2D + D * (D + 1)/2$ state variables, corresponding to its beliefs on the profitability and the shock to exporting costs of each export destination, and its beliefs for the whole covariance matrix. Additionally, a firm will have to choose from every combination of export status $d \in \Xi$, where the size of Ξ grows exponentially with the number of destinations. This represents a very complex computational problem. Moreover, all these variables need to be discretized in order for the problem to be computationally solvable. Subsection 4.2 will describe the many simplifying assumptions I place in order to estimate my empirical model.

4.1 Parametrization of the Demand Shock

Before describing the simplifying assumptions I make, I define the assumption for the functional form of demand shifter $h(\cdot)$ as contained in Equation 24:

$$h(\theta_{jt}) = \kappa \exp(-\lambda(-g\theta_{jt})) \quad \text{where} \ \ \kappa, \lambda, g > 0 \tag{46}$$

in which κ controls the upper-bound of the $h(\cdot)$ function and λ and g control its growth rate. This parametrization has the advantage of being a continuous, differentiable, bounded, positive and monotone function.

4.2 Simplifying Assumptions

First of all, I will only assume five potential export destinations, that is, $D = 5$. These five destinations will be the top five export destinations from my Mexican customs data, which are the United States, Canada, Spain, Germany and China. While this is done in order to map the estimation more easily to my similarity index between export destinations, it can be easily changed to having whole regions as export destinations i.e. Europe, North America, etc.

In order to reduce the number of state variables in the firms' problem, I suppose the shocks to exporting costs η_j are the same for every destination in a given period, which effectively reduces the number of state variables by $D-1$. Further, I assume that the variance of export profitability, that is $\Sigma_{jj}\ \forall j \in D$, is the same for every export destination. This again reduces the number of state variables by $D-1$. Finally I assume that, at any point in time, firms know the true correlation between destinations' export profitabilities, which together with the previous assumption implies that a firm's belief on the variance of θ is sufficient for inferring covariance matrix Σ_θ^p. These assumptions reduce the total number of state variables to $D+2$, being a firm's beliefs on the mean profitability of each export destination, its beliefs on the variance of these profitabilities and the current common shock to exporting costs.

To simplify the estimation of the model, I take several parameters from the literature. I set the discount factor $\beta = 0.95$ and assume an elasticity of substitution $\sigma = 4$, following the work by Broda and Weinstein (2006). In terms of the parameters of demand shock $h(\cdot)$, the scalar affecting the shock to exporting costs ξ and the variance of the signal for export profitability σ_ϵ^2, I use the estimates in Cebreros (2016) and set them equal to $\kappa = 1.20$, $\lambda = 2.64$, $g = 2.69$, $\xi = 0.02$ and $\sigma_\epsilon^2 = 7.93$. Moreover, I assume that the correlation coefficient between two export destinations is given by the similarity index computed in Section 3.3, thus reflecting that the more similar two export destinations are, the higher the covariance between these countries' export profitability. To further simplify the estimation, I take exporting fixed costs and iceberg-type trade costs as given and arbitrarily set them equal to $f_j = 0.1$ and $\tau_j = 10\%\ \forall j \in D$.

To make the estimation computationally feasible, I need to discretize the state variables of the model. For this, I assume that a firm's beliefs on its mean export profitability in a destination θ_j, the variance of this profitability σ_θ^2 and the size of the shock to exporting costs η can each only take two values: high and low. All these simplifying assumptions yield a representation of a firm's value function, as stated in Equation 45, as a 64×64 sized matrix, taking into account the number of combinations for the vector of mean export profitability and for export status d.

4.3 Estimation of Information Spillovers

I estimate the model using a Simulated Method of Moments methodology, in which I choose the parameter vector that minimizes the moment-based errors according to the model. For a given guess of the parameters, I iterate a firm's value function for each combination of its beliefs $(\mu_\theta^p, \Sigma_\theta^p)$, the state of the exporting cost shock η and chosen export status $d \in \mathbb{R}^D$. I then take a large number of firms $N = 1,000$, where each firm gets a random draw of their vector of export profitabilities, and simulate how these firms make their dynamic entry and exit choices for a total of $T = 12$ periods -as this is the number of years in my Mexican customs data-. From this simulation, I compute several moments, compare them to the corresponding ones from the data and find the parameters that generate the best fit. The moments I use for this moment-matching exercise are the following:

1. Entry rates into each export destinations (five moments).

2. Average number of destinations exported by a firm in total (one moment).

3. Average number of destinations exported by a firm in a single period (one moment).

Again, I estimate seven parameters: each of the destinations' mean export profitabilities, the variance of these export profitabilities and the value of the shock to exporting costs. Variation in entry rates across export destinations should allow me to identify the mean export profitability of each destination. The variance of export profitability should be identified by having variation in the average number of destinations exported in total, as higher variation should lead to lower entry in total, and finally the number of destinations exported in a single period should allow me to identify the size of the shock to exporting costs.

4.4 Estimation Results

Results are shown in Table 5. According to the model, Canada, China and Germany have around the same export profitability for a Mexican exporter. It is not striking the very large estimate for the US as in the data around 80% of Mexican exporters enter the country at some point, therefore a high export profitability is required to rationalize this behavior. What is surprising is the high export profitability of Spain, relative to for example Germany. According to the data, only 6% of firms export to Spain at some point and this is around the same entry rate as that of Germany. One could think that these two countries should have similar trade and fixed exporting costs and thus, the result does not make much sense. On the other hand, while one might think that China would have much higher export profitability,

Statistic	Estimate
θ_{CAN}	0.117
θ_{CHN}	0.121
θ_{DEU}	0.337
θ_{ESP}	1.202
θ_{USA}	1.969
σ_θ^2	1.334
η	5.427

Table 5: Estimation Results

the reality is that only 4.7% of Mexican firms export to it at some point and thus, the estimate is around the same magnitude as that of other countries.

The estimate for the variance of export profitability is not very informative given that the assumption of it being common across all export destinations is probably very restricting, but suggests there is large dispersion in export profitability between firms. Lastly, the estimate for the shock to exporting costs seems to be high relative to the arbitrarily chosen fixed exporting costs, which points to the fact that the f_j exporting costs should in fact be larger.

To evaluate the in-sample performance of the model and its estimation, Figure 2 presents a comparison of how the moments look in the data and those predicted by the model. As can been seen, the model seems to do a good job in terms of matching the average number of destinations exported in a single period and in total in a firm's tenure as an exporter. The model predicts that all firms will enter the US at some point in their tenure, a result that while not far from the real entry rate, could reflect the fact that trade costs and fixed costs of exporting to the US are higher than those arbitrarily-fixed in my estimation. While the results for Canada, China and Spain seem reasonable, the model over-predicts entry into Germany. This again could be the result of Mexican firms actually facing higher trade costs and fixed costs of exporting with this destination together with the high entry rate for the US which might be pushing Mexican firms into Germany as well.

5 Counterfactual Simulations

One of the contributions of this paper is to use my empirical model of export supply to perform several interesting counterfactual simulations. I will take the estimates found in

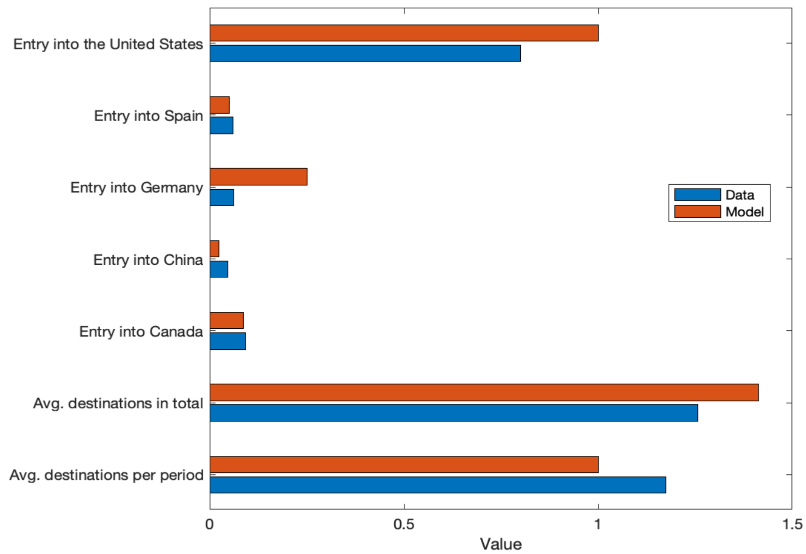

Figure 2: In-Sample Model Performance.

Section 4 and simulate the model under two distinct counterfactual scenarios: (1) Evaluate the effect of information spillovers and (2) Evaluate the effect of a reduction in trade costs. This is done in order to explore both the effect of information spillovers over the geographic spread of exports and to provide evidence of a potential second-order effect of free trade agreements: the diversification of a country's exported destinations.

5.1 Effect of Information Spillovers

I will shut down information spillovers by assuming an alternative distribution for a firm's export profitability. Specifically, I will assume that firms take a random draw from the following distribution function, which is common knowledge for all firms:

$$\theta \sim \mathbb{N}(\hat{\mu}_\theta, \hat{\Sigma}'_\theta) \quad \text{where } \hat{\Sigma}'_\theta \equiv I_D \odot \hat{\Sigma}_\theta \tag{47}$$

That is, I am assuming that export profitability is not correlated among export destinations. This effectively shuts down information spillovers since firms can not learn from past export experience in other export destinations. With this alternative covariance structure and taking the rest of the estimated parameters as given, I simulate a large number of firms $N = 1,000$ and solve their dynamic optimization problem for $T = 12$ periods, then compute the same moments from this counterfactual simulation and compare them to those from the estimation in Section 4.4. Results for this counterfactual exercise are shown in Fig-

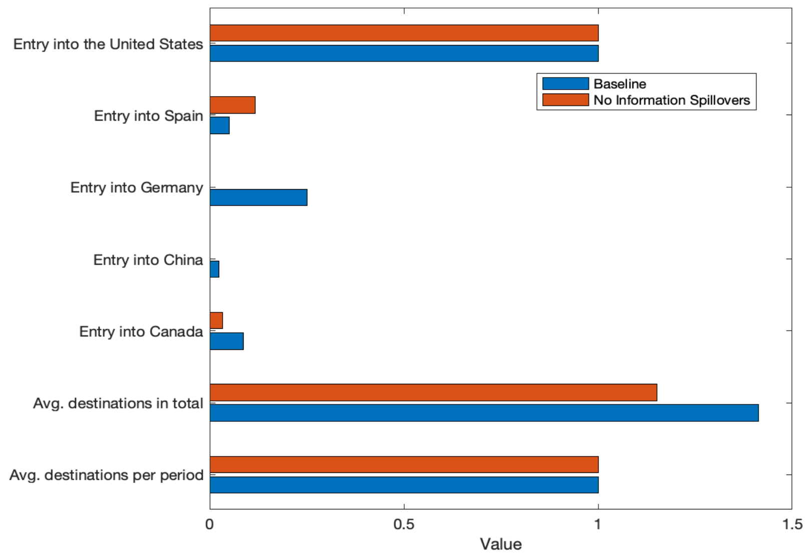

Figure 3: No Information Spillovers Scenario.

ure 3, which compares the moments from the baseline simulation -that is, with my estimated parameters- against those under this alternative specification for the covariance matrix.

The expected result would be that without information spillovers, both entry rates and the number of destinations exported decrease. When a firm does not learn about a destination from its export experience and if its prior belief is that profitability is low in this destination, the firm will not export to it -unless it gets a particularly low realization of the shock to exporting costs-. As can be seen in the corresponding figure, results are in line with this intuition. Without information spillovers the average number of destinations exported in a firm's tenure decreases, which is driven by a decrease in entry rates into Canada, China and Germany even though the entry rate of Spain slightly increases. Meanwhile, the entry rate for the US does not change under this alternative scenario which could be the result of the destination being so profitable for Mexican firms that even without the benefit of being able to learn about other countries, Mexican firms still choose to enter to it.

Overall, the model seems to provide evidence supporting the initial hypothesis of information spillovers contributing to export diversification in terms of the average number of destinations a firm exports to in its tenure. Results indicate that without information spillovers, the number of destinations exported in a firm's tenure would decrease from 1.41 to 1.15 destinations on average, that is, export diversification would be 18.54% lower compared to the baseline scenario in which spillovers actively contribute to a firm's learning process.

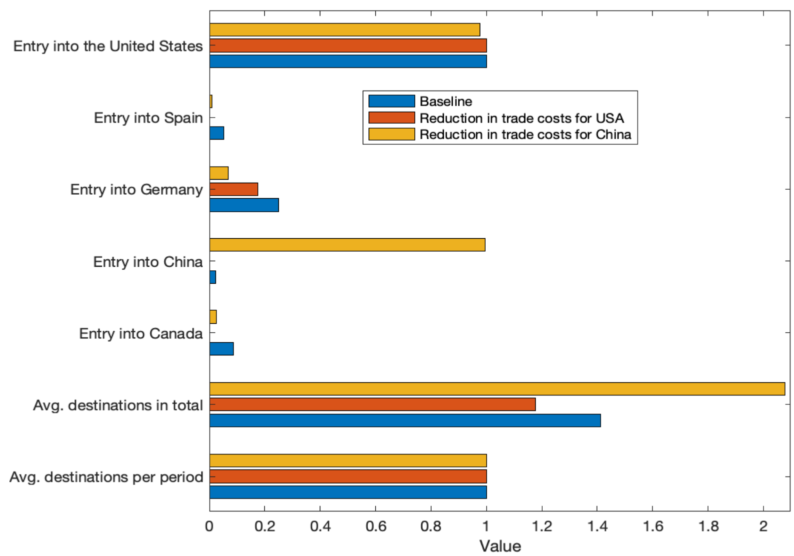

Figure 4: Reduction in Trade Costs Scenario.

5.2 Effect of a Reduction in Trade Costs

The objective of this counterfactual simulation is to estimate how a reduction in trade costs, for example the signing of a free trade agreement, affects the geographic spread of a country's exports. To my knowledge this is an open question in the literature and its clearly a very relevant one, since diversification in terms of destinations exported to would be a second-order effect of free trade agreements and thus, highly relevant in terms of economic policy.

To perform this simulation, I simply take my estimated model and simulate it for the number of firms and periods as in the previous counterfactual, but now artificially decreasing the trade costs firms face when exporting to a particular export destination. The results of course depend on which trade cost was the one reduced, as not all trade cost reductions will generate the same pattern of entry and therefore, not the same pattern of information spillovers. I focus on eliminating trade costs that Mexican firms face when exporting to the United States or when exporting to China, which means that I set iceberg-type trade costs $\tau_{\text{US}} = 1$ and in a different scenario $\tau_{\text{CHN}} = 1$. Results for this counterfactual are shown in Figure 4.

A reduction in trade costs of a particular export destination should not only increase the overall level of trade, but in particular increase the level of trade with respect to destinations that are more similar to the export destination with the lower trade costs, however I do not get these results. When trade costs with the US are lower, the resulting entry rate of every destination except the US is lower. One plausible explanation for this behavior is, as highlighted in Section 2.3.1, firms while exporting to the US learn that exporting to the rest of the countries is not actually profitable and thus higher entry into the US -given the reduction in trade costs- is lowering entry rates into other countries through learning about their actual unprofitability. The issue with this explanation is that entry rates into the US do not increase -trivially as all firms were already exporting there at some point in their tenure- and thus, stating that firms are learning given the reduction in trade costs does not make much sense. Results for the reduction in trade costs with China go in the same direction. Entry rates into all other destinations decrease, even slightly for that of the US. Meanwhile, the entry rate for China itself is higher which is what increases the average number of destinations exported in a firm's tenure and therefore cannot be considered as an increase in diversification because of information spillovers, which is the objective of this counterfactual exercise.

The results for this counterfactual go in line with this. As can be seen in Figure 4, when trade costs with the US are reduced, both the average number of destinations exported in a single period and in total increase. This result seems to be driven by an increase in the entry rate for Canada, which went from an entry rate of around 30% in the baseline to an entry rate of around 70% in this alternative scenario. The reason for why entry into Canada increases significantly is because Canada is the country most similar to the US in terms of their imports from Mexico -they share a similarity index of 0.79- and therefore, a reduction in trade costs with the US generates larger entry into Canada because of these information spillovers. Entry rates into the rest of the countries are not significantly affected which again could be the result of the US not being similar to those countries. If firms entering into the US do not learn much about these other countries, then the decrease in trade costs does not lead to a significant change in the number of firms exporting to these countries.

For the case of the reduction in trade costs for China, I do not observe the same pattern. The reduction in trade costs does expand trade by increasing the average number of destinations exported both per period and in total, but this increase seems to be entirely driven by the increase in the entry rate into China itself. In fact, entry rates into all other countries either stay constant or stay decrease, as with the US or Spain -the former seems to be so profitable that firms will keep exporting to it and the later is where the model and its estimation are not able to generate any entry whatsoever-, which could be the result of the low similarity that China has with the rest of the export destinations -an average similarity index of 0.47-. Overall, the model seems to be able to replicate the initial hypothesis of information spillovers contributing to export diversification -in terms of number of destinations exported to- given a decrease in trade costs with a particular country. As mentioned before, this counterfactual exercise speaks directly to the potential effects that any reduction in trade costs -as the signing of a free trade agreement- might have and thus it is of importance in terms of economic policy.

6 Discussion

The objective of this paper was to provide evidence of information spillovers and to develop a structural model of export supply and learning that allowed me to conduct policy-relevant counterfactual simulations. Using data on the universe of Mexican exporters and computing an import-based similarity index between export destinations, results shows that the probability that a firm makes a bad decision with respect to entry into an unprofitable export market is lower the higher the amount of relevant export experience a firm has with respect to that destination. Another implication of information spillovers tested in the paper is that if destinations contain information about other destinations and firms are aware of this, then destinations are also valuable for how informative they are with respect to countries that a firm has not exported to in the past. Results provide evidence in favor of this hypothesis, where the higher the informativeness of a destination, the more likely that a firm starts exporting to it. The empirical evidence here presented suggests the existence of information spillovers among export destinations.

With my empirical strategy as motivation, I build a model of export supply and information spillovers. Firms discretely choose where to export while facing demand uncertainty in these destinations. Firms hold prior beliefs on their own profitability and update them according to Bayes' Rule as they accumulate export experience. Assuming there is correlation in a firm's export profitability between export destinations, while exporting to a particular country a firm not only learns about its own profitability in that country but also about its profitability in other similar export destinations. Firms face a dynamic problem as they are aware that their current export choices will affect their beliefs in future periods and thus, future entry and exit choices. I structurally estimate the model using a simulated method of moments approach and the Mexican customs data.

Results are promising to some extent. The model is able to replicate to some degree the average number of destinations exported both in a single period and in total in a firm's tenure as well as the entry rates into the top five export destinations for Mexican firms. In terms of the conducted counterfactuals, the model predicts that without information spillovers entry rates for most export destinations would decrease, which reflects lower export diversification. In particular, the average number of destinations exported in a firm's tenure would be 18.5% lower. I also conduct the counterfactual exercise of reducing trade costs with a country in particular which should result in higher trade in terms of destinations exported but I do not get this result, which I believe is not due to a failure of the model or firms learning about unprofitable destinations but rather due to the shortcomings of my estimation strategy up to this point.

In conclusion, while the paper can indeed be improved in many of its areas, it is successful in showing empirical evidence on the existence of information spillovers and in building an export supply model that seeks to explain export dynamics in the presence of uncertainty and learning. Its estimation and the counterfactual simulations that follow, provide evidence for the second-order effects on trade that information spillovers generate, which speak directly to their importance regarding trade policy and free trade agreements.

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