Superstar Exporters: An Empirical Investigation of Strategic Interactions in Danish Export Markets*

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Abstract

In many countries, exports are highly concentrated among a few "superstar" firms. We estimate the export decisions of superstar firms as the result of a complete information, simultaneous, discrete choice, static entry game. We employ a dataset on the universe of Danish trade transactions by firm, product and destination. We also obtain detailed information on applied, preferential tariff protection from the MAcMap-HS6 database. We find evidence of strong negative competitive effects of entry: in the absence of strategic competitive effects, firms would be 53.2 percentage points more likely to export to a given market. Next, we run two counterfactual exercises. We show that failing to account for the strategic interaction among superstar exporters leads to: *(i)* overstating the probability that firms would start exporting to a market following tariff elimination by a factor of two; and, *(ii)* overstating the probability that firms would stop exporting to a market if tariffs were imposed by a factor of more than five.

Keywords: Export participation · Strategic interaction · Multiple equilibria · Trade policy.
JEL codes: F12, F14, L13.

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1 Introduction

In many countries, exports are highly concentrated among a few "superstar" firms (Freund & Pierola, 2015). For example, in the United States, the top 1 percent of exporters accounted for 80 percent of total exports in 2000 (Bernard et al., 2007). In Denmark, the top 1 percent of exporters accounted for 47 percent of total exports in 2007, and, on average, the top 5 firms in an industry accounted for 80 percent of exports. Motivated by these observations, we conduct an empirical analysis of export decisions where superstar firms behave strategically. Then, we use our estimated model to run two counterfactual exercises and investigate the effect of changes in tariffs on the export decisions of the superstar firms.

Our main objective is to contribute to the understanding of the role of superstars in international trade. Despite the dominance of a few large exporters in world trade, trade models have traditionally relied on a monopolistic competition setting, where firms are infinitesimal in scale, take prices as given, and compete non-strategically (see Neary, 2010). Recently, trade economists have been developing new theoretical models with oligopolistic markets; i.e., markets where only a few dominant firms compete.[1] These new models feature firms that behave strategically, so that the decision of each firm is influenced by the decisions of its competitors. However, this literature remains to date mostly theoretical, and the prediction that the export decisions of oligopolistic firms are interdependent has not been tested empirically. In this paper, we aim to fill this gap in the literature.

To develop our analysis, we apply the econometric approach in Ciliberto & Tamer (2009) to model the export decisions of firms as a complete information, simultaneous, discrete choice, static entry game. Compared to previous studies on firms' export decisions, the unit of analysis is not the individual firm but the market, defined as an

[1] See, in particular, Neary (2015), Eaton et al. (2012), Bekkers & Francois (2013), Koska & Stähler (2014) and Parenti (2018). There is an earlier literature of oligopolistic markets and trade building on Brander (1981) and Brander & Krugman (1983), but this literature has arguably remained much less influential than either the perfect competition or monopolistic competition settings; see Neary (2010) for a review.

industry-destination combination; and the outcome of interest is the market equilibrium, defined as a vector of market-specific participation decisions of all Danish superstars. The key assumption is that a firm enters an export market only if it makes non-negative profits. To solve the game we use the notion of Nash equilibrium, whereby all firms are maximizing profits and no firm would want to unilaterally change its participation decision. In a discrete choice setting, this leads to a set of moment inequalities, which we estimate using Ciliberto & Tamer (2009).

The main parameters of interest in our empirical model are the effects of the strategic interaction, or "competitive effects", which capture the effect that a firm's export decision has on its competitors' export decisions. Standard models of oligopoly predict a negative effect, as a competitor's market entry reduces other firms' profits, and thus entry. However, positive effects are possible in the presence of positive externalities including informational spillovers, which are particularly important in an international trade context.[2] While the earlier literature on entry games assumes, for identification reasons, that the competitive effect is known to be negative (see Bresnahan & Reiss (1990) and Berry (1992)), the econometric approach of Ciliberto & Tamer (2009) allows for both positive and negative effects.

We use two datasets in our analysis. First, we employ a register database provided by Denmark Statistics, which covers the universe of trade transactions by firm, product and destination. This database allows us to identify superstar exporters and to empirically model their export decisions. Second, we obtain detailed information on applied, preferential tariff protection in 2007 from the third version of the MAcMap-HS6 database (Guimbard et al., 2012). We use these data to run our policy experiments.

We find evidence of strong negative competitive effects. On average, in the absence of competitive effects superstar firms would be 53.2 percentage points more likely to export

[2]The literature on export spillovers shows that firms are more likely to start exporting to markets already served by other domestic firms; see *inter alia* Aitken et al. (1997) and Koenig et al. (2010). Choquette & Meinen (2015) present evidence on positive export spillovers based on Danish data. We differ from this literature in two respects. First, we focus on superstar exporters; i.e., the set of firms for which strategic interactions may be relevant. Second, we estimate an equilibrium model for the market outcome, which allows us to explicitly take into account the simultaneity of export decisions.

to a market. This implies that the presence of other Danish competitors in a specific export market significantly reduces profits and hence export participation. This finding has important implications for trade policy. As trade is liberalized, positive effects on profits are counter-balanced by negative effects due to competitor entry. Estimates that do not take these competitive effects into account will therefore overestimate the entry response due to trade liberalization.

We run two counterfactual exercises in order to quantify these biases. First, we simulate the effects of eliminating tariffs in markets where tariffs are imposed. Secondly, we simulate the effects of introducing tariffs in markets where trade is duty-free. In both exercises, we compute the new equilibria for the export markets, and compare results with and without competitive effects between firms. Allowing for competitive effects between firms, we find that eliminating tariffs would increase the export propensity by 6.5 percentage points while introducing tariffs would decrease the export propensity by 2.4 percentage points. In a framework without competitive effects, in contrast, these effects of trade policy on export entry and exit would be overestimated by a factor of two to five.

Finally, we find that a given superstar's effect on its competitors' export decisions depends on the number of other countries where the firm is exporting its variety. The heterogeneity in the competitive effects implies that there exist multiple equilibria, both in the identity and in the number of firms. Thus, the flexible methodology proposed by Tamer (2003) and Ciliberto and Tamer (2009) is appropriate to study the strategic behavior of superstar exporters. The finding that multiple equilibria are important empirically may be also be informative for the theoretical literature that aims at incorporating oligopolistic interactions into trade models. To date, this literature typically imposes uniqueness of the market equilibrium; e.g., by assuming sequential entry of firms as in Gaubert & Itskhoki (2018) and Eaton et al. (2012).

This paper contributes to the growing literature on the importance of large firms for aggregate fluctuations (di Giovanni & Levchenko, 2012) and on the role of superstar exporters as drivers of export patterns and comparative advantage (Freund & Pierola, 2015; Gaubert & Itskhoki, 2018). We augment this literature by modeling the strategic interaction between large exporters in their export market choices.

Our paper is also closely related to the literature on the determinants of firms' export market decisions; see, in particular, Roberts & Tybout (1997), Bernard & Jensen (2004) and Das et al. (2007). To date, this literature has treated observations on individual firms as independent. In contrast, we model the export decision as the outcome of oligopolistic strategic interactions. Our policy experiments build on previous studies that have found positive effects of tariff liberalization on export participation (Bernard et al., 2011; Buono & Lalanne, 2012). We extend this line of work by showing that the direct (positive) effect on profits as trade is liberalized is partly offset by an indirect (negative) effect resulting from the entry of competitors.[3]

Finally, we contribute to the empirical literature on models with moment inequalities, which has been steadily growing in the last few years.[4] Our paper complements Morales et al. (2019) and Dickstein & Morales (2018). Both of these two papers use moment inequality conditions, the first one to show that having similarities with a prior export destination in geographic location, language, and income per capita jointly reduces the cost of foreign market entry; the second one to show that larger firms possess better knowledge of market conditions in foreign countries.

This paper proceeds as follows. Section 2 presents the empirical approach. Section 3 introduces the data and discusses observed market structures. Sections 4 and 5 present results from single agent (probit) estimations and the equilibrium model, respectively. In Section 6 we do comparative statics exercises to measure the effect of changes in the exogenous variables on the export propensity of the firms. In Section 7 we perform our two counterfactual exercises where we eliminate tariffs in markets that have positive tariffs, and we introduce tariffs in markets that do not have tariffs. Section 8 concludes.

[3]An earlier theoretical literature starting with Brander & Spencer (1985) analyzes how governments may use strategic trade policy to shift profits from foreign to domestic firms. Here, instead, we only consider the effects of trade policy on the strategic interaction between domestic firms.

[4]See, e.g., Ciliberto et al. (2016), Ho & Lee (2017), Jia (2008) and Ho & Pakes (2014).

2 Empirical Model of Export Decisions

We build on previous models of export market entry (see, e.g., Roberts & Tybout, 1997), with the key innovation being that we allow for strategic interactions among superstar exporters. Our unit of observation is a market and the outcome of interest is the market equilibrium; i.e., the vector of export decisions of all potential entrants in the market. This is in contrast to the previous literature on firms' export market choices, which considers each firm's export decision in isolation.

We define a market Ic as a combination of an industry $I = 1, \ldots, N_I$ and country of destination $c = 1, \ldots, N_c$. For example, I might be the chocolate and confectionery industry, while c could be Germany. In each market Ic, there is a set of $i = 1, \ldots K_{Ic}$ potential entrants. We further define the set of potential entrants in Section 2.2. To ease exposition, and following the terminology in the trade literature, we refer to a firm within an industry as a 'variety'. A market structure is the vector of equilibrium export decisions $\mathbf{y}_{Ic} = (y_{1Ic}, \ldots y_{K_{Ic},Ic})$, where y_{iIc} is equal to 1 if variety i serves market Ic, and it is equal to 0 otherwise.

2.1 Profit Specification and Definition of the Market Equilibrium

Following Roberts & Tybout (1997), the profits of the exporters are modeled with a reduced-form expression of exogenous competitor and market characteristics that are observable to producers.[5] The profit of variety i in market Ic is given as follows:

$$\pi_{iIc} = \mathbf{X}'_{Ic}\boldsymbol{\alpha} + \mathbf{Z}'_{iIc}\boldsymbol{\beta} + \sum_{j \neq i} y_{jIc}\delta_1 + \sum_{j \neq i} y_{jIc} \cdot Z_{j\ell Ic} \cdot \delta_\ell + \sum_{j \neq i} y_{jIc} \cdot X_{hIc} \cdot \delta_h + \epsilon_{iIc}, \quad (1)$$

for $i, j \in I$. In this profit function, $\mathbf{X}_{Ic} = (X_{Ic,1}, \ldots, X_{Ic,N_X})$ is a vector of N_X market-specific variables, for example the geographical distance from Denmark. $\mathbf{Z}_{iIc} = (Z_{iIc,1}, \ldots Z_{iIc,N_Z})$

[5] An important difference between our work and Roberts & Tybout (1997) is that they look at a *dynamic* model of (single firm) entry, while we look at a *static* model of strategic entry with multiple firms.

is a vector of N_Z competitor- and market-specific variables, for example the number of other destinations to which variety i is exported. $\boldsymbol{\alpha} = (\alpha_1, \ldots \alpha_{N_X})$ and $\boldsymbol{\beta} = (\beta_1, \ldots \beta_{N_Z})$ are the corresponding parameter vectors to estimate.

ϵ_{iIc} is unobserved by the econometrician, but we maintain that it is observed by all players in market Ic. Thus, we model the decision of a superstar firm to export its variety $i \in I$ to destination c in the context of a complete information, simultaneous move, static discrete choice game. This is the same modeling assumption made in Bresnahan & Reiss (1990), Berry (1992), Mazzeo (2002), Tamer (2003) and Ciliberto & Tamer (2009). We maintain that in each market firms are in a long-run equilibrium.[6]

The key parameters of interest that capture the effect that a firm's export market presence has on its competitors' profits are δ_1, δ_ℓ, and δ_h. The parameter δ_1 captures the constant effect that a firm's presence has on the profits of its competitors. ℓ is one of the variables in $\mathbf{Z}_{iIc}$, and the parameter δ_ℓ measures whether the competitive effects change with changes in this firm-specific variable. Finally, h denotes one of the variables in $\mathbf{X}_{Ic}$ and the parameter δ_h captures how competitive effects vary across markets with changes in this market-specific variable.

Importantly, the model allows for both positive and negative effects of competitors on profits. This flexibility is crucial because the literature on export spillovers suggests that there may be positive interactions between firms in their export market decisions; see *inter alia* Aitken et al. (1997), Koenig et al. (2010) and Choquette & Meinen (2015). The idea is that firms may benefit from the export experience of their peers; e.g., due to informational spillovers, network effects, external scale economies in serving export markets, or other positive externalities. On the other hand, standard models of oligopolistic markets would predict negative effects of competitor entry on profits. This will be the case if competition between Danish producers is fierce, and the presence of other Danish competitors on the export market therefore reduces sales and profits. Whether the net effect of these opposing forces is positive or negative is an empirical question, and will determine the sign of the

[6] This assumption has a long tradition in both industrial organization and international trade because it allows for tractability. In the Online Appendix, we show that the identities of the export superstars, and their market-specific entry decisions, are indeed highly persistent over time.

competitive effects δ_1, δ_ℓ, and δ_h.

In each market, a firm decides to export its variety i as long as $\pi_{iIc} \geq 0$. This leads to a set of inequality conditions for all potential entrants within a market, where each firm's decision affects its competitors' decision via the competitive effects δ_1, δ_ℓ, and δ_h. In each market, we therefore have a system of K_{Ic} simultaneous inequalities (recall that K_{Ic} is the number of potential entrants in the market).

We use the pure strategy Nash Equilibrium solution concept to solve this entry game. A set of export decisions is an equilibrium outcome of the game if no individual firm can improve her pay-off by individually changing her action, taking the actions of all other potential entrants into account.

In their path-breaking contribution, Bresnahan & Reiss (1990) show that with more than two firms one must assume away any heterogeneity across firms in the effect of observable determinants of profits in order to have a model with a unique equilibrium in the number of firms. However, in three-player games, for example, where one firm is large and the other two firms are small, there can be multiple equilibria where one equilibrium includes the large firm as a monopolist while the other equilibrium has the smaller two firms as duopolists. In our analysis, one of the competitor-and-market specific variables affects the competitive effects across firms (through the parameter δ_ℓ), which, in turn, may lead to the existence of multiple equilibria. Ciliberto & Tamer (2009) provide a methodology that allows general forms of heterogeneity in the effect of the observable determinants of profits.

2.1.1 Comparison To Previous Empirical Work

Previous empirical work on firms' export decisions is to a large extent motivated by theoretical models with a continuum of monopolistically competitive, heterogeneous firms (see, e.g., Melitz, 2003). In this type of model, export decisions depend on a market-specific export threshold. The export threshold is endogenously determined by market aggregates, which in turn depend on the *mass* of firms that are present in a market.

However, any *individual* firm cannot affect the export threshold, and thus other firms' export decisions. As noted by Eaton et al. (2012), the advantage of the continuum assumption is that "(...) we can model aggregate outcomes as driven by parameters governing the distributions of individual outcomes, but not on the realization of these outcomes themselves."[7]

In a monopolistic competition set-up, we would thus predict that the δ parameters in the profit equation (1) are zero: any *individual* firm does not affect the entry decision of another firm. This parameter restriction, in turn, suggests that the export decision of each firm can be analyzed in isolation within a single equation framework (though differences in the export threshold across markets should be appropriately controlled for). For the large mass of smaller firms, the continuum assumption – and relatedly the assumption that any single firm does not affect market outcomes – might be a reasonable approximation to firm conduct. However, these assumptions become tenuous once we focus on large superstar exporters. For this subset of firms, export decisions can therefore not be analyzed within the single equation model.

2.2 Definition of Potential Entrants

Our empirical analysis exploits Danish register-data, including information on firms' export decisions. The set of potential entrants K_{Ic} in a market Ic is defined as the set of large Danish manufacturing exporters (the "superstars") which serve industry I in at least one of the export destinations c. In Section 3, we introduce the data and discuss how superstars are identified.

Our definition of the set of potential entrants is potentially restrictive in three respects.

First, and most importantly, we limit our analysis to strategic interactions between *Danish* superstar firms (because we do not observe the export decisions of foreign or third country competitors). To the extent that products from different origins are imperfect substitutes (see, e.g., Feenstra et al., 2018), competition between two Danish firms would

[7]Thus, the export threshold can be modeled as a function of the underlying parameters of the model, including fixed and variable trade costs, the parameters governing the productivity distribution, etc.

indeed be fiercer than competition between a Danish and a foreign firm.

We may be concerned that the presence of foreign competitors could bias the estimated competitive effects. What is the likely direction of this bias? For simplicity, consider an industry with two Danish superstar firms i and j, and a set of foreign superstars. If Danish and foreign firms compete strategically, the presence of foreign superstars in a market has a negative effect on the profits (and, thus, on the export probability) of *both* firms i and j. Equivalently, in markets where fewer foreign competitors are present, we would expect the export probability of *both* Danish firms to increase. In consequence, foreign competition would result in a spuriously positive correlation between the export decisions of Danish superstar firms, implying an upward bias in the estimated competitive effects.

Second, firms which sell only on domestic markets are not included in the analysis. Excluding non-exporting firms is not very restrictive, because larger firms (for which strategic interactions are relevant) are typically active on both domestic and export markets. Nevertheless, in the Online Appendix we provide results for an extension of our model where large domestic competitors are included in the sample.

Finally, the set of potential entrants K_{Ic} only includes manufacturing firms. Wholesalers, retailers and other trade intermediaries are thus excluded from the analysis.[8] The presence of trade intermediaries may complicate our analysis of competitive effects because it implies measurement error in firms' export decisions. However, larger firms are more likely to serve foreign markets exclusively via direct exports (see, e.g., Abel-Koch, 2013). We would therefore argue that the measurement error (as well as the resulting biases) are likely to be small in our framework; cf. the Online Appendix for further discussion.

[8]In the Online Appendix, we show that our empirical results are robust to accounting for competition from non-manufacturing firms.

2.3 Identification

We now briefly discuss the identification and estimation methodology, and refer to Ciliberto & Tamer (2009) for a more detailed and comprehensive presentation.

The fundamental identification problem that we face is the one that Manski (1993) called the "reflection" problem. Firms might be exporting to the same destination because of exogenous (contextual) effects, for example, because a market is particularly attractive. Firms may export because of correlated effects, such as common supply or demand shocks (unobservable to the econometrician), so that firms' export decisions may be correlated even absent any interdependence in export decisions. Finally, the export decision is also determined by the strategic interaction between the firms (endogenous effects). One crucial concern is that if industry- or market-specific unobserved common shocks affect all potential competitors in a market and are not accounted for, we might find a spuriously positive sign for the competitive effects, δ_1, δ_ℓ, and δ_h.

Our equilibrium approach permits us to identify the competitive effects because we model the strategic interaction through a classical simultaneous equation system. To begin with, the exogenous variables in $\mathbf{X}_{Ic}$ and $\mathbf{Z}_{iIc}$ control for the exogenous observable factors that make exporting into a specific market particularly attractive. We also exploit exogenous variation across markets in the number of potential entrants, K_{Ic}. In particular, when there is only one potential firm in the market, the model reduces to the probit case, and the parameters of the exogenous variables can be point identified. As in Ciliberto & Tamer (2009), we maintain that we have a random sample of observations $(\mathbf{y}_{Ic}, \mathbf{X}_{Ic}, \mathbf{Z}_{Ic}), Ic = 1 \ldots N_{Ic}$, and $N_{Ic} \to \infty$.

Exclusion restrictions play an important role in the identification of the competitive effects. In the profit equation in (1), a subset of the competitor characteristics in $\mathbf{Z}_{iIc}$ enters only variety i's profit but not profits of its competitors $j \neq i$. These variables are assumed to fulfil the exclusion restriction. In contrast, one of the variables in $\mathbf{Z}_{iIc}$ is also allowed to affect the profits of other firms (via the parameter δ_ℓ). This variable does not fulfill the exclusion restriction.

To understand the idea behind the exclusion restrictions, it is useful to distinguish two channels through which the characteristics of competitor j may affect the export decision of firm i. First, there is an *indirect* channel: any characteristic of j that has an effect on j's export decision y_{jIc} will – through this effect on y_{jIc} – also affect the export decision of firm i. Second, there may also be a *direct* channel: for example, consider a case where an increase in competitor j's characteristic $Z_{j\ell Ic}$ implies that j competes more aggressively conditional on entry. In this case, the effect of $Z_{j\ell Ic}$ on firm i's export decision goes beyond its impact on y_{jIc}. In sum, competitor characteristics that only have an indirect effect on export decisions satisfy the exclusion restrictions, while variables that have a direct effect on export decisions do not.

We maintain that the random vector ϵ is continuously distributed on R^K independently of $X = (X_1, \ldots X_K)$ and $Z = (Z_1, \ldots Z_K)$ and has a joint distribution function F that is known to the econometrician. More specifically, we model ϵ_{iIc} as the sum of five components:

$$\epsilon_{iIc} = \eta_i + \eta_{Ic} + \eta_I + \eta_c + \eta_{iIc}. \tag{2}$$

First, we allow for random demand or supply shocks that are common across markets for a given variety, here denoted by η_i. Second, we include random shocks to profitability that are common for all competitors in a given market, here denoted by η_{Ic}. Third, we include a component that is common across markets and varieties for a given industry, η_I. Fourth, we include a component that is common across industries and varieties for a given destination, η_c. Finally, there is an idiosyncratic component η_{iIc}. All components are assumed to be drawn from standard normal distributions in four of our specifications, while a more flexible variance-covariance structure is considered in two other specifications.

2.4 Estimation

We let $\boldsymbol{\theta}$ denote the vector of parameters to be estimated.

We begin by estimating the empirical probability of observing the market structures conditional on the exogenous characteristics (including the number of potential entrants).

To estimate the conditional choice probability vector $P(\mathbf{y}|\mathbf{K}, \mathbf{X}, \mathbf{Z})$, we use a nonparametric conditional expectation frequency estimator that counts the fraction of times an outcome (a market structure) is observed among all the market observations with that number of potential entrants and with those exogenous characteristics.

Next, we derive the predicted choice probabilities of the market structures for the values of the exogenous variables and different parameter values. Because of the possibility of multiple equilibria, and because we do not want to introduce arbitrary equilibrium selection assumptions, we follow Ciliberto & Tamer (2009) and derive the following upper and lower bounds on conditional choice probabilities for every possible number of potential entrants:

$$\begin{aligned}\mathbf{H}_{L,K_{Ic}}(\theta, \mathbf{X}, \mathbf{Z}) &\equiv \begin{bmatrix} H_L^1(\theta, X, Z) \\ \vdots \\ H_L^{2^{K_{Ic}}}(\theta, X, Z) \end{bmatrix} \leq \begin{bmatrix} \Pr(\mathbf{y}_1|X, Z) \\ \vdots \\ \Pr(\mathbf{y}_{2^{K_{Ic}}}|X, Z) \end{bmatrix} \leq \begin{bmatrix} H_U^1(\theta, X, Z) \\ \vdots \\ H_U^{2^{K_{Ic}}}(\theta, X, Z) \end{bmatrix} \\ &\equiv \mathbf{H}_{U,K_{Ic}}(\theta, \mathbf{X}, \mathbf{Z}) \end{aligned} \tag{3}$$

where $\Pr(\mathbf{y}|X, Z)$ is a $2^{K_{Ic}}$ vector of conditional choice probabilities. The inequalities are interpreted element by element.

The $\mathbf{H}$'s are functions of $\boldsymbol{\theta}$, the set of all the parameters to be estimated, and of the distribution functions F of the random vector ϵ. Specifically, the errors η_i, η_{Ic}, η_I, η_c are each drawn from normal distributions with mean zero and variance 1/4, so that the sum of these error components has a variance that is normalized to 1. The idiosyncratic error η_{iIc} is drawn from a standard normal distribution. In columns (5) and (6) of Table 6 below, we introduce a more flexible specification, where we allow the unobservables η_{iIc} to be correlated within a market, and we estimate the variance of η_i as well as the variance of the sum of η_{Ic}, η_I, η_c.

The lower bound function $\mathbf{H}_L$ is the probability that a particular market structure is predicted to be the unique equilibrium in a market. The upper bound function $\mathbf{H_U}$

is the probability that a market structure is a unique equilibrium or one of the multiple equilibria, and so it is equal to $\mathbf{H}_L$ plus the probability that a market structure can be one of the multiple equilibria in the market. To compute these lower and upper bounds we proceed as follows.

First, we take the simulated errors, together with the exogenous variables, and an initial parameter guess, and we compute the profits of each potential entrant in a market under every possible market structure. From these profits, we determine the equilibria for each market-simulation combination. For example, in a market where there are two potential entrants, there are four possible market structures: (0,0), (0,1), (1,0), (1,1), where the first number in each pair corresponds to the entry decision of the first potential entrant, and the second number corresponds to the entry decision of the second potential entrant. A market structure is an equilibrium if none of the two potential entrants has an incentive to change its entry decision, and that can be determined by comparing the profits of each firm across market structures. Thus, (1,0), the market structure where the first firm enters and the second does not, is an equilibrium if: i) the first firm is not better off by not entering, that is, if the profit of the first firm is not negative; and, ii) if the second firm is not better off by entering, that is, the profit of the second firm would be negative in the market structure (1,1). Notice, that there might be multiple equilibria in this game. For example, (0,1) and (1,0) might both be equilibria of the entry game for this particular market-simulation draw.

Second, we use the predicted equilibria to update $\mathbf{H}_{L,K_{Ic}}$ and $\mathbf{H}_{U,K_{Ic}}$. Specifically, if there is a unique equilibrium for the simulated draw in a specific market, then this specific market-simulation increases the corresponding entry in $\mathbf{H}_{L,K_{Ic}}$ and $\mathbf{H}_{U,K_{Ic}}$ by one. If there are multiple equilibria, only the corresponding entry in the lower bound, $\mathbf{H}_{L,K_{Ic}}$, increases by one. In the example above, if there are two equilibria, (1,0) and (0,1), only $H_L^{(1,0)}$ and $H_L^{(0,1)}$ would be increased by one. $H_U^{(1,0)}$ an $H_U^{(0,1)}$ would remain unchanged. We repeat this exercise for all the markets and simulations.

Third, we take the computed values of $\mathbf{H}_{L,K_{Ic}}$ and $\mathbf{H}_{U,K_{Ic}}$ and divide them by the number of simulations (here, 100). These are now probabilities that can be used to *sandwich* the empirical probability.

Finally, the last step consists of minimizing an appropriately defined distance function constructed from the differences between the probabilities of market structures observed in the data, and the lower and upper probabilities predicted by the equilibrium model. Our inferential procedures uses the following objective function:

$$Q(\theta) = \int \left[\| \left(P(\mathbf{X}) - H_L(\mathbf{X}, \theta)\right)_- \| + \left\| \left(P(\mathbf{X}) - H_U(\mathbf{X}, \theta)\right)_+ \right\| \right] dF_x, \tag{4}$$

where $(A)_- = [a_1 1[a_1 \leq 0], \ldots, a_{2^k} 1[a_{2^K} \leq 0]]$ and similarly for $(A)_+$ for a 2^k vector A and where $\|.\|$ is the Euclidian norm. Ciliberto & Tamer (2009) show that $Q(\theta) \geq \mathbf{0}$ for all $\theta \in \Theta$ and that $Q(\theta) = \mathbf{0}$ if and only if $\theta \in \Theta$. In practice, the distance function is constructed by taking the squared difference between the empirical probabilities and the lower bounds predicted by the model whenever the first are lower than the latter; and the squared difference between the empirical probabilities and the upper bounds predicted by the model whenever the first are larger than the latter. We sum over the squared differences across markets and market structures. The parameter are estimated by minimizing this distance function.

As Tamer (2003) and Ciliberto & Tamer (2009) discuss in detail, this is a conditional moment *inequality* model, whose identified feature is the *set* Θ of parameter values that obey these restrictions for all $\mathbf{X}, \mathbf{Z}$, almost everywhere. In general, the set Θ is not a singleton. More details about the estimation and inference is provided in the Online Appendix.

3 Data and Stylized Facts

3.1 Description of Data Set

Our starting point is a data set from Denmark on the universe of export transactions. We focus on a cross-section for the year 2007, for which we have information on tariffs.

We observe the eight-digit products each firm is exporting, and to which destinations it is serving these products.

Our empirical analysis focuses on industries rather than products, because we want to account for competition across different product codes that are close substitutes. For each firm and destination, we aggregate product-level export information up to the industry-level using a correspondence table between eight-digit CN codes and four-digit NACE industry codes. The product-level data might not capture the relevant competitive effects. For example, within the "Chocolate and confectionery industry", there are different eight-digit product codes for "chocolate, not filled", "chocolate, filled", or "white chocolate". Arguably, producers within this industry are competing with each other even if they are completely specialized in different eight-digit products.

Our estimation sample includes superstar exporters, defined as firms with a share in industry-level exports of *at least five percent*.[9] For each industry, the remaining firms are bundled into a "competitive fringe". For most of the analysis, we assume that these fringe firms do not affect the market outcome, defined as the behavior of the superstar firms. This assumption is motivated by previous research arguing that small producers do not compete directly with large producers; e.g., because they produce niche products (Audretsch et al., 1999; Holmes & Stevens, 2014).

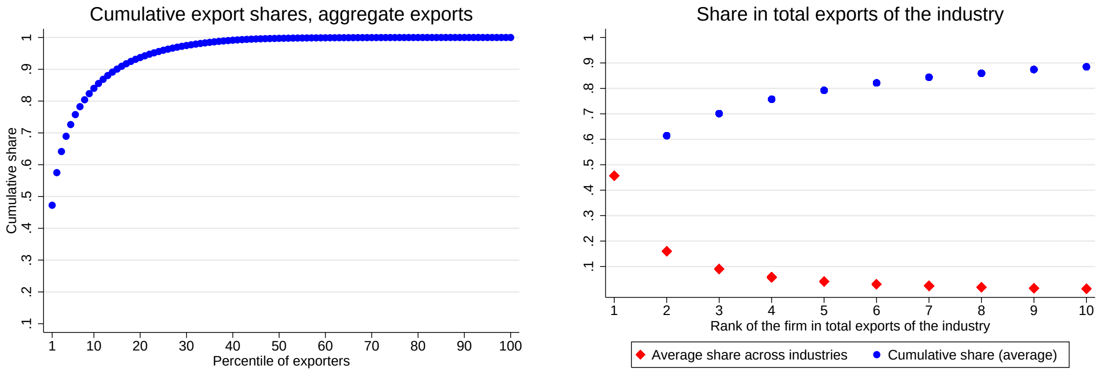
We restrict the sample in several dimensions in order to focus on the issue at hand. First, we only consider manufacturing firms; cf. the discussion in Section 2.2. Second, we want to focus on destinations where exporting is in principle attractive for Danish firms. We therefore only keep the top 100 destinations (as measured by the number of entrants across all industries) and only markets where we see positive exports of firms in our sample for at least two years over the period 2003–2007. Our final sample accounts for 72 percent of overall Danish manufacturing exports.[10]

After keeping only destinations for which key variables (GDP and distance) are avail-

[9] Note that industry membership is not based on the balance sheet information (which typically assigns firms to their "core" activity) but on the export data; firms may therefore be active in more than one industry. We record at least one superstar in each four-digit manufacturing industry.

[10] We perform a number of robustness checks regarding the construction of the sample; see the Online Appendix for details and results.

Figure 1: Export Concentration in Danish Manufacturing



(a) Cumulative Shares for Aggregate Exports (b) Export Concentration by Industry

able, we are left with 98 destinations, 206 industries, and 8,938 markets.

3.2 Export Superstars and Export Concentration

Figure 1 highlights the concentration of exports among a few superstars for our sample of Danish manufacturing firms. Among all firms (including the competitive fringe), the top 1 percent of exporters account for 47 percent of overall manufacturing exports, while the top 10 percent account for 85 percent (see Figure 1(a)). While this level of concentration is somewhat lower than for example in the United States (Bernard et al., 2007), it is comparable to other European countries (see World Trade Organization, 2008).

Next, we turn to the industry level. Figure 1(b) shows that the top firms again account for the bulk of exports: on average, the largest exporter covers approximately 45 percent of industry-level exports. The top 5 exporters together have a cumulative share of 80 percent in the average industry. However, the second largest firm is typically less than half as big as the top firm in terms of exports. Together with Figure 1(a), these numbers imply that exploring the behavior of superstar exporters is crucial for understanding aggregate export patterns.

Table 1 shows that export superstars are distinctly different from the mass of fringe firms. The top panel classifies firms as superstars if the firm is a superstar in at least one of the industries in which it is active. It highlights that superstar firms are superior to

Table 1: Export Superstars vs. Fringe Firms/Varieties

	Superstar Firms		Fringe Firms	
	Mean	N	Mean	N
Number of employees	285.0	595	34.53	3,766
Log labor productivity	13.23	585	13.09	3,375
Lagged export status	0.988	595	0.861	3,766
Number of industries	16.04	595	5.145	3,766
	Superstar Varieties		Fringe Varieties	
	Mean	N	Mean	N
Share in total industry exports	0.203	798	0.002	26,295
Lagged export status	0.939	798	0.547	26,295
Number of destinations	22.45	798	3.411	26,295
Rank within firm portfolio	2.203	798	9.254	26,295
Core industry dummy	0.643	798	0.139	26,295

Notes: Superstar firms are defined as firms which have a share in industry-wide exports of 5 percent for at least one industry in which they are active. Superstar varieties are firm-industry combinations with a share in industry-wide exports of at least 5 percent.

fringe firms in many dimensions, including size, productivity, and export persistence. On average, superstar firms are active in 16 industries compared to 5 for fringe firms, though they are typically classified as superstars only in their core industry.

The lower panel of Table 1 compares key firm-industry-specific variables for superstar and fringe varieties.[11] Superstar varieties have on average a share in overall industry-wide exports of 20 percent (compared to 0.2 percent for fringe varieties). Moreover, superstar varieties are active on significantly more export markets: the average superstar variety is exported to 22 destinations, while the average fringe variety is only sold in three destinations. Again, we also find that superstar varieties have a significantly higher persistence in export status.

In the remaining analysis, our focus will be on superstar varieties.

3.3 Observed Market Structures

We are interested in the market-specific export choices of superstars, defined by a dummy variable y_{iIc} equal to one if variety i records positive exports in market Ic, where a

[11] A firm may be a superstar only in a subset of the industries in which it is active; i.e., a firm might have both superstar and fringe varieties.

Table 2: Market Structures

Number of potential entrants K_{Ic}	Number of actual entrants 0 %	1 %	2 %	3 %	4 %	5 %	6 %	7 %	Total No.
1	16.4	83.6							506
2	13.7	48.13	38.17						1,095
3	11.1	46.79	25.24	16.87					1,541
4	11.2	39	26.42	15.4	7.98				2,169
5	9.95	35.65	22.16	13.28	12.15	6.81			1,498
6	11.22	28.21	17.89	15.04	12.03	10.08	5.53		1,230
7	11.06	24.42	18.73	12.92	9.31	9.86	8.32	5.37	913
Total	*11.56*	*40.45*	*23.49*	*12.24*	*6.57*	*3.53*	*1.61*	*0.55*	*8,952*

Notes: The number of potential entrants is given by the number of superstar varieties with a share in total industry exports of more than 5 percent. Each cell reports the percentage of markets (industry-destination combinations) for which we observe a given number of actual entrants.

market was defined in Section 2 as a combination of an industry I and a destination c. The outcome of interest is the equilibrium market structure, given by the vector of export decisions of all potential entrants in a market.

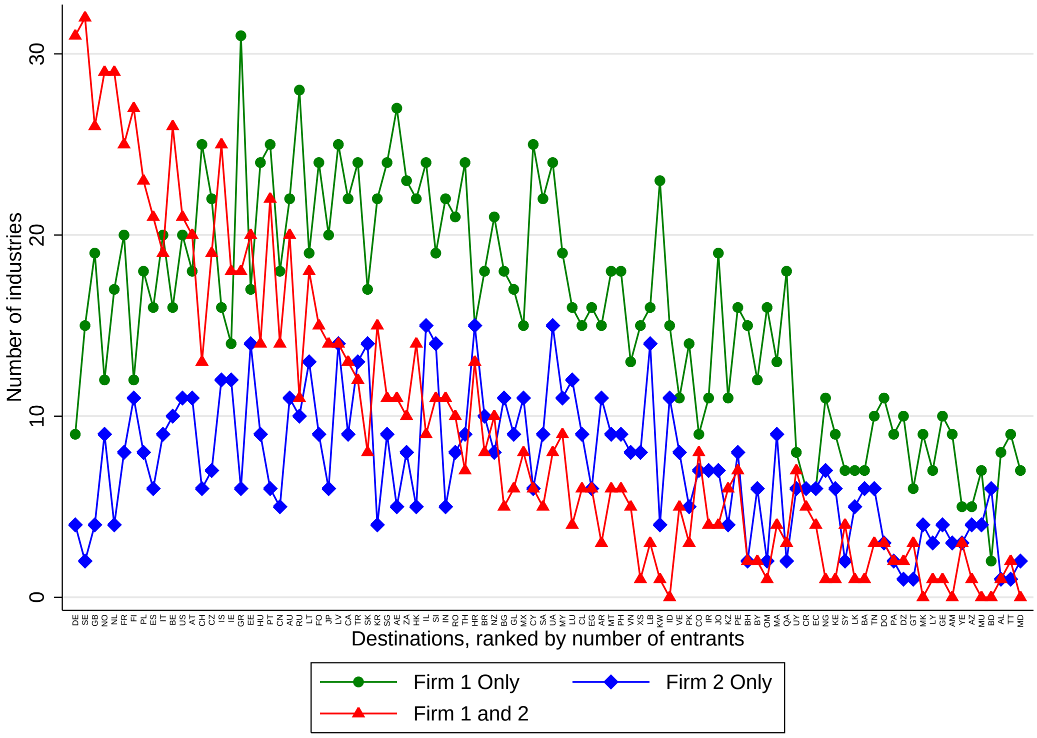
Table 2 summarizes the observed market structures in our sample, separately for markets with different numbers of potential entrants K_{Ic}. For example, there are 1,095 markets with two potential entrants. In around half of these markets (48 percent), we see only one of the two superstar firms exporting. In 38 percent of the markets, both firms export, whereas a small share of markets (14 percent) is not served by any of the two firms. Note that there are also 505 markets with only one potential entrant. As explained in Section 2, these markets do not contribute to the estimation of the competitive effects, but help identify the other parameters of the profit function.

In the last line of Table 2, we also report the market structures for all 8,938 markets (i.e., independent on the number of potential entrants). The most common market structure, accounting for 40 percent of markets, is one where we only see a single superstar firm exporting. We observe two exporters in 24 percent of the markets, and three exporters in 12 percent of the markets. Very few markets have four or more exporters.

The maximum number of potential entrants in our sample is seven, while the median is four. With up to seven potential entrants, there are up to $2^7 = 128$ different market structures that we must account for.

Table 2 reports the *number* of entrants in each market, but does not allow us to

Figure 2: Market Structures for Top 2 Firms



distinguish market structures by the *identity* of the entrants. Figure 2, instead, considers the identity of the exporting firms. We rank firms by their share in total industry-wide exports and focus on the top 2 competitors within an industry (which we refer to as Firm 1 and Firm 2). On the horizontal axis, the destinations are ranked by their popularity, which is measured by the number of actual entrants across all industries. On the vertical axis, we plot the frequency of market structures in that destination, where we distinguish between markets where (*i*) only Firm 1 enters, (*ii*) only Firm 2 enters, and (*iii*) both Firm 1 and Firm 2 enter.[12] As expected, it is more likely that the top 2 competitors both enter in the most popular destinations, such as Germany, Sweden, and Great Britain. Moreover, the number of industries in which we see both firms exporting sharply declines in the more difficult destinations.

Since Firm 1 is the top competitor, it should be more likely that Firm 1 is the sole

[12] We exclude markets with no entrants and markets where other firms beside the top 2 enter. We also exclude industries with only one potential entrant.

exporter in a given destination; and this is indeed reflected in Figure 2. However, there are also many instances where Firm 2 exports to a destination and Firm 1 does not.[13] This pattern in the data is at odds with the basic model of firm heterogeneity in Melitz (2003), where any market served by Firm 2 should also be served by Firm 1. Eaton et al. (2011) explain this type of pattern with random firm-and-market specific entry shocks. Importantly, our empirical model laid out in Section 2 explicitly allows for such random shocks to profitability as well. In addition, we will argue that the existence of markets where only Firm 2 exports can (partly) be explained by the strategic interaction between firms, where the presence of Firm 2 preempts entry of Firm 1.

3.4 Variable Definitions

Table 3 summarizes the exogenous variables governing the profit function. Many of these variables are included in logs in the empirical model (see below), but to ease interpretation we report summary statistics for variables in levels here.

Competitor-Specific Variables

First, we discuss the variables included in the vector $\mathbf{Z}_{iIc}$.

We count the number of industries where a firm is an exporter, and we call this variable *Firm Industries*$_i$. We also rank the firm's varieties (i.e., the industries in which the firm exports) by total export sales and we call this variable *Variety Rank*$_i$. These two variables vary only across competitors. They are inspired by the literature on multi-product firms, which emphasizes economies of scope in exporting multiple products; see *inter alia* Eckel & Neary (2010), Bernard et al. (2011) and Mayer et al. (2014). Thus, we would expect firms which are active in more industries, and thus have a higher value of *Firm Industries*$_i$, to be more likely to serve a given market. Moreover, the literature predicts that multi-product firms are more likely to export their core product to a given market, and that

[13] This finding is closely related to the fact that exporting firms do not adhere to a strict hierarchy of export destinations (in the sense that any firm exporting to the $m+1$-th most popular market also exports to the m-th most popular market); see Lawless (2009) and Eaton et al. (2011).

Table 3: Summary Statistics

	Mean	Std dev	N
Competitor-specific variables $\mathbf{Z}_{iIc}$			
Firm Industries$_i$	23.31	20.03	37,256
Variety Rank$_i$	1.731	1.937	37,256
Variety Destinations$_{iIc}$	30.07	24.08	37,256
Market-specific variables $\mathbf{X}_{Ic}$			
GDP$_c$	857.3	2,010	37,256
Geographical Distance$_c$	4.066	3.968	37,256
Industry Size$_I$	91,677	68,522	37,256
HHI$_{Ic}$	0.192	0.138	36,708
Tariff$_{Ic}$	0.0401	0.147	36,078
Tariff$_{Ic} > 0$	0.424	0.494	36,078

Notes: The table reports summary statistics for all control variables included in the vectors $\mathbf{Z}_{iIc}$ and $\mathbf{X}_{Ic}$ and used in our empirical model. GDP is measured in billion USD; Geographical Distance is measured in 1000km; and Industry size is measured in million DKK.

the probability of exporting decreases as we move away from the firm's core competency. This prediction is captured by the variable *Variety Rank*$_i$.

Next, for each variety and destination, we count the number of *other* destinations to which the variety is exported and call this variable *Variety Destinations*$_{iIc}$. The idea here is that varieties are more likely to be exported to a given market the more successful they are on other markets: for example, firms may learn about their export profitability from exporting to other destinations (see Albornoz et al. (2012), Morales et al. (2019)); demand may be correlated across markets (see e.g. Nguyen (2012)); and – more in general – being successful on other markets may be a sign that the variety offers characteristics highly demanded by consumers.

Market-Specific Variables

Next, we review the variables which are included in the vector $\mathbf{X}_{Ic}$. Recall that a market Ic is a combination of an industry I and a destination c.

We use information on GDP from the World Development Indicators (WDI) and geographical distance from the CEPII's GeoDist database to measure market size and transportation costs. We denote these variables *GDP*$_c$ and *Distance*$_c$.

For each industry, *Industry Size*$_I$ denotes the total revenue at manufacturing firms with positive exports in this industry. We include this variable to control for differences across industries in the role of the competitive fringe. To understand this modeling choice, consider the ideal framework where there is a dominant set of firms (the superstars) and a fringe of competitive firms. In such a model, competitive firms will enter if the superstars do not cover all of the market demand, which would happen if the competitive fringe has lower costs, or if the market size (total demand) is large. Since the former is not likely to be the case, we maintain that the industry size proxies for the role of the competitive fringe.

In some of our specifications, we also include the market-specific Herfindahl-Hirschman index, HHI_{Ic}. To construct this variable, we use information on trade by product, exporter, and importer from the BACI database of the CEPII. We aggregate these data up to the industry-country-pair level in order to match the market definition in our empirical model. HHI_{Ic} is then defined as the sum of squared import shares across all import origins. A higher value of HHI_{Ic} implies that the import market is more concentrated. We use this variable to control for competition from non-Danish competitors.[14]

Tariffs

We employ data on applied, preferential tariff protection in 2007 from the third version of the MAcMap-HS6 database (Guimbard et al., 2012) to construct the variable $Tariff_{Ic}$.[15] We aggregate product-level tariffs up to the industry level, weighting products by their importance for overall Danish exports. The average tariff across markets in our sample is 4 percent (see Table 3). However, Figure 3 shows that exports are duty-free in the majority of markets. Thus, we also construct an indicator variable $Tariff_{Ic} > 0$ equal to one for markets with positive tariffs, and zero otherwise.

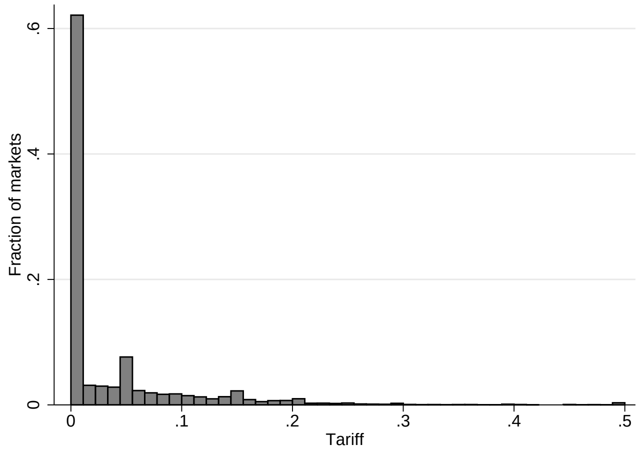
Standardization and Discretization of Variables

In the following, all variables (except for indicator variables) are standardized. When we estimate the equilibrium model in Section 5, we furthermore discretize all variables. The

[14]There are slightly fewer observations for this variable because a few products that appear in the Danish data are not included in the BACI database.

[15]We thank Houssein Guimbard for giving us access to these data.

Figure 3: Distribution of Tariffs



Note: Tariffs are capped at 50 percent.

discretization is described in detail in Section A in the Online Appendix. In the case of the variable $Tariff_{Ic}$, the very long tail of the distribution (see Figure 3) would leave us with few observations in each bin. Thus, in the equilibrium model we employ the indicator variable $Tariff_{Ic} > 0$.

Note that all control variables in Table 3 (except for indicator variables and the HHI) are included in logs in the empirical model.

4 Results from a Single Equation Probit Model

In this section, we estimate a model where the simultaneity of entry decisions is not accounted for. Thus, the model in Equation (1) reduces to a (standard) single equation probit model, where the unit of analysis is the firm-industry-destination (and not the market). Our main explanatory variable of interest is the number of other superstar competitors that enter a given export market, $\sum_{j \neq i} y_{jIc}$, and we denote its corresponding parameter in the simple probit model by δ_{probit}. Importantly, $\sum_{j \neq i} y_{jIc}$ is taken as exogenous in this section, while it is modelled as an equilibrium outcome of the entry game in Section 5. δ_{probit} is therefore conceptually different from the competitive effect δ_1 in Equation 1.

4.1 Benchmark Specifications

Table 4 reports the parameter estimates and standard errors for different specifications with and without market random effects and with different sets of control variables. In addition to the variables listed in Table 3, we also control for variation across industries in the number of potential competitors, K_{Ic}. Including K_{Ic} in the estimation is important because the number of *potential* competitors gives the upper bound for the number of *actual* competitors faced in a market. Relatedly, the number of potential entrants is a crucial source of exogenous variation in previous empirical works on entry (cf. Berry (1992), for example). In fact, we will use the variation in K_{Ic} in the full equilibrium analysis, and we want to be able to compare results from both approaches.

Table 5 reports marginal effects based on columns (3) to (5) of Table 4. We calculate the marginal effect of competitor entry as the change in the predicted probability of exporting if a firm does not face any competition in the foreign market (i.e., if the count of competitors active in market Ic is set equal to zero). The marginal effect of all other variables is computed as the change in predicted probability when the variable is increased by one unit.[16] For the standardized control variables, the marginal effects thus correspond to the effects of increasing each variable by one standard deviation.

Column (1) of Table 4 includes a set of basic controls but does not account for unobserved market heterogeneity. The main parameter of interest is δ_{probit}, which is the coefficient on the count of the number of competitors active in market Ic. The estimate of δ_{probit} is positive and significant. Thus, the presence of a competitor in a market is predicted to increase the export probability, which supports the spillover hypothesis. Note, however, that positive market-specific random shocks to profitability, η_{Ic}, may increase the export probability of all firms. The positive estimate of δ_{probit} in column (1) may thus be confounded with market attractiveness.

To address this concern, column (2) adds market-level random effects η_{Ic}.[17] We now

[16]In the econometrics literature, this method of calculating marginal effects is referred to as the "finite-difference method". The approach will facilitate comparison with results from the equilibrium model.

[17]We constrain the variance of the random effects to be equal to one. This restriction facilitates comparison of the results with those from the equilibrium model in Section 5.

Table 4: Parameter Estimates from the Simple Probit Model

	Dependent Variable: Variety Export Status, by Market					
	(1)	(2)	(3)	(4)	(5)	(6)
δ_{probit}	0.118***	-0.550***	-0.560***	-0.580***	-0.589***	-0.621***
	(0.007)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)
Potential K_{Ic}	-0.099***	0.093***	0.095***	0.098***	0.104***	0.139***
	(0.006)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Firm Industries$_i$	0.027***	0.056***	0.048***	0.039***	0.041***	0.028**
	(0.010)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Variety Rank$_i$	0.033***	-0.027**	-0.023*	-0.023*	-0.023*	-0.006
	(0.009)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Variety Destinations$_{iIc}$	0.827***	1.111***	1.147***	1.186***	1.191***	1.178***
	(0.011)	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)
GDP_c	0.376***	0.743***	0.794***	0.837***	0.842***	0.871***
	(0.008)	(0.015)	(0.016)	(0.016)	(0.016)	(0.017)
Geographical Distance$_c$	-0.415***	-0.804***	-0.804***	-0.774***	-0.610***	-0.812***
	(0.009)	(0.015)	(0.016)	(0.017)	(0.021)	(0.017)
Industry Size$_I$	-0.116***	-0.030**	-0.019	-0.030*	-0.006	-0.051***
	(0.009)	(0.015)	(0.016)	(0.016)	(0.016)	(0.018)
HHI_{Ic}			-0.037**	-0.080***	-0.087***	-0.077***
			(0.015)	(0.015)	(0.015)	(0.015)
$Tariff_{Ic}$				-0.175***		-0.188***
				(0.014)		(0.015)
$Tariff_{Ic} > 0$					-0.672***	
					(0.040)	
$\overline{\textit{Variety Rank}}_{-i}$						0.013
						(0.024)
$\overline{\textit{Variety Destinations}}_{-iIc}$						0.165***
						(0.026)
$\overline{\textit{Firm Industries}}_{-i}$						-0.039
						(0.024)
Observations	37,256	37,256	36,708	36,078	36,078	35,594
Number of markets	8,952	8,952	8,816	8,664	8,664	8,180
Market random effects	No	Yes	Yes	Yes	Yes	Yes

Notes: The table gives coefficient estimates from a probit model for the firm-industry-destination specific export status. All specifications except for column (1) include market (industry-destination) random effects. δ_{probit} is the coefficient on the count of other competitors that are active in a market. *Potential* K_{Ic} denotes the number of potential entrants in a market. All other control variables (except for the indicator variable $Tariff_{Ic} > 0$) are standardized. Standard errors in parentheses. *,**,*** denote significance at the 10%, 5%, 1% levels, respectively.

find a negative estimate of δ_{probit}, in line with standard models of strategic interaction: the presence of competitors decreases profits, and hence the probability of exporting to market Ic. The same pattern of sign reversal after accounting for market unobserved

Table 5: Marginal Effects in the Simple Probit Model

	Dependent Variable: Variety Export Status, by Market		
	(3)	(4)	(5)
N Competitor Entrants $(\sum_{j\neq i} y_{jIc})^{a}$	0.2005	0.2029	0.204
Competitor-specific variables $\mathbf{Z}_{iIc}{}^{b}$			
Firm Industries$_i$	0.0115	0.0092	0.0096
Variety Rank$_i$	-0.0055	-0.0053	-0.0053
Variety Destinations$_{iIc}$	0.2626	0.2658	0.2659
Market-specific variables $\mathbf{X}_{Ic}{}^{b}$			
Potential K_{Ic}	0.0226	0.023	0.0242
GDP$_c$	0.1868	0.1927	0.1932
Geographical Distance$_c$	-0.1787	-0.1694	-0.1352
Industry Size$_I$	-0.0045	-0.0069	-0.0015
HHI$_{Ic}$	-0.0087	-0.0185	-0.0201
Tariff$_{Ic}$		-0.0405	
Tariff$_{Ic} > 0$			-0.0683

Notes: The table reports marginal effects for columns (3) to (5) of Table 4. All control variables (except for *Potential* K_{Ic} and *Tariff*$_{Ic} > 0$) are standardized. [a] The marginal effect of competitor entry is calculated as the change in the predicted probability of exporting if a firm does not face any competition in the foreign market (i.e., if the count of competitors active in market Ic is set equal to zero). [b] Marginal effects are computed as the change in predicted probability when the variable is increased by one unit.

heterogeneity is found in previous studies (e.g., Ciliberto et al., 2016).

In column (3), we additionally control for the level of concentration in the import market. Including HHI_{Ic} does, however, not have a large impact on the estimated coefficient δ_{probit}, which is very similar to the estimate in column (2). Based on column (3), we predict the probability of exporting to increase by 20.05 percentage points as the number of competitors faced in an export market is reduced to zero; see Table 5. The magnitude of the effect is thus quite large.

We expect competition to be tougher in markets with higher levels of concentration, and this should reduce the export probability of Danish firms. The estimated effect of HHI_{Ic} in column (3) confirms this intuition. However, the corresponding marginal effect is rather small: a one standard deviation increase in HHI_{Ic} reduces the market-specific export probability by 0.9 percentage points.

In columns (4) and (5) of Tables 4 and 5, we show that export participation is less likely in markets with higher tariffs. The tariffs are measured by the continuous variable

$\textit{Tariff}_{Ic}$ in column (4)[18] and the binary variable $\textit{Tariff}_{Ic} > 0$ in column (5). We find that one standard deviation increase in tariffs is predicted to decrease export participation by 4.05 percentage points. When we employ the binary tariff variable, we find that firms are 6.83 percentage points less likely to export to destination markets with positive tariffs.

Next, we briefly discuss results for our competitor-specific variables included in the vector $\mathbf{Z}_{iIc}$. In line with the literature on multi-product exporters, we find a positive effect of $\textit{Firm Industries}_i$: firms with a larger industry portfolio are more likely to serve a given export market. Similarly, the effect of $\textit{Variety Rank}_i$ is negative in most columns that include market random effects η_{Ic}. Thus, the export probability falls from the firm's core industry to its peripheral industries. A variety's presence in other destinations ($\textit{Variety Destination}_{iIc}$) captures the general attractiveness of the variety to consumers across all destinations. Accordingly, it raises the destination-specific export probability. The corresponding marginal effect is sizable: we predict that a one standard deviation increase in $\textit{Variety Destination}_{iIc}$ increases the export probability by 26 percentage points.

Recall from Section 2.3 that exclusion restrictions will play an important role in the identification of the competitive effects in the equilibrium model, and that these exclusion restrictions rely on elements of the vector $\mathbf{Z}_{iIc}$. A variable satisfies the exclusion restriction if it affects the decision of firm i to serve an export market without *directly* affecting the decision of its competitors j. In the last column of Table 4, we include average competitor characteristics as control variables in the simple probit model.[19] If we find a significant coefficient for one of these averages, that variable is unlikely to fulfill the exclusion restriction. Column (6) shows that $\overline{\textit{Variety Destinations}}_{-iIc}$ enters with a positive coefficient and that the variable is highly statistically significant. In the equilibrium model, it will therefore be important to allow the competitive effects to vary with the set of destinations to which a firm is exporting. The other two averages of competitor characteristics, $\overline{\textit{Variety Rank}}_{-i}$ and $\overline{\textit{Firm Industries}}_{-i}$, in contrast, do not affect variety

[18] Following common practice in the literature (see, e.g., Debaere & Mostashari (2010)), tariffs are included as $\ln(1 + \text{Tariff}_{Ic})$. In particular, $1 + \text{Tariff}_{Ic}$ can be interpreted as the price increase on the import market which is due to the tariff.

[19] Here, markets with only one potential entrant are excluded from the sample, because we cannot compute average competitor characteristics.

i's export decision, suggesting that these variables fulfill the exclusion restriction.

Finally, we also briefly discuss the effects of market-specific control variables. We find that the superstar firms are more likely to export in industries with more potential entrants K_{Ic}, which suggests that the number of potential entrants is picking up some exogenous attractiveness of the market. As predicted by the gravity equation, we also find that varieties are more likely exported to larger and geographically closer markets. A one standard deviation increase in GDP increases the probability of firms' being present in a market by roughly 19 percent, while a one standard deviation increase in distance reduces the probability by 14 to 18 percent. The effect of industry size, $Industry\ Size_I$, is negative but only marginally significant.

To summarize, our probit estimations suggest that negative effects due to competition between superstar exporters outweigh any positive effects from informational spillovers; i.e., the net effect is negative. Notably, this finding is quite different from previous results in the extensive literature on export spillovers. In contrast to that literature, we focus on superstar firms here. It is in fact only for such a sample of large firms that we would expect oligopolistic strategic interactions to be important.

4.2 Falsification Test

Before we turn to the equilibrium model, we briefly discuss a falsification test that we implement in the single equation probit model; details for this analysis are provided in the Online Appendix. In the falsification test, we analyze how the entry behavior of superstar firms in industry I depends on the entry decisions of superstar firms from other, unrelated industries $I' \neq I$. Superstar firms interact strategically only if they are competing with each other on output markets, and we would thus expect that negative effects of competitor entry should only be present within industries, but not across industries.

We proceed as follows. For each market Ic, we randomly draw $K_{Ic} - 1$ superstars from different industries I'. We next count the number of randomly drawn superstars from industries I' which entered destination c. We denote the parameter on this variable by $\delta_{unrelated}$.[20] Including the count of superstars from industries I' as an additional control variable in the single equation probit model, we find that $\widehat{\delta}_{unrelated}$ is greater than zero and statistically significant for all 50 simulations. The associated marginal effects are, however, small: if all 'unrelated' superstars would exit a market, we would predict the export probability to decrease by 4.6 to 6.6 percentage points.

Importantly, we thus confirm that negative effects of competitor entry are present only *within* industries, substantiating our interpretation that these negative effects are due to strategic interactions between competing firms. How could we rationalize these positive effects of other firms' export decisions that are working *across* across industries? One plausible interpretation is that there are destination-specific informational spillovers that work not only within industries but also across industries. Choquette & Meinen (2015) provide empirical evidence of such spillovers, that are due to input-output linkages across firms.

4.3 Robustness Analysis

In the Online Appendix to this paper, we also provide an extensive robustness analysis for the single equation probit model, where we consider *(i)* extensions to include additional control variables (e.g., firm productivity or competition/spillovers from the competitive fringe); *(ii)* alternative ways of constructing the sample (e.g., including more than the top-100 destinations); *(iii)* alternative definitions of the superstar firms (e.g., defining superstar firms based on their share in total industry revenue, rather than total industry exports); and *(iv)* variation in δ_{probit} across industries.

5 Results from the Equilibrium Model

We now present the estimation results for the equilibrium model. The object of interest is either the set Θ or the (possibly partially identified) true parameter $\theta \in \Theta$. We report

[20] Note how drawing $K_{Ic} - 1$ superstars from other industries eases comparability of the estimated effects within and across industries, δ_{probit} and $\delta_{unrelated}$

confidence regions for θ. The confidence regions for the latter are weakly larger than for the former, and coincide asymptotically in the case of point identification. To build the confidence regions we use the methodology of Chernozhukov et al. (2007).[21]

Column (1) of Table 6 presents estimations results for the specification with our basic control variables and only the constant competitive effect δ_1, so that $\delta_\ell = 0$ and $\delta_h = 0$. There are three exogenous variables (GDP_c, $Distance_c$ and $Industry\ Size_I$) that are common among the potential entrants. Additionally, there are three variables ($Firm\ Industries_i$, $Variety\ Rank_i$ and $Variety\ Destinations_{iIc}$) that are specific to the potential entrants, and thus are assumed to fulfill the exclusion restriction (cf. Section 2.3).

The parameter δ_1 is estimated to be in [-8.308,-4.858]. Thus, the effect is negative and statistically significant as predicted in standard oligopoly models: the presence of other Danish competitors in a market reduces profits, and therefore the export probability. Furthermore, any potential informational spillovers seem to be too small to counterbalance these negative competitive effects.

The signs of the control variables broadly reflect results from the simple probit model. In particular, $Variety\ Destinations_{iIc}$, GDP_c and $Distance_c$ are statistically significant and estimated with the expected signs. The coefficients of the other two competitor-specific variables ($Firm\ Industries_i$, $Variety\ Rank_i$) are, however, no longer statistically significant. Interestingly, we now find a positive effect of $Industry\ Size_I$. This is also different from the probit regressions, where the estimated effect was negative, though often not statistically significant. We interpret this as evidence that the superstar firms are more likely to export if the competitive fringe, here proxied by the variable $Industry\ Size_I$, is larger.

Columns (2) and (3) add the market-specific Herfindahl-Hirschmann Index HHI_{Ic} and the binary variable $Tariff_{Ic} > 0$, respectively. Including these control variables does not have a marked effect on δ_1. The negative coefficient estimate of HHI_{Ic} implies that Danish superstars are less likely to enter markets where imports are more concentrated. The effect

[21] We remark here that, as in Ciliberto & Tamer (2009), these confidence sets are constructed by reporting the minimum and maximum values for each individual parameter, and that this does not imply that any combination of individual parameters, each one of which lying within the minimum and the maximum, will belong to the identified set.

Table 6: Estimates from the Equilibrium Model

	(1)	(2)	(3)	(4)	(5)	(6)
Constant Competitive Effect (δ_1)	[-8.308,-4.858]	[-8.293,-4.713]	[-8.232,-4.936]	[-10.744,-5.653]	[-8.031,-7.577]	
Interactions						
$\delta_{\text{Variety Destinations}}$				[0.927,1.270]	[1.676,1.864]	
δ_{Distance}				[-0.198,0.127]	[-0.107,0.029]	
δ_{GDP}				[-0.158,0.127]	[-0.011,0.129]	
Competitor-specific variables $\mathbf{Z}_{iIc}$						
Firm Industries$_i$	[-0.026,0.194]	[-0.026,0.224]	[-0.061,0.182]	[-0.008,0.155]	[-0.012,0.083]	[-0.037,0.463]
Variety Rank$_i$	[-0.256,0.025]	[-0.256,0.025]	[-0.256,0.016]	[-0.149,0.075]	[-0.081,0.046]	[-0.347,0.219]
Variety Destinations$_{iIc}$	[0.763,1.044]	[0.697,1.045]	[0.700,0.967]	[1.243,1.650]	[1.763,1.951]	[1.750,2.940]
Market-specific variables $\mathbf{X}_{Ic}$						
Geographical Distance$_c$	[-0.946,-0.615]	[-1.234,-0.692]	[-1.439,-0.596]	[-0.934,-0.540]	[-1.261,-0.981]	[-0.846,-0.333]
GDP$_c$	[0.720,1.076]	[0.708,1.221]	[0.824,1.326]	[1.097,1.476]	[1.911,2.161]	[0.681,1.396]
Industry Size$_I$	[0.080,0.453]	[0.119,0.653]	[0.438,0.842]	[0.000,0.407]	[0.417,0.729]	[-0.440,-0.109]
HHI$_{iIc}$		[-0.625,-0.029]	[-0.436,0.007]	[-0.312,-0.062]	[-0.366,-0.092]	[-0.265,0.236]
Tariff$_{Ic} > 0$			[-3.191,-0.837]	[-2.033,-1.259]	[-2.973,-2.421]	[-2.040,-0.750]
Constant	[4.070,7.584]	[3.798,7.468]	[4.344,7.441]	[4.532,9.205]	[7.251,7.501]	[0.000,0.516]
$\sigma_{variety}$	–	–	–	–	[0.001,0.040]	[1.625,2.896]
σ_{market}	–	–	–	–	[2.351,2.476]	[0.125,0.791]
ρ	–	–	–	–	[0.984,0.990]	[-0.165,0.500]
Function Value	2,453.8	3,036.93	3,449.1	3,315.37	2,731.74	4,495.12
Number Observations	8,938	8,802	8,664	8,664	8,664	8,664

Notes: These set estimates contain the 95% confidence region for the true parameter θ. See Chernozhukov et al. (2007) and Ciliberto & Tamer (2009) for more details on constructing these confidence regions.

of $Tariff_{Ic} > 0$ is estimated to be in [-3.191,-0.837], which confirms that superstars are less likely to export to markets with positive tariffs.

Column (4) investigates whether the competitive effects vary across competitors and/or markets; i.e., we estimate the parameters δ_ℓ and δ_h in Equation (1). Specifically, we test the hypothesis that dominant competitors with a broader destination portfolio have a larger negative effect on the profits of their competitors. We thus allow the competitive effect to change with the number of destinations to which a variety is exported. This effect is measured by the parameter $\delta_{\text{Variety Destinations}}$. Moreover, we test the hypothesis that competitive effects vary across destinations according to the standard gravity forces. We thus also allow for the competitive effects to change with the geographical distance and GDP of the destination country. These effects are measured, respectively, by δ_{Distance} and δ_{GDP}.

We do not find evidence that competitive effects vary across destination markets: δ_{Distance} and δ_{GDP} are estimated to be statistically insignificant. Turning to the variation across competitors, we find $\delta_{\text{Variety Destinations}}$ to be positive. Thus, the larger the number of *other* destinations that a firm serves, the *smaller* (in absolute value) its effect on competitors' profits. There are several potential interpretations for this surprising result. First, firms that serve many export markets may have a high visibility to their competitors. This reasoning implies not only larger negative effects on profits due to strategic interactions but also a larger potential for informational spillovers. The latter may explain why we find $\delta_{\text{Variety Destinations}} > 0$. Second, firms that serve a large number of other export markets may compete less aggressively in a given destination, because each destination has a lower importance for their overall exports.

In column (5), we allow for a more flexible variance-covariance matrix of the unobservables. So far, we have maintained that η_i, η_I, η_c, η_{Ic}, and η_{iIc} are drawn from (five) independent standard normal distributions. We relax this assumption in two ways. First, we allow the idiosyncratic shocks η_{iIc} to be correlated across varieties within the same market, and estimate the corresponding correlation coefficient (denoted by ρ). Second, we estimate the variance of η_i, denoted $\sigma^2_{variety}$, and the variance of the (sum of the) market unobservables $\eta_I + \eta_c + \eta_{Ic}$, denoted σ^2_{market}. We continue to restrict the variance of η_{iIc} to be equal to 1. (Note that one of the variances has to be set equal to 1 because this is a discrete choice model.)

We find that the idiosyncratic shocks are almost perfectly correlated across varieties within a market: $\widehat{\rho}$ is positive and strikingly close to 1. This high correlation indicates that idiosyncratic shocks to profitability are almost indistinguishable from market-specific shocks. The estimate of $\sigma_{variety}$ is very small – essentially zero ([0.001,0.040]) – suggesting that export decisions are not driven by unobservables at the variety level. In contrast, the estimate of σ_{market} is quite large, and equal to [2.351,2.476]. Thus, industry, destination and market unobservables are important determinants of firms' export decisions. The other parameter estimates are similar in magnitude and statistical significance to the ones in column (4).

We conclude our analysis with the specification in column (6), where we assume that all the competitive effects are equal to zero. This is equivalent to estimating a model where firms decide whether to export independently of each other, as assumed in models of monopolistic competition. Results from this specification will be used as a benchmark for comparison to uncover the importance of competitive effects in our counterfactual analysis. We estimate the parameters of the exogenous variables with the same signs as in column (5), although with slightly different magnitudes.

With regard to the parameters ρ, $\sigma_{variety}$ and σ_{market}, we see some interesting differences in column (6) compared to column (5). For example, we now estimate $\sigma_{variety}$ to be in [1.625,2.896], therefore much larger than in column (5). Intuitively, this model has fewer competitor-specific variables, and this may rationalize why it exhibits a larger variation in competitor-specific shocks. Finally, observe that ρ is imprecisely estimated in column (6). We also infer that assuming a model with no strategic interactions biases the estimates of the variances and covariances of the unobservables in a significant way.

Table 7: Fit: Market Structures

Number of potential entrants K_{Ic}	Number of predicted entrants 0 %	1 %	2 %	3 %	4 %	5 %	6 %	% Correctly predicted
1	10.32	89.68						79.72
2	5.80	61.27	32.92					51.40
3	3.01	51.58	42.19	3.23				41.31
4	1.97	42.49	49.30	6.13	0.10			34.88
5	1.13	33.51	53.94	11.05	0.37	0.00		29.65
6	0.83	28.14	54.75	15.27	1.01	0.01	0.00	23.28
7	0.58	22.96	52.65	20.80	2.89	0.13	0.00	21.38
Total	1.32	36.39	51.15	10.42	0.70	0.02	0.00	36.66

Notes: This table reports the number of predicted entrants based on estimates in column (5) of Table 6, and compares these predictions with the actual number of entrants observed in the data (cf. Table 2).

5.1 Fit

In the following, we will focus on the specification in column (5) of Table 6. There are three ways to determine how well our model fits the data.

First, we compute the percentage of *market structures* that the model predicts correctly. Empirically, in each market we only observe one equilibrium outcome, but the model potentially predicts multiple market equilibria. In order to construct our first measure of fit, we therefore proceed as follows. We draw 100 new simulations of the random shocks to profitability, η_i, η_{Ic}, η_I, η_c and η_{iIc} in Equation (2), and compute a new ϵ_{iIc} for each firm in each market. Based on these new simulations, we find the equilibria in each market at the value of the parameter where the distance function in Equation (4) is minimized for the specification in column (5) of Table 6, and the values of the exogenous variables. Then, we check if any of the equilibria predicted by the model matches the market structure observed in the data. If one of the predicted equilibria matches the market structure observed in the data, then that is a positive match.

We present our results in the last column of Table 7. In markets with one potential entrant, we correctly predict the market structure observed in the data in 79.72 percent of market-simulations. In markets with two potential entrants, the number of correct predictions is 51.40 percent. The percentage of market structures that we predict correctly declines, until it reaches its lowest value of 21.38 percent for markets with seven potential entrants. Overall, we correctly predict 36.66 percent of the market structures that are observed in the data.

For our second measure of fit, we find the distribution of the *number of firms* predicted by the model for each market-simulation, and for any given number of potential entrants. We again use the predicted equilibria for the 100 simulations we run above. In markets for which our model predicts multiple equilibria, we use all the predicted outcomes to construct the distribution of the number of firms predicted by the model. So, if we predict an equilibrium with 2 firms and another one with 3 firms, we consider both predictions.

We present our results in Table 7. In markets with one potential entrant, our model predicts that the firm will enter in 89.68 percent of market-simulations. In the data, the superstar is observed as entering in 83.6 percent of markets; cf. Table 2. The fit is clearly very satisfactory for markets with only one potential entrant. In markets with two potential entrants, our model predicts that there will only be one entrant in 61.27 percent of the market-simulations (vs. 48.13 percent of markets observed in the data), and two entrants in 32.92 percent of the market-simulations (vs. 38.17 of markets observed in the data). The model does not do as well in predicting the number of firms as we increase the number of potential entrants, but there is an important observation to be made. Because of the existence of multiple equilibria, the sum of the probabilities is no longer equal to 1 in Table 7, and thus the comparison with the values in Table 2 is not as helpful. Overall, we observe that the model does not do well in predicting markets with large number of entrants.

Thirdly, we can compare the values of the distance function at the parameter where it is minimized across columns that use the same exogenous variables to determine the best specification.[22] The distance function is equal to 3315.37 in column (4) and to 3449.1 in column (3), which implies that column (4) provides a better fit to the data than column 3. This is not surprising since the specification in column (4) has more free parameters than the one in column (3). Similarly, the function value is lower in column (5) than in column (4), so the specification with free variances and correlations also fits the data better. The

[22]Because columns (1) and (2) are based on different sets of exogenous variables, a direct comparison of the distance functions is not meaningful.

distance function in column (6) is much higher than in columns (3)–(5), implying that not including the competitive effects leads to a much worse fit.

5.2 Occurrence of Multiple Equilibria

We analyze the occurrence of multiple equilibria as follows. We use the 100 new simulations of the random shocks η_i, η_{Ic}, η_I, η_c, and η_{iIc} from the analysis in Section 5.1 and determine the equilibria for each market-simulation draw at the value of the parameter where the distance function in Equation (4) is minimized for the specification in column (5) of Table 6. We can then identify the market-simulation draws with multiple equilibria, both in the identity and number of competitors. Finally, we compute the fraction of market-simulation draws with multiple equilibria. Table 8 presents the results of this exercise.

In markets with two potential entrants, we predict on average 1.39 equilibria. Notably, these multiple equilibria are only in terms of the identity of the firms; i.e., with two firms there are markets where either of the firms being an exporter will be an equilibrium outcome. If there were informational spillovers and other positive externalities in exporting, we would also expect there to be multiple equilibria in the number of firms; i.e., equilibria where either both firms export or no firm exports. In contrast, Table 8 shows that the equilibria are always unique in the number of firms.

Next, we look at markets with three potential entrants, and find that on average there are 2.33 equilibria (out of eight possible market structures). Moreover, in 6.87 percent of the simulation-market draws (here equal to 100×1502) there are multiple equilibria in the number of firms. For example, these could be equilibria where either one large competitor or two smaller competitors export.

The results for the other configurations with more potential entrants are analogous to the case just analyzed with three potential entrants. For example, when there are seven potential entrants, on average there are 11.02 equilibria, and 27.94 percent of the market-simulations with seven potential entrants have equilibria with different numbers

Table 8: Evidence of Multiple Equilibria in the Identity and Number of Firms

Number of potential entrants	Number of possible market structures	Average number of market equilibria[a]	Multiple equilibria in number of firms (%)[b]	Number of markets
$K_{Ic} = 1$	2	1	–	484
$K_{Ic} = 2$	4	1.39	–	1,057
$K_{Ic} = 3$	8	2.33	6.87	1,502
$K_{Ic} = 4$	16	3.62	17.85	2,097
$K_{Ic} = 5$	32	5.44	21.62	1,443
$K_{Ic} = 6$	64	7.84	28.54	1,196
$K_{Ic} = 7$	128	11.02	27.94	885
Mean	–	7.89	24.51	8,664

Notes: This table is based on estimates in column (5) of Table 6. Markets with one potential entrants are excluded from the Table because there cannot be multiple equilibria in those markets.
[a] This is the average across market-simulation draws with the same number of potential entrants.
[b] Gives the percent of simulation-market-draws for which there are multiple equilibria in the number of firms.

of firms. These results confirm the necessity to use a flexible approach as in Ciliberto & Tamer (2009) to study strategic interactions in export markets.

6 Propensity to Export and Comparative Statics

In this section, we compare the propensities to export predicted by our model with the ones observed in the data and present comparative statics that focus on the individual export propensity. The propensity is computed by taking the ratio of the predicted number of entrants divided by the number of potential entrants.

Recall that the outcome of the equilibrium model is a market structure, or a vector of export decisions by multiple firms. Following Ciliberto & Tamer (2009), marginal effects are then to be computed for the market structures, as one would do when studying the marginal effects in a multinomial logit estimation. Here, instead, we focus on the response of individual firms. Our focus on the export propensity facilitates comparison with the marginal effects from the single-equation probit analysis in Table 5, as well as comparison with the mainstream literature in international trade.

To this aim, in Table 9 export propensities are calculated *(i)* for the observed values of the exogenous variables and the value of the parameter where the distance function in Equation (4) is minimized for the specification in column (5) of Table 6; and *(ii)* for the observed values of the exogenous variables and the value of the parameter where the distance function is minimized for the specification in column (6) of Table 6 (i.e., the model without competitive effects). Note how comparison of the export propensities in *(i)* and *(ii)* will allow us to quantify the importance of competitive effects in determining export decisions. Finally, we also compute export propensities *(iii)* for a one standard deviation increase in each of the exogenous variables, holding other variables at their observed values. (This last exercise again uses the estimated parameters in column (5) of Table 6.)

6.1 Propensity to Export

We first compare the propensities to export predicted by our model in column (5) of Table 6 with the ones observed in the data. In particular, we determine the equilibria for each of the markets and each of the simulations at the observed values of the exogenous variables $\mathbf{X}_{Ic}$ and $\mathbf{Z}_{iIc}$ and the estimated parameters. (This is an analogous exercise to the one we did in the previous section when we computed the percentage of multiple equilibria in the data.) To compute the propensity to export, we compute the ratio of firms exporting over the number of potential entrants. Thus, the propensity to export is an average propensity and it will vary by the number of potential entrants.

The first row of Table 9 presents the propensities to export that are computed in this fashion, separately for markets with $K_{Ic} = 1, \ldots, K_{Ic} = 7$ entrants. We can compare these numbers with those observed in the data (reported in the third row of Table 9). We find that the predicted export propensity is 0.897 in markets with one potential entrant, compared to 0.836 in the data. In markets with two potential entrants, the predicted export propensity is 0.636, which is again very close to the actual propensity of 0.624 in the data. Thus, we again conclude that the model does a good job at fitting the data. Both the predicted and the actual export propensity decline with the number of potential entrants. Averaging across all markets, the export propensity predicted by our model stands at 0.340 (compared with 0.439 in the data).

Table 9: Comparative Statics in the Equilibrium Model

	Propensity to export by number of potential entrants							All markets	
	$K_{Ic}=1$	$K_{Ic}=2$	$K_{Ic}=3$	$K_{Ic}=4$	$K_{Ic}=5$	$K_{Ic}=6$	$K_{Ic}=7$	Propensity to export	Comparative statics
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Model									
Original values ($\delta \neq 0$)[a]	0.897	0.636	0.485	0.400	0.352	0.312	0.290	0.340	
Original values ($\delta = 0$)[b]	0.896	0.893	0.874	0.865	0.872	0.873	0.871	0.872	0.532
Data	0.836	0.624	0.497	0.428	0.409	0.402	0.394	0.439	
Market-specific variables $\mathbf{Z}_{Ic}$[c]									
Geographical Distance$_c$	0.855	0.594	0.455	0.374	0.331	0.294	0.273	0.321	-0.019
GDP$_c$	0.950	0.713	0.541	0.445	0.391	0.346	0.320	0.372	0.032
Industry Size$_I$	0.912	0.654	0.498	0.410	0.361	0.320	0.297	0.347	0.007
HHI$_{Ic}$	0.890	0.628	0.480	0.395	0.348	0.309	0.287	0.336	-0.004
Competitor-specific variables $\mathbf{X}_{iIc}$[c]									
Firm Industries$_i$	0.897	0.636	0.486	0.400	0.352	0.313	0.290	0.340	0.000
Variety Destinations$_{iIc}$	0.947	0.706	0.526	0.427	0.373	0.329	0.304	0.359	0.019
Variety Rank$_i$	0.896	0.635	0.485	0.400	0.352	0.312	0.290	0.340	0.000
Number Observations	484	1,057	1,502	2,097	1,443	1,196	885	8,664	

Notes: This table is based on estimates in column (5) of Table 6, unless noted otherwise. In columns (1) to (7), the propensity to export is calculated for all markets with $K_{Ic} = 1, \ldots K_{Ic} = 7$ potential entrants. In column (8), the overall effect is calculated as the weighted average of the effects in columns (1) to (7), with weights equal to the number of markets with a given number of potential entrants. In column (9), the marginal effect is calculated as the change in predicted probability.

[a] Predicted export propensity, based on estimates from column (5) of Table 6. [b] Predicted export propensity, based on estimates from column (6) of Table 6.

[c] Predicted export propensity as the explanatory variables are individually increased by one standard deviation; based on estimates from column (5) of Table 6.

6.2 Comparative Statics: Competitive Effects

We begin our comparative statics exercise by investigating the role of competition as a determinant of superstar firms' export decisions. The second row of Table 9 shows the predicted export propensities in the model where all the competitive effects (δ_1, δ_{Distance}, δ_{GDP}, and $\delta_{\text{Variety Destinations}}$) are set equal to zero; i.e., using the parameter estimates in column (6) of Table 6. Using the same simulations of the error components which we used for the first row of Table 9, we compute the equilibria for each market-simulation.

In markets with one potential entrant this exercise obviously does not make any difference. With more than one potential entrant, however, we find that the competitive effects are very important. With two potential entrants, the predicted export propensity increases from 0.636 in the model with competitive effects to 0.893, in the model without competitive effects, which is a dramatic increase.[23] Competitive effects are crucial also in markets with more than two potential entrants. For example, if we set all competitive effects equal to zero, the export propensity increases from 0.485 to 0.874 in markets with three potential entrants; and from 0.393 to 0.877 in markets with four potential entrants.

Overall, without the competitive effects firms are predicted to be 53.2 percentage points more likely to export to a given market. Clearly, competition in export markets is an important determinant of export decisions. This number can be compared with the marginal effect of 20.4 percentage points in the probit model of Table 5. The effect that we find in the equilibrium model with strategic interactions is thus more than twice as large as in the single agent probit model.

6.3 Comparative Statics: Exogenous Profit Determinants

Next, to measure the economic effect of changes in the exogenous variables (except for tariffs, which are investigated in Section 7) we consider a one standard deviation increase in each variable, holding all other variables at their original values. For the individual variables, we have to change the variable for each firm at a time, and then take the average

[23] Notice that the new propensity to export is very close to the one we measure when there is only one potential entrant, which is a helpful cross-check on our methodological approach.

effect across all the potential firms in the market. We repeat the simulation exercise above and determine the new export propensities at the original parameter estimates. Results are presented in Table 9.

Consider a one standard increase in the distance from Denmark. We now find that the export propensity with one potential entrant is 0.855, with two potential entrants it is 0.594, and with seven potential entrants it is 0.273. When averaging across all markets the propensity to export is now 0.321. The difference between 0.340 and 0.321 is -0.019, which means that if distance increases by a one standard deviation, the propensity to export decreases, for each firm, by 1.9 percentage points.

This effect is considerably smaller than the 13.52 percentage point drop that we found in the simple probit model; cf. column (5) of Table 5. The effect of a change in an exogenous variable in the context of our equilibrium model can be quite different than if we consider the same effect in a model where each firm is making its entry decision independently. In particular, the effect of a change in the exogenous variable is larger when compounded over all the potential entrants. For example, the effect is -0.017 ($= 0.273 - 0.290$) in markets with seven potential entrants. When compounded over all the seven potential entrants, this would imply that there is a 11.9 percentage point higher probability that *at least one* of the firms will not export to a market if distance increases by one standard deviation. Note how this compounded effect is very similar in magnitude to the marginal effect in Table 5. We will return to this comparison shortly.

We find that one standard deviation increase in the GDP of the destination country is associated with a 3.2 percentage point increase in the propensity to export. For industry size, the same effect amounts to 0.7 percentage points. For the HHI, we find that a one standard deviation increase in the HHI is associated with a 0.4 percentage point decrease in the propensity to export.

We conclude the analysis of exogenous changes in the market-specific variables by computing the probability that at least one firm will export after a one standard deviation increase in the geographical distance, the GDP, the industry size, and the HHI. Those changes in the probabilities are equal to, respectively, -0.077, 0.129, 0.028, and -0.016.[24] These numbers are largely comparable to the ones in column (5) of Table 5, where we found the marginal effects of geographical distance, GDP, industry size, and the HHI, equal to, respectively, -0.135, 0.193, -0.002, and -0.020. Some of the differences may be explained by the different specification that we are running, since GDP and geographical distance are also interacting with the competitive effects in column (5) of Table 6.

Finally, we study changes in the export propensity for a one standard deviation increase in each of the competitor-specific variables. In contrast to the changes in the market-specific variables which affect the profits of all the potential firms in a market, changes in the competitor-specific variables only affect one firm at the time. We find that a one standard deviation increase in $\textit{Variety Destinations}_{iIc}$ increases the propensity to export by 1.9 percentage points. Recall that the other two competitor-specific variables were not statistically significant in the equilibrium model.

7 Policy Experiments

Table 10 presents the results from two policy experiments. The first policy experiment consists of setting the binary variable $\textit{Tariffs}_{Ic}$ equal to zero in all markets with positive tariffs and recomputing the equilibria to see how the propensity to export is affected. The results of this counterfactual exercise are presented in the top panel of Table 10. The second policy experiment consists of setting the binary variable $\textit{Tariffs}_{Ic}$ equal to one in those markets that do not have tariffs. The results for this counterfactual exercise are presented in the bottom panel of Table 10.

For both policy experiments, we are particularly interested in how the strategic interactions between superstar exporters affect firms' export decisions after a trade policy change. For example, consider the case where trade is liberalized. If firms interact strategically, positive effects on profits due to trade liberalization are counter-balanced by negative

[24]These numbers are derived by multiplying the ones in the last column of Table 9 by 4.03, which is the weighted average number of potential entrants in the sample used in Table 9.

effects due to competitor entry. Thus, a model without strategic interactions (which does not take into account the effects of competitor entry) would overestimate the export entry response of superstar exporters. Similarly, when new trade barriers are being imposed, reduced competition from competitors who exit will mitigate the negative direct effect on firms' export profits. A model without strategic interactions would therefore overstate firm's export exit response.

In our simulations, we quantify these biases. In particular, for each policy experiment, we first simulate the change in export propensities using the parameter where the distance function in Equation (4) is minimized for the specification in column (5) of Table 6. Next, we compare these results to those from simulations using the parameter where the distance function is minimized for the specification in column (6) of Table 6. The latter set of simulations does not allow for competitive effects, and can thus serve as a useful benchmark for comparison.

7.1 Eliminating Tariffs in Markets with Positive Tariffs

Consider first the case of markets with positive tariffs. Out of the 3,601 export markets with positive tariffs, there are 199 markets with one potential entrant, 386 with two potential entrants, and so on. The first row of Table 10 shows the export propensity at the estimated parameters and the original values of the exogenous variables. We compute these propensities in the same fashion as we did in Table 9, except that we now take the average only across markets with positive tariffs. For example, before the policy change, the predicted propensity to export is 0.520 in markets with two potential entrants.

Next, consider the counterfactual scenario where tariffs are eliminated. The second row of Table 10 reports the new propensities to export. In markets with three potential entrants, the propensity increases from 0.396 to 0.505 as trade becomes duty free. Similarly, in markets with seven potential entrants the propensity is now 0.302, compared to 0.243 in the original situation with positive tariffs. If we consider the probability that *at least* one firm exports in markets with seven potential entrants, this increases by 41.3

percentage points.[25] When averaging across all markets, we find that the propensity to export increases from 0.283 to 0.348 if tariffs are eliminated. The difference is 6.5 percentage points, which is a sizable effect. Across all market structures, the probability that *at least* one firm exports increases by 27.6 percentage points.[26]

Next, we ask by how much we overestimate the entry response due to trade liberalization if the strategic interaction between superstar exporters is not taken into account. To address this line of inquiry, we perform the same counterfactual exercise using estimates from column (6) of Table 6. We first compute the propensities to export at the original values of the exogenous variables, i.e., with positive tariffs. The results are presented in the third row of Table 10. Consider now what happens to the export propensities if we eliminate tariffs. We compute the new equilibria in each market and we find that the average propensity to export increases from 0.373 to 0.512; i.e., by 13.9 percentage points. This is a much larger effect than the 6.5 percentage point effect we find when accounting for competitive effects (cf. above). Thus, the increase in export propensity is overestimated by a factor of two when strategic interactions are not taken into account.

7.2 Introducing Tariffs in Markets without Tariffs

Our second policy experiment introduces tariffs in markets which currently have no tariffs. The exercise is similar to the one that we just described, except that now we look at a different set of markets. Thus, now we change the binary variable $Tariffs_{Ic}$ from 0 to 1 before recomputing the equilibria in each market-simulation.

The results of this counterfactual exercise are presented in the bottom panel of Table 10. They show, for example, that introducing a tariff decreases the propensity to export from 0.403 to 0.370 in markets with four potential entrants. On average, the propensity to export drops from 0.342 to 0.318, or by 2.4 percentage points. If we repeat this last exercise using the estimates from column (6) of Table 6, we find that the average

[25] (0.302-0.243) $\times$ 7, which is equal to 0.413.

[26] This is calculated as the comparative statics effect across all markets (0.065) times the weighted average number of potential entrants in markets with positive tariffs, which is equal to 4.24.

Table 10: Policy Experiment

	Propensity to export by number of potential entrants							All markets	
	$K_{Ic}=1$	$K_{Ic}=2$	$K_{Ic}=3$	$K_{Ic}=4$	$K_{Ic}=5$	$K_{Ic}=6$	$K_{Ic}=7$	Propensity to export	Comparative statics
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Markets with positive tariffs									
– with competitive effects[a]									
original values	0.757	0.520	0.396	0.327	0.288	0.256	0.243	0.283	
all tariffs zero	0.928	0.673	0.505	0.416	0.364	0.322	0.302	0.348	0.065
– without competitive effects[b]									
original values	0.661	0.481	0.408	0.360	0.355	0.344	0.371	0.373	
all tariffs zero	0.798	0.632	0.545	0.500	0.497	0.487	0.516	0.512	0.139
Number of observations	199	386	596	893	616	549	372	3,611	
Panel B: Markets with zero tariffs									
– with competitive effects[a]									
original values	0.924	0.637	0.489	0.403	0.354	0.315	0.288	0.342	
all tariffs >0	0.872	0.581	0.448	0.370	0.326	0.291	0.267	0.318	-0.024
– without competitive effects[b]									
original values	0.802	0.638	0.586	0.538	0.530	0.529	0.530	0.550	
all tariffs >0	0.677	0.499	0.451	0.404	0.394	0.393	0.396	0.415	-0.135
Number of observations	285	671	906	1,204	827	647	513	5,053	

Notes: This table reports results from our policy analysis. We run two policy experiments, both of which consist of computing equilibria with simulated unobservables as we change the tariffs. The upper panel of the table focuses on markets with positive tariffs; the lower panel on markets with zero tariffs. Rows labeled "original values" report the propensity to export at the original values of the variables and at the estimated parameters. Rows labeled "all tariffs = 0" report the predicted propensity to export after the tariff indicator is set equal to zero for all markets with positive tariffs. Rows labeled "all tariffs > 0" report the predicted propensity to export after the tariff indicator is set equal to one for all markets with zero tariffs. [a] Uses estimates from column (5) of Table 6. [b] Uses estimates from column (6) of Table 6.

propensity to export would be predicted to drop by 13.5 percentage points (now the average number of potential entrants is 4.11). Again, the change in export propensity is grossly overestimated when strategic interactions are not taken into account.

In sum, the strategic interaction between superstar exporters implies that changes in tariffs have a less dramatic effect than what we would predict in single-firm models, where each firm acts independently of the other firms. Our simulations show that the bias in single-firm models can be very large, overstating the entry or exit response due to changes in tariffs by a factor of two to more than five.

8 Conclusion

We study the determinants of export decisions by superstar firms, defined as firms with a share in industry-level exports of at least five percent. We model their export decisions as the result of a strategic game of entry, which we estimate adapting the methodology in Ciliberto & Tamer (2009) to an international trade framework. We find that competitive effects have a large impact on firms' export decisions: in the absence of strategic interactions, superstar exporters would be 53.2 percentage points more like to export to a given market.

We also employ our model to analyze implications for trade policy. We show that failing to account for the strategic interaction among superstar exporters leads to: *(i)* overstating the increase in export propensity if tariffs were liberalized by a factor of two; and, *(ii)* overstating the drop in export propensity if tariffs were imposed by a factor of more than five.

Finally, we find that the competitive effects vary across firms. Negative competitive effects are smaller for firms with a larger export portfolio in terms of the export destinations. These heterogeneous competitive effects imply that there exist multiple equilibria, both in the identity and in the number of firms.

There are some limitations to our analysis. To begin with, we have modeled the strategic interaction among the firms as a static game. Our static model allows us to incorporate very general forms of heterogeneity among firms as well as multiple equilibria. To our knowledge, these are features that have not yet been modeled in dynamic games. We think of our approach as complementary to one where firms are modeled as playing a dynamic game, but where most of the heterogeneity across firms is necessarily assumed away.

Secondly, we have assumed that export decisions are independent across markets. For example, a Danish firms that is deciding whether to export to the Netherlands does not take into account its decision on whether to export to Belgium. This assumption is clearly at odds with the empirical evidence (see, e.g., Albornoz et al. (2012) and Morales et al. (2019)), but relaxing it is very difficult because it would require us to model firms' decisions as if they were building a network rather than one single link. We leave this challenging task to future work.

Finally, we have maintained that the Herfindahl-Hirschman Index (HHI) captures the role of non-Danish exporters in the import markets. Arguably, we would expect that the strategic interaction between non-Danish and Danish firms is more complex and nuanced than the one that can be captured by a single aggregate measure like the HHI. We think that there is a lot to benefit from merging firm-product level data from different countries, and we hope to see that direction pursued in future empirical work.

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