Essays on Firms in International Trade

by

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Introduction

Since the late 1990s, the research focus in international trade has shifted to the firm-level emphasizing the heterogeneity of firms and their core role in shaping international trade flows. Nowadays, it is a well-established fact that not all firms in a country export and that those firms that do export are more productive than purely domestic firms. This stylized fact on the relationship between exporting and productivity has triggered a large literature. Among others, two results emerge from these studies. First, exporting is characterized by sunk and fixed costs which more productive firms are better equipped to pay and which, therefore, self-select into the export market. Second, exporting can also increase firm productivity, termed learning by exporting, e.g. because exporting allows firms to exploit scale economies or because firms have to adjust to fiercer competition in the export market.

This thesis relates to this literature by investigating the role of exporting costs and firm productivity dynamics. Among others, estimates in monetary values of sunk and yearly fixed costs of exporting are obtained in order to assess how important these costs really are. Moreover, it is investigated what factors may reduce the relevance of exporting costs; these factors may be internal to the firm such as a firm's experience in international trade, or external to the firm such as spillover effects from other firms. Productivity dynamics are investigated with particular focus on the impact of increased competition on firm productivity. Changes in the competitive environment are measured in relation to trade liberalization and to the significant rise of Chinese exports during the last 15 years. Moreover, it is assessed whether exporting influences firms' productivity dynamics.

The thesis consists of four chapters where each chapter comprises an individual essay. Two of the four chapters are currently under peer review process: Chapter 2 is in the process of being revised for re-submission to the *Canadian Journal of Economics* and Chapter 3, which is collaborative work with Eliane Choquette, has been revised and re-submitted to *The World Economy*.

The first chapter - "Productivity and Exporting Dynamics in the Face of Trade Liberalization"- analyzes the relationship between exporting and productivity during a period of trade liberalization. The textile sector experienced a phase of trade liberalization between 1995 and 2005 when WTO ruling required the abolishment of all quota restrictions for textile products. Such a phase of trade liberalization may lead to productivity improvements of textile firms due to increased competitive pressure (De Loecker, 2011) which in turn may lead to increased selection into the export market. Hence trade liberalization may have an indirect effect on export participation through the productivity channel. Increased export participation may again have feedback effects on firm productivity (learning by exporting).

I develop an empirical model which allows assessing these different mechanisms within a common framework. In the model a firm's productivity development endogenously depends on its exporting decisions and the degree of trade liberalization. Moreover, short-run export profits depend on firm productivity. The firm then makes an optimal export market participation decision accounting for sunk and fixed costs of exporting. The model is estimated structurally which allows a quantification of exporting costs in monetary values. The static demand and production function parameters are estimated using the algorithm of Ackerberg et al. (2006), while the dynamic exporting cost parameters are estimated using Bajari et al.'s (2007) method for dynamic discrete choice models.

Estimation results show that trade liberalization indeed influences firm productivity positively. Moreover, firm productivity is estimated to be an important determinant for short-run export profits and sunk export market entry costs are estimated to be substantial. These two points underline the relevance of the selection effect of more productive firms into the export market. A counterfactual analysis suggests that the indirect effect of trade liberalization on exporting via the productivity channel is only of minor importance. Furthermore, the results indicate that firms in the textile sector in Denmark did not experience productivity improvements from exporting during this period.

In Chapter 2 - "Sunk Costs of Exporting and the Role of Experience in International Trade" - I estimate the importance of country-specific sunk costs while paying special attention to the role that previous experience in international trade may have for exporting to a market. Generally, firms may benefit from experience related to importing from a specific market and from experience of exporting to other markets. The former point implies that firms may collect foreign-market-specific knowledge from importing from a country which facilitates exporting to that country; e.g. by familiarizing the firm with the foreign market's conditions. General export experience may be relevant if sunk costs of exporting consist of a global and a market-specific component. Moreover, export experience from other markets may be relevant as it can ease entry into markets which are similar in some characteristics such as language or geographic region. If the depth of experience also matters, the latter effects should be higher if firms have export experience from several markets. Moreover, it is assessed whether experience matters only for the decision to enter a market, or also for the decision stay in a market.

I motivate an empirical model which allows for these different mechanisms. The importance of sunk costs is inferred from the degree of state dependence of firms' export participation in a market. The applied econometric model addresses a variety of potential biases of the state dependence parameter and, furthermore, accounts for other explanations than sunk costs that could induce persistency in firms' export decisions. Even after controlling for such aspects, destination-specific sunk costs are found to matter. Firms' experiences in international trade can, however, help firms to overcome these costs more easily. In particular, import experience from a market is found to facilitate exporting this country. Furthermore, export experience from other markets can increase the probability of exporting to a country. This latter effect turns out to be conditional on the characteristics and number of markets served by a firm suggesting that global sunk costs of exporting are of limited importance only. The results show that importing from a market both effects the probability of entering the market (in case the firm does not export to the country) and to stay in the market (in case the firm already exports there). Export experience from other markets may also influence both decisions, while the evidence related to the decision to enter a market appears more robust.

In the third chapter - "Export Spillovers: Opening the Black Box" - we analyze export spillovers; i.e. the observation that a firm's exporting activity is influenced by exporting activities of other firms. While evidence for export spillovers becomes increasingly available, the specific mechanisms behind this phenomenon are subject to speculations. We suggest three channels through which export spillovers may occur, namely; (i) labor movement, (ii) inter-industry linkages, and (iii) intra-industry spillovers.

Access to rich Danish data allows us to investigate the importance of these channels. In particular, we exploit a transaction-level export data set of all manufacturing firms in Denmark over the period 1995-2006, which we merge with firm accounting data, employer-employee linked data and combine with information from yearly input-output tables. The transaction-level trade data enable us to account for the fact that export spillovers are likely to be destination-specific; i.e. it is the information about a specific market that flows from one firm to the other. Linked employer-employees data allow us to track the movement of employees between firms enabling us to investigate the effect of hiring a person that has previously worked for a firm exporting to a specific market on the probability that the new firm starts to export to this country in the following years (labor movement channel). Information from input-output tables allow us to distinguish inter-industry linkages into forward and backward linkages which is why we can assess whether information is exchanged through interactions between buyers and suppliers and in what direction the information flows. Finally, an example of intra-industry spillovers is the signaling of a business opportunity in a particular export market by firms selling similar products.

Our empirical analysis is based on a binary choice fixed effect logit model. We present a careful identification strategy where we control for a variety of observed and unobserved heterogeneity in order to identify export spillovers. A first finding is that export spillovers indeed are destination-specific. We then proceed with the investigation of the channels through which these spillovers may occur. First, our results point towards the importance of the labor mobility channel. We find that firms hiring employees with knowledge about specific export destinations acquired in previous jobs are significantly more likely to start exporting to these countries. This result is robust to allowing the hiring decision to be endogeneous using an instrumental variable approach. Moreover, our results suggest that intra- and inter-industry are also important for explaining export spillovers. We find that intra-industry spillovers are characterized by spatial decay suggesting that firms mainly observe their direct environment. In contrast, we do not find evidence for spatial decay in case of inter-industry spillovers.

Sub-sample estimations show that intra-industry spillovers are particularly important for smaller firms. Forward linkages are only experienced by medium sized firms, while backward linkages are relevant for small and medium sized firms. These results suggest that relatively smaller firms may be more open to this kind of information given their limited amount of internal resources for market research. Moreover, we find that relatively larger firms mainly benefit from foreign market-specific information transmitted by recently hired employees which may be due to the fact that larger firms have more resources available to react upon the knowledge brought up by new employees than smaller enterprisers. Finally, we find that export spillovers are most relevant for less developed countries suggesting that information related to less obvious export markets is particularly valuable in the export decision.

Chapter 4 - "Import Competition from China and Productivity of Danish Firms" - analyzes the impact of Chinese import penetration on firm productivity. The rise of Chinese exports during the last decade has triggered a literature that investigates the consequences for the receiving countries. A recent contribution (Ashournia et al., 2012) points out that even within industries, firm exposure to increased competition from China varies strongly. The authors show that it is therefore important to construct firm-level measures of exposure to import competition in order to truly identify the effect of Chinese import competition on wages of low-skilled workers.

Detailed Danish data on firms' sales by product allow me to follow this study and to construct a firm-specific measure of Chinese import competition. Another advantage of the data is that I can account for the presence of multi-product firms, omitted prices and unobserved demand shocks when estimating firm productivity and therefore account for recent advancements in the estimation of production functions (e.g. De Loecker, 2011).

For the empirical implementation, I use a modified version of the Ackerberg et al. (2006) algorithm in order to estimate total factor productivity. I then specify two estimation equations in order to analyze the impact of Chinese import competition on firm productivity.

The estimation results show that increased import competition from China positively impacts firm productivity indeed. However, not all firms are affected equally. In particular, the largest effects are found when estimating the model on a sub-sample of firms which produce rather homogeneous goods while firms producing rather differentiated goods do not appear to react to increased competitive pressure from China. These results are robust to IV estimations. Moreover, the results suggest that firms producing rather homogenous goods react to increased competition from China by changing their pricing behavior; in particular, by reducing their prices.

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Chapter 1

Productivity and Exporting Dynamics in the Face of Trade Liberalization

Productivity and Exporting Dynamics in the Face of Trade Liberalization

*Philipp Meinen**

Abstract

This paper investigates the relationship between exporting and productivity during a phase of trade liberalization. Trade liberalization has shown to influence firm productivity which in turn may increase selection into the export market. Increased selection into exporting may again have feedback effects on productivity (learning by exporting). The present paper develops an empirical model which allows assessing these different mechanisms within a common framework. In the model a firm's productivity development endogenously depends on its exporting decisions and the degree of trade liberalization. Moreover, short-run export profits depend on firm productivity. The firm then makes an optimal export market participation decision accounting for sunk and fixed costs of exporting. Structural estimation of the model suggests that trade liberalization indeed influences firm productivity positively while no learning by exporting is detected. Moreover, sunk costs of exporting are substantial indicating the importance of the selection effect. A counterfactual experiment suggests that the indirect effect of trade liberalization on exporting via the productivity channel is only of minor importance.

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1 Introduction

The relationship between firms' exporting decisions and firm-level productivity has been the focus of a large literature in international trade. Many studies have documented that productivity is a key determinant for selection into exporting by estimating export productivity premia.[1] The theoretical foundation for these empirical studies is the well-known Melitz (2003) model where only the most productive firms select into the export market due to fixed costs of exporting. Moreover, several scholars investigate productivity effects from exporting termed learning by exporting. Learning by exporting may be related to such things as scale economies, technology upgrading and tougher competition in the international market. Among others, Van Biesebroeck (2005), De Loecker (2007), and, more recently, Aw et al. (2011) present evidence for positive productivity effects from exporting for firms located in Sub-Saharan Africa, Slovenia, and Taiwan.

The present paper studies the relationship between exporting and productivity during a phase of trade liberalization. In particular, I am analyzing exporting and productivity dynamics of Danish firms belonging to the textile sector which experienced a phase of trade liberalization from mid-1990 until 2005 when WTO ruling required the abolishment of all quota restrictions for textile products.[2] Existing evidence suggests that such periods of trade liberalization can have positive effects on firm productivity (e.g. Pavcnik, 2002). Closely related to the current paper, De Loecker (2011) shows that the mentioned phase of trade liberalization in the textile sector had positive productivity effects for Belgium textile firms. He explains this finding by increased competitive pressure forcing firms to adjust and become more efficient. Another channel through which trade liberalization may effect firm productivity is by leading to a greater availability of imported inputs.[3] Such improvements in productivity can in turn translate into increased selection into the export market. Hence, trade liberalization can indirectly impact firms' exporting

[1] See e.g. Greenaway and Kneller (2007) and Wagner (2007) for surveys of this literature.

[2] Note that the EU reintroduced / extended certain quota restrictions even after 2004.

[3] Bas and Strauss-Kahn (2011) show that firms can improve their productivity by importing due to a better fit of imported inputs (complementarity channel) and technology transfers imbedded in the imported goods (technology channel). Kasahara and Lapham (2012) and Bas (2009) present theoretical models incorporating the idea of positive productivity effects from importing.

dynamics through its effect on productivity. Bas (2012) presents evidence for this indirect effect of trade liberalization on exporting by showing that input trade liberalization led to increased export participation of Argentinean firms. Increased selection into the export market may then again have feedback effects on productivity (learning by exporting).

The contribution of the present paper is to develop and estimate an empirical, structural model which combines these previously independently treated mechanisms allowing an assessment of the importance of the respective mechanisms within a common framework. In the model, firm-level productivity dynamics can be endogenously affected by trade liberalization and exporting activities, while at the same time a firm's export market participation decision is modeled where firm productivity determines short-run export profits. Hence, trade liberalization can indirectly affect exporting through productivity effects. The overall model setup is comparable to Aw et al. (2011) in that a firm's optimization problem contains a static and a dynamic part. In the static part, lagged realizations of trade liberalization and export status can influence firm productivity. Moreover, current realizations of firm productivity determine a firm's short-run profits from exporting. In the dynamic part, the firm makes an optimal export market participation decision accounting for sunk and fixed costs of exporting.[4]

To model the static decision problem, I draw from recent insights presented by De Loecker (2011) who shows how to estimate the impact of trade liberalization on firm productivity while accounting for unobserved price and demand shocks. I apply a similar approach in the current paper, whereas I am not able to use product-level data implying that I consider quota protection at the 4-digit NACE industry-level.[5] Besides trade

[4]Recent studies indicate that productivity premia for importers can be higher than that for exporters (e.g. Smeets and Warzynski (2013)). It may therefore be interesting to also consider firms' import decisions in the model. Given the focus of the available literature, I decided to concentrate on the relationship between trade liberalization, productivity, and exporting in the present paper. Including firms' import decisions would increase the complexity of the model and may actually require a different modeling choice.

[5]I tried to use data from a survey on Danish firms sales by product; however, too few firms in the textile sector are part of this survey making an econometric analysis within the current setup infeasible. This survey potentially also provides information on prices which could help address an omitted price variable bias in the estimation approach. However, the price information is not available for many firms in the textile sector which is why I decided to follow De Loecker's approach of accounting for unobserved prices (see below).

liberalization, I allow lagged export status to affect current productivity and therefore additionally account for learning by exporting. To model short-run export profits, I rely on insights from Aguirregabiria (2010) who shows how to consistently estimate the parameters of interest in a setting similar to mine.

The dynamic part of the model is comparable to other recent studies which structurally estimate firms' export decisions (Das et al. 2007; Aw et al., 2011; Kasahara and Lapham, 2012). I do depart from these papers in terms of the estimation approach; instead of Bayesian or maximum likelihood based approaches, I use the estimation routine suggested by Bajari et al. (2007, henceforth BBL) in the current paper. The estimation approach consists of two steps and is based on a simple rationale. In the first step of this approach, non-parametric estimates of the data are obtained describing how firms behave at every state. In the second step, the equilibrium conditions from the underlying model are imposed to uncover why firms behave in the observed way. One advantage of this estimator is that it can deal efficiently with a fairly large state space by making use of simulation techniques (Aguirregabiria and Mira, 2010). On the other hand, the finite sample bias may be larger.

Before presenting the estimation results from the structural model, I try to replicate some evidence on the relationships between exporting and productivity as well as productivity and trade liberalization from existing studies. The results from these reduced-form regressions are as expected. First, the usual trade premium in terms of productivity is found for exporting firms. Second, firm-level productivity is positively correlated with trade liberalization at the 4-digit NACE industry level. While these results point towards the expected correlations, they do not allow to make any causal statements.

I therefore turn to the estimation of the structural model. The results show that productivity evolution indeed is endogenous. In particular, it is positively impacted by trade liberalization. On the other hand, learning by exporting does not appear to be a relevant phenomenon for firms in the textile-producing industry in Denmark. Estimation of short-run export profits reveals that firm characteristics are important determinants of exporting profits and, in particular, firm-level productivity appears to be important.

The dynamic part of the model allows to estimate sunk and fixed costs of exporting in monetary values. Sunk export market entry costs are estimated to be substantial amounting on average to USD 545,000. This figure underlines the relevance of the selection effect given that only more productive are able to pay them. Yearly fixed costs of exporting amount on average to USD 29,000. The textile sector has a large amount of fairly small firms which is why I also estimate these costs separately for small and large firms. This distinction suggests that there can be significant variation in entry costs depending on firm size. While sunk costs for smaller firms on average amount to USD 400,000, for larger firms they amount on average to USD 1,000,000. Comparing these costs estimates to other studies which also analyze the textile sector suggest that these parameters are in the medium range of available cost estimates.

Overall, the results suggest that self-selection of high productivity firms is a driving channel for firms' export market participation. On the other hand, learning by exporting does not seem to play an important role for firms in the textile industry in Denmark. Moreover, I can corroborate existing studies in that trade liberalization has a positive effect on firm productivity. As a final exercise, I can use the estimated parameters of the model to investigate the indirect effect of trade liberalization on exporting via the productivity channel. In particular, I can perform a counterfactual experiment where I simulate the development of the firms based on the estimated parameters while assuming full trade liberalization during all years. I can then compare the simulated export market entry and exit rates with the predicted rates based on the actual development of trade liberalization. The results suggest that this indirect effect of trade liberalization on export participation is only of minor relevance. This can be explained by the estimated effect of trade liberalization on productivity which is too small to significantly raise export market entry.

The rest of the paper is structured as follows. In the next section I outline the most important parts of the empirical model. Section 3 describes the data and presents some reduced-form evidence on the relationships between trade liberalization, productivity, and exporting. In section 4 I present the estimation approach while section 5 contains the results. Section 6 concludes.

2 An Empirical Model of Firm Export Participation

In the following I present a model of firm-level export participation and endogenous productivity dynamics in the face of trade liberalization. The underlying assumptions of the model are in several ways similar to those of the models of Das et al. (2007) and Aw et al. (2011). I assume that firms engage in monopolistic competition both in the domestic and foreign markets. Firms' demand schedules vary by industry, while firms are heterogenous in terms of marginal production costs implying varying export profit trajectories across firms. Moreover, I focus on the decision to export and firms' productivity dynamics and abstract from the decision to enter or exit production. The general model setup follows Aw et al. (2011) in several ways, while I depart by allowing for a more complex production function, by applying a different estimation approach both with respect to the static and the dynamic decision problems, and by considering the role of trade liberalization. On the other hand, I do not consider R&D investments and unobserved foreign demand shocks in this study as they do. Similar to their model, a firm's decision problem is distinguished into a static and a dynamic part. In the static part, a firm's productivity and input choice determine short-run export profits. In the dynamic part, firms optimally decide on export market participation. This is a dynamic decision problem as firms have to pay sunk costs and fixed costs of exporting. This decision is allowed to have feedback effects to firm productivity (learning by exporting).

2.1 Static Decision

A firm i faces a standard Cobb-Douglas production function where a unit of output Q_{it} depends on the choice of the inputs capital (K_{it}), labor (L_{it}), and materials (M_{it}) as well as a productivity shock (ω_{it}) and an error term (u_{it}) capturing measurement error and idiosyncratic shocks to production.

$$Q_{it} = K_{it}^{\alpha_k} L_{it}^{\alpha_l} M_{it}^{\alpha_m} \exp(\omega_{it} + u_{it}). \tag{1}$$

On the demand side, the firm faces a standard CES demand system with different substitution patterns by industry d.

$$Q_{it} = Q_{dt}\Big(\frac{P_{it}}{P_{dt}}\Big)^{\eta_d}\exp(\xi_{jt}). \tag{2}$$

Hence, the demand for firm i depends on its own price (P_{it}), the average price in the industry (P_{dt}), an aggregate demand shifter (Q_{dt}), the segment-specific elasticity of substitution ($|\eta_d| > 1$) and unobserved, segment j specific demand shocks (ξ_{jt}). The industry level d is the 2-digit NACE industry classification, as this is the most detailed level for which I can obtain industry prices P_{dt}. The segment level j is the most detailed industry classification; i.e. NACE 4-digit. Klette and Griliches (1996) and De Loecker (2011) show how this demand system together with the standard Cobb-Douglas production function can be exploited to deal with the omitted price variable bias related to a potential correlation of inputs with omitted firm-level prices. Moreover, the applied approach is crucial in order to obtain productivity estimates that are purged from price and demand variation. Otherwise a relationship between productivity and trade liberalization would be identified which simply mirrors the effect of trade liberalization on prices and demand (De Loecker, 2011). The approach involves solving equation (2) for the price P_{it} and plugging this term together with equation (1) into the expression for firm revenue $R_{it} = P_{it}Q_{it}$. Taking logs of the resulting equation and defining log deflated revenue by $\tilde{r}_{it} = r_{it} - p_{dt}$ (where lower case letters indicate variables in logs) results in the following expression:

$$\tilde{r}_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \sum_d d_{it}\beta_d q_{dt} + \omega^*_{it} + \xi^*_{jt} + u_{it} \tag{3}$$

Note that the coefficients here are reduced form coefficients as indicated by the use of β instead of α. In particular, $\beta_h = \big(\frac{\eta_d+1}{\eta_d}\big)\alpha_h$ for $h = k, l, m$. Similarly, the unobserved productivity shock is pre-multiplied by $\big(\frac{\eta_d+1}{\eta_d}\big)$ leading to ω^* and the unobserved demand shock is pre-multiplied by $|\eta_d|^{-1}$ leading to ξ^*, where $\frac{1}{\eta_d} = \beta_d$ is the inverse of the segment-specific demand parameter and q_{dt} refers to segment-level output. To be precise, q_{dt} is the market share weighted sum of domestic industry-level output computed as $q_{dt} = \sum_{i=1}^{N_d} ms_{idt}\ln R_{it}$ where N_d denotes number of firms in industry d, ms_{idt} is firm i's market share in industry d and R_{it} is firm i's domestic revenue (Klette and Griliches, 1996).[6] As indicated by equation (3), q_{dt} is expanded to $\sum_d d_{it}\beta_d q_{dt}$ in order to estimate the equation jointly for all industries where d_{it} is a dummy variable switching on if firm i belongs to industry d.

Equation (3) will be used to obtain estimates of firm productivity and sector-specific demand elasticities which are required to model firms' export participation decisions. I should point out that the demand elasticities are obtained from the market share weighted domestic industry-level output. Hence, the inverse of the coefficients β_d (with $d =$ (NACE 17, NACE 18)) are domestic demand elasticities. I use these demand elasticities also for the foreign market implying that I assume that domestic and foreign demand schedules are similar. This assumption may appear strong which is why I account for the possibility of differing domestic and foreign demand schedules in an extension in the appendix. I should, however, already note that the firms in the textile producing sectors in Denmark are often small and produce differentiated goods which may imply that domestic and foreign demand schedules are not too different for these firms. The demand elasticities are important as they allow dealing with the fact that I do not observe export market profits, but only export market revenue. Among others, Das et al. (2007) deal with this problem by exploiting a simple link between exporting profits and exporting revenue which holds under the broad assumption of profit maximizing firms:

$$\pi_{it} = r_{it}^X - \ln(|\eta_d|), \tag{4}$$

where superscript X indicates the export market, r_{it}^X is log export market revenue and π_{it} is gross (of sunk and fixed costs) exporting profits. Hence, given the estimated demand elasticities, I can use firms' exporting sales to model exporting profits. I model export revenue equivalent to total revenue (i.e. as a function of firm-level inputs and productivity) and unobserved shocks specific to the export market.

[6]Note that I do account for imports when computing ms_{idt}.

2.2 Transition of the State Variables

Before describing the firm's dynamic optimization problem, I need to specify how the state variables transition over time. A standard assumption for productivity is that it evolves over time as a Markov process. As noted before, firm-level productivity is allowed to be endogenously affected by a firm's export participation and by trade liberalization. I therefore specify the law of motion of productivity as follows

$$\omega_{it} = g(\omega_{it-1}) + e_{it-1} + qr_{jt-1} + \upsilon_{it} \tag{5}$$

where e_{it-1} is an indicator variable of firm i's export market participation in the previous year, qr_{jt-1} measures the one year lagged degree of protection of segment j in which firm i is active and υ_{it} is an iid zero-mean shock with standard deviation ϑ_{υ} which accounts for the stochastic nature of the productivity process. Including e_{it-1} in the Markov process allows for the possibility of learning by exporting. Hence, from this equation I can identify the effects of trade liberalization and exporting on productivity. Note that ω_{it-1} in equation (5) controls for unobserved time-varying differences among firms as well as the well known selection effect of more productive firms into the export market (De Loecker, 2012).

Equation (5) allows to identify the effect of trade liberalization on productivity while it is silent about the exact mechanism that is at play. As mentioned in the introduction, firms' productivity responses to reduced protection may be the result of increased competition and improved availability of foreign inputs. The former point relates to a situation where increased competitive pressure forces firms to reduce their X-inefficiencies, cut some slack or eliminate some other agency problem.[7] The latter channel rests on the idea that trade liberalization allows firms to source better quality (high technology) or low cost inputs. As the quotas were imposed against imports from developing countries, the mechanism related to better quality inputs was probably not very important. Moreover, under the rules of the Multi Fibre Agreement (MFA), which governed the textile quotas

[7] Recent evidence suggest that firms respond to increased low wage competition by upgrading the skill share of their workforce (Ashournia et al. (2013)). Such behavior may also result in higher firm-level productivity.

until 1994, countries were allowed to set their own quotas on imports from developing countries in case of market disruptions. Most likely, the EU was not very keen on keeping required inputs out which may also cast doubts on the relevance of the price channel.[8] In line with De Loecker (2011), I therefore believe that the competition channel was more relevant in the present analysis which is why I will mainly refer to this mechanism when discussing productivity responses to trade liberalization. Nevertheless, I should emphasize that the coefficient on qr_{jt-1} may capture both effects.

Regarding the other state variables, I assume that firm-level inputs labor and materials follow first order Markov processes conditional on lagged export status. Capital is assumed to be constant over time and quota protection is assumed to follow an exogenous first order Markov process. Note that I have to discretize all variables when modeling the dynamic decision process. I do so by using a grid that is uniform in the space of percentiles of the empirical distribution of the variables. Productivity and firm inputs are discretized into eight bins and quota protection is discretized into four bins.[9]

2.3 Dynamic Decision

The exporting decision has to be modeled in a dynamic framework as firms have to pay irreversible sunk costs (SC) when entering the export market for the first time. Moreover, firms have to pay per-period fixed costs (FC) when they export. Gross exporting profits $\pi_{it}(\cdot)$ therefore need to be adjusted by these costs. As standard in the literature of dynamic discrete choice models, I assume that there is a choice-specific iid shock $\varepsilon_{it}(e)$ which is additive separable in the profit function. Firm i's per-period flow payoff from exporting is then given by

$$\Pi_{it}(\cdot) = \pi_{it}(\cdot) - e_{it-1}\gamma_{FC} - (1 - e_{it-1})\gamma_{SC} + \varepsilon_{it}(e_{it}), \tag{6}$$

[8]The data on imports of textile products seems to supports this conjecture. While imports of final goods grew on average by 5.3% in each year between 1995 and 2004 (the period during which quotas where phased out) and by 9.2% between 2005 and 2007 (when quotas where fully removed), imports of intermediate goods remained almost constant during both periods suggesting that quotas mainly restricted imports of final goods.

[9]Note that keeping capital constant over time is in line with previous studies such as Das et al. (2007) and Aw et al. (2011). Furthermore, Aw et al. (2011) also discretize capital into eight bins.

where $\pi_{it}(\cdot)$ are gross exporting profits and γ_{FC} and γ_{SC} are the log transformed fixed ($\ln(FC)$) and sunk costs ($\ln(SC)$) of exporting, respectively. I assume that a firm's decision process is Markovian, implying that firms only condition on the current state vector and their private shocks when deciding whether to export (see e.g. Ryan, 2011). This assumption seems reasonable, given that all observable state variables evolve as first order Markov processes so that their current realizations provide the firm with all the necessary information when making its export decision. Thus, each firm's strategy $\sigma_i(\boldsymbol{s}, \varepsilon_i)$ is a mapping from states and shocks to actions: $\sigma_i : (\boldsymbol{s}, \varepsilon_i) \to e_i$, where the vector $\boldsymbol{s}$ contains all observable state variables. Further, given an infinite horizon, bounded profits and a discount factor δ below unity, firm i's expected exporting profits in a given state can be written recursively as:

$$V_i(\boldsymbol{s};\boldsymbol{\sigma}) = E_\varepsilon[\Pi_i(\boldsymbol{\sigma}(\boldsymbol{s},\boldsymbol{\varepsilon}), \boldsymbol{s}, \varepsilon_i) + \delta \int V_i(\boldsymbol{s}';\boldsymbol{\sigma}) dP(\boldsymbol{s}'|\boldsymbol{\sigma}(\boldsymbol{s},\boldsymbol{\varepsilon}), \boldsymbol{s})|\boldsymbol{s}], \tag{7}$$

where bold letters indicate vector notation; i.e. $\mathbf{s}$, $\mathbf{e}$, and $\boldsymbol{\varepsilon}$ are vectors of observed states, actions, and private shocks, respectively. Moreover, V_i is firm i's value function; to be precise, V_i is firm i's ex ante value function by reflecting expected profits before private shocks are realized. Given the above assumptions, in equilibrium we have that $V_i(\boldsymbol{s};\boldsymbol{\sigma}) \geq V_i(\boldsymbol{s};\boldsymbol{\sigma}')$ implying that the profile $\boldsymbol{\sigma}$ is a Markov perfect equilibrium (BBL).

3 Data

3.1 Data Sources and Summary Statistics

The analysis is based on firms in textile-producing industries (2-digit NACE codes 17 and 18) that were located in Denmark during the period 1993-2004.[10] This is an interesting sector for studying the effect of trade liberalization on productivity and exporting as it experienced a phase of trade liberalization between 1995 and the beginning of 2005 when WTO ruling required the abolishment of all quota protection on textile products. It should be noted that the textile industry has undergone significant restructuring since

[10]Note that during data cleaning I drop observations with strange values such as negative domestic sales, firms that leave and re-enter the sample, and firms that are in the sample for less than 3 years.

the 1970s with the upcoming of increased low-wage competition from countries in South-East Asia and production offshoring to these countries. As a result, the structure of the sector within the EU in general and in Denmark in particular has changed towards small, privately owned firms. For instance, in 1999 the average EU textile-producing firm only had 19 employees (Olsen et al., 2004). The average number of employees of the firms analyzed in this study is 32, while the median is 15. Olsen et al. (2004) point out that this structure is in line with a high degree of product differentiation as well as niche production. On the one hand, such a structure may make firms less responsive to increased low-wage competition. On the other hand, such a structure may imply a very low degree of industry concentration making coordinated efforts (e.g. in terms of research and development) difficult. This may, however, be important to face an increased price pressure from abroad. It is therefore an interesting question to ask to what extent these largely small and capital-intensive firms were able to face the increased low-wage competition following the reduction in quota protection. In particular, it is analyzed whether these firms were able to face this competition by improving their productivity and potentially exploiting new export opportunities.

In total, there are 346 firms in my sample with a total number of observations of 2892. Table 1 provides summary statistics on the variables used in the empirical analysis. It can be seen that, unlike many other countries, most firms in the textile industry in Denmark export in a given year (72%). This is in line with the understanding of Denmark being a small open economy. In total, there are 104 export initiations and 98 export market exits. This variation in export status is important in order to identify sunk and fixed costs of exporting. Table 2 presents the number of observations by trading status and segment j over the sample period.

Most of the data are sourced from Statistics Denmark providing firm-level accounting data and customs data on the firm's international trading activities. Furthermore, I merge data from the EU commission on import quotas to my data set. The EU commission provides online information on the implementation of quotas for textile products by foreign market for all years since 1993.[11] Note that the EU commission lists the quotas by product

[11] The quota data can be downloaded from http://trade.ec.europa.eu/sigl/querytextiles.htm

category and foreign market for which the quota applies. The products are classified into special categories which are linked to 8-digit CN codes by a correspondence table. In total, a quota was imposed on 122 products (EU category) in my data set and the EU imposed import quotas on products from 57 countries. I build a data set containing all countries and product categories over the sample period which states whether the EU imposed a quota on products p from country c in year t. I then construct a protection variable qr_{jt} which varies by segment j and by time t using this data set. As in De Loecker (2011), the average protection that applies to a product in a given year looks as follows:

$$qr_{pt} = \sum_{c} a_{ct} qr_{cpt}. \tag{8}$$

qr_{cpt} is a dummy variable which is equal to 1 if the EU imposes a quota on imports of product p from country c in year t and which switches to zero if the quota no longer applies.[12] a_{ct} is a weight of the supplying country c in year t. In the analysis below, I use a country's GDP as weight which is an indicator of a country's production potentials. Moreover, as a check of robustness, in the appendix I present results when using equal weights across countries. To obtain a segment-specific protection variable, I take the simple average of qr_{pt} across all products belonging to segment j. Figure 1 presents plots of this variable for each 4-digit industry over time. The reduction in magnitude of this variable over time indicates the degree of trade liberalization that firms in the textile producing sectors where facing. Note that I use the correspondence between EU product categories and 8-digit CN codes as well as the correspondence between 8-digit CN codes and the prodcom classification to merge the protection data by 4-digit NACE industry to my firm-level data set.

3.2 Some Background on the Implementation of Quotas

Until 1994 quotas were organized under the Multi Fibre Arrangement (MFA). Quotas were negotiated bilaterally between developed economies and developing countries, whereas

[12]Note that the quota data also contain information on quota levels. However, quotas are measured in different units (e.g. kg, m^3) making a mapping into one coherent measure difficult. I therefore decided to follow De Loecker's (2011) "cleaner" approach based on a dummy variable.

the former imposed restrictions on textile imports from the latter to protect domestic industries. Until 1992 most quotas of EU member countries were already negotiated for the whole bloc and after 1992 all quotas were managed at the EU level without member-specific rules. The allocation of quotas under the MFA was administered by the exporting country. So while e.g. the EU decided on the general implementation of quotas (against which product and country as well as the quota level), the exporting country was responsible for allocating the quotas to the firms. The idea behind this was to shift the quota rents to developing countries (Dayaratna-Banda and Whalles, 2007). In 1995 the Agreement on Textiles and Clothing (ATC) took effect which was a transitional instrument to phase out all textile quotas in four steps during a 10 years period.[13]

As also emphasized by De Loecker (2011), an important working assumption is the exogeneity of the quotas which means that level of protection (qr_{jt}) is not correlated with shocks to productivity (v_{it}). This assumption implies that an individual Danish firm had no power over the implementation of quotas and was not involved in the timing decisions of the phasing out process of specific quotas. Given that both decisions were made at the EU level, the assumption appears plausible.

3.3 A First Look at the Data

To motivate the consecutive analysis, I present some initial evidence on the relationship between exporting and productivity and trade liberalization and productivity. First, in Table 3 columns (i) and (ii), I present the trade premium of exporting firms relative to non-exporting firms in terms of labor productivity. In particular, I regress the log of value added per employee on a dummy variable indicating firms' export participation. In column (i) I control for segment fixed effects and obtain a trade premium of 49%. In column (ii) I consider time series evidence by estimating a firm fixed effect specification. The coefficient on the exporting dummy is again positive and highly significant while it reduces in magnitude. The results therefore suggest a relationship between exporting and productivity while it is not possible to make statements about the direction of causality.

[13]Step 1 (1995-1997): elimination of quotas equivalent to 16% of 1990 imports. Step 2 (1998-2001): 17%. Step 3 (2002-2004): 18%. Step 4 (2005) 49% (see www.wto.org for more details).

Estimation of the structural model will allow to draw conclusions about this issue.

In columns (iii) and (iv) of Table 3 I regress log labor productivity on the protection variable while I again first consider segment fixed effects and then firm fixed effects. In either case a negative and significant effect is obtained. It is important to stress that the negative sign is expected here as more protection implies a higher value of the variable qr_{jt}. Hence, firm productivity and trade liberalization are positively correlated. The magnitude of the coefficients are substantial suggesting that a removal of all quota restrictions raises firm productivity by 25% and 18%, respectively. In section 5 I will re-estimate these effects while considering total factor productivity instead of labor productivity and accounting for unobserved prices and demand shocks.

4 Estimation

4.1 Estimation of Productivity and Demand Elasticities

As mentioned before, I use equation (3) to estimate firm productivity and sector-specific demand elasticities. Comparable to De Loecker (2011), I assume that the unobserved, segment-specific demand shock ξ_{jt} can be decomposed into the following components:

$$\xi_{jt} = \xi_j + \xi_t + \tau qr_{jt} + \tilde{\xi}_{jt} \tag{9}$$

ξ_j are segment-specific dummy variables, ξ_t are year fixed effects, τ is a parameter to be estimated in front of the sector-specific protection variable qr_{jt} and $\tilde{\xi}_{jt}$ is an iid demand shock. I therefore use the same measure of trade liberalization qr_{jt} in order to assess its effect on firm productivity and to proxy for unobserved demand shocks. The main difference is that I use the lagged realization of trade liberalization to assess the effect on productivity. This should account for the fact that it can take some time for firms to reorganize, cut slack, and e.g. introduce an improved supply chain management (examples which potentially affect ω_{it} without affecting the inputs). Less protection, however, can affect demand (and prices) and hence firm revenue instantaneously as shown in equation

(9). The resulting estimation equation then looks as follows:

$$\tilde{r}_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \sum_d d_{it}\beta_d q_{dt} + \sum_{jt} \kappa_{jt} D_{jt} + \tau^* qr_{jt} + \omega^*_{it} + v_{it}, \quad (10)$$

where $v_{it} = u_{it} + \tilde{\xi}_{jt}$ captures idiosyncratic shocks to production (u_{it}) and demand ($\tilde{\xi}_{jt}$). I collect the segment dummy variable as well as the year fixed effects in $\kappa_{jt} D = \sum_{jt} \kappa_{jt} D_{jt}$. Equation (10) can then be estimated using the common approaches to the estimation of production functions. As standard nowadays, I use a control function approach to estimate equation (10). Recent advancements in this literature point towards problems regarding the identification of the labor coefficient in the first stage of estimation routines à la Olley and Pakes (1996) and Levinsohn and Petrin (2003). I therefore use the Ackerberg et al. (2006) approach to estimate equation (10) which specifically deals with this issue. In the following, I shortly outline the estimation algorithm.

I follow the insight from Levinsohn and Petrin (2003) and use intermediate inputs m_{it} as proxy for the unobserved productivity shock ω_{it}. As De Loecker (2011) points out in a setting similar to this paper, the important point to note is that a firm's choice of materials is directly related to it's productivity, capital stock and all demand variables which influence a firm's residual demand and therefore its optimal input choice. The material demand equation is then given by

$$m_{it} = m_t(k_{it}, l_{it}, \omega_{it}, qr_{jt}, q_{dt}, D, e_{it}). \quad (11)$$

Note that I also include firm i's export status into equation (2) to allow for differences in input demand between exporting and non-exporting firms. De Loecker (2011) shows that the monotonicity of input demand in productivity is preserved under the current assumption of monopolistic competition implying that a function $h(\cdot)$ exists which can proxy for productivity

$$\omega_{it} = h_t(k_{it}, l_{it}, m_{it}, qr_{jt}, q_{dt}, D, e_{it}). \quad (12)$$

The first step of the algorithm consists of estimating

$$\tilde{r}_{it} = \phi_t(l_{it}, k_{it}, m_{it}, qr_{jt}, q_{dt}, D, e_{it}) + v_{it}, \tag{13}$$

where

$$\phi_t(\cdot) = \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_s q_{dt} + \kappa_{jt} D + \tau^* qr_{jt} + h_t(\cdot). \tag{14}$$

I approximate the function $h_t(\cdot)$ using a polynomial expansion of order four of its argument and obtain $\hat{\phi}_{it}$. Hence, the first step allows me to compute productivity for any parameter value as $\omega(\beta_l, \beta_k, \beta_m, \beta_d, \kappa_{jt}, \tau^*) = \hat{\phi} - \beta_l l_{it} - \beta_k k_{it} - \beta_m m_{it} - \beta_s q_{dt} - \kappa_{jt} D - \tau^* qr_{jt}$. The second stage then relies on the law of motion of productivity (equation 5) in order to obtain the innovation to productivity $v_{it}(\beta_l, \beta_k, \beta_m, \beta_d, \kappa_{jt}, \tau^*,)$ as the residual from non-parametrically regressing $\omega(\beta_l, \beta_k, \beta_m, \beta_d, \kappa_{jt}, \tau^*)$ on its lag and qr_{jt-1} and e_{it-1}. I can then specify moments to identify the parameters of interest (see De Loecker (2011) for more details).

$$E\left(v_{it}(\cdot) \begin{pmatrix} l_{it-1} \\ m_{it-1} \\ k_{it} \\ q_{dt-1} \\ qr_{jt} \\ D \end{pmatrix} \right) = 0 \tag{15}$$

Note that I follow De Loecker (2011) in the practical implementation and do not consider interactions between the segment and time dummies and the other variables. Instead, I include D into the non-parametric regression of ω_{it} on ω_{it-1}, qr_{jt} and e_{it} when constructing the innovation v_{it} and I thereby obtain an estimate of productivity while controlling for segment and year dummies. Finally, the sample analog of equation (5) is given by

$$\frac{1}{T}\frac{1}{N}\sum_t\sum_i \upsilon_{it}(\beta)\begin{pmatrix} l_{it-1} \\ m_{it-1} \\ k_{it} \\ q_{dt-1} \\ qr_{jt} \\ D \end{pmatrix} \tag{16}$$

which is minimized by GMM. I then compute productivity ω from

$$\hat{\omega}_{it} = \Big(\tilde{r}_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_s q_{dt} - \hat{\tau}^* qr_{jt}\Big)\Big(\frac{\hat{\eta}_d}{\hat{\eta}_d + 1}\Big). \tag{17}$$

4.2 Estimation of Exporting Costs

The dynamic decision problem is estimated using BBL's algorithm for dynamic discrete choice models. The algorithm is based on the above assumption of a Markov perfect equilibrium, i.e. each firms' behavior only depends on the current state and its current private shock. The estimation approach belongs to the class of conditional choice probability estimators (CCP) (Hotz and Miller, 1993) and specifically relates to Hotz et al. (1994) by making use of forward simulation. The algorithm consists of two parts; first the policy function and the law of motion of the state variables are estimated. In the second step, the structural parameters are estimated using the optimality condition for equilibrium.

In the current setup, the structural parameters of the model are the discount rate δ, the profit function Π_i, and the distribution of the private shocks. In the following, δ is treated as known and the private shocks are assumed to be drawn from a type-1 extreme value distribution. The profit functions are assumed to be known up to a finite parameter vector $\boldsymbol{\theta}$. The dynamic structural parameters of the profit function are obtained from imposing the equilibrium condition: If firms follow Markov strategies, then in equilibrium $V_i(\boldsymbol{s};\boldsymbol{\sigma}) \geq V_i(\boldsymbol{s};\boldsymbol{\sigma}')$. In the following, I outline the estimation details for the two steps of the algorithm.

First step

In the first step, I estimate the coefficients of the gross export profit equation, the transition probabilities of the states, and the policy function. The obtained parameters are then used to calculate the value function.

Estimation of gross export equation

As mentioned above, firms' export sales depend on the same arguments as total revenue which is why I model export profits as a function of a firm's choice of inputs and it's productivity. Moreover, I approximate unobserved export market demand shocks using the same proxy as for total sales; i.e. qr_{jt}. Remember that qr_{jt} measures trade liberalization by capturing changes in quota protection of the EU textile market. This measure may also have affected Danish firms' export profits as these firms may have faced tougher competition in EU export markets. Moreover, the reduction in quota protection affected other developed economies so that Danish firms also may have faced tougher competition in those markets. Note that I do not consider 4-digit NACE industry and time dummies in the dynamic decision problem as this would simply make the state space too large. I do, however, consider a linear time trend. Gross export profits are therefore given by

$$\pi_{it} = r^X_{it} - \ln(|\eta_d|) = \gamma_k k_{it} + \gamma_l l_{it} + \gamma_m m_{it} + \gamma_\omega \omega_{it} + \gamma_{qr} qr_{jt} + \gamma_t trend + u^X_{it}, \qquad (18)$$

where γ_h $(h = k, l, m, \omega, qr, t)$ are unknown parameters, and u^X_{it} is an error term. This equation contains the observable state variables $\boldsymbol{s}$ the firm conditions on when marking the optimal export participation decision. Note that this gross export profit equation reflects a static optimization problem implying that its parameters can be estimated in the first step separately. This possibility is ensured by assuming conditional independence between gross profits and the choice-specific shocks ($\varepsilon_{it}(e)$) as pointed out by Aguirregabiria and Mira (2010). The conditional independence assumption consists of two parts. First, the unobserved states $\varepsilon_{it}(e)$ and u^X_{it} have exogenous transition probabilities implying that their transitions do not depend on the firm's current export decision. Second, conditional on the observed state variables s, $\varepsilon_{it}(e)$ and u^X_{it} have independent transitions and $\varepsilon_{it}(e)$ is not serially correlated (Aguirregabiria, 2010).

Despite the conditional independence assumption, estimating the gross export profit equation (18) by OLS would lead to a selection bias if u_{it}^X is not mean independent of the firm's exporting decision in period $t-1$. Assuming mean independence here may be too strong which is why I draw from the insight of Aguirregabiria (2010) and make the following two assumptions to address this issue. First, I assume that the error term u_{it}^X follows a first order Markov process:

$$u_{it}^X = f(u_{it-1}^X) + \zeta_{it}. \tag{19}$$

This assumption is standard. Second, I assume that the innovation ζ_{it} is iid and unknown to the firm when it makes the decision to export in period t. Note that this assumption is significantly weaker than assuming that u_{it}^X is unknown to the firm when it makes the exporting decision. In particular, this assumption allows the selection of the firm to depend on u_{it-1}^X. Therefore, if a firm is exporting in periods t and $t-1$, the estimation equation for gross export profits becomes

$$\pi_{it} = \gamma_h s_t + f(\pi_{it-1}^* - \gamma_h s_{t-1}) + \zeta_{it}. \tag{20}$$

Note that given the second of the just stated assumptions, we have that

$$E(\zeta_{it}|s_t, s_{t-1}, \pi_{it-1}^*, e_{it} = e_{it-1} = 1) = 0$$

so that equation (20) can be estimated by least squares. In particular, I estimate the equation by non-linear least squares and approximate the function $f(\cdot)$ by a polynomial series approximation ($u_{it}^X = \rho_1 u_{it-1}^X + \rho_2 (u_{it-1}^X)^2 + \zeta_{it}$). Further note that I estimate the equation based on the discretized state space. The state vector in the dynamic programming problem is then extended by u_{it-1}^X. I construct u_{it-1}^X based on the residuals from equation (20) by first estimating the density of the innovation ζ_{it} using a Gaussian kernel as suggested by Aguirregabiria (2010) and then applying the law of motion of u_{it}^X given by equation (19). I discretize u_{it-1}^X into four bins.

Estimation of transition probabilities

As mentioned before, the transition probabilities for productivity are estimated from equation (5) and those for u_{it}^X are given by equation (19). Firms' inputs follow first order Markov processes conditional on lagged export status. I estimate these transitions probabilities using polynomial series approximations. Note that for the implementation of the dynamic model, in all cases I draw the innovations from a distribution with zero mean and some standard deviation ϑ.[14] Moreover, qr_{jt} is assumed to follow an exogenous first order Markov process which I estimate using a frequency estimator.

Estimation of policy function

Given discrete choice data and the assumptions of choice-specific shocks entering profits additively ($\Pi_i(\boldsymbol{e}, \boldsymbol{s}, \varepsilon_i) = \tilde{\Pi}_i(\boldsymbol{e}, \boldsymbol{s}) + \varepsilon_i(e_i)$), the choice-specific value function is given by

$$v_i(e_i, \boldsymbol{s}) = E_\varepsilon[\Pi_i(e_i, \boldsymbol{s}) + \delta \int V_i(\boldsymbol{s}'; \boldsymbol{\sigma}) dP(\boldsymbol{s}'|e_i, \boldsymbol{s})], \tag{21}$$

so that firm i optimally chooses an action e_i which satisfies

$$v(e_i, \boldsymbol{s}) + \varepsilon_i(e_i) \geq v(e_i', \boldsymbol{s}) + \varepsilon_i(e_i'). \tag{22}$$

This is the policy rule which needs to be estimated in the first stage. Remember that I assume that the choice-specific shocks have a type-1 extreme value distribution. The choice-specific value function $v_i(e_i, s)$ can therefore be estimated directly from the data by making use of the result from Hotz and Miller (1993) who show that, given the assumptions on the choice-specific shocks, for any two actions e_i and e_i',

$$v(e_i', \boldsymbol{s}) - v(e_i, \boldsymbol{s}) = \ln(Pr(e_i'|\boldsymbol{s})) - \ln(Pr(e_i|\boldsymbol{s})), \tag{23}$$

where $Pr(e_i|\boldsymbol{s})$ is the probability of observing choice e_i in state s. Given that the state space is relatively large, I follow BBL's suggestion and estimate $Pr(e_i|\boldsymbol{s})$ as flexibly parameterized functions of the actions and states; in particular, I use a second order polynomial

[14] The standard deviations are obtained from the distributions of the residuals of the respective regressions.

expansion and a probit model.

Estimating the value function

After estimating the gross export equation, the transition probabilities and the equilibrium policy functions, it is possible to compute the equilibrium value functions which then allow to estimate the structural parameters of the model. BBL suggest to use forward simulation (Hotz et al., 1994) for this purpose following these steps:

1. Starting at state $\boldsymbol{s}_1 = \boldsymbol{s}$, draw private shocks ε_{i1} from the type 1 extreme value distribution

2. Calculate the specified action $e_{i1} = \sigma_i(\boldsymbol{s}_1, \varepsilon_{i1})$ for each firm i using the estimates for the policy function (note, I make use of the linearity of the parameters in firms' profits here and calculate profits later).

3. Draw a new state $\boldsymbol{s}_2$ using the estimated transition probabilities

4. Repeat steps 1-3 for T periods

The firm's discounted sum of profits is then averaged over many simulation paths n_s yielding an estimate for firm i's value function denoted $\hat{V}_i(\boldsymbol{s}; \boldsymbol{\sigma}; \boldsymbol{\theta})$. Such an estimate can be obtained for any policy pair $(\boldsymbol{\sigma}, \boldsymbol{\theta})$ including $(\hat{\boldsymbol{\sigma}}, \boldsymbol{\theta})$ where $\hat{\boldsymbol{\sigma}}$ is the estimated policy profile from the first stage.

Note that the unknown parameters (θ) enter firms' profit functions linearly implying that $\Pi_i(\boldsymbol{e}, \boldsymbol{s}, \boldsymbol{\varepsilon}; \boldsymbol{\theta}) = \boldsymbol{\Psi}_i(\boldsymbol{e}, \boldsymbol{s}, \boldsymbol{\varepsilon})\boldsymbol{\theta}$, where $\Psi_i^1 \ldots \Psi_i^M$ is an M-dimensional vector of basis functions. The value function can then be rewritten as:

$$V_i(\boldsymbol{s}, \boldsymbol{\sigma}; \theta) = E[\sum_{t=1}^{\infty} \delta^t \Psi_i(\boldsymbol{\sigma}(\boldsymbol{s}_t, \boldsymbol{\varepsilon}_t), \boldsymbol{s}_t, \varepsilon_{it}) | \boldsymbol{s}_0 = \boldsymbol{s}] \cdot \theta = \boldsymbol{W}_i(\boldsymbol{s}; \boldsymbol{\sigma}) \cdot \theta.$$

This can lead to substantial savings in computational time as W_i does not depend on the unknown parameters θ. Hence, for any σ, one can use forward simulation to estimate W_i

and then obtain V_i for any value of θ. In the current setup, this amounts to

$$\begin{aligned}
V_i(\boldsymbol{s},\boldsymbol{\sigma},\theta) &= \boldsymbol{W}^1(\boldsymbol{s},\boldsymbol{\sigma}) - \boldsymbol{W}^2(\boldsymbol{s},\boldsymbol{\sigma})\cdot\gamma_{FC} - \boldsymbol{W}^3(\boldsymbol{s},\boldsymbol{\sigma})\cdot\gamma_{EC} + \boldsymbol{W}^4(\boldsymbol{s},\boldsymbol{\sigma}) \\
&= E[\sum_{t=0}^{\infty}\delta^t\boldsymbol{\sigma}(\boldsymbol{s}_t,\boldsymbol{\varepsilon}_t)\Pi_i(\boldsymbol{s})|\boldsymbol{s}_0=\boldsymbol{s}] \\
&\quad -E[\sum_{t=0}^{\infty}\delta^t\boldsymbol{\sigma}(\boldsymbol{s}_t,\boldsymbol{\varepsilon}_t)\boldsymbol{\sigma}(\boldsymbol{s}_{t-1},\boldsymbol{\varepsilon}_{t-1}|\boldsymbol{s}_0=\boldsymbol{s}]\cdot\gamma_{FC} \\
&\quad -E[\sum_{t=0}^{\infty}\delta^t\boldsymbol{\sigma}(\boldsymbol{s}_t,\boldsymbol{\varepsilon}_t)(1-\boldsymbol{\sigma}(\boldsymbol{s}_{t-1},\boldsymbol{\varepsilon}_{t-1})|\boldsymbol{s}_0=\boldsymbol{s}]\cdot\gamma_{EC} \\
&\quad +E[\sum_{t=0}^{\infty}\delta^t\varepsilon(\boldsymbol{\sigma}(\boldsymbol{s}_t,\boldsymbol{\varepsilon}_t))|\boldsymbol{s}_0=\boldsymbol{s}],
\end{aligned}$$

where the first term gives the static profit of firm i given that the current state is $\boldsymbol{s}$. This term is calculated based on the parameters of the gross export profit equation (20) which is evaluated on the grid points of the discretized state space. The second and third terms are the expected present fixed and sunk entry costs of exporting respectively, and the last term is the expected present value of the realized private shocks with $\varepsilon(\boldsymbol{\sigma}(\boldsymbol{s}_t,\boldsymbol{\varepsilon}))$ being the shock related to the action chosen at time t.

Second step

The second step of the algorithm makes use of the equilibrium condition; namely that for all firms i and states s and alternative Markov policies σ_i', in equilibrium the following condition holds:

$$V_i(\boldsymbol{s};\boldsymbol{\sigma};\theta) \geq V_i(\boldsymbol{s};\boldsymbol{\sigma}';\theta) \tag{24}$$

This equilibrium condition defines a set of parameters θ that rationalize the strategy profile $\boldsymbol{\sigma}$. BBL propose a minimum distance estimator to obtain θ. Following BBL, I let $x \in \chi$ index the equilibrium conditions so that each x denotes a particular $(i,\boldsymbol{s},\sigma_i')$ combination. Then, I define

$$g(x;\theta,\varphi) = V_i(\boldsymbol{s};\boldsymbol{\sigma};\theta,\varphi) - V_i(\boldsymbol{s};\boldsymbol{\sigma}';\theta,\varphi).$$

Note that the dependence on φ is due to the fact that $\boldsymbol{\sigma}$ and P are parameterized by φ. Next, define the function

$$Q(\theta, \varphi) = \int (\min\{g(x; \theta, \varphi), 0\})^2 dH(x).$$

H is a distribution over the set χ of inequalities. BBL point out that the true parameter vector θ_0 satisfies $Q(\theta_0, \varphi_0) = 0 = \min Q(\theta, \varphi_0)$ and that θ can be estimated by minimizing the sample analog of $Q(\theta, \varphi_0)$.

For this purpose, denote X_k ($k = 1 \dots n_I$) the set of inequalities from χ chosen by the econometrician. BBL suggest to choose firms and states at random and then consider alternative policies σ' which are slight perturbations of the estimated policy σ (e.g. $\sigma' = \sigma + \epsilon$). For each chosen inequality X_k, one can then use forward simulation to construct the analog V_i terms. The suggested estimator then minimizes the following objective function

$$Q_n(\theta, \varphi) = \frac{1}{n_I} \sum_{k=1}^{n_I} (\min\{\hat{g}(X_k; \theta, \varphi), 0\})^2. \tag{25}$$

5 Estimation Results

5.1 Main Results

I present the results from estimating the production function in Table 4. I present both the scaled parameter estimates β and the true technology parameters α. The estimated input elasticities are of common magnitude and imply increasing returns to scale. The coefficient of the protection variable is positive and significant indicating that, as expected, the period of trade liberalization implied a negative demand shock for the firms. Moreover, Table 4 contains the coefficients on industry output (β_s) whose inverse represent demand elasticities. The elasticities for the NACE 2-digit sectors 17 and 18 amount to -7.7 and -8.1 and are therefore fairly similar.

In Table 5 I present the estimation results for the law of motion of productivity (equation 5). I present results based on continuous and discrete data; the results obtained from discrete data are the estimates that I use to model the law of motion of productivity in the dynamic part of the model. A couple of observations are worth noting here. First, note that the function $g(\cdot)$ in equation (5) is usually approximated by a polynomial expansion. I follow this approach in the first column of Table 5 and find an insignificant squared term of ω_{it-1}. I therefore drop this term and focus on results presented in the subsequent columns. As expected, firm productivity developments are very persistent which is indicated by the large coefficient on lagged productivity. Moreover, I find that trade liberalization indeed impacts firm productivity positively. The coefficient estimate suggests that removing all quota protection would on average increase productivity by 5.3%. On the other hand, the coefficient on lagged export status is insignificant suggesting that firms in the textile sector in Denmark did not experience productivity improvements from exporting during the sample period. One important channel through which exporting may affect productivity is related to contacts with buyers and competitors in the export market which may provide firms with relevant information to improve their efficiency. De Loeker (2007) presents evidence for this channel by showing that his finding of learning by exporting of Slovenian firms was too a large extent driven by exports to high income countries where such contacts are particularly valuable. Given that Denmark is a high income country and that the Danish textile sector is characterized by a large share of exporting firms, such contacts may not be as relevant for firms that start exporting in my sample which may explain the insignificant effect. Another reason for finding an insignificant effect may be that there is not sufficient export market entry. Theoretically, learning by exporting is most important for firms that start to export. The observed 104 export initiations may not be enough in order to identify the effect. The next column in Table 5 presents results when dropping the insignificant lagged export status variable and the last column presents the same model estimated on discretized data which I use to model the transition process of productivity in the dynamic part of the model.[15]

I next turn to Table 6 which contains estimation results for the gross export profit equation. Results in column (i) indicate that the trend variable is insignificant. To prevent having redundant state variables in the dynamic optimization problem, I drop the trend variable and re-estimate the model in column (ii). The coefficient of the protection variable

[15]In the appendix I present estimation results of the transition probabilities of the other observed state variables as well as estimation results of the policy function.

turns out to be positive but insignificant which is why I do not consider this variable in the dynamic decision problem either.[16] The estimates therefore do not suggest that there is a direct effect of trade liberalization on export profits for textile firms in Denmark implying that the varieties exported by the firms are not affected by increased exports from developing countries. On the other hand, a firm's input choice and, in particular, a firm's productivity are important determinants of short-run export profits as shown by the results in column (iii). Moreover, the results show that the assumption of a first order Markov process of u_{it}^X is warranted given its persistency which is indicated by ρ_1. Note that I use the estimates of ρ_1 and ρ_2 to model the transition process of u_{it}^X over time in the dynamic part of the model.

Before discussing the dynamic parameter estimates in detail, a couple of things are worth noting. First, I should point out that I estimate the standard errors analytically.[17] BBL suggest to use bootstrapping or sub-sampling to estimate the standard errors, however, this is problematic in the current setup due to the computational burden. The analytical standard errors might be biased as they do not incorporate the simulation error from the first step. I deal with this issue in the appendix by bootstrapping the standard errors for one set of results to evaluate the potential bias. I can already note that this bias appears to be small. Further note, that I present parameters obtained from estimations with the discount rate δ set to 0.90 and 0.95. These discount rates have been chosen by other studies (Das et al., 2007, Aw et al., 2011, Kasahara and Lapham, 2012) which structurally estimate optimal export market participation decisions and therefore allow better comparisons across studies. Finally, given that I am estimating a structural model, I can interpret the parameter estimates in monetary values.

The dynamic parameter estimates are presented in Table 7; the cost estimates are presented in in local currency (DKK) as well as USD and for discount rates of 0.90 and 0.95. In order to facilitate comparisons across studies, I focus on USD values in the following discussion. I first present results based on a discount rate of 0.90. Sunk export

[16] I only consider the effect of qr_{jt} on the productivity process as indicated by equation (5).

[17] To be precise, I compute the inverse of the Hessian matrix and then obtain the standard errors as the square root of the diagonal elements.

market entry costs are estimated to amount to USD 545,000 on average and yearly fixed costs of exporting to USD 27,000. These parameter estimates therefore suggest that export market entry indeed is very costly and underline the relevance of the self-selection mechanism. It is possible that these costs differ between small and large firms as e.g. noted by Aw et al. (2011). This may be particularly true for firms in the textile sector in Denmark which comprises many small firms (remember that the median number of employees is 15). I therefore allow the entry costs to be different for small and large firms, where a small firm is defined as a firm with a capital stock below the median. The results suggest that this distinction is indeed important in order to get an accurate understanding of these costs. For small firms sunk costs on average amount to USD 402,000 and for large firms to USD 1,026,000. I should note that the sunk costs parameter for large firms is estimated less precisely which can be explained by fewer export market initiations among these firms.

The remaining columns of Table 7 present parameter estimates for a discount rate of 0.95. The estimated parameters are very similar to those based on a discount rate of 0.90. The main differences are that fixed costs are estimated to be slightly higher when using a discount rate of 0.95 and that the parameters are estimated more precisely when using this discount rate. The slight increase in fixed costs can be explained by the fact that the discount rate and the cost parameters are highly collinear (Rust, 1987); i.e. both impose similar effects on export market entry. For instance, raising exporting costs tends to postpone export market entry; a similar effect is obtained from lowering the discount factor. Moreover, estimating the parameters more precisely when using a discount rate of 0.95 may imply that this discount rate is more adequate for the firms in this sample. Finally, it is important to remember that these cost estimates are based on the assumption of similar domestic and foreign demand elasticities. However, competition abroad may be believed to be fiercer than at home (implying a higher $|\eta_d|$ and therefore lower exporting profits), which would imply that the presented cost estimates should be interpreted as an upper bound. An extension in the appendix confirms this conjecture as the estimated cost parameters decrease when allowing for different foreign demand elasticities (sunk costs are estimated to amount on average to USD 435,000 and fixed costs to USD 19,000).

In Table 8 I compare these cost estimates with estimates from other studies of firms in the textile sector. Among the few studies that apply structural estimation approaches to firms' optimal export decisions, there are two papers which also look at the textile sector. Kasahara and Lapham (2012) estimate sunk and fixed costs of exporting for Chilean firms in the textile sector. These authors use a maximum likelihood approach to estimate the model and set the discount rate δ equal to 0.95. Das et al. (2007) estimate the parameters of interest for Columbian firms in the knitted fabrics sector which is a sub-sector of the textile industry. They apply a Bayesian approach to estimate the model and use a discount factor δ of 0.90. In the last two rows of Table 8, I again present the results from the current paper to ease comparison. Das et al. also estimate sunk costs separately for small and large firms. In their case, the parameter estimates are very similar for small and large firms amounting to around USD 400,000. Hence, their cost estimates for small firms are very similar to that for small firms found in this study. On the other hand, there appears to be a lot more variation in these costs depending on firm size in Denmark given that the costs estimate for larger firms is significantly higher in the present study. Higher entry costs for larger firms are also found by Aw et al. (2011) for firms in the electronics industry in Taiwan. Generally, it seems intuitive that small firms pay lower entry costs given that they operate on smaller scales. Nevertheless, the difference in entry costs found in the present study is striking. The explanation may lie in the left-skewed size distribution of the Danish textile sector. The firms with a capital stock above the median are significantly larger than the other firms which can imply much higher entry costs for these firms. Moreover, larger firms may tend to enter several markets in the first period while small firms only start exporting to one market. Due to market-specific entry costs, total costs of starting to export may therefore be higher for larger firms. Kasahara and Lapham estimate sunk and fixed costs averaged across all firms in the Chilean textile sector. Their sunk cost estimate amounts to USD 790,000 which is larger compared to the estimate obtained in this paper. Overall, I therefore conclude that my parameter estimates are within the medium range of available cost estimates while their appears to be more variation in these costs according to firm size compared to other studies.

5.2 In-sample Performance

In this sub-section I assess the in-sample performance of the model. In particular, I am interested in the extent to which the model correctly predicts export market entry and exit. To analyze this issue, I use the estimated parameters of the model and take the observations of all firms in the initial period of their appearance in the data. I then draw the choice-specific shocks $\varepsilon_{it}(e)$ and the innovations of the transitions processes of the state variables and simulate forward the export market trajectories of each firm for all years of its appearance in the data. To be precise, I use the estimated transition probabilities and the draws of their innovations to simulate forward the evolution of the state variables. Moreover, I use equation (20) to evaluate gross profits from exporting in a given period and I use equation (7) to determine the decision rule of the firm which can be written as $e_{it} = I(e^*_{it} > \varepsilon_{it}(0))$, where $I(\cdot)$ is an indicator function,

$$e^*_{it} = \Pi(s_{it}, \varepsilon_{it}, e_{it-1}|\theta) + \delta \Delta E_t V_{it+1}(s_{it}, \varepsilon_{it}|\theta), \quad (26)$$

and

$$\Delta E_t V_{it+1}(s_{it}, \varepsilon_{it}|\theta) = E_t[V_{it+1}|e_{it} = 1] - E_t[V_{it+1}|e_{it} = 0]. \quad (27)$$

The first component of equation (26) measures the current period profits from exporting and the second component measures the option value of being able to export in the next period without incurring entry costs as shown by equation (27) (also see Das et al., 2007). I use equation (26) to determine a firm's export status in a given period in the simulations.

For each firm, I simulate its export market trajectory 500 times and in each simulation round I construct export market entry and exit rates and then compute the averages across simulation rounds. In Table 9 I present these predicted rates together with the actual rates. The model over-predicts export market entry by around 1.7 percentage points. On the other hand, export market exit is predicted very precisely. I believe that despite over-predicting entry, the model still performs reasonably well in that the predicted entry and exit rates are relatively close to the actual rates. In the following sub-section I use the estimated parameters of the model to conduct a counterfactual analysis.

5.3 Counterfactual Analysis

In this final sub-section, I use the model to conduct a counterfactual exercise. The focus of this paper is on productivity and exporting dynamics during a phase of trade liberalization for firms in the textile producing industry in Denmark. I already established a couple of results related to the relationships between exporting, productivity and trade liberalization. First, trade liberalization positively affects firm productivity. Second, exporting is characterized by substantial sunk entry costs which more productive firms find easier to pay. Third, I do not find evidence for learning by exporting. A final mechanism which I mentioned in the introduction and which still needs to be investigated, is the indirect effect of trade liberalization on exporting via the productivity channel; i.e. trade liberalization raises firm productivity which may translate into increased selection into the export market.

The advantage of a structural model is that I can analyze these relationships in a common framework. To investigate the last mechanism, i.e. the indirect effect of trade liberalization on exporting via the productivity channel, I conduct a counterfactual experiment. In particular, I compare the predicted export market turnover rates from Table 9 column (ii) with those obtained from simulations with qr_{jt} set equal to zero; i.e. full trade liberalization in every period. The results presented in Table 9 column (iii) indicate that export market entry and exit are marginally affected only. To be precise, the export market entry rate does not change while the export market exit rate decreases marginally. An explanation for this outcome may be that productivity improvements related to trade liberalization allow some firms to better accommodate temporary negative shocks in the export market which allows them to stay in this market. However, overall the indirect effect of trade liberalization on exporting via the productivity channel appears to be only of minor importance which is related to the fact that the effect of trade liberalization on firm productivity simply is too small in order to significantly increase export market entry.

6 Conclusion

This paper analyzes firms' exporting and productivity dynamics during a period of trade liberalization. The relationship between exporting and productivity has been the subject of a large literature focussing on self-selection and learning by exporting. During a phase of trade liberalization the selection effect may be even more pronounced as trade liberalization can influence firm productivity which in turn can increase selection into the export market. Increased selection into the export market may then again have feedback effects on productivity.

The present paper develops an empirical model which allows assessing these different mechanisms within a common framework and thereby assessing their relative importance. In the model a firm's productivity development endogenously depends on its exporting decisions and the degree of trade liberalization. Moreover, short-run export profits depend on firm productivity. The firm then makes an optimal export market participation decision accounting for sunk and fixed costs of exporting. The model is estimated structurally where the static demand and production function parameters are estimated using the algorithm of Ackerberg et al. (2006), while the dynamic exporting cost parameters are estimated using BBL's method for dynamic discrete choice models. The model is applied to data of Danish textile producing firms which experienced a phase of trade liberalization during the period 1993-2004.

The estimation results suggest that trade liberalization indeed influences firm productivity positively while no learning by exporting is detected. Moreover, sunk costs of exporting are substantial indicating the importance of the selection effect. A counterfactual experiment suggests that the indirect effect of trade liberalization on exporting via the productivity channel is only of minor importance.

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Tables

Table 1: Summary Statistics (values based on the local currency, DKK)

	Mean	St.Dev.	Min	Max
Log Sales	16.25	1.47	9.93	20.49
Log Capital	14.80	1.63	8.27	20.20
Log Labor	2.79	1.17	0.00	6.01
Log Materials	15.65	1.57	9.42	19.99
Protection	0.62	0.30	0.00	1.00
Export Dummy	0.72	0.45	0.00	1.00
Log Export Sales	14.76	2.52	6.48	20.35

Table 2: Export Status by Segment

Industry	Export Dummy		Total
	0	1	
1710	18	46	64
1720	36	69	105
1730	82	49	131
1740	229	504	733
1751	17	101	118
1752	82	142	224
1754	27	61	88
1760	20	94	114
1771	4	33	37
1772	23	205	228
1821	22	81	103
1822	152	294	446
1823	18	186	204
1824	64	172	236
1830	21	40	61
Total	815	2,077	2,892

Table 3: Reduced Form Estimations

	Export Productivity Premium		Productivity and Trade Liberalization	
	i	ii	iii	iv
Export Dummy	0.485*** (0.025)	0.128*** (0.033)		
Protection Variable			-0.251*** (0.051)	-0.181*** (0.034)
Constant	12.243*** (0.076)	12.485*** (0.025)	12.728*** (0.083)	12.689*** (0.022)
Segment Dummies	yes		yes	
Firm Fixed Effects		yes		yes
Observations	2,892	2,892	2,892	2,892

Robust standard errors in parenthesis; ***, **, and * denote significance at 1, 5, and 10 %-level; dependent variable: labor productivity

Table 4: Production Function Parameters

Reduced Form Coefficients		Implied Coefficients	
β_l	0.177*** (0.039)	α_l	0.203
β_m	0.753*** (0.031)	α_m	0.864
β_k	0.076*** (0.022)	α_k	0.087
τ^*_{qr}	0.094*** (0.035)	τ_{qr}	0.108
β_s NACE 17	-0.130*** (0.015)	η_{17}	-7.684
β_s NACE 18	-0.123*** (0.025)	η_{18}	-8.106
Returns to Scale			1.154

Block-bootstrapped standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.01, obs. 2546

Table 5: Law of Motion Productivity

	Continuous Data			Discrete Data
ω_{t-1}	2.672**	0.612***	0.611***	0.609***
	(1.271)	(0.042)	(0.042)	(0.019)
ω_{t-1}^2	-0.143			
	(0.090)			
e_{t-1}	-0.015	-0.007		
	(0.010)	(0.010)		
qr_{jt-1}	-0.047***	-0.053***	-0.053***	-0.046***
	(0.014)	(0.016)	(0.016)	(0.012)
Constant	-4.621	2.797***	2.797***	2.805***
	(4.476)	(0.302)	(0.302)	(0.135)

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; obs. = 2546

Table 6: Gross Export Profit Equation

	(i)	(ii)	(iii)
ω_{it}	0.494***	0.496***	0.498***
	(0.157)	(0.155)	(0.155)
k_{it}	0.315***	0.314***	0.317***
	(0.106)	(0.105)	(0.105)
l_{it}	0.316***	0.316***	0.317***
	(0.062)	(0.061)	(0.061)
m_{it}	0.470***	0.470***	0.471***
	(0.063)	(0.063)	(0.063)
qr_{jt}	-0.052	-0.047	
	(0.139)	(0.138)	
$trend$	-0.008		
	(0.061)		
ρ_1	0.872***	0.869***	0.869***
	(0.028)	(0.014)	(0.014)
ρ_2	0.025***	0.025***	0.025***
	(0.009)	(0.009)	(0.009)
Constant	14.756	-0.898	-0.948
	(122.828)	(1.598)	(1.597)

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; obs. 1632

Table 7: Dynamic Parameter Estimates

	$\delta = 0.90$						$\delta = 0.95$					
	Para-meters i	DKK ii	USD iii	Para-meters iv	DKK v	USD vi	Para-meters vii	DKK viii	USD ix	Para-meters x	DKK xi	USD xii
γ_{FC}	11.949	154,616	26,685	11.958	155,983	26,920	12.023	166,475	28,731	12.055	172,009	29,686
	(0.557)			(0.568)			(0.346)			(0.352)		
γ_{SC}	14.966	3,160,055	545,382				14.966	3,158,475	545,110			
	(1.109)						(0.56)					
γ_{SC} (small)				14.661	2,329,583	402,054				14.662	2,331,914	402,457
				(1.378)						(0.681)		
γ_{SC} (large)				15.598	5,942,854	1,025,656				15.542	5,620,887	970,088
				(2.048)						(1.053)		

Standard errors in parentheses; T =200, # of simulation draws = 20, # of alternative policies (n_I) = 150, # of alternative paths (n_s) = 100; Exchange rate DKK-USD= 5.7942

Table 8: Comparison of Dynamic Parameter Estimates

Author	Country	Sector	Estimator	δ	Sunk Costs			Fixed Costs
					Mean	Small	Large	Mean
Das, Roberts, Tybout	Columbia	Knitted Fabrics	Bayesian	0.90		412	402	insignificant
Kasahara, Lapham	Chile	Textiles	Maximum Likelihood	0.95	790			37
This paper	Denmark	Textiles	BBL	0.90	545	402	1,026	27
				0.95	545	402	970	29

Cost figures are presented in thousands USD

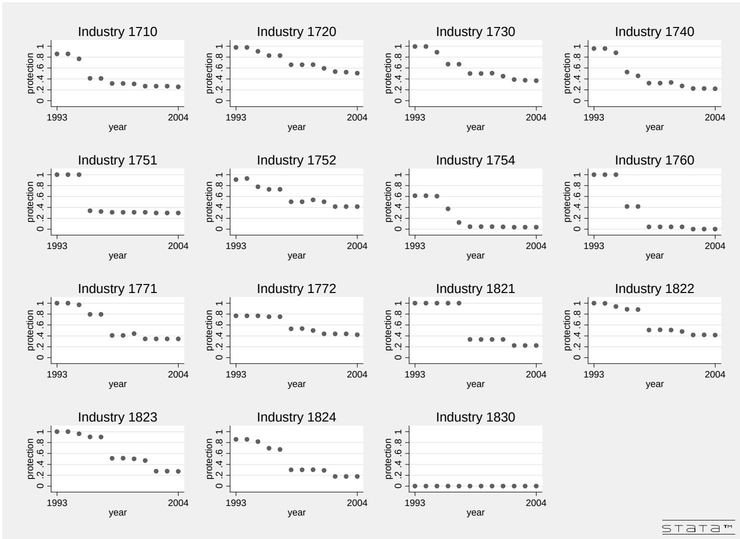
Table 9: In-Sample Performance and Counterfactual Analysis

	Actual	Predicted	Counterfactual Analysis
Entry Rate	0.041	0.058	0.058
Exit Rate	0.039	0.041	0.040

Results based on 500 simulation rounds and $\delta = 0.95$

Figures

Figure 1: Trade Liberalization



Appendix A: Alternative Protection Variable

This section contains estimation results for the alternative protection variable which is based on an unweighted average; i.e. a_{ct} in equation (8) corresponds to equal weights instead of weights according to a country's GDP.

Table A.1: Production Function Parameters

Reduced Form Coefficients		Implied Coefficients	
β_l	0.176***	α_l	0.192
	(0.033)		
β_m	0.754***	α_m	0.822
	(0.038)		
β_k	0.076***	α_k	0.083
	(0.019)		
τ^*	0.077*	τ	0.084
	(0.04)		
β_s	-0.084	η_{17}	-11.869
NACE 17	(0.067)		
β_s	-0.08***	η_{18}	-12.446
NACE 18	(0.031)		
Returns to Scale			1.097

Block-bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1; obs. 2546

Table A.2: Law of Motion Productivity

	i	ii
ω_{t-1}	2.190**	0.598***
	(1.083)	(0.043)
ω^2_{t-1}	-0.143	
	(0.10)	
e_{t-1}	-0.013	-0.006
	(0.010)	(0.010)
qr_{jt-1}	-0.039***	-0.043***
	(0.013)	(0.015)
Constant	-2.197	2.225***
	(2.93)	(0.239)

Robust standard errors in parentheses;
*** p<0.01, ** p<0.05, * p<0.1; obs. = 2546

Appendix B: Transition Probabilities of State Variables and Policy Function Estimates

In this appendix I present estimation results of the transition probabilities of all state variables and the policy function which I use in the estimation of the dynamic decision problem. Table B.1 presents the estimated transition probabilities except for the protection variable qr_{jt}. I estimate these probabilities using a polynomial series approximation of the lagged dependent variable. If the squared lagged dependent variable is insignificant, I drop it from the model. Table B.2 presents transition probabilities for qr_{jt} which are obtained from a frequency estimator. Finally, Table B.3 presents estimation results of the policy function. Note that even though most coefficients are insignificant, the model predicts the outcome correctly in 92% of the cases.

Table B.1: Transition Probabilities of ω, m, l, and u^X_{it-1}

	TFP	Materials	Labor	u^X_{it-1}
Dependent variable (t-1)	0.609***	0.939***	0.728***	0.869***
	(0.019)	(0.010)	(0.034)	(0.014)
Dependent variable (t-1) squared			0.038***	0.025***
			(0.005)	(0.009)
Export Status (t-1)		0.103***	0.050**	
		(0.028)	(0.021)	
Protection Variable (t-1)	-0.046***			
	(0.012)			
Constant	2.806***	0.898***	0.332***	-0.948
	(0.134)	(0.137)	(0.047)	(1.597)
Std. dev. residuals	0.151	0.504	0.332	0.823
Number of observations	2,546	2,546	2,546	1,737

Table B.2: Transition Probabilities of Protection Variable

	1	2	3	4
1	0.957	1.000	1.000	1.000
2	0.125	0.950	1.000	1.000
3	0.045	0.250	0.977	1.000
4	0.059	0.088	0.294	1.000

Table B.3: Policy Function Estimates

	coef	se
k	-0.073	0.153
k^2	-0.036*	0.019
ω	0.032	0.089
ω^2	0.006	0.009
l	-0.055	0.132
l^2	0.003	0.020
u_{t-1}	-0.658***	0.169
u_{t-1}^2	0.048	0.040
m	-0.214	0.165
m^2	0.021	0.023
e_{t-1}	1.696***	0.298
$k * \omega$	-0.011	0.014
$k * l$	0.050**	0.024
$k * u_{t-1}$	0.012	0.032
$k * m$	0.043	0.027
$k * e_{t-1}$	0.042	0.065
$\omega * l$	-0.012	0.013
$\omega * u_{t-1}$	-0.003	0.017
$\omega * m$	0.006	0.016
$\omega * e_{t-1}$	-0.016	0.036
$l * u_{t-1}$	0.006	0.031
$l * m$	-0.034	0.027
$l * e_{t-1}$	-0.030	0.065
$u_{t-1} * m$	0.095**	0.038
$u_{t-1} * e_{t-1}$	0.024	0.083
$m * e_{t-1}$	0.163**	0.077
Number of observations	2,546	

Appendix C: Robustness

In this appendix I perform two robustness checks with respect to the dynamic parameter estimates. The first robustness check relates to the standard errors which I will obtain by bootstrapping instead of relying on the analytical standard errors from the second step of the BBL algorithm. Second, I investigate the assumption of similar domestic and export demand elasticities. I do so by estimating a foreign demand elasticity premium for the firms in the sample.

Bootstrapping the Standard Errors

BBL suggest to use bootstrapping to obtain the standard errors. In this section I follow their advice to assess the adequacy of the analytical standard errors presented in the main text. For this purpose, I restrict the number of Monte-Carlo simulations to five and focus on a discount rate of 0.95. I follow the algorithm outlined by Cameron and Trivedi (2005) and implement a nonparametric bootstrap while accounting for the panel dimension of the data. I obtain the standard errors as the square root of $s^2_{\hat{\theta}} = \frac{1}{B-1}\sum_{b=1}^{B}(\hat{\theta}^*_b - \bar{\hat{\theta}})^2$, where $\hat{\theta}$ is the vector containing the estimated dynamic parameters, $b = 1 \ldots B$ is the number of bootstrap replications, $\hat{\theta}^*_b$ is the estimate of θ during each bootstrap replication, and $\bar{\hat{\theta}} = B^{-1}\sum_{b=1}^{B}\hat{\theta}^*_b$.

The estimation results are presented in Table C.1. First, note that the coefficient estimates are slightly larger compared to those in Table 7. The difference is explained by the lower number of Monte Carlo simulations used here. Next, notice that the analytical standard errors are fairly similar to those obtained from bootstrapping. I am therefore confident that the presented analytical standard errors in the main text are not severely biased.

Table C.1: Bootstrapping Standard Errors

	Parameters	Bootstrapped se	USD
γ_{FC}	12.064		29,952
	(0.332)	(0.469)	
γ_{SC}	14.974		549,818
	(0.559)	(0.516)	

Standard errors in parentheses; T =200, # of simulation draws = 5, # of alternative policies (n_I) = 150, # of alternative paths (n_s) = 100; exchange rate DKK-USD= 5.7942; # of bootstrap simulation = 50; δ=0.95

Foreign Demand Elasticity

Equation (4) presents a general result on the relationship between export revenue and export profits. A similar relationship can be established for domestic sales and profits which implies that variable costs of domestic production C_{it}^D are given by $C_{it}^D = R_{it}^D(1 - |\eta_d|^{-1})$ with superscript D indexing the domestic market and η_d, as before, being the domestic demand elasticity. I now allow the domestic and foreign demand elasticities to be different and, in particular, follow Das et al. (2007) by introducing a foreign demand elasticity premium implying that a firm incurs total production costs of

$$C_{it} = C_{it}^X + C_{it}^D = R_{it}^X(1 - |\eta_d|^{-1}(1 - v_d)) + R_{it}^D(1 - |\eta_d|^{-1}),$$

where $(1 - v_d)$ gives the inverse of the foreign demand elasticity premium. Rearranging this expression yields an equation based on observable data which allows estimating v_d

$$1 - \frac{C_{it}}{R_{it}} = |\eta_d|^{-1}\left(1 - v_d\frac{R_{it}^X}{R_{it}}\right) + \xi_{it}, \tag{28}$$

where ξ_{it} captures measurement error in production costs and $R_{it} = R_{it}^X + R_{it}^D$. I estimate this equation by non-linear least squares using the estimates of η_d^{-1} from the production function as starting values. I obtain relatively low foreign demand elasticity premia. The ratio of the foreign to domestic demand elasticities amounts to 1.36 and 1.33 in the two NACE 2-digit sectors 17 and 18. As a comparison, Das et al. (2007) estimate this ratio to equal 1.95 for Columbian firms in the textile sector. The relatively low foreign demand elasticity premia for Danish firms are indeed in line with the characterization of firms in this sector as being mainly small and focussing on product differentiation which implies that competition on the world market is not expected to be much fiercer than on the domestic market.

Table C.2 presents dynamic parameters estimates when considering the estimated foreign demand elasticity premia. Fixed and sunk costs of exporting are estimated to be lower which is due to the fact that the estimated foreign demand elasticity premia imply lower profits from exporting. The presented parameters in the main text may therefore be seen as an upper bound of estimated cost parameters.

Table C.2: Dynamic Parameters Estimates Considering Foreign Demand Elasticity Premium

	Parameters	USD
γ_{FC}	11.626	19,321
	(0.371)	
γ_{SC}	14.741	435,453
	(0.625)	

Standard errors in parentheses; δ=0.95, T =200, # of simulation draws = 5, # of alternative policies (n_I) = 150, # of alternative paths (n_s) = 100; exchange rate DKK-USD= 5.7942;

Chapter 2

Sunk Costs of Exporting and the Role of Experience in International Trade

Sunk Costs of Exporting and the Role of Experience in International Trade

Philipp Meinen[*]

Abstract

This paper estimates the importance of destination-specific sunk costs of exporting and investigates the role of firms' previous experiences in interactional trade for the decision to export to a market. The importance of sunk costs is inferred from the state dependence of firms' export activities in a market. The applied econometric model addresses a variety of potential biases of the state dependence parameter and, furthermore, accounts for other explanations than sunk costs that could induce persistency in firms' export decisions. Even after controlling for such aspects, destination-specific sunk costs are found to matter. Firms' experiences in international trade can, however, help firms to overcome these costs more easily. In particular, import experience from a market is found to facilitate exporting to the country. Furthermore, export experience from other markets can increase the probability of exporting to a country. This latter effect turns out to be conditional on the characteristics and number of markets served by a firm.

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1 Introduction

A key finding of the literature on heterogenous firms in international trade is that only a fraction of firms export. Theoretical (Melitz, 2003) and empirical studies (Wagner, 2007) show that self-selection of more productive firms plays a major role for this finding. Self-selection into the export market is usually explained by sunk costs which only the more productive firms are able to pay. Since the seminal work by Roberts and Tybout (1997), many empirical studies have confirmed this conjecture illustrating the importance of sunk costs by depicting the strong state dependence of firms' export decisions.[1] A common feature of these studies is that they base their analysis on the firm level, while sunk costs of exporting may vary at the country level.[2] This distinction is important for our understanding of the nature of sunk costs of exporting; adding the destination dimension to the picture allows us to investigate the expansion of firms' export activities within and across markets and to account for possible interdependencies of exporting costs across several markets.

Generally, when considering the decision to enter individual export markets, a firm's prior experience in international trade may determine the importance of entry costs into a new market. Thanks to the increased availability of transaction-level export data sets, more recently a literature has emerged that models a firm's export decision with respect to individual markets while paying special attention to the role of experience. For instance, Albornoz et al. (forthcoming) propose a model where firms are uncertain about their ability as exporters and learn about it only if they start exporting. In the model, firms first enter one market, learn about their exporting profitability and then increase exports sales in the first destination and start exporting to other markets or withdraw from exporting, respectively. They call this theory sequential exporting and provide evidence for the

[1] Bernard and Wagner (2001) for Germany, Bugamelli and Infante (2003) for Italy, Bernard and Jensen (2004) for the US, Campa (2004) and Manez et al. (2008) for Spain, Das et al. (2007) for Columbia, Requena-Silvente (2005) for UK SMEs, and Muuls and Pisu (2009) for Belgium.

[2] More recently, there are studies with similar identification strategies that consider the firm-country level in their analysis. Gullstrand (2011) analyzes the Swedish food sector, Medin and Maurseth (2012) analyze the Norwegian seafood exports, and Moxnes (2010) analyzes the non-oil manufacturing sector in Norway. While these studies also find significant state dependence of exporting activities in individual markets, the modeling approaches approaches are different.

predictions of the model. Morales et al. (2011) suggest that experience from markets with certain cultural or geographical characteristics eases entry into markets with similar attributes. They develop and estimate a structural model which supports this theory using Chilean data. A similar idea is put forward by Defever et al. (2010) using Chinese data and Lawless (2011) using Irish data. Moxnes (2010) motivates an empirical model where he distinguishes between global and country-specific sunk costs. He estimates the model on Norwegian data concluding that sunk costs are largely destination-specific while the analysis is restricted to only five destination markets.[3]

The present paper relates to these studies by assessing the importance of country-specific sunk costs and the role of firms' experiences in international trade. I extend Roberts and Tybout's model to the firm-country level and identify the relevance of market-specific sunk costs from the degree of state dependence of firms' exporting activities in individual markets. The paper contributes to the existing literature by investigating three distinct aspects. First, it focusses on identifying "true state dependence" in order to obtain an unbiased estimate of the importance of market-specific sunk costs. Specifically, the empirical model applied in this paper allows for a very general pattern of correlation between the unobservable determinants of the export decisions and the state dependence parameter and therefore accounts for a variety of potential biases. Moreover, I account for the fact that state dependence may be interpreted as an indication of sunk costs as well as within market learning effects. Timoshenko (2013) incorporates this aspect into a model at the firm level suggesting that persistency in exporting may also be the result of accumulated knowledge about the export market which firms loose if they stop exporting. Extended to the firm-destination level considered in this paper, the idea implies that an additional year of experience in a market increases the probability of staying in this market. If not explicitly modeled, this aspect would be picked up by the state dependence parameter and falsely be interpreted as sunk costs. Studies that identify market specific sunk costs from the state dependence of firms' exporting activities usually do not account for these points.

[3]Further note that Medin and Maurseth (2012) present evidence for sunk costs specific to countries and products using Norwegian data.

The second contribution concerns the relationship between exporting and importing. I assess whether market-specific knowledge related to importing from a market influences a firm's export decision with respect to this country. This mechanism is different from other studies about the interdependence of exporting and importing. Those studies are usually conducted at the firm level and assume that importing leads to exporting through a productivity channel; i.e. importing leads to productivity improvements helping firms to bear the sunk costs of exporting (Kasahara and Lapham, 2012; Bas, 2010). By investigating the relationship at the country level, this paper focuses on a mechanism based on information exchange. Moreover, the empirical model in this paper is very flexible and does not impose assumptions on the direction of causality; instead importing may induce exporting and vice versa.

The third contribution relates to the analysis of the importance of export experience from other markets. It is investigated whether experience from other export markets matters in general, or whether the role of experience depends on certain conditions; i.e. the number of markets served and / or the characteristics of markets served. The role of experience is further distinguished into effects on the probability of starting to export to a market and on staying in an export market. Hence, the analysis allows to make inference on whether previous experience in international trade matters rather for sunk costs or per period fixed costs of exporting.

By investigating the importance of market-specific sunk costs, this paper also relates to the discussion on permanent vs. temporary exporters. An important contribution in this regard was made by Eaton et al. (2007) who showed that firms frequently export to individual markets for a short period only; an observation which would contradict the relevance of market-specific sunk costs. However, Eaton et al. (2007) also show that these temporary exporters are responsible for only small export volumes. Their interpretation of these findings is that by exporting only small volumes, firms can circumvent paying the full sunk cost of exporting and test a market for some time. If the test is successful, firms increase their sales to the market and thereby lock into it; otherwise they withdraw from the market.[4] Békés and Muraközy (2012) present another study confirming

[4]See Akhmetova (2010) for a model incorporating that idea.

that temporary exporters are important in terms of number of transactions and hardly matter in terms of export volume; but these authors offer an alternative explanation for this observation. In particular, they develop a model where firms endogenously choose between variable and sunk cost trade technologies; temporary exporters choose the former and permanent exporters choose the latter technology. The present paper identifies the importance of sunk costs by estimating the state dependence of firms' export activities which rests on comparing the behavior of exporting and non-exporting firms. The presence of temporary exporters in the data may therefor imply that state dependence is weak and sunk costs are low. In the framework of Békés and Muraközy (2012) such a result would imply that sunk costs were underestimated as some of the exporting firms have opted for the variable cost trade technology implying that these firms have never paid any sunk costs. Although Békés and Muraközy (2012) propose a simple approach to "filter out" temporary exporters, I decided against applying a filter and instead treat each observation equally in the analysis. One reason for this decision is that some of temporary exporters may actually have payed sunk costs of exporting and simply did not succeed in the export market. Moreover, it is also possible that destination-specific sunk costs are not that important after all. In such a case removing all temporary exporters from the estimation sample would lead to artificially high sunk costs. In the end, it would not be surprising to find significant state dependence if the analysis was conducted exclusively on permanently exporting firms.[5]

I apply three kinds of econometric models suited to investigate each of the three mentioned contributions. First, I focus on identifying true state dependence by estimating a dynamic random effects probit model with autocorrelated errors. Second, I investigate the relationship between exporting and importing by jointly estimating a firm's export and import decisions with respect to individual markets using a bivariate random effects probit model. As a side effect, this approach sheds some light on determinants of firms' import decisions and sunk costs of importing. This may be of interest when considering recent studies which point out that firms' import behavior is very similar to their export

[5]Furthermore, applying a filter to identify temporary exporters has an arbitrary component, i.e. after how many years of exporting to a market is exporting permanent?

behavior (e.g. Bernard et al., 2007) and which suggest that importing is also characterized by sunk costs (e.g. Vogel and Wagner, 2010).[6] Third, I assess the role of export experience from other markets for the probability to export to a particular country. It is important to control for a variety of unobserved components in firms' profits in order to identify the effects of interest which is why I switch from a non-linear framework to a linear probability model. Specifically, I estimate the model by GMM accounting for a variety of fixed effects as well as country- and firm-specific trends.

The analysis is based on register data containing balance-sheet information and transaction level trade data for firms from the furniture manufacturing sector in Denmark. This is an interesting sector to study for the current purpose due to its high involvement in international trade. The firms in this sector are very successful globally and source an important share of their inputs from abroad. Moreover, many firms are two-way traders enabling an investigation of the relationship of firms' export and import activities in different markets. To assess the robustness of the results, I also perform estimations on firms from other sectors.

The estimation results suggest that not allowing for a general error structure can lead to important biases of the state dependence parameters as the residuals exhibit significant serial correlation. Specifically, sunk costs are underestimated if autocorrelation in the error term is ignored. The results further confirm that sunk costs are not the only explanation for finding significant state dependence. In particular, the results underline the importance of controlling for accumulated export market experience when investigating the role of market-specific sunk costs. Adding this variable to the estimation equation reduces the state dependence parameter by more than 35%. Moreover, the problem of autocorrelation in the disturbance term almost vanishes when controlling for accumulated export market experience. Nevertheless, even when conditioning on this variable, the results show that market-specific sunk costs are important: a firm that has exported to a market last year is 23% more likely to export to this market today compared to a firm

[6]Common examples of sunk costs of exporting are information requirements about business practices, customers' tastes, competition, and distributors in the foreign markets. Sunk costs of importing are e.g. related to search costs for potential suppliers, the inspection of products, the contract negotiations and the learning and acquisition of customs procedures (e.g. Vogel and Wagner, 2010).

without export activities in this country in the previous period.

I then turn to investigating the role of firms' prior experiences in international trade for the decision to export to a market. I start by analyzing the importance of import experience from a market by jointly estimating export and import participation decisions. The estimations lead to several interesting results. First of all, exporting to and importing from a market are influenced by similar observed and unobserved determinants of firms' profits. In particular, time constant unobserved heterogeneity is found to be highly correlated between both equations. Moreover, the results suggest that importing from a market significantly raises the probability of a firm to export to this country. I confirm the robustness of these findings by estimating similar specifications with a linear probability model to allow for different kinds of fixed effects.

Next, I investigate the role of experience from other markets while accounting for firm-country fixed effects as well as country- and firm-specific yearly shocks. While controlling for the former type of shock does not matter much for the results, allowing for the latter type turns out to be important. This points towards the existence of firms which are on a growing trend gradually expanding to other markets. Such a behavior generates a path-dependency in the data which would be falsely interpreted as learning from other markets if not considered in the empirical model. When controlling for these trends, the results suggest that experience from other markets in general does not affect a firm's export decision with respect to a particular country. Instead, the role of experience is conditional on the characteristics of markets and the depth of experience in terms of number of markets served. Specifically, the results suggest that firms benefit from export experience from markets which are culturally or geographically similar to the market of interest. Experience matters mainly for the decision to enter a market suggesting that they reduce the importance of market-specific sunk costs.

The rest of the paper is structured as follows; the next section presents the empirical model and the estimation approach. In section 3 I present the data and some descriptive evidence. Section 4 contains the estimation results and section 5 concludes.

2 Econometric Approach

2.1 A Simple Model

Roberts and Tybout (1997) develop a multi-period model of firms' export participation with sunk costs of exporting. I extend this model to the destination level where firms face country-specific sunk costs of exporting. In this simple setup, entry into specific markets may be easier (i) if firms have knowledge about a market from exporting activities in this country two or more years ago, (ii) if firms have market-specific knowledge due to importing activities in this country, and/or (iii) if firms have exporting experience from other markets. This latter point may be particularly relevant if firms have experience from markets which are similar to the new destination market in some characteristics (Morales et al., 2011). Moreover, this point may also depend on the number of other countries to which a firm already exports; it is possible that a firm that exports to just one market may still find it difficult to enter a new market, while a firm serving already several export markets finds it rather easy to add an additional market to its portfolio. For instance, the latter firm may have more employees with knowledge about exporting and opportunities in different regions of the world.

In the model, firm i exports in period t to market d ($y_{idt}^{ex} = 1$) if expected profits associated with exporting to market d in year t are positive. Gross profits π_{idt} depend on firm characteristics and exogenous macro-level variables and need to be adjusted for sunk (entry) costs of exporting F_{id}^{0}. If the firm has exported to market d in year $t-1$, it does not have to pay F_{id}^{0} in period t. Further, if the firm has last exported to d in year $t-j$ ($j \geq 2$), the firm faces entry costs of $F_{id}^{j} < F_{id}^{0}$. This aspect allows for the possibility that a firm can preserve market-specific knowledge from exporting activities two or more years ago which may facilitate re-entering the market in period t. Moreover, the firm may benefit from importing activities in market d in period $t-1$ ($y_{id,t-1}^{im} = 1$). This is because importing from market d may provide the firm with relevant knowledge about the market easing exporting to d in year t by T_{id}. Also exporting to other markets than country d ($-d$) in the previous year ($y_{i-d,t-1}^{ex} = 1$) may influence the export decision with respect to d in year t captured by G_i e.g. because firms may not have to pay general sunk costs of exporting in this period.[7] Finally, leaving the export market implies exit costs of L_{id}. Period t exporting profits from market d are then given by

$$\begin{aligned} R_{idt} = y^{ex}_{idt}[\pi_{idt} - F^0_{id}(1 - y^{ex}_{id,t-1}) + T_{id}y^{im}_{id,t-1} + G_i y^{ex}_{i-d,t-1} \\ - \sum_{j=2}^{J_{id}} (F^j_{id} - F^0_{id})\tilde{y}^{ex}_{id,t-j}] - L_{id}y^{ex}_{id,t-1}(1 - y^{ex}_{idt}) \end{aligned}$$

with $\tilde{y}^{ex}_{id,t-j} = \prod_{k=1}^{j-1}(1 - y^{ex}_{i,t-k})$ taking the value 1 if the firm last exported to market d j years ago and 0 otherwise. In line with the model of Roberts and Tybout (1997), this expression yields the following dynamic binary choice equation:

$$y^{ex}_{idt} = \begin{cases} 1 & \text{if } \pi^*_{idt} - F^0_{id} + (F^0_{id} + L_{id})y^{ex}_{id,t-1} + T_{id}y^{im}_{id,t-1} + G_i y^{ex}_{i-d,t-1} \\ & + \sum_{j=2}^{J_{it}}(F^0_{id} - F^j_{id})\tilde{y}^{ex}_{id,t-j} \geq 0 \\ 0 & \text{otherwise,} \end{cases} \tag{1}$$

with π^*_{idt} denoting the increment to gross future profits for firm i from exporting to market d in period t. Equation (1) implies that the importance of country-specific sunk costs of exporting, the relevance of export experience from other markets and the importance of import experience from a specific market can be inferred from dummy variables indicating firm i's export and import participation in markets d and $-d$.

2.2 Econometric Model

Equation (1) readily leads to an estimation equation by specifying a reduced form empirical model approximating $\pi^*_{idt} - F^0_{id}$ by

$$\pi^*_{idt} - F^0_{id} = x'_{idt}\beta + \mu_t + \varepsilon_{idt}, \tag{2}$$

where x_{idt} refers to a set of control variables that vary at the firm and destination levels,

[7] Note that the modeling approach does not allow firms to take into account the dynamic effects of exporting to one country on the future stream of profits they could potentially obtain in other countries. This limited rationality assumption is required to keep to model manageable in the current setup. Morales et al. (2011) provide an approach to account for such aspects which is, however, based on different identification assumptions.

μ_t are time fixed effects and ε_{idt} is an error term. To be precise, I control for productivity (TFP[8]), size (number of employees) and 4-digit NACE industry classification of the firms.[9] Existing studies show that size and productivity are important determinants of firms' export participation possibly because they allow firms to overcome the sunk costs of exporting (e.g. Bernard and Jensen, 2004). Both variables are lagged by one year to alleviate endogeneity concerns. At the country level I control for market size (GDP), population, the real bilateral exchange rate and bilateral distance between Denmark and the foreign market. All independent variables are log transformed. I then define $\gamma_1 = F_d^0 + L_d$, $\gamma_j = F_d^0 - F_d^j$ $(j = 2, \ldots, J)$, $\gamma_m = T_d$, and $\gamma_g = G_d$ and substitute (2) into (1) to obtain the following binary choice model

$$y_{idt}^{ex} = \begin{cases} 1 & \text{if } x'_{idt}\beta + \gamma^1 y_{id,t-1}^{ex} + \sum_{j=2}^{J} \gamma^j \tilde{y}_{id,t-j}^{ex} + \gamma^m y_{id,t-1}^{im} + \gamma^g y_{i-d,t-1}^{ex} + \mu_t + \varepsilon_{idt} \geq 0 \\ 0 & \text{otherwise .} \end{cases} \tag{3}$$

The error term ε_{idt} consists of a time-constant component α_{id} and a transitory component ω_{idt}. This distinction is important in order to estimate true state dependence. If ignored, the serial correlation induced in ε_{idt} by α_{id} would be picked up by the lagged dependent variable and therefore misinterpreted as an indication of sunk costs. Note that α_{id} allows for persistent differences in firms' profits from exporting to specific markets, e.g. caused by general differences in managerial abilities or specific knowledge of managers about certain markets. α_{id} is assumed to be i.i.d. normal across firms and countries with variance σ_α^2 and $\text{COV}(x_{idt}, \alpha_{id}) = 0$.

Another source of spurious state dependence is serial correlation in the transitory error component. I account for this by assuming $\omega_{idt} = \delta\omega_{id,t-1} + \nu_{idt}$ where ν_{idt} is i.i.d. normal across firms, countries and time. If shocks are persistent (high δ), sunk costs of exporting may be less relevant as firm-country combinations with a positive shock today believe that this situation will persist in the future leading to high entry. This persistency of the

[8] TFP is estimated structurally using a modified version of the Ackerberg et al. (2006) approach. See the appendix for details on the estimation approach.

[9] The furniture manufacturing sector (NACE 3-digit sector 361) can be subdivided into five 4-digit NACE sectors.

transitory shock would be picked up by γ_1 if ignored and therefore falsely attributed to high entry costs (Bernard and Jensen, 2004). On the other hand, a negative δ would imply an underestimation of sunk costs. The assumptions made on the error structure imply that the correlation of ε_{idt} over time depends on two components; namely $\lambda = \frac{\sigma_\alpha^2}{\sigma_\alpha^2+\sigma_\omega^2}$ and δ. Note that for estimation purposes σ_ω^2 is normalized to unity.

Finally, it is important to note that sunk costs are not the only explanation for finding persistency in a firm's export status. Timoshenko (2013) shows that besides sunk costs, within market learning can also help to rationalize state dependence. The argument is that firms increase their knowledge about a market with each additional year that they serve it. Firms will continue to export to this market if leaving the market implies loosing this knowledge which they can only use when exporting. Timoshenko develops her model at the firm level and shows that the state dependence parameter captures both sunk costs and within market learning effects if the latter is not explicitly modeled. She proposes to separately identify within market learning by introducing an "export market age" variable which captures the accumulated export experience of a firm. This approach can be extended to the destination dimension by introducing $eage_{idt}$ which counts the number of years of consecutive export participation of firm i in market d in year t. Specifically, in line with Timoshenko, the law of motion of $eage_{idt}$ is as follows: If a firm exports to market d in period t, export market age increases in the next period $t + \Delta t$ by Δt: $eage_{idt+\Delta t} = eage_{idt} + \Delta t$. If a firm does not export to market d in period t, export market age decreases to zero in period $t + \Delta t$.[10] Hence, a simple approach is offered to sperate within market learning from sunk costs.[11]

[10] Timoshenko (2013) suggests to log transform this variable in order to separately identify the effects of state dependence and $eage_{idt}$ in the first period of export market entry relying on functional form. The problem of the nonexistence of the log of zero is then handled by adding a constant (e.g. 1) to $eage_{idt}$. I experimented with this suggestion; however, I found that in my case the results depended heavily on the constant that I added to $eage_{idt}$. For this reason I decided not to use the log transformation as the choice of the constant is somewhat arbitrary.

[11] As firms may already export to a market in the first year of my data set, this variable is bounded from above. In particular, given that I use at most five years of pre-sample information (1996-2000), the variable cannot take on values larger than five.

2.3 Estimation

Nonlinear Models

Initial conditions

The binary nature of the dependent variable suggests maximum likelihood (ML) as a natural estimation choice. One aspect that needs to be addressed here is the initial conditions problem to prevent an upward bias of the sunk costs parameter (Stewart, 2007). The problem arises because the history of the stochastic process under investigation is not observed from its beginning and it is unlikely that the initial conditions are exogenous to α_{id}. The most commonly applied solution to this problem goes back to Heckman (1981) who suggests to approximate the conditional distribution of the initial conditions by a reduced-form expression using pre-sample information. In the present setup, firms' export behavior is observed in years $1 \ldots T$ and the lag structure reaches back for J years. Hence, equation (3) can be estimated for the years $J+1$ to T and information from the years $t \leq J$ is available to use Heckman's approximation to solve the initial conditions problem:

$$y_{idt}^{ex} = \begin{cases} 1 & \text{if } x_{idt}^{\prime p}\beta^p + \mu_t + \varepsilon_{idt}^p \geq 0 \\ 0 & \text{otherwise} \quad \forall\, t \leq J, \end{cases} \tag{4}$$

where the superscript p indicates pre-sample information.[12] I assume a similar error structure as before for ε^p and allow the random effects in the pre-sample and sample periods to be correlated ($\varepsilon_{idt}^p = \eta\alpha_{id} + \delta^p\omega_{id,t-1}^p + \nu_{idt}^p$).[13] The system of equations (3) and (4) is then estimated jointly. This solution to the initial conditions problem has been used widely and shown to perform well (e.g. Akay, 2009). Moreover, this solution allows to deal with the AR1 structure in a natural way.

Approximating the integral

The AR1 error structure introduces another estimation issue by requiring the evaluation

[12] x^p contains the same explanatory variables as before. Additionally, I supplement x^p by firm-level variables lagged by two years and destination market GDP lagged by one year.

[13] Note that I follow Stewart (2007) and restrict η to be positive.

of a T-dimensional integral of normal densities which renders standard ML infeasible. I therefore resort to maximum simulated likelihood (MSL). In particular, I use the GHK algorithm of Geweke, Hajivassiliou and Keane as described in Lee (1997) to estimate the model. I drop the *id* subscripts in the following presentation and only consider a one-year lag structure to ease notation. Lee suggests to generate $u_1, \ldots, u_{T-1}$ independent uniform [0,1] random variables and to obtain α from a N(0,1) random variable generator. The random variables $\nu_1, \ldots, \nu_{T-1}$ can then be generated recursively from $t = 1$ to $T - 1$ by computing

1. $\nu_t = -k_t \Phi^{-1}[u_t \Phi(k_t(x_t'\beta + \gamma^1 y_{t-1}^{ex} + \sigma_\alpha \alpha + \delta\omega_{t-1}))]$ and
2. updating the error process $\omega_t = \delta\omega_{t-1} + \nu_t$,

where $k_t = (2y_t - 1)$ and Φ (Φ^{-1}) is the (inverse) normal cumulative distribution function. Collecting the RHS variables except for the error components of the main and pre-sample equations into z_t and z_t^p respectively, the simulated log likelihood for each firm-country pair with R generated random variables is given by[14]

$$L = \sum_1^N \ln\Big\{\frac{1}{R}\sum_{r=1}^R \Big[\prod_{t=1}^J \Phi\Big(k_t(z_t^p + \eta\sigma_\alpha\alpha^{(r)} + \delta\omega_{t-1}^{(r)})\Big) \times \prod_{t=J+1}^T \Phi\Big(k_t(z_t + \sigma_\alpha\alpha^{(r)} + \delta\omega_{t-1}^{(r)})\Big)\Big]\Big\}$$

The only requirement for consistency of this estimation routine is that R tends to infinity as the number of observations N tends to infinity; in particular, R should increase at a rate larger than $\sqrt{N}$ to ensure asymptotical accordance to standard ML (Lee, 1995, 1997).[15]

[14]See also Greene (2003) for an illustration of the MSL approach for a random effects probit model.

[15]I generate the random variables from Halton sequences instead of pseudo-random draws as they have shown to provide better accuracy with fewer draws. For instance, for the case of mixed logit models, better accuracy is achieved with 100 Halton draws than with 1000 pseudo random draws (Train, 2009). Generally, there is no clear guidance on what is the right number of draws. Lee's (1997) Monte Carlo experiments for dynamic discrete choice models suggest no significant increase in estimation accuracy from above 50 pseudo-random draws. In the appendix, I compare results obtained from estimations with 100 and 250 draws. The coefficient estimates are very similar; this is particularly true for the coefficient of interest on lagged export status. Moreover, the appendix contains estimation results on simulated data which allows to compare actual to estimated parameters. Finally, note that maximization is done using a Quasi-Newton method (DFP - Davidon, Fletcher, and Powell).

Joint estimation of export and import decisions

A final estimation issue relates to the lagged import variable in the export equation. If unobserved heterogeneity of a firm's export decisions is correlated with that of its import decisions, joint estimation of firm's export and import participation is required in order to distinguish cross-equation state dependence and correlated unobserved heterogeneity (Stewart, 2007). This implies that I have to specify an import participation equation. Recent studies point out that firms' import behavior is very similar to their export behavior (e.g. Bernard et al., 2007) and that importing is also characterized by sunk costs (e.g. Vogel and Wagner, 2010). I follow this literature and model firms' import decisions similar to their export decisions by also considering sunk costs and the role of experience. I then estimate both participation equations jointly using a bivariate dynamic discrete choice model. I drop the AR1 error structure for this purpose as otherwise estimations become computationally infeasible. I assume that the time-constant error components in both equations (α_{ex}, α_{im}) are jointly normal with variances $\sigma^2_{\alpha_{ex}}$, $\sigma^2_{\alpha_{im}}$ and correlation ρ_α and that the transitory error components ($\omega_{ex,t}, \omega_{im,t}$) are jointly normal with unit variances and correlation ρ_ω.

The initial condition problem is again addressed by Heckman's approach. I follow Alessie et al. (2004) and include the individual-specific effects α_{ex} and α_{im} in both presample equations and allow them to be freely correlated between equations. To ease notation, define $k^h_t = (2y^h_t - 1)$ with $h = (ex, im)$. Collecting the parameters to be estimated into θ, the likelihood function becomes

$$
\begin{aligned}
l(\theta) = \int_{\alpha_{ex}} \int_{\alpha_{im}} \prod_{t=1}^{J} \Phi_2\Big(k^{ex}_t(z^{ex,p} + \eta_1\alpha_{ex} + \eta_2\alpha_{im}), k^{im}_t(z^{im,p} + \eta_3\alpha_{im} + \eta_4\alpha_{ex}), \rho^{p*}_\omega)\Big) \\
\times \prod_{t=J+1}^{T} \Phi_2\Big(k^{ex}_t(z^{ex}_t + \alpha_{ex}), k^{im}_t(z^{im}_t + \alpha_{im}), \rho^*_\omega\Big)\phi_2\Big(\alpha_{ex}, \alpha_{im}\Big) d\alpha_{ex} d\alpha_{im},
\end{aligned}
$$

where Φ_2 denotes the bivariate standard normal cumulative distribution function and $\phi_2(\cdot)$ is the bivariate normal distribution of a_{ex} and a_{im} with variances $(\sigma^2_{a_{ex}}, \sigma^2_{a_{im}})$ and correlation ρ_a.[16] Estimation of this model requires the evaluation of a double integral

[16]Note that technically the model is identified by functional form. Nevertheless, Miranda (2011) suggests

for which no analytical solution is available. I address this issue by again resorting to MSL using an estimation algorithm similar to that in Kano (2008) and Miranda (2011). I generate Halton sequences and calculate the corresponding values following a standard normal distribution using the inverse-probability transformation. Next, I generate R bivariate normal random variables per firm-country pair by Cholesky factorization $[(a_{ex}^{(1)}, a_{im}^{(1)}), \ldots, (a_{ex}^{(R)}, a_{im}^{(R)})]$ and approximate the individual likelihood by $\mathrm{l}(\theta) = \frac{1}{R}\sum_{\alpha_{ex}^{(r)}:r=1}^{R}\sum_{\alpha_{im}^{(r)}:r=1}^{R}\big[\prod_{t=1}^{J}\Phi_2(\,\cdot\,)\times\prod_{t=J+1}^{T}\Phi_2(\,\cdot\,)\big]$.

Average partial effects

To evaluate the economic meaning of the coefficient estimates of the non-linear models, I calculate average partial effects (APE). Following Wooldridge (2005), I obtain APEs from

$$N^{-1}\sum_{i=1}^{N}\Phi(x'_{idt}\hat{\beta}_a + \hat{\gamma}_a^1 y_{id,t-1}^{ex} + \sum_{j=2}^{J}\hat{\gamma}_a^j \tilde{y}_{id,t-j}^{ex} + \hat{\gamma}_a^m y_{id,t-1}^{im} + \hat{\gamma}_a^g y_{i-d,t-1}^{ex} + \hat{\mu}_a^t),$$

where the subscript a indicates multiplication by $(1+\hat{\sigma}_a^2)^{(-1/2)}$. This approach implies averaging out the unobserved time-constant error component. I calculate counterfactual outcome probabilities at the sample mean by fixing the coefficients of interest $(\gamma^1, \gamma^2, \gamma^3, \gamma^m)$ at zero and then changing them to unity one by one.

Linear Probability Model

The non-linear models presented above are important in order to identify true state dependence as well as the effect of importing on exporting. However, a drawback of these models is that they are computationally very expensive which makes it difficult to control for unobserved heterogeneity by introducing a variety of fixed effects. In fact, due to the incidental parameter problem, allowing for firm-country fixed effects is impossible in these models. However, such controls can be crucial when evaluating the effect of experience

adding exclusion restrictions to help identification. I follow his strategy here. First, similar to the univariate model, I add additional lags of the firm-level variables and destination market GDP to the pre-sample equations. Second, the variable $eage_{idt}$ is excluded from the import equation.

from other markets on a firm's export decisions. For instance, a firm may simply be on a growing trend and thus expand progressively to more markets. If such a possibility is neglected in the empirical model, it may show up as gains from experience from other markets.

Thus, I use a linear probability model with a variety of fixed effects when analyzing the role of experience from other markets. In this framework, the unobserved error component α is treated as fixed making the assumption $\text{COV}(x_t, \alpha) = 0$ redundant. Moreover, given that α is a firm-country pair fixed effect, it subsumes firm and country fixed effects. Hence, this modeling approach accounts for a variety of fixed effects and can be further supplemented by country- and firm-specific trends. Also note that by using a GMM approach for estimation, endogeneity concerns of lagged export and import variables can be addressed in a common IV setting. The drawback of this estimator is that point estimates are less reliable, and in particular, that they may lie outside the unit interval.

A common approach to estimate a model like equation (3) in a GMM setting is to take first differences to eliminate α and then to instrument for the endogenous lagged dependent variable Δy^{ex}_{t-1} using lagged values of y^{ex}_t for years $t \geq 2$ (Arellano and Bond, 1991). The estimation approach is commonly referred to as difference GMM (diff-GMM) and is applied in this paper whenever a linear probability framework is chosen.[17]

3 Data

3.1 Data Sources

The analysis in the present study is based on firms with at least 10 employees from the furniture industry (3-digit NACE rev.1.1 code 361) in Denmark. In Denmark, firms in this sector are known for high quality products and the focus on design making them also globally successful. The sector is also characterized by a high import activity sourcing from abroad an important amount of inputs used in production. This combination of strong export orientation and reliance on imported materials makes the sector an interesting case to study the relationship between exporting and importing.

[17]See Roodman (2009) for more details on this estimation routines and its implementation in Stata.

The sample contains 11 years (1996-2006) while it is worth noting that the first two years of the sample cannot be used for estimations due to lagging firm-level variables by one year and using additional lags of the firm-level variables as exclusion restrictions in the pre-sample equation of the non-linear estimation approach. The estimation sample therefore reaches from 1998 to 2006. Note that the AR1 error structure in the econometric analysis requires a balanced sample to estimate the non-linear model. Using a balanced panel circumvents problems related to modeling firm creation and destruction and is in line with other papers in the literature such as Moxnes (2010) and Bernard and Jensen (2004). On the other hand, estimations are conducted on a selected sample. After imposing this condition and cleaning the data[18], 106 firms are left for the analysis.

The data mainly consists of register data from Statistics Denmark. I merge firm-level balance-sheet information to the foreign trade statistic from Danish customs using a unique firm identifier. The trade data is available on the transaction level providing information on exports and imports to destination and from origin markets, respectively. Given the large computational burden of MSL, I constrain the number of countries considered in the analysis to 55.[19] These countries account for about 95% of total exports and imports of the firms in the sample. I finally merge foreign market information to the data set; GDP (constant USD 2000) and population data are sourced from World Development Indicators[20] and data on bilateral distance come from CEPII. The real bilateral exchange rate variable is constructed based on data on nominal exchange rates from Penn World Tables and GDP deflators from WEO (IMF).

Table 1 presents some summary statistics for the data used in estimations; i.e. 1998 to 2006. The table groups the observations by firms' trading activities in individual markets; i.e. no trader, only importer, only exporter and two-way trader. The observational unit in the econometric analysis is the firm-country-year triad with a total number of observations of 51,516. The clear majority of observations relates to non-traders (i.e. firms that do

[18]Firms with negative domestic sales, firms that leave the sample and reappear later, and firms which switch sectors during the sample period are dropped.

[19]Note that the number of markets is reduced to 54 in the estimations as the GDP deflator series for Romania contains several missings. In total, the firms in the sample trade with 153 countries.

[20]Note that GDP data for Taiwan is taken from Penn World Tables.

not trade with a specific country in a given year) followed by only exporters and two-way traders while only importers form the smallest group. The unconditional means of these groups suggest a ranking in terms of productivity and size going from non-traders in the bottom over only importers and only exporters to two-way traders in the top.

In Table 2 I present some evidence on the role of temporary exporters by depicting the numbers and trade volumes of export starters, stoppers, continuing exporters and single-year exporters. In line with Eaton et al. (2007), export starters are defined as firms that do not export to market d in $t-1$, but export to d in t and $t+1$. Export stoppers export to market d in $t-1$ and t, and do not export there in $t+1$. Single-year exporters export to d in t while not exporting there in $t-1$ and $t+1$. Finally, continuously exporting firms export to market d in all three periods. The table reports means over the sample period which suggest that continuously exporting firms are the most important group in this sample. They account for about three quarter in terms of number of trading observations and for about 97% of the total export volume. In terms of numbers, single year exporters account for 9% of the trading observations while they hardly matter in terms export volume. This observation is in line with other studies (Eaton et al. (2007), Békés and Muraközy (2012)). Generally, the presence of temporary exporters may imply that destination-specific sunk costs of exporting are not very important. On the other hand, most trading observations actually relate to continuously exporting firm which is in line with sunk costs of exporting. Hence, the investigation of the importance of country-specific sunk costs as measured by the degree of state dependence of exporting requires an econometric analysis as done in the following section.

4 Estimation Results

This section contains the estimation results. First, I present results from the non-linear model where the focus is on identifying true state dependence as well as investigating the relationship between exporting to and importing from a market. I then turn to the linear probability model to analyze the role of export experience from other markets for a firm's decision to export to a market. Finally, I extend the analysis to other sectors to assess the generalizability of the results.

4.1 Non-linear Models

Estimating Market-specific Sunk Costs

In Table 3 I present estimation results for the non-linear model where the focus is on identifying true state dependence of exporting to individual markets. In the upper part of the table I present parameter estimates and test statistics and in the lower part of the table I display average partial effects (APE) to evaluate the economic meaning of the coefficient estimates. In column (i) I estimate the model without considering an AR1 process in the error and the export market age variable ($eage_{idt}$). The results clearly point towards the importance of market-specific sunk costs as suggested by the large coefficient on lagged export status which is the most important predictor for current export status. This is confirmed by an average partial effect (APE) of 33%. Moreover, having last exported to market d two or three years ago significantly increases the probability of exporting to this market today, while the APEs are much smaller compared to that of one year lagged export status. The other coefficients in column (i) suggest that more productive and larger firms are more likely to export to a market. Conditional on population, firms export to larger markets in terms of GDP and for a given level of development, firms export to less populated markets, or in other words, to wealthier markets in terms of GDP per capita. The real bilateral exchange rate exhibits a significant effect suggesting that real depreciations of the Danish Krone against a foreign currency increase the probability of exporting to this country. Furthermore, firms are more likely to export to markets located close by. Finally, the estimate of λ suggests that roughly one third of the error variance is due to the time-constant error component. Note that the number of observations is 51,516, where 17,172 refer to the three pre-sample years and 34,344 to the sample years.

In column (ii) I allow for an AR1 error process. δ is estimated to equal -0.35 implying significant negative serial correlation in the transitory error component. As a consequence, the importance of sunk costs is underestimated in column (i) where δ is neglected. This can be seen by comparing the APEs of lagged export status in columns (i) and (ii); when accounting for δ, the APE increases from 33% to 46%. Moreover, the results suggest that there is a significant positive AR1 process in the pre-sample period δ^p. This can be explained by the fact that the pre-sample equation is a reduced-form specification to account for the initial conditions problem. To be precise, this specification does not contain the lagged dependent variable so that the persistency (implied by the large and highly significant lagged dependent variable in the sample equation) is moved to the error term and then picked up by δ^p. Before commenting on the finding of a negative AR1 process in the main equation, I present the results from column (iii) where I add $eage_{idt}$ to the estimation equation which will provide useful for this discussion.

Adding $eage_{idt}$ to the model turns out to have two important implications. First, controlling for this variable reduces the importance of state dependence. This can be seen by a smaller coefficient on lagged export status as well as an APE that reduces to 28%. Hence, in line with Timoshenko's (2013) results for the firm-level, within market learning is an explanation for finding significant state dependence also at the firm-country level. Not controlling for this aspect therefore results in overstating the importance of sunk costs as the magnitude of state dependence is usually fully attributed to sunk costs. The second important implication of adding $eage_{idt}$ to the model is that δ reduces from -0.35 to -0.09 and that it is now weakly significant only. This may help to understand the finding of a negative AR1 process in column (ii). Generally, from a purely econometric point of view, a negative AR1 process implies that the firms' beliefs about the profitability of exporting to a particular market are higher than expected today (conditional on covariates) and they will be lower than expected to tomorrow (conditional on covariates). As seen, the export market age variable enters the regression with a positive and highly significant coefficient and it reduces the importance of the lagged dependent variable. As Timoshenko points out, the positive effect of this variable can be interpreted as an indication of "age-dependent" sales which grow exogenously over time if a firm continues to export to a market. Such an interpretation is in line with a learning model as in Arkolakis and Papageorgiou (2009) where an additional year of selling to a market provides a firm with an additional signal about demand conditions. When not conditioning on this variable in column (ii), firms are not allowed to take the aspect of "age-dependent" sales into account which implies that expected profits in the following periods are repeatedly understated. It seems that this mechanism is then picked up by the AR1 process implying a negative δ.

In the last column of Table 3, I re-estimate the model from column (iii) while dropping the AR1 process. As expected, the coefficient on lagged export status decreases slightly when the AR1 process is neglected. When considering this rather small decline in the magnitude of the coefficient, the large computational burden associated with estimating δ, and, in particular, the fact that δ is weakly significant only in column (iii), I believe it is reasonable to drop the AR1 process in the estimations that follow. The estimates in column (iv) suggest that market-specific sunk costs of exporting are still substantial; the APE implies that a firm that has exported last year to market d is 23% more likely to export to d today than a firm that has not exported to d in the previous year.

The Relationship Between Exporting and Importing

As mentioned before, in the case that a firm's export and import participation are driven by similar unobserved factors, adding an import variable to export equation may lead to endogeneity problems. I address this issue by jointly estimating a firm's export and import participation decisions using a bivariate dynamic discrete choice model. The results are presented in columns (i) and (ii) of Table 4. The coefficients in the first four rows present the effects of lagged export status, previous export market experience and export market age on current export status (column: export equation) and the effects of lagged import status, previous import market experience and import market age on current import status (column: import equation), respectively. The fifth variable termed cross equation state dependence gives the effect of lagged import status on current export status (column: export equation) and the effect of lagged export status on current import status (column: import equation), respectively.

The results suggest that firms' export and import decisions are indeed fairly similar. Equivalently to exporting, lagged import status in a market is the best predictor for current import status in a market suggesting that importing is also characterized by sunk costs. Moreover, except for population, the variables in both equations behave similarly. Surprisingly, this is also true for the coefficient on the real exchange rate. Besides observable determinants, also the unobservable determinants of export and import participation in a market are similar as indicated by the positive correlation between both error components in the two equations; this is particularly true for the time-constant error components as indicated by the high coefficient of correlation.

Regarding cross-equation state dependence, the results show that importing from a market significantly increases the probability of exporting to this country. Moreover, the results for the import equation suggest that this relationship also exits for the opposite direction; exporting to a market increases the probability of sourcing from there. According to the average partial effects, both effects are further of comparable magnitude. This implies that importing from a market facilitates starting to export there and vice versa. One explanation for these results may be that a firm assembles knowledge about a market from selling to it which provides the firm with information about potential suppliers for inputs or vice versa. Such an explanation is in line with the common understanding that a large part of sunk costs is related to costs of information gathering.

In columns (iii) and (iv) I present similar results based on separately estimating the export and import equations. As expected, due to the positive correlation of the unobserved time constant error components, the coefficients on the cross equation state dependence parameters increase. However, this increase is relatively small suggesting that the bias arising from the correlation in the error components is not very important.

4.2 Linear Probability Model

The results so far have several important implications. I shortly summarize them before commencing with the next step of the analysis. First, the results show that state dependence can partly be explained by within market learning effects. Second, even when controlling for within market learning, the state dependence parameter remains statistically significant and economically important suggesting that market-specific sunk costs are relevant. Third, the results suggest that import experience from a market positively impacts the decision to export this country. Finally, according to the results presented above, controlling for within market learning reduces autocorrelation in the transitory error component making an explicit modeling of the AR1 process (which is rather cumbersome) redundant.

These results are important, but are also prone to caveats. These caveats are mainly related to not controlling for a variety of fixed effects in the above estimations. This is particularly important when investigating the role of experience from international trade for exporting. Such unobserved components in firms' profits may be specific to the foreign market, to the firm, or both and, moreover, may even change over time. For instance, firms may find it easier to export to a country because of some institutional features or some regulatory changes in that country. If mainly firms that already export to other markets react to such aspects and thus export to this country, this may show up as an indication of the relevance of experience from other markets. Similarly, in line with the literature on sequential exporting, a firm may simply be on a growing trend and thus expend gradually to new export markets. This could again show up as an indication of learning from other markets if not adequately controlled for. Finally, certain firms may have special relations (which are unobserved by the econometrican) with certain markets which may ease exporting to these countries (e.g. a stock of employees with relevant market-specific knowledge or foreign-owned firms) which should be accounted for by the econometric model when investigating the role of experience.

This sub-section focuses on the analysis of the role of export experience in international trade for the decision to export to a market while accounting for these kinds of unobserved effects. For this reason, the linear probability model is applied in this sub-section which controls for firm-country par fixed effects which also subsume firm and country fixed effects. Moreover, the estimations will be supplemented with country-year and firm-year dummies, respectively.

Compared to the previous section, experience enters the model differently in this section in order to improve our understanding of the mechanisms behind the effects found before. Specifically, experience is allowed to influence a firm's decision to enter a market and to stay in a market. As mentioned before, sunk costs are often associated with costs of information gathering which may imply that experience in international trade is particularly important for entering a new market. Experience may also matter for the decision to stay in a market as it may influence per period fixed costs of exporting to a specific country; e.g. if some of the fixed costs of exporting can be shared across destinations or if some of the fixed costs related to exporting to a market are shared with fixed costs of importing from this country. Moreover, it is analyzed whether export experience from other markets matters in general or whether it is conditional on certain aspects; whereas two points are of interest here. First, it assessed whether the depth of experience matters, where depth here refers to the number of other markets that a firm serves. Second, it assessed whether the role of experience is conditional on the characteristics of markets already served; in particular, it is investigated whether experience is more important if it stems from markets that are similar in some characteristics to the market of interest.

Below, I start by estimating the baseline models from above using the Diff-GMM approach to see whether the results are robust to the inclusion of firm-country fixed effects. Then I will turn to the in-depth analysis of experience in international trade.

Baseline Results with LPM

In Table 5 I repeat some of the baseline estimations presented in the previous section. I start out by estimating the model without considering the role of import experience but conditioning on $eage_{idt}$. As before, this variable enters the equation with a positive and highly significant coefficient. Moreover, the estimated coefficient for sunk costs (22%) is very similar to the estimated average partial effect found above (23%). Note that I treat all experience terms as well as TFP as endogenous in the estimation using common GMM-style instruments. The test statistics in the bottom of the table indicate the validity of this modeling approach. In contrast to the results from the non-linear model, the real bilateral exchange rate and the population of the foreign market no longer exhibit significant effects. This is mostly likely due to the fixed effects that are included in the model. In column (ii) I add the variable for import experience to the model; the positive and significant effect of this variable is confirmed also when controlling for firm-country fixed effects. The magnitude of the coefficient suggests that this effect also economically importance raising the probability of exporting to this market by 7%. In columns (iii) and (iv) I add country- and firm-specific trends to the model. Even though the state dependence parameter decreases somewhat in magnitude (19% in column (iv)), the results remain qualitatively similar emphasizing the robustness of the findings.

Table 5 shows that the findings from the non-linear model are not specific to the modeling choice and robust to the inclusion of firm-country fixed effects as well as different kinds of trends. In the following, I conduct a more thorough analysis of the role of experience in international trade. The first issue that I consider is whether experience matters for the decision to start exporting to a market (i.e. for sunk costs), for the decision to stay in a market (i.e. for fixed costs) or for both decisions. I identify the effect of importing from a market on the sunk costs of exporting to this market by including $y^{imp}_{id,t-1}(1 - y^{exp}_{id,t-1})$ in the model and the effect on the fixed costs is identified by adding $y^{imp}_{id,t-1}y^{exp}_{id,t-1}$ to the model. Moreover, I allow firms to gain from export experience from other markets by introducing $y^{exp}_{i-d,t-1}$ to the model. Similar to importing, I distinguish the effect of experience from other markets into a sunk costs and fixed costs component (i.e. by adding $y^{exp}_{i-d,t-1}(1-y^{exp}_{id,t-1})$ and $y^{exp}_{i-d,t-1}y^{exp}_{id,t-1}$). Note that the lagged dependent $y^{exp}_{id,t-1}$ is now interacted with several variables which affects the interpretation of the coefficient on this variable. In the following, I therefore focus the discussion on the experience variables.

The Role of Export Experience

The results in column (i) of Table 6 show that export experience from other markets matters only for the decision to start exporting to a country while importing from a market increases both the probability of entering that market (in case a firm does not export to the market) as well as the probability of staying in the market (in case a firm already exports to that market). The results are robust to the inclusion of country-year fixed effects in column (ii). In column (iii) I add firm-specific trends to the model which renders the effect of experience from other markets insignificant, while the coefficients on both import variables remain highly significant and are both of similar magnitude. Hence, the results suggest that importing from a market implies a reduction in the perceived importance of sunk costs as well as per period fixed costs. On the other hand, experience from other markets does not appear to matter for the decision to export to a market.

This latter finding seems surprising at first; but it may actually just be an artefact of the measure of experience. Specifically, experience is modeled with the help of a dummy variable indicating whether a firm exported to at least one market other than d in the previous period. This measure may simply be too crude; for instance, experience may depend on the number of markets served by a firm. A firm with lots of export experience in different markets of the world may find it easy to add another market to its portfolio, while experience from only one particular market may simply be not enough to significantly lower exporting costs with respect to other markets. Such a story would actually question the importance of global sunk costs of exporting which a firm pays the first time it exports independent of the market and which it does not have to pay again when entering new markets. To test this conjecture, in addition to the dummies, I include variables for experience from other markets based on counts in the model; i.e. these variables count the number of other markets a firm exported to in period $t-1$. The results in column (iv) suggest that this distinction is important; experience from several markets exhibits a significant effect on the probability to start exporting to a market. Moreover, a weakly significant effect is found on per period fixed costs. Column (v) shows that this finding is robust to including country-year dummies in the model. However, when adding firm-year dummies in column (vi), the effect of experience from other markets on the sunk costs of exporting to market d becomes only weakly significant and the effect on per period fixed costs disappears completely. In the remaining three columns of Table 6 I drop the dummy variables on experience from other markets while keeping the count variables and obtain similar results as in columns (iv) to (vi).

It is possible that the lack of robust evidence for the role of export experience from other markets is still related to an inadequate measure for this type of experience. In particular, it is possible that the role of experience depends on the characteristics of markets already served by a firm. Firms may find it easier to start exporting to markets which are similar in some characteristics to markets that they already serve (Morales et al., 2011). I therefore account for this possibility by distinguishing the role of experience from markets with characteristics similar to market d and experience from markets with dissimilar characteristics. I use the common gravity variables to determine whether two countries are similar; i.e. I consider two countries to be culturally similar if they speak the same language or have a common colonial history and I consider two countries to be geographically similar if they share a common border or are located in the same region of the world.[21] The estimation results are presented in Table 7. The results show that this distinction indeed is crucial for identifying the effect of experience from other markets. Experience from other markets with similar characteristics like market d both increase the probability of starting to export to that market and the probability of continuing to export to that market. Note that this effect is specific to the count variables of experience suggesting that it is important to have experience from more than just one market. These results are robust to including firm-year fixed effects in the model and to both measures of similarity; i.e. cultural and geographical similarity.

The results from the linear probability model provide some important insights for our understanding of the role of experience in international trade. First, a very robust finding is that importing from a market facilitates exporting to that market. Second, export experience from other markets can help exporting to a market if certain conditions are fulfilled; specifically, if the experience comes from markets which are culturally or geographically similar to the market of interest and if the firm has experience from more than just one other market. Note that the conditionality of the experience effect from other markets suggests that general sunk costs of exporting are of limited importance only and that sunk costs are instead largely destination specific while accumulated experience from other markets can help in reducing their importance. Third, import experience and experience from other markets (if the mentioned conditions are fulfilled) matter for the decision to enter a market as well as the decision to stay in a market suggesting that experience matters for sunk costs and per period fixed costs.

These results are obtained from estimations on firms belonging to the furniture manufacturing sector. As mentioned before, many firms in this sector engage in exporting and importing which begs the question of whether the results are specific to this industry. In the following section I therefore check the robustness of the results using data on firms belonging to different sectors.

[21] The geographic regions are: North-, East-, South-, West-, and Middle-Africa; Caribbean, North-, Central-, and South-America; East-, South-, South-East-, West-, and Central-Asia; North-, East-, South-, West-Europe; Oceania. Variables on language, colonial history and borders are taken from CEPII.

4.3 Robustness and Generalization

In this sub-section I present estimation results for firms belonging to different sectors than the furniture industry. The data cleaning and sample selection for these firms follows the same rules as for the furniture sector presented in section 3. Moreover, the same set of destination markets is considered in the analysis. Note that estimating the models from before for all manufacturing firms pooled together becomes difficult when controlling for firm-year dummies.[22] For this reason, I aggregate the major sectors together into four groups. Each group is small enough to estimate the model with firm-year fixed effects and large enough to provide efficient results even after adding all the dummies to the regressions. For each group I estimate five specifications. First, I estimate a baseline model as presented in Table 5 to evaluate the importance of market-specific sunk costs and import experience from a market. Then, I supplement the estimations with additional experience terms, whereas I only consider the role of experience from other markets based on count variable as they have shown to matter before. For each type of similarity (cultural and geographical) I estimate the model first with country-year dummies and then with firm-year dummies.

The estimation results are presented in Tables 8 and 9, where each table contains the results for two groups of sectors. Note that I control for productivity using labor productivity (value added per employee) instead of TFP in the estimations presented in this sub-section. The results provide several important insights. First of all, the results from the baseline specification show significant state dependence in all cases independent of the sector. Moreover, export market age always enters the estimation with a positive and highly significant coefficient. Similarly, market experience from two years ago increases the probability of re-entering the market in this period throughout the estimations. Furthermore, the import variable is always highly significant and exhibits an effect of a magnitude comparable to above (6-7%). When splitting the effect of importing from a market into that on the decision to enter a market and on the decision to stay in a market, the estimations confirm the results from above in that importing significantly

[22] The computational burden becomes very large as the matrix of covariates becomes huge.

affects both decisions. These results are robust to controlling for experience from other markets and to adding country-year and firm-year dummies to the model.

The findings from before concerning the role of experience from other markets are generally confirmed by the results for the two sectors presented in Table 8. First, highly significant effects from experience are found when controlling for country-year effects. Second, when adding firm-year dummies, only the effects of experience from markets with similar characteristics remain significant. Specifically, the results suggest that experience from other markets with similar cultural characteristics mainly affects the decision to enter another market, while experience from other markets in geographic proximity to the market of interest both affect the perceived importance of sunk costs and per period fixed costs of exporting to this country.

In Table 9, on the other hand, the results regarding experience from other markets turn out to be more sensitive. In one sector (columns i-v) only weakly significant effect of experience from other markets are found when controlling for country-year dummies. The results become stronger in terms of significance for experience from culturally similar markets when adding firm-year dummies to the estimations, while they remain weakly significant for geographically similar markets. In this sector experience from other markets furthermore rather affects the fixed costs of exporting. In the other sector (columns vi-x), as usual highly significant effects are found when controlling for country-year fixed effects. However, when adding firm-year dummies to the model, the significance of the effects vanishes almost completely.

I conclude this section by stating that overall the results appear robust; only the effects of export experience from other markets turn out to be more sensitive. While the results are in line with the findings for the furniture sector in two groups of sectors, only weakly significant effects are found in the third group and basically no significant effects are found in the fourth group when adding firm-year dummies to the model.

5 Conclusion

This paper estimates the importance of country-specific sunk costs and pays special attention to the role that previous experience in international trade may have for exporting to a market. In the model firms can benefit from experience related to importing from a specific market and from experience of exporting to other markets. The former point implies that firms may collect foreign-market-specific knowledge related to importing from a country which facilitates exporting to that country; e.g. by familiarizing the firm with the foreign market's conditions. General export experience may be relevant if sunk costs of exporting consist of a global and a market-specific component. Moreover, export experience from other markets may be relevant as it can ease entry into markets which are similar in some characteristics such as language or geographic location. If the depth of experience also matters, the latter effects should be higher if firms have export experience from several markets. Moreover, it is assessed whether experience matters only for the decision to enter a market, or also for the decision stay in a market.

I motivate an empirical model which allows for these different mechanisms. The importance of sunk costs is inferred from the degree of state dependence of firms' export participation in a market. The applied econometric model addresses a variety of potential biases of the state dependence parameter and, furthermore, accounts for other explanations than sunk costs that could induce persistency in firms' export decisions. Even after controlling for such aspects, destination-specific sunk costs are found to matter. Firms' experiences in international trade can, however, help firms to overcome these costs more easily. In particular, import experience from a market is found to facilitate exporting this country. Furthermore, export experience from other markets can increase the probability of exporting to a country. This latter effect turns out to be conditional on the characteristics and number of markets served by a firm suggesting that global sunk costs of exporting are only of limited importance. The results show that importing from a market both effects the probability of entering the market (in case the firm does not export to the country) and to stay in the market (in case the firm already exports there). The former aspect is in line with a story where importing reduces the information gathering costs necessary to start exporting to a market. The latter point suggests that firms may also share some of the per period fixed costs related to importing from and exporting to a market in case they conduct both activities in one country. Export experience from other markets may also influence both decisions, while the evidence related to the decision to enter a market appears more robust.

Overall, this paper adds to our understanding of firms' internationalization strategies by depicting the role of firms' experience in international trade and the interconnectedness between their exporting activities in different markets on the one hand and their exporting and importing activities in the same markets on the other hand. Moreover, the paper shows that sunk costs are not the only explanation for persistency in firms' export activities. Neglecting such explanations implies overstating the importance of country-specific sunk costs.

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6 Tables

Table 1: Summary Statistics

	Whole Sample	No-Trader	Importer	Exporter	Two-Way-Trader
Log TFP (t-1)	10.282	10.256	10.381	10.382	10.426
	(0.336)	(0.334)	(0.339)	(0.331)	(0.297)
Log No. of Employees (t-1)	3.728	3.588	4.101	4.272	4.574
	(0.929)	(0.86)	(0.931)	(0.975)	(0.95)
Log GDP	25.675				
	(1.734)				
Log Population	16.417				
	(1.809)				
Log of Real Exchange Rate	4.591				
	(0.655)				
Log Distance	7.821				
	(1.104)				
No. of Observations	51,516	41,787	1,749	5,187	2,793

Table contains summary statistics: Sample mean and standard deviation (in parenthesis)

Table 2: Firms that start exporting, stop exporting, continuously export and export a single year to a market

	Starters	Stoppers	Single Year	Continuous
Absolute				
Number	79	74	79	653
Total Export Volume (in mill. DKK)	45	15	9	1957
Shares				
Number	8.9%	8.4%	8.9%	73.8%
Total Export Volume	2.2%	0.7%	0.4%	96.6%

Numbers are time means over the sample period 1997-2006

Table 3: Non-linear model (MSL)

	(i)		(ii)		(iii)		(iv)	
Lagged Export Status	1.831***	(0.054)	2.366***	(0.076)	1.536***	(0.119)	1.353***	(0.054)
Last Exported Two Years Ago	0.574***	(0.06)	0.284***	(0.066)	0.827***	(0.076)	0.909***	(0.058)
Last Exported Three Years Ago	0.235***	(0.071)	0.391***	(0.079)	0.547***	(0.07)	0.558***	(0.069)
Export Market Age					0.261***	(0.022)	0.29***	(0.015)
TFP (t-1)	0.353***	(0.05)	0.356***	(0.051)	0.318***	(0.046)	0.322***	(0.047)
No. of Employees (t-1)	0.553***	(0.027)	0.5***	(0.031)	0.362***	(0.021)	0.372***	(0.02)
GDP	0.535***	(0.029)	0.47***	(0.032)	0.302***	(0.022)	0.309***	(0.021)
Population	-0.429***	(0.027)	-0.379***	(0.029)	-0.238***	(0.02)	-0.243***	(0.02)
Bilateral Distance	-0.132***	(0.015)	-0.121***	(0.015)	-0.107***	(0.014)	-0.111***	(0.014)
Bilateral Exchange Rate	-0.199***	(0.022)	-0.1854***	(0.022)	-0.1708***	(0.019)	-0.1756***	(0.019)
δ^p (pre-sample)			0.466***	(0.062)	0.279***	(0.071)		
$\delta(J+1\dots T)$			-0.35***	(0.022)	-0.09*	(0.05)		
λ	0.293***	(0.028)	0.252***	(0.037)	0.055***	(0.015)	0.054***	(0.014)
η	4.257***	(0.345)	3.53***	(0.469)	10.109***	(1.652)	11.835***	(1.686)
Number of Observations	51,516		51,516		51,516		51,516	
Log-Likelihood	-8895.79		-8801.22		-8715.54		-8726.20	
Average Partial Effects								
Lagged Export Status	0.331		0.461		0.282		0.232	
Last Exported Two Years Ago	0.065		0.023		0.113		0.130	
Last Exported Three Years Ago	0.000		0.033		0.066		0.068	

All regression contain year and 4-digit NACE industry dummies; standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; simulations based on 100 draws; pre-sample estimates and constant terms omitted from table

Table 4: Joint estimation of export and import participation (MSL)

	Joint Estimation				Separate Estimation			
	Export Equation (i)		Import Equation (ii)		Export Equation (iii)		Import Equation (iv)	
Lagged Exp / Imp Status	1.338***	(0.055)	1.359***	(0.058)	1.345***	(0.054)	1.375***	(0.058)
Last Exp/Imp Two Years Ago	0.875***	(0.058)	0.839***	(0.064)	0.905***	(0.058)	0.843***	(0.066)
Last Exp/Imp Three Years Ago	0.535***	(0.069)	0.626***	(0.076)	0.555***	(0.069)	0.628***	(0.078)
Export Market Age	0.275***	(0.015)	0.266***	(0.018)	0.285***	(0.015)	0.262***	(0.019)
Cross Equation State Dependence	0.142***	(0.043)	0.219***	(0.049)	0.261***	(0.042)	0.327***	(0.036)
TFP (t-1)	0.196***	(0.045)	0.077*	(0.047)	0.308***	(0.047)	0.092*	(0.049)
No. of Employees (t-1)	0.342***	(0.02)	0.279***	(0.019)	0.352***	(0.02)	0.283***	(0.019)
GDP	0.289***	(0.021)	0.106***	(0.018)	0.31***	(0.022)	0.109***	(0.018)
Population	-0.225***	(0.019)	0.034**	(0.017)	-0.254***	(0.021)	0.019	(0.017)
Bilateral Distance	-0.141***	(0.016)	-0.237***	(0.018)	-0.089***	(0.014)	-0.183***	(0.016)
Bilateral Exchange Rate	-0.16***	(0.02)	-0.07**	(0.031)	-0.17***	(0.019)	-0.071**	(0.031)
σ_α	0.387***	(0.038)	0.288***	(0.039)				
ρ_α	0.849***	(0.061)						
ρ_ν	0.227***	(0.027)						
λ					0.051***	(0.013)	0.033**	(0.013)
η					11.726***	(1.68)	16.082***	(3.405)
Number of Observations	51516				51516		51516	
Log-Likelihood	-15845.14				-8727.10		-7104.06	
Average Partial Effects								
Lagged Exp / Imp Status	0.238		0.209		0.229		0.183	
Last Exp/Imp Two Years Ago	0.129		0.095		0.128		0.077	
Last Exp/Imp Three Years Ago	0.067		0.062		0.067		0.049	
Cross Equation State Dependence	0.015		0.016		0.027		0.020	

All regression contain year dummies; standard errors in parentheses; , *** p<0.01, ** p<0.05, * p<0.1; regression in columns (iii) and (iv) contain 4-digit NACE industry dummies; simulations based on 25 draws; pre-sample estimates and constant terms omitted from table

Table 5: Linear Probability Model (Diff-GMM) - baseline models

	(i)		(ii)		(iii)		(iv)	
Export Status (t-1)	0.223***	(0.028)	0.221***	(0.028)	0.204***	(0.028)	0.190***	(0.027)
Last exported (t-2)	0.126***	(0.023)	0.125***	(0.023)	0.117***	(0.022)	0.105***	(0.02)
Last exported (t-3)	0.033*	(0.017)	0.032*	(0.017)	0.029*	(0.017)	0.025	(0.016)
Export market age	0.163***	(0.023)	0.161***	(0.023)	0.160***	(0.022)	0.150***	(0.02)
Import Status (t-1)			0.070***	(0.018)	0.061***	(0.017)	0.061***	(0.017)
Tfp (t-1)	0.027**	(0.012)	0.027**	(0.012)	0.027**	(0.012)		
Employees (t-1)	0.025***	(0.009)	0.025***	(0.009)	0.025***	(0.009)		
GDP	0.121***	(0.035)	0.117***	(0.035)			0.116***	(0.034)
Population	0.077	(0.063)	0.088	(0.063)			0.082	(0.06)
Real Xrat	-0.017	(0.014)	-0.018	(0.014)			-0.018	(0.014)
Number of Obs.	40,068		40,068		40,068		40,068	
AR 1 test (p-value)	0.550		0.551		0.581		0.628	
Hansen (p-value)	0.504		0.471		0.473		0.000	
Country-year FE					yes			
Firm-year FE							yes	

Regressions contain year and 4-digit NACE industry dummies; clustered standard errors in parentheses;
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Linear Probability Model (Diff-GMM) - general experience

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(xi)
Export status (t-1)	0.201**	0.193**	0.214**	0.207**	0.198**	0.169	0.286***	0.268***	0.263***
	(0.098)	(0.094)	(0.097)	(0.102)	(0.098)	(0.103)	(0.042)	(0.042)	(0.040)
Last exported (t-2)	0.125***	0.117***	0.105***	0.112***	0.104***	0.098***	0.113***	0.105***	0.098***
	(0.023)	(0.022)	(0.020)	(0.023)	(0.022)	(0.020)	(0.023)	(0.022)	(0.020)
Last exported (t-3)	0.032*	0.029*	0.025	0.026	0.022	0.023	0.026	0.022	0.023
	(0.017)	(0.017)	(0.016)	(0.017)	(0.016)	(0.016)	(0.017)	(0.016)	(0.016)
Export market age	0.162***	0.160***	0.150***	0.168***	0.167***	0.153***	0.168***	0.167***	0.153***
	(0.023)	(0.022)	(0.020)	(0.026)	(0.025)	(0.020)	(0.026)	(0.025)	(0.020)
Exper. - start (t-1) - dummy	0.020***	0.020***	0.026	-0.020*	-0.020*	-0.041			
	(0.006)	(0.006)	(0.024)	(0.012)	(0.012)	(0.038)			
Exper. - stay (t-1)- dummy	0.042	0.032	0.002	0.066	0.056	0.058			
	(0.096)	(0.092)	(0.091)	(0.102)	(0.098)	(0.096)			
Exper. - start (t-1)- count				0.022***	0.022***	0.013*	0.022***	0.022***	0.013*
				(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Exper. - stay (t-1)- count				0.017*	0.016*	0.008	0.017*	0.016*	0.008
				(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.008)
Import - starter (t-1)	0.075***	0.064**	0.061**	0.073***	0.062**	0.063**	0.073***	0.062**	0.062**
	(0.026)	(0.025)	(0.024)	(0.026)	(0.025)	(0.024)	(0.027)	(0.025)	(0.024)
Import - stay (t-1)	0.068***	0.060***	0.061***	0.061***	0.054***	0.060***	0.062***	0.054***	0.060***
	(0.021)	(0.021)	(0.020)	(0.021)	(0.021)	(0.020)	(0.021)	(0.021)	(0.020)
Tfp (t-1)	0.028**	0.027**		0.037**	0.037**		0.038**	0.037***	
	(0.012)	(0.012)		(0.015)	(0.014)		(0.015)	(0.014)	
Employees (t-1)	0.025***	0.025***		0.026***	0.026***		0.027***	0.027***	
	(0.009)	(0.009)		(0.010)	(0.010)		(0.010)	(0.010)	
GDP	0.117***		0.115***	0.123***		0.117***	0.123***		0.117***
	(0.035)		(0.034)	(0.036)		(0.034)	(0.036)		(0.034)
Population	0.089		0.082	0.089		0.083	0.088		0.083
	(0.063)		(0.060)	(0.064)		(0.060)	(0.064)		(0.060)
Real Xrat	-0.018		-0.018	-0.019		-0.019	-0.019		-0.019
	(0.014)		(0.014)	(0.014)		(0.014)	(0.014)		(0.014)
Observations	40,068	40,068	40,068	40,068	40,068	40,068	40,068	40,068	40,068
AR 1 test (p-value)	0.549	0.582	0.629	0.372	0.400	0.630	0.396	0.423	0.645
Hansen (p-value)	0.476	0.476	0.522	0.219	0.218	0.325	0.218	0.219	0.000
Country-year dummies		yes			yes			yes	
Firm-year dummies			yes			yes			yes

Regressions contain year and 4-digit NACE industry dummies; clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7: Linear Probability Model (Diff-GMM) - experience from similar / dissimilar markets

	Similarity - culture (language & colony)						Similarity - geography (border & geogr. regions)					
	(i)		(ii)		(iii)		(iv)		(v)		(vi)	
Export status (t-1)	0.199**	(0.097)	0.168*	(0.102)	0.264***	(0.04)	0.199**	(0.098)	0.173*	(0.103)	0.258***	(0.04)
Last exported (t-2)	0.101***	(0.022)	0.096***	(0.02)	0.096***	(0.02)	0.103***	(0.022)	0.094***	(0.02)	0.095***	(0.02)
Last exported (t-3)	0.021	(0.016)	0.022	(0.016)	0.022	(0.016)	0.021	(0.016)	0.021	(0.016)	0.021	(0.016)
Export market age	0.162***	(0.024)	0.150***	(0.02)	0.150***	(0.02)	0.167***	(0.025)	0.151***	(0.019)	0.152***	(0.019)
Dummies												
Similar - start (t-1)	-0.036*	(0.021)	-0.052	(0.043)			-0.057**	(0.024)	-0.083**	(0.042)		
Dissim. - start (t-1)	-0.015	(0.011)	-0.040	(0.038)			-0.019	(0.012)	-0.036	(0.039)		
Similar - stay (t-1)	0.039	(0.101)	0.053	(0.1)			-0.015	(0.105)	-0.022	(0.1)		
Dissim. - stay (t-1)	0.062	(0.098)	0.058	(0.096)			0.062	(0.099)	0.062	(0.097)		
Counts												
Similar - start (t-1)	0.052***	(0.014)	0.050***	(0.015)	0.047***	(0.013)	0.061***	(0.019)	0.061***	(0.016)	0.042***	(0.012)
Dissim. - start (t-1)	0.017**	(0.008)	0.012	(0.008)	0.011	(0.008)	0.021**	(0.008)	0.012	(0.008)	0.011	(0.008)
Similar - stay (t-1)	0.047***	(0.015)	0.044***	(0.015)	0.042***	(0.014)	0.066***	(0.025)	0.064***	(0.019)	0.040**	(0.015)
Dissim. - stay (t-1)	0.011	(0.009)	0.007	(0.008)	0.007	(0.008)	0.016*	(0.009)	0.007	(0.008)	0.006	(0.008)
Import - starter (t-1)	0.060**	(0.025)	0.063**	(0.024)	0.062**	(0.024)	0.060**	(0.025)	0.060**	(0.024)	0.061**	(0.024)
Import - stay (t-1)	0.054***	(0.021)	0.061***	(0.02)	0.061***	(0.02)	0.052**	(0.021)	0.058***	(0.02)	0.059***	(0.02)
Tfp (t-1)	0.035**	(0.014)					0.038***	(0.015)				
Employees (t-1)	0.027***	(0.01)					0.027***	(0.01)				
GDP			0.116***	(0.034)	0.116***	(0.034)			0.111***	(0.035)	0.111***	(0.035)
Population			0.100*	(0.06)	0.099	(0.06)			0.096	(0.06)	0.096	(0.06)
Real Xrat			-0.020	(0.014)	-0.020	(0.014)			-0.020	(0.014)	-0.021	(0.014)
Observations	40,068		40,068		40,068		40,068		40,068		40,068	
AR 1 test (p-value)	0.495		0.719		0.735		0.372		0.568		0.571	
Hansen (p-value)	0.222		0.000		0.000		0.196		0.417		0.000	
Country-year dummies	yes						yes					
Firm-year dummies			yes		yes				yes		yes	

Regressions contain year and 4-digit NACE industry dummies; clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 8: Linear Probability Model (Diff-GMM) - based on other sectors I

	DA: Food, beverages and tobacco; DE: Pulp, paper, publishing and printing					DG: Chemicals, man-made firbes; DH: Rubber and plastic; DI: Other non-metallic mineral products				
	Base	Cultural Similarity		Geogr. Similarity		Base	Cultural Similarity		Geogr. Similarity	
	(i)	(ii)	(iii)	(iv)	(v)	(i)	(ii)	(iii)	(iv)	(v)
Export status (t-1)	0.370***	0.318***	0.218***	0.320***	0.214***	0.399***	0.456***	0.340***	0.463***	0.343***
	(0.026)	(0.032)	(0.028)	(0.032)	(0.028)	(0.024)	(0.039)	(0.033)	(0.040)	(0.033)
Last exported (t-2)	0.173***	0.136***	0.070***	0.139***	0.070***	0.213***	0.219***	0.168***	0.222***	0.168***
	(0.025)	(0.022)	(0.016)	(0.022)	(0.016)	(0.025)	(0.026)	(0.021)	(0.027)	(0.021)
Last exported (t-3)	0.040**	0.026	0.011	0.028*	0.012	0.041**	0.043**	0.025*	0.044***	0.026*
	(0.016)	(0.016)	(0.014)	(0.016)	(0.014)	(0.016)	(0.017)	(0.015)	(0.017)	(0.015)
Export market age	0.188***	0.165***	0.158***	0.167***	0.158***	0.147***	0.141***	0.126***	0.138***	0.122***
	(0.019)	(0.017)	(0.017)	(0.017)	(0.017)	(0.015)	(0.015)	(0.013)	(0.014)	(0.013)
Exper. sim. - start (t-1)		0.057***	0.026***	0.053***	0.022***		0.063***	0.041**	0.070***	0.053***
		(0.008)	(0.008)	(0.009)	(0.008)		(0.010)	(0.019)	(0.011)	(0.019)
Exper. dissim. - start (t-1)		0.029***	-0.003	0.030***	-0.004		0.049***	0.026	0.049***	0.027
		(0.004)	(0.004)	(0.004)	(0.004)		(0.007)	(0.018)	(0.007)	(0.018)
Exper. sim. - stay (t-1)		0.054***	0.022**	0.071***	0.034***		0.051***	0.030	0.092***	0.071***
		(0.011)	(0.011)	(0.013)	(0.011)		(0.011)	(0.020)	(0.013)	(0.020)
Exper. dissim. - stay (t-1)		0.030***	-0.001	0.029***	-0.004		0.046***	0.028	0.043***	0.026
		(0.004)	(0.004)	(0.004)	(0.004)		(0.007)	(0.018)	(0.007)	(0.018)
Import (t-1)	0.074***					0.061***				
	(0.014)					(0.013)				
Import - starter (t-1)		0.074***	0.058***	0.077***	0.059***		0.068***	0.033**	0.074***	0.035**
		(0.014)	(0.013)	(0.014)	(0.013)		(0.018)	(0.015)	(0.019)	(0.015)
Import - stay (t-1)		0.039**	0.035**	0.040**	0.035**		0.053***	0.053***	0.047***	0.046***
		(0.018)	(0.017)	(0.018)	(0.017)		(0.017)	(0.016)	(0.017)	(0.015)
Labor Productivity (t-1)	0.027***	0.051***		0.054***		0.015**	0.032***		0.032***	
	(0.006)	(0.008)		(0.009)		(0.006)	(0.008)		(0.008)	
Employees (t-1)	0.020***	0.022***		0.024***		0.010	-0.030***		-0.030***	
	(0.005)	(0.006)		(0.006)		(0.007)	(0.010)		(0.010)	
GDP	0.021		0.017		0.018	0.051**		0.050**		0.049**
	(0.015)		(0.014)		(0.014)	(0.022)		(0.021)		(0.021)
Population	0.012		-0.000		0.009	0.054		0.044		0.064*
	(0.025)		(0.023)		(0.023)	(0.038)		(0.036)		(0.037)
Real Xrat	-0.025***		-0.024***		-0.024***	-0.024**		-0.023**		-0.022**
	(0.006)		(0.006)		(0.006)	(0.010)		(0.009)		(0.009)
Observations	140,238	140,238	140,238	140,238	140,238	92,232	92,232	92,232	92,232	92,232
AR 1 test (p-value)	0.837	0.876	0.031	0.805	0.030	0.498	0.205	0.264	0.141	0.196
Hansen (p-value)	0.981	0.682	0.000	0.685	0.000	0.339	0.539	0.155	0.470	0.083
Country-year dummies		yes		yes			yes		yes	
Firm-year dummies			yes		yes			yes		yes

All regressions contain year dummies; similarity variable based on counts; *** p<0.01, ** p<0.05, * p<0.1

Table 9: Linear Probability Model (Diff-GMM) - based on other sectors II

	DJ: Basic metals and fabricated metal products					DK: Machinery and equipment n.e.c. DL: electrical and optical equipment				
	Base	Cultural Similarity		Geogr. Similarity		Base	Cultural Similarity		Geogr. Similarity	
	(i)	(ii)	(iii)	(iv)	(v)	(i)	(ii)	(iii)	(iv)	(v)
Export status (t-1)	0.239***	0.187***	0.216***	0.172***	0.215***	0.273***	0.323***	0.201***	0.334***	0.199***
	(0.025)	(0.041)	(0.030)	(0.040)	(0.030)	(0.014)	(0.023)	(0.020)	(0.024)	(0.020)
Last exported (t-2)	0.122***	0.100***	0.113***	0.094***	0.113***	0.151***	0.161***	0.108***	0.165***	0.107***
	(0.023)	(0.019)	(0.018)	(0.018)	(0.018)	(0.014)	(0.015)	(0.012)	(0.016)	(0.012)
Last exported (t-3)	0.018	0.009	0.019	0.008	0.019	0.038***	0.047***	0.017	0.049***	0.016
	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)	(0.012)	(0.013)	(0.011)	(0.013)	(0.011)
Export market age	0.137***	0.113***	0.129***	0.111***	0.132***	0.129***	0.118***	0.112***	0.119***	0.110***
	(0.022)	(0.014)	(0.018)	(0.014)	(0.018)	(0.010)	(0.010)	(0.008)	(0.010)	(0.008)
Exper. sim. - start (t-1)		0.009	0.037***	-0.012	0.015		0.060***	0.010	0.063***	0.012
		(0.014)	(0.011)	(0.010)	(0.010)		(0.007)	(0.010)	(0.008)	(0.009)
Exper. dissim. - start (t-1)		-0.010	0.010	-0.014	0.011		0.042***	-0.006	0.044***	-0.007
		(0.009)	(0.007)	(0.009)	(0.007)		(0.005)	(0.008)	(0.005)	(0.008)
Exper. sim. - stay (t-1)		0.027*	0.057***	-0.002	0.026*		0.067***	0.015	0.068***	0.016*
		(0.016)	(0.013)	(0.012)	(0.014)		(0.008)	(0.010)	(0.009)	(0.010)
Exper. dissim. - stay (t-1)		-0.010	0.010	-0.013	0.012*		0.039***	-0.006	0.041***	-0.008
		(0.008)	(0.007)	(0.008)	(0.007)		(0.005)	(0.008)	(0.005)	(0.008)
Import (t-1)	0.062***					0.062***				
	(0.016)					(0.008)				
Import - starter (t-1)		0.051**	0.073***	0.043**	0.072***		0.083***	0.053***	0.085***	0.052***
		(0.020)	(0.017)	(0.019)	(0.017)		(0.015)	(0.012)	(0.015)	(0.012)
Import - stay (t-1)		0.031	0.053***	0.025	0.052***		0.072***	0.045***	0.073***	0.044***
		(0.019)	(0.019)	(0.019)	(0.018)		(0.010)	(0.007)	(0.010)	(0.007)
Labor Productivity (t-1)	0.002	-0.009		-0.014		0.025***	0.050***		0.053***	
	(0.005)	(0.009)		(0.009)		(0.007)	(0.009)		(0.009)	
Employees (t-1)	0.003	0.001		-0.000		0.026***	-0.050***		-0.053***	
	(0.005)	(0.005)		(0.005)		(0.007)	(0.012)		(0.013)	
GDP	0.049***		0.049***		0.048***	0.101***		0.107***		0.106***
	(0.015)		(0.014)		(0.014)	(0.022)		(0.021)		(0.021)
Population	-0.018		-0.025		-0.016	-0.048		-0.071*		-0.040
	(0.028)		(0.027)		(0.028)	(0.039)		(0.037)		(0.038)
Real Xrat	-0.008		-0.008		-0.008	-0.026***		-0.025***		-0.024***
	(0.006)		(0.006)		(0.006)	(0.010)		(0.009)		(0.009)
Observations	117,180	117,180	117,180	117,180	117,180	155,358	155,358	155,358	155,358	155,358
AR 1 test (p-value)	0.078	0.078	0.075	0.116	0.105	0.025	0.299	0.034	0.316	0.032
Hansen (p-value)	0.235	0.260	0.217	0.233	0.187	0.969	0.917	0.000	0.944	0.550
Country-year dummies		yes		yes			yes		yes	
Firm-year dummies			yes		yes			yes		yes

All regressions contain year dummies; similarity variable based on counts; *** p<0.01, ** p<0.05, * p<0.1

Appendix A: TFP Estimation

The literature on productivity estimations provides different approaches for obtaining TFP (see van Beveren (2012) for a recent survey). In this paper, I apply a structural approach and specifically use a modified version of the approach suggested by Ackerberg et al. (2006) which allows TFP to be affected by firms export and import decisions. Consider a standard Cobb-Douglas value added production function:

$$y_{it} = \alpha_0 + \alpha_l l_{it} + \alpha_k k_{it} + \omega_{it} + \epsilon_{it}, \tag{5}$$

where all variables are presented in logs. y_{it} represents value added of firm i in year t, l_{it} and k_{it} are firm-level inputs of labor and capital, ω_{it} is a measure of unobserved (by the econometrican, and observed by the manager) firm-level productivity and ϵ_{it} is noise. I follow the insight from Levinsohn and Petrin (2003) and use intermediate inputs m_{it} as proxy for the unobserved productivity shock ω_{it}.

$$m_{it} = h_t(k_{it}, l_{it}, \omega_{it}, exp_{it}, imp_{it}), \tag{6}$$

where exp_{it} and imp_{it} are dummy variables indicating whether firm i exports and/or imports in year t. Note that including exp_{it} and imp_{it} in the equation implies that I allow for differences in input demand depending on a firm's trading activities. Inverting the equation for ω and substituting into the production function yields the estimation equation for the first step of the algorithm:

$$y_{it} = \phi_t(k_{it}, l_{it}, m_{it}, exp_{it}, imp_{it}) + \epsilon_{it} \tag{7}$$

where $\phi_t(\cdot) = \beta_l l_{it} + \beta_k k_{it} + h_t^{-1}(k_{it}, l_{it}, m_{it}, exp_{it}, imp_{it})$, i.e. output net of ϵ_{it}. I approximate the function $h_t^{-1}(\cdot)$ using a polynomial expansion of order four of its argument and obtain $\hat{\phi}_{it}$. Hence, the first step allows me to compute productivity for any parameter value as $\omega(\beta_l, \beta_k) = \hat{\phi} - \beta_l l_{it} - \beta_k k_{it}$. The second stage then relies on the law of motion of productivity which is modeled as a Markov process allowing productivity to be affected by lagged realizations of exp_{it} and imp_{it}:

$$\omega_{it} = g(\omega_{it-1}) + exp_{it-1} + imp_{it-1} + \upsilon_{it}. \tag{8}$$

I can obtain the innovation to productivity $\upsilon_{it}(\beta_l, \beta_k)$ as the residual from non-parametrically regressing $\omega(\beta_l, \beta_k)$ on its lag, exp_{it-1} and imp_{it-1}. Next, I can specify moments to identify the parameters of interest

$$E\left(\upsilon_{it}(\cdot)\begin{pmatrix} l_{it-1} \\ k_{it} \end{pmatrix}\right) = 0 \tag{9}$$

and minimize the sample analog of this equation by GMM. I present the coefficients on labor and capital from the production function and the coefficients on exp_{it-1} and imp_{it-1} from the Markov process in the table below.

Table A.1: Production Function and Law of Motion of Productivity

Coef. Production Function			
k_{it}	0.200 (0.022)	l_{it}	0.782 (0.014)
Coef. Law of Motion Productivity			
imp_{it-1}	0.049 (0.009)	exp_{it-1}	0.014 (0.009)

Std. Errors for prod. fct. obtained by bootstrapping (200 repl.)

Appendix B: Robustness - number of draws and generated data

Results with 100 and 250 draws

In Table B.1 I present estimation results for the baseline MSL model with AR1 error process based on 100 and 250 draws. The results indicate that coefficient estimates are very similar in both columns. In particular, the results for the coefficient of interest on lagged export status as well as it's average partial effect is hardly affected from increasing the number of draws.[23]

[23] Note that these estimations are based on the same data set used in the paper but using changes in the nominal exchange rate instead of the real exchange rate. As the GDP deflator data required to

Table B.1: Baseline estimations of MSL model with AR1 error

	100 draws		250 draws	
Lagged Export Status	2.411***	(0.076)	2.415***	(0.076)
Last Exported Two Years Ago	0.303***	(0.066)	0.299***	(0.066)
Last Exported Three Years Ago	0.424***	(0.079)	0.421***	(0.079)
TFP (t-1)	0.377***	(0.051)	0.379***	(0.052)
No. of Employees (t-1)	0.439***	(0.03)	0.39***	(0.033)
GDP	0.521***	(0.029)	0.454***	(0.032)
Population	-0.469***	(0.028)	-0.408***	(0.03)
Bilateral Distance	-0.115***	(0.015)	-0.107***	(0.015)
Bilateral Exchange Rate	0.0004	(0.002)	0.0004	(0.002)
δ^p (pre-sample)	0.467***	(0.067)	0.484***	(0.061)
$\delta(J+1\dots T)$	-0.354***	(0.021)	-0.359***	(0.022)
λ	0.252***	(0.037)	0.253***	(0.036)
η	3.567***	(0.488)	3.494***	(0.454)
Number of Observations	52,470		52,470	
Average Partial Effects				
Lagged Export Status	0.474		0.473	
Last Exported Two Years Ago	0.024		0.023	
Last Exported Three Years Ago	0.036		0.035	

All regressions contain year, 4-digit NACE industry, and region dummies; standard errors in parentheses; ***, ** and * denote significance at the 1, 5 and 10 percent levels

Dynamic Discrete Choice Model with AR1 on Generated Data

In this appendix, I present estimation results from the MSL model with AR1 process on simulated data. The data are generated as follows: α is generated from the standard normal distribution implying that λ $(= \frac{\alpha^2}{\alpha^2+1})$ is equal to 0.5. The independent variables x1 and x2 are generated from the uniform distribution on the intervals [-0.5, 0.5] and [1/3, 1 1/3], respectively. The instrument (Inst_{t1}) is generated from the uniform distribution on the interval [0, 1] and the transitory error component is generated from the standard normal.

The actual parameter estimates are presented in the first column of Table 6.1 In columns (ii) to (iv), results are presented for 9000 observations. In particular, 9 time periods are considered and the number of individuals is set to 1000. Equivalently to the models estimated in the paper, three periods are used for the pre-sample equation and six periods for the main equation. The parameters of interest (i.e. the lagged dependent

calculate the real exchange rate is missing for Romania, the analysis in the paper is conducted on 54 markets, while the results presented in this appendix are based on 55 countries.

variable and δ) are highlighted (bold) in the table. In column (v) I increase the number of individuals to 5830 while still considering 9 time periods. The data set is therefore directly comparable to the one used for estimations in appendix B.1. Moreover, as in the paper, 100 draws are used for estimations. The results indicate that the estimator performs well.

Table 6.1: Dynamic discrete choice model with AR1 on generate data

	(i)	(ii)		(iii)		(iv)		(v)	
	Actual	50 draws		100 draws		250 draws		100 draws	
	Coeff	Coeff	StE	Coeff	StE	Coeff	StE	Coeff	StE
Initial values									
x1	0.5	0.64	(0.11)	0.50	(0.11)	0.35	(0.11)	0.54	(0.05)
x2	-5	-4.83	(0.17)	-4.86	(0.17)	-4.68	(0.16)	-4.83	(0.07)
Inst t1	0.5	0.32	(0.11)	0.51	(0.11)	0.45	(0.11)	0.54	(0.05)
cons	3	2.95	(0.13)	2.91	(0.13)	2.84	(0.12)	2.86	(0.05)
Main equation									
ly1	**2**	**2.01**	**(0.11)**	**2.07**	**(0.1)**	**2.07**	**(0.11)**	**2.00**	**(0.04)**
x1	1.5	1.40	(0.11)	1.37	(0.11)	1.56	(0.12)	1.50	(0.05)
x2	-5.3	-5.27	(0.21)	-5.42	(0.21)	-5.49	(0.24)	-5.22	(0.09)
cons	2.5	2.44	(0.12)	2.55	(0.13)	2.54	(0.13)	2.45	(0.05)
δ^p (pre-sample)	0.4	0.38	(0.05)	0.34	(0.06)	0.32	(0.05)	0.31	(0.02)
$\boldsymbol{\delta(J \dots T)}$	**-0.3**	**-0.28**	**(0.06)**	**-0.29**	**(0.05)**	**-0.33**	**(0.06)**	**-0.29**	**(0.02)**
λ	0.5	0.49	(0.03)	0.50	(0.03)	0.51	(0.03)	0.48	(0.01)
θ	0.2	0.07	(0.05)	0.18	(0.05)	0.17	(0.05)	0.16	(0.02)
Observations		9000		9000		9000		52470	

Bivariate Dynamic Discrete Choice Model on Generated Data

In the following, I present estimation results from the MSL model for a bivariate dynamic discrete choice model. The actual parameter estimates are presented in the first column of Table 6.1. The number of individuals is set to 1000 and 9 time periods are considered. In column (v) 5830 individuals are considered. Equivalently to the models estimated in the paper, three periods are used for the pre-sample equation and six periods for the main equation. The parameters of main interest are highlighted (bold) in the table; these are the lagged depended variables, the variables for cross equation state dependence and the correlation coefficients for the individual specific effects (α) and the transitory error component (ω) in the main equations. The data generating process is as follows: The independent variables x1 and x2 are generated from the uniform distribution on the intervals [-0.5.0.5] and [1/3,1 1/3], respectively.

The individual specific components (a_1, a_2) are generated from the standard normal bivariate distribution with correlation 0.5.

The transitory error components in the initial period (ξ_1, ξ_2) and the main equations (ω_1, ω_2) are generated from the standard normal bivariate distribution with correlation 0.4 and 0.3 respectively.

The exclusion restriction for the initial period (Inst_{t1}) is generated from the uniform distribution on the interval [-3/4, 1/4]. The instruments for equations 1 and 2 $(\text{Inst}_{y1}, \text{Inst}_{y2})$ are binary variables generated from the standard normal.

Initial Equations

$y_{11}^* = 4x_1 - 4.5x_2 + 3 + 0.2a_1 + 0.1a_2 + \xi_{1t} - 1.5\text{Inst}_{t1} + 0.3\text{Inst}_{y1}$

$y_{21}^* = -4.5x_1 - 3.5x_2 + 3 + 0.1a_1 + 0.2a_2 + \xi_{2t} - 0.5\text{Inst}_{t1} + 0.5\text{Inst}_{y2}$

Main Equations

$y_{1t}^* = 0.6y_{1,t-1} + 0.2y_{2i,t-1} + 4x_1 - 4x_2 + 2.5 + a_1 + \omega_{1t} + 0.1\text{Inst}_{y1}$

$y_{2t}^* = 0.4y_{2,t-1} + 0.3y_{1i,t-1} - 4x_1 - 3x_2 + 2 + a_2 + \omega_{2t} + 0.3\text{Inst}_{y2}$

Table 6.1: Dynamic bivariate probit on generated data

	(i)	(ii)		(iii)		(iv)		(v)	
	Actual	50 draws		100 draws		250 draws		100 draws	
	Coeff	Coeff	StE	Coeff	StE	Coeff	StE	Coeff	StE
Y1									
Initial values									
x1	4	4.30	(0.19)	3.94	(0.18)	4.18	(0.19)	4.02	(0.08)
x2	-5.5	-5.87	(0.25)	-5.06	(0.21)	-5.67	(0.23)	-5.39	(0.09)
Inst t1	-1	-1.22	(0.14)	-0.93	(0.13)	-1.09	(0.14)	-0.94	(0.06)
Inst y1	0.2	0.19	(0.08)	0.43	(0.08)	0.28	(0.08)	0.23	(0.03)
cons	2.5	2.67	(0.15)	2.12	(0.14)	2.61	(0.15)	2.44	(0.06)
Main equation									
ly1	**2**	**1.95**	**(0.07)**	**1.91**	**(0.07)**	**1.96**	**(0.08)**	**1.97**	**(0.03)**
ly2	**0.2**	**0.14**	**(0.06)**	**0.23**	**(0.07)**	**0.15**	**(0.07)**	**0.25**	**(0.03)**
x1	4	3.82	(0.14)	3.72	(0.14)	4.08	(0.16)	3.96	(0.06)
x2	-5	-4.70	(0.17)	-4.95	(0.17)	-5.01	(0.18)	-4.91	(0.07)
Inst y1	0.1	0.13	(0.06)	0.05	(0.06)	0.04	(0.06)	0.08	(0.02)
cons	2.5	2.31	(0.12)	2.50	(0.12)	2.54	(0.13)	2.46	(0.05)
Y2									
Initial values									
x1	-4.5	-4.57	(0.18)	-4.53	(0.18)	-4.55	(0.18)	-4.42	(0.07)
x2	-5	-5.09	(0.19)	-5.16	(0.19)	-5.13	(0.19)	-4.92	(0.08)
Inst t1	-0.5	-0.62	(0.12)	-0.52	(0.12)	-0.50	(0.12)	-0.42	(0.05)
Inst y2	0.5	0.40	(0.07)	0.50	(0.07)	0.54	(0.07)	0.50	(0.03)
cons	3	3.09	(0.14)	3.11	(0.14)	3.04	(0.14)	2.97	(0.06)
Main equation									
ly2	**1.5**	**1.49**	**(0.07)**	**1.41**	**(0.06)**	**1.45**	**(0.07)**	**1.52**	**(0.03)**
ly1	**0.5**	**0.50**	**(0.07)**	**0.46**	**(0.07)**	**0.52**	**(0.07)**	**0.51**	**(0.03)**
x1	-4	-3.94	(0.15)	-3.75	(0.14)	-3.98	(0.15)	-4.03	(0.06)
x2	-4.5	-4.51	(0.16)	-4.24	(0.15)	-4.35	(0.16)	-4.47	(0.07)
Inst y2	0.3	0.10	(0.06)	0.13	(0.05)	0.00	(0.05)	-0.03	(0.02)
cons	2	2.19	(0.12)	2.04	(0.11)	2.08	(0.11)	2.14	(0.05)
$\boldsymbol{\rho_a}$	**0.5**	**0.53**	**(0.06)**	**0.54**	**(0.06)**	**0.50**	**(0.05)**	**0.50**	**(0.02)**
ρ_ξ	0.4	0.52	(0.06)	0.37	(0.07)	0.34	(0.07)	0.40	(0.03)
$\boldsymbol{\rho_\omega}$	**0.3**	**0.26**	**(0.06)**	**0.31**	**(0.06)**	**0.27**	**(0.06)**	**0.27**	**(0.02)**
σ_{a1}	1	0.91	(0.06)	0.96	(0.06)	1.04	(0.07)	0.95	(0.03)
σ_{a2}	1	1.05	(0.06)	0.94	(0.06)	1.02	(0.06)	0.98	(0.03)
η_1	0.2	0.16	(0.08)	0.19	(0.07)	0.15	(0.06)	0.18	(0.03)
η_2	0.1	0.14	(0.07)	0.06	(0.07)	0.13	(0.06)	0.12	(0.03)
η_3	0.1	0.20	(0.07)	0.17	(0.07)	0.08	(0.06)	0.08	(0.03)
η_4	0.2	0.09	(0.06)	0.15	(0.07)	0.26	(0.06)	0.21	(0.03)
Observations		9000		9000		9000		52470	

Chapter 3

Export Spillovers: Opening the Black Box

Export Spillovers: Opening the black box

Philipp Meinen[*]

Abstract

This paper studies the importance of export spillovers in a firm's decision to enter specific export markets and extends the current state of the literature by assessing different mechanisms through which they may occur, namely; (i) labor movement, (ii) intra-industry spillovers, and (iii) inter-industry linkages. We do so by exploiting a unique dataset covering the period 1995-2006 which combines transaction-level export data of all manufacturing firms in Denmark, firm accounting data, employer-employee linked data and information from yearly input-output tables. We corroborate the literature on export spillovers by presenting robust evidence of destination-specific export spillovers. We find strong evidence that labor mobility as well as intra- and inter-industry linkages are important channels for export spillovers. We find that for smaller firms intra-industry spillovers are particularly relevant, for medium-sized firms backward and forward linkages have larger effects, while relatively larger firms mainly benefit from foreign market specific information transmitted by recently hired employees. We, furthermore, find that export spillovers are most relevant for less developed countries suggesting that information related to less obvious export markets is particularly valuable in the export decision.

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Keywords: Export spillovers, labor mobility, industrial linkages, linked employer-employee data, transaction-level export data

JEL-Codes: F10, R12

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1 Introduction

Numerous papers in the international trade literature analyzing the determinants of firms' export behavior have concluded that the sunk costs associated with entering foreign markets play an important role in firms' export decisions.[1] As part of this literature, scholars have tried to uncover what reduces the importance of these costs to better understand what pushes firms to internationalize. In light of that, previous research has argued that firms' involvement in international markets may reduce the costs of internationalization for other firms, i.e. non-exporting firms may learn to export from other firms' export experience, a phenomenon termed export spillovers in the literature(Aitken et al., 1997). The bulk of the empirical literature on export spillovers consists of firm-level studies focusing on the response of non-exporting firms to the presence of exporting firms in their surroundings and present mixed evidence; while some provide support for the presence of positive export spillovers (Greenaway and Kneller, 2008; Barrios et al., 2003; Clerides et al., 1998), others reject their relevance (Aitken et al., 1997; Bernard and Jensen, 2004; Lawless, 2010).[2]. More recently, studies based on transaction-level trade data provide evidence for destination-specific export spillovers. These studies show that a firm's decision to start exporting to a particular market is influenced by the presence of other firms exporting to that market. This relationship has so far been established for Spain (Requena-Silvente and Giménez, 2007; Castillo-Gimenez et al., 2011), France (Koenig, 2009; Koenig et al., 2010), Russia and the US (Cassey and Schmeiser, 2011).

While evidence for destination-specific export spillovers becomes increasingly available, the specific mechanisms behind this phenomenon are subject to speculations. The common identification strategy of export spillovers is to regress a dummy variable indicating whether a firm starts to export to a specific country on the mass of firms in a region exporting to that market while controlling for a variety of observed and unobserved factors. We extend the current state of literature in two ways. First, we specifically allow

[1]See Wagner (2007) for a survey of the literature.

[2]See Greenaway and Kneller (2008) for a survey of the literature. Some of the studies mentioned above distinguish between the presence of foreign-owned exporting multinationals and domestically-owned exporters, while others do not.

for alternative hypotheses that may explain the positive relationship between the mass of firms exporting to a specific market and a firm's decision to enter that market. Second, we have access to rich data which allows us to open the black box of export spillovers by distinguishing different channels through which these spillovers may occur. In particular, we track the movement of employees between firms to investigate the effect of hiring a person that has previously worked for a firm exporting to a specific market on the probability that the new firm starts to export to this market in the following years. Beside the labor mobility channel, we consider two additional channels which we term intra-industry and inter-industry linkages. An example of the former channel is the signalling of a business opportunity in a particular export market by firms selling similar products. Export spillovers may also occur through interactions between buyers and suppliers operating in different industries.

The empirical analysis is based on a unique data set covering the period 1995-2006 which combines transaction-level trade data of all manufacturing firms in Denmark with firm accounting data, employer-employee linked data and information from input-output tables. The availability of transaction-level trade data allows us to follow the recent literature on export spillovers and account for their destination specificity. The linked employer-employee data is the key to identifying the labor mobility channel, while we use yearly input-output tables to construct measures of the interconnectedness of different industries to investigate the inter-industry channels. We estimate a binary choice fixed effect logit model and present a careful identification strategy where we control for a variety of observed and unobserved heterogeneity in order to identify export spillovers.

Our results corroborate the existing literature in that we find evidence for export spillovers once we allow them to be destination specific. In addition to controlling for many observed and unobserved factors in our estimations, we would like to distinguish this effect from other explanations for why firms adopt similar export expansion patterns. We therefore allow for the following two alternative hypotheses; (i) change in comparative advantage and (ii) sequential exporting. The first hypothesis expresses the view that contemporaneous changes in comparative advantage of a region in Denmark and/or in a foreign market drive the effect. We address this concern in two ways. First, we add region- and country-specific trends to the estimations which allow for different trends over time in Danish regions and foreign markets. Second, we assess whether the effect is driven by continuously exporting firms or rather export starters. If mainly the latter firms were responsible for the finding, one should indeed worry that some kind of contemporaneous shock drives the results. Our results remain unchanged following the inclusion of region- and country-specific trends and show that non-exporting firms positively respond to the presence of both continuous exporters and export starters. Both results suggest that the spillover effects we find are not driven by changes in comparative advantage. The second hypothesis builds on the recent literature on sequential exporting (Albornoz et al., 2010; Morales et al., 2011) which documents that firms enter markets in a specific order and learn about potential markets which are similar in certain characteristics to markets they already serve. If all firms in Denmark act in this way, our results would simply capture this sequencing of expansions to new export markets. To address this concern, we add detailed information on firms' past export activities in different regions of the world to our estimations and again do not find any change with respect to the spillover variable.

We therefore conclude that our findings are suggestive of the presence of export spillovers and continue with exploring the channels through which they may occur. First, our results point towards the importance of labor mobility in the realization of export spillovers. We find that firms hiring employees with knowledge about specific export destinations acquired in previous jobs are significantly more likely to start exporting to the these countries. This result is robust to allowing the hiring decision to be endogeneous using an instrumental variable approach. Moreover, our results suggest that intra-industry as well as backward and forward linkages are important for explaining export spillovers.[3] We find that intra-industry spillovers are characterized by spatial decay suggesting that firms mainly observe their direct environment. In contrast, we do not find evidence for spatial decay in case of inter-industry spillovers.

Sub-sample estimations show that intra-industry spillovers are particularly important for smaller firms. Forward linkages are only experienced by medium sized firms, while

[3]Note that we also present results where the greater Copenhagen area is dropped from the sample. Given the importance of this area for the Danish economy, we were worried that our estimations were driven by this region. However, our results are robust to this sensitivity check.

backward linkages are relevant for small and medium sized firms. Larger firms mainly benefit from foreign market specific information transmitted by recently hired employees. Furthermore, we find that export spillovers are most relevant for non-EU countries (in particular developing economies) suggesting that information related to less obvious export markets is particularly valuable in the export decision.

The rest of the paper is structured as follows. In section 2 we define export spillovers and motivate the different channels of export spillovers. Section 3 presents the econometric model as well as the data and discusses the identification strategy. Section 4 contains the results and section 5 concludes.

2 A Conceptual Framework for Export Spillovers

Differences across export markets make it difficult for firms to properly assess the potential costs and benefits related to the decision of starting to export to a specific country. For this reason, firms generally need to gather information about business practices, customers' tastes, competition and legal environments, as well as to find distributors for their products in the foreign market they intend to serve in order to be successful. Gathering such information can be costly for firms, especially since the majority of these costs are sunk. As a result only a fraction of firms are able to afford exporting. A lot of focus in the trade literature has been on productivity differences as the main explanation for the selection of firms into exporting, as more productive firms are better equipped to face the sunk costs associated with exporting (Melitz, 2003).

Parallel to this literature, an interest has emerged in studying the presence of other firms involved in international trade as a factor that could induce non-exporting firms to export, working partly through the reduction of (information gathering) sunk costs.[4] This phenomenon is termed export spillovers in the international trade literature and has been explained via three main mechanisms; information spillovers/externalities, competition effects and cost-sharing between firms at proximity (Aitken et al., 1997). More recently,

[4]It could also work through technological transfer or productivity spillovers between exporting and non-exporting firms. Studies have previously shown support to the learning-by-exporting hypothesis which may result in productivity spillovers between exporting and non-exporting firms.

such spillovers have been studied more formally. Koenig (2009) provides a simple model à la Roberts and Tybout (1997) to rationalize the link between destination-specific export spillovers related to information flows and sunk costs. Cassey and Schmeiser (2011) develop a model based on Chaney (2009) showing that destination-specific export spillovers can also work through the intensive margin via a cost-sharing mechanism.

In this paper, we are particularly interested in export spillovers coming from information externalities and refer to export spillovers when the presence of exporting firms leads to export market entry by previously non-exporting firms. In this context, we define spillovers as the transfer of knowledge[5] between two firms which is not internalized by the sending firm, without assuming anything about the firms' intentions of transferring the information (DeClercq, 2007). The literature on export spillover is largely silent on how the information is transmitted from one firm to the other. We try to open this black box in this paper by motivating three channels through which the information may flow and showing for which destination markets and firms the different channels are particularly relevant.[6]

A first channel is inter-firm labor movement; in our case the movement of one employee from a manufacturing firm exporting to a specific market to a manufacturing firm not exporting to that market. We assume that while working in an exporting firm before, this employee has gained information about how to conduct business in the countries the firm was active in. Hence, this employee may use his knowledge about (and contacts in) the foreign markets and help the focal firm to start exporting to the same markets. This channel may be of special importance in a country like Denmark which is known for its flexible labor market inducing high labor mobility. The consequences of labor mobility on firm performance have been studied in other literature streams. For instance, in the body

[5]It is not possible to distinguish between the type of knowledge transferred, for instance whether it is knowledge about international markets or technological knowledge. The latter could help firms to increase their productivity and their probability of being able to export. However, by focusing our analysis at the destination-level, we believe the first type of knowledge to be the most relevant. Technological knowledge transfer is likely to result in higher productivity for the recipient firm and therefore a higher chance of exporting, though not necessarily in a particular market.

[6]A channel for export spillovers, which we do not consider in our analysis due to data limitation, is public export promotion programs related to trade fares where firms can share experiences and advice on how to approach a specific market. Evidence for such effects is weak (Bernard and Jensen, 2004).

of research focusing on the consequences of FDI for hosting economies, the movement of people from foreign owned to domestically owned firms has been identified as a channel for knowledge transfer between the two entities resulting in higher productivity and wages in the domestic firms (Balsvik (2011); Poole (forthcoming)). This is in line with a wider stream of literature which focuses on the effect of labor mobility on different measures of firm performance providing evidence of learning-by-hiring (Parrota and Pozzoli, 2012). Closer to our paper, evidence of a positive relationship between hiring managers (or employees) from an exporting firm and the recruiting firm's propensity to start exporting in subsequent years has been recently found (Andersen and Choquette, 2011; Mion and Opromolla, 2011; Molina and Muendler, 2009).[7] Overall, this evidence points towards the importance of labor mobility in explaining how export spillovers work at the firm level.

A second channel via which export spillovers may occur relates to intra-industry linkages, i.e. through knowledge transfer between firms active in the same industry. For instance, information externalities may be experienced through the signalling of market opportunities by exporting firms, also termed as demonstration effect in the literature (Greenaway et al., 2004). If a firm is successful in a foreign market, this may induce other firms to imitate their strategy and try to export to that country. Prior research argues that in situations of uncertainty firms tend to mimic the behavior of firms that are similar to them or that they see as models as it may be an inexpensive way for firms to assess potential opportunities (DiMaggio and Powell, 1983). Evidence of such mimetic behavior has been found in relation to the presence of multinational firms and its effect on domestically owned firms' export involvement (Belderbos et al., 2010). Similarly, legitimacy may push firms to enter specific markets in order to prevent being seen as laggards and missing on opportunities that similar firms are exploiting (Clerides and Kassinis, 2009).

Export spillovers may also be an outcome of industrial linkages between firms from different industries (Kneller and Pisu, 2007). Indeed, buyer-supplier relationships may open the door for knowledge exchange about international markets, which could for instance take place when a buyer specifies product characteristics that are tailored to a specific ex-

[7] Another stream of literature investigates the relationship between employing immigrants and a firm's exports to the countries of origins of the foreign workers. Hiller (2013) provides a recent contribution to this literature.

port market. This way, the supplier learns about the taste, technical requirements as well as opportunities in this market which may result in subsequent market entry. Anecdotal evidence furthermore documents that when customers establish a subsidiary in a foreign country, they may ask their suppliers to "follow" them and serve the foreign market. This may lead to export market entry if the suppliers choose to adopt this entry mode. Hence, inter-firm linkages may increase the recipient's awareness about opportunities in a specific export market and subsequently lead to the decision of entering it. The research focusing on inter-industry linkages in the context of international trade has generally distinguished between forward and backward linkages and focused on linkages between multinational and domestic firms. Prior evidence shows that backward linkages (i.e. linkages between a firm and its buyers) are important channels for export spillovers from FDI, and particularly for the intensive margin of exports of domestic firms (Kneller and Pisu, 2007) as well as for productivity spillovers from FDI (Javorcik, 2004). Based on these findings, it appears that information externalities generated by the presence of multinational firms are more prone to occur from the contact between domestic firms and their customers. In this paper we extend the reach of such linkages to the context of destination-specific export spillovers from exporting firms, i.e. where all exporting firms, both domestically- and foreign-owned, are considered as potential sources of market specific, export-related information spillovers.

Export spillovers have generally been studied in relation to geographical proximity; although proximity may matter more for certain channels than for others. For instance, it may be easier to monitor competitors' strategies on international markets when they are located close by. Inter-industry linkages may also be accentuated by geographical proximity where face-to-face contact and information exchange may be more frequent and easier. On the other hand, industrial linkages are not necessarily geographically bounded as buyer-supplier relationships imply frequent contacts, whether they are located at proximity or not (Kneller and Pisu, 2007). Hence we would expect the effect of intra-industry linkages to be amplified by geographical proximity, but not necessarily the one of inter-industry linkages.

As a final exercise in this paper, we investigate whether the importance of the mentioned channels varies across destination markets and firm size. Information requirements for export market entry into culturally and geographically more distant markets are likely to be higher and therefore we expect export spillovers to be particularly relevant for such markets. Moreover, smaller firms may be more prone to observe the behavior of competitors and open to information from business partners as they have less capacities for conducting their own market research. On the other hand, larger firms tend to have a higher employee turnover and are perhaps better equipped in terms of resources to fully exploit the knowledge of their new employees. Hence, we would expect them to benefit more from the labor mobility channel compared to smaller firms.

3 Estimation Approach and Data

3.1 Econometric Model

To assess the importance of export spillovers and of the channels introduced above, we model firms' decision to enter individual export markets in a way similar to Koenig et al. (2010). We assume that firm i starts exporting to country j in period t if the realized sum of profits abroad is larger than zero, where export profits positively depend on the supply capacities of the firm (e.g. productivity, size) as well as on demand capacities of the foreign market (e.g. size of the market) and decrease in trade frictions (e.g. geographical distance between Denmark and the foreign market). We model the probability that firm i starts exporting to market j as

$$P(y_{ijt} = 1 | x_{ijt}, \varepsilon_{ijt}) = \Lambda(x'_{ijt}\beta + \mu_t + \alpha_{ij} + \omega_{ijt}), \tag{1}$$

where y_{ijt} is an indicator variable for export market entry and x_{ijt} contains firm-, region-, and destination-level covariates. The composite error term ε_{ijt} consists of a transitory component ω_{ijt} and a time constant component α_{ij}. Λ is the logistic cumulative distribution function indicating that we estimate the model by fixed effect logit. This estimator exploits the sufficient statistic $\sum_t y_{ijt} = c$ (with $1 < c < T$) in order to eliminate the firm-country pair fixed effect α_{ij}. Consequently, our sample only includes firm-destination pairs for which there is at least one switch from non-exporting to exporting over the period observed, leaving out firm-destination pairs in which a firm is continuously non-exporting or continuously exporting to a destination.[8] Note that controlling for firm-country-pair fixed effects implies also controlling for firm, destination and region[9] fixed effects individually. Hence, this estimator allows us to control for a large amount of unobserved heterogeneity. μ_t is a time fixed effect controlling for yearly shocks common to all firms, e.g. related to the business cycle. We cluster our standard errors at the regional level as suggested by Moulton (1990) and Cameron et al. (2006).

3.2 Data

Our data set is based on the population of manufacturing firms located in Denmark for the period from 1995 to 2006.[10] The trade data come from the Danish customs and provide us with yearly information on export and import values for trading firms in Denmark at the firm-destination level. We merge the trade data with firm-level data available from Statistics Denmark for the same period using a unique identifier common to both data sets. Moreover, we merge regional information available from Statistics Denmark and destination market information to the data set. The data for destination market GDP and population come from the World Development Indicator (WDI) database[11] and data on bilateral exchange rates are taken from Penn World Tables. Table 1 presents summary statistics of our variables.

We base the analysis on exports from Danish firms to 81 countries. These countries belong to the 95% of Denmark's most important export destinations in terms of number of firm-country relations.[12] Further note that we drop firms which change location during

[8]We should note that while this estimator allows us to deal with firm-country pair fixed effects, it also implies that we base our analysis on a selected sample; i.e. firms that start to export to a market. Controlling for fixed effects is crucial in the current setup which is why we believe that a bias from neglecting them is much more severe compared to a potential sample selection bias. Another advantage of the estimator is that it facilitates comparisons with other studies.

[9]Controlling for α_{ij} implies controlling for region fixed effects as we do not allow firms to switch location during the sample period. See the explanation in the data section.

[10]As we do not have access to ownership data, we do not distinguish between foreign-owned and domestically-owned exporters and non-exporters. As such, our sample includes both domestically- and foreign-owned firms.

[11]Except for Taiwan for which the information is available from Penn World Tables.

[12]One exemption is the Faroe-Islands which we drop due to data limitations. Another small restriction

the sample period because these cases often appear to be data mistakes.[13]

As we investigate whether export spillovers are geographically bounded, the definition of regions is critical. Instead of focussing on administrative regions, we define regions according to functional-economic areas in Denmark (Anderson, 2000). In particular, we base the regional definition on the commuting areas in Denmark, in which municipalities are grouped together according to where most people live and work. We use this classification for two reasons: first, the administrative classification in Denmark is very detailed resulting in a large amount of "regions" including very few firms. Second, we believe that the commuting areas classification provide a less random division of the territory. This classification identifies 51 regions (compared to over 270 municipalities) for our analysis, which is nevertheless very detailed compared to other studies on export spillovers. Note that the smallest unit of observation is the municipality, meaning that a municipality is never divided into two commuting areas and consequently that a commuting area is never smaller than a municipality (Anderson, 2000). Hence, we can be sure in which commuting area a firm is located by using a correspondence table between municipalities and commuting areas.

Our final data set contains information on 4,511 firms that start exporting during 1995 and 2006, amounting to 248,793 firm-country-year observations.

3.3 Definitions of Variables

Dependent Variables

We are interested in the effect of export spillovers and their channels on the probability to start exporting to a specific market. Export market entry is modeled with the help of a dummy variable equal to 1 if a firm is exporting to country j at time t but was not exporting to country j in the previous period, and equal to 0 when a firm is not exporting to country j in both $t-1$ and t. Observations for subsequent years after which a firm

is that firms located at the island Bornholm are excluded from our analysis.

[13]This implies dropping 334 firms that enter at least one export market over the period.

starts exporting to a specific country are coded as missing.[14]

Spillover Variables

We construct several export spillover variables, each of which accounts for spillovers at different aggregation levels.[15] The most aggregated export spillover variable is constructed as the number of exporting firms in a region in year t. We define the second spillover variable as the number of exporting firms within the same region and the same 2-digit industry firm i operates in to capture industry-specific spillovers (intra-industry spillovers). The third variable is computed by counting the number of exporting firms within a region which are exporting to the same market j at time t belonging to a different 2-digit industry than firm i. Thus this variable captures foreign-market-specific inter-industry spillovers. The fourth variable accounts for country- and industry-specific spillovers and is constructed as the number of firms within the same region and 2-digit industry exporting to the same country j in year t (destination-specific intra-industry spillovers). As firms from the same 2-digit industry are more likely to be competitors, this variable would for instance capture the signaling effect mentioned in section 2.

Channel Variables

To further disentangle inter-industry export spillovers, we follow the literature on spillovers from multinational firms (Javorcik, 2004) and create two variables for forward and backward linkages using yearly input-output tables from Statistics Denmark. In our case, forward linkages represent relations between a non-exporting firm and its supplier(s) while backward linkages represent relations between a non-exporting firm and its buyer(s). Backward linkages are defined as:

[14] A firm may be considered to start exporting to a specific country more than once over the period, for instance if it stopped exporting to that country for at least two years and then starts again.

[15] Note that we construct the variables based on all firms in our data set, i.e. firms that continuously export to a market as well new exporters in a market.

$$Back_{kt} = \sum_{s} a_{kst} * Spill_{jst} \quad for\ s \neq k,$$

where a_{kst} represents the amount of interconnectedness between two industries (2-digits). It is constructed as the share of the output produced by firms in sector k that is sold to firms in sector $s \neq k$. a_{kst} is multiplied by the number of firms exporting to market j in industry s and summed across all sector $s \neq k$. Similarly, the forward linkages variable is computed as:

$$For_{kt} = \sum_{h} b_{hkt} * Spill_{jht} \ \ for\ h \neq k,$$

where b_{hkt} represents the share of total input bought by sector k from sector $h \neq k$, which is multiplied by the number of firms exporting to a specific market j in industry h and summed across all sectors $h \neq k$.

Finally, we account for the labor movement channel by exploiting a linked employer-employee data set. We are interested in the effect of hiring a person who has previously worked in a manufacturing firm exporting to a specific market on the probability that the new firm starts exporting to this market in the subsequent years. Such effects are most likely only related to the hiring of workers who have some influence on a firm's decision process. That is why we only consider the hiring of individuals that have earned a wage above firm-average at their previous and their current employer.[16] This wage condition basically implies that we focus on the movement of white collar workers. We construct the labor mobility variable by counting the number of above average wage employees firm i hires in period t who have worked in year $t-1$ for a manufacturing firm exporting to market j. We call this variable $Lmob_{ijt}$. To ensure that we capture the effect of hiring a person with foreign market-specific knowledge rather than general hiring effects, we

[16] To prevent that our results are driven by spinoffs or M&A activities, we replace the mobility variable with a zero if either of the following two conditions are met: 1) a firm hires more than 10 employees in a given year and 65% of the newly hired labor force comes from the same firm; 2) a firm hires more than 76 individuals in a year. These conditions are based on the percentile distribution of firms' hiring activities and particularly, we set up the cut-off at the 75th percentile. As robustness checks, we vary this threshold and do not find qualitative changes in our results. The estimates are presented in appendix.

normalize this variable by the total number of workers (with above average wage in both previous and new firms) firm i hires in year t ($Lmob_{it}$):

$$Lmob\_share_{ijt} = \frac{Lmob_{ijt}}{Lmob_{it}}.$$

Additional Control Variables and Identification Issues

The identification of export spillovers and their channels requires a careful assessment of other factors which may influence a firm's export decisions as well as of econometric issues related to simultaneity and reverse causality biases. In light of that we include firm, regional and destination specific controls. We present a table containing all the variables including their descriptions in the appendix.

At the firm-level, we control for firm productivity[17] as we expect more productive firms to export because they can overcome the fixed costs of exporting easier (Melitz, 2003). Moreover, as more productive firms may self-select into denser areas (Melitz and Ottaviano, 2008), controlling for firm productivity prevents an upward bias of the coefficient estimate of the spillover variable. Furthermore, we expect larger firms and firms with a more qualified labor force to be more likely to export which is why we control for firm size and average wage. We also include a dummy controlling for whether a firm imported from country j in period $t-1$. Importing from market j provides a firm with foreign market-specific knowledge which may influence its decision to export to this market.

It is important to stress that we are interested in export spillovers related to information flows rather than general agglomeration effects related to urbanization. That is why we account for the degree of regional industrial agglomeration and the general level of competition within a region. Otherwise, our export spillover variable may identify industrial agglomeration or general competition effects rather than export spillovers. We measure industrial agglomeration as the region-industry (2-digit) share of national industrial activity. To control for situations where the region-industry share is large because the region is large, we normalize by the region share of national manufacturing activity as suggested by Aitken et al. (1997). The general level of competition is proxied by the total

[17]Labor productivity; i.e.deflated value added over number of employees.

number of manufacturing firms in the region. We, furthermore, control for population at the regional level. The effect of regional population on firms' exporting behavior is ambiguous and may bias the spillover variable if not accounted for. On the one hand, a larger population could indicate a larger "domestic" market, which could reduce the propensity of exporting (Koenig et al., 2010). On the other hand, a larger regional population possibly leads to a larger pool of qualified workers which could increase the productivity of firms in the region and consequently positively influence their export propensity.

Moreover, we control for the destination countries' market potential by including their GDP and population. The effect of market potential on exports is ambiguous depending on whether the market opportunity or the competition effect dominates (Melitz and Ottaviano, 2008). We also control for changes in the nominal bilateral exchange rate between Denmark and the destination market to capture changes in comparative advantage related to exchange rate movements.[18]

Besides controlling for observable factors, we also control for a variety of unobserved heterogeneity by firm-destination-pair fixed effects, which also subsume firm, region, and destination fixed effects separately. The firm fixed effects capture any time constant firm heterogeneity. Note that controlling for firm fixed effects implies controlling for region fixed effects as our sample does not contain firms which change location. Region fixed effects imply controlling for time-constant region characteristics; e.g. related to transportation infrastructure. Thus we prevent a bias of our spillover variable from picking up the effect of firms that agglomerate because they export rather than firms that export because of agglomeration. By controlling for country fixed effects, we allow for time constant differences in trade costs between Denmark and destination markets; e.g. related to a common border. Firm-country-pair fixed effects additionally allow for time constant special relations between a firm and a destination country, e.g. through FDI or employees from that country. We also include time and industry dummies to account for the overall development over time and for industrial peculiarities.

Finally, to address remaining endogeneity concerns, we lag all spillover and firm-level control variables by one year. First of all, this prevents a reverse-causality bias between

[18]Foreign currency over Danish Krone (year 2000 = 1).

firm controls and their exporting decisions. Moreover, lagging the spillover variables prevents a simultaneity bias of the spillover variable related to supply and demand shocks affecting firm i's and the surrounding firms' export status simultaneously (Koenig et al., 2010). Also, a potential reverse causality bias is addressed related to the fact that if firm i's export behavior is impacted by surrounding firms' export status, the surrounding firms' export status is impacted by firm i's export behavior.

4 Results

4.1 Export Spillovers and Export Market Entry

Before analyzing the channels of export spillovers motivated in section 2, we investigate whether we can at all document the presence of export spillovers in our data and if so how specific they are. We do so by introducing the four spillovers variables presented earlier, one at a time, in columns (i) to (iv) of Table 2. In columns (i) and (ii) the spillover variables are more general in the sense that they are not destination specific. In column (i) the spillover variable is simply the sum of exporting firms that are present in the same region and in column (ii) we count the number of exporting firms in the region that are in the same industry as the firm of interest. Both variables have insignificant coefficients suggesting that the mere presence of exporting firms (irrespective of the markets that they serve) does not increases the probability of a firm to start exporting to a country. In columns (iii) and (iv) we do condition on the countries the firms are active in; i.e. we count the number of firms in a region that are exporting to a particular market and that belong to the same (column iii) or to a different (column iv) industry as the firm of interest. In both columns we obtain positive and highly significant coefficients on the spillover variables. Our results therefore emphasize the importance of the destination dimension for identifying export spillovers and corroborate what previous studies have found (Koenig, 2009; Koenig et al., 2010).

In column (v) we add both intra- and inter-industry destination-specific spillovers to the estimation equation and find that the marginal effect of one additional firm in the same industry located in the same region and exporting to a specific country is 0.0018.[19] This is equivalent to saying that an additional firm located in a specific region exporting to a particular market increases a firm's probability belonging to that industry and located in that region to start exporting to that market by 1.12%.[20] Inter-industry spillovers have a smaller (0.17%) yet significant effect on the decision to start exporting. Hence, our findings suggest that intra-industry spillovers play an important role in the understanding of export spillovers. The other covariates in Table 2 are as expected and indicate that larger and more productive firms have a higher probability of starting to export. Similarly, importing from a country increases the probability to also start exporting to it. Moreover, holding population constant, Danish firms start exporting larger markets in terms of GDP and holding GDP constant, they start export to more developed countries in terms of GDP per capita.

To ensure that the findings above really capture export spillovers, we next consider alternative hypotheses which may also explain the effect of the spillover variables. First, we tackle the issue that firms may behave similarly simply because they are similarly affected by a change in comparative advantage. Despite controlling for region and destination market fixed effects and hence for time constant differences in the comparative advantage of a region in Denmark relative to foreign markets, the comparative advantage of a country or region may change over time. We address this concern by controlling for region and market specific linear time trends. Table 3 column (i) shows that our results are robust to the inclusion of these trends.

Second, we consider whether the intra- and inter-industry spillover effects we find come from continuously exporting firms or rather from export starters. Greenaway and Kneller (2008) point out that gains from export spillovers may decay over time suggesting that information from new exporting firms may be more relevant for potential entrants. On the other hand, if the whole effect is driven by export starters, one may worry that the coefficient picks up contemporaneous shocks in foreign demand or policy changes.

[19] Train (2009) shows that the marginal effect in terms of percentage point changes of probability can be calculated as 0.0018=0.013*0.159*(1-0.159), where 0.159 is the average probability of starting to export to some country (P(y=1|x)).

[20] We compute the change in probability as 1.12=[0.0018/0.159]*100 (see e.g. Kneller and Pisu (2007)).

To investigate this issue, in column (ii) we distinguish the effect of export spillovers into those from export starters and continuous exporters. We consider as export starters firms that started to export in year t or $t-1$. Hence continuous exporters are those that have exported to one market for at least 3 periods. The results in column (ii) show that both types of firms are an almost equally important source of export spillovers.

Third, we address the issue that firms may enter the same markets simply because they follow a similar expansion path. Indeed, the emerging literature on sequential exporting shows that firms tend to expand gradually, gaining experience in one export market and afterwards expanding in similar markets (e.g. Morales et al. (2011)). To control for this, we group our 81 destination markets into regions, according to the UN geographical groupings (see Table A.2 in the appendix), and include a dummy indicating firms' export participation in each of these regions. We find that most of these dummies are significant, indicating that indeed, previous exporting experience at the firm level matters for the decision to enter an additional export market close-by to a market already served. However, our results regarding the export spillovers remain unchanged in column (iii) of Table 3, suggesting that they are not driven by the sequential exporting phenomena.

Because our main results remain unchanged after controlling for alternative explanations, we conclude that the results are suggestive of export spillovers. We continue with the investigation of the different channels through which export spillovers may occur. Note that we keep the region- and country-specific linear trends as well as the sequential exporting controls in the regressions that follow.[21]

4.2 Channels of Export Spillovers

Spatial Decay

We start by assessing how locally bounded export spillovers really are. In line with our discussion on the geographical proximity of spillovers in section 2, we test whether export spillovers are mainly driven by neighboring firms or whether they come from firms

[21] We also checked whether our results are driven by the fact that we use firm-level and not plant-level data. An implicit assumption made in this paper is that it is the presence of other headquarters that matters for export spillovers rather than the presence of specific plants. As a robustness check we therefore base our analysis on single plant firms only. Our results are robust to this check.

located anywhere in Denmark. As shown in Table 4 column (i), we find that intra-industry spillovers from proximate firms play a large role in a firm's decision to enter a particular export market. Essentially, we find that both firms inside and outside the region are driving the intra-industry spillovers, but that the within-region effect is considerably larger. On the other hand, for inter-industry spillovers geographical proximity does not appear to be as important since both coefficients are of similar magnitude. This result supports the argument from section 2 that proximity is less relevant for inter-industry spillovers as buyer-seller relations are not confined by geography. Based on these results, in the remainder of the paper we will distinguish between within and outside region for intra-industry spillovers but will account for inter-industry spillovers across the entire country.

Inter-industry Channels

The results above suggest that intra-industry spillovers are an important source of export spillovers. Yet, inter-industry spillovers also matter and in this section we take a closer look at this channel by distinguishing between backward and forward linkages. As shown in Table 4 column (ii), we find that both backward and forward linkages matter as channels for export spillovers. It is important to note that the forward and backward variables are index numbers while the inter-industry variable in column (i) counts the number of firms. For this reason the coefficients on forward and backward linkages are not directly comparable to the coefficients on inter- and intra-industry spillovers. In terms of marginal effects, the results suggest that backward and forward linkages are almost equally important: a 1% increase in the export participation in a given market of firms belonging to the sourcing industry is associated with a 1% increases in the probability of firms in the supplying industry to start exporting to that market. The effect of the forward variable amounts to 1,1 %. This suggests that knowledge relevant to the export decision both flows from buyers to suppliers and also the other way around from suppliers to buyers. This in contrast to previous studies on productivity and export spillovers from FDI which usually find that only backward linkages matter (Kneller and Pisu (2007) and Javorcik (2004)).

Labor Mobility

The final channel that we investigate is labor mobility. It is possible that the spillover effects which we have found so far are partly related to the movement of labor between firms rather than industrial linkages or signalling effects. To see whether our previous interpretation of the spillover variables is warranted and to what extent learning by hiring also exists with respect to exporting, we control for hiring of employees with foreign market specific experience. As noted before, we normalize this variable by total hiring and only consider those individuals that have earned above average wage in the previous and current firm.

As some time may be needed for the recruiting firm to exploit the knowledge of its new employees, we also introduce lagged hiring variables to assess when the effect appears. In particular, in Table 5 we introduce the hiring variables first without lags (column i) and then with one year and two years lag (columns ii and iii respectively). We find that the effect is positive and significant when hiring occurs in year t and/or time $t-1$, while it is insignificant when lagged by two years. The results suggest that firms react upon market-specific knowledge of newly hired employees during the first one or two years when the new employee joins the firm. If the firm does not exploit the knowledge of the new employee during this time span, it most likely will not do so in the following periods either.

One concern with the hiring variable in year t is that we do not observe the timing of events on a monthly basis; i.e. it is possible that a firm starts exporting to a market in March and hires the new worker only in May. As our data does not allow to rule out such cases, we focus on the one year lagged hiring variable in the remainder of the paper. In column (iv) of Table 5 this variable is significant at the 5% level and the magnitude of the coefficient suggests that a one percentage point increase in the share of newly hired employees with experience in a market increases the probability to start exporting to this country by 4.9% in the next period. Our results therefore suggest that labor mobility is an important channel for export spillovers. Moreover, we find that the other spillover variables are not affected by controlling for labor mobility suggesting that these variables indeed capture different mechanisms through which export spillovers occur.

In the last column of Table 5 we exclude the greater Copenhagen area from the estimation sample. Given the size of Denmark and the importance of its national capital (Copenhagen) in terms of population and agglomeration of firms, one may argue that the effect that we find is purely driven by this region. However, results in column (v) show that such concerns are not warranted; if anything, the results become stronger.

Endogeneity of hiring

If firms hire employees with foreign market specific experience because they want to start exporting to that market in the future, our results involving labor mobility may suffer from an endogeneity bias. We address this potential problem using an IV approach in a linear-probability framework. We instrument for firm i's hiring of workers with foreign-market-specific export experience by the total number of individuals hired by other firms within the same region with foreign-market-specific experience that earned above average wage in their previous employment. This variable gives an indication of the mobility of workers with this profile in a given year which likely increases the probability that a firm hires them while it does not directly affect a firm's export decision. The first stage estimation results presented in the appendix (Table A.3) suggest that this instrument performs well as it is highly correlated with the endogenous variable. This is confirmed by a test of weak instruments and the reasonably high F-test of the excluded instrument presented in the bottom of Table 5.

We present the estimation results in Table 5. In column (i) we estimate a fixed effect linear probability model to compare the results to our fixed effect logit estimates from Table 4. We can see that the results are qualitatively similar. We believe that this justifies the application of the linear probability model here and comforts us that the findings for the IV strategy are not driven by the choice of model. In columns (ii) we then re-estimate the model while instrumenting for the hiring variable. Note that we still account for firm-country pair fixed effects as well as region- and country-specific linear trends.[22] The results show that the coefficient of interest is highly significant while it

[22]We estimate the models by two-step IV-GMM and partial out the region- and country-specific linear time trends as well as the year fixed effects.

increases in magnitude.[23] The coefficients of the other explanatory variables are hardly affected by the IV estimation. A test of endogeneity presented in the bottom of the table cannot reject the null hypotheses of exogeneity of the hiring decision. Given these results and the good performance of our instrument, we conclude that our findings involving labor mobility are indeed robust and not driven by endogeneity considerations. Note that our instrument varies at the region as well as the destination dimension while we still control for region and destination-specific time trends. In columns (iii) and (iv) we repeat the estimations from the first two columns while dropping these trends. The results hardly change compared to those in columns (i) and (ii).

Export spillovers by country groups and firm size

We proceed our analysis by investigating for which types of countries and for which firms export spillovers are particularly important. Intuitively, we would expect that export spillovers are particularly important for more geographically and culturally distant countries. These markets are less obvious export destinations and are most likely related to larger information requirements compared to e.g. EU countries. Moreover, if the effects of the different channels are fully driven by EU countries, one may wonder whether we really identify export spillovers or rather capture the fact that most exporting firms in Denmark will export to Germany, Sweden and Norway. Hence, we assess the importance of export spillovers for different groups of countries (neighboring countries, other EU15 countries, other high income countries and all other countries (medium and low income countries)).[24] As expected, in Table 7 we find the largest and most significant effects for medium and low income countries. All channels are important for this group of countries. The labor mobility effect and the effects from forward and backward linkages are fully driven by non-EU15 countries, while the intra-industry linkages matter for all groups of countries. These results comfort us in our belief of identifying information externalities.

[23] The increase in magnitude may be explained by the fact that our instrument varies at the country and region dimension only which is why we may identify the local average treatment effect rather than the average treatment effect.

[24] Appendix 1 contains a list of all countries considered in our analysis and their classification according to the four groups.

Finally, in Table 8 we investigate whether the importance of export spillovers differs according to firm size and particularly if the importance of the investigated channels is specific to certain groups of firms. In the literature, it has been mentioned that smaller firms could be more affected by export spillovers (Bernard and Jensen, 2004), possibly because of their limited amount of internal resources constraining their ability to gather knowledge about international markets. We categorize firms in three groups: firms with less than 50 employees, firms with between 50 and 99 employees, and firms with 100 employees and more. The results confirm that intra-industry spillovers are most important for smaller firms, while they hardly impact medium sized and large firms. Similarly, backward linkages matter significantly for small firms. For medium sized firms, we also find that backward linkages are important and furthermore that forward linkages matter for these firms. The labor mobility channel is relevant only for larger firms. This may be due to the fact that larger firms have more resources available to react upon the knowledge brought up by new employees than smaller enterprisers. Moreover, these firms have a higher turnover of employees than smaller firms increasing the probability of hiring people with foreign-market-specific knowledge and they may simply also have the financial resources needed to hire individuals with an international profile. Our results therefore to some extent support Bernard and Jensen's (2004) claim that smaller firms are more impacted by the presence of other exporting firms than larger ones.

5 Conclusion

In this paper we investigate the importance of information spillovers from exporting firms to non-exporting firms and distinguish between different channels through which such spillovers may occur. In particular, we consider export spillovers generated through (i) movement of labor between firms, (ii) intra-industry spillovers, and (iii) inter-industry linkages.

We corroborate the literature on export spillovers by presenting robust evidence of destination-specific export spillovers. When distinguishing between intra- and inter-industry spillovers, we find that both are important for a firm's decision to enter an export market, and that such spillovers are all the more important for firms below 100 employees and export markets outside the EU15 member countries. The results for intra-industry spillover imply that one additional firm in a region exporting to a specific market increases the probability of other close by firms from that industry to also start exporting to this market by 1.11%. When considering the multiplier effect that our findings imply, this effect is also economically meaningful. While export spillovers have generally been studied assuming that proximity between firms is a necessity, we find that depending on the channels we are looking at, proximity matters to a different extent. Indeed, intra-industry spillovers are mostly geographically confined while proximity does not seem to matter for inter-industry spillovers. Hence, by only focusing on surrounding firms, previous contributions have missed out the nuance in the role of proximity for the realization of export spillovers.

When further disentangling the channels of export spillovers, we find that inter-industry spillovers are generally smaller than intra-industry spillovers and that they are driven by both backward and forward linkages. Backward and forward linkages, as well as intra-industry spillovers remain highly significant after controlling for firm-level hiring of people with market-specific export experience. We find that learning-by-hiring is relevant with respect to exporting. In particular, hiring people with foreign market-specific knowledge significantly increases the probability that this firm starts to export to this market. This effect is most important for destination markets outside EU15 and for firms of above 100 employees. The magnitude of the effect is also considerable for these firms.

Overall, our results show strong evidence for the importance of export spillovers, suggesting that foreign market specific information is important for firms' export decisions and that such knowledge can come from other firms. Our findings provide support to the view that firms are not isolated entities but rather are part of a larger system and that their internationalization decisions are impacted by the behavior of other firms. Moreover, from a policy perspective the results suggest that the exchange of such information should be fostered; e.g. through the means of trade fairs. This point is particularly true for smaller firms as they mainly learn from intra-industry linkages. Moreover, policy makers should be aware that firms not targeted by export promotion initiatives may nevertheless be indirectly affected via spillover effects. Hence, including this multiplier effect into policy and program evaluation may result in higher expected benefits than otherwise forecasted if export spillovers are left out of the equation. Finally, our results are relevant in terms of labor market regulations. We find that labor mobility increases firms' exporting activities implying that a country's welfare is indirectly affected via this channel, not least in the case of Denmark.

As in any other work, this study presents limitations. First, similar to most research done on export spillovers and on firm data in international trade in general, our analysis focuses on one country only, which could raise doubt as to whether our study suffers from a country-bias. In response to that, the fact that we, in the first part of our analysis, corroborate the results of previous research by showing evidence of destination-specific export spillovers comforts us that our results are not special to the case of Denmark. We would nevertheless invite future research to test the importance of the export spillovers channels introduced in this paper for other countries. Second, despite that we explicitly test for alternative hypotheses which could drive our results, a potential inaccuracy could remain based on the fact that we are unable to control for firm ownership. Indeed, it may be that foreign-owned firms are more likely to export and thereby such characteristic should be controlled for. This is partly accounted for by firm fixed-effects, but cases in which ownership type is changing throughout the period are not dealt with. Foreign ownership would however bias our results only if foreign-owned firms are systematically more likely to react to the presence of exporting firms.

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Table 1: Summary Statistics

	Nb obs.	Mean	Std. Dev.
Spillover variables (t-1)			
General, within region	248793	266.09	286.98
Intra-industry, within region	248793	40.25	48.85
Market-specific, intra-industry, within region	248793	7.37	13.29
Market-specific, inter-industry, within region	248793	38.13	67.32
Spillover Channel			
Market specific, backward linkages DK (t-1)	248793	7.67	10.64
Market specific, forward linkages DK (t-1)	248793	6.34	8.05
Market specific, mobility share DK (t)	248793	0.12	0.29
Market specific, mobility share DK (t-1)	212564	0.12	0.29
Market specific, mobility share DK (t-2)	167686	0.12	0.28
Firm controls(t-1)			
Log Labor Productivity	248793	12.90	0.49
Log Employment	248793	3.82	1.31
Log Wages	248793	5.12	0.19
Import Status	248793	0.10	0.30
Regional Controls			
Total number of firms (in Tsd)	248793	0.74	0.87
Industrial Agglomeration	248793	2.09	3.54
Population (in 10 Tsd)	248793	61.27	77.97
Country Controls			
Log GDP	248793	25.41	1.89
Log Population	248793	16.40	1.97
Exchange rate	248793	1.11	0.35

Table 2: Spillover Variables - from general to specific definition

	(i) General spillovers		(ii) Industry-specific		(iii) Market-specific intra-industry		(iv) Market-specific inter-industry		(v) Market-specific intra-& inter	
Spillover Variables (t-1)										
All Industries, All Markets	0.001	(0.001)								
Industry Specific, All Markets			0.001	(0.001)						
Market Specific, Intra-Industry					0.014***	(0.004)			0.013***	(0.003)
Market Specific, Inter-Industry							0.003***	(0.001)	0.002***	(0.001)
Firm controls (t-1)										
Log Labor Productivity	0.352***	(0.037)	0.352***	(0.037)	0.352***	(0.036)	0.353***	(0.037)	0.353***	(0.036)
Log Employment	0.825***	(0.046)	0.825***	(0.046)	0.826***	(0.046)	0.826***	(0.046)	0.826***	(0.046)
Log Wages	0.302***	(0.095)	0.301***	(0.095)	0.299***	(0.096)	0.299***	(0.095)	0.298***	(0.096)
Import Status	0.351***	(0.027)	0.350***	(0.027)	0.350***	(0.027)	0.350***	(0.027)	0.350***	(0.027)
Regional Controls										
Total number of firms	-0.308	(0.219)	-0.298	(0.249)	-0.273	(0.242)	-0.251	(0.25)	-0.254	(0.233)
Industrial Agglomeration	0.014*	(0.008)	0.014*	(0.008)	0.014*	(0.008)	0.014*	(0.008)	0.014*	(0.008)
Population	-0.066*	(0.036)	-0.072**	(0.033)	-0.070**	(0.03)	-0.067**	(0.031)	-0.066**	(0.029)
Country Controls										
Log GDP	1.736***	(0.097)	1.737***	(0.097)	1.648***	(0.105)	1.647***	(0.11)	1.595***	(0.116)
Log Population	-2.020***	(0.183)	-2.019***	(0.183)	-1.963***	(0.18)	-2.006***	(0.182)	-1.959***	(0.18)
Exchange rate	-0.076***	(0.02)	-0.076***	(0.02)	-0.082***	(0.02)	-0.083***	(0.02)	-0.086***	(0.02)
Number Obs.	248,793		248,793		248,793		248,793		248,793	
Log-Likelihood	-73,900		-73,900		-73,878		-73,893		-73,875	
Pseudo R-squared	0.049		0.049		0.049		0.049		0.049	

Fixed effect logit regressions, all regressions contain year and industry dummies; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit.

Table 3: Alternative Hypotheses

	Region & Country Trends (i)		Who carries information (ii)		Sequential Exporting (iii)	
Spillover variables (t-1)						
Market Specific, Intra-Industry	0.011***	(0.002)			0.011***	(0.002)
Market Specific, Inter-Industry	0.002***	(0.001)			0.002***	(0.001)
Market Specific, Intra-Industry STARTER			0.014**	(0.006)		
Market Specific, Intra-Industry CONTINUOUS			0.012***	(0.002)		
Market Specific, Inter-Industry STARTER			0.004***	(0.001)		
Market Specific, Inter-Industry CONTINUOUS			0.003**	(0.002)		
Firm controls (t-1)						
Log Labor Productivity	0.354***	(0.035)	0.379***	(0.053)	0.262***	(0.037)
Log Employment	0.821***	(0.047)	0.841***	(0.057)	0.653***	(0.045)
Log Wages	0.319***	(0.095)	0.195*	(0.108)	0.266***	(0.095)
Import Status	0.350***	(0.029)	0.312***	(0.035)	0.323***	(0.027)
Regional Controls						
Total number of firms	-0.231	(0.182)	-0.330	(0.242)	-0.251	(0.169)
Industrial Agglomeration	0.012	(0.009)	0.016**	(0.008)	0.010	(0.008)
Population	-0.025	(0.035)	-0.052	(0.096)	-0.021	(0.032)
Country Controls						
Log GDP	1.972***	(0.18)	1.604***	(0.413)	2.005***	(0.19)
Log Population	-3.266***	(1.121)	-0.305	(2.381)	-3.253***	(1.115)
Exchange rate	-0.346***	(0.071)	-0.493***	(0.065)	-0.351***	(0.073)
Number Obs.	248,793		145,134		248,793	
Log-Likelihood	-73,403		-44,992		-72,718	
Pseudo R-squared	0.055		0.062		0.064	

Fixed effect logit regressions, all regressions contain year and industry dummies, as well as region and destination specific linear trends; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit.

Table 4: Spatial Decay & Industrial Linkages

	(i) Spatial decay		(ii) Industrial linkages	
Spillover variables (t-1)				
Market specific, intra-industry within region	0.008***	(0.002)	0.009***	(0.001)
Market specific, intra-industry outside region	0.004***	(0.001)	0.004***	(0.001)
Market specific, inter-industry within region	0.002***	(0.001)		
Market specific, inter-industry outside region	0.002***	(0)		
Channels				
Market specific, backward linkages DK (t-1)			0.012***	(0.003)
Market specific, forward linkages DK (t-1)			0.013***	(0.004)
Firm controls (t-1)				
Log Labor Productivity	0.263***	(0.037)	0.263***	(0.037)
Log Employment	0.655***	(0.045)	0.652***	(0.046)
Log Wages	0.268***	(0.095)	0.280***	(0.095)
Import Status	0.317***	(0.027)	0.320***	(0.027)
Regional Controls				
Total number of firms	-0.268	(0.167)	-0.264	(0.165)
Industrial Agglomeration	0.010	(0.008)	0.010	(0.008)
Population	-0.005	(0.032)	0.001	(0.032)
Country Controls				
Log GDP	1.910***	(0.19)	1.934***	(0.188)
Log Population	-2.858**	(1.113)	-3.077***	(1.119)
Exchange rate	-0.318***	(0.072)	-0.331***	(0.069)
Number Obs.	248,793		248,793	
Log-Likelihood	-72,678		-72,677	
Pseudo R-squared	0.065		0.065	

Fixed effect logit regressions, all regressions contain year and industry dummies, region and destination specific linear trends, and dummies controlling for firms' past export participation in different regions of the world; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit.

Table 5: Labor Mobility and Sensitivity to Dropping the Greater Copenhagen Area

	(i) Labor mobility I		(ii) Labor mobility II		(iii) Labor mobility III		(iv) Labor mobility IV		(v) Drop Copenhagen	
Channels, market specific (t-1)										
Intra-ind within region	0.009***	(0.001)	0.008***	(0.002)	0.013***	(0.002)	0.008***	(0.002)	0.013***	(0.004)
Intra-ind outside region	0.004***	(0.001)	0.004***	(0.001)	0.004***	(0.001)	0.004***	(0.001)	0.005***	(0.001)
Backward linkages DK (t-1)	0.012***	(0.003)	0.012***	(0.003)	0.013***	(0.005)	0.012***	(0.003)	0.013***	(0.004)
Forward linkages DK (t-1)	0.013***	(0.004)	0.011***	(0.004)	0.009	(0.006)	0.011***	(0.004)	0.012**	(0.005)
Mobility DK (t)	0.081***	(0.03)	0.085***	(0.031)	0.079**	(0.031)				
Mobility DK (t-1)			0.072***	(0.025)	0.079**	(0.031)	0.059**	(0.026)	0.079***	(0.028)
Mobility DK (t-2)					0.020	(0.034)				
Firm controls (t-1)										
Log Labor Productivity	0.262***	(0.037)	0.254***	(0.036)	0.300***	(0.039)	0.255***	(0.036)	0.250***	(0.051)
Log Employment	0.650***	(0.045)	0.645***	(0.047)	0.659***	(0.063)	0.648***	(0.047)	0.630***	(0.062)
Log Wages	0.282***	(0.095)	0.222**	(0.107)	0.185*	(0.098)	0.223**	(0.107)	0.218	(0.161)
Import Status	0.320***	(0.027)	0.295***	(0.031)	0.294***	(0.034)	0.295***	(0.031)	0.315***	(0.037)
Regional Controls										
Total number of firms	-0.255	(0.166)	-0.226	(0.172)	-0.342*	(0.203)	-0.236	(0.171)	0.177	(0.686)
Industrial Agglomeration	0.010	(0.008)	0.012	(0.008)	0.017***	(0.006)	0.012	(0.008)	0.013	(0.008)
Population	0.000	(0.032)	0.010	(0.039)	-0.029	(0.063)	0.010	(0.039)	-0.121	(0.24)
Country Controls										
Log GDP	1.934***	(0.189)	2.216***	(0.223)	2.178***	(0.383)	2.215***	(0.223)	2.160***	(0.298)
Log Population	-3.077***	(1.117)	-3.080**	(1.407)	-2.173	(1.818)	-3.095**	(1.404)	-2.475	(1.749)
Exchange rate	-0.332***	(0.069)	-0.321***	(0.077)	-0.396***	(0.068)	-0.321***	(0.077)	-0.405***	(0.066)
Number Obs.	248,793		212,564		167,686		212,564		159,207	
Log-Likelihood	-72,669		-63,160		-50,831		-63,168		-47,003	
Pseudo R-squared	0.065		0.066		0.064		0.066		0.070	

Fixed effect logit regressions, all regressions contain year and industry dummies, region and destination specific linear trends and dummies controlling for firms' past export participation in different regions of the world; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit.

Table 6: IV Estimations - assess endogeneity of firm hiring

	(i) Linear probability model		(ii) IV		(iii) Linear probability model		(iv) IV	
Channels (t-1)								
Market specific, intra-industry within region	0.002***	(0,0003)	0.002***	(0,0003)	0.001***	(0,0004)	0.001***	(0,0004)
Market specific, intra-industry outside region	0.001***	(0,0002)	0.001***	(0,0002)	0.001***	(0,0002)	0.001***	(0,0002)
Market specific, backward linkages DK	0.002***	(0,001)	0.002***	(0,0005)	0.001***	(0,0004)	0.001***	(0,0005)
Market specific, forward linkages DK	0.002***	(0,001)	0.002***	(0,001)	0.001*	(0,001)	0.001	(0,001)
Market specific, mobility DK	0.012**	(0,005)	0.189***	(0,034)	0.012**	(0,005)	0.181***	(0,036)
Firm controls (t-1)								
Log Labor Productivity	0.040***	(0,006)	0.042***	(0,005)	0.040***	(0,006)	0.042***	(0,006)
Log Employment	0.091***	(0,008)	0.080***	(0,009)	0.092***	(0,008)	0.082***	(0,009)
Log Wages	0.017	(0,023)	0.002	(0,021)	0.012	(0,023)	-0.004	(0,021)
Import Status	0.061***	(0,005)	0.061***	(0,005)	0.062***	(0,005)	0.061***	(0,004)
Regional Controls								
Total number of firms	-0.047	(0,031)	-0.053	(0,033)	-0.094***	(0,035)	-0.088**	(0,038)
Industrial Agglomeration	0.003*	(0,001)	0.003**	(0,001)	0.003**	(0,001)	0.003***	(0,001)
Population	0.008	(0,007)	0.005	(0,009)	-0.015***	(0,004)	-0.015***	(0,005)
Country Controls								
Log GDP	0.388***	(0,035)	0.379***	(0,035)	0.171***	(0,022)	0.164***	(0,022)
Log Population	-0.494**	(0,241)	-0.445*	(0,237)	-0.256***	(0,029)	-0.236***	(0,03)
Exchange rate	-0.059***	(0,013)	-0.060***	(0,014)	-0.025***	(0,003)	-0.024***	(0,003)
Number Obs.	212,564		212,564		212,564		212,564	
Kleibergen-Paap Wald rk test (p-value)			0.000		0.000			
F-test of excluded IV			66.64		56.37			
Test of endogeneity (H0: exogeneity; p-value)			0.251		0.279			
Country- & region-specific trends	yes		yes		no		no	

Fixed effect linear probability models; all regressions contain year and industry dummies and dummies controlling for firms' past export participation in different regions of the world; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit; first stage estimation results are moved to the appendix.

Table 7: Differences Across Country Groups

	(i) Neighboring countries		(ii) EU15 countries		(iii) High income countries		(iv) Rest of the world	
Channels (t-1)								
Market specific, intra-industry within region	0.008***	(0,002)	0.012***	(0,003)	0.008***	(0,003)	0.006**	(0,003)
Market specific, intra-industry outside region	0.002	(0,002)	0.004**	(0,002)	-0.001	(0,001)	0.008***	(0,001)
Market specific, backward linkages	0.009	(0,006)	0.005	(0,005)	0.011**	(0,005)	0.016*	(0,009)
Market specific, forward linkages	-0.001	(0,006)	0.013	(0,009)	0.001	(0,007)	0.062***	(0,01)
Labor Mobility	-0.023	(0,061)	-0.040	(0,071)	0.094***	(0,025)	0.120**	(0,05)
Firm controls (t-1)								
Log Labor Productivity	0.473***	(0,118)	0.401***	(0,067)	0.164***	(0,034)	0.203***	(0,052)
Log Employment	1.171***	(0,154)	0.926***	(0,115)	0.523***	(0,04)	0.518***	(0,061)
Log Wages	0.220	(0,202)	0.249	(0,28)	0.082	(0,235)	0.315**	(0,148)
Import Status	0.203**	(0,098)	0.268***	(0,042)	0.212***	(0,056)	0.386***	(0,055)
Regional Controls								
Total number of firms	0.645	(0,557)	-0.873**	(0,436)	-0.655**	(0,31)	0.189	(0,257)
Industrial Agglomeration	-0.011	(0,039)	-0.016	(0,03)	0.023***	(0,008)	0.018	(0,015)
Population	0.512***	(0,105)	0.163	(0,118)	-0.124**	(0,059)	0.010	(0,07)
Country Controls								
Log GDP	10.514**	(4,636)	4.017***	(1,214)	2.654***	(0,492)	1.897***	(0,408)
Log Population	5.347	(17,517)	13.982***	(4,18)	2.174	(2,93)	-7.806***	(2,958)
Exchange rate	0.443	(1,613)	-1.131	(0,934)	-0.830***	(0,131)	-0.289***	(0,065)
Number Obs.	13,873		39,613		59,391		99,687	
Log-Likelihood	-4,087		-11,634		-17,988		-29,013	
Pseudo R-squared	0.105		0.095		0.054		0.069	

Fixed effect logit regressions, all regressions contain year and industry dummies, region and destination specific linear trends and dummies controlling for firms' past export participation in different regions of the world; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit.

Table 8: Differences Across Firm Groups (by no. of employees)

	(i) < 50		(ii) 50 to 99		(iii) > 99	
Channels (t-1)						
Market specific, intra-industry within region	0.008***	(0,002)	0.004	(0,008)	0.009	(0,006)
Market specific, intra-industry outside region	0.004***	(0,002)	0.004**	(0,002)	0.003	(0,002)
Market specific, backward linkages	0.011***	(0,003)	0.022***	(0,009)	-0.002	(0,008)
Market specific, forward linkages	0.007*	(0,004)	0.042***	(0,014)	0.003	(0,011)
Labor Mobility	0.078	(0,057)	-0.016	(0,046)	0.092***	(0,031)
Firm controls (t-1)						
Log Labor Productivity	0.251***	(0,05)	0.333***	(0,084)	0.209**	(0,097)
Log Employment	0.775***	(0,075)	0.578***	(0,104)	0.322***	(0,102)
Log Wages	0.198*	(0,106)	0.140	(0,357)	0.302	(0,229)
Import Status	0.374***	(0,042)	0.302***	(0,078)	0.186	(0,114)
Regional Controls						
Total number of firms	-0.558*	(0,303)	0.196	(0,834)	0.183	(0,395)
Industrial Agglomeration	-0.029**	(0,013)	0.113***	(0,037)	0.022	(0,015)
Population	-0.005	(0,072)	0.221	(0,237)	-0.078	(0,088)
Country Controls						
Log GDP	2.338***	(0,388)	2.620***	(0,748)	2.218***	(0,436)
Log Population	-7.562***	(2,007)	2.415	(3,696)	0.244	(3,048)
Exchange rate	-0.391***	(0,083)	-0.119	(0,109)	-0.331***	(0,109)
Number Obs.	113,445		41,835		57,284	
Log-Likelihood	-32,908		-12,432		-17,410	
Pseudo R-squared	0.077		0.065		0.068	

Fixed effect logit regressions, all regressions contain year and industry dummies, region and destination specific linear trends and dummies controlling for firms' past export participation in different regions of the world; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit.

Appendix

In this appendix we present four tables. First, in Table A.1 we present a list of all variables used in the estimations including brief variable descriptions. Second, in Table A.2 we present the list of destination markets considered in the analysis. In the table we further show the number of export initiations in each market during the sample period and the geographic region the market is located in which we use to control for a firm's exporting experience in different regions of the world. Finally, the table shows the grouping of countries into neighbors, EU15, high income (HIC) and low income countries (LIC) which we use when performing sub-sample estimations. Table A.3 presents first stage estimation results from the IV regressions. In Table A.4 we finally assess the sensitivity of our results regarding the labor mobility variable. We perform two sets of robustness checks. First, we check whether the results are driven by our approach of handling M&A and spinoff activities. Second, we present results based on absolute hiring instead of share of people hired with export market experience.

In our data, we do not observe directly whether two firms merge or a spinoff is established. We therefore have to make sure that we do not count such activities as hiring of new employees. As mentioned in footnote 13, we address this issue by imposing two conditions on the hiring variable. First, we do not consider as hiring if more than 65% of the newly hired labor force comes from the same firm given that this firm hires more than 10 employees. We interpret hiring many people from the same firm as an indication of M&A or spinoff activities. Second, we replace the mobility variable with a zero when a firm hires more than 76 employees in one year. Given the size distribution of Danish firms with an overwhelming majority of small and medium sized firms (Parrota and Pozzoli, 2012), hiring many employees in one year is an indication of substantial restructuring such as M&A activities. We choose these cutoffs by looking at the distribution of these variables; in particular, in either case we cut the upper 25th percentiles of the distribution.

In Table A.4 columns (i) to (iii) we show regressions results based on different cutoffs. First, in column (i) we present the results from the paper based on the lower 75th percentiles to ease comparisons. In column (ii) we then use a different cutoff condition for the share of the newly hired labor force coming from the same firm. One may argue that

65% of newly hired employees coming from the same firm is still fairly high. We therefore now cut the upper 40th percentile of the distribution of this variable which corresponds to a share of 12%. The results in column (ii) are robust to this change. In column (iii) we change the condition of total amount of people hired. Instead of cutting the upper 75th percentile of this variable, we now cut the upper 10th percentile as one may argue that despite the size distribution of firms in Denmark, it is still possible that a firm hires more than 76 employees in one year. Cutting the upper 10th percentile amounts to not considering cases where firms hire more than 322 people in one year. The results in column (iii) are again robust.

In column (iv) we finally present results based on absolute hiring. In the paper we look at the share of people hired with foreign market specific experience out of total newly hired employees (conditioning on having earned above average wage in previous and new firms in both cases). We do so in order to control for general hiring effects. Alternatively, we can use the absolute number of newly hired employees with foreign market specific experience that have earned above average wage in the last and the new firm. To control for general hiring effects, we add the number of newly hired people that have earned above average wage in the last and the new firm without foreign market experience to the regression equation. The results in column (iv) show that the coefficient on the variable of newly hired employees with foreign market experience is highly significant and positive while the effect of hiring employees without this characteristic is insignificant. These results therefore support the robustness of our findings.

Table A.1: List of Variables

Variables	Description
Dependent Variable	
Export Status	Dummy variable equal to 1 if a firm is exporting to country j at time t and was not exporting to country j in the previous period. It is equal to 0 when a firm is not exporting to country j in both periods and observations for subsequent years after which a firm starts exporting to a specific country are coded as missing
Spillover variables (t-1)	
General, within region	# of exporting firms in a region
Intra-industry, within region	# of exporting firms within the same region and the same 2-digit industry as firm i
Market-specific, intra-industry, within region	# of firms within a region which are exporting to the same market j belonging to the same 2-digit industry as firm i
Market-specific, inter-industry, within region	# of firms within a region which are exporting to the same market j belonging to a different 2-digit industry than firm i
Market-specific, intra-industry, outside region	# of firms which are exporting to the same market j belonging to the same 2-digit industry but are located in a different region as firm i
Market-specific, inter-industry, outside region	# of firms which are exporting to the same market j belonging to a different 2-digit industry and are located in a different region than firm i
Spillover Channel	
Market specific, backward linkages DK (t-1)	Measures the presence of firms that are exporting to the same market j and belonging to industries that are supplied by the sector in which firm i operates
Market specific, forward linkages DK (t-1)	Measures the presence of firms that are exporting to the same market j and belonging to industries that are supplying the sector in which firm i operates
Market specific, mobility share DK (t-1)	Number of above average wage employees firm i hires who have worked in the previous year for a manufacturing firm exporting to market j, normalized by the total number of workers (with above average wage in both previous and new firms) firm i hires in that year
Firm controls(t-1)	
Log Labor Productivity	Log of labor productivity (value added per employee)
Log Employment	Log of number of employees
Log Wages	Log of average wages
Import Status	Dummy variable indicating whether firm i imports a good from country j
Region and Industry Controls	
Total number of firms (in Tsd)	Number of manufacturing firms within a region
Industrial Agglomeration	Region-industry (2-digit) share of national industrial activity normalized by the region share of national manufacturing activity
Population (in 10 Tsd)	Populaton living within a region
Country Controls	
Log GDP	Log of GDP of importing country
Log Population	Log of population of importing country
Exchange rate	Bilateral Exchange Rate (Foreign Currency / DKK; 2000=100)
Variables for Robustness Checks	
Market-specific, intra-industry, STARTER	Like the variable "Market-specific, intra-industry, within region", but based on firms that started to export in the current or previous period
Market-specific, intra-industry, CONTINUOUS	Like the variable "Market-specific, intra-industry, within region", but based on firms that have exported for three consecutive periods
Market-specific, inter-industry, STARTER	Like the variable "Market-specific, inter-industry, within region", but based on firms that started to export in the current or previous period
Market-specific, inter-industry, CONTINUOUS	Like the variable "Market-specific, inter-industry, within region", but based on firms that have exported for three consecutive periods
Mobility (absolute) - without export experience	Number of workers with above average wage in the previous and the new firm that firm i hires
Mobility (absolute) - with export experience	Number of above average wage (in previous and new firm) employees that firm i hires who have worked in the previous year for a manufacturing firm exporting to market j

Table A.2: List of countries

Country	Number of Exp Starter	Regions	Country Group	Country	Number of Exp Starter	Regions	Country Group
ARE	688	w_asia	HIC	KOR	639	e_asia	HIC
ARG	372	s_america	LIC	KWT	370	w_asia	HIC
AUS	812	oceania	HIC	LBN	297	w_asia	LIC
AUT	834	w_europe	EU15	LKA	199	s_asia	LIC
BEL	970	w_europe	EU15	LTU	1060	n_europe	LIC
BGD	164	s_asia	LIC	LUX	523	w_europe	EU15
BGR	477	e_europe	LIC	LVA	916	n_europe	LIC
BHR	279	w_asia	HIC	MAR	251	n_africa	LIC
BLR	193	e_europe	LIC	MEX	484	c_america	LIC
BRA	488	s_america	LIC	MLT	366	s_europe	LIC
CAN	1014	n_america	HIC	MYS	507	se_asia	LIC
CHE	1520	w_europe	HIC	NGA	240	w_africa	LIC
CHL	413	s_america	LIC	NLD	1002	w_europe	EU15
CHN	928	e_asia	LIC	NOR	2140	n_europe	Neighbor
COL	207	s_america	LIC	NZL	516	oceania	HIC
CRI	176	c_america	LIC	OMN	206	w_asia	LIC
CYP	425	w_asia	HIC	PAK	246	s_asia	LIC
CZE	1009	e_europe	LIC	PER	196	s_america	LIC
DEU	940	w_europe	Neighbor	PHL	354	se_asia	LIC
ECU	192	s_america	LIC	POL	1582	e_europe	LIC
EGY	487	n_africa	LIC	PRT	734	s_europe	EU15
ESP	968	s_europe	EU15	ROM	572	e_europe	LIC
EST	1091	n_europe	LIC	RUS	946	e_europe	LIC
FIN	950	n_europe	EU15	SAU	635	w_asia	LIC
FRA	967	w_europe	EU15	SGP	690	se_asia	HIC
GBR	969	n_europe	EU15	SRB	349	s_europe	LIC
GRC	735	s_europe	EU15	SVK	607	e_europe	LIC
GRL	1533	n_america	HIC	SVN	628	s_europe	HIC
HKG	803	e_asia	HIC	SWE	958	n_europe	Neighbor
HRV	463	s_europe	LIC	SYR	177	w_asia	LIC
HUN	875	e_europe	LIC	THA	532	se_asia	LIC
IDN	396	se_asia	LIC	TUN	195	n_africa	LIC
IND	566	s_asia	LIC	TUR	881	w_asia	LIC
IRL	940	n_europe	EU15	TWN	505	e_asia	HIC
IRN	260	s_asia	LIC	UKR	518	e_europe	LIC
ISL	1541	n_europe	HIC	URY	186	s_america	LIC
ISR	728	w_asia	HIC	USA	1440	n_america	HIC
ITA	1067	s_europe	EU15	VEN	234	s_america	LIC
JOR	314	w_asia	LIC	VNM	311	se_asia	LIC
JPN	822	e_asia	HIC	ZAF	633	s_africa	LIC
KEN	223	e_africa	LIC				

Table A.3: First Stage Estimation Results (see Table 4)

	(i) With Trends		(ii) No Trends	
Channels (t-1)				
Market specific, intra-industry within region	-0.000	(0,0002)	-0.000	(0,0003)
Market specific, intra-industry outside region	-0.000	(0,0001)	0.000	(0,0001)
Market specific, backward linkages	0.000	(0,001)	0.000	(0,001)
Market specific, forward linkages	-0.001	(0,001)	-0.000	(0,001)
Firm controls (t-1)				
Log Labor Productivity	-0.010*	(0,006)	-0.010*	(0,006)
Log Employment	0.055***	(0,008)	0.056***	(0,008)
Log Wages	0.084***	(0,024)	0.084***	(0,024)
Import Status	0.001	(0,004)	0.001	(0,004)
Regional Controls				
Total number of firms	0.048	(0,049)	0.011	(0,045)
Industrial Agglomeration	-0.002	(0,001)	-0.001	(0,002)
Population	0.004	(0,012)	-0.003	(0,006)
Country Controls				
Log GDP	0.039	(0,037)	0.034**	(0,015)
Log Population	-0.220	(0,157)	-0.099***	(0,026)
Exchange rate	0.003	(0,006)	-0.006**	(0,003)
Excluded Instrument				
Regional mobility	0.000***	(0,0001)	0.001***	(0,0001)

Table A.4: Sensitivity Analysis of Labor Mobility

	(i) baseline		(ii) alt. cutoff i		(iii) alt. cutoff ii		(iv) baseline	
Channels (t-1)								
Market Specific, Within region Intra-Industry	0.008***	(0,002)	0.008***	(0,002)	0.008***	(0,002)	0.008***	(0,002)
Market Specific, Outside region Intra-Industry	0.004***	(0,001)	0.004***	(0,001)	0.004***	(0,001)	0.004***	(0,001)
Market specific, backward linkages	0.012***	(0,003)	0.012***	(0,003)	0.012***	(0,003)	0.012***	(0,003)
Market specific, forward linkages	0.011***	(0,004)	0.011***	(0,004)	0.011***	(0,004)	0.011***	(0,004)
Mobility - share	0.059**	(0,026)	0.059**	(0,025)	0.055**	(0,027)		
Mobility (absolute number) - without export experience							-0.007	(0,007)
Mobility (absolute number) - with export experience							0.021***	(0,006)
Firm controls (t-1)								
Log Labor Productivity	0.255***	(0,036)	0.254***	(0,036)	0.255***	(0,036)	0.255***	(0,036)
Log Employment	0.648***	(0,047)	0.648***	(0,047)	0.648***	(0,048)	0.651***	(0,05)
Log Wages	0.223**	(0,107)	0.223**	(0,107)	0.223**	(0,107)	0.223**	(0,107)
Import Status	0.295***	(0,031)	0.295***	(0,031)	0.295***	(0,031)	0.294***	(0,031)
Regional Controls								
Total number of firms	-0.236	(0,171)	-0.235	(0,171)	-0.235	(0,171)	-0.231	(0,173)
Industrial Agglomeration	0.012	(0,008)	0.012	(0,008)	0.012	(0,008)	0.012	(0,008)
Population	0.010	(0,039)	0.011	(0,039)	0.010	(0,039)	0.013	(0,04)
Country Controls								
Log GDP	2.215***	(0,223)	2.215***	(0,223)	2.216***	(0,223)	2.216***	(0,223)
Log Population	-3.095**	(1,404)	-3.096**	(1,404)	-3.098**	(1,404)	-3.118**	(1,404)
Exchange rate	-0.321***	(0,077)	-0.321***	(0,077)	-0.321***	(0,077)	-0.321***	(0,076)
Number Obs.	212,564		212,564		212,564		212,564	
Log-Likelihood	-63,168		-63,168		-63,169		-63,167	
Pseudo R-squared	0.066		0.066		0.066		0.066	

Fixed effect logit regressions, all regressions contain year and industry dummies, region and destination specific linear trends and dummies controlling for firms' past export participation in different regions of the world; clustered standard errors (region-level) in parentheses; ***, ** and * denote significance at the 1, 5, and 10 per cent level; firm-country-year triad as observational unit.

Chapter 4

Import Competition from China and Productivity of Danish Firms

Import Competition from China and Productivity of Danish Firms

*Philipp Meinen**

Abstract

This paper investigates whether increased competition from China impacts firm productivity. I make use of detailed Danish data providing information on firms' sales by product which allows constructing a firm-specific competition measure. Moreover, I can compute a firm-specific deflator to account for potential biases in productivity estimations. I find that import competition in final goods leads to positive productivity effects of firms producing mainly homogenous goods. In particular, these firms seem to change their pricing behavior as a consequence of increased import competition from China leading to a reduction in prices.

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Keywords: Chinese Import Competition, Firm Productivity, Transaction Data
JEL-Codes: D21 F14 L25

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1 Introduction

China's extraordinary growth during the last four decades has led to dramatic changes of the Chinese economy. A striking feature of this development is China's export performance where its firms have become increasingly competitive in the global market. During the last years, China has taken over Germany's position as the largest exporting nation in the world inspiring scholars to investigate the consequences of China's export performance on the receiving countries.

The main interest of this literature lies on the impact of import competition from China on the labor markets in developed economies. Autor et al. (2012) analyze the effect of import penetration from China on local labor markets in the US and find that increased exposure to Chinese imports leads to higher unemployment and reduced wages. Ashournia et al. (2012) analyze the effect of Chinese import competition on wages in Denmark. They use detailed Danish data which allow them to construct firm-specific competition measures. They show that this is important in order to truly identify the effect of Chinese import penetration. The reason is that, in line with the literature on heterogenous firms, firms vary strongly in their exposure to import competition. As a consequence, they find negative wage effects for low-skilled workers when using the firm-specific competition measure, but not when using industry-level measures of Chinese import penetration. Utar (2012) exploits China's WTO accession in 2002 to investigate the effect of Chinese import penetration on sales and employment of Danish textile producing firms. She finds that both outcomes are negatively affected.

Another stream of the literature has investigated China's role for trade-induced technological change. Bloom et al. (2011) show that Chinese import penetration led to increased innovation, productivity and exit of EU firms. Utar and Ruiz (2012) show that US imports from China impact Mexican export oriented plants as they face tougher competition on the US export market. The authors show negative employment effects and positive productivity effects for these plants. Using a survey on yearly changes in average output prices of Italian manufacturing firms, Bugamelli et al. (2010) present evidence that Chinese import competition led to a reduction of prices. The present paper relates to these studies by analyzing the relationship between import competition from China and firm productivity in Denmark. The contribution compared to previous studies in this area is largely data driven as the rich Danish data allow me to get a clearer understanding of how firms react as well as which firms react to increased competition from China.

The important feature of the Danish data for the current study is that it provides information on firms' sales by product in a given year. This is important for two main reasons related to variable construction and estimation of firm productivity. In terms of variable construction, I can follow Ashournia et al. (2012) and compute a firm-specific measure of exposure to Chinese import competition. This ensures a clearer identification of the effect compared to Bloom et al. (2011), Utar and Ruiz (2012) and Bugamelli et al. (2010) who have to rely on industry-level measures due to data limitations. A clearer identification is also ensured as I can focus on competition in final goods which is actually supposed to lead to firm adjustments. Moreover, I can identify firms that produce rather homogenous and rather differentiated goods and hence investigate to what extent product differentiation protects firms from competitive pressure.

In terms of estimation approach, the product-level dimension of the Danish data is important in order to follow the recent literature on estimation of firm productivity while accounting for unobserved prices, unobserved demand shocks and the presence of multi-product firms. De Loecker (2011) shows that neglecting these aspects can lead to important biases when estimating the effect of trade liberalization on productivity. Similarly, Smeets and Warzynski (2012) show that accounting for these issues is important when estimating the effect of exporting on productivity. In the present study, I follow Smeets and Warzynski (2012) and compute a firm-specific deflator which allows dealing with the mentioned potential biases. I then estimate firm productivity using a modified version of the Ackerberg et al. (2006) algorithm which allows lagged import competition from China to affect firm productivity.

The estimation results show that increased import competition from China indeed positively impacts firm productivity. However, not all firms are affected equally. In particular, the largest effects are found when estimating the model on a sub-sample of firms which produce rather homogeneous goods while firms producing rather differentiated goods do not appear to react to increased competitive pressure from China. These results are based on deflating firm output using the computed firm-level price index and are robust to IV estimations. When instead using an industry-level deflator, the estimation results are significantly weaker. This is in line with a situation where firms producing rather homogeneous goods react to increased competitive pressure from China by raising their productivity, and in particular, by lowering their prices relative to firms facing less competitive pressure.

The rest of the paper is structured as follows, section 2 outlines the empirical approach. In section 3, I describe the data and the construction of the variables. Section 4 contains the results and section 5 concludes.

2 Empirical Methodology

Recent contributions in the field of structural estimation of production functions point towards potential biases related to not observing prices in most firm-level data sets. The common approach of estimating a production function when prices are unobserved is to deflate value added using an industry-level price index and to motivate a standard Cobb-Douglas value added production function:

$$y_{it} = \alpha_0 + \alpha_l l_{it} + \alpha_k k_{it} + \omega_{it} + \epsilon_{it}. \tag{1}$$

All variables in equation (1) are presented in lower-case letters which indicate logs. y_{it} represents value added of firm i in year t deflated by an industry-level price index p_s where s denotes the sector. l_{it} and k_{it} are firm-level inputs of labor and capital, ω_{it} is a measure of unobserved (by the econometrican, and observed by the manager) firm-level productivity and ϵ_{it} is noise. Klette and Griliches (1996) were the first to point out that this approach can lead to an omitted variable bias. In particular, the approach implies that the difference between firm-level and sector-level prices $(p_{it} - p_{st})$ is moved to the error term leading to endogeneity concerns as unobserved firm-level prices are likely to be correlated with the choice of firm-level inputs. De Loecker (2011) states a second source of bias related to the fact that estimated productivity, ω_{it}, will contain unobserved demand shocks.

Smeets and Warzynski (2012) discuss both sources of bias in detail and provide an easy fix given that the researcher has access to firm-level price information. In particular, in line with Eslava et al. (2004), they suggest to compute a firm-level deflator. The advantage of this approach is that it can be combined with a standard value added production function which ensures comparability with other studies. For this reason, I follow this approach in the current paper and compute a firm-level price index using a Tornqvist index which gives the weighted average of the growth in prices of all products k produced by firm i in year t (Eslava et al., 2004):

$$\Delta P_{it} = \sum_{k=1}^{K} \bar{h}_{kit} \Delta \ln(P_{kit}),$$

where $\Delta\ln(P_{kit}) = \ln(P_{kit}) - \ln(P_{kit-1})$, $\bar{h}_{kit} = \frac{h_{kit} - h_{kit-1}}{2}$, P_{kit} is the price of product k charged by firm i in year t and h_{kit} is the share of product k in firm i's total sales in year t.[1] I take 1997 as base year ($P_{i,1997} = 100$) and then add the computed firm-level price change to the index:[2]

$$\ln P_{it} = \ln P_{it-1} + \Delta P_{it}$$

for $t > 1997$. The price levels are obtained by simply taking the exponential of the natural log of prices $\ln P_{it}$. I then estimate equation (1) while deflating value added with the firm-level price index. The goal of estimating the production function is to obtain an estimate of true total factor productivity, ω (TFP). I do so by using a modified version of the Ackerberg et al. (2006) approach which allows lagged import competition from China to affect current productivity. In the following, I shortly summarize the estimation strategy.

I follow the insight from Levinsohn and Petrin (2003) and use intermediate inputs m_{it}

[1]As noted by Eslava et al. (2004), I also find large outliers in the distribution of the growth of prices. I therefore follow their approach and trim the data; in particular, I trim 3% and 1.5% of the left and right tails of the distribution of the growth in prices. This implies that I do not consider cases where the price of a 10-digit CN product grows or falls by more than 350% in one year. Moreover, I trim the 1% tails at both ends of the distribution of the final price index as this variable still has a number of extreme outliers.

[2]In line with Smeets and Warzynski (2012) I deal with firms entering the sample after the base year 1997 by computing the industry average price for the first year of their appearance and then follow a similar procedure as described above. Further note that in the commodity statistic price information is missing in one third of the observations. I construct the price index using available price information only. The appendix provides more details on this issue.

as proxy for the unobserved productivity shock ω_{it}.[3]

$$m_{it} = h_t(k_{it}, l_{it}, \omega_{it}, CIC_{it}). \tag{2}$$

CIC_{it} is the import competition variable which I will explain in the next section. Including CIC_{it} into equation (2) allows for differences in input demand depending on a firm's exposure to import competition from China. Inverting equation (2) for ω and substituting into equation (1) yields the estimation equation for the first step of the algorithm:

$$y_{it} = \phi_t(k_{it}, l_{it}, m_{it}, CIC_{it}) + \epsilon_{it} \tag{3}$$

where $\phi_t(\cdot) = \beta_l l_{it} + \beta_k k_{it} + h_t^{-1}(k_{it}, l_{it}, m_{it}, CIC_{it})$, i.e. output net of ϵ_{it}. I approximate the function $h_t^{-1}(\cdot)$ using a polynomial expansion of order four of its argument and obtain $\hat{\phi}_{it}$. Hence, the first step allows me to compute productivity for any parameter value as $\omega(\beta_l, \beta_k) = \hat{\phi} - \beta_l l_{it} - \beta_k k_{it}$. The second stage then relies on the law of motion of productivity which is modeled as a Markov process allowing productivity to be affected by lagged realizations of the import competition variable:

$$\omega_{it} = g(\omega_{it-1}) + CIC_{it-1} + \upsilon_{it}. \tag{4}$$

I can obtain the innovation to productivity $\upsilon_{it}(\beta_l, \beta_k)$ as the residual from non-parametrically regressing $\omega(\beta_l, \beta_k)$ on its lag and CIC_{it-1}. Next, I can specify moments to identify the parameters of interest

$$E\left(\upsilon_{it}(\cdot)\begin{pmatrix} l_{it-1} \\ k_{it} \end{pmatrix}\right) = 0 \tag{5}$$

and minimize the sample analog of equation (5) by GMM. I estimate the production function separately by NACE subsection. Table 1 columns (ii) and (iii) present the parameter estimates for labor and capital by industry. Moreover, in column (iv) of Table 1 I present simple correlations between estimated TFP and the price bias $(p_{it} - p_{st})$ by industry.

[3]Note that I deflate the inputs materials and capital using a materials and investment price index, respectively.

In each industry the correlation coefficient is negative implying that, as expected, more productive firms on average charge lower prices.[4]

The purpose of obtaining TFP is to estimate the impact of Chinese import competition on firm productivity. Remember that CIC_{it-1} measures the degree of competition that firm i faces from Chinese final goods imports. Firms may react to increased foreign competition by eliminating X-inefficiencies which might show up as improvements in productivity. The literature proposes two approaches for investigating this relationship. First, De Loecker (2010) provides a general framework for estimating productivity effects while allowing for endogenous productivity processes. The estimation of TFP presented above is in line with this framework which implies to estimate the law of motion of productivity given in equation (4) in order to identify the effect of Chinese import competition on firm productivity. I follow this approach in the current paper and approximate the function $g(\cdot)$ using a polynomial series expansion of order two. Moreover, I use a second approach which is more commonly applied in other studies and which implies regressing TFP on a measure of Chinese import competition while controlling for unobserved heterogeneity:

$$\text{TFP}_{it} = \beta_1 CIC_{it-1} + \gamma_i + \gamma_s + \gamma_t + \nu_{it}, \tag{6}$$

where γ_i, γ_s and γ_t are firm, industry, and year fixed effects and ν_{it} is an error term.

3 Data

I combine several data sets to construct my sample. First, I make use of the commodity statistic which provides information on manufacturing firms' sales by product at the 10-digit CN level for the period 1997-2008. I aggregate the product information at the 6-digit HS level as I merge additional variables to this data set which are available on this level of aggregation only. Using an unique firm identifier, I merge transaction-level trade data in order to compute firms' domestic sales by product.[5] I, furthermore, use

[4] This finding is in line with Smeets and Warzynski (2012).

[5] Computed domestic sales by product are negative in ca. 10% of of the observations. In the appendix I state the reasons for finding negative domestic sales by product and describe how I deal with these cases.

these data to compute total Danish imports from China and from the rest of the world by product. Moreover, I merge firm-level accounting data to my data set which is essential for estimating the production function. All three data sets are sourced from Statistics Denmark. Furthermore, I merge 6-digit HS product-level import demand elasticities to my data set provided by Broda and Weinstein (2006). These elasticities of substitution allow me to compute measures of the degree of product differentiation of the firms in the sample. As a final data source, I use WTO's comprehensive tariff data which provides EU tariff information on Chinese imports at the 6-digit product level.

The main variable of interest in my analysis is Chinese import competition. Ashournia et al. (2012) exploit the product dimension of the Danish data in order to construct a firm-specific measure of exposure to Chinese import competition CIC_{it}:

$$CIC_{it} = \sum_{k \in \Omega_i} s_{ik} \frac{M_{kt}^{CH}}{M_{kt} + D_{kt}}. \tag{7}$$

M_{kt}^{CH} is Danish imports of product k from China in year t, M_{kt} is total Danish imports of product k in year t and D_{kt} is total domestic sales of product k in year t. Note that I only consider imports and domestic sales of final goods. To obtain a firm-specific competition variable, I take the weighted average of Chinese import competition in the set of firm i's products Ω_i. Following Ashournia et al. (2012), I define the weights s_{ik} as the share of product k in firm i's set of products during the pre-sample period. I use the years 1997 and 1998 as pre-sample period[6] and keep s_{ik} constant during the sample period to measure the extent to which firms are affected by increased import competition from China in subsequent periods.[7]

Table 1 presents some descriptive evidence regarding this variable. Column (v) depicts

[6] I allow firms to enter the sample after 1997 and consider their first year of appearance as pre-sample period. Note that this kind of definition implies that firms which are in the sample in 1997 have to stay in the sample for at least four periods and firms that enter the sample after 1997 have to stay for at least three periods. Additional data cleaning implies that I drop firms which leave and re-enter the sample and observations with unusual values (e.g. negative domestic sales).

[7] HS product categories change over time and may be merged or split into existing or new categories. This problem also exists at the 6-digit HS level which is why I follow Van Beveren et al. (2012) in concording the 6-digit product codes over time. This is important in the current study as s_{ik} is kept constant over the sample period.

the change of this variable over the sample period 1999-2008 by NACE industry. The variable increases in all industries indicating the rise of Chinese imports during this period. Column (vi) further shows that there is significant variation in terms of the magnitude of this variable across industries where the textile sector is affected mainly. Columns (vii) to (x) depict the distribution of CIC_{it} by industry suggesting that even within industries, this variable varies a lot. These observations are in line with those by Ashournia et al. (2012).

One may worry about endogeneity when regressing TFP on a measure of Chinese import competition. For instance, there may be unobserved technology shocks which influence both firm productivity and imports from China. I therefore use an IV approach to assess the robustness of my results. The instrumentation strategy is similar to that of Bernard et al. (2006) in that I use both tariff information and lags of the competition variable.[8] Specifically, I use EU tariffs on Chinese products at the 6-digit product-level and construct a firm-specific protection variable. I do so by taking the weighted average of tariffs on products which belong to the set of firm i's products Ω_i where the weights are again given by s_{ik}. Tariffs have to be exogenous to the firms in order to be valid instruments. Given that they are decided at the EU-level, I believe that it is reasonable to assume that they are exogenous to firms in Denmark.

4 Results

Table 2 contains the estimation results. In column (i) I present the results from estimating the law of motion of productivity which allows lagged Chinese import competition to affect current productivity. This is the identification strategy suggested by De Loecker (2010) which is consistent with the modeling of the productivity process in the estimation algorithm. The estimated effect is positive and highly significant suggesting that a percentage point increase in Chinese import competition raises firm productivity by 0.27%.

[8] Bernard et al. (2006) analyze the effect of import penetration from low-wage countries on firm survival and employment growth in the US. Their competition measure varies at the industry-level and they find that low-wage competition negatively affects both probability of firm survival and employment growth.

As mentioned before, other studies identify the effect of Chinese import competition on firm productivity by motivating an estimation equation similar to equation (6). This model identifies the within firm effect given the inclusion of firm fixed effects. Moreover, the model contains industry and year dummies. The results in column (ii) from estimating this model show that the coefficient of interest increases in magnitude implying a marginal effect of 0.52% while it is significant at the 10%-level only. In column (iii) I re-estimate this model while including industry-year dummies to control for unobserved industry-specific trends. The coefficient increases further in magnitude while it is significant at the 5%-level. Hence, overall these results suggest that Danish firms indeed appear to react to increased Chinese import competition by raising their productivity.

In the following I try to get a better understanding which firms actually react to increased competitive pressure from China by distinguishing firms into those that sell rather homogenous goods and those that sell rather differentiated goods. Economic intuition suggests that mainly the former group of firms is affected. I can test this hypothesis by using the mentioned product-level elasticities of substitution which allow me to construct a firm-specific measure of product differentiation; to be precise, I construct this measure as the weighted average of elasticities belonging to products produced by a firm where the weights are given by the share of a product in a firm's total sales.[9] Table 1 column (xi) presents the mean of these elasticities by industry. I then re-estimate the model from column (ii) separately for firms with above and below average elasticities of substitution. The results presented in columns (iv) and (v) confirm the conjecture from before. In particular, when estimating the model on the sample of firms which produce rather homogenous goods (high elasticity of substitution), the coefficient is highly significant and almost triples in terms of magnitude leading to a marginal effect of 1.46%. Hence, these firms indeed seem to react to increased competition from China by raising their productivity while firms that produce rather differentiated goods do not seem to experience much competitive pressure from Chinese imports given that no significant effect is found for these firms (column v). In columns (vi) and (vii) I split the sample

[9]Note that for some firms the elasticities of substitution are missing (7% of the observations). In such a case I impute the missing elasticity by using the weighted average of elasticities in the firm's industry where the weights are given by a firm's share of sales in the industry.

according to the median instead of the average elasticity of substitution. Comparable results are found while the coefficient of interest does not increase as much as before for firms producing rather homogenous goods.

In the remaining columns of Table 2 I account for endogeneity concerns and re-estimate the models from columns (ii) and (iv) to (vii) using the mentioned IV approach. The findings from before are confirmed while the coefficients become even stronger in terms of significance and coefficient magnitude.

The results so far suggest that manufacturing firms in Denmark do react to increased import competition from China and, in particular, that these are firms that produce rather homogenous goods. Next, I try to get a better understanding of how these firms react. In particular, I am interested in whether these firms change their pricing behavior. After all, import competition from China is most likely related to low-wage competition which may put pressure on prices charged by Danish firms. To investigate this issue, I re-estimate the same models as presented in Table 2 while TFP is now obtained after deflating output by a 2-digit NACE industry price index instead of using the firm-level price index.

The results are presented in Table 3. Estimating the law of motion of productivity in column (i) leads to virtually similar results as before. In column (ii), I estimate equation (6) and the coefficient of interest increases in magnitude as in Table 2; even though not as much while the coefficient now is significant at the 5%-level. However, when adding industry-year dummies to the model in column (iii), the coefficient loses significance. Moreover, when estimating the model separately for firms producing rather homogenous and rather differentiated goods, only weakly significant coefficients are found for firms with an above average or above the median elasticity of substitution and these coefficients are considerably smaller compared to those in Table 2. These findings are basically confirmed by the IV estimations presented in columns (viii) to (xii) while the results become even weaker in terms of significance.

Regarding pricing behavior, finding smaller and less significant coefficients when using the industry-level deflator instead of the firm-level deflator is in line with a situation where firms indeed react to increased competition from China by becoming more productive and reducing their prices relative to firms facing less competition from China. In particular, using the industry-level price index implies an over-deflation of outputs for these firms which then leads to an underestimation of the productivity effect.[10] Interestingly, this mechanism is mainly found for firms which produce rather homogenous goods which is in line with economic intuition. Hence, Chinese import competition mainly affects firms which cannot circumvent this competitive pressure by producing specific varieties leaving these firms with the option of raising their efficiency and reducing prices.

5 Conclusion

Overall, I conclude that increased competition from China forces some firms to adjust to a changing environment by increasing their efficiency and reducing their prices. This effect is mainly found for firms producing rather homogenous goods. Product differentiation, on the other hand, seems to protect firms from increased competitive pressure related to Chinese import penetration.

[10] Smeets and Warzynski (2012) make an similar observation when analyzing productivity effects from exporting; i.e. they only find evidence for these effects when using a firm-level deflator.

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Tables

Table 1: Production Function Estimates and Import Competition Variable

Sector	Obs	Prod. Fct.		Corr. TFP	Chinese Import Competition						Elast. of
		L	K	price bias	Δ	Mean	sd	p25	p50	p75	of Subst.
	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi
Food, beverages, tobacco (DA)	1815	0.75	0.25	-0.524	0.001	0.002	0.006	0.000	0.000	0.000	12.54
Textiles, textile products (DB)	745	0.87	0.11	-0.498	0.064	0.110	0.106	0.035	0.084	0.158	9.52
Pulp, paper, publishing, printing (DE)	737	0.82	0.12	-0.512	0.003	0.002	0.007	0.000	0.001	0.002	3.41
Rubber, plastic (DH)	631	0.83	0.18	-0.628	0.007	0.015	0.022	0.000	0.004	0.019	3.81
Other non-metallic mineral prod. (DI)	791	0.90	0.10	-0.542	0.008	0.005	0.022	0.000	0.000	0.001	6.22
Basic and fabricated metal (DJ)	1038	0.98	0.10	-0.663	0.011	0.013	0.024	0.000	0.003	0.019	9.15
Machinery and equipment (DK)	1383	0.91	0.01	-0.710	0.021	0.014	0.023	0.001	0.006	0.017	12.87
Electrical and optical equipment (DL)	675	0.95	0.09	-0.694	0.023	0.037	0.046	0.004	0.019	0.052	5.27
Furniture, recycling (DN)	1442	0.92	0.09	-0.622	0.071	0.036	0.044	0.004	0.017	0.055	3.05

Table 2: Chinese Import Competition and TFP - Firm-level Price Index

	Ordinary Least Squares							Instrumental Variable Estimations				
	law of motion of TFP	base-line (eq. 6)	industry-year dummies	split acc. to elasticity of substitution				base-line (eq. 6)	split acc. to elasticity of substitution			
				sample mean		sample median			sample mean		sample median	
				above	below	above	below		above	below	above	below
	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
ω_{it-1}	0.952***											
	(0.088)											
ω^2_{it-1}	-0.000											
	(0.004)											
CIC_{it-1}	0.266***	0.517*	0.742**	1.459***	0.076	0.844**	-0.043	0.734**	2.290***	0.209	1.457***	-0.165
	(0.068)	(0.302)	(0.331)	(0.557)	(0.291)	(0.382)	(0.448)	(0.352)	(0.855)	(0.319)	(0.511)	(0.429)
Number of obs.	7,877	7,877	7,877	2,358	5,519	3,934	3,934	6,285	1,880	4,405	3,151	3,126
R-squared	0.882	0.153	0.181	0.173	0.149	0.228	0.081	0.001	0.006	-0.000	0.001	-0.000
F-test (excl. instruments)								182.66	21.68	282.53	69.97	280.23
Hansen J statisitc (p-val)								0.240	0.191	0.466	0.159	0.915

*** p<0.01, ** p<0.05, * p<0.1, dependent variable is TFP, columns (ii)-(xii) contain year, industry (NACE 2-digit) and firm fixed effects, constant term omitted from output table

Table 3: Chinese Import Competition and TFP - Industry-level Price Index

	Ordinary Least Squares							Instrumental Variable Estimations				
	law of	base-	industry-	split acc. to elasticity of substitution				base-	split acc. to elasticity of substitution			
	motion	line	year	sample mean		sample median		line	sample mean		sample median	
	of TFP	(eq. 6)	dummies	above	below	above	below	(eq. 6)	above	below	above	below
	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
ω_{it-1}	0.972***											
	(0.108)											
ω^2_{it-1}	-0.001											
	(0.005)											
CIC_{it-1}	0.261***	0.434**	0.410*	0.603*	0.342	0.396*	0.447	0.521*	0.513	0.489*	0.642*	0.363
	(0.057)	(0.188)	(0.225)	(0.322)	(0.224)	(0.229)	(0.320)	(0.267)	(0.650)	(0.280)	(0.379)	(0.362)
Number of obs.	7,877	7,877	7,877	2,358	5,519	3,934	3,934	6,285	1,880	4,405	3,151	3,126
R-squared	0.892	0.160	0.192	0.169	0.158	0.210	0.111	0.001	0.001	0.000	-0.000	0.001
F-test (excl. instruments)								182.66	21.68	282.53	69.97	280.23
Hansen J statisitc (p-val)								0.338	0.250	0.716	0.154	0.328

*** p<0.01, ** p<0.05, * p<0.1, dependent variable is TFP, columns (ii)-(xii) contain year, industry (NACE 2-digit) and firm fixed effects, constant term omitted from output table

Appendix: Data Issues

The commodity statistic is a survey of firms' sales by product providing information both on value and volume of each transaction. It covers roughly one third of all manufacturing firms in Denmark which account for about 90% of total sales in the manufacturing sector. The data are available at a quarterly basis at the 10-digit CN product level. There are two issues with these data related to missing price information and computation of domestic sales which I discuss in this appendix.

Missing Price Information

While the information on value by transaction is almost fully available, the information on volume by transaction is missing in approximately one third of the observations implying that price information is missing in these cases. In the analysis presented in this paper I use a price index which is based on available price information only. This obviously reduces the number of observations available for estimation because observations with missing price information are dropped. As a check of robustness, in this appendix I construct a price index while imputing missing price information. I impute missing price information using the weighted average of the firm-level price index in an industry in a given year where the weights are given by the share of a firm's sales in total sales of the industry in that year. I then re-run the baseline regressions for the firms in the sectors presented in Table 1.

The results are presented in Table A1 where the number of observations available for estimations increases from 7,877 to 18,603. In column (i), I estimate the law of motion of productivity and find a positive and highly significant coefficient. In column (ii) I estimate the alternative outcome equation (6). While the coefficient increases in magnitude, it is not significant at conventional levels. In the following columns, I split the sample according to the average and median elasticity of substation. In line with the results from the paper, positive and significant effects are found for firms producing rather homogenous goods. However, the coefficients are only significant at the 10%-level. This may be explained by the fact that imputed price information replaces actual firm-level price information only too some extent.

Table A.1: Results With Imputed Missing Price Information

	law of motion of TFP	base-line (eq. 6)	split acc. to elasticity of substitution			
			sample mean		sample median	
			above	below	above	below
	i	ii	iii	iv	v	vi
ω_{it-1}	1.421***					
	(0.090)					
ω^2_{it-1}	-0.023***					
	(0.004)					
CIC_{it-1}	0.166***	0.300	0.827*	0.142	0.477*	0.110
	(0.050)	(0.214)	(0.460)	(0.216)	(0.282)	(0.319)
Number of obs.	18,603	18,603	5,589	13,014	9,297	9,297
R-squared	0.832	0.067	0.056	0.075	0.070	0.068

*** p<0.01, ** p<0.05, * p<0.1, dependent variable is TFP, columns (ii)-(vi) and (viii)-(xii) contain year, industry (NACE 2-digit) and firm fixed effects, constant term omitted from output table

Computing Domestic Sales by Product

The proxy of Chinese import competition requires information on firms' domestic sales by product. For this reason, I make use of a transaction-level trade data set from Danish customs which provides information at the 8-digit CN product-level of firms' exports and imports. By aggregating the data in the commodity statistic to the 8-digit CN product level, I can merge the trade data and the commodity statistic and compute firms' domestic sales by product. The problem with merging these two data sets is that domestic sales by product can be understated for some exporting firms. The reason is that in the commodity statistic firms report only total sales by product from plants which main activity belongs to the manufacturing sector while the trade data include total exports by product of a firm (e.g. also exports that originate from a plant which main activity belongs to the service sector). Another reason why domestic sales may by understated for exporting firms is that the export statistics also include sales of so called traded goods (”salg af handelsvarer”). These goods are reported under a single code in the commodity statistic where it is not possible to distinguish resale of different commodities. As a result, exports by product may even be larger than total sales by product reported by firms in the commodity statistic. Indeed, negative domestic sales are found in a bit less than ten percent of the observations which I drop from the sample. Dropping these observations may have an impact on the measure of Chinese import competition if e.g. many observations of a firm are affected during the pre-sample period. In such a case the weights s_{ik} would not mirror the true importance of a product in a firm's sales. I address this potential concern by not considering firms in the analysis if they have negative domestic sales by product during the pre-sample period and these products account for more than half of the firm's total sales during this period. By dropping these firms I therefore make sure that the variable CIC_{it} indeed measure the degree of competition at the firm level as the weights s_{ik} provide an adequate measure of the importance of a product in a firm's product mix.

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