FACULTY OF SOCIAL SCIENCES
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How Firms Expand in Export Markets

Evidence from Danish Data on Exporter-Importer Relationships and Export Promotion Services

PhD Dissertation

Magnus Tolum Buus

Supervisor: Jakob Roland Munch

Submitted: September 2, 2019

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Contents

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Magnus Tolum Buus
September 2, 2019

Introduction

This PhD dissertation consists of three self-contained chapters that all study separate aspects of firms' expansion in export markets. Although the three projects study different questions, and do so using different approaches, they share a common focus on how firms grow in foreign markets and how firm-specific trade policies support this growth.

The first chapter documents that Danish firms face considerable network effects in export markets. That is, exporters that formed many buyer relationships in the past will tend to form more relationships in the future. I identify the causal effect by exploiting a policy managed by the Trade Council in Denmark. I show that the network effect is so strong that new exporters deliberately charge low prices, thereby forgoing present profits, in order to accumulate buyers, because building a buyer network ease the formation of new buyer relationships subsequently. The presence of strong network effects make trade policies aimed at matching Danish exporters with foreign buyers more effective. The next two chapters analyze the effects of such programs in more detail.

The second chapter empirically examines the effectiveness of a particular firm specific-trade policy, namely export promotion services (EPS). Further, it explores several potential mechanisms and determines through which of these the policy works. We identify causal effects of purchasing EPS by relying on the Trade Council in Denmark's random targeting across firms and show that purchasing EPS effectively boost exporters' sales. Further, we show that increased sales are accompanied by modest price increases and roughly unchanged (marginal) production costs. Therefore, we conclude that the boost in sales is caused neither by a drop in prices nor by costly quality upgrading, and, instead, we interpret the effect of EPS as a simple outward shift in foreign demand.

The third chapter also examines the effects of export promotion services (EPS) on Danish firms' performance on export markets, but focus as well as empirical approach differ from the second chapter. Here, we distinguish between two potential channels through which EPS can benefit exporters. First, purchasing EPS can boost foreign demand (the second chapter documented this channel and examined it in more detail). Second, purchasing EPS can reduce the costs associated with export participation. The main objective in this chapter is to disentangle these effects. We find that purchasing EPS increases foreign demand (in accordance with the findings in the second chapter) and, quite surprisingly, substantially reduces costs for continuing exporters while leaving entry costs unaffected. In other words, EPS help Danish exporters maintain existing markets rather than entering new ones. We show that this has important implications for policy-makers seeking to increase export participation and export revenue by allocating more resources to these programs: Improving the effectiveness of EPS is more efficient than reducing the price of EPS.

For convenience, the three abstracts are listed below.

1. Network Effects and Dynamic Pricing in Export Markets

This paper demonstrates that new exporters charge low prices in order to accumulate buyers, then increase prices as their network of buyers expands. I use a novel data set on firm-to-firm exports by Danish firms to document two empirical findings. First, exporters charge different prices from their buyers within narrowly defined markets. Second, exporters with larger buyer networks form more new buyer relationships. Based on these findings, I present a parsimonious dynamic model, where (i) exporters are able to price discriminate between buyers based on when their relationship is formed, and (ii) it is costly to find new buyers, but the cost is decreasing in the size of the network. The model predicts that exporters optimally increase prices as their network grows. Finally, I show that this prediction is in accordance with the data. The presence of network effects improves the benefits of trade policies aimed at matching exporters with foreign buyers and must be accounted for when evaluating such programs.

2. Firm-Specific Trade Policy: Evidence on Effectiveness and Mechanisms

with Jakob R. Munch, Joel B. Rodrigue, and Georg Schaur

Most countries engage in a variety of firm-specific trade policies. In this paper we examine the effectiveness and the mechanisms behind a firm-specific trade policy, export promotion. We use detailed data from the Danish Trade Council to solve measurement problems, and we exploit randomness in the targeting of the policy across firms to solve selection problems. We first find that the firm-specific trade policy boost exports of firms along the intensive margin. Next, we show that this is due to increasing sales, while marginal costs, export prices and quality remain roughly constant. This suggests that firms use the firm-specific trade policy to increase demand for their products on foreign markets consistent with a trade expansion theory such as Arkolakis (2010).

3. Export Promotion: Market Demand and Entry Cost Effects

with Jakob R. Munch, Joel B. Rodrigue, and Georg Schaur

This paper presents and structurally estimates a model of firms' decisions to purchase destination-specific export promotion services (EPS) and export. The model structure allows us to disentangle the dual effect of EPS on foreign demand and export costs. Using firm-level data for the Danish machinery industry, EPS are found to increase demand and substantially reduce costs for continuing exporters, whereas entry costs are unaffected. This finding is important for how policy-makers should adjust firm-specific trade policy. Using model simulations, we show that improving EPS, through a larger effect on demand, is a more efficient way to increase export participation and export revenue than reducing EPS prices.

Introduktion

Denne ph.d.-afhandling består af tre selvstændige kapitler, der alle beskæftiger sig med aspekter af virksomheders vækst på eksportmarkeder. Selvom de tre kapitler søger svar på forskellige spørgsmål og gør brug af forskellige metoder, omhandler de alle, hvordan virksomheder vokser på udenlandske markeder, og hvordan virksomhedsspecifikke, handelspolitiske tiltag understøtter denne vækst.

Det første kapital dokumenterer, at danske virksomheder oplever betydelige netværkseffekter på eksportmarkeder. Det betyder, at eksportører, der dannede mange handelsforbindelser førhen, generelt er i stand til at danne flere handelsforbindelser fremover. Jeg identificerer den kausale effekt ved at udnytte et eksportfremmende værktøj udbudt af Eksportrådet i Danmark. Jeg viser, at netværkseffekten er så stor, at nye eksportører sætter relativt lave priser - og dermed giver afkald på profit nu og her – for at tiltrække købere, fordi opbygningen af et kundenetværk letter den videre akkumulering af nye købere. Tilstedeværelsen af stærke netværkseffekter gør handelspolitiske tiltag, der har til formål at parre danske eksportører med udenlandske købere, mere effektive. De følgende to kapitler analyserer effekterne af sådanne programmer mere detaljeret.

Det andet kapitel er en empirisk analyse af effekterne af et specifik handelspolitisk tiltag, nemlig eksportpromoveringsydelser (EPY). Desuden fremlægger vi adskillige mekanismer og udpeger, gennem hvilke af disse EPY virker. For at identificere kausale effekter af at købe EPY udnytter vi, at Eksportrådet tilfældigt kontakter virksomheder for at promovere EPY. Vi viser, at køb af EPY effektivt øger eksportørers salg. Derefter viser vi, at tilvæksten i salg ledsages af beskedne prisstigninger og nogenlunde uændrede (marginale) produktionsomkostninger. På den baggrund konkluderer vi, at tilvæksten i salg skyldes hverken prisnedslag eller omkostningskrævende kvalitetsforbedringer, men i stedet bunder i en simpel forøgelse af udenlandsk efterspørgsel.

The tredje kapitel undersøger ligeledes effekterne af eksportpromoveringsydelser (EPY) på danske virksomheders præstationer på eksportmarkeder, men fokus såvel som empirisk tilgang er forskellig fra andet kapitel. I denne analyse skelner vi mellem to potentielle kanaler, gennem hvilke EPY kan gavne eksportører. For det første kan EPY forøge den udenlandske efterspørgsel (andet kapitel dokumenterede denne kanal og undersøgte den detaljeret). For det andet kan EPY mindske de omkostninger, der er forbundet med eksportdeltagelse. Det overordnede formål med dette kapitel er at adskille disse to effekter. Vi finder, at køb af EPY forøger udenlandsk efterspørgsel (i overensstemmelse med konklusionerne fra andet kapitel) og – ganske overraskende – mindsker omkostningerne ved at fortsætte som eksportør betydeligt, mens omkostningerne ved at påbegynde eksport er upåvirkede. Med andre ord hjælper EPY virksomheder med at fastholde eksisterende eksportmarkeder, snarere end at hjælpe dem med at træde ind på nye. Vi viser, at dette forhold bør inddrages, hvis man ønsker at øge eksportdeltagelse og –omsætning ved at bevilge flere ressourcer til handelspolitiske tiltag: Forbedring af kvaliteten af EPY er mere efficient end at sænke prisen.

De tre abstracts er indsat heruner.

1. Network Effects and Dynamic Pricing in Export Markets

Denne artikel viser, at nye eksportører sætter lave priser med henblik på at akkumulere købere for derefter at sætte priserne op, når deres netværk udvides. Jeg anvender et nyt datasæt indeholdende alle danske eksportører og deres udenlandske importører til at dokumnetere to empiriske tendenser. For det første opnår eksportører forskellige priser fra deres købere inden for meget snævert definerede markeder. For det andet indleder eksportører med store netværk flere nye køberrelationer. Baseret på disse tendenser præsenterer jeg en simpel, dynamisk model, hvor (i) eksporterer er i stand til at prisdiskriminere mellem deres købere på baggrund af, hvornår deres relation er indledt, og (ii) det er omkostningsfuldt at finde nye købere, men omkostningen er aftagende i netværkets størrelse. Modellen prædikterer, at eksportører øger deres priser, når deres netværk udvides. Slutteligt viser jeg, at denne prædiktion understøttes af data. Tilstedeværelsen af netværkseffekter øger fordelen ved handelspolitiske tiltag, der har til formål at parre eksportører med udenlandske importører, og dette bør tages i betragtning, når sådanne programmer evalueres.

2. Firm-Specific Trade Policy: Evidence on Effectiveness and Mechanisms

med Jakob R. Munch, Joel B. Rodrigue og Georg Schaur

De fleste lande bruger ressourcer på virksomhedsspecifikke tiltag, der har til formål at øge eksportdeltagelse- og omsætning. I denne artikel undersøger vi effektiviteten af og mekanismerne bag et sådant tiltag, nemlig eksportpromoveringsydelser. Vi anvender detaljeret data fra Eksportrådet i Danmark til at observere, hvad der ofte ikke lader sig observere, og drager fordel af Eksportrådets tilfældige henvendelser til virksomheder til at løse selektionsproblemer. Vi viser, at eksportpromoveringsydelser øger virksomheders eksport langs den intensive margin. Desuden viser vi, at dette er et udtryk for større salg, alt imens marginale produktionsomkostninger, eksportpriser og produktkvalitet forbliver nogenlunde uændrede. Det tyder på, at virksomheder anvender disse virksomhedsspecifikke tiltag til at øge efterspørgslen efter deres produkter på udenlandske markeder på en måde, der er konsistent med eksportekspansionsstrategier så som Arkolakis (2010).

3. Export Promotion: Market Demand and Entry Cost Effects

med Jakob R. Munch, Joel B. Rodrigue og Georg Schaur

Denne artikel præsenterer en model omhandlende virksomheders køb af eksportpromoveringsydelser (EPY) og indtrædelse på eksportmarkeder. Modellens struktur tillader os at adskille de simultane effekter af EPY på udenlandsk efterspørgsel og eksportomkostninger. Ved at anvende virksomhedsdata for den danske maskinindustri finder vi, at EPY øger den udenlandske efterspørgsel samt mindsker omkostninger ved at vedblive på eksisterende markeder markant, mens omkostninger forbundet med at træde ind på nye markeder er upåvirkede. Dette resultat har betydning for, hvordan man bør justere handelspolitiske tiltag. Ved hjælp af modelsimulationer kan vi vise, at forbedringer af EPY, sådan at effekten på udenlandsk efterspørgsel forøges, er en mere efficient metode til at øge eksportdeltagelse og –omsætning end at reducere priserne på EPY.

Chapter 1

Network Effects and Dynamic Pricing in Export Markets

Network Effects and Dynamic Pricing in Export Markets

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Abstract

This paper demonstrates that new exporters charge low prices in order to accumulate buyers, then increase prices as their network of buyers expands. I use a novel data set on firm-to-firm exports by Danish firms to document two empirical findings. First, exporters charge different prices from their buyers within narrowly defined markets. Second, exporters with larger buyer networks form more new buyer relationships. Based on these findings, I present a parsimonious dynamic model, where (i) exporters are able to price discriminate between buyers based on when their relationship is formed, and (ii) it is costly to find new buyers, but the cost is decreasing in the size of the network. The model predicts that exporters optimally increase prices as their network grows. Finally, I show that this prediction is in accordance with the data. The presence of network effects improves the benefits of trade policies aimed at matching exporters with foreign buyers and must be accounted for when evaluating such programs.

Keywords: Firm-to-firm trade, network effects, customer accumulation, dynamic pricing

1 Introduction

How do exporters grow? As growth of exporters, especially new exporters, is often an explicit policy objective, this question is important for the design of optimal trade policies. It is well-documented that new exporters, conditional on survival, *do* grow gradually over time (e.g. Ruhl and Willis, 2017). *How* exporters grow, on the other hand, is less clear. Several influential papers have stressed the importance of the extensive buyer margin: New exporters lack immediate access to foreign buyers and must engage in market-specific investments, such as marketing, to reach them (most notably Arkolakis, 2010, 2016; Eaton et al., 2014, 2016). Recently, Rodrigue and Tan (2019) and Piveteau (2019) have suggested that exporters price low early on to accumulate buyers, then increase prices as their market share grows. Fitzgerald et al. (2017) and Berman et al. (2019), however, conclude that this hypothesis is not compatible with the observed patterns of Irish and French exporters, respectively. The extent to which exporters use dynamic pricing as a means of buyer accumulation is, therefore, unresolved. One critical limitation of the existing evidence is, however, the lack of information on individual buyers, such that conclusions are based on more aggregate dynamics of, e.g., sales and prices at the firm × product × destination level.

Using a novel data set on firm-to-firm exports by Danish firms, this paper is the first to explicitly document that exporters increase prices as they reach more buyers. Further, I provide an empirically founded, theoretical framework through which this result can be interpreted. To do this, I start by presenting two empirical findings. First, exporters charge different prices from their buyers within narrowly defined markets. This means that exporters price discriminate between their buyers and, thus, are *able* to charge different prices from buyer relationships formed at different points in time. Second, exporters with larger buyer networks form more new buyer relationships. This network effect implies that the value of reaching a new buyer exceeds the profits generated from the particular relationship, and, thus, that exporters have *incentive* to set prices lower than in the static optimum in order to attract more buyers. I then present a parsimonious dynamic model based on these features and show that *if* the size of the network effect is positive, but decreasing in the size of the network, *then* exporters optimally increase prices as their network grows. Based on existing evidence, this condition is likely satisfied. Finally, I show empirically that exporters indeed increase prices as they reach more buyers.

Deviations from the law of one price are classical topics for economic research. In the context of international trade, numerous studies have pointed out the sizable dispersion of prices across *exporters*, within markets, and attributed this to cross-firm heterogeneity in factors such as productivity and product quality (e.g. Kugler and Verhoogen, 2011; Manova and Yu, 2017; Roberts et al., 2017; Piveteau and Smagghue, 2019).[1] The dispersion of prices across *importers*, within exporter × market pairs, on the other hand, has received little attention.[2,3] I show that the price dispersion across importers, within exporter × markets, is substantial: Ranking all exporter × importer relationships in terms of prices, the third quartile is characterized by a price 65 percent larger than the first quartile. I, then, provide evidence suggesting that the dispersion cannot be explained purely by measurement error in unit values, quantity discounts, or quality differentiation. Instead, I interpret the dispersion as a consequence of exporters simply selling seemingly similar products to different importers at different prices, and I will refer to this as *price discrimination*.

The idea that trade propagates through networks is not new. In an early paper, Rauch and Trindade (2002) show that the presence of ethnic Chinese networks facilitates trade between countries. More generally, the importance of intermediaries, agents (such as wholesalers and retailers) that facilitate matching between exporters and foreign buyers, have been documented by several studies.[4] Chaney (2014, 2018) propose models where exporters' geographic expansion abroad depend on the location of existing consumers because existing connections lower the cost of finding new connections nearby. The same logic motivates the recent literature on "extended gravity" as initiated by Morales et al. (forthcoming). Recently, the appearance of transaction-level trade data sets from a number of countries have permitted researchers to study several aspects of how firm-to-firm networks shape international trade (I review this literature below). In this paper, I define an exporter's network as the number of previously served importers and show that the size of the network has a positive and causal impact on the number of new buyer relationships formed by the exporter. I will refer to this as the *network effect*. To do this, I exploit a policy managed by the Trade Council (TC) in Denmark. I combine the transaction-level trade data with data on exporters' purchases of destination-specific "Partner Search and Match Making" (PSMM) services provided by the TC. The explicit purpose of these services is to help Danish exporters find importers abroad. I instrument the purchase decision by exporters using random approaches by the TC, as suggested by Buus et al. (2019), and show that exporters tend to form more new buyer relationships upon purchasing PSMM. Therefore, I can exogenously shift the size of exporters' networks, and, thus, isolate the network effect. I find that adding one importer to an exporter's network increases the number of new buyer relationships formed

[1] Though not based on export prices, Allen (2014) and Steinwender (2018) rationalize spatial price dispersion in homogeneous goods markets with the presence of information frictions. Similar forces are likely to drive some of the price dispersion across exporters in international goods markets.

[2] To the best of my knowledge, this topic has only been touched upon by Monarch (2018) in the context of price dispersion across US importers.

[3] I use the terms *buyer* and *importer* interchangeably throughout the paper.

[4] Among the most notable are Rauch and Watson (2004), Petropoulou (2011), Bernard et al. (2010), Blum et al. (2010), Felbermayr and Jung (2011), Ahn et al. (2011), Antras and Costinot (2011), Bernard et al. (2015), and Akerman (2018).

in the following year by 0.36-0.38. In comparison, the average exporter forms 0.52 new buyer relationships each year.

I make no attempt to explain or rationalize the presence of neither price discrimination nor network effects. Rather, my interest is to examine how these findings affect exporters' expansion strategy, specifically in terms of dynamic pricing. I propose a parsimonious dynamic model where exporters encounter buyers, and trade relationships are established if exporters post a sufficiently low price. The two empirical findings—the presence of price discrimination and network effects—inform the modelling setup. First, exporters are able to charge different prices from their importers. This provides the *possibility* for exporters to price discriminate between importers encountered at different points in time. Second, it is costly to find new importers, but the marginal cost of reaching an importer is decreasing in the size of the buyer network. This provides an *incentive* for exporters to charge prices below the static optimum in order to attract more buyers and extend their network at the expense of lower current profits. I show that *if* the size of the network effect is positive, but decreasing in the size of the network, *then* exporters optimally increase prices as their network grows. Existing evidence suggests that this condition is satisfied. Eaton et al. (2014, 2016) develop and structurally estimate dynamic models of exporters' search for importers, and show that the cost of searching, for a given search intensity, is decreasing in the size of the buyer network. They, too, refer to this as a network effect.

Finally, taking the model to the data, I examine if exporters charge higher prices from new buyer relationships when their network is large than when their network is small. As transactions are recorded at daily frequency, importers can accurately be ranked in the order they match with an exporter. This means that for each exporter × importer relationship, I observe the exact size of the exporter's network on the *date* of the match. At this highly disaggregated level, variation in prices can more convincingly be attributed to variation in network size. Following a simple, but rigorous, estimation strategy, I exploit variation within narrowly defined export spells and control for (product) market-wide developments. I find that exporters charge higher prices as their network grows. For exporters that managed to form more than five relationships, the price charged from the fifth buyer was about 15 percent higher than the price charged from the first buyer.

This paper touches upon several strands of the economic literature. Most broadly, it relates to the literature on how firms expand in export markets. Though not a novel topic, this question has received a large amount of academic interest in recent years. In a nutshell, it is well-documented that new exporters grow gradually conditional on survival (Ruhl and Willis, 2017, among others). Acknowledging that new exporters do not have immediate access to all customers in a foreign market, accumulation of customers has become a widely accepted source of growth for new exporters. However, there is little consensus on *how* exporters accumulate customers.

In his seminal analysis, Arkolakis (2010) suggests that exporters build a customer base through marketing investments. Arkolakis (2016) shows that this mechanism, in combination with idiosyncratic productivity shocks, is able to predict exporters' growth. Within the macroeconomic literature, Drozd and Nosal (2012) show that a model featuring costly customer accumulation accounts for several puzzles regarding international prices, and Gourio and Rudanko (2014) provides a micro-foundation for such a model using a search theoretical framework. The empirical literature on the effectiveness of export promotion services provides evidence on a wide-spread category of destination-specific investments. Volpe Martincus and Carballo (2008), Van Biesebroeck et al. (2015), Munch and Schaur (2018), and Buus et al. (2019) show that purchasing export promotion services effectively increase firms' sales in existing export markets. In the present paper, I show that a particular type of export promotion services, namely "Partner Search and Match Making", specifically help Danish exporters match with more importers abroad. As such, "Partner Search and Match Making" services can be thought of as akin to marketing investments in the spirit of Arkolakis (2010).

An alternative, though by no means contradicting, mechanism is that exporters' *current* customer base depends positively on *previous* performance. Rodrigue and Tan (2019) develop a model where consumers' utility from a given product depends directly on the product's past market share. Intuitively, this can be interpreted as consumers having taste for "brand recognition": They are more willing to buy the product if many others bought it previously. Piveteau (2019), instead, assume that the customer base itself is increasing in the exporter's previous sales. This mechanism can arise if consumers have imperfect information about product characteristics and, therefore, use previous sales as a signal. Though the underlying modelling assumptions slightly differ, the two models share a central prediction: Exporters face an incentive to set low prices initially, in order to attract customers early on, then increase prices as the customer base grows. Foster et al. (2016) make use of a similar mechanism to explain the gradual growth of newly established firms in the US domestic market for commodity-like products. Similar models have also been applied to explain macroeconomic developments, e.g. by Ravn et al. (2006) and Paciello et al. (2019).

Whereas the importance of marketing investments as a source of growth in foreign markets is well-established, the role of dynamic pricing is unsettled. Naturally, if dynamic pricing plays an important role for the expansion of exporters, one would expect their prices to grow over time. Indeed, the models in Rodrigue and Tan (2019) and Piveteau (2019) are, to some extent, motivated by such findings for Chinese and French exporters, respectively.[5] On the other hand, Fitzgerald et al. (2017) document that Irish firms' export prices are largely *stable* over time and suggest that a model where exporters grow by accumulating customers through marketing investments, in the spirit of Arkolakis (2010), is better in line with their findings. Berman et al. (2019) and Bastos et al. (2018) document that French and Portuguese firms' export prices, respectively, are slightly *decreasing* over time and suggest that these findings are more in line with a model where exporters learn about their idiosyncratic demand, in the spirit of Jovanovic (1982), and surviving exporters grow as they update their demand expectations upwards. Both Fitzgerald et al. (2017) and Berman et al. (2019) explicitly conclude that their findings are at odds with theories on exporter expansion that give rise to dynamic pricing. In light of the inconclusive evidence on this topic, it is important to note that the findings presented in this paper stand irrespective of the "true" relationship between exporters' age and prices: Appropriately choosing the econometric specification allows me to interpret the effect of larger network on prices as *additional* to any effect of age. This is possible only because of the very disaggregated level of my data.

This paper also adds to the relatively new, but rapidly growing, literature on firm-to-firm relationships in international trade, as recently reviewed by Bernard and Moxnes (2018). Benguria (2015), Heise et al. (2016), Bernard et al. (2018), Carballo et al. (2018), Sugita et al. (2019), and Lenoir et al. (2019) propose static matching models to rationalize cross-sectional patterns of exporter-importer relationships. Krolikowski and McCallum (2019) add search frictions to a dynamic Melitz-type framework causing some exporters to be left unmatched, and Monarch (2018) develops a dynamic discrete choice model of importers' sourcing decision where the presence of switching costs affect consumer prices. Closer to my paper are Eaton et al. (2014) and Eaton et al. (2016) both of which develop and structurally estimate complex dynamic models where the presence of search frictions introduce a wedge between exporters and importers that would otherwise have engaged in trade. Both papers allow exporters to have multiple importer relationships and, importantly, feature positive network effects. Specifically, searching for importers is costly, but the cost is allowed to depend on (and found to be decreasing in) the number of previous buyer matches. This is very close in spirit to the class of costumer-base models with costly accumulation. However, neither Eaton et al. (2014) nor Eaton et al. (2016) provide

[5] Zhao (2018) provides similar evidence for Chinese exporters, and Foster et al. (2008) provide similar evidence for the US domestic market for commodity-like products.

exporters with an incentive to use prices as an attraction device. Lastly, two papers examine the trade dynamics *within* existing trade relationships. Monarch and Schmidt-Eisenlohr (2018) rationalizes increasing sales within relationships with a model featuring gradual learning of reliability, and, closer to my paper, Heise (2019) rationalizes decreasing prices within relationships with a model featuring accumulation of relationship capital. None of the cited papers on firm-to-firm trade in export markets examine the role of prices as a device to accumulate importers.

The remainder of the paper is structured as follows. Section 2 outlines the data and present two empirical findings: First, the presence of price discrimination across importers, and, second, the presence of network effects. Section 3 presents a parsimonious model of exporters' use of dynamic pricing, and Section 4 provides empirical evidence in favor of the central model prediction: Exporters increase their prices as their network grows. Section 5 concludes.

2 Empirical Analysis

In this section, I first describe the underlying data sets, outline sample restrictions, and provide brief summary statistics. Then, I present two empirical findings that will guide the model proposed in the following section.

2.1 Data

The backbone of this paper is the Danish transaction-level customs data from 2007 to 2016. It contains all transactions of products from Denmark to countries outside the European Union at the daily level. Classical customs data allows the researcher to identify exports, measured in both values and quantities, by product and destination for all exporting firms. The present data set adds information about the *buyer margin*, that is all transactions contain a unique identifier for the foreign importer.

To be specific, the raw data set's unit of observation is an exporter × product × importer × destination × date. I refer to such an observation as a *transaction*.[6] An *exporter* is a Danish firm characterized by a unique identifier that allows me to merge the data to other Danish firm-level registers. A *product* is classified according to the 8-digit Combined Nomenclature (CN8). An *importer* is characterized by a unique, but otherwise meaningless, identifier. A *destination* is all countries outside the European Union (EU).[7] The *date* refers to the day on which the transaction was handled by the Danish customs authorities. For each transaction, I observe its f.o.b. value in Danish Kroner (DKK) and its quantity.[8] I construct unit values by dividing values with quantities and refer to these as "prices" in the remainder of the paper.

I restrict and process the data in several ways. First, I exclude exporter × importer pairs characterized by no more than one transaction throughout the entire sample period. Eventually, I will define an exporter's *network* as the number of importers previously served within a destination. The idea is that exporters are able to reach new importers

[6]Very few importers, served by Danish exporters, operate across destinations, and I do not make any attempt to exploit variation within importers, across destinations. Thus, I consider an exporter × importer pair (exporter × importer × product triplet) to be equivalent to an exporter × importer × destination triplet (exporter × importer × product × destination quadruplet).

[7]Danish firms report exports destined for outside the EU to the Danish customs authorities, which then transfer the data to Statistics Denmark. Firm are obliged to inform customs authorities about the buyer's name. For exports destined for inside the EU, Danish firms report directly to Statistics Denmark, and reporting the buyer's name is not mandatory. Therefore, data at this level of aggregation, is not available for Danish firms' exports to destinations within the EU.

[8]The data contains quantities in kilos for all products and, additionally, quantities in a supplementary unit (such as pieces and liters) for a subset of products. If the supplementary unit is present and the same for all trade flows within a product category, I apply quantities in this unit. Otherwise, I apply quantities in kilos.

through their network. Following Eaton et al. (2014), I consider "single-transaction relationships" as "failures" that do not contribute to the network. In order to ensure comparison across all empirical specifications, even those where network does not a play a role, I disregard these single-transaction relationships altogether. Second, I restrict attention to manufacturing (NACE C) firms with employees. The main reason is to avoid whole-sellers that purely distribute products produced by other firms. I obtain information on industry affiliation and number of employees from the Firm Statistics Register, covering the universe of private sector Danish firms. Third, to account for changes in product categories over time, I apply the algorithm proposed by Van Beveren et al. (2012), aggregating categories to the so-called CN8+ level. Fourth, I aggregate the data to the yearly level. In practice, this means that I do not distinguish between exporter-importer relationships characterized by many small transactions and few large transactions, respectively. However, I keep track of the exact date for the *first* transaction for any exporter-importer relationship. Fifth, to address the concern of "partial-year bias", as highlighted by Bernard et al. (2017), I construct so-called pseudo-years and rely on these instead of calendar years. The idea is that the first *calendar* year of an export spell[9] will generally be shorter than 12 months, which biases the first-year level of, say, export value downwards, and biases the first-to-second-year growth rate upwards. In practice, I define spell-specific pseudo-years as 12 months periods starting from the month in which the spell was initiated. As will become apparent later, a major part of my empirical analysis will rely on newly established export spells, and so correcting for partial-year bias is a first-order issue.[10]

I merge the data to two auxiliary data sets. First of all, I obtain information on Danish firms' purchases of export promotion services (EPS) provided by the Trade Council (TC) in Denmark. In Section 2.3, I take advantage of these data to construct an exogenous shock to the number of importer relationships exporters form. This data set is outlined in detail in Buus et al. (2019). In a nutshell, it contains the full list of Danish firms that purchased EPS together with the full list of firms that were approached by the TC and offered EPS, both at the firms × destination × year level. EPS are classified by type. Whereas Buus et al. (2019) utilized all types, I restrict attention to EPS labelled "Partner Search and Match Making" because the explicit purpose of these services is to help Danish exporters find importers abroad. Applying the EPS data restricts the sample in two ways. First, data for 2016 is not available, so the sample is restricted to 2007-2015.[11] Second, as TC does not offer EPS to all destinations, I follow Buus et al. (2019) and restrict attention to destinations for which a Danish firm purchased EPS at some point during the years for which data on EPS is available (2002-2015). In practice, this is of little concern as TC offers EPS to all major Danish export destinations. As a second auxiliary data set, I use the classical, exporter × product × destination × year level, customs data to track the history of each exporter × destination pair back to 2000. This way, I can distinguish new exporters from old exporters in my main sample.

I will refer to the data set outlined above as my *raw sample*. It contains around 3,300 unique Danish exporters, exporting 5,600 unique products to 177,000 unique foreign importers spread across 51 destinations. The largest destinations in terms of export value are the US, Norway, China, Russia, and Japan.

Brief summary statistics are presented in Table 1. The top panel shows the distribution of the number of exporters across four levels of "markets". First, 241.4 Danish exporters served each destination in each year on average. Second, most product × destination × year triplets were served by only one Danish exporter, though the average market was

[9]Throughout this paper, I define *export spells* at several levels of aggregation as sequences of consecutive years during which, e.g., exporter × destination pairs report positive export value.

[10]As described below, I distinguish between spells that are left-censored and *not* left-censored. Whereas the application of pseudo-years is, of course, targeted *not* left-censored spells, I attribute pseudo-years to all spells using the month in which the spell first occurred in my sample.

[11]I will still use 2016 to determine if an export spell ended in 2015.

Table 1: Summary Statistics, Raw Sample

	Mean	Percentiles				
		5	25	50	75	95
Exporters per...						
destination × year	241.4	13.2	59.5	172.7	295.7	845.4
Value (%)	.	100.0	98.3	92.2	75.7	38.0
product × destination × year	2.1	1.0	1.0	1.0	2.0	5.0
Value (%)	.	100.0	100.0	100.0	75.5	50.1
importer × destination × year	1.1	1.0	1.0	1.0	1.0	2.0
Value (%)	.	100.0	100.0	100.0	100.0	18.6
product × importer × destination × year	1.0	1.0	1.0	1.0	1.0	1.0
Value (%)	.	100.0	100.0	100.0	100.0	100.0
Importers per...						
destination × year	987.6	23.4	130.3	441.8	1,053.7	4,475.8
Value (%)	.	100.0	98.3	92.4	76.5	42.2
product × destination × year	4.9	1.0	1.0	2.0	4.0	15.0
Value (%)	.	100.0	100.0	94.1	82.4	55.8
exporter × destination × year	4.6	1.0	1.0	2.0	4.0	15.0
Value (%)	.	100.0	100.0	95.2	83.2	39.8
exporter × product × destination × year	2.4	1.0	1.0	1.0	2.0	7.0
Value (%)	.	100.0	100.0	100.0	85.5	41.8

"Value" is the share of total export sales obtained by exporters (in the top panel) or importers (in the bottom panel) *above and including* the given percentile. Percentiles are calculated as averages of the five adjacent observations around the given percentile in order to comply with Statistic Denmark's rules on data confidentiality.

served by 2.1. However, the markets served by at least two exporters received 75.5 percent of the export value. Third, the majority of foreign importers are served by one Danish exporter only: the 95th percentile is served by two. Fourth, this regularity is even more pronounced at the product level: Basically no foreign importers purchase the same product from two Danish exporters. The bottom panel resembles these statistics, but now from the perspective of the foreign importers. First, the average destination × year pair were inhabited by 987.6 importers, though the distribution is heavily right-skewed.[12] Second, the average product × destination × year triplet was inhabited by 4.9 importers, and markets with at least two importers received 94.1 percent of the Danish export value. Third, Danish exporters served 4.6 importers in each destination × year on average, and 95.2 percent of the export value was sold by exporters serving at least two importers. Fourth, even for the same product, exporters served 2.4 importers per destination × year pair on average, and 85.5 of the export volume was sold by exporters serving at least two importers per product.

There are three main takeaways from these summary statistics. Firstly, several foreign importers serve Danish exporters in each product × destination × year market. Thus, it is *not* the case that foreign markets are dominated by a single importer. Secondly, most Danish exporters serve multiple importers in each destination, and exporters with multiple importers are responsible for the lion's share of the total export value. This means that Danish exporters do *not* generally trade with a single local partner. Thirdly, even though most Danish exporters serve only one foreign importer for each of their products, around 35 percent of exporter × product pairs make use of at least two importers in the same destination, and these constitute 85.5 percent of the export value. These regularities motivate an analysis of how exporters expand in foreign markets characterized by many potential buyers, where exporters have incentives to serve multiple, and not just one, importer.

For my empirical analysis, I need to adjust the raw sample to two different levels of aggregation.

For my analysis of export prices in Section 2.2 and 4, I make use of the raw sample at its existing level of aggregation, that is the exporter × product × importer × destination × year level. However, I clean the data set in the following way. It is well-established in the empirical literature on export prices, obtained as unit values, that these are exposed to measurement error (ME), e.g. due to misreporting. As I will examine the distribution of export prices in my empirical analysis, mitigating the impact of measurement error is a first-order concern, which I address in two ways. Firstly, the extensive use of fixed effects throughout the paper will absorb any ME that systematically varies across the level of fixed effects. For example, in Section 2.2, I examine the price distribution within exporter × product × destination × year quadruplets, across importers. This eliminates concerns associated with, e.g., that some products are more difficult to measure, that some exporters tend to misreport more, that some destinations are more closely monitored by the Danish customs authorities, that rules on reporting changes over time, or *any* combination of these separate concerns. Secondly, following common practice in the literature, e.g. Manova and Zhang (2012), I suspect outliers to be the result of severe ME. Specifically, I consider an observation to be an outlier if it meets either of the following two criteria: (i) the value, quantity, and/or price is below the 1st percentile or above the 99th percentile of the respective distribution, and/or (ii) the year-to-year price growth is below the 1st percentile or above the 99th percentile of the price-growth distribution.[13] This way, I exploit both the cross-sectional and across-year variation to detect outliers. If an observation is considered an outlier, I disregard the entire exporter × product × importer × destination *spell*. I consider this to be a conservative approach to the concern of ME.

[12]For comparison, Bernard et al. (2018) report that Norwegian exporters served 5,992 importers in the US and 1,489 importers in China in 2006. In the present sample, Danish exporters served 4,818 importers in the US and 2,081 importers in China in 2007 (2006 is not available).

[13]Addressing that different products are measured in different units and that the level of prices varies systematically across destination and over time, I purge values, quantities and prices for product × destination × year fixed effects before imposing criterion (i).

For my analysis of network effects in Section 2.3 I simply aggregate the raw sample to the exporter × destination × year level.[14] The main variable of interest is the number of importer relationships formed by exporters by destination and year.

Finally, for each of the two estimation samples, I distinguish between exporter × destination spells that are left-censored and *not* left-censored. The reason for doing so is, as we will see, that an exporter's network is not properly defined if it belongs to a left-censored spell. I define a spell as *not* left-censored if it meets either of the following conditions: (i) the spell was initiated later than 2007, or (ii) the spell was initiated in 2007 *and* the exporter did not export to the particular destination at any point in time from 2000-2006 according to the general customs data.

Having outlined the data, I now present two empirical findings. First, in Section 2.2, I document that exporters price discriminate between their buyers. Then, in Section 2.3, I document that exporters face network effects. I use both findings to guide the model presented in Section 3.

2.2 Price Discrimination

In this subsection, I document that exporters generally obtain quite different prices from their buyers within narrow markets, defined as product × destination × year triplets. That is, the price dispersion across buyers, within exporter × market pairs, is substantial. I further provide evidence suggesting that this dispersion is not entirely explained by three simple factors: measurement error in prices, quantity discounts, and quality differentiation.

For this part of the analysis, I apply the exporter × product × importer × destination × year data set, cleaned for price outliers as described in Section 2.1. As I do not require information on the lengths of any export spells and in order to make the analysis as general as possible, I apply both left-censored and *not* left-censored spells in this part of the analysis. Focusing solely on *not* left-censored spells, however, produce qualitatively similar results.

Table 2 shows that the cleaned sample consists of 211,757 markets of which 66,345 are served by more than one Danish exporter. It is a well-known fact that exporters, serving the same market, obtain very different prices. Define exporter × market prices, p_{im}, as

$$p_{im} = \log\left(\frac{\sum_{j\in\Omega_{im}} S_{ijm}}{\sum_{j\in\Omega_{im}} Q_{ijm}}\right),$$

where S_{ijm} is the value sold by exporter i to importer j in market m, Q_{ijm} is the quantity, and Ω_{im} is the set of importers served by i in m. Prices are then de-meaned by market fixed effects in order to facilitate comparison across exporters, within markets, and dubbed $\tilde{p}_{im}$. This leaves 274,806 observations of $\tilde{p}_{im}$.

Figure 1 shows the distribution of $\tilde{p}_{im}$ (dashed line), and Table 2 (top panel, third row) provides the corresponding statistics. The third (first) quartile is 0.66 (-0.68), meaning that the exporter on the third quartile obtains a price almost twice as high as the mean exporter.[15] I will refer to the width of this distribution as the degree of price *dispersion*.

Dis-aggregating further, the cleaned sample consists of 420,218 exporter × market pairs of which 139,930 served more than one importer. Define exporter × importer × market prices simply as

$$p_{ijm} = \log\left(\frac{S_{ijm}}{Q_{ijm}}\right). \tag{1}$$

Prices are then de-meaned by exporter × market fixed effects in order to facilitate comparison across buyers, within exporter × market pairs, and dubbed $\tilde{p}_{ijm}$. This leaves 670,535 observations of $\tilde{p}_{ijm}$.

[14] I re-formulate the pseudo-years to this level of aggregation such that pseudo-years are exporter × destination spell-specific.

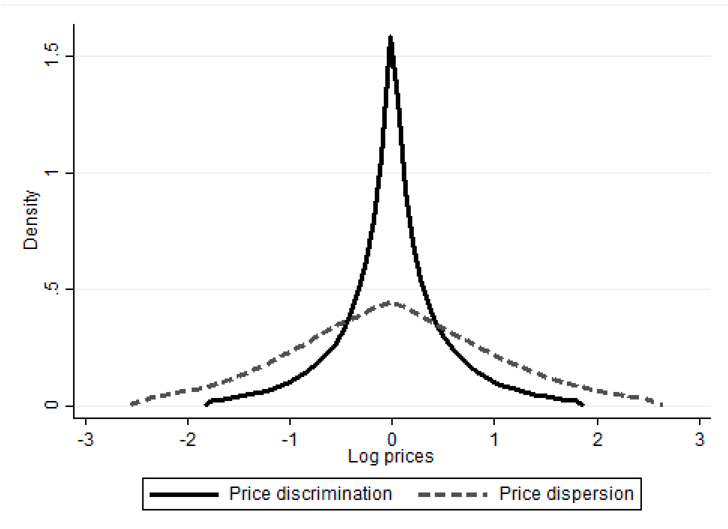
[15] $(\exp(0.66) - 1) \times 100\% = 94\%$.

Table 2: Summary Statistics, Cleaned Sample

	N	Mean	SD	Percentiles				
				5	25	50	75	95
#Exporters per market	211,757	1.98	4.66	1.00	1.00	1.00	2.00	5.00
... given #Exporters> 1	66,345	4.14	7.90	2.00	2.00	2.00	4.00	10.00
Prices ($\tilde{p}_{im}$)	274,806	0.00	1.05	-1.75	-0.68	-0.01	0.66	1.80
Quantities ($\tilde{q}_{im}$)	274,806	0.00	2.00	-3.32	-1.36	0.00	1.35	3.34
#Importers per exporter × market	420,218	2.26	5.93	1.00	1.00	1.00	2.00	6.00
... given #Importers> 1	139,930	4.79	9.79	2.00	2.00	3.00	4.00	13.00
Prices ($\tilde{p}_{ijm}$)	670,535	0.00	0.62	-1.01	-0.25	0.00	0.25	1.03
Quantities ($\tilde{q}_{ijm}$)	670,535	0.00	1.40	-2.33	-0.84	0.00	0.85	2.32
Quality ladders ($\tilde{\lambda}_p^{\text{quality}}$)	1,306	0.00	0.52	-0.90	-0.28	0.08	0.36	0.70
Price ladders ($\tilde{\lambda}_m^{\text{price}}$)	16,487	0.00	2.11	-3.40	-1.34	-0.07	1.36	3.46
Price ladders ($\tilde{\lambda}_{im}^{\text{price}}$)	38,714	0.00	2.54	-4.33	-1.59	0.10	1.76	3.85

Exporter × market level prices and quantities ($\tilde{p}_{im}$ and $\tilde{q}_{im}$) are log-transformed and de-meaned by market fixed effects (FEs) (excl. singletons). Exporter × importer × market level prices and quantities ($\tilde{p}_{ijm}$ and $\tilde{q}_{ijm}$) are log-transformed and de-meaned by exporter × market FEs (excl. singletons). Price and quality ladders ($\tilde{\lambda}_p^{\text{quality}}$, $\tilde{\lambda}_m^{\text{price}}$, and $\tilde{\lambda}_{im}^{\text{price}}$) are constructed as explained in section 2.2.3 and de-meaned by destination × year FEs. Percentiles are calculated as averages of the five adjacent observations around the given percentile in order to comply with Statistic Denmark's rules on data confidentiality.

Figure 1: Price Discrimination and Price Dispersion



Notes: "Price discrimination" is the distribution of ijm level prices, de-meaned by im fixed effects (excl. singletons), where i refers to an exporter, j to an importer, and m to a (product × destination × year) market. "Price dispersion" is the distribution of im level prices, de-meaned by m fixed effects (excl. singletons). The bottom and top 1 percent of each distribution are excluded as outliers.

Figure 1 (solid line) shows the distribution of $\tilde{p}_{ijm}$ and Table 2 (middle panel, third row) provides the corresponding statistics. The third (first) quartile is 0.25 (-0.25), meaning that importer on the third quartile pays a price almost one third higher than the mean importer.[16] I will refer to the width of this distribution as the degree of price *discrimination*.

Whereas, as expected, the degree of price *dispersion* is much larger, the degree of price *discrimination* is substantial. The term "price discrimination" indicates my interpretation of this finding: Exporters are able to charge different prices from their buyers without otherwise treating them differently. I incorporate this feature in my theoretical model, presented in Section 3, by allowing exporters to charge different prices from concurrent relationships. However, the observed degree of price discrimination could be explained in other ways. In the remainder of this subsection, I will propose three simple factors that would rationalize this finding and provide evidence suggesting that this is *not* the case in the data.

2.2.1 Measurement Error

It is well-known that export prices, obtained as unit values, suffer from measurement error. Presence of (a large degree of) measurement error would in principle be able to explain the observed price discrimination.

Assume that the observed price discrimination is entirely explained by measurement error. Then, exporters actually obtain the same price, $\bar{p}_{im}$, from all its buyers in market m, and the observed prices are merely

$$p_{ijm} = \bar{p}_{im} + \epsilon_{ijm}, \tag{2}$$

where ϵ_{ijm} is an i.i.d. (measurement) error. If this was the case, the observed degree of price discrimination (*across* importer, *within* markets) would be no larger than the dispersion in prices *within* exporter × importer pairs, *across* years. In other words, the *intra*-temporal dispersion should be no larger than the *inter*-temporal dispersion.[17] Figure 2 clearly shows that this is not the case: The *intra*-temporal distribution (solid line), that is the degree of price discrimination, is wider than the *inter*-temporal distribution (dashed line).

Further, if the observed price discrimination was entirely due to an i.i.d. measurement error, an exporter's ranking of buyers, rank_{ijm}, in terms of price would evolve randomly over time.[18] To test this, I estimate the simple equation

$$\text{rank}'_{ijm} = \alpha_0 + \alpha_1 \text{rank}_{ijm} + error_{ijm} \tag{3}$$

with OLS where rank'_{ijm} is the ranking in year $y+1$ *among* the relationships present in year y (so that newly established relationships do not influence the ranking of existing relationships).

Table 3 shows that the inter-temporal rank correlation is large and highly statistically significant (0.812), even for exporters that serve many buyers in the same market (0.675 for exporters serving more than 20 importers).

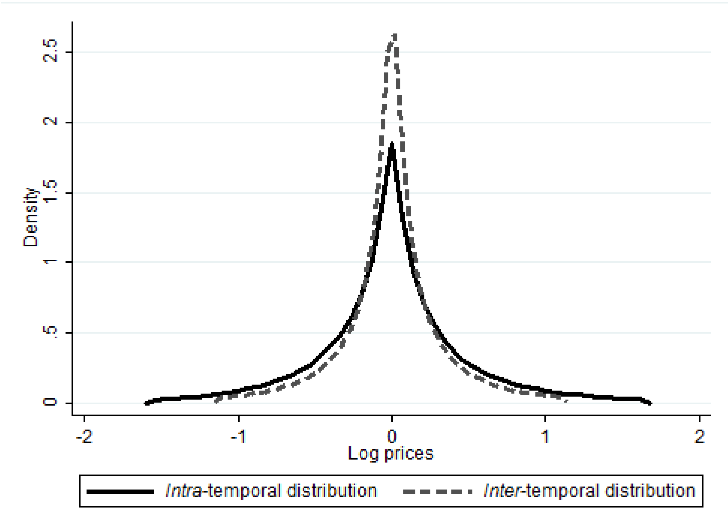
In total, the facts that (i) the intra-temporal dispersion of prices (what I have dubbed price discrimination) is larger than the inter-temporal dispersion, and (ii) the inter-temporal rank correlation of prices is large suggest that the observed degree of price discrimination is not entirely due to measurement errors (that is, equation (2) does not hold).

[16] $(\exp(0.25) - 1) \times 100\% = 28\%$.

[17] To be specific, I define the inter-temporal dispersion as the distribution of p_{ijm} de-meaned by exporter × product × importer × destination and destination × year fixed effects. The destination × year fixed effect ensures that the inter-temporal dispersion is not magnified by macroeconomic fluctuations in prices and exchange rates.

[18] Applying rank correlations are popular in settings where mis-measured variables are prevalent, such as in the inter-generational mobility literature, see e.g. Chetty et al. (2014a,b).

Figure 2: Price Discrimination - Measurement Error



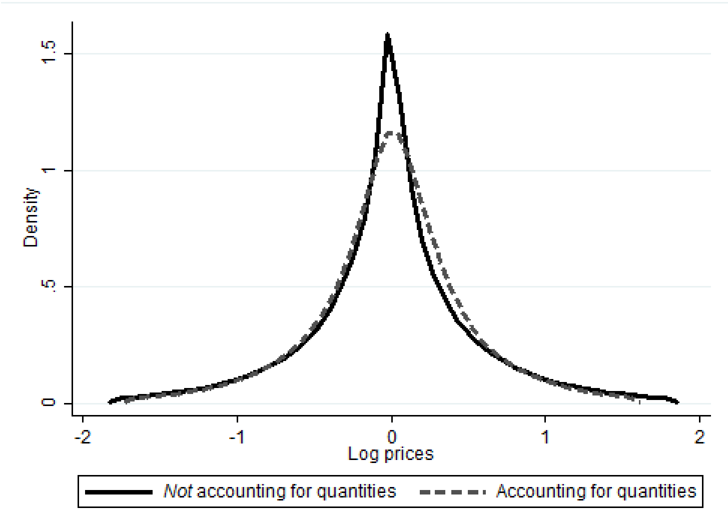
Notes: "*Intra*-temporal distribution" is the distribution of ijm level prices, de-meaned by im fixed effects (excl. singletons), where i refers to an exporter, j to an importer, and m to a (product × destination × year) market. "*Inter*-temporal distribution" is the distribution of ijm level prices, de-meaned by $ijpd$ spell and dy fixed effects (excl. singletons). "*Intra*-temporal distribution" differs from "price discrimination" in Figure 1 because "*intra*-temporal distribution" only includes those observations, where "*inter*-temporal distribution" also exists. The bottom and top 1 percent of each distribution are excluded.

Table 3: Rank Correlation of Prices

	(1)	(2)	(3)	(4)	(5)
#Importers	>1	>5	>10	>15	>20
rank'_{ijm}	0.812***	0.765***	0.729***	0.700***	0.675***
	(0.009)	(0.013)	(0.015)	(0.017)	(0.019)
R-squared	0.660	0.585	0.531	0.490	0.456
Observations	187,760	95,685	70,509	57,570	48,989

The unit of observation is exporter × importer × market (ijm), where a market is a product × destination × year (pdy) triplet. Each column represents separate OLS estimates of the rank correlation α_1 in equation (2). "#Importers" refers to the number of importers served by the exporter. Standard errors clustered at exporter × product are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

Figure 3: Price Discrimination - Quantity Discounts



Notes: "*Not* accounting for prices" is the distribution of ijm level prices, de-meaned by im fixed effects (excl. singletons), where i refers to an exporter, j to an importer, and m to a (product × destination × year) market. The distribution is identical to "price discrimination" in Figure 1. "Accounting for quantities" is the distribution of the residuals, $\hat{\varepsilon}_{ijm}$, from equation (4). The bottom and top 1 percent of each distribution are excluded.

2.2.2 Quantity Discounts

The observed price discrimination could be entirely due to quantity discounts. In this case, the variation in quantities should explain the corresponding variation in prices.

To test this, I simply estimate the correlation between prices and quantities q_{ijm} from the regression equation

$$p_{ijm} = \beta q_{ijm} + \mathbf{FE}_{im} + \varepsilon_{ijm}, \tag{4}$$

where the exporter × market fixed effect, $\mathbf{FE}_{im}$, ensures that only within-exporter variation identifies β. I obtain the OLS estimate $\hat{\beta} = -0.163$, which is highly statistically significant. As expected, larger quantities sold is associated with lower prices, suggesting that quantity discounts are indeed present. Furthermore, the variation in quantities does explain a non-negligible share of the price variation (the within-R^2 of regression (4) is 0.137). Needless to say, this is purely a correlation, and the attribution to quantity discounts is only suggestive.

Figure 3 plots $\tilde{p}_{ijm}$, that is the degree of price discrimination, together with the residuals from equation (4), $\hat{\varepsilon}_{ijm}$. Per construction, the standard deviation of $\tilde{p}_{ijm}$ exceeds that of $\hat{\varepsilon}_{ijm}$. Figure 3 shows that quantities do explain the tails of the price distribution, such that very small and very large prices are indeed explained by differences in quantities sold. It seems reasonable that very small and very large orders are affiliated with very large and very small prices, respectively. Also, as it is commonly accepted that measurement errors in prices primarily stem from measurement errors in quantities, controlling for quantities remedy the observations where quantities are unreasonably small or large compared to values.

However, whereas Figure 3 shows that the tails of the price distribution are to a large degree explained by variation in quantities, the price variation around the mean is not. In fact, whereas the third (first) quartile of $\tilde{p}_{ijm}$ is 0.25 (-0.25), the third (first) quartile of $\hat{\varepsilon}_{ijm}$ is 0.26 (-0.27). This means that conditioning on quantities *widens* the interquartile range of the price distribution. Therefore, quantity discounts seem unable to explain the overall presence of price discrimination.

2.2.3 Quality Differentiation

In the empirical international trade literature, price dispersion across exporters, within markets, is often rationalized with quality differentiation. That is, conditional on quantities sold, variation in prices across exporters must be due to differences in product quality. In this case, the degree of dispersion in prices and quality should be positively, and closely, correlated across markets.

Khandelwal (2010) estimates product-specific degrees of quality dispersion, referred to as quality ladders, based on US import data. That is, if a large, or long, quality ladder is assigned to a product, it means that the US imported a broad spectre of quality levels for this product. Table 2 (bottom panel, first row) shows that quality ladders are available for 1,306 unique products.[19]

There is no a priori guarantee that these ladders coincide with those faced by Danish exporters, especially outside the US. If, however, these serve as a reasonable proxy, we should expect the quality ladders to be positively and strongly correlated with observed price dispersion. This is because we expect markets with large room for quality differentiation to also be the markets where exporters are able to charge very different prices.

To test this, I construct market specific measures of price dispersion, in the spirit of Khandelwal (2010), as the log-difference between the market's maximum and minimum price: $\lambda_m^{\text{price}} = \log\left(P_m^{\max} - P_m^{\min}\right)$. I then estimate the equation

$$\lambda_m^{\text{price}} = \gamma\lambda_p^{\text{quality}} + \mathbf{FE}_{dy} + error_m, \tag{5}$$

where $\lambda_p^{\text{quality}}$ is Khandelwal (2010)'s quality ladders. I include a destination × year fixed effect to account for the fact that the level of price dispersion is likely to vary systematically across countries and time. The conjecture is that the OLS estimate of γ is positive.

Table 4 presents the results. Column 1 shows that price dispersion is indeed positively and strongly correlated with quality dispersion. As quality and price "ladders" are more meaningful in markets served by many exporters, column 2-4 re-estimate equation (5) for markets served by more than 5, 10, and 15 exporters, respectively. Whereas the smaller sample sizes mitigate statistical significance, the estimated correlations magnify.

Now, if the observed price discrimination is due to quality differentiation by exporters across their buyers, we would expect exporters that serve markets with long quality ladders to have large room for quality-based price discrimination, and vice versa.

To test this, I, equivalent to above, construct exporter × market specific measures of price discrimination as the log-difference between the exporter × market pair's maximum and minimum price, $\lambda_{im}^{\text{price}} = \log\left(P_{im}^{\max} - P_{im}^{\min}\right)$, and estimate the equation

$$\lambda_{im}^{\text{price}} = \delta\lambda_p^{\text{quality}} + \mathbf{FE}_{dy} + error_{im}. \tag{6}$$

A positive OLS estimate of δ would imply that exporters operating in markets with long quality ladders tend to price discriminate a lot between their buyers. Column 5 in Table 4 shows that δ is small—and even negative when

[19]Quality ladders are obtained from Amit Khandelwal's personal website. I aggregate them from the HS10 level to the CN8+ level using simple averages. As Khandelwal (2010) does not consider the universe of products, quality ladders are available only for a subset of my sample. Specifically, of the 670,535 observations of $\tilde{p}_{ijm}$, 26.0 percent are matched to a quality ladder. These constitute a somewhat larger share in terms of export sales, namely 33.9 percent.

Table 4: Quality Differentiation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.:	λ_m^{price}				$\lambda_{im}^{\text{price}}$			
#exporters$_m$ / #importers$_{im}$	>1	>5	>10	>15	>1	>5	>10	>15
$\lambda_p^{\text{quality}}$	0.567***	0.743**	0.639	1.124*	0.00625	-0.395	-0.497	-0.262
	(0.190)	(0.364)	(0.517)	(0.663)	(0.364)	(0.485)	(0.469)	(0.398)
dy FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared (within)	0.017	0.038	0.030	0.084	0.000	0.006	0.001	0.003
Observations	16,487	2,417	786	324	38,714	6,103	2,116	1,173

Column 1-4 contains estimates of γ from equation (5), and the unit of observation is market (m), where a market is a product × destination × year (pdy) triplet. Column 5-8 contains estimates of δ from equation (6), and the unit of observation is exporter × market (ijm). "#exporters$_m$" refers to the number of exporters present in a market. "#importers$_{im}$" refers to the number of importers served by an exporter. Standard errors clustered at product (the level of $\lambda_p^{\text{quality}}$) are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

Table 5: Average Number of New Importer Relationships and Network Size by Exporter Age

	Total	Exporter age								
		1	2	3	4	5	6	7	8	9
#importers$_{idy}$	0.52	0.54	0.48	0.50	0.52	0.51	0.50	0.49	0.52	0.54
network$_{idy}$	1.57	0.54	1.40	2.20	2.98	3.73	4.51	5.26	6.13	7.51
N	60,851	29,789	11,831	7,064	4,725	3,230	2,128	1,231	657	196

Unit of observation is exporter × destination × year. #importers$_{idy}$ is the number of *new* importers served by exporter i in destination d in year y. network$_{idy}$ is the sum of all new importers encountered by i in d *prior* to year d (see equation (8). Exporter age is the tenure within an export × destination spell.

restricting attention to exporters serving many importers in column 6-8—and highly statistically insignificant. This means that exporters that are able to price discriminate a lot across their buyers are *not* over-represented in markets with long quality ladders.

In conclusion, these results are hard to reconcile with the hypothesis that the observed price discrimination is entirely due to quality differentiation across buyers.

2.3 Network Effects

In this subsection, I document that Danish exporters face considerable network effects in foreign markets. Specifically, I find that exporters that served more importers in the past, and, thus, have a larger network, are able to form more new importer relationships subsequently, and I claim that this effect is causal.

For this part of the analysis, I apply the exporter × importer × destination × year data set as outlined in Section 2.1. As will become apparent shortly, the network variable is not properly defined for left-censored export spells, and these are therefore excluded. This leaves 60,851 exporter × importer × destination × year quadruplets.

The first row of Table 5 shows that the average exporter forms 0.52 new importer relationships each year.[20] Further,

[20]Prior to constructing Table 5 and estimating any regressions, I exclude exporters that form extremely many new relationships in the same year. Specifically, I consider an exporter × destination × year triplet "unusual" if the number of new relationships exceeds the 99th percentile. If an

this number is strikingly stable over the export spell: Old exporters do not generally match with more new importers than new exporters and vice versa.[21] However, I will examine if exporters are able to form more buyer relationships when their network is large than when their network is small.

To fix ideas, consider the regression equation

$$\#\text{importers}_{idy} = \alpha \text{network}_{idy} + \mathbf{FE}_{id} + \mathbf{FE}_{dy} + error_{idy}, \tag{7}$$

where $\#\text{importers}_{idy}$ is the number of *new* importer relationships formed by exporter i in destination d in year y. I define network_{idy} as the sum of all importers served by exporter i in destination d *prior* to year y. To be exact, network_{idy} is defined as

$$\text{network}_{idy} = \begin{cases} 0 & \text{if } T_{idy} = 1 \\ \sum_{s=1}^{T_{idy}-1} \#\text{importers}_{idy-s} & \text{if } T_{idy} > 1 \end{cases}, \tag{8}$$

where T_{idy} is the *tenure* of exporter i in destination d in year y.[22] The second row of Table 5 shows that the network indeed grows gradually as exporters mature. The remaining elements of equation (7) are as follows. α represents the size of the network effect. $\mathbf{FE}_{id}$ is an exporter × destination spell fixed effect (FE) that controls for any time-invariant heterogeneity in exporters' ability to form new importer relationships, including productivity and destination-specific ties. $\mathbf{FE}_{dy}$ is a destination × year FE that controls for any market-wide factors, including exchange rate fluctuations and business cycles.

Whereas the framing provided here indicates that α in equation (7) is expected to be positive, this is not a priori obvious. In his analysis of the effect of marketing costs in international trade, Arkolakis (2010) assumes that the cost of reaching new consumers *increases* with the number of consumers reached, because, in the words of Eaton et al. (2014), the pool of easy-to-reach buyers becomes "fished out". This argument implies a negative value of α. Nevertheless, Eaton et al. (2014) structurally estimate a model of exporters' search for importers and find that search costs are *decreasing* in the size of the network, thus implying positive network effects.

Column 1 in Table 6 presents the OLS estimate of equation (7). An increase in the network by one importer is associated with 0.299 more new importer matches. However, there is no reason to believe that this reflects the causal effect. As is well-known in the econometric literature on dynamic panel models, the FE specification of equation (7) produces an estimate of α that is biased and inconsistent.[23] In the context of dynamic panel models, the canonical solution is an instrumental variable technique where the lagged dependent variable is instrumented by its higher-order lags. This approach is not applicable here, as the network is a function (the sum) of the entire history of lagged dependent variables, see equation (8), and, thus, we need a different identification strategy. I show below that the network effect is identified, if equation (7) can be augmented by a strictly exogenous variable, that is a regressor that can provide exogenous variation in $\#\text{importers}_{idy}$.

exporter × destination spell contains an "unusual" triplet, I exclude the entire spell. After doing so, the maximum number of relationships formed in a year is four.

[21]It can seem self-contradicting that the average exporter at age one, the first export year, can form less than one new importer relationship. However, recall from Section 2.1 that we only consider exporter-importer relationships that exchanged at least two transactions throughout the sample years.

[22]In the empirical specifications below, I define T_{idy} as the tenure within a exporter × destination *spell*, where a spell is defined as a sequence of consecutive years during which i exported to d. This means that former exporters that re-enter a destination are not able to take advantage of its previous network.

[23]The reason is that the within-transformed error terms in equation (7) exhibit auto-correlation, which introduces a non-zero correlation between the within-transformed lagged dependent variable and the within-transformed error term.

Table 6: Network Effects (I)

Dep. var.: #importers$_{idy}$	(1)	(2)	(3)	(4)	(5)
Estimator	OLS	OLS	IV	OLS	IV
network$_{idy}$	0.299***				
	(0.009)				
PSMM$_{idy}$		-0.0334	0.830**		
		(0.0782)	(0.415)		
PSMM$_{idy,y-1}$				0.0799	0.259
				(0.0865)	(0.302)
id spell FE	YES	YES	YES	YES	YES
dy FE	YES	YES	YES	YES	YES
First-stage F-statistic			39.8		52.7
R-squared (within)	0.126	0.000	-0.004	0.000	0.000
Observations	42,886	42,886	42,886	42,886	42,886

The unit of observation is exporter × destination × year (idy). The dependent variable is #importers$_{idy}$, the number of *new* importer relationships formed by i in d in y. network$_{idy}$ is the sum of importers served by i in d previous to y. PSMM$_{idy}$ (PSMM$_{idy,y-1}$) is an indicator variable equal to 1 if i purchased "Partner Search and Match Making" services for d in y (or $y-1$). "IV" indicates that PSMM$_{idy}$ (PSMM$_{idy,y-1}$) is instrumented by approach$_{idy}$ (approach$_{idy,y-1}$), an indicator variable equal to one if i was approached by the Trade Council in Denmark and offered export promotion services for d in y (or $y-1$). Standard errors clustered at the exporter are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

As proposed by Buus et al. (2019), I take advantage of a policy managed by the Trade Council (TC) in Denmark. The TC organizes all governmental export promotion activities in Denmark, and offers tailored and destination-specific export promotion services (EPS) to Danish firms. Crucially, the TC actively approaches Danish firms and offer them EPS. Buus et al. (2019) show that exporters are much more likely to purchase EPS if they were approached by the TC and, therefore, propose to use an indicator for whether an exporter was approached by the TC as an instrument for whether the exporter purchased EPS. This addresses the concern of endogeneity induced by self-selection. Call the instrument approach$_{idy}$. See Buus et al. (2019) for more details and evidence on the instrument's exogeneity.

One group of EPS is labelled "Partner Search and Match Making" (PSMM), and the explicit purpose of these services is to help Danish exporters find importers abroad. As this is exactly what we are looking for, I restrict attention to EPS of the type PSMM. To test if purchases of PSMM, instrumented by approach$_{idy}$, actually does provide variation in #importers$_{idy}$, I estimate the simple auxiliary regression equation

$$\#\text{importers}_{idy} = \beta \text{PSMM}_{idy} + \mathbf{FE}_{id} + \mathbf{FE}_{dy} + error_{idy}, \tag{9}$$

where PSMM$_{idy}$ is a binary indicator for whether exporter i purchased PSMM in destination d in year y.[24] The FE specification of equation (9) resembles that of equation (7). $\mathbf{FE}_{id}$ is a firm × destination *spell* FE, accounting for any time-invariant ability to form new importer relationships and, in the context of PSMM, any time-invariant characteristics that would make an approach by TC more or less likely, such as industry affiliation. $\mathbf{FE}_{dy}$ is a destination × year FE controlling for any market specific developments, including the intensity with which the TC approaches exporters.

[24]To be specific, I assume that PSMM is effective in 12 months upon purchase. I set PSMM$_{idy}$ equal to one if the exporter × destination specific pseudo year, y, contains any of these months. In practice, this closely assembles the assumption of Broocks and Van Biesebroeck (2017) and Buus et al. (2019) who define define a treatment indicator to take value one if EPS were purchased in *calendar* year y and/or $y-1$.

Column 2-3 in Table 6 presents the OLS and IV estimates, respectively, of equation (9). The OLS estimate is close to zero (-0.0334) and highly statistically insignificant, whereas the IV estimate is close to one (0.830) and statistically significant at the 5 percent level. The relationship between the IV and OLS estimates broadly resembles the findings of Buus et al. (2019) who show that exporters increase their export sales upon purchasing EPS, and that the OLS estimate is biased towards zero. This is possibly because exporters that self-select into EPS have recently been hit by a negative shock and seek assistance to recover or even survive in the foreign market. The result that exporters on average find almost one new exporter upon purchasing PMSS seems reasonable as PMSS have that particular purpose.[25]

The conclusion from this exercise is that PSMM_{idy} instrumented by approach_{idy} serves as a proper shifter for the amount of new importer relationships an exporter forms. I will now show how this can be exploited to identify the network effect.

Augmenting regression equation (7) by adding PSMM_{idy} as predictor (where FEs are ignored for the sake of notational simplicity) yields

$$\#\text{importers}_{idt} = \alpha \text{network}_{idt} + \beta \text{PSMM}_{idt} + error_{idt}, \tag{10}$$

where t refers to the tenure of exporter i in destination d. Now, consider an exporter with a tenure of T years, and write the panel equation (10) as a system of equations:

$$\begin{aligned}
\#\text{importers}_{id1} &= \alpha \text{network}_{id1} + \beta \text{PSMM}_{id1} + error_{id1} \\
\#\text{importers}_{id2} &= \alpha \text{network}_{id2} + \beta \text{PSMM}_{id2} + error_{id3} \\
\#\text{importers}_{id3} &= \alpha \text{network}_{id3} + \beta \text{PSMM}_{id3} + error_{id3} \\
&\vdots \\
\#\text{importers}_{idT} &= \alpha \text{network}_{idT} + \beta \text{PSMM}_{idT} + error_{idT},
\end{aligned}$$

Simply applying the definition of network_{idt} in equation (8) and substituting in its components using the system's remaining equations then yields

$$\begin{aligned}
\#\text{importers}_{id1} &= \beta \text{PSMM}_{id1} + error_{id1} \\
\#\text{importers}_{id2} &= \beta \text{PSMM}_{id2} + \alpha\beta \text{PSMM}_{id1} + \widetilde{error}_{id2} \\
\#\text{importers}_{id3} &= \beta \text{PSMM}_{id3} + \alpha\beta \left[(\alpha+1)\text{PSMM}_{id1} + \text{PSMM}_{id2}\right] + \widetilde{error}_{id3} \\
&\vdots \\
\#\text{importers}_{idT} &= \beta \text{PSMM}_{idT} + \alpha\beta \left[\sum_{s=1}^{T-1} (\alpha+1)^{T-1-s} \text{PSMM}_{ids}\right] + \widetilde{error}_{idT},
\end{aligned} \tag{11}$$

where "tildes" indicate that the error terms are composites of present and prior errors. α is identified from the *dynamic* effect of purchasing PSMM. To be specific, the implicit identifying assumption is that purchases of PSMM instantly affects the exporter's ability to match with new importers (the first term in each equation in system (11)), whereas *previous* purchases of PSMM affects the *current* ability to match with new importers only through the accumulation of

[25] In its own right, this finding is a small contribution to the literature on the effects of firm-specific trade policies and adds to the explanations of how these work. For example, Buus et al. (2019) find that exporters manage to increase their sales of existing products on existing markets upon purchasing EPS. A part of the explanation is likely to be that the TC helps exporters find new importers.

Table 7: Network Effects (II)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
#Equations	2	3	4	5	6	7	8
network_{idy}	1.012	0.503*	0.380**	0.241	0.364**	0.006	0.080
	(1.480)	(0.277)	(0.188)	(0.198)	(0.144)	(0.173)	(0.072)
PSMM_{idy}	0.402	0.741*	0.661	0.515	0.723	0.668**	0.756
	(0.414)	(0.403)	(0.413)	(0.462)	(0.466)	(0.333)	(0.477)
id spell FE	YES	YES	YES	YES	YES	YES	YES
dy FE	YES	YES	YES	YES	YES	YES	YES
Hansen p-value	0.892	0.341	0.579	0.366	0.768	0.296	0.667
Observations	11,828	7,063	4,724	3,229	2,128	1,231	657

The unit of observation is exporter × destination × year (idy). The dependent variable is $\#\text{importers}_{idy}$, the number of *new* importers served by i in d in y. network_{idy} is the sum of importers served by i in d previous to y. PSMM_{idy} is an indicator variable equal to 1 if i purchased "Partner Search and Match Making" (PSMM) services for d in y. Estimates are obtained from numerical, iterative GMM estimation of equation system (11). The weight matrix is robust to arbitrary correlation among observations within exporters. PSMM_{idy} is instrumented by approach_{idy}, an indicator variable equal to one if i was approached by the Trade Council in Denmark and offered PSMM for d in y. FEs are accounted for by within-transformation of all variables prior to estimation. Standard errors clustered at the exporter are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

importers in the year PSMM was purchased, that is, through the network effect (the remaining terms in each equation in system (11)).

Hence, a potential threat to this identification strategy is that previous purchases of PSMM directly affects the exporter's current ability to form new importer relationships. This would be the case if the implementation process is slow and extents beyond the one year period assumed above. Such direct lagged effects of PSMM would, in system (11), be attributed to the network effect, which would then be biased upwards. To get a rough idea of whether the applied time horizon of PSMM's effectiveness is appropriate, I re-estimate the auxiliary model (9), but extent the assumed effectiveness of PSMM from one to two years upon purchase. Call the re-formulated indicator $\text{PSMM}_{idy,y-1}$. If two years is a more appropriate time horizon for the effectiveness of PSMM than one year, we should expect $\text{PSMM}_{idy,y-1}$ to be a better predictor of new importer matches than PSMM_{idy}. The results are presented in column 4 and 5 in Table 6. Compared to the original results (column 2 and 3), the OLS estimate (0.0799) is still close to zero, but the IV estimate (0.259) is more than three times smaller and statistically insignificant. This result suggests that the effectiveness of PSMM does not generally extent beyond one year, that PSMM_{idy} is a reasonable representation of the effect of PSMM, and that it is reasonable to attribute the effects of previous purchases of EPS to the network effect.

I estimate α and β from the equation system (11) using a system-of-equations general method of moments (GMM) procedure, where all occurrences of PSMM_{idt} are instrumented by approach_{idt}. The identifying assumption resembles that of two-stage least squares (2SLS) fixed effects estimation: all instruments must be uncorrelated with all error terms, within and across equations.

The results are presented in Table 7. Each column represents separate estimations of system (11), where I vary the amount of equations to include in the estimation procedure. Specifically, column 1 presents results based on only the top two equations in (11), restricting the sample to exporter × destination spells that reach a tenure of *at least* two years. This is the minimal requirement in order to identify α. On the other hand, column 7 presents results based on eight equations, restricting the sample to exporter × destination spells that reach a tenure of *at least* eight years.[26] This represents the extremes in a trade-off between, on the one hand, exploiting the structure of system (11) as much as possible by including many equations, and, on the other hand, maximizing the sample size by using few equations.

Including between three and six equations (column 2-5 in Table 7) produce estimates of the network effect, α in equation (10), between 0.241 and 0.503, with varying levels of significance. Focusing on the two estimates that are statistically significant at the 5 percent level (column 3 and 5), these are almost identical: 0.380 and 0.364, respectively. I consider these the best estimates of the network effect. This means that increasing an exporter's network by one exporter will, all else equal, induce the exporter to form almost 0.4 more new importer relationships in the subsequent year.

Table 7 also presents estimates of the effect purchasing PSMM, β in equation (10). Though of secondary interest, the relatively stable coefficients across columns (between 0.515 and 0.741 in columns 2-5), and the fact that these, though slightly smaller, are easily within reach of the causal estimate of 0.83 in column 3 of Table 6 are reassuring and add credibility to the estimation procedure.

The takeaway from this subsection is that exporters face considerable network effects: Exporters are able to form more new importer relationships when their network is large than when their network was small. This feature is a crucial component in the theoretical model, presented in Section 3, as it provides exporters with an incentive to price low upon entry in order to attract more new importers and expand their network.

2.4 Within-Relationship Dynamics

Recall that the objective of this paper is to examine exporters' pricing behavior *across* importers. However, in order to formulate the theoretical model, presented in Section 3, we must take a stand on potential dynamics *within* existing exporter × importer relationships.[27] In this section, I show that neither prices nor quantities sold develop systematically within relationships beyond market-wide growth. Through the lens of a model of firm dynamics, this motivates a simple setting where exporters expect to sell a constant quantity of goods at constant price throughout a relationship (conditional on market-level aggregates).

To fix ideas, consider the regression equation

$$y_{ijm} = \alpha \text{age}_{ijm} + \mathbf{FE}_{ijpd} + error_{ijm}, \tag{12}$$

where y_{ijm} is the outcome variable of interest, e.g. the price charged by exporter i from importer j in market m,[28] age_{ijm} is the age of the relationship spell, and $\mathbf{FE}_{ijpd}$ is a relationship spell fixed effect. The OLS estimate of α reveals if y_{ijm} develops linearly with relationship age within that particular relationship. I estimate equation (12) applying the exporter × product × importer × destination × year data set, cleaned for price outliers as described in Section 2.1. This is the same data set I used to document the presence of price discrimination across importers in Section 2.2. However, for this section, I exclude left-censored spells, as relationship age is otherwise not properly defined.

[26]In principle, the sample length of nine years allows a maximum of nine equations. However, as only 196 exporter × destination observations reached a tenure of nine years, the GMM procedure is unable to converge.

[27]To be precise, I define a relationship in this section as an exporter × product × importer × destination spell. Making relationships product specific, in contrast to Section 2.3, is necessary in order to properly define prices. I follow the same approach when examining price dynamics *across* importers in Section 4.

[28]Recall from Section 2.2 that a market is defined as a product × destination × year (pdy) triplet.

Table 8: Within-Relationship Dynamics in Prices and Quantities

Sample:	Full				$ijpd$ relationships that lasted at least six years			
Dep. var.:	p_{ijm}	$\tilde{p}_{ijm}$	q_{ijm}	$\tilde{q}_{ijm}$	p_{ijm}	$\tilde{p}_{ijm}$	q_{ijm}	$\tilde{q}_{ijm}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
age$_{ijm}$	0.0233***	-0.00684	0.00510	-0.0111				
	(0.00418)	(0.00422)	(0.0110)	(0.0117)				
age$_{ijm}$=2					0.0817***	0.0482*	0.0672	-0.0562
					(0.0205)	(0.0282)	(0.0463)	(0.0550)
age$_{ijm}$=3					0.0890***	0.0177	0.195***	0.0856
					(0.0223)	(0.0360)	(0.0549)	(0.0686)
age$_{ijm}$=4					0.0952***	-0.0202	0.218***	0.121*
					(0.0216)	(0.0289)	(0.0612)	(0.0665)
age$_{ijm}$=5					0.112***	0.00529	0.203***	-0.00588
					(0.0241)	(0.0308)	(0.0755)	(0.0930)
$ipjd$ FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared (within)	0.004	0.000	0.000	0.000	0.013	0.003	0.010	0.006
Observations	25,155	19,923	25,155	19,923	4,405	3,621	4,405	3,621

The unit of observation is exporter × importer × market (ijm), where market is a product × destination × year (pdy) triplet. p_{ijm} and q_{ijm} are log of prices and log of quantities, respectively. Tildes indicate that the variable is demeaned by market-level means (market-level singletons are excluded). age$_{ijm}$ is the age of the ijm relationship within a spell. When these are included as dummies (column 5-8), age$_{ijm}$=1 is the omitted reference category. The last year of each spell is excluded as to avoid the influence of partial-year bias. Standard errors clustered at the exporter-product are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

Column 1 in Table 8 shows the result from regression (12), where the outcome variable is log-price ($y_{ijm} = p_{ijm}$). For each year the relationship matures, the price increases by 2.33 percent. Instead of solely relying on the linear effect, I augment equation (12) with a full set of age dummies and re-estimate. Column 5 reports the price trajectory for the first five years of relationships lasting at least six years.[29] These results confirm that prices are indeed increasing within relationships.

Heise (2019) shows that exporters systematically obtain lower prices from their US importers as the relationship matures relative to market-wide price trends. Specifically, he shows that prices decline by about 0.03 percent per *month* with additional declines in relationships that trade often (exchange many transactions).

In order to disentangle relationship specific price dynamics from market-wide developments (such as inflation), I follow Heise (2019) and de-mean log-prices by the market-level averages and re-estimate equation (12).[30] Column 2 in Table 8 shows that relative prices fall slightly by 0.684 percent when relationships mature by one year, but this effect is statistically insignificant at any appropriate level. In principle, this effect is larger in magnitude than the one documented by Heise (2019) (converting his result to the yearly level yields $((1 - 0.0003)^{12} - 1) \times 100\% = -0.36\%$). However, as I fail to obtain a statistical significant effect (potentially due to my much smaller sample compared to Heise (2019)), and as the dummy specification reveals a highly non-monotonic trajectory of relative prices (column 6), I conclude that systematic dynamics in relative prices within relationships are either absent or negligible in my sample.

Column 3 in Table 8 shows the result from regression (12), where the outcome variable is log-quantity ($y_{ijm} = q_{ijm}$). For each year the relationship matures, the quantity increase by 0.510 percent, but this is highly insignificant. However, the dummy specification (column 7) reveals that quantities increase significantly the first couple of years, then stagnate at a level significantly higher than the initial amount. This is in line with Monarch and Schmidt-Eisenlohr (2018) who show that trade between exporters and US importers are increasing as relationships mature, then falls off towards their end.[31]

Following the approach outlined above, I now test if quantities evolve within relationships *beyond* market-wide developments, by re-estimating equation (12) with relative quantities (quantities de-meaned by market-level averages) as outcome. Column 4 in in Table 8 shows that the linear effect of age on relative quantities is slightly negative and insignificant, and the dummy specification (column 8) shows that the trajectory is non-monotonic and that relative quantities five years into the relationship are no larger than in the initial year. I conclude that quantities do increase within relationships, but that I am unable to reject that this is entirely due to market-wide trends.

Overall, the takeaway from these exercises is that neither prices nor quantities evolve systematically within relationships *beyond* market-wide developments. This motivates the conveniently simple model setting I propose in the next section.

[29] I require relationships to last six years instead of five, because I exclude the last year of each relationship to avoid influence of partial-year bias. The use of pseudo-years (see Section 2.1) removes any partial-year bias in a spell's first year, but *not* in a spell's last year. As this is of little concern when examining price developments, it is a first-order concern when examining quantities, as I do below.

[30] The reason for de-meaning the dependent variable prior to estimation instead of simply including a market fixed effect on the right-hand side of equation (12) is that α in this case would not be identified, as within-relationship changes in age and years are indistinguishable.

[31] Monarch and Schmidt-Eisenlohr (2018)'s approach differs slightly from mine as they (i) consider sales, not quantities, and (ii) aggregate sales across products within relationships.

3 Model

In this section, I present a parsimonious model of dynamic price setting based on the empirical findings presented in the previous section. Most importantly, (i) sellers are able to charge different prices from their buyers, and (ii) sellers enjoy network effects. Furthermore, I abstract from within-relationship dynamics of prices and quantities sold. I assume that sellers need to reach buyers, thus building a customer base, in order to sell their products. Sellers actively make use of price posting as an attraction device, and the model predicts that sellers will increase their prices as their customer base—or, in other words, network—grows.

The model is close in spirit to the customer accumulation models presented by Rodrigue and Tan (2019) and Piveteau (2019). In contrast to these papers, but in line with the search models of Eaton et al. (2014, 2016), I assume that the network effect works through the cost of reaching new buyers. Though Heise (2019) models sellers' optimal price setting *within* existing buyer relationships, the dynamic trade-off between current and future profits that sellers face in my model closely resembles his framework.

In the model presented below, sellers can only affect the network accumulation process through their price setting behavior. In Appendix A, I extend the model such that sellers endogenously choose the intensity with which they search for more buyers.[32] The extended model more closely resembles the empirical findings in Section 2.3, but as predictions regarding sellers' optimal price setting are unaffected, the details are relegated to the appendix.

3.1 Setup

The market is inhabited by a mass of buyers, each characterized by unit-demand and an unobservable reservation price r, distributed according to the commonly known cumulative distribution function G. Exporters are single-product producers and produce at constant marginal costs mc.

In order for trade to occur, the exporter must reach the individual buyer. In every period, exporters reach an exogenous mass (normalized to one) of hitherto unreached buyers and post a non-negotiable price p. If a buyer is reached and p does not exceed the buyer's reservation price, they form a relationship. This means that a seller posting the price p forms $\Pr(p \leq r) = 1 - G(p)$ new relationships.

A seller-buyer match exchange one unit of quantity at price p in all subsequent periods.[33] Constant quantities and prices throughout relationships are motivated by the findings presented in Section 2.4. The price is never re-negotiated, even if the seller chooses to post a different price for new buyers. The fact that sellers are able to charge one price from new relationships, while maintaining another for existing relationships, is motivated by the findings presented in Section 2.2. This setup allows sellers to disregard existing relationships when choosing the optimal price to charge from new buyers, which greatly simplifies the model.

Reaching out to buyers is costly, and sellers incur a mandatory per-period search cost $c(m)$, where m is the mass of a seller's relationships, which I refer to as its *network*. Importantly, I assume that $c'(m) < 0$, that is, as the seller's network expands, reaching new buyers becomes less expensive. This assumption is motivated by the empirical findings presented in Section 2.3, and I refer to this as the *network effect*. The network effect is essential to the model, because it provides the seller with an incentive to reach buyers in the present period—besides extracting profits from the particular

[32]Though I use the word "search", neither the benchmark model nor the extended model are search models in line with, e.g., Eaton et al. (2014, 2016). Rather, "search" in my model is closer in the spirit to the marketing investments in Arkolakis (2010).

[33]Allowing relationships to dissolve for exogenous reasons is simple, and this possibility is ignored only for the sake of notational simplicity.

buyer—in order to reach buyers less costly in subsequent periods. Further, I assume that $c''(m) > 0$, that is, c is convex such that the *marginal* gain from a larger network is decreasing (or, in other words, the effect of larger network on search costs becomes less negative as the network grows). This assumption is motivated by structural estimates provided by Eaton et al. (2014, 2016). They present a theoretical framework where exporters search for foreign importers, and where exporters incur search costs that depend on the size of their network. The estimated search cost function is decreasing and convex in the size of the exporter's network.

A sellers network m evolves as

$$m' = m + \big(1 - G(p)\big) + \varepsilon, \tag{13}$$

where primes indicate the next period, $1 - G(p)$ is the mass of relationships established in the present period, and ε is a mean-zero i.i.d. disturbance term that captures e.g. fluctuations in the quality of new relationships.[34,35]

3.2 Seller's Optimization Problem

I now turn to the seller's inter-temporal optimization problem. Recall that when seller-buyer relationships are formed, they never dissolve, the price p is never re-negotiated, and one unit of quantity is traded in each period. This means that profits stemming from existing relationships can be ignored when the seller chooses which price to optimally post for potential new buyers.

Setting price p implies an immediate profit flow of $(p - mc)(1 - G(p))$ from new buyers, where $p - mc$ is the immediate per-buyer profit flow, and $1 - G(p)$ is the mass of new buyers. Given that sellers discount future profits by $0 < \beta < 1$, the continuation value of this profit flow, $\pi(p)$, is

$$\pi(p) = \frac{(p - mc)(1 - G(p))}{1 - \beta}. \tag{14}$$

Therefore, the seller's value function is

$$V(m) = \max_p \left[\pi(p) - c(m) + \beta E V(m')\right], \tag{15}$$

where the expectation operator is with respect to ε.

Differentiating the value function (15) with respect to p and applying (13) and (14), I obtain the first-order condition

$$p - \frac{1 - G(p)}{g(p)} = mc - \beta(1 - \beta) E V(m'), \tag{16}$$

where $g(p) = G'(p)$.

In order to obtain a closed-form solution for the optimal price p, I impose a parametric assumption on the distribution of buyers' reservation prices $G(r)$. Specifically, I assume that r is Pareto distributed with shape parameter $\eta > 1$, that is,

$$G(r) = 1 - r^{-\eta}. \tag{17}$$

The shape parameter η is an inverse measure of the dispersion of reservation prices. That is, if η is large, most buyers have relatively small reservation prices and only few buyers have relatively high reservation prices. It is often

[34] Allowing the network to depreciate over time is simple, and, again, is ignored only for simplicity.

[35] In the context of "Partner Search and Match Making" services as applied in Section 2.3 to provide exogenous variation in exporters' networks, the model counterpart to an approach by the Trade Council is a positive realization of ε.

argued, e.g. by Chaney (2008), that the distribution of productivity across firms is Pareto. If more productive importers tend to have higher reservation prices, assumption (17) seems reasonable.

Substituting (17) into (16) and re-arranging yields

$$p = \frac{\eta}{\eta - 1}\left[mc - \beta(1-\beta)EV'(m')\right]. \tag{18}$$

Disregarding the dynamic network accumulation for a moment, the Pareto distribution delivers a well-known solution, where sellers set prices as a constant markup, $\eta/(\eta - 1)$, over marginal costs, mc. If η is large, so that most buyers have relatively low reservation prices, sellers optimally charge relatively low markups.

Two features of expression (18) merit note. Firstly, it defines the optimal price posted by the seller only through an implicit function, as next period's network, m', depends on the price. Secondly, in the presence of dynamic network accumulation, sellers generally post lower prices than the standard static framework entails. That is, firms could increase their instant profits by increasing their prices. However, firms optimally post lower prices to attract more buyers, which extents their network, and, thus, lower their search costs in subsequent periods.

To see this more explicitly, differentiate the value function (15) with respect to m, apply the envelope condition, and substitute into (18) recursively to obtain

$$p = \frac{\eta}{\eta - 1}\left[mc - (1-\beta)E\sum_{j=1}^{\infty}\beta^j \underbrace{\left(-c'(m_j)\right)}_{>0}\right], \tag{19}$$

where m_j is the size of the network j periods ahead.

Expression (19) shows that the negative impact by network on search costs (the fact that $c'(m) < 0$) is driving the price below the static optimum. Furthermore, as c is convex (the fact that $c''(m) > 0$), the *marginal* effect of larger network on search costs goes to zero as m becomes large. This means that, as m becomes large, the entire infinite sum in equation (19) will go to zero, and, consequently, the optimal price will approach the optimal static price equal to $\left[\eta/(\eta - 1)\right] mc$.

To sum up, sellers with small networks face large search costs. However, they also face large *reductions* in search costs if they manage to expand their network, and, hence, they charge low prices—and forgo present profits—in order to attract new buyers. As the network expands, search costs fall, but so do potential reductions in search costs from further enlarging the network. Therefore, the incentive to accumulate buyers is smaller, and sellers will charge higher prices. In the end, as reductions in search costs diminish, sellers will charge a price close to the static optimum.

One might be interested in the *speed* with which prices approach the static optimum as a function of network size. Unfortunately, this is, in principle, not determined from the current assumptions. Simple, and quite general, assumptions about the shape of the cost function, c, however, imply that the speed with which sellers increase prices is decreasing in network size. For instance, this is the case for the function $c(m) = m^{-\delta}$ for $\delta > 0$. This implies that prices increase quickly for small network sizes, then level off as they approach the static optimum.

Note that the simple implementation of network effects through the cost of acquiring a fixed number of new customers have implications that are at odds with the empirical findings presented in Section 2.3. There, I showed that exporters with larger network are able to form more new relationships. However, in the model sellers are introduced to a fixed number of buyers in each period, but sellers with larger network sell to a *smaller* fraction simply because they require higher prices. In Appendix A, I extent the model with an endogenous search effort and show that sellers still increase their prices as their network grows *and*, under some regularity conditions, form more new relationships.

Table 9: Average Prices by Exporter × Product Age

	Total	Exporter × product age								
		1	2	3	4	5	6	7	8	9
All exporter × product pairs										
Mean	0.00	0.00936	-0.0134	-0.00380	-0.00829	-0.0228	-0.0180	-0.0196	-0.0640	-0.0558
N	75,232	44,309	11,662	7,054	5,081	3,218	1,826	1,061	714	307
Exporter × product pairs that formed at least 6 importer relationships										
Mean	0.00	-0.00529	0.00464	0.00282	0.00262	-0.00551	0.0219	0.0124	-0.0427	-0.0360
N	26,323	7,112	5,939	4,175	3,505	2,413	1,371	865	646	298
Exporter × product pairs that formed at least 11 importer relationships										
Mean	0.00	-0.00509	-0.0104	0.00950	0.0171	-0.0103	0.0190	0.0193	-0.0279	-0.0295
N	14,694	3,294	2,947	2,294	2,179	1,641	882	625	557	275

The unit of observation is exporter × importer × market (ijm), where market is a product × destination × year (pdy) triplet. Only the first year of each $ipjd$ relationship within a id spell is kept. Prices are de-meaned by market fixed effects. Exporter × product age is the tenure within an export × destination spell. fpd triplets that obtain a network larger than the 99th percentile are excluded.

4 Dynamic Pricing

The model presented in Section 3 predicts a simple pattern for exporters' dynamic price setting. Upon entry into a new market in which the exporter does not have a network, the exporter should post relatively low prices. As the exporter accumulates importers, it should post higher prices to potential new buyers. This prediction is easily testable.

In the theoretical model, exporters were presented as single-product producers. In practice, many exporters produce and export several products to the same destination. In line with the evidence of exporters' price discrimination across their importers presented in Section 2.2, I will here treat an exporter × product pair as the data counterpart to an exporter in the model. This means that exporters build a network for each of their products separately. In line with Section 2.3, I assume that networks are built within exporter × destination spells, and, consequently, that networks are lost upon exit, even in the case of later re-entry.

For this part of the analysis, I apply the exporter × product × importer × destination × year data set, cleaned for price outliers as described in Section 2.1. As in Section 2.3, the network variable is not properly defined for left-censored spells, and these are excluded. Further, for each relationship within an exporter × destination spell, I keep only the *first year* of data.[36,37] This way, potential *within*-relationship price developments, of which the theoretical model is silent, do not interfere with the *across*-relationship price developments, which are the main interest of this paper. This leaves 75,232 observations. Table 9 presents average prices across exporter × product pair age. There is a small tendency for first-year exporters to obtain relatively high prices, but this could be purely a selection effect.

To test the central model prediction—that exporters increase their prices as their network grows—I simply regress the (log) price obtained from an exporter × product × importer relationship on the size of the exporter × product pair's network. The conjecture is that the OLS estimate is positive.

[36]Recall that as all years are converted to pseudo-years, the first year of a relationship is indeed the relationship's first 12 months.

[37]To be precise, I keep only the first year of data for each exporter × product × importer × destination quadruplet within an exporter × destination spell. This means that if an exporter × product pair forms several relationship spells with the same importer within the same exporter × destination spell, only the first year of the first relationship spell will be kept for this analysis.

Consider the regression equation

$$p_{ijm\tau} = \gamma \text{network}_{im\tau} + \mathbf{FE}_{ipd} + \mathbf{FE}_m + \mathbf{FE}_{month} + error_{ijm\tau} \tag{20}$$

where τ is the exact *date* of which the relationship was established. $p_{ijm\tau}$ is the log price obtained by the exporter during the relationships *first year* only. The network, $\text{network}_{im\tau}$, is the number of importers served prior to date τ. The FE specification largely resembles that of equation (7). In particular, $\mathbf{FE}_{ipd}$ ensures that γ is identified from variation *within* an exporter × product × destination triplet, *across* importers encountered at different points in time.[38] $\mathbf{FE}_m$ controls for market-level price-developments, such that the potential network effect on prices is identified as relative to product-specific inflation (recall that a market is defined as a product × destination × year triplet). Importantly, the combinations of $\mathbf{FE}_{ipd}$ and $\mathbf{FE}_m$ controls for linear effects of export × product pairs' age on prices. This is because within-exporter changes in age and years are indistinguishable. In turn, this means that if exporters change their prices systematically with their age, the estimated effect should be interpreted as additive to this age effect.[39] To address the concern of within-year inflation, I add $\mathbf{FE}_{month}$ in order to control for the month in which the relationship was initiated. This allows for proper comparison between relationships initiated in, say, January and December.

I do not make an attempt to exploit the instrumental variable approach proposed in Section 2.3. Recall that the key identifying assumption necessary to identify model (10) from the system of equations (11) was that the dynamic effect of purchasing PSMM works *only* through the network effect. Model (10) is formulated at the yearly level, which makes this assumption plausible. However, model (20) is formulated at the daily level, which make the assumption impractical (for example, it seems far-fetched to assume that PSMM purchased in February was the direct cause of the meeting of an importer in March, but not in April). A compromise would be to perform the present exercise on more aggregated, e.g. yearly, data. However, this would eliminate within-year variation in price setting caused by within-year variation in network size, which is a considerable part of the present identifying variation. Instead, I will rely on, potentially, non-causal evidence, but interpret the results through the lens of the theoretical model formulated in Section 3.

As presented in column 1 of Table 10, exporters increase prices by 0.792 percent each time it forms a new relationship, but the estimate is highly statistically insignificant. If dynamic pricing is indeed present in the data, two factors (or a combination of the two) could explain the insignificant estimate. First, statistical significance might be mitigated by the presence of a large amount of relatively small (in terms of export sales) exporter × pairs that are either very short-lived or only manage to accumulate a very few importers. Second, recall from the model that we should expect prices to develop non-linearly: Prices should increase relatively fast for small network sizes, then level off as they approach the static optimum. In this case, the presence of exporter × product pairs with relatively large networks would drive the estimate towards zero.

In order to eliminate the first concern—the presence of small, "short" spells—I restrict the estimation sample to exporter × product pairs that managed to form more than five importer relationships. Table 9 shows that this leaves 26,323 observations.[40] Column 2 in Table 10 shows that the estimated effect of network size on price (γ from equation (20)) is only slightly larger than before and still statistically insignificant.

[38] To be accurate, $\mathbf{FE}_{ipd}$ is a product × (exporter × destination spell) FE.

[39] The fixed effects specification in equation (20) controls for linear age trends, but not for potential nonlinearities, that is deviations from the linear trend. Explicitly adding a full set of age dummies to (20) solves this issue. I do so as a robustness check by the end of this section, and show that the results are unchanged.

[40] Exporter × product pairs that manage to form more than five importer relationships within an exporter × destination spell constitute 42.5 percent of the total export value among the sample of all *not* left-censored spells. However, shorter spells are, of course, over-represented in this sample.

Table 10: Network Effect on Prices

Dep. var.:	$p_{fpid\tau}$					$q_{fpid\tau}$	
Sample:	Full	Exporter × product pairs that formed more than 5 importer relationships		Exporter × product pairs that formed more than 10 importer relationships			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\text{network}_{im\tau}$	0.00792	0.00877		0.0109*		0.0112	
	(0.00501)	(0.00554)		(0.00623)		(0.00807)	
$\mathbb{1}(\text{network}_{im\tau} = 1)$			0.0471		0.0520		0.0822
			(0.0311)		(0.0478)		(0.101)
$\mathbb{1}(\text{network}_{im\tau} = 2)$			0.102***		0.0825*		-0.0482
			(0.0341)		(0.0479)		(0.105)
$\mathbb{1}(\text{network}_{im\tau} = 3)$			0.115***		0.0581		-0.00561
			(0.0368)		(0.0544)		(0.109)
$\mathbb{1}(\text{network}_{im\tau} = 4)$			0.145***		0.0739		0.0150
			(0.0426)		(0.0546)		(0.114)
$\mathbb{1}(\text{network}_{im\tau} = 5)$			0.155***		0.131**		-0.0270
			(0.0488)		(0.0608)		(0.123)
$\mathbb{1}(\text{network}_{im\tau} = 6)$					0.0779		0.0600
					(0.0511)		(0.120)
$\mathbb{1}(\text{network}_{im\tau} = 7)$					0.106*		-0.0172
					(0.0597)		(0.124)
$\mathbb{1}(\text{network}_{im\tau} = 8)$					0.0546		0.136
					(0.0624)		(0.131)
$\mathbb{1}(\text{network}_{im\tau} = 9)$					0.144**		0.0885
					(0.0654)		(0.146)
$\mathbb{1}(\text{network}_{im\tau} = 10)$					0.150**		0.157
					(0.0640)		(0.156)
fpd FE	YES	YES	YES	YES	YES	YES	YES
pdy FE	YES	YES	YES	YES	YES	YES	YES
month FE	YES	YES	YES	YES	YES	YES	YES
R-squared (within)	0.001	0.001	0.003	0.004	0.003	0.001	0.002
Observations	49,802	22,961	13,023	11,332	6,957	11,332	6,957

The unit of observation is exporter × product × importer × destination × date ($fpid\tau$). The dependent variables, $p_{fpid\tau}$ and $q_{fpid\tau}$, are the log-price obtained from and log-quantity sold to, respectively, importer i, encountered at τ, in the *first* year of the $fpid$ relationship, *within* the current fd spell. $\mathbb{1}(\text{network}_{im\tau} = k) = n$ is a dummy equal to one if f had a network of n importers in d in y. The omitted reference category is $\mathbb{1}(\text{network}_{im\tau} = k) = 0$. Column 1 presents results based on all observations. Column 2-3 (4-5) present results based on fpd triplets that formed more than 5 (10) importer relationships. fpd triplets that obtain a network larger than the 99th percentile are excluded. Standard errors clustered at the exporter-product are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

In order to address the second concern—that the price effect is non-linear and that exporter × product pairs with large networks keep prices relatively stable—I reformulate regression equation (20) to include a full set of network-size dummies:

$$p_{ijm\tau} = \sum_{k=1}^{K} \gamma_k \mathbb{1}\left(\text{network}_{im\tau} = k\right) + \mathbf{FE}_{ipd} + \mathbf{FE}_{m} + \mathbf{FE}_{month} + error_{ijm\tau}, \tag{21}$$

where $\mathbb{1}(\cdot)$ is the indicator function, K is the size of the sample's largest network, and $\text{network}_{im\tau} = 0$ is the omitted reference category.

I estimate equation (21) on the same sample of "long" spells as above, and restrict interest to the first six relationships formed by each exporter × product pair, that is setting $K = 5$.[41] Column 3 in Table 10 shows the results. Upon entry, exporter × product pairs rapidly increase prices as they form more relationships: The price charged from the third relationship (formed when the network consisted of two importers) is 10.2 percent larger than the price charged from the first relationship (formed without a network). Then, prices keep increasing, but at a more modest rate, such that exporter × product pairs earn a price premium of 15.5 percent from their sixth relationship relative to their first relationship. Recall that these price premiums should be interpreted *beyond* any market-wide developments *and*

To examine the price trajectory for even "longer" spells, I further restrict the sample to consist only of exporter × product pairs that formed more than ten importer relationship within an exporter × destination spell. First, I re-estimate the linear effect from equation (20). Column 4 in Table 10 shows that exporter × product pairs increase prices by 1.09 percent each time they form a new importer relationship (statistically significant at the 10 percent level). Second, I allow for a non-linear effect by re-estimating equation (21) and restricting interest to the first eleven relationships, that is setting $K = 10$. Column 5 shows the results. Relative to the price charged from their first relationship, exporter × product pairs charge 8.25 percent higher prices from their third relationship, 13.1 percent higher from their sixth relationship, and 15.0 percent higher from their eleventh relationship. Though the trajectory is less monotone than before, the qualitative picture is the same: Exporter × product pairs first rapidly increase prices, then dampen the the growth rate as their network expands.

Before concluding this section, I perform three simple robustness checks to support my findings. In the first check, I examine the corresponding development in quantities across importers. In the latter two, I augment the fixed effects specifications in equation (20) and (21).

The theoretical model formulated in Section 3 attributes the price premium documented above entirely to the network effect, but completely disregard any developments in the amount of *quantity* sold to different importers encountered at different points in time. If, on the other hand, exporters generally meet larger importers first—simply because they are more visible—they will tend to sell smaller quantities along the way. In the presence of quantity discounts, which I document in the cross-section in Section 2.2, this could explain the increasing prices. To test this hypothesis, I re-estimate equation (20) and (21) with log quantities sold as dependent variable. A large negative estimate would support this hypothesis. Column 6 and 7 in Table 10 present the results for exporter × product pairs that form more than 10 importer relationships. The linear effect on larger network on quantities is positive, but insignificant, and the quantity trajectory for the first eleven relationships is highly non-monotonic with no point estimate significantly

In the full sample including both left-censored and *not* left-censored spells, that is the sample applied in Section 2.2, exporter × product pairs for which we *observe* more than five importer matches constitute 75.6 percent of the total export value. As we do not observe the full network for left-censored spells, the true export value share constituted by exporter × product pairs that form more than five importer relationship is generally larger. In conclusion, this sub-sample of exporter × product pairs is responsible of the lion's share of Danish export value.

[41] Recall that an exporter × product pair has a network of five importers when the sixth importer relationship is formed.

different from zero. Therefor, I find no evidence suggesting that the positive network effect on prices is explained by a corresponding fall in quantities sold.

I now turn to the fixed effects (FE) specification in equation (20) and (21). A threat to my identification strategy is that underlying factors—that are not accounted for by included FEs—are driving both the increase in network size and the price growth. First, recall that the current FE specification includes both an exporter × product × destination FE ($\mathbf{FE}_{ipd}$) and a market FE ($\mathbf{FE}_m$). As mentioned above, this controls for linear effects of exporter × product × destination specific age on prices, but not deviations around such a trend. Rodrigue and Tan (2019) and Piveteau (2019) document that that prices for Chinese and French exporters, respectively, do increase over time. In the present context, network size is, per construction, weakly increasing in age. To rule out that age is driving the results, I augment equation (20) and (21) with age dummies. Table 11 presents the results, resembling the structure of Table 10. Point estimates change only slightly, and all qualitative conclusions prevail. Second, underlying supply-side dynamics could drive both the increase in network and the growth in prices. In Rodrigue and Tan (2019), exporters respond to growing foreign demand by improving product quality, which further increase both market share and prices. A similar mechanism, where exporters expand their customer base by offering products of higher quality, could explain the simultaneous increase in network and prices. As is common in the literature (e.g. Manova and Zhang, 2012; Fitzgerald et al., 2017), I address this concern by augmenting the FE specification with an exporter × product × year FE. The underlying assumption is that marginal production costs are identical across destinations, and that quality upgrading requires more expensive production inputs which will increase marginal production costs. Table 12 presents the results. Point estimates change only slightly, and all qualitative conclusions prevail.

In conclusion, I have found that exporters charge higher prices from new buyers as their network grows, which is in accordance with the predictions produced by the model outlined in Section 3. Further, these price increases are *beyond* those potentially caused by (i) market-wide developments, (i) systematic dynamics related to age, and (iii) costly quality upgrading.

5 Conclusion

The goal of this paper has been two-fold. First, to empirically document that exporters charge higher prices as they form more importer relationships. Second, to provide empirical regularities as well as a simple theoretical framework that, combined, demonstrate that firms use dynamic pricing as a strategy to expand in export markets.

Using a novel data set on firm-to-firm exports by Danish firms, I presented two empirical findings. First, Danish exporters *price discriminate* between their foreign buyers: Ranking all importer relationships in terms of prices, the third quartile is characterized by a price 65 percent larger than the first quartile. Second, Danish exporters enjoy large *network effects* in foreign markets: Adding one importer to an exporters network increases the number of new buyer relationships formed in the following year by 0.36-0.38. I implement these findings in a simple dynamic model, where exporters must match with foreign importers in order to trade. The model predicts that exporters price low upon entry, then increase prices as their network expands.

These findings speak directly to a series of concurrent academic papers, examining expansion strategies of firms in general and exporters in particular. Whereas the bulk of these papers rely on more aggregated data, this paper illustrates that firm-to-firm trade data provides valuable information to the literature. As most existing papers using similar transaction level trade data are exploring cross-sectional regularities, only few examine how firm-to-firm relationships shape exporters' gradual expansion in foreign markets. Therefore, there is both need and room for more research on these topics.

This paper is relevant for how policy-makers should optimally design firm specific trade policies, and how the value of such policies should be properly evaluated. The presence of sizable network effects in foreign markets implies that exporters value their importer relationships *beyond* the profits generated from the particular match as the network itself is a source to further expansion. Further, exporters' first relationships are particularly valuable. Therefore, matching exporters, especially new exporters, to foreign importers should be a primary objective to policy-makers that wish to promote export participation and sales. In turn, this means that proper evaluation of firm specific trade policies, aiming at matching exporters with importers abroad, should take the network effects into account. Failing to account for the indirect value of matching with an importer—the value of more easily forming relationships subsequently—would undervalue the policy, especially as such programs are often targeted new exporters.

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A Model Extension

In this section, I extent the model presented in Section 3 with an endogenous search effort. In the model outlined in Section 3, exporters reach a fixed mass (normalized to one) of new importers in each period and form $(1 - G(p))$ new relationships, where p is the posted price, and G is the commonly known distribution of importers' reservation prices. As in the main text, I impose the assumption $G(p) = 1 - p^{-\eta}$, where $\eta > 1$ is the Pareto distribution's shape parameter.

Now, I allow exporters to reach s new importers. This means that exporters sell to $sp^{-\eta}$ new importers in each period and obtain an immediate profit flow of $(p - mc)sp^{-\eta}$, where mc is the constant marginal production cost. As in the main text, relationships never dissolve and prices are never re-negotiated, which means that the continuation value of this profit flow is

$$\pi(p, s) = \frac{(p - mc)sp^{-\eta}}{1 - \beta}, \tag{22}$$

where β is the discount factor.

The network, m, evolves as

$$m' = m + sp^{-\eta} + \varepsilon, \tag{23}$$

where ε is a mean-zero i.i.d. disturbance term.

Reaching s new importers is associated with a cost of $c(s, m)$. To fix ideas, I specifically assume that

$$c(m, s) = s^{\gamma} m^{-\delta}, \tag{24}$$

where $\gamma > 1$ and $\delta > 0$. This implies that $c(s, m)$ is increasing and strictly convex in s ($c_s(s, m) > 0$) and $c_{ss}(s, m) > 0$) and, as in the main text, decreasing and strictly convex in m ($c_m(s, m) < 0$) and $c_{mm}(s, m) > 0$). To ensure that $c(m, s)$ is convex, I further assume $\gamma - 1 > \delta$.

The exporter's value function is

$$V(m) = \max_{p,s} \left[\pi(p, s) - c(m, s) + \beta EV(m')\right]. \tag{25}$$

The first order condition with respect to p is identical to the one obtained in (18) the main text:

$$p = \frac{\eta}{\eta - 1} \left[mc - \beta(1 - \beta)EV'(m')\right]. \tag{26}$$

The first order condition with respect to s is

$$s = \left(\frac{m^{\delta}}{\gamma} p^{-\eta} \left[\frac{p - mc}{1 - \beta} + \beta EV'(m')\right]\right)^{\frac{1}{\gamma-1}}. \tag{27}$$

Substituting (26) into (27) and re-arranging yields an expression of s as a function of m and p:

$$s = \left(\frac{1}{\gamma\eta(1 - \beta)} p^{1-\eta} m^{\delta}\right)^{\frac{1}{\gamma-1}}. \tag{28}$$

To obtain an easily interpretable expression for how search effort varies with the size of the network, simply take the elasticity w.r.t. m on both sides of (28):

$$\frac{\mathrm{d}s}{\mathrm{d}m}\frac{m}{s} = \frac{1}{\gamma - 1}\left(\delta - (\eta - 1)\frac{m}{p}\frac{\mathrm{d}p}{\mathrm{d}m}\right). \tag{29}$$

As the size of the network increases, this affects optimal search effort through two channels. First, a larger network diminishes the cost of searching, which increases the optimal search effort. This effect is increasing in δ, the rate at which search costs falls with the size of the network.[42] I refer to this as the "cost channel". Second, a larger network leads to increasing prices as shown in (26) and discussed in the main text. This leads to two opposing effects on search effort. Firstly, higher prices increase the per-buyer profits, which increases the marginal return to search effort. Secondly, higher prices decrease the share of buyers among the reached importers, which decreases the marginal return to search effort. The net effect on search through higher prices, however, is surely negative as $\eta > 1$. I refer to this as the "indirect price channel". Whether the "cost channel" dominates the "indirect price channel", such that search effort is increasing in the size of the network, depends on model parameters.

However, for the amount of new importers ($sp^{-\eta}$) to be increasing in the size of the network, the requirement is even stronger. This is due to the "direct cost effect", where the positive impact of network on prices directly decreases the amount of new importers. From (29) we easily obtain

$$\frac{\mathrm{d}(sp^{-\eta})}{\mathrm{d}m}\frac{m}{sp^{-\eta}} = \frac{1}{\gamma-1}\left(\delta - (\eta\gamma-1)\frac{m}{p}\frac{\mathrm{d}p}{\mathrm{d}m}\right). \tag{30}$$

For expression (30) to be positive, we require

$$\begin{aligned}\delta &> (\eta\gamma-1)\frac{m}{p}\frac{\mathrm{d}p}{\mathrm{d}m} \\ &= (\eta\gamma-1)\frac{\eta-1}{\eta}\frac{-\beta(1-\beta)EV''(m')}{mc-\beta(1-\beta)EV'(m')}m,\end{aligned} \tag{31}$$

where the equality comes from (26) and that $\mathrm{d}p/\mathrm{d}m = -\beta(1-\beta)EV''(m')$, where $EV''(m') < 0$ is from the concavity of the value function.[43]

Whether this inequality holds, such that the number of new importer relationships is increasing in the size of the network, depends on the underlying parameters and the shape of the value function (for which there is no intuitive expression). It is easy to show, however, that a sufficient condition for (31) to hold for large m is that the elasticity of the marginal value function, that is $\mathrm{El}_m V'(m)$ is asymptotically constant as m grows. Under this relatively mild regularity condition, the "cost channel" will dominate both the "indirect price channel" and the "direct price channel", such that sellers will sell to a growing number of new buyers as m grows, at least for large m.

[42] Note from (24) that $\delta = -\frac{m}{c(s,m)}\frac{\mathrm{d}c(s,m)}{\mathrm{d}m}$.

[43] The value function is concave as long as $\pi(p,s) - c(m,s)$ is concave. $\pi(p,s)$ is concave for all prices, p, below (and including) the static optimum. As claimed above, $c(m,s)$ is convex for $\gamma - 1 > \delta$. Thus, under this assumption, $\pi(p,s) - c(m,s)$ is concave.

B Additional Tables

Table 11: Network Effect on Prices, Including Age FE

Dep. var.:	$p_{fpid\tau}$					$q_{fpid\tau}$	
Sample:	Full	Exporter × product pairs that formed more than 5 importer relationships		Exporter × product pairs that formed more than 10 importer relationships			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
network$_{im\tau}$	0.00797	0.00890		0.0109*		0.0122	
	(0.00502)	(0.00556)		(0.00627)		(0.00802)	
$\mathbb{1}$ (network$_{im\tau}$ = 1)			0.0572*		0.0549		0.0777
			(0.0313)		(0.0481)		(0.101)
$\mathbb{1}$ (network$_{im\tau}$ = 2)			0.119***		0.0884*		-0.0575
			(0.0343)		(0.0481)		(0.106)
$\mathbb{1}$ (network$_{im\tau}$ = 3)			0.134***		0.0655		-0.0187
			(0.0371)		(0.0547)		(0.111)
$\mathbb{1}$ (network$_{im\tau}$ = 4)			0.165***		0.0815		0.00135
			(0.0427)		(0.0549)		(0.115)
$\mathbb{1}$ (network$_{im\tau}$ = 5)			0.170***		0.139**		-0.0417
			(0.0487)		(0.0614)		(0.124)
$\mathbb{1}$ (network$_{im\tau}$ = 6)					0.0861*		0.0436
					(0.0514)		(0.121)
$\mathbb{1}$ (network$_{im\tau}$ = 7)					0.114*		-0.0328
					(0.0601)		(0.125)
$\mathbb{1}$ (network$_{im\tau}$ = 8)					0.0627		0.119
					(0.0626)		(0.131)
$\mathbb{1}$ (network$_{im\tau}$ = 9)					0.151**		0.0720
					(0.0657)		(0.146)
$\mathbb{1}$ (network$_{im\tau}$ = 10)					0.156**		0.143
					(0.0643)		(0.156)
age FE	YES	YES	YES	YES	YES	YES	YES
fpd FE	YES	YES	YES	YES	YES	YES	YES
pdy FE	YES	YES	YES	YES	YES	YES	YES
month FE	YES	YES	YES	YES	YES	YES	YES
R-squared (within)	0.001	0.001	0.003	0.004	0.003	0.001	0.002
Observations	49,802	22,961	13,023	11,332	6,957	11,332	6,957

The unit of observation is exporter × product × importer × destination × date ($fpid\tau$). The dependent variables, $p_{fpid\tau}$ and $q_{fpid\tau}$, are the log-price obtained from and log-quantity sold to, respectively, importer i, encountered at τ, in the *first* year of the $fpid$ relationship, *within* the current fd spell. $\mathbb{1}$ (network$_{im\tau}$ = k) = n is a dummy equal to one if f had a network of n importers in d in y. The omitted reference category is $\mathbb{1}$ (network$_{im\tau}$ = k) = 0. Column 1 presents results based on all observations. Column 2-3 (4-5) present results based on fpd triplets that formed more than 5 (10) importer relationships. fpd triplets that obtain a network larger than the 99th percentile are excluded. Standard errors clustered at the exporter-product are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

Table 12: Network Effect on Prices, Including fpy FE

Dep. var.:	$p_{fpid\tau}$					$q_{fpid\tau}$	
Sample:	Full	Exporter × product pairs that formed more than 5 importer relationships		Exporter × product pairs that formed more than 10 importer relationships			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
network$_{im\tau}$	0.0102	0.0111*		0.0108		0.0160*	
	(0.00647)	(0.00655)		(0.00697)		(0.00862)	
$\mathbb{1}$ (network$_{im\tau}$ = 1)			0.0586*		0.0505		0.0857
			(0.0318)		(0.0485)		(0.102)
$\mathbb{1}$ (network$_{im\tau}$ = 2)			0.124***		0.0964**		-0.0692
			(0.0348)		(0.0486)		(0.107)
$\mathbb{1}$ (network$_{im\tau}$ = 3)			0.134***		0.0715		-0.0237
			(0.0375)		(0.0553)		(0.112)
$\mathbb{1}$ (network$_{im\tau}$ = 4)			0.164***		0.0877		-0.00471
			(0.0434)		(0.0549)		(0.115)
$\mathbb{1}$ (network$_{im\tau}$ = 5)			0.163***		0.139**		-0.0504
			(0.0496)		(0.0618)		(0.125)
$\mathbb{1}$ (network$_{im\tau}$ = 6)					0.0914*		0.0391
					(0.0513)		(0.121)
$\mathbb{1}$ (network$_{im\tau}$ = 7)					0.119*		-0.0370
					(0.0606)		(0.127)
$\mathbb{1}$ (network$_{im\tau}$ = 8)					0.0665		0.112
					(0.0628)		(0.132)
$\mathbb{1}$ (network$_{im\tau}$ = 9)					0.145**		0.0824
					(0.0662)		(0.147)
$\mathbb{1}$ (network$_{im\tau}$ = 10)					0.133**		0.187
					(0.0649)		(0.159)
fpy FE	YES	YES	YES	YES	YES	YES	YES
fpd FE	YES	YES	YES	YES	YES	YES	YES
pdy FE	YES	YES	YES	YES	YES	YES	YES
month FE	YES	YES	YES	YES	YES	YES	YES
R-squared (within)	0.001	0.001	0.003	0.004	0.003	0.001	0.002
Observations	44,894	22,354	12,566	11,215	6,883	11,215	6,883

The unit of observation is exporter × product × importer × destination × date ($fpid\tau$). The dependent variables, $p_{fpid\tau}$ and $q_{fpid\tau}$, are the log-price obtained from and log-quantity sold to, respectively, importer i, encountered at τ, in the *first* year of the $fpid$ relationship, *within* the current fd spell. $\mathbb{1}$ (network$_{im\tau}$ $= k) = n$ is a dummy equal to one if f had a network of n importers in d in y. The omitted reference category is $\mathbb{1}$ (network$_{im\tau}$ $= k) = 0$. Column 1 presents results based on all observations. Column 2-3 (4-5) present results based on fpd triplets that formed more than 5 (10) importer relationships. fpd triplets that obtain a network larger than the 99th percentile are excluded. Standard errors clustered at the exporter-product are reported in parentheses. Asterisks indicate statistical significance: * p<0.1; ** p<0.05; *** p<0.01.

Chapter 2

Firm-Specific Trade Policy: Evidence on Effectiveness and Mechanisms

Firm-Specific Trade Policy: Evidence on Effectiveness and Mechanisms

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Abstract

Most countries engage in a variety of firm-specific trade policies. In this paper we examine the effectiveness and the mechanisms behind a firm-specific trade policy, export promotion. We use detailed data from the Danish Trade Council to solve measurement problems, and we exploit randomness in the targeting of the policy across firms to solve selection problems. We first find that the firm-specific trade policy boost exports of firms along the intensive margin. Next, we show that this is due to increasing sales, while marginal costs, export prices and quality remain roughly constant. This suggests that firms use the firm-specific trade policy to increase demand for their products on foreign markets consistent with a trade expansion theory such as Arkolakis (2010).

Keywords: Firm-specific trade policy, Firm-level export data, adjustment mechanisms

1 Introduction

A recent literature examines adjustments in prices, quality and markups to understand firm's responses to tariff liberalizations and success in export markets (De Loecker et al., 2016; Fan et al., 2015; Khandelwal et al., 2013; Fitzgerald et al., 2016; Rodrigue and Tang, 2019). Beyond tariffs, measurement of wide spread trade policies and related evidence are less common (Goldberg and Pavcnik, 2016), as information on trade facilitation, export promotion, trade missions, subsidies, export credits etc. are not collected in standard data sets. In addition, these policies often depend on firm's self selection to achieve their desired goals. Consequently, the existing empirical literature provides limited evidence on the effectiveness to increase export flows, and evidence on how to interpret these policies with respect to standard trade models, WTO rules, and other agreements regulating international commerce.

We solve several data and identification challenges to fill this gap in the literature. First, firm's selection to use these trade policy instruments may be related to expected success on export markets, or, an attempt to revitalize failing markets. We develop an exogenous instrument based on the Danish Trade Council's strategy to distribute destination-specific export promotion services across firms. Second, the Trade Council's services are at the firm-destination level.

We apply detailed data to determine effects of export promotion on sales and prices at the destination-product level. Therefore, we observe and examine the relevant intensive margin of trade associated with variation in export promotion services. Finally, standard margins of adjustment such as markups, marginal costs, product quality and input quality are not directly observable, but we apply recent developments in structural techniques to measure these outcomes. This allows us to examine adjustment mechanisms by estimating the effects of export promotion on firm-level production, markups, marginal costs, product quality, and inputs.

At the firm level, our empirical strategy provides the first instrumental variable estimates to examine effectiveness of promotion services.[1] We provide evidence and institutional background to show that the Trade Council's own selection of firms is random conditional on firm, product and destination characteristics and is not associated with already observable export performance. Our first stage shows that the Trade Council's approach of firms with information regarding export promotion services has a positive effect on take-up, suggesting that to reach their full potential, trade policies relying on self-selection must overcome information asymmetries.

In the second stage, conditional on high dimensional fixed effects, accounting for self-selection raises the effectiveness of export promotion. Therefore, self-selection downward biases OLS and other estimation techniques. A simple possible explanation is that firms with declining export performance seek out the trade council for help with export markets. Similarly, Van Biesebroeck et al. (2016) argue that the demand and effectiveness for promotion services increases in downturns. A more nuanced explanation is that firms that self-select to seek out services have good export managements, therefore additional services have limited ability to improve performance.

Exploiting destination and product level variation allows us to provide evidence regarding effects of export promotion on export prices. This evidence does not exist in the literature as most work considers more aggregate firm, industry, or country level information. We discuss how price effects combined with evidence on supply side effects of export promotion are useful to distinguish several mechanisms that have recently been studied to examine the effects of trade liberalizations. We find that firms use export promotion to increase sales on foreign markets. Most of this effect is due to quantity adjustments, although we do provide evidence for small and dynamic increases in export prices. We consider this is in line with Fitzgerald et al. (2016), who find that exporters dynamically grow markets without significant price adjustments. At the firm-product level, we provide evidence that export promotion significantly increases production, but is not associated with any discernible marginal cost effects. Combined, these margins of adjustment imply that export promotion has a significant and positive effect on the perceived quality of the exported products, but no real changes in marginal production costs that we would expect to go along with changes in physical quality if, for example, firms hire better inputs to improve their products (Kugler and Verhoogen, 2012).

We make several additional contributions to the literature. In a recent paper Munch and Schaur (2018) examine the effect of export promotion on firm level performance beyond export measures. They apply matching estimators to examine the effect of promotion on firm level performance measures including employment, total sales, and value added and they provide a cost-benefit calculation of export promotion. By contrast, we focus on the mechanisms behind export promotion and examine effects of export promotion on prices and product level mechanism consistent with trade theory and the complimentary literature that examines firms' response to tariff liberalization. Also, we apply an instrumental variable technique rather than relying on observables to solve the identification problem. Furthermore,

[1] At the country level, Rose (2007) instruments for the number of foreign missions that provide export promotion services with destination-specific variable that capture the importance of the destination and the desirability for foreign services officers to live in these destinations. Using firm-level export data, but destination level efforts of export promotion, Creusen and Lejour (2012) use foreign GDP, GDP growth and distance to instrument for aggregate destination level export promotion services.

throughout they assume that export promotion does not affect the firm's sales in other markets or the sales of competing firms. Using product level data, we directly examine spillover effects according to theories of multi-product firms.

A substantial literature examines the effectiveness of export promotion. At the aggregate level, the evidence is mixed (Rose, 2007; Head and Ries, 2010; Cassey, 2014; Bernard and Jensen, 2004; Lederman et al., 2010).[2] At the firm level, evidence shows positive and significant effects for the destination and product extensive margin (i.e. export promotion leads firms to export more products to more markets), the intensive margin and export survival (Volpe Martincus and Carballo, 2008, 2010b,a, 2012; Van Biesebroeck et al., 2015; Cadot et al., 2015). Most of this existing evidence is focused on export promotion activities in developing countries and emphasizes export promotion effects on the extensive margin.

The exception is Van Biesebroeck et al. (2015). For a developed economy, Canada, they identify a strong intensive margin effect.[3] Across various estimators, export promotion raises average exports per market between 5 and 14 percent. They also find positive effects on the product and destination extensive margin. We apply two stage least squares and exploit the destination variation to absorb unobserved heterogeneity across export markets with fixed effects. For example, we account for changes in non-tariff barriers that may have led firms to seek services from trade promotion agencies. In our preferred specification, export promotion raises exports by about 4.7 percent in the OLS and about 7 percent in the IV specification. These estimates are not only smaller in magnitude compared to Van Biesebroeck et al. (2015), they also apply only within treated destinations. Therefore, we confirm positive intensive margin effects, but smaller than what we expect form the existing literature.

Exploiting the destination variation in the export promotion instrument allows for a more careful look at the product margin. Within destinations, we do not find evidence that export promotion affects firms' product extensive margin. Also, across the products firms sell within destinations, the effects are homogeneous. Multi-product firm theories develop tradeoffs between the number of products, the destinations and the intensive margin. Contrary to the existing evidence, our evidence suggests that export promotion does not result in changes in product level export patterns we would expect from these theories.

In the developing market context, Atkin et al. (2017) provide evidence on the relationship between export success and product quality applying a randomized experiment. Auer et al. (2018) examine firms' pricing-to-market decisions and how these decisions interact with product quality on export markets using detailed data on automobiles. More broadly, a recent literature provides evidence for firms quality differentiation across destinations and incentives to upgrade quality as a result of standard tariff policy (Manova and Zhang, 2012; Bastos et al., 2018; Fan et al., 2018; Flach, 2016). To our knowledge, we are the first to provide evidence on non-tariff policies and their effects on quality.

Understanding what determines export success is important to understanding welfare effects of trade and the design of export promotion activities. Within export destinations, we apply direct measures of product quality that take into account variable markups and marginal costs to examine the effects of export promotion on quality. If firms expand export sales due to promotion services, fixed cost arguments and reduced distribution costs suggest that firms may invest to upgrade product quality (e.g. Manova and Zhang (2012)), or, firms may be able to reach higher income consumers with a greater willingness to pay for quality (e.g. Auer et al. (2018)). On the other hand, if promotion services lower per-unit trade costs, then firms may lower export qualities (Hummels and Skiba, 2004). We do not find evidence that trade expansion due to export promotion raise marginal production costs. We find that export promotion

[2]For a detailed review see Van Biesebroeck et al. (2016); Broocks and Van Biesebroeck (2017).

[3]Similar to our data, they observe firms that received export promotion services including the country (office) which provided the services. They examine if promotion services affect firms' total exports using multiple estimators. They do not exploit the destination level variation.

has a limited effect on export prices, but a significant positive effect on export quality.[4] Combined, this suggest that export promotion is most appropriately interpreted as an export expansion due to improved visibility captured as an increase in *perceived* quality (Arkolakis, 2010; Gervais, 2015).

The paper proceeds as follows. In section 2, we describe the data and the institutional setting for export promotion in Denmark. In section 3 we lay down the empirical strategy and we discuss how identification is achieved. Section 4 presents the results and section 5 concludes.

2 Data

2.1 Export Promotion in Denmark

The Trade Council (TC) organizes all governmental export-promotion activities in Denmark, and offers tailored export-promotion services to Danish firms. The promotion services are provided by caseworkers employed by the TC at the Danish embassies and consulates abroad, and export-promotion services are then naturally destination-specific. Firms are charged for these services, but prices are heavily subsidized (at around half of costs to provide the services). In practice, firms pay a fixed rate per caseworker hour.

The TC offers a variety of services. The largest portion of these, partner search and matchmaking, helps firms find new trade partners such as distributors in foreign markets. Other services include intelligence and analysis on political and economic conditions, advertising, fairs, exhibitions, public relations activities, and communication with customs authorities and diplomacy. The TC's services are intended for firms interested in engaging in new export activities as well as firms interested in expanding existing exporting activities.

Crucial for our identification strategy, the TC actively approaches firms and offer them export-promotion services. The TC has no overall strategy for which firms to approach nor is there any coordination across embassies and consulates. Instead, each embassy and consulate approaches firms based on information about industry-specific conditions in the local destination market. This suggests that, once these conditions are controlled for, firms are approached randomly. We will discuss empirical identification further in section 3.2.

2.2 Data Sources

First, we briefly describe the data sets needed for the empirical analysis. Then we describe how these data sets are merged and how this shapes the final estimation samples.

We collect data on export-promotion services from the TC. For the years 2002-2015, we have the full list of firms that purchased promotion services by country for which the services were directed. Furthermore, we have the full list of firms that were approached by the TC and the location of the embassy or consulate responsible for the approach. That is, for every firm, destination, and year we observe a) whether a given firm purchased export-promotion services, and b) whether a given firm was approached by the TC and offered export-promotion services.

Our export data comes from the statistics for International Trade in Goods. For each firm and year we have exports disaggregated by product and destination country. Trade flows are recorded according to the eight-digit Combined Nomenclature (CN8). To account for changes in product categories over time, we apply the algorithm proposed by Van Beveren et al. (2012), aggregating categories to the so-called CN8+ level. For each trade flow we observe its

[4]Prices weakly increase, perhaps as consumers learn the true quality of the product (Bagwell and Staiger, 1989).

f.o.b. value in Danish Kroner (DKK) and its quantity.[5] The trade data consists of two sub-systems, Intrastat (trade with EU countries) and Extrasta (trade with non-EU countries). Intrastat does not have complete coverage as firms are only obliged to report intra-EU trade if the annual export value exceeds a threshold (5 million DKK in 2015). Extrastat has close-to-complete coverage. However, extra-EU transactions of less than 7,500 DKK are not required to be categorized as separate products. To ensure comparability across intra- and extra-EU exports, we exclude all trade flows with a value lower than this threshold. We construct unit values by dividing values with quantities and refer to these as "prices" in the remainder of the paper.

We collect production data from the statistics for Manufacturers' Sales of Goods. This is the source for the Danish Prodcom statistics, regulated by Eurostat. For each firm and year, we have sales, in terms of value and quantity, by product (CN8, aggregated to CN8+). The unit of quantities vary across products.[6] Importantly, the data set covers only sales of own goods, that is goods extracted, produced, processed or assembled by the reporting firm, and, thus, not resales. Both domestic and export sales are included. The data set covers all firms with at least 10 employees operating within mining and quarrying (NACE B) and manufacturing (NACE C). As for the export data, we construct unit values by dividing values by quantities.

Finally, we extract firm-level characteristics, e.g. industry codes and number of employees, from the Firm Statistics Register and Firm Accounts Statistics, covering the universe of private sector Danish firms.

2.3 Estimation Samples

Ultimately, we are interested in two estimation samples, consisting of the same set of firms but at two different levels of aggregation: the firm-product-destination-year level and the firm-product-year level. We start by describing the sample of firms resulting from merging the various data sources outlined above. We then describe the two estimation samples and provide brief summary statistics for each. All considered data sources apply the same unique firm identifier, easing the merging procedure.

2.3.1 Firm Sample

Access to data on export promotion services restricts the sample period to 2002-2015. As our empirical analysis examines effects along the intensive export margin only, we restrict the sample to exporting firms, that is firm-years present in the export data. Further, as part of our empirical analysis examines the effect on production costs, we restrict the sample to manufacturing firms (NACE C) with employees. This data set consists of total exports sales of 3.4 trillion DKK and 46,287 firm-year observations, see column 1 and 2 in Table 1.

As the TC does not offer export promotion services to all destinations, we restrict interest to destinations for which a Danish firm purchased export promotion services at some point during the sample years. This leaves 77 countries, including all major destinations for Danish exports. Column 3 and 4 in Table 1 shows that this restriction maintains export sales of 3.1 trillion DKK and 43,622 firm-years.

[5]We observe quantities in kilos for all products and, additionally, quantities in a supplementary unit (such as pieces and liters) for a subset of products. If the supplementary unit is present and the same for all trade flows within a product category, we apply quantities in this unit. Otherwise, we apply quantities in kilos.

[6]At the CN8 level, all quantities are reported in the same unit within a product-year pair. However, this unit changes over time for some products. Furthermore, the aggregation of product codes from CN8 to CN8+ gives rise to some cases where units differ even within product-year pairs. As comparability of prices, and thus quantities, within product categories are crucial for our analysis, we define product categories in terms of product-unit pairs, and refer to such pairs as "products" in the remainder of the paper.

We then restrict the sample to only include firms present in the sales (Prodcom) data. First of all, this limits the sample to firms with at least 10 employees. Column 5 and 6 in Table 1 shows that this restriction maintains export sales of 2.3 trillion DKK and 18,181 firm-years.

2.3.2 Firm-Destination-Year Sample

We now turn to data at less aggregated levels. First, consider the firm-destination-year level. We do not apply this level of aggregation for any empirical specifications, but it is the natural level for which to introduce the treatment indicator and the corresponding instrument.

Our promotion data allows us to classify firm-destination-year triplets into four mutually exclusive groups: "not promoted, not approached", "not promoted, approached", "promoted, not approached", and "promoted, approached", see Table 2.

For the empirical analysis, we define a binary treatment indicator, TCS_{fdy}, in the following way: TCS_{fdy} takes value one if firm f purchased export promotion services for destination d in year y and/or $y-1$.[7] This timing convention is also applied by Broocks and Van Biesebroeck (2017) and reflects that (as we will see later) the effect of export promotion services under some circumstances is delayed. We define a binary instrument accordingly, based on whether the firm-destination-year triplet was approached by the TC or not.

2.3.3 Firm-Product-Destination-Year Sample

Next, consider the least aggregated estimation sample, at the firm-product-destination-year level. The top panel of Table 3 shows that the firm sample of 18,181 firm-years turns into 880,955 firm-product-destination-year quadruplets (after the initial year, 2002, is excluded as the treatment indicator TCS_{fdy} is not defined).

At this level of aggregation, the treatment indicator, TCS_{fpdy}, is simply defined as $TCS_{fpdy} = TCS_{fdy}$. That is, if firm f was treated in destination d in year y, we consider all of its products to be treated. The instrument is defined accordingly. According to these definitions, 4.8 percent of the observations were treated, and 3.1 percent were approached by the TC.

Column 5 of Table 3 shows that average export sales are approximately 2.5 million DKK with a standard deviation of 27.2 million DKK, indicating that the dispersion in sales is massive. Quadruplets that received promotion (column 3 and 4) are generally larger, in terms of export sales, than quadruplets that did not receive promotion (column 1 and 2). There is also heterogeneity within treatment groups, as quadruplets that were approached by TC (column 2 and 4) are larger on average than quadruplets that were not approached (column 1 and 3).

In order to facilitate comparison of prices across products, these are first log-transformed, then de-meaned by product fixed effects, before averages and standard deviations are obtained and presented in Table 3. This means that the overall average price is zero by definition, see column 5. As for export sales, the standard deviation of prices (1.184 log-points) indicates vast dispersion. Of course, this dispersion is to some extent explained by firm and destination heterogeneity. Quadruplets approached by TC enjoyed higher prices than those not approached.

Overall, the high degree of variation in both export sales and export prices will help our regression based analysis. However, the heterogeneity in sales and prices across promoted and not promoted observations as well as across

[7] Formally, let $d_{fd,t}$ be a binary indicator that takes value one if firm f purchased promotion services for destination d in year y. We then define $TCS_{fdy} = \max(d_{fd,t}, d_{fd,t-1})$.

approached and not approached observations needs to be addressed carefully in order to isolate the causal effect of purchasing promotion.

2.3.4 Firm-Product-Year Sample

Finally, consider the estimation sample at the firm-product-year level, presented in the bottom panel of Table 3. At this level of aggregation, the treatment indicator, TCS_{fpt}, takes value one if $TCS_{fpdy} = 1$ for any d and zero otherwise. That is, a fpy triplet is considered treated if firm f exported product p to destination d in year y and purchased promotion in destination d in year y or $y-1$. The instrument is defined accordingly.

This sample consists of 49,457 firm-product-year triplets and contains two groups of variables: observed (quantities, prices, and export status) and estimated (marginals costs, expenditure shares, and output elasticities) variables. Of these, 14.2 percent were treated, and 10.8 percent were approached by the TC.

Quantities exhibit qualitatively the same pattern as export sales (considered above) in the sense that sizes are increasing across columns. Treated triplets generally enjoyed lower prices than triplets that were not treated. Importantly, part of this heterogeneity is (potentially) explained by differences between exported and non-exported products. Whereas all considered firms are exporting, firms do not generally export all the products they produce. Of all triplets, 67.5 pct. were exported. By definition, all promoted and approached triplets are necessarily exported.

Using the sales (Prodcom) data together with firm-level characteristics from the Firm Statistics Register and Firm Accounts Statistics, the remaining variables presented in the bottom panel of Table 3 are estimated by applying the estimation procedures proposed by De Loecker and Warzynski (2012) and extended by De Loecker et al. (2016) to obtain firm-product-year specific marginal cost estimates. The main insight is that marginal costs are identified from the firm's short-run cost-minimization problem, such that the demand side can be left unspecified. Econometrically, the procedure mainly relies on estimation of production functions, which is a well-studied topic in the empirical IO literature. The appendix outlines the estimation procedure in more detail.

Consider first the main variable of interest, estimated marginal production costs. As is the case for output prices, the magnitudes of marginal costs are not directly comparable across products. Instead, to get an overall idea of the estimated magnitudes, we can simply calculate the markups, which *are* comparable across products, by dividing output prices with marginal costs. Across all observations in the estimation sample, the average markup is 1.89. The estimated marginal costs exhibit a large degree of dispersion, even higher than for prices. Triplets that were promoted and/or approached had lower than average marginal costs. This reflects to some extent that firms export the products for which their production is more efficient. But even within the three groups that did have some contact to the TC (column 2-4) there is considerable heterogeneity, with approached triplets having lower marginal costs among the promoted triplets, and the promoted triplets overall having lower marginal costs than the approached but not promoted triplets.

We are also interested in two additional estimated variables, expenditure shares and output elasticities. In accordance with the applied estimation procedure, these serve as components of marginal costs. For details, see the appendix. When we examine the effects of purchasing promotion on marginal costs, additionally examining the effects on these components will help us understand *how* promotion services are affecting marginal costs. Expenditure shares are estimates of the fraction of firm-level expenditures allocated to each product within the firm, thus bounded between zero and one. Output elsticities are estimates of the elasticity of produced quantities with respect to real material inputs. As the applied estimation procedure is based on trans-log production functions, these elasticities vary across both firms, products, and time. An average estimate of 0.533 (column 5) means that a 1 pct. increase in real material inputs (allocated to that particular product) will increase production by 0.533 pct. Taking output elasticities as a measure of production efficiency, the pattern across groups reflects that of marginal costs in the sense that output elasticities are increasing across columns.

As was the case for export sales and export prices, we have documented substantial heterogeneity in production efficiency across the four groups of firm-product-year triplets. Addressing these differences is key in our empirical analysis.

3 Empirical Strategy

In this section we first explain how we identify the effect of export promotion on export values and prices. We then outline several mechanisms through which export promotion might work and explain the empirical strategy to examine these.

3.1 Empirical Models and Predictions

Let $TCS_{fdy} = 1$ if firm f received trade council services to promote exports to destination d in year y, in year $y-1$, or, both (Broocks and Van Biesebroeck, 2017). Let $Exports_{fpdy}$ and $Price_{fpdy}$ be the firm's f.o.b. export value and price of product p realized in destination d in year y. To examine effectiveness of export promotion to increase exports our baseline empirical model relates export values to export promotion

$$ln(Exports_{fpdy}) = \beta_0 + \beta_1 TCS_{fdy} + FE + u_{fpdy}, \quad (1)$$

where FE is a set of fixed effects which we specify below. The parameter of interest is β_1. Based on the existing literature we expect that export promotion raises export values.

To examine the effect of export promotion on prices we relate unit values to export promotion

$$ln(Price_{fpdy}) = \gamma_0 + \gamma_1 TCS_{fdy} + FE + v_{fpdy} \quad (2)$$

Our parameters of interest, γ_1 and β_1, capture the effect of export promotion on export values and prices. Given the log-separability of unit values, the total effect on sales, β_1, decomposes into the price effect, γ_1, and the residual quantity effect, $\beta_1 - \gamma_1$.

According to the literature the effect of export promotion on prices is ambiguous. Given that we strongly anticipate that export promotion increases export sales ($\beta_1 > 0$), the effect on export prices (the sign of γ_1) is informative of the underlying mechanisms through which export promotion boosts sales. If firms, upon purchasing export promotion, engage in innovation and update technology to lower marginal cost (Bustos, 2011; Lileeva and Trefler, 2010), we expect exporters to reduce prices, that is $\gamma_1 < 0$. In this case, the increase in sales is, to some extent, caused by higher demand due to lower prices. On the other hand, if firms, upon purchasing export promotion, engage in costly quality upgrading (Rodrigue and Tang, 2019), we expect exporters to increase prices, that is $\gamma_1 > 0$. In this case, the increase in sales is, to some extent, caused by higher demand due to higher product quality. Finally, export promotion may be considered a strategy to increase foreign demand through advertising, marketing efforts and matching with new buyers without affecting marginal costs of supplying the foreign market. In that case export promotion is akin to a marketing strategy that expands demand on the foreign market without affecting prices (Arkolakis, 2010; Fitzgerald et al., 2016), in which case we expect $\gamma_1 = 0$. We will refer to the latter case, where exporters expand despite unchanged prices, as an increase in *perceived* product quality, which can be interpreted broadly as an increase in product appeal, visibility, or popularity.

3.2 Identification

The promotion indicator varies across three dimensions: firms, destinations, and years. Within destination-year pairs, not all firms necessarily purchase promotion. Within firm-year pairs, firm do not necessarily purchase promotion for all destinations. Within firm-destination pairs, firms do not necessarily purchase promotion for all years. Our parameters of interest, $\beta_1 \times 100$ and $\gamma_1 \times 100$, translate this variation in the promotion indicator into percentage changes in export values and prices.

In order to identify the causal effects we must address the natural endogeneity concern: Exporters may self-select into export promotion based on unobservable information that is also systematically related to export performance. We address this challenge in two steps. First, we apply a high-dimensional fixed effects strategy to effectively control for several dimensions of unobserved supply-side and demand-side heterogeneity. Second, we introduce an exogenous instrument based on the Trade Council's (TC) strategy to distribute export promotion services across firms. We discuss the two steps in more detail.

We address unobservable exporter characteristics using fixed effects. For example, Holmes and Stevens (2012) shows that firms with high scale invest to reduce distance and border costs. Consequently, highly productive firms, or firms highly productive in certain products, may be more likely to engage in actions to reduce trade costs. In this case, we would expect a positive bias in the estimated effect on sales. Across several specifications we use firm-year, firm-product, and firm-product-year effects to account for productivity and heterogeneity in marginal costs of production. For example, conditional on firm-product-year fixed effects, the identifying variation in promotion purchases arises from comparing changes in export flows to treated destinations with changes in export flows to non-treated destinations for the same firm, product, and year.

If scale is relevant to self-select into export promotion, then we expect that firms are more likely to invest in destinations that have sufficient scale to recover the investment. In this case, we would expect a positive bias in the estimated effect on sales. We address this unobserved demand side heterogeneity across several specifications with firm-destination, destination-year, firm-product-destination and HS6product-destination-year fixed effects. For example, conditional on firm-product-destination fixed effects, the identifying variation in promotion purchases arises from comparing changes in export flows in treated years with changes in export flows to non-treated years for the same firm, product, and destination. In addition to accounting for changes in product level demand across destinations, these fixed effects also account for export costs across markets and unobserved changes in trade policy. For example, imagine that China increase non-tariff barriers in certain products relative to other export destinations and Danish firms purchase information to navigate these changes. Then, more restrictive trade policies are correlated with self-selection into export promotion. In this case, we would expect a negative bias in the estimated effect on sales. The HS6product-destination-year fixed effect accounts for this source of variation by restricting the identifying variation to differences between treated and un-treated firms exporting similar products to the same destination in the same year.

In all of our specifications we account for heterogeneity across products. These fixed effects account for unit differences in prices. For example, some products may be more appropriately measured in piece counts while other may be measured in gallons. As long as the conversion of these units to weight is stable, product fixed effects account for this measurement problem.

The more rigorous the fixed effects, the more limited is the variation we exploit to identify the coefficients. Examining changes in coefficient estimates due to the inclusion of fixed effects and changing identification samples, we determine our preferred specification, which includes firm-product-year, firm-product-destination, and destination-year fixed effects. To our knowledge, this is the most rigorous fixed effect strategy to identify promotion effects in the existing literature.

If, despite our rigorous fixed effect approach, selection of firms into export promotion is still endogenous due to time varying information we can't control with fixed effects, then only randomization will break the endogeneity. It is unclear which way the bias would go. Firm's may have information about future success that leads them to approach the council to deepen their export experience. If they are right, then trade council services are associated with greater export performance generating positive bias. On the other hand, Van Biesebroeck et al. (2016) argue that export promotion may be particularly effective in downturns and provide evidence that export promotion helped Belgian and Peruvian firms during the global recession. Therefore, firms concerned about their future success on export markets may be more likely to approach the council for help, leading to a negative bias. It is challenging to predict which way the bias goes, because firms may self-select for both of these reasons. Unfortunately, we do not have the ability to randomly select firms for export promotion, but the trade council data provides us with a similar experiment.

The TC approaches firms to advertise its services. For each firm-destination-year observation in our data we observe if the firm approach the TC, or, if the TC first approached the firm. In our data, among all treated firm-destination-year observations about 50 percent were initiated by the TC, and among all untreated observations less than 1 percent were approached by the TC (Table 2). This means that most approached firms take up the service reflecting that the price is low and heavily subsidized. Let $z_{fpdy} = 1$ if the TC approached a firm for promotion services and zero otherwise. Then, z_{fpdy} is a valid instrument if it predicts the treatment indicator and is exogenous conditional on fixed effects.

The TC approaches firms based on industry, firm, and destination-specific information. For example, they see whether products are selling well in certain destinations and approach firms that produce such products. They may observe basic firm characteristics such as size to predict who may be interested in services. Conditional on that, case workers just call firms up to promote their services (the list of all Danish firms by industry is publicly available at cvr.dk). In our empirical model we account for a much wider range of unobserved firm, product and destination characteristics. To our knowledge, the trade council does not have more information than we do to predict success in export markets. Therefore, conditional on our fixed effects, the Trade Council attempt to approach firms for services is as good as random. Then, as long as z_{fpdy} predicts the promotion indicator, the trade council approaching firms for services is a valid instrument to break any remaining endogeneity.

To examine the validity of our identification assumptions we examine both the treatment and the instrument for pre-trends. As a straight forward placebo test we predate treatment to the year before the actual treatment and estimate our baseline regressions. We also predate our instrument and estimate the baseline using two stage least squares. In both cases we expect that treatment does not affect export sales. Otherwise, sales and/or prices would be predictive of treatment. Next, we examine if the instrument is directly associated with export sales before treatment. We predate z_{fpdy} by one period and examine if the TC's approach of firms was associated with export performance in the previous period. Specifically, we follow (Autor, 2003) and include both leads and lags of the treatment indicator to our model. This allows us to examine potential dynamic effects of export promotion and rule out pre-trends.

3.3 Product-Level Heterogeneity

International trade is dominated by multiproduct firms that optimize across their product mix (Bernard et al., 2010; Eckel and Neary, 2010; Eckel et al., 2015). If firms sell multiple products within each destination, then specifying the treatment indicator at firm-destination-year level potentially ignores two sources of heterogeneity.

First, if promotion is destination-product specific, then a firm may ask for services as part of the learning process to successfully establish a low performing product in the export market (Timoshenko, 2015). In that sense, export promotion can be considered a subsidy to maintain export markets and avoid early exit (Arkolakis et al., 2018). In that case, for multiproduct firms, the treatment indicator is mis-measured in that it assigns treatment to all of a firm's products in a given destination even though the firm only purchased services for a particularly low performing product. Alternatively, export promotion may be an investment strategy to lower trade costs for products that have sufficient scale to recover fixed costs from these investments (Holmes and Stevens, 2012). In this case, firms demand export promotion services for their high performing products, but the promotion indicator considers all of the firm's products within the destination treated.[8]

Second, even if promotion is at the destination level, then it may not be equally effective across all products. For example, a firm may receive intelligence on import permits and customs valuation, but not all products the firm sells may be equally subject to the same regulations (Bowen and Crowley, 2016).

We distinguish core products by export performance and within the firm as a whole to examine if export promotion is a mechanism firms use to more actively promote their core competence on foreign markets. We then estimate our baseline models with an interaction term between the treatment indicator and an indicator that equals one if the product is a core product for the firm. We also estimate our baseline empirical models on the sample of core products to examine firm's use and effectiveness of export promotion across core and non-core products.

3.4 Substitution

Rotemberg (2018) examines the effects of subsidies for small firms on sales. He shows that subsidies determine firm-level sales via two effects, a direct effect and a competition effect. In this set-up, if individual firms' treatment does not affect the destination market as a whole (the standard monopolistic competition assumption), then the direct effect captures export promotions ability to reduce trade distortions and increase exports. However, if only few firms compete on the destination market, or, treated firms are large compared to other firms, then export promotion reduces the average price in the market, making the market more competitive. In that case, not only do treated firms gain sales due to mitigated trade distortions, non-treated competing firms lose sales because market prices drop compared to their own prices.

This creates a challenge for identification and effectiveness of export promotion. From an identification point of view this results is a violation of he stable-unit-treatment-value assumption (Rubin, 2005). We examine these indirect effects in several ways.

If the direct effect is the main coefficient of interest, then a simple solution is to include destination-product-year fixed effects as we have in our most rigorous specification. If sufficient variation remains to identify the model, then these fixed effects account for average prices in the destination market. This solution is straightforward, but not satisfying if

[8]While the actual fixed costs of export promotion are subsidized and likely too small to justify such a mechanism, the more substantial cost may be in implementing and executing and export strategy based on the received information. Both are required for export promotion to be effective.

the concern is whether export promotion raises exports as a whole. For example, the fixed effect specification does not tell us whether the direct effects come at the cost of reducing export sales of competing non-treated Danish firms. To examine this we develop an alternative strategy.

We directly examine if treatment of some firms reduced sales of non-treated firms in the same destination market. To do this, we drop the treated trade flows. Then, within a product-destination market in a given year, we assign a treatment indicator equal to one to all the untreated flows within that product-destination combination, if an actually treated flow exists in that destination of that product. In other words, we are testing the performance of non-treated flows in treated product-destination markets. If the treated flows are large relative to the total market, then, based on Rubin (2005) we expect a negative sign such that treated flows crowd out existing non-treated flows. If treated flows are small relative to the total market, then we expect no effect.

3.5 Mechanisms

In the previous subsections we discussed identification of the effect of destination-specific export promotion on export sales and prices across products and destinations. Next we use structural estimates at the firm-product-year level for marginal costs and its components to further distinguish mechanisms through which export promotion works. Based on the discussion from the previous sections there are several cases to distinguish.

Eckel et al. (2015) show that firms' core competency may be characterized by their high quality product. Rodrigue and Tang (2019) show that firms invest into quality to grow their export markets. If export promotion supports firms' effort to produce and sell higher quality products on foreign markets, then in this case we expect that positive export promotion effects go along with higher prices and higher marginal costs of production.

Alternatively, Eckel and Neary (2010) argue that firms' core products are characterized by their high productivity. Bustos (2011) shows in theory and empirics the liberalization of export markets leads firms to invest to lower marginal costs of serving the foreign market and increase export sales. Therefore, if export promotion supports firms investments to upgrade productivity and increase export sales, then we expect that positive export promotion effects are associated with lower prices, higher productivity and lower marginal costs.

Rotemberg (2018) shows that if subsidies mitigate distortions, then this results in lower prices. However, if these distortions are not captured by input prices and observed inputs, then marginal costs are unaffected. Therefore, if export promotion is a policy to mitigate export related distortions, then we expect that export promotion allows firms to lower prices in destination markets to increases sales with constant or lower marginal costs.

Instead of affecting the cost and production structure of exporting firms, export promotion may simply be a way to increase demand without much effect on marginal costs and prices (Arkolakis, 2010; Fitzgerald et al., 2016). For example, export promotion may let the firm reach more consumers through e.g. trade fairs or additional partner matches. In this case we expect that export promotion raises sales without effects on marginal cost and prices. If marginal cost adjust along without associated changes in prices, then export promotion results in markup changes as a consequence of advertising or marketing activity.

4 Results

In this section we discuss our regression results. We start with the effect of export promotion on export values and prices. Next we examine the effect of export promotion on marginal costs and its components.

4.1 Export Promotion, Exports, and Prices

Table 4 reports estimates for both of our main empirical models applying OLS and Two-Stage-Least-Squares estimators. In addition to estimates and standard errors clustered at the firm-destination-year level, the bottom panel reports the fixed effects included in each specification. First stage statistics support our instrumental variable approach.

Focusing on OLS estimates, as expected, columns 1 to 7 show that export promotion has a positive and significant effect on export values. Across the columns destination-year, firm-destination, firm-year, firm-product, product and product-year fixed effects account for unobserved destination-specific heterogeneity, product characteristics at the firm level, and firm productivity. In the last three columns we estimate with firm-product-destination, firm-year, firm-product-year, destination year and industry-destination-year fixed effects. These specifications allow for heterogeneity in productivity across firms and products. More importantly, they account for unobserved heterogeneity in trade frictions across destinations and products that could be correlated with firm's self-selection to purchase trade promotion. The specification in column 7 even accounts for unobserved changes in industry-specific trade policy over time within destinations and 6-digit HS industries. Across these specifications the estimates are remarkably stable and imply that export promotion raises export values by about 3.5-5 percent. For the average Danish exporter, this is equivalent to a revenue boost of around 3-400 thousand DKK.

Recall that in our empirical model export values are exactly log separable into quantities and prices. Below the results for export values, the OLS estimates show that export promotion does not affect prices. Therefore, the effect of export promotion on export values must be driven by an increase in the export quantities at constant prices.

Below the OLS estimates we report our instrumental variable estimates. Compared to the OLS estimates, the export promotion effects on export values and prices increase. Based on these results we conclude that if self-selection is an issue, then it seems to be lower performing firms and firms realizing lower prices on export markets that seek help from the Trade Council. Once we account for this selection using our instrument, the effect of export promotion on export values increases. The First-Stage statistics reported at the bottom of Tables 4 confirm that the instrument is predictive and not weak.

The weak IV estimates on export prices show that most of the export value effect is still due to an increase in export quantities. However, column 6 shows that about a third of the export value effect is due to a higher export prices significant at the 5 percent level, but the effect becomes insignificant when we focus identification on variation within destinations and industries in column 7. In this case, promotion effects are identified from comparing products that are treated with export promotion, to similar products within the same industry sold in the same destination in the untreated control group. Compared to column 6, the effect of promotion on prices drops by half and the standard error increases resulting in insignificant estimates. This difference in estimates may be due to two reasons. First, the more rigorous fixed effects account for important unobserved heterogeneity. Second, the significant change in sample size. To examine what is driving the effect we estimated the specifications in columns 5 and 6 on the sample of column 7. We observe that specifications 5 and 6 produce similar estimates as specification 7 over that same sample. Therefore, we conclude that the change in estimates is due to sampling and we will focus on specifications 5 and 6 to maximize our variation and sample size.

Consequently, we conclude that for the most part the positive effect on export values is consistent with export promotion driven shift in demand, and, if anything, export promotion leads to somewhat higher prices. This addresses the potential policy concern that perhaps export promotion is a government financed strategy to increase firm's competitiveness on foreign markets by lowering export prices. We will examine marginal costs, markups and quality estimates to further examine the mechanisms behind these export promotion effects. Before doing so, we will further examine the validity of our estimates regarding identification and interpretation of the estimates.

4.2 Parallel Trends

We now examine if firms that were approached by the trade council or purchased promotion services already had superior export performance before treatment, or, even before they were approached by the trade council. To examine these temporal effects of trade promotion, we augment models (5) and (6) of Table 4 with the lag and lead of the promotion indicator. The coefficient on the lag identifies if treatment in $y-1$ has a significant effect on exports in y. The coefficient on the lead, $t+1$, identifies if exports in period y that are treated with promotion in $t+1$ already outperform exports that are not treated with export promotion. To examine pre-trends in the trade council's approaching of firms with export promotion services we repeat the same estimation, but replace the treatment indicator with our instrument. Finally, to examine validity of our instrumental variable approach, we repeat the estimation, but replace the treatment indicator with predicted treatment from the first stage in the instrumental variable regression. In the absence of pre-trends, we expect the coefficients on the lead variables to not significantly affect export values and prices in period y. Table 5 reports the results.[9]

The top panel of columns 1 and 2 of Table 5 reports the effects of actual treatment with export promotion in periods, $y-1$, y and $t+1$ on log export values in period y. Trade flows treated in period t+1 do not show systematically different export performance in period y before they receive promotion.[10] Therefore, we rule out that treated firms were already outperforming non-treated firms before receiving promotion services. Furthermore, export promotion in period y increases export performance in period y. However, this effect is temporary, as export performance in t of trade flows that were treated in t-1 are not significantly different from non-treated flows.

The middle panel of columns 1 and 2 of Table 5 reports similar results as the top panel, but where we replace actual treatment with our instrument, an indicator that equals 1 if the firm was approached with an offer of promotion services for a given destination and year. Again, the results show that trade flows in period y that are approached in period $t+1$ do not outperform other trade flows. We also note that trade flows approached in period y do weakly outperform other flows and trade flows approached in $y-1$ significantly outperform trade flows in period y. This pattern is reasonable. It likely takes some time between being approached with trade promotion services and actual treatment (even if both occur within the same year). As a consequence these effects take longer to materialize than actual treatment with promotion. This justifies our application a treatment indicator that spans two time periods in the main regression results.

Finally, we replace the treatment variable and the instrument with the prediction from the first stage of the IV regression. This prediction can be interpreted as the likelihood of receiving treatment, having been approached by the trade council. Similar to the instrument itself, the results do not provide evidence for pre-trends and the effects take some time to kick in.The bottom panel of columns 1 and 2 of Table 5 report these results.

Furthermore, coefficients based on predicted treatment in the bottom panel are higher than actual treatment in the top panel of Table 5. This confirms our intuition from the main estimation results that the instrument solves a negative

[9]For these regressions, the treatment indicator TCS_{fpdy} is simply equal to one (for all p) if firm f purchased promotion services for destination d in year y, that is $TCS_{fpdy} = d_{fdy}$, *not* $TCS_{fpdy} = \max(d_{fd,y}, d_{fd,y-1})$ as is the case for the main regressions reported in Table 4.

[10]Adding further leads thus not change this conclusion, but drops a significant part of the sample as we require that firms are active on the same export market in these consecutive time periods.

selection bias. Underperforming trade-flows self-select into promotion resulting in a negative bias in OLS estimates. The estimates in the bottom panel are also greater than in the middle panel. The reason is that the middle panel essentially reports intent-to-treat estimates. Not all firms that are approached by the trade council actually take up services. If export promotion is performance improving, this creates a negative bias that is resolved in the instrumental variable estimates in the bottom panel.

In summary, the first stage statistics and the results in Table 5 support our identification assumptions. Firms' purchasing of promotion services and the trade councils approach of firms to sell services is independent of pre-existing trends.

In columns 3 and 4 of Table 5 we repeat the same examination of pre-trend for export prices. The top panel shows that treatment in period t+1 is not systematically associated with prices in period t, confirming that there are no systematic differences in prices between treated and untreated firms immediately before treatment. The contemporaneous effect of treatment on prices is also not significant. However, treatment in period t-1 significantly raises prices in period t.

In the middle panel and bottom panel of columns 3 and 4 show a similar pattern for firms that were approached by the trade council and predicted treatment. There is no pre-treatment effect and contemporaneous effect. However, in both cases the lagged effect doubles in magnitude and are just marginally insignificant in the most rigorous specification in column 4.

Overall we conclude that we do not find evidence for pre-trends in export values and prices and that export prices show lower export promotion effects that are slower to respond to treatment compared to export values.

4.3 Multi-Product Firms

Next we examine potential heterogeneity in export promotion effects across firms' products. We have two objectives. First, most of international trade is driven by multi-product firms and we want to understand how these firms may use export promotion across their product mix. Second, to examine mechanisms in later sections we must assign the observed firm-destination-year specific treatment at the firm-product-year level. For firms that export multiple products to a treated destination, and, firms that export multiple products across destinations this section will facilitate our approach to identify promotion effects on firm-product level mechanisms in later sections.

In Table 6 we define a firm's core-export product as the product that has the greatest total export sales over our sample period. We then augment our baseline specifications with an interaction term of promotion with an indicator that equals one for a firm's core product. A given firm may export its core product and several non-core products to a treated destination. On the other hand, a given firm may export its core product to a treated destination and a non-core product to a different treated destination. Therefore, within treated destinations and across destinations, if the interaction effect is positive, then core products have greater treatment effects relative to non-core products.

Columns 1 and 2 of Table 6 show that in OLS regressions export promotion has a positive and significant direct effect. The interaction terms are small and insignificant. Results in columns 3 and 4 show that as we instrument for both, promotion and the interaction of promotion with the core indicator, the direct effects increase in magnitude, and the interaction effects remain insignificant.

Next we split our sample to allow for even more heterogeneity while examining promotion effects on core products. Columns 5 and 6 report OLS and IV results when we estimate promotion effects over the sample of firms' core products. These total effects for core products are significant and similar in magnitude to the total promotion effects over the whole sample estimated in Table 4.

Nocke and Yeaple (2014) model firms marginal costs of supplying a product as a function of managerial or organizational capital. There is a trade-off as expanding with one product requires reallocation of managerial capital at the expense of higher marginal production costs of other products. Therefore, within destinations, as firms focus on their core products, this could imply that firms drop non-core products to reallocate managerial capital across products to support their core competencies.

Table 7 reports results where we regress the number of of products a firm exports at the destination-year level on export promotion. According to OLS and IV estimates, we do not find significant effects on the product mix.[11]

We draw several conclusions. First, within and across destinations, evidence shows that export promotion affects core and non-core products in similar ways. This is consistent with the standard modeling assumption that trade costs are similar across these products.

Second, effects of promotion on the the number of products exported are not significant. Therefore, the promotion effects we report are due to export adjustments within the existing firm-destination level product baskets and not driven by attrition of low performing products. In the theory of Nocke and Yeaple (2014), export promotion is therefore consistent with an expansion of managerial export capital as opposed to a reallocation across products.

4.4 Substitution

Now we examine if treated flows affect untreated flows, or the stable unit treatment assumption. Within each product-destination market in any given year we drop the treated flows, but assign an indicator equal to one to the untreated flows if a treated flow exists within the given market. Then we estimate our baseline specification of export sales on treatment corresponding to columns (5) and (6) from Table 4. In this case, treatment effects are identified from within destination market changes in treatment status. Table 7 reports the results. Across all specification we do not find evidence that treatment affects untreated flows in a significant way. If anything, treatment raises exports of untreated flows. Therefore we conclude that export promotion leads to net trade creation and does not crowd out exports of non-treated firms.

4.5 Mechanisms

The results in the previous sections show that export promotion raises export sales and quantities, and has a weak positive effect on prices. Assuming that marginal costs are firm-product specific (De Loecker et al., 2016), with product-firm-year fixed effects any effect on prices corresponds to changes in markups. What we do not observe from the export data, however, is how marginal costs are affected by export promotion.

Table 9 examines the effect of export promotion on marginal costs, input expenditure shares, quantity produced, and the output elasticity of materials. The export promotion indicator is destination-specific. Therefore, at the firm level, we consider a product treated if it is exported to a destination for which the firm received treatment.

Columns 1 and 2 report estimates of export promotion accounting for firm-product and firm-year, firm-product and product-year fixed effects. The results show that export promotion is associated with an increase in production and expenditure shares. Therefore, export promotion is associated with specialization in treated products. The effects are large. Within firm-product and firm-year firm-product observations, export promotion raises output by up to 21 percent, which is significantly larger than what we see in the export results.

[11]Conclusions are similar if we use the log number of products as dependent variable.

There are several identification issues. At the firm product level the estimates combine the effect of export promotion on expanding existing export markets (the intensive margin) and entry into new markets (the extensive margin). In our export regressions we mostly focus on the intensive margin. Furthermore, exporters are more productive and, according to our definition of treatment at this level of aggregation, non-exported products cannot be treated. As a result, promotion may be correlated with firm-product pairs that constitute a large share of firm's total production.

To account for this, we augment the specifications in columns 1 and 2 with an export status indicator and a variable that counts the number of destinations to which a firm exports. Holding export status and the number of export destinations fixed, the promotion effects are then more aligned with the intensive margin effects in Table 4. Export promotion increases output of treated products between 3.5 and 5.5 percent. The IV estimates in column 5 shows a relatively large effect of 0.186, but this effect is also estimated with a relatively large standard error. Expenditure shares on treated products increase along with the increase in production. The production technology remains unaffected, as output elasticities remain unchanged. Combining all components, our evidence shows that export promotion leads to an increase in production of products that are exported to treated destinations. As the expenditure shares increase, this increase in production is associated with increased specialization. However, the increase in production and specialization does not significantly affect marginal costs of production, as we would expect if firms upgrade physical aspects of the product such as quality.

We do not report out the estimates on export status and number of destination markets.[12] However, the coefficients are as expected and significant. Exporters have lower marginal costs, greater expenditure shares and they produce more output. Firms that export a given product to more markets have lower marginal costs, greater expenditure shares and produce greater output of that product. In sum, firms with lower marginal costs are more likely to export and export greater quantities to more markets.

4.6 Export Promotion and Quality

The previous results show that export promotion is effective in raising export sales and that this effect is mostly due to increased export quantities with small positive effects on prices. Following De Loecker et al. (2016) we estimate marginal costs at the firm-product-year level. Therefore, the price effects we report in Table 4 from empirical specifications with firm-product-year fixed effects are appropriately interpreted as markup effects. We now combine these various margins to estimate the effect of export promotion on quality. To accomplish this we have to overcome two empirical challenges.

First, we need to measure quality consistent with variable markups. We use an approach developed by Forlani et al. (2016) and recently applied by Stiebale and Vencappa (2018). For a broad class of preferences including quadratic and generalized CES utility, firm-product-destination-year specific measure of log quality can be approximated as

$$\gamma_{fpdy} \approx \mu_{fpdy} p_{fpdy} + (\mu_{fpdy} - 1) q_{fpdy} \tag{3}$$

where, μ_{fpdy} is a measure of markups, p_{fpdy} is the log price and q_{fpdy} is the log quantity sold. As is standard in the literature on quality estimates mostly based on CES utility functions, implied product quality is measured as a weighted sum of quantities sold and the price obtained. With CES utility the weights are based on the constant elasticity of substitution (e.g. see Khandelwal (2010)). The generalized formula in (3) shows that greater quality is associated with greater markups that may vary over time, products and destinations. Using our detailed data on export sales and our

[12] Results are available upon request.

measures of marginal costs we combine the marginal cost estimates, mc_{fpt}, obtained from De Loecker et al. (2016) with export prices to compute $\mu_{fpdy} = \frac{p_{fpdy}}{mc_{fpy}}$. These markups turn out to be reasonable with a value of about 1.25 at the median. Substituting export prices and quantities in the above expressions we obtain a measure of log quality.

Second, to examine how export promotion affects quality, we want a sample of firm-product-destination-year observations in the export data that is tightly matched with marginal cost information from the production data. There are two challenges. Some products that are exported by Danish firms are not produced by Danish firms. This may be due to carry along trade (Bernard et al., 2019), or, misreporting of product codes. In addition, the output data necessary to estimate marginal costs in the production data does not always match the quantity measure in the export data. Conditional on both (observing the same products and quantity measure), we combine the export data with the marginal cost data to examine quality.

Table 10 reports OLS and IV estimates for the effect of export promotion on quality. For completeness, we also report effects on export prices and quantities over the limited sample. Both OLS and IV provide positive and statistically significant estimates. The IV estimate is larger in accordance with the larger effects on quantities and prices. The key difference for interpretation between columns 1 and 2 is the presence of the firm-product-year fixed effect. The firm-product-year fixed effect directly accounts for heterogeneity in marginal costs.[13] The quality estimate on both specifications identical. This suggests that adjustment in marginal costs do not affect the quality estimates. This is consistent with the results we report in Table 9 that show no effect of export promotion on marginal costs.[14] Therefore, while we do not find any significant effects of export promotion on marginal costs, the results do provide evidence that export promotion results in an increase in perceived quality by the buyers of the product.

The OLS results provide evidence that over the limited sample export promotion has a positive and significant effect on prices, but not on quantities. These results are not consistent with the baseline estimates in Table 4, where the effect on prices is small and export value effects are driven by quantity adjustments. A reason for this difference is sampling based on products and comparable quantity measures. However, the IV estimates are in line with the estimates in Table 4 and similar in magnitude.

5 Conclusions

A vast literature in international trade examines the effects of tariffs on trade flows, technology upgrading, quality upgrading, prices and markups. As average world wide tariffs have been decreasing, trade policies such as as export promotion, credits, trade missions, etc have become relatively more prominent. A substantial literature exists that examines the effectiveness of these export-support programs, but which existing mechanisms are relevant to interpret these policies from a theory point of view is still unclear. We know that export promotion affects the intensive and and extensive margin of firm-level exports. The question is why?

In this paper we take advantage of unique identification experiment provided by the operations of the Danish Trade Council. We combine this identification strategy with recently developed structural techniques to measure margins that are important to understand the effects of tariffs.

Our results show that export promotion raises the intensive margin of exports. The effects are small compared

[13] Up to the non-lineariy in the quality formula.

[14] We also examined the relationship between export promotion and marginal costs on the more limited sample we employ for the quality estimation. The conclusion is the same and available upon request.

to the existing literature, but nevertheless it is reasonable to proceed to examine adjustment margins. We find some evidence for dynamic price adjustments, but the majority of the effect seems to be due to increasing quantities.

Applying a new measure of quality, price, quantity and markup effects combine to a positive effect of export promotion on product quality. However, we do not find evidence that physical production costs respond to export promotion. Therefore, export expansions due to export promotion are akin to improved visibility captured as an increase in perceived quality (Arkolakis, 2010; Gervais, 2015).

Our approach provides guidance for future research on firm-specific trade policies that require self-selection. The evidence and magnitudes provide guidance to capture welfare effects within existing and new trade theories.

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Table 1: Firm sample

	Manufacturing firms w. employees		Restricting to promoted destinations		Restricting to firm-years in PRODCOM	
year	Export sales	N	Export sales	N	Export sales	N
2002	185	3,378	157	3,183	119	1,204
2003	188	3,381	158	3,182	120	1,214
2004	196	3,274	168	3,100	131	1,398
2005	216	3,221	184	3,030	151	1,386
2006	234	3,300	205	3,097	169	1,407
2007	249	3,288	221	3,063	134	1,135
2008	258	3,267	233	3,085	144	1,174
2009	228	3,188	201	3,007	130	1,177
2010	228	3,245	220	3,064	152	1,202
2011	260	3,223	251	3,071	197	1,364
2012	276	3,299	264	3,116	215	1,334
2013	276	3,385	262	3,188	212	1,381
2014	283	3,418	269	3,205	225	1,403
2015	276	3,420	261	3,231	214	1,402
Total	3,354	46,287	3,053	43,622	2,316	18,181

Unit of observation: firm-year. Export sales are measured in billion DKK. Firm-product-destination-year observations with a value of less than 7,500 DKK are excluded from all samples.

Table 2: Number of observations, across treatment and instrument

	Not promoted		Promoted		Total
	Not approached	Approached	Not approached	Approached	
2002	16,076	15	275	172	16,538
2003	16,373	27	254	214	16,868
2004	19,324	22	306	251	19,903
2005	19,493	30	251	234	20,008
2006	20,440	39	161	187	20,827
2007	17,867	26	125	133	18,151
2008	18,550	23	165	125	18,863
2009	18,545	15	129	175	18,864
2010	19,373	54	106	131	19,664
2011	21,436	39	135	151	21,761
2012	21,647	27	145	161	21,980
2013	22,043	49	106	159	22,357
2014	22,596	83	98	170	22,947
2015	22,738	141	89	155	23,123
Total	276,501	590	2,345	2,418	281,854

Unit of observation: firm-destination-year.

Table 3: Descriptive statistics, means and (standard deviations)

	Not promoted		Promoted		Total
	Not approached	Approached	Not approached	Approached	
Firm-product-destination-year level export data					
Export sales	2.352	3.546	4.016	6.258	2.495
	(24.855)	(41.107)	(26.213)	(71.500)	(27.211)
Export prices	0.000	0.119	-0.077	0.026	0.000
	(1.184)	(1.219)	(1.175)	(1.181)	(1.184)
N	834,055	4,957	19,463	22,480	880,955
Firm-product-year level production data					
Quantities	-0.140	0.359	0.645	0.889	0.000
	(2.213)	(2.087)	(1.910)	(1.889)	(2.196)
Prices	0.000	0.083	-0.013	-0.004	0.000
	(1.221)	(1.365)	(1.119)	(1.048)	(1.202)
Export status	0.617	1.000	1.000	1.000	0.675
	(0.486)	(0.000)	(0.000)	(0.000)	(0.468)
Marginal costs	0.043	-0.076	-0.193	-0.277	0.000
	(1.964)	(1.992)	(1.634)	(1.598)	(1.920)
Expenditure shares	0.333	0.423	0.337	0.320	0.332
	(0.394)	(0.413)	(0.390)	(0.382)	(0.393)
Output Elasticity	0.527	0.536	0.553	0.572	0.533
	(0.183)	(0.129)	(0.156)	(0.148)	(0.179)
N	41,940	503	2,172	4,842	49,457

In the top panel, the promotion indicator is defined as $TCS_{fpdy} = \max(d_{fd,y}, d_{fd,y-1})$, where $d_{fd,y}$ be a binary indicator that takes value one if firm f purchased promotion services for destination d in year y. In the bottom panel, the promotion indicator is defined as TCS_{fpy} that takes value one if $TCS_{fpdy} = 1$ for any d and zero otherwise. In both panels, the approach indicators are defined accordingly. In accordance with these definitions, data for 2002 is excluded. *Export sales* are in million DKK. *Export prices*, *Quantities*, *Prices*, and *Marginal costs* are in logarithms, then purged for product dummies. *Export status* is a binary indicator. *Marginal costs*, *Expenditure shares*, and *Output elasticities* are estimated. *Expenditure shares* is the share of firm-level input expenditures allocated to the given product. *Output elasticities* are the elasticity of output w.r.t. product-level material inputs.

Table 4: Export Value and Price Effects

Estimator	Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Export Value	0.0363***	0.0361***	0.0484***	0.0511***	0.0346***	0.0346***	0.0474***
OLS		(0.0119)	(0.0110)	(0.0118)	(0.0126)	(0.0120)	(0.0127)	(0.0181)
	Price	0.00372	0.00389	0.00566	0.00752	0.00102	0.00531	-0.0005
		(0.00727)	(0.00668)	(0.00580)	(0.00565)	(0.00571)	(0.00554)	(0.0093)
	Export Value	0.0582***	0.0518***	0.0770***	0.0772***	0.0635***	0.0636***	0.0709**
IV		(0.0221)	(0.0200)	(0.0215)	(0.0228)	(0.0229)	(0.0241)	(0.0337)
	Price	-0.008	0.00325	0.00681	0.0129	0.00875	0.0198**	0.00978
		(0.0128)	(0.0121)	(0.0106)	(0.0103)	(0.0105)	(0.0101)	(0.0166)
Observations		871,232	870,134	813,127	737,220	721,737	651,065	423,467
Fixed Effects		FD DY P	FY FD DY P	FY FP FD PY DY	FPY FD DY	FY FPD PY DY	FPY FPD DY	FPY FPD HS6DY
IV F-Stat		4,014	4,059	3,933	3,917	3,529	3,525	2,532

Unit of observation: firm−product−destination−year. Standard errors clustered at the firm−destination−year level in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table 5: Parallel Trends

Treatment	Effect on Export Values in period t		Effect on Export Prices in period t	
Purchased Promotion in:				
t+1	0.0177	0.0100	0.001	0.005
	(0.0160)	(0.0165)	(0.007)	(0.007)
t	0.0312**	0.0345**	-0.001	0.005
	(0.0158)	(0.016)	(0.007)	(0.007)
t-1	0.0234	0.0222	0.0126**	0.0132**
	(0.0144)	(0.0146)	(0.006)	(0.006)
Approached by Trade Council in:				
t+1	0.0183	0.013	0.009	0.006
	(0.023)	(0.023)	(0.009)	(0.008)
t	0.034	0.031	0.008	0.009
	(0.023)	(0.024)	(0.008)	(0.008)
t-1	0.044**	0.050**	0.018**	0.020**
	(0.021)	(0.021)	(0.008)	(0.008)
Predicted Treatment in:				
t+1	0.025	0.018	0.012	0.008
	(0.031)	(0.031)	(0.012)	(0.011)
t	0.046	0.043	0.011	0.012
	(0.032)	(0.032)	(0.011)	(0.011)
t-1	0.061**	0.068***	0.025**	0.028**
	(0.028)	(0.028)	(0.011)	(0.011)
Fixed Effects	FY FPD PY DY	FPY FPD DY	FY FPD PY DY	FPY FPD DY
Observations	379,577	355,216	379,577	355,216

Unit of observation: firm−product−destination−year. Standard errors clustered at the firm−destination−year level in parentheses.*** p<0.01, ** p<0.05, * p<0.1. All coefficients estimated with OLS.

Table 6: Export Promotion Effects on Core and Non-Core Products

	(1)	(2)	(3)	(4)	(5)	(6)
Estimator	OLS	OLS	IV	IV	OLS	IV
Sample		All Exports			Exports of Core Products	
Promotion	0.0351**	0.0351**	0.0673**	0.0673**	0.0476**	0.0835**
	(0.0137)	(0.0147)	(0.0264)	(0.0285)	(0.0194)	(0.0329)
Promotion	-0.003	-0.002	-0.018	-0.016		
×Core	(0.0227)	(0.0232)	(0.04)	(0.0413)		
Observations	721,737	651,065	721,737	651,065	162,833	162,833
Fixed Effects	FY FPD PY	FPY FPD	FY FPD PY	FPY FPD	FPY FPD	FPY FPD
	DY	DY	DY	DY	DY	DY
IV F-Stat(VB)			1257.7	1187.6		8,699

Core products are defined as the product with the largest export value within the firm−product pair across all sample years Standard errors clustered at the firm−destination−year level in parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table 7: Promotion Effects on Product Mix

	(1)	(2)	(3)	(4)
Estimator	OLS	OLS	IV	IV
Promotion	-0.0875	-0.0394	0.104	0.105
	(0.0710)	(0.0707)	(0.131)	(0.130)
Observations	251,552	251,552	251,552	251,552
Fixed Effects	FY FD	FY FD DY	FY FD	FY FD DY
IV F-Stat(VB)			11,741	12,030

Unit of observation: Firm−destination−year. Robust standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table 8: Substitution. Effects on sales by non-treated firms.

	(1)	(2)	(3)	(4)
Estimator	OLS	OLS	IV	IV
Promotion	-0.002	0.00913	0.0124	0.0228*
	(0.00625)	(0.00643)	(0.0125)	(0.0128)
Observations	682,516	614,313	682,516	614,313
Fixed Effects	FY FPD PY	FPY FPD	FY FPD PY	FY FD DY
	DY	DY	DY	
IV F-Stat(VB)			34,790	29,609

Unit of observation: Firm−product−destination−year. Standard errors clustered at the firm−destination−year level in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table 9: Mechanisms

Estimator	Dependent Variable	(1)	(2)	(3)	(4)
	Marginal Cost	-0.0229	0.0624	0.00867	0.0872*
		(0.0186)	(0.0450)	(0.0187)	(0.0452)
OLS	Expenditure Share	0.133**	0.283***	0.0727***	0.138***
		(0.0129)	(0.0269)	(0.0126)	(0.0252)
	Quantity	0.156***	0.210***	0.0360**	0.0548
		(0.0177)	(0.0473)	(0.0173)	(0.0466)
	Output Elasticity Materials	0.00198	-0.000500	-0.000562	-0.00347
		(0.00128)	(0.00290)	(0.00129)	(0.00297)
	Marginal Cost	-0.0772***	-0.0424	-0.0297	-0.0103
		(0.0298)	(0.0773)	(0.0305)	(0.0793)
IV	Expenditure Share	0.156***	0.414***	0.0546**	0.177***
		(0.0216)	(0.0461)	(0.0217)	(0.0435)
	Quantity	0.243***	0.432***	0.0463*	0.186**
		(0.0280)	(0.0821)	(0.0276)	(0.0813)
	Output Elasticity Materials	0.00216	0.00477	-0.000225	-0.000092
		(0.00208)	(0.00486)	(0.00216)	(0.00508)
Export Controls		No	No	Yes	Yes
Observations		47,085	24,606	47,085	24,606
Fixed effects		FP	FY FP PY	FP	FY FP PY
IV F-stat		7,405	1,886	6,757	1,727

The top and bottom 1 percent of the markup distribution are excluded to avoid outliers. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 The export controls include and indicator for export status and the number of destinations to which a firm exports each product.

Table 10: Quality Effects

	(1)	(2)
OLS		
Quality	0.360**	0.360**
	(0.167)	(0.164)
Price	0.0154**	0.0149**
	(0.00660)	(0.00662)
Quantity	0.0102	0.0143
	(0.0218)	(0.0217)
IV		
Quality	0.978***	0.889***
	(0.304)	(0.300)
Price	0.0221**	0.0214*
	(0.0111)	(0.0111)
Quantity	0.0962**	0.102***
	(0.0385)	(0.0383)
Observations	117,493	115,846
Fixed Effects	FY FPD PY DY	FPY FPD DY
IV F-Stat	2,835	2,823

Unit of observation: FPDY. Standard errors clustered at the FDY level in paranthese. * p<0.1, ** p<0.05, *** p<0.01.Top and bottom 3 pct. of quality estimates excluded as outliers. Average (median) markup is 2.43 (1.25).

A Estimation of Marginal Costs

In this section, we briefly outline the procedure for estimation of marginal costs at the firm-product-year level as suggested by De Loecker et al. (2016). The notation is adjusted to fit our particular data and empirical framework and, thus, is slightly less general than that used by De Loecker et al. (2016).

Assume that firm f produces product p in year y according to the production function

$$Q_{fpy} = F_p \left(L_{fpy}, K_{fpy}, M_{fpy} \right) \Omega_{fy}, \tag{4}$$

where Q_{fpy} is physical output, L_{fpy} is labor, K_{fpy} is capital, M_{fpy} is materials, and Ω_{fy} is total factor productivity. Notice carefully that the production technology is product-specific (but not firm-specific), whereas productivity is firm-specific (but not product-specific).

Assume that material input, M_{fpy}, is freely adjustable and can be chosen optimally by the firm in each year, whereas labor, L_{fpy}, and capital, K_{fpy}, are dynamic inputs that the firm takes as given in each year. Therefore, the firm's short-run cost-minimization problem w.r.t. optimal material input delivers the following optimality condition

$$\frac{\partial Q_{fpy}(\cdot)}{\partial M_{fpy}} \frac{M_{fpy}}{Q_{fpy}} = \frac{P_{fpy}}{\lambda_{fpy}} \frac{W_{fpy} M_{fpy}}{P_{fpy} Q_{fpy}}, \tag{5}$$

where P_{fpy} is the output price, W_{fpy} is the input price of materials, and λ_{fpy} is the Lagrange multiplier associated with the cost-minimization problem given some output level.

A key insight is that λ_{fpy} can be interpreted as the marginal cost of production, MC_{fpy}, which, therefore, can be expressed as

$$\begin{aligned} MC_{fpy} &= P_{fpy} \left(\frac{\partial Q_{fpy}(\cdot)}{\partial M_{fpy}} \frac{M_{fpy}}{Q_{fpy}} \right)^{-1} \frac{W_{fpy} M_{fpy}}{P_{fpy} Q_{fpy}} \\ &= P_{fpy} \left(\theta^M_{fpy} \right)^{-1} \alpha^M_{fpy}, \end{aligned} \tag{6}$$

where θ^M_{fpy} is the output elasticity w.r.t. material input, and α^M_{fpy} is material expenditures allocated to the production of product p as a share of total sales of product p. As P_{fpy} is observable, the challenge is to estimate θ^M_{fpy} and α^M_{fpy}.

Estimation of θ^M_{fpy} calls for the estimation of the production function F_p. Taking logs of equation (4) and adding a measurement error of output yields

$$q_{fpy} = f_p \left(x_{fpy}; \beta \right) + \omega_{fy} + \epsilon_{fpy}, \tag{7}$$

where x_{fpy} is a vector containing all inputs, and β are the parameters governing the production function. Specifically, following De Loecker et al. (2016), we assume that f_p takes a translog form.

Note that x_{fpy} is unobserved, as the allocation of inputs across products within the firm is unobserved, and given by $x_{fpy} = \rho_{fpy} + x_{fy} - w_{fpy}$, where x_{fy} is the firm level input (in practice, appropriately deflated observed material expenditures), ρ_{fpy} is the (unobserved) allocation of material expenditures within the firm, and w_{fpy} is the (unobserved) firm-product specific input price. Crucially, both ρ_{fpy} and w_{fpy} are assumed to apply to all inputs within the firm-product-year triplet. Now, equation (7) can be re-written as

$$q_{fpy} = f_p \left(x_{fy}; \beta \right) + A \left(\rho_{fpy}, x_{fy}; \beta \right) + B \left(w_{fpy}, \rho_{fpy}, x_{fy}; \beta \right) + \omega_{fy} + \epsilon_{fpy}. \tag{8}$$

First, the unobserved term $A(\cdot)$ arises from the unobserved input allocation parameters ρ_{fpy}. Second, the unobserved term $B(\cdot)$ arises from the unobserved input prices w_{fpy}. The functional forms of both terms are cumbersome, but follow directly from the assumed translog form of f_p. The objective is to estimate β. Standard methods of production function estimation address the endogenity arising from the fact that productivity, ω_{fy} is unobserved, but do not offer a way to handle the unobserved terms $A(\cdot)$ and $B(\cdot)$.

De Loecker et al. (2016) deals with the $A(\cdot)$ term by estimating β based on single-product firms only. This, however, potentially introduces a sample-selection problem because single-product firms are expected to be relatively un-productive, which is handled by explicitly introducing a control variable capturing the probability of remaining a single-product firm, closely resembling the correction for endogeneous firm exit in Olley and Pakes (1996). The $B(\cdot)$ term is handled by assuming that variation in *input* prices stems from variation in *output* quality and, thus, approximating input prices, w_{fpy}, by approximating output quality. We include a number of proxies, most notably output prices and market shares. Crucially, we assume that input prices are not a function of the level of input itself. This allows us to control for input prices and, still, identify β from f_p.

Now, having addressed the endogeneity concerns arising from the $A(\cdot)$ and $B(\cdot)$ terms, β is estimated by closely following the procedure proposed by Levinsohn and Petrin (2003), where unobserved productivity, ω_{fpy}, is controlled for by the inverted material demand function, and where moment moment conditions are based on the innovation in shocks to productivity. Specifically, we implement a GMM estimation procedure, as suggested by Wooldridge (2009), where moment conditions are formed on the joint error term of shocks to productivity and the measurement error in output, ϵ_{fpy}. β is estimated separately for the 21 sections into which CN8 product codes are categorized.

Together with estimates of β the procedure also delivers estimates of the parameters governing the assumed input price function, and these, as for β, apply to both single- and multi-product firms. Thus, estimated input prices for all firm-product-year triplets, $\hat{w}_{fpy}$, are available. Then, the input allocation parameters, ρ_{fpy}, are recovered in the following way. For a (multi-product) firm producing J products, we can recover the J unobserved input allocations and the unobserved productivity (ω_{fy}), realizing that $J + 1$ equations are available: one production function on the form (8) for each product, together with the fact that the input allocations should sum to one. This leaves one system of equations for each firm-year pair, which are solved numerically one by one.

Finally, having obtained estimates of w_{fpy} and ρ_{fpy} allows us to obtain estimates of physical product-specific inputs, x_{fpy}. Together with the estimates of β, this delivers an estimate of the output elasticities of material input, θ^M_{fpy}. Further, the estimates of ρ_{fpy} together with observables deliver an estimate of α^M_{fpy}. Estimates of marginal costs, MC_{fpy}, are then given by equation (6).

Chapter 3

Export Promotion: Market Demand and Entry Cost Effects

Export Promotion: Market Demand and Entry Cost Effects

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Abstract

This paper presents and structurally estimates a model of firms' decisions to purchase destination-specific export promotion services (EPS) and export. The model structure allows us to disentangle the dual effect of EPS on foreign demand and export costs. Using firm-level data for the Danish machinery industry, EPS are found to increase demand and substantially reduce costs for continuing exporters, whereas entry costs are unaffected. This finding is important for how policy-makers should adjust firm-specific trade policy. Using model simulations, we show that improving EPS, through a larger effect on demand, is a more efficient way to increase export participation and export revenue than reducing EPS prices.

Keywords: Firm-specific trade policy, Firm-level export data, Export demand

1 Introduction

Nearly all countries invest significant resources in promoting domestic products in export markets. Case in point: the Danish Trade Council has an annual budget of roughly DKK 400 million,[1] and hundreds of employees located at more than 100 embassies, consulates general, and trade commissions. Among its primary mandates, is the goal of growing Danish exports in foreign markets. This approach is hardly unique: targeted, firm-specific, and government-supported trade policy is a near ubiquitous feature of the global trading system.

Yet, until recently, there has been relatively little analysis of the benefits (or costs) of these common, and costly, programs. To our knowledge there does not yet exist any study that jointly estimates the impact that export promotion has on direct export costs alongside its impact on firm-level demand in targeted export markets. As such, this paper directly addresses this lingering question: *How* does export promotion jointly impact firm entry and growth? More specifically, how much of the benefit from export promotion can be attributed to boosting demand in export markets relative to reducing the firm-level cost of entry? Understanding the margins through which promotion operates and the degree to which its impact varies across heterogeneous firms and export regions is imperative for designing effective and efficient policy.

[1]This corresponds to approximately USD 65 million.

Early firm-level studies, such as Bernard and Jensen (2004) and Görg, Henry, and Strobl (2008), find little impact of state-level export promotion expenditures on export activity. A number of recent contributions use highly disaggregated promotion data, similar to that used here, to study the impact of firm-level trade policies on firm-level export outcomes (Volpe Martincus and Carballo 2008, 2010a,b,c; Van Biesebroeck, Yu, and Chen 2015). Munch and Schaur (2018) provide compelling benefits of promotion services are causal determinants of improved export success. Building on this work, Buus et al. (2019) demonstrate that, among Danish exporters, promotion primarily drives increases in quantity sold while leaving export prices and product characteristics largely unchanged.

At the same time, understanding the nature of firm-level export entry costs and how they influence firm-level exporting and growth has rich history in the international trade literature. Seminal contributions by Roberts and Tybout (1997), Clerides, Lach and Tybout (1998), and Bernard and Jensen (1999), among others, strongly indicate that proxies for firm-level entry costs are key determinants of the firm's decision to enter export markets. Das, Roberts and Tybout (2007) provide a methodology to quantify these costs and a long literature following this approach confirm (a) that export entry costs are indeed important determinants of firm-level entry decisions and (b) that the implied costs to the individual firm is often substantial. For example, Das, Roberts and Tybout (2007) find that the sunk cost of entering export markets for a new Columbian exporter can range between USD 344,000-430,000, which often constitutes a large portion of an exporter's annual revenue. We similarly find that fixed trade costs are large in Denmark, but further characterize the large discounts that accrue to firms through targeted export promotion services.

This last feature, either implied or explicit, is often a key justification for the existence of export promotion, export subsidization, and trade councils across the globe. It also highlights a key empirical challenge. Both the decision to export and purchase promotion are likely to be jointly determined and potentially endogenous to the evolution of firm-level characteristics, such as demand and productivity. For example, we might anticipate that firms which expect to export in the future might choose to purchase promotion services today in order to facilitate entry into export markets and boost initial demand. Our estimation approach accounts for the joint nature of these decisions and the dual impact they may have on firm primitives, such as demand, and the evolution for firm profits through time.

The natural complementarity between firm-level exporting and promotion is inherently related to research studying the impact of exporting and key firm-level investment aimed at growing firm-level profits. Recent research on export dynamics has emphasized the complementarity between investment and exporting activities. Costantini and Melitz (2008), Ederington and McCalman (2008), Atkeson and Burstein (2010), Lileeva and Trefler (2010), Bustos (2011), Kasahara and Lapham (2013) and Rho and Rodrigue (2016) highlight this link across firm-level decisions and emphasize the impact it may have on the evolution of firm-level outcomes over time. In particular, our approach closely follows the structure posited in Aw, Roberts and Xu (2011), with the exception that our findings highlight the impact of promotion on demand rather than firm-level productivity as in Rodrigue and Soumonni (2014). In addition to demand, we allow promotion to affect costs associated with exporting. Thus, our framework allows us to disentangle the potentially dual effects of promotion on the *demand* faced on a foreign market and the *costs* related to serving that market.

Our estimation shows that purchasing EPS boosts demand by around 3 percent in the subsequent year. The estimated effects of promotion on fixed and sunk export costs, respectively, differ greatly. First, promotion does not lower sunk export costs at all, that is promotion does not provide an advantage to entering firms (beyond the effect on demand). Second, promotion lower fixed export costs substantially, that is promotion provides a large advantage for continuing exporters. To examine the importance of export promotion in terms of export participation and export revenue across regions, we simulate restricted versions of the model where the effectiveness of promotion is limited in different ways.

The simulations show, unsurprisingly, that less effective promotion services implies that fewer firms will purchase them. However, the negative impact on export participation rates *exceeds* the negative impact on promotion take-up rates. That is, the presence of promotion services have implications beyond the firms that actually take advantage of these. This is because firms take into account the *possibility* to purchase promotion in the future—and the benefits it implies—when making their export choice. This means that the value of export promotion services, and firm-specific trade policies more broadly, cannot be evaluated properly based only on acquiring firms.

Unlike preceding work on export promotion, disentangling the joint decisions to acquire promotion and export allows us to address a host of unanswered, policy-relevant questions. For instance, it is not obvious that even with significant promotion-driven export growth that this class of policies are an efficient mechanism through which governments increase aggregate export sales. Given the cost of exporting, export promotion agencies generally subsidize revenue-generating activities in which profit-maximizing firms would not otherwise engage. Since export promotion is most commonly financed by taxpayers, at a bear minimum we might expect reasonably suspicious policymakers to be hesitant to transfer funds from citizens to firms without a full accounting of all of the costs and benefits associated with these policies.

Our counterfactual experiments allow us to directly characterize the impact on Danish exporters of (i) a reduction in costs of acquiring export promotion services and (ii) an increased focus on boosting firm demand. For each export market under study we quantify the impact that a 25 percent reduction in promotion costs and a doubling of promotion effectiveness on foreign demand, respectively, have on the endogenous uptake of promotion services, observed export rates, and the value of sales in targeted export markets. In this sense, our study is the first to provide a dollar-value on the benefits of targeted trade policy. Our approach allows us to characterize the types of firms which respond to these changes (e.g. small vs large firms) and account for the gains in export sales which accrue to Denmark both immediately and in the long-run. Within this framework, we can also quantify, e.g., the cost of a one percentage point increase in exporting through the Danish Trade Council. However, we postpone such cost-benefit analyses to future versions of this project.

In a nutshell, both policy experiments—reducing costs of acquiring promotion and increasing the effect of promotion on demand—imply higher take-up rates of promotion, higher export participation, and higher export revenue. Neither are surprising. Though the experiments can seem more or less equivalent, our simulations highlight that the implications differ significantly. Whereas reducing the price of promotion does incentivize some non-exporters to enter new export markets, many existing exporters will acquire promotion simply to lower their (fixed) export costs and increase profits. On the other hand, our simulations show that improving the effect of promotion on demand will increase export participation and total export revenue *beyond* the effect of cheaper promotion *without* giving rise to larger quantities of promotion sold. If policy-makers are considering to expand their effort through firm-specific trade policies, these simulations suggest that improving the quality of these services outperforms the alternative of simply lowering the price.

The remainder of the paper is structured as follows. Section 2 outlines the model. Section 3 describes the estimation procedure, and Section 4 presents the data. Section 5 summarizes the empirical results, discusses model performance, and, lastly, conducts two counterfactual policy experiments. Section 6 concludes.

2 Model

We present a structural model of export entry decisions and export promotion purchases by heterogeneous firms. The model closely resembles those proposed by Das et al. (2007), Aw et al. (2011), and Rodrigue and Soumonni (2014), but adjusted to our purpose along two simple dimensions. First, export promotion purchases are allowed to affect export costs, and not just foreign demand as in Rodrigue and Soumonni (2014). Second, as export promotion services are destination-specific, in contrast to R&D investments in Aw et al. (2011) and abatement decisions in Rodrigue and Soumonni (2014), we extent the model to include multiple export markets.

2.1 Marginal Costs, Revenues and Profits

Firm i's short-run marginal cost function is:

$$\ln c_{it} = \ln c(k_{it}, \omega_{it}) = \beta_0 + \beta_k \ln k_{it} + \beta_w w_t - \omega_{it} \tag{1}$$

where k_{it} is the firm's stock of productive capital, w_t is the set of relevant variable input prices and ω_{it} is firm-level productivity. There are three typical, data motivated, assumptions on the cost function. First, each firm is a separate organizational entity, and each firm produces a single output which can be sold at home or abroad. Second, there are two sources of short-run cost heterogeneity: differences in firm-level capital stocks and productivity. Third, we assume that marginal costs do not vary with firm-level output. As such, demand shocks in one market do not affect the static output decision in the other markets.

Domestic and export markets are assumed to be monopolistically competitive in the Dixit and Stiglitz (1977) sense. However, we allow each firm to face a different demand curve and charge different markups in each market j where $j = 0$ denotes the domestic market and $j = 1, ..., N$ denotes individual export markets. Specifically, firm i faces the following demand curve q_{it}^j in market j:

$$q_{it}^j = Q_t^j (p_{it}^j / P_t^j)^{\eta_j} e^{z_{it}^j (d_{it-1}^j)} = \frac{I_t^j}{P_t^j} \left(\frac{p_{it}^j}{P_t^j} \right)^{\eta_j} e^{z_{it}^j (d_{it-1}^j)} = \Phi_t^j (p_{it}^j)^{\eta_j} e^{z_{it}^j (d_{it-1}^j)} \tag{2}$$

where Q_t^j and P_t^j are the industry aggregate output and price index, I_t^j is total market size and $\eta_j < -1$ is the elasticity of demand, which is constant. The individual firm's demand in each market depends on industry aggregates Φ_t^j, the elasticity of demand, its own price p_{it}^j and a firm-specific demand shifter $z_{it}^j(d_{it-1}^j)$. The firm-specific demand shifter $z_{it}^j(d_{it-1}^j)$ in turn depends on the firm's history of export promotion decisions d_{it-1}^j.

Each period firm i decides where to export, for which markets to purchase promotion services, and sets the price for its output in each market to maximize the discounted sum of profits. The firm's optimal price p_{it}^j implies that the log of revenue r_{it}^j in market j is:

$$\ln r_{it}^j = (\eta_j + 1) \ln \left(\frac{\eta_j}{\eta_j + 1} \right) + \ln \Phi_t^j + (\eta_j + 1)(\beta_0 + \beta_k \ln k_{it} + \beta_w \ln w_t - \omega_{it}) + z_{it}^j (d_{it-1}^j) \tag{3}$$

so that the firm's domestic revenue is a function of aggregate market conditions, the firm's capital stock, firm-specific productivity and firm-and-market specific demand. Market revenues depend on export promotion decisions through the markets-specific demand shocks d_{it-1}^j.

Both firm-specific productivity and the export demand shocks capture various sources of heterogeneity, and as such, it is important to interpret their effect cautiously. Specifically, we will rely on domestic revenue to identify firm-level productivity under the assumption that domestic demand shocks are zero, $z_{it}^0 = 0 \; \forall \; i, t$. In this case, the term ω_{it} captures any source of firm-level heterogeneity that affects the firm's revenues at home and abroad; this may be product quality, for example, but we will refer to it as productivity.

In this case export demand shocks, z_{it}^j for $j = 1, ..., N$, capture all sources of export revenue heterogeneity, arising from differences in either cost or demand, that are unique to a specific export market. We are particularly interested in identifying the component of the export demand shifter that depends on export promotion activities since a stated object of export promotion activities is to grow export sales. If firm-level export promotion activities improve product appeal or the efficiency with which the firm produces the "version" of the product for export, we cannot separately identify these effects without detailed data on the nature of export promotion itself. We will be more specific regarding the functional form of z_{it}^j in the following section.

The structure of the model allows us to calculate operating profits in each market, $\pi_{it}^j = -\eta_j^{-1} r_{it}^j(\Phi_t^j, k_{it}, \omega_{it}, z_{it}^j)$, and, as such, the short-run profits are observable with data on domestic and export revenues. These will be important for determining the export and program participation decisions described in the dynamic model below.

2.2 The Evolution of Productivity and Export Demand

We assume that productivity evolves over time as a Markov process that depends on lagged productivity and a random shock:[2]

$$\begin{aligned} \omega_{it} &= g(\omega_{it-1}) + \xi_{it} \\ &= \alpha_0 + \alpha_1 \omega_{it-1} + \xi_{it}. \end{aligned} \tag{4}$$

The stochastic element of productivity evolution is captured by ξ_{it}. We assume that ξ_{it} is an iid draw from a distribution with zero mean and variance σ_ξ^2. Note that the stochastic element of productivity is carried forward into future periods through the Markov process.

We also model the export demand shock as a first-order Markov-process which depends on both past export promotion activity and export decisions:

$$\begin{aligned} z_{it}^j &= h(z_{it-1}^j, d_{it-1}^j, e_{ijt-1}^j) + \mu_{it} \\ &= \gamma_0 + \gamma_1 z_{it-1}^j + \gamma_2 d_{it-1}^j + \gamma_3 e_{it-1}^j + \gamma_4 d_{it-1}^j e_{it-1}^j + \mu_{it} \end{aligned} \tag{5}$$

where d_{it-1}^j and e_{it-1}^j are binary variables that captures whether or not firm i purchased promotion services or exported to market j in year t, respectively, while μ_{it} is an iid shock to export demand, $\mu_{it} \sim N(0, \sigma_\mu^2)$.[3] The persistence in z captures factors such as the nature of the firm's product or destination markets that lead to persistence in export demand over time. The coefficient γ_2 captures any effect that export promotion has on export sales in the j^{th} export market. Likewise, γ_3 tests whether previous exporters in that market experience faster export demand growth than new exporters while γ_4 captures the complementarity or substitutability of export promotion and export experience in the j^{th} export market.

[2]We experimented with alternative structures for the productivity process in which productivity depends on lagged export status (as in theories of'learning-by-exporting') or lagged promotion status. These co-variates were not found to be statistically significant and, as such, are omitted hereafter for parsimony.

[3]We have restricted the parameters governing the export demand process to be the same across locations for parsimony. Allowing these to vary across locations is an issue we will explore in future versions of this paper.

The export demand equation is key, but also presents a unique challenge. Suppose there are learning-by-exporting effects that are particular to the export market. Omitting these terms may result in a positive estimate of γ_2, the export promotion coefficient, even if there is no actual impact of export promotion on export demand simply because export promotion and actual exporting are positively correlated. Including the export terms allows us to separately identify the promotion effect from other activities correlated with exporting. Separately identifying the export promotion and exports effects in equation (5) is difficult in a reduced-form context since all firms for which we observe positive export revenues in years t and $t-1$ (so that we have some information regarding z_t in consecutive years) must also have exported in year $t-1$ so that $e^j_{it} = e^j_{it-1} = 1$. As such we will not be able to use standard methods to separately identify γ_3 from γ_0 or γ_4 from γ_2.

As in Aw et al. (2011) and Rodrigue and Soumonni (2014) we will assume that capital is fixed over time for each firm i. Due to the short time series in our data, there is little variation over time in firm-level capital stock (particularly relative to the cross-sectional variation). We will, however, allow for cross-sectional variation in capital stock across firms. Last, we treat the aggregate state variables $\ln \Phi^j_t$ for $j = 1, ..., N$ as exogenous and assume that the firm expects that they will remain constant over time.[4]

2.3 Export Promotion and Exporting Decisions Over Time

We next consider the firm's dynamic decisions to purchase export promotion services and export. We assume that the firm first observes the fixed and sunk costs of exporting to market j, γ^F_{ijt} and γ^S_{ijt}, and decides whether or not to export in the current year. If the firm chooses to export and was an exporter in the previous year, it pays the fixed cost, γ^F_{ijt}. If the firm chooses to export but was *not* an exporter in the previous year, it pays the sunk cost, γ^S_{ijt}. Importantly, the value of these cost depend on the firm's past export promotion decision. If the firm purchased export promotion services last year, it only pays a fraction δ_F of the fixed export costs or a fraction δ_S of sunk export costs.[5] After making its export decision, the firm observes the fixed and sunk costs of participating in an export promotion program, γ^E_{it} and γ^D_{it}, and makes the discrete decision to purchase promotion services in the current year. Firms must pay the fixed cost if the participated in the previous year and the sunk cost if they did *not*. All fixed and sunk costs are assumed to be *iid* draws from the joint distribution G^γ.[6]

Denote the value of firm i in market j and year t before it observes fixed or sunk costs by V^j_{it}:

$$V^j_{it}(s_{it}) = \max_{e^j_{it}\in(0,1)} \left\{0, V^{Ej}_{it}(s_{it})\right\} \tag{6}$$

where $V^{Ej}_{it}(s_{it})$ is the continuation value of the firm:

$$V^{Ej}_{it} = \int \left[\pi^j_{it} - \delta_F^{d^j_{it-1}} e^j_{it-1}\gamma^{Fj}_{it} - \delta_S^{d^j_{it-1}}(1 - e^j_{it-1})\gamma^{Sj}_{it} + V^{Pj}_{it}(s^j_{it})\right] dG^\gamma \tag{7}$$

where s^j_{it} the state variables of the firm in market j, $s^j_{it} = (\omega_{it}, z^j_{it}, k_i, \Phi^j_t, e^j_{it-1}, d^j_{it-1})$, d^j_{it-1} and e^j_{it-1} capture the firm's past promotion and export decisions in market j, respectively, and V^{Pj}_{it} is the value of a firm which exports to market

[4]Allowing for for destination-specific trends trends in market size is an issue we will explore in future versions of this paper.

[5]Note that whereas fixed and sunk export costs are allowed to differ across regions, the effects of promotion on these costs are not. This model restriction is mostly motivated by identification issues, a point we elaborate on in Section 4.

[6]An alternative assumption is that the decision to export and the decision to adopt export promotion are made simultaneously. While this leads to a similar model, the computational difficulty associated with calculating the probability of each decision is substantially greater.

j after it making its optimal export promotion decision:

$$V_{it}^{Pj}(s_{it}^j) = \int \max_{d_{it}^j \in (0,1)} \Big\{ \delta E_t V_{it+1}^j(s_{it+1}|e_{it}^j, d_{it}^j = 1) - d_{it-1}^j \gamma_{it}^{Ej} - (1 - d_{it-1}^j)\gamma_{it}^{Dj}, \quad (8)$$
$$\delta E_t V_{it+1}^j(s_{it+1}|e_{it}^j, d_{it}^j = 0) \Big\} \, dG^\gamma$$

The net benefit (or loss) to export promotion and exporting, conditional on previous decisions, is embedded in the value functions. The tradeoffs facing the firms are captured in the expected future value of any possible choice:

$$E_t V_{it+1}^j(s_{it+1}^j|e_{it}^j, d_{it}^j) = \int_{\Phi'} \int_{z'} \int_{\omega'} V_{it+1}^j(s')dF(\omega'|\omega_{it})dF(z^{j\prime}|z_{it}^j, e_{it}^j, d_{it}^j)dG(\Phi^{j\prime}|\Phi_t^j) \quad (9)$$

Note that the domestic market is simply a special case of the foreign markets with the exceptions that firm-specific heterogeneity is embedded entirely in productivity, there are no sunk entry costs, and we abstract from promotion activities on the domestic market.

The model explicitly recognizes that current choices affect the evolution of firm and market-specific state variables and potentially influence future export and promotion decisions. For example, the return to export promotion depends on export decisions through the sunk cost associated with export behavior. Similarly, the return to exporting intuitively depends on the past promotion decisions which influence the path of export demand, the level of fixed and sunk export costs, and the sunk cost of acquiring promotion services. Using equation (8) we define the marginal benefit of export promotion in destination j as the difference in expected future returns between investing or not investing in promotion for any vector of state variables, s_{it}:

$$MBP_{it}^j(s_{it}^j|e_{it}^j) = E_t V_{it+1}^j(s_{it+1}^j|e_{it}^j, d_{it}^j = 1) - E_t V_{it+1}^j(s_{it+1}^j|e_{it}^j, d_{it}^j = 0) \quad (10)$$

As alluded to earlier, the difference in the marginal benefit of promotion between between an exporting firm and a non-exporting firm can be defined as:

$$\Delta MBP_{it}^j(s_{it}^j) = MBP_{it}^j(s_{it}^j|e_{it}^j = 1) - MBP_{it}^j(s_{it}^j|e_{it}^j = 0). \quad (11)$$

This difference will be positive if the return to promotion is higher for current exporters to destination j relative to firms that do not currently export to j. In this case, we expect that γ_2 and γ_4 in equation (5) are positive, suggesting complementarity between the decision to export and participate in export promotion.

Likewise, for any given state vector, the marginal benefit of exporting to country j can be defined as:

$$MBE_{it}^j(s_{it}^j|d_{it-1}^j) = \pi_{it}^j(s_{it}^j) + V_{it}^{Pj}(s_{it}^j|d_{it-1}^j, e_{it}^j = 1) - V_{it}^{Pj}(s_{it}^j|d_{it-1}^j, e_{it}^j = 0) \quad (12)$$

This reflects current export profits plus the expected gain in future export profit from being an exporter to country j. Analogous to the marginal benefit of promotion, the marginal benefit of exporting will depend on past export promotion decisions when there is a sunk cost to export promotion where $\Delta MBE_{it}^j(s_{it}^j) = MBE_{it}^j(s_{it}^j|d_{it}^j = 1) - MBE_{it}^j(s_{it}^j|d_{it}^j = 0)$ indicates the marginal effect of promotion on the return to exporting.

3 Estimation

We estimate the model in two steps; in the first step we employ control function techniques similar to Olley and Pakes (1996), Levinsohn and Petrin (2003), Doraszelski and Jaumandrau (2013), De Loecker et al (2016) and Gandhi et al. (2016) to recover the parameters of the revenue function and the evolution of productivity. In the second stage, we describe a Bayesian MCMC method to estimate the dynamic parameters and capture the impact of export promotion on export decisions over time.[7]

3.1 Markups and Productivity

As a first step, we recover an estimate of the markups in each destination, including the domestic market. Setting marginal revenue equal to marginal cost in each market we can write total variable cost, tvc_{it}, as a combination of domestic and export revenue to each location weighted by their respective elasticities:

$$tvc_{it} = \sum_j q_{it}^j c_{it} = \sum_j r_{it}^j \left(1 + \frac{1}{\eta_j}\right) + \varepsilon_{it} \quad (13)$$

where the error term ε_{it} captures measurement error in total variable cost. Estimating equation (13) by OLS we retrieve the estimate of η_j in each export market. We turn next to estimating the parameters of the productivity process.

Recall that the domestic revenue function is

$$\ln r_{it}^0 = (\eta_0 + 1) \ln \left(\frac{\eta_0}{\eta_0 + 1}\right) + \ln \Phi_t^0 + (\eta_0 + 1)(\beta_0 + \beta_k \ln k_{it} + \beta_w \ln w_t - \omega_{it}) + u_{it} \quad (14)$$

where we have added an iid error term to equation (3). The composite error includes both an iid component and firm-specific, time varying productivity: $-(\eta_0 + 1)\omega_{it} + u_{it}$. We rewrite unobserved productivity as a non-parametric function of observables that are correlated with it. Specifically, we consider firm-level demand for raw materials, m_{it}, and energy, n_{it}, as observables which are correlated with firm-level productivity innovations. As long as productivity shocks are not strictly Hick's neutral, the relative demand for m_{it} and n_{it} will not be a function of z_{it}, but will contain information on firm-level productivity.[8] As such, we write productivity as a function of input demand, $\omega_{it} = \omega(k_{it}, m_{it}, n_{it})$, and recast the domestic revenue function in (14) as

$$\begin{aligned} \ln r_{it}^0 &= \varrho_0 + \sum_{t=1}^{T} \varrho_t D_t + (\eta_0 + 1)(\beta_k \ln k_{it} - \omega_{it}) + u_{it} \\ &= \varrho_0 + \sum_{t=1}^{T} \varrho_t D_t + f(k_{it}, m_{it}, n_{it}) + v_{it} \end{aligned} \quad (15)$$

where ϱ_0 is a constant, D_t is a set of year dummies and we approximate $f(\cdot)$ by a fourth order polynomial of its arguments. We denote the fitted value of the $f(\cdot)$ function as $\hat{\varphi}_{it}$. According to our model the estimate of $\hat{\varphi}_{it}$ captures $(\eta_0 + 1)(\beta_k \ln k_{it} - \omega_{it})$ which is a function of capital and productivity. We estimate (15) by OLS, recover an estimate of the composite term, $\hat{\varphi}_{it}$ and construct a productivity series for each firm. Specifically, inserting $\hat{\varphi}_{it}$ into (4) we write the estimating equation

$$\hat{\varphi}_{it} = \beta_k^* \ln k_{it} - \alpha_0^* + \alpha_1(\hat{\varphi}_{it-1} - \beta_k^* \ln k_{it-1}) + \xi_{it}^* \quad (16)$$

where the asterisk indicates that the coefficients are scaled by $(\eta_0 + 1)$. Equation (16) is estimated by non-linear least squares and the parameters are retrieved given η_0.[9]

[7] Given the generalized type II Tobit likelihood function in our model, classical estimation techniques such as Maximum Likelihood Estimation often do not perform well. Hence we choose to use Bayesian MCMC methods to estimate the dynamic parameters of the model.

[8] Numerous studies find that technical change is not Hick's neutral. See Jorgenson, Gollop, and Fraumeni (1987) for an example.

[9] Standard errors are computed by bootstrapping over equations (13),(15), and (16).

3.2 Export Promotion Costs, Export Costs and Foreign Demand

The remaining parameters of the model are estimated using the discrete decisions for exporting and promotion. Given firm-level productivity series, $\omega_i \equiv (\omega_{i1}, ..., \omega_{iT})$ and the observed firm-level series for exporting $e_i^j \equiv (e_{i1}^j, ..., e_{iT}^j)$, export revenues $r_i^j \equiv (r_{i1}^j, ..., r_{iT}^j)$, and export promotion $d_i^j \equiv (d_{i1}^j, ..., d_{iT}^j)$ we can write the i^{th} firm's contribution to the likelihood function as

$$P(e_i^j, d_i^j, r_i^j | \omega_i, k_i, \Phi^j) = P(e_i^j, d_i^j | \omega_i, k_i, \Phi^j, z_i^{j+}) h(z_i^{j+} | d_i^{j-}, e_i^{j-}, de_i^{j-}) \quad (17)$$

where z_i^{j+} is the time series of export market shocks for firm i in years in which it exports, $d_i^{j-} \equiv (d_{i0}^j, ..., d_{iT-1}^j)$ is the sequence of lagged export promotion decisions, $e_i^{j-} \equiv (e_{i0}^j, ..., e_{iT-1}^j)$ is the sequence of lagged export decisions and $de_i^{j-} \equiv (de_{i0}^j, ..., de_{iT-1}^j)$ is their interaction. Equation (17) expresses the joint probability of discrete export and promotion decisions, conditional on export market shocks and the marginal distribution of z. In the empirical implementation, we simply take export and promotion decisions in year 0 as given.

Given the parameters of the export shock process we simulate exports shocks conditional on past decisions, construct the density $h(z_i^{j+} | d_i^{j-}, e_i^{j-}, de_i^{j-})$, and evaluate the likelihood function. Although we observe export and export promotion decisions in each year, we only observe information on export sales in years when the firm chooses to export. We use simulation based methods, described below, to separately identify the impact of previous export and promotion decisions on the evolution of export demand (γ_2, γ_3, γ_4) from the autoregressive coefficients (γ_0, γ_1) of export demand.

3.2.1 Simulating Export Shocks and Identifying Export Market Returns

Following the methodology of Das, Roberts and Tybout (2007) and Rodrigue and Soumonni (2014), we account for the history of export promotion and exporting on the firm's current export demand. Define the set of uncensored export demand shocks for firm i as

$$\begin{aligned} z_i^{j+} \quad = \quad & \Big\{ z_{it}^{j+} = \ln r_{it}^j - (\eta_j + 1) \ln \left(\frac{\eta_j}{\eta_j + 1} \right) - \ln \Phi_t^j - (\eta_j + 1)(\beta_0 + \beta_k \ln k_{it} + \beta_w \ln w_t \\ & -\omega_{it}); r_{it}^j > 0 \Big\} \end{aligned}$$

Let v_{it}^{j+} be the demeaned autoregressive export demand process

$$v_{it}^{j+} = z_{it}^{j+} - (\gamma_0 + \gamma_2 d_{it-1}^j + \gamma_3 e_{it-1}^j + \gamma_4 d_{it-1}^j e_{it-1}^j)(1 - \gamma_1)^{-1}$$

conditional on d_{it-1}^j and e_{it-1}^j. The component of export demand v_{it}^j is key to our analysis as it captures the portion of export demand that is carried forward from the previous period. Our model requires simulating these shocks in a fashion whereby they are consistent with the model's estimated autoregressive process and the firm-specific history of export and promotion decisions.

To derive the density function of the uncensored export demand shocks we assume that the z_{it}^j process is in long-run equilibrium. The transition density of z_{it}^j then implies that

$$z_{it}^{j+} | d_{it-1}^j, e_{it-1}^j \sim N((\gamma_0 + \gamma_2 d_{it-1}^j + \gamma_3 e_{it-1}^j + \gamma_4 d_{it-1}^j e_{it-1}^j)(1 - \gamma_1)^{-1}, \sigma_\mu^2 (1 - \gamma_1^2)^{-1})$$

and $h(z_i^{j+} | d_i^{j-}, e_i^{j-}) = N((\gamma_0 + \gamma_2 d_{it-1}^j + \gamma_3 e_{it-1}^j + \gamma_4 d_{it-1}^j e_{it-1}^j)(1 - \gamma_1)^{-1}, \Sigma_{zz})$ where the diagonal elements of Σ_{zz} are determined by $E[(v_{it}^j)^2] = \sigma_\mu^2 (1 - \gamma_1^2)^{-1}$ and the off-diagonal elements are $E[v_{it}^j v_{it-k}^j] = \gamma_1^{|k|} \sigma_\mu^2 (1 - \gamma_1^2)^{-1} \; \forall \; k \neq 0$.

Two features here merit comment. First, the mean of the distribution of export demand shocks varies across the distribution of heterogeneous firms with different promotion and export histories. Second, the demeaned component of the export demand shock contains information on the autoregressive process of export demand separate from previous export and promotion decisions. The second feature ensures that each firm's series of demand shocks is consistent with the model's autoregressive process, while the first adjusts this process for each firm and year to account for the dynamic effects of exporting and promotion over time.

To simulate the entire vector of export demand shocks z^j we start by considering the vector of export shocks for firm i from year 1 to T as a $T \times 1$ vector $z_{i1}^{jT} = (z_{i1}^j, ..., z_{iT}^j)$. We express the set of uncensored export demand shocks z_i^{j+} as a $q_i^j \times 1$ vector where $q_i^j = \sum_{t=1}^T e_{it}^j$. Exploiting the fact that $\mu_{it}^j \sim N(0, \sigma_\mu^2)$ we write

$$z_{i1}^{jT} | z_i^{j+}, d_i^{j-}, e_i^{j-}, de_i^{j-} \sim N(\Gamma_0 \iota + \Gamma_1 v_i^{j+} + \Gamma_2 d_i^{j-} + \Gamma_3 e_i^{j-} + \Gamma_4 de_i^{j-}, \Sigma_{zz} - \Sigma_{zz^+}(\Sigma_{z^+z^+})^{-1}(\Sigma_{zz^+})')$$

where $\Sigma_{zz} = E[v_{i1}^{jT} v_{i1}^{jT\prime}]$, $\Sigma_{zz^+} = E[v_{i1}^{jT} v_i^{j+\prime}]$ and $\Gamma_1 = \Sigma_{zz^+}\Sigma_{z^+z^+}$. We compute the elements of these matrices as $E(v_{it}^j v_{it+k}^{j\prime}) = \gamma_1^{|k|}\sigma_\mu^2(1-\gamma_1^2)^{-1}$. The matrices $\Gamma_m, m = 0, 2, 3, 4$, are $T \times T$ lower triangular matrices where the elements are given by $(\gamma_m(1-\gamma_1^2))(\sigma_\mu^2(1-\gamma_1))^{-1}\Sigma_{zz}^l$ and Σ_{zz}^l is the lower triangle of Σ_{zz}.

The dimension and composition of the Σ_{zz^+} and $\Sigma_{z^+z^+}$ matrices vary across firms. Because the z_{it}^j are serially correlated we exploit information in each year that the firm exports to calculate $E[z_{i1}^{jT} | d_i^-, e_i^{j-}, de_i^{j-}, v_i^{j+}]$. Moreover, because z_{it}^j is stationary the weight placed on v_{it}^j is highest in year t and declines monotonically with $|s|$. We use the entire history of promotion and export decisions to simulate export profit shocks for both exporting and non-exporting firms. However, unlike the demeaned export profit shocks v_{it}^j, export promotion and export decisions in year t do not reveal any additional information about the level of previous (or current) export demand once we have accounted for its impact on the mean of the distribution of z_{it}^j. For this reason Γ_m matrices, $m = 0, 2, 3, 4$, are lower triangular.

The distributions above allow us to write the vector of export demand shock components as

$$z_{i1}^{jT} = \begin{cases} \Gamma_0 \iota + \Gamma_1 v_i^{j+} + \Gamma_2 d_i^{j-} + \Gamma_3 e_i^{j-} + \Gamma_4 de_i^{j-} + \Gamma_5 \eta_i^j & \text{if } q_i^j > 0 \\ \Gamma_0 \iota + \Gamma_2 d_i^{j-} + \Gamma_3 e_i^{j-} + \Gamma_4 de_i^{j-} + \Gamma_5 \eta_i^j & \text{if } q_i^j = 0 \end{cases} \quad (18)$$

where $\Gamma_5 \Gamma_5' = \Sigma_{zz} - \Sigma_{zz^+}(\Sigma_{z^+z^+})^{-1}(\Sigma_{zz^+})'$ and η_i^j is a $T \times 1$ vector of a independent and identically distributed standard normal random variable. Note that $\Gamma_5\Gamma_5'$ has rank $T - q_i^j$ reflecting that Γ_5 has q_i^j zero columns and only $T - q_i^j$ elements of η_i^j actually have an impact in determining z_{i0}^{jT}. In contrast, Γ_2, Γ_3, and Γ_4 impact z_{it}^j in each year and firm regardless of the firm i's current export status.

The promotion and export parameters γ_2, γ_3 and γ_4 are identified by comparing changes in the evolution of z_t^j across firms with different promotion or export histories. For example, consider two firms with identical export demand shocks in the same country in year 1, identical promotion histories, but different export histories in country j. Further, suppose the first firm exports in years 1 and 3, while the second exports in all 3 years. Any difference in their export demand shocks z_t^j must be due to gains derived from past exporting γ_3 or random error, μ_t^j. Under the assumption that μ_t^j is normally distributed across firms and time differences in the evolution of z_t^j across firms identify gains from exporting specific to market j. Likewise, variation in export promotion histories and z_t^j across firms identify γ_2 and γ_4.

The simulation based estimation is key to identifying the export demand parameters. We would not otherwise be able to exploit variation in data from firms which do not export in consecutive years. This, in turn, allows us to simulate

$$P(e_i^j, d_i^j, r_i^j | \omega_i, k_i, \Phi^j) = P(e_i^j, d_i^j | \omega_i, k_i, \Phi^j, z_i^{j+}) h(z_i^{j+} | d_i^{j-}, e_i^{j-}, de_i^{j-}).$$

Specifically, we draw a set of S η_i vectors, use (18) to evaluate $P(e_i^j, d_i^j|\omega_i, k_i, \Phi^j, z_i^{j+})h(z_i^{j+}|d_i^{j-}, e_i^{j-}, de_i^{j-})$ at each η_i and average over the S outcomes.[10]

3.2.2 Conditional Choice Probabilities

The model allows us to express the promotion and export probabilities as functions of firm values and the sunk and fixed cost parameters. Specifically, assuming that the sunk and fixed costs are *iid* draws from a known distribution, the joint promotion and export probabilities are the product of the choice probabilities for d_{it}^j and e_{it}^j in each year, conditional on s_{it}^j. The probability of exporting can be written as:

$$P(e_{it}^j = 1|s_{it}^j) = P\left(e_{it-1}^j \delta_F^{d_{it-1}^j} \gamma_{it}^{Fj} + \delta_S^{d_{it-1}^j}(1 - e_{it-1}^j)\gamma_{it}^{Sj} \leq \pi_{it}^j + V_{it}^{Pj}(e_{it}^j = 1) - V_{it}^{Pj}(e_{it}^j = 0)\right) \quad (19)$$

The sunk and fixed costs are identified from differential entry and exit behavior across similar firms with different export histories. Similarly, the promotion probability is:

$$\begin{aligned} P(d_{it}^j = 1|s_{it}^j) \quad = \quad & P\left(d_{it-1}^j \gamma_{it}^{Ej} + (1 - d_{it-1}^j)\gamma_{it}^{Dj} \leq \right. \\ & \left. \delta E_t V_{it+1}^j(s_{it+1}^j|e_{it}^j, d_{it}^j = 1) - \delta E_t V_{it+1}^j(s_{it+1}^j|e_{it}^j, d_{it}^j = 0)\right) \end{aligned} \quad (20)$$

The promotion probability depends on the *current* export decision due to the model's timing assumption requiring export decisions to be made ahead of export promotion decisions.

The promotion and export probabilities depend on sunk and fixed cost parameters, export and promotion histories, and the expected value functions, $E_t V_{it+1}^j$ and V_{it}^{Pj}. The expected value functions can be constructed by iterating on the system of equations defined by (7), (8) and (9). Solving the firm's dynamic problem in turn captures the endogenous selection of firms into exporting or promotion. As in Das, Roberts and Tybout (2007) we employ a Bayesian Monte Carlo Markov Chain (MCMC) estimator to characterize the posterior distribution of the dynamic parameters.[11]

Last, we assume that all fixed and sunk costs are drawn from separate, independent exponential distributions. The estimated sunk and fixed costs can then be interpreted as the the means of those distributions. In practice

4 Data

We estimate the model using a sample of manufacturing firms in the Danish machinery industry between 2010 and 2015. We focus on the machinery industry for two reasons. First, machinery is the most important component of total Danish exports of products. Second, machinery firms have been a relatively frequent buyer of export promotion services (EPS). We restrict attention to the period 2010-2015 to mitigate influence of the Great Recession.

The data set is constructed by merging several sources of register data. First, we obtain firm level characteristics from the Firm Statistics Register and Firm Accounts Statistics, both provided by Statistics Denmark. These data

[10] In practice we set S=10.

[11] After a necessary period of convergence, realizations from the Markov chain are considered draws from the posterior distribution. In practice, we adopt very diffuse priors, initialize all parameter values to zero, and perform 30,000 iterations of the MCMC with relatively large step sizes to ensure that the chain move relatively quickly through the support of the posterior distribution. These Markov chains are plotted in Appendix B.1. To fine-tune the estimation results, we perform 30,000 new iterations, using the mean value of the latter 10,000 draws as starting values, with smaller step sizes. These Markov chains are plotted in Appendix B.2. We consider the latter 10,000 draws from the new iterations as draws from the posterior distribution. The results presented in Section 5.2 are based on these draws.

sets cover the population of private Danish firms. We construct the sample by requiring firms to meet all of the following requirements in all years from 2010-2015: (i) the firm belongs to the industry "Manufacture of machinery and equipment n.e.c." (NACE 28), (ii) the firm has registered employees, and (iii) the firm has registered positive values for all variables needed in the estimation procedure outlined above (such as domestic sales and capital). The resulting sample consists of a balanced panel of 516 firms. Second, we obtain data on EPS from the Trade Council (TC) in Denmark. For each firm in our sample we observe purchases of EPS by destination and year.[12] Third, we obtain firm-destination level export data from the statistics for International Trade in Goods, also provided by Statistics Denmark. For each firm in our sample we observe the value of exported products by destination and year.

As the TC does not offer export promotion services to all destinations, we restrict interest to destinations for which Danish firms (not necessarily belonging to our sample) purchased EPS at some point during the sample years. This leaves 77 countries, including all major destinations for Danish exports. In order to further limit the dimensionality of the firm's optimization problem, we group destinations into regions and restrict attention to Europe, North America, and Asia.[13] All nominal variables are deflated with industry specific price indices provided by Statistics Denmark.[14] Recall from the estimation procedure outlined above that the initial sample year (2010) is used only to retrieve export and EPS status which are state variables to the firm in the first model year (2011). In the summary statistics presented below, the initial year is included for completeness. However, the reader should bear in mind that the model estimation is based on revenue data only for the model years (2011-2015).

Table 1 presents summary statistics for number of observations, domestic sales, and export sales across export status and years. The top panel shows that less than 200 firms per year (around 40 percent) do not participate in any of the considered export markets. Europe is by far the most common export market, and North America is slightly more popular than Asia. Export participation is increasing across all regions, though not monotonically. The second panel shows that exporters are generally larger than non-exporters in terms of domestic sales. Among exporters, participants in the least popular region (Asia) are the largest on average, whereas participants in the most popular region (Europe) are the smallest on average. Whereas average domestic sales among non-exporters decrease slightly over the model years, average domestic sales have been increasing among exporters. Whereas exporters to North America and Asia are larger than exporters to Europe in terms of domestic sales, the bottom panel shows that exporters to North America and Asia export smaller volumes than exporters to Europe. Notably, exporters to Europe and Asia obtain smaller revenues in 2015 than in 2011 (the first model year), whereas exporters to North America obtain slightly higher revenues.

Table 2 displays summary statistics on number of observations, domestic sales, and export sales across export status, EPS status, and regions. Within each panel and column, the four export-EPS status combinations are mutually exclusive. The top panel shows that only a minority of firms purchase EPS, and, among those firms that do purchase EPS, most firms are exporters. In addition to being the most popular export region, Europe is also the most popular EPS region. On the other hand, even though North America is a more popular export region than Asia, more firms purchase EPS to Asia. The middle panel shows that, among exporters, firms that purchase EPS are relatively large in

[12]See Buus et al. (2019) for more details on this data set.

[13]*Europe*: France, Netherlands, Germany, Italy, UK, Ireland, Greece, Portugal, Spain, Belgium, Luxembourg, Iceland, Norway, Sweden, Finland, Austria, Switzerland, Turkey, Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Hungary, Romania, Bulgaria, Albania, Ukraine, Russia, Kazakhstan, Slovenia, Croatia, Bosnia, Cyprus. *North America*: USA, Canada, Mexico. *Asia*: India, Bangladesh, Thailand, Vietnam, Indonesia, Malaysia, Singapore, China, South Korea, Japan, Taiwan, Hong Kong.

[14]Capital is deflated using the price index for gross fixed capital formation of fixed assets. Expenditures of raw materials, expenditures of energy, and total variable costs are deflated using the price index for intermediate production. Revenues are deflated using the producer price index.

Table 1: Summary statistics by export status, region, and year

	Non-exporters	Exporters			
		Any region	Europe	North America	Asia
Observations (%)					
2010	40.5	59.5	55.8	30.0	28.5
2011	40.5	59.5	55.2	31.2	31.2
2012	37.4	62.6	57.9	35.5	31.2
2013	36.0	64.0	60.9	36.2	32.4
2014	34.7	65.3	62.0	37.6	31.8
2015	37.0	63.0	59.7	36.4	34.1
Total	37.7	62.3	58.6	34.5	31.5
Mean domestic sales (millions of 2015 Danish kroner (DKK))					
2010	11.33	23.41	24.41	29.92	29.30
2011	12.34	26.98	27.97	33.00	34.87
2012	11.29	28.10	29.22	33.02	36.44
2013	10.93	26.95	27.24	33.66	36.04
2014	11.26	27.84	28.00	36.75	38.15
2015	11.41	30.07	30.37	35.96	37.84
Total	11.44	27.27	27.90	33.87	35.58
Mean export sales (millions of 2015 Danish kroner (DKK))					
2010	0	31.28	27.04	4.301	7.814
2011	0	36.59	31.73	6.530	7.087
2012	0	34.97	30.87	5.964	6.052
2013	0	32.64	27.99	5.989	5.166
2014	0	33.38	28.33	6.436	5.692
2015	0	35.28	29.73	6.851	5.808
Total	0	34.02	29.25	6.054	6.232

Unit of observation is firm-year.

Table 2: Summary statistics by export and EPS status, yearly averages

	Any region	Europe	North America	Asia
Observations (%)				
Neither	37.4	41.1	65.3	68.3
Only export	55.8	54.8	33.5	29.3
Only EPS	0.3	0.3	0.2	0.2
Both	6.5	3.8	1.0	2.2
Domestic sales (millions of 2015 Danish kroner (DKK))				
Neither	11.45	12.00	14.62	14.66
Only export	25.12	26.89	33.63	33.96
Only EPS	10.90	8.172	-	40.65
Both	45.64	42.35	41.92	56.85
Export sales (millions of 2015 Danish kroner (DKK))				
Neither	0	0	0	0
Only export	26.87	26.14	5.631	5.335
Only EPS	0	0	0	0
Both	95.11	74.09	20.20	18.02

Unit of observation is firm-year. "-" means that the contents are omitted to comply with Statistics Denmark's rules on data confidentiality.

terms of domestic sales. The bottom panel shows that this is also true in terms of export sales.

Table 3 presents region specific transition rates in and out export and EPS participation. First of all, the export decision is highly persistent. Focusing on the majority of firms that do not purchase EPS (the first two rows of each panel), around 90 percent of non-exporters will continue not to export, and a similar share of exporters will continue to export. Turning to firms that purchase EPS (the last two rows in each panel), the persistence in EPS status depends crucially on the export status: Non-exporters literally never continue to purchase EPS, whereas a large share of exporters do (varying from 32 percent in Europe to 56 percent in Asia). The fundamental conjecture is that firms purchase EPS in order to enter new export markets and/or continue to serve (and boosting sales in) existing markets. The (few) non-exporters experience varying success in terms of entering new markets: 60 percent succeed in Asia, but this is the case for only 25 percent in Europe, and none in North America. On the other hand, exporters that purchase EPS are very unlikely to exit their markets in the following year: 4.1 percent exit Europe, 1.6 percent exit Asia, and none exit North America.

Some of the summary statistics merit note in terms of the model parameters we are able to identify. Firstly, as is present in Table 2, relatively few firms purchase EPS, especially among non-exporters. This immediately implies that relatively few observations will identify the effect of purchasing EPS on the sunk cost of exporting (δ_S) in section 2. Secondly, as is present in Table 3, no non-exporters that purchased EPS in North America transitioned into exporting in the following year. This means that we cannot identify an effect of purchasing EPS on sunk cost of exporting specifically for North America, and motivates why we restrict the model to include a region-wide effect, δ_S.

Lastly, one could worry that the transition rates based on the aggregated regions, reported in 3, do not reflect the underlying, destination-specific transition rates. For example, consider a firm exporting to Sweden, but not to Germany,

Table 3: Annual transition rates (%)

Status in year t	Status in year $t+1$			
	Neither	Only export	Only EPS	Both
Europe				
Neither	87.6	11.4	0.6	0.5
Only export	7.4	88.6	0.0	4.0
Only EPS	75.0	25.0	0.0	0.0
Both	4.1	64.3	0.0	31.6
North America				
Neither	91.5	8.2	0.2	0.1
Only export	12.6	85.3	0.0	2.1
Only EPS	100.0	0.0	0.0	0.0
Both	0.0	57.1	0.0	42.9
Asia				
Neither	92.6	7.3	0.1	0.0
Only export	13.7	83.6	0.1	2.6
Only EPS	40.0	20.0	0.0	40.0
Both	1.6	42.6	0.0	55.7

that purchase EPS to Germany. In the following year, the firm exports to both Sweden and Germany, without purchasing EPS anywhere. This would, of course, mean that the firm successfully transitioned from "Only EPS" to "Only export", applying the labels of Table 3, in the case of Germany (and from "Only export" to "Only export in the case of Sweden). When aggregating Sweden and Germany to Europe, however, the firm would be characterized as transitioning from "Both" to "only export". Therefore, the sparse nature of Table 3 could be a mechanical consequence of this aggregation procedure. To address this worry, Table 15 in Appendix A reports the average transition rates across destinations within each region. Comparing to Table 3, two things come to mind. First, the fact that relatively few firms transition from "Only EPS" to "Only export" or "Both" in the aggregated data is also present in the dis-aggregated data (though it is larger than zero for the case of North America discussed above). This means that the apparent inefficiency of EPS in terms of transitioning non-exporters into exporters still stands in the dis-aggregated data. Second, the relatively few transitions from "Both" to "Neither" or "Only EPS" in the aggregated data is only to a lesser extent present in the dis-aggregated data. In Table 15, more exporters that purchased EPS exit the export market in the following year than in Table 3. This means that the aggregation procedure will tend to exaggerate the effect of EPS on maintaining existing export markets, which in the model corresponds to the effect of purchasing EPS on the fixed cost of exporting, that is δ_F.

5 Empirical Results

In this section, we first present the estimates obtained from the static and dynamic estimation procedure outlined in section 3.1 and 3.2, respectively. Then we present results from in-sample simulations to examine model performance and highlight important model mechanisms. Finally, we perform two simple out-of-sample policy experiments.

5.1 Static Estimates

The parameter estimates from the static estimation procedure are presented in the top panel of Table 4. First, consider the parameters $1 + 1/\eta_j$ for $j = 0, 1, 2, 3$ estimated from equation (13). These reflect the correlation between total variable costs and revenue from each of the four markets (one domestic and three export markets), and are most easily interpreted by the substitution elasticities and markups they imply, given the assumed market structure. For the domestic market, Europe, North America, and Asia the estimated substitution elasticities are -6.8, -3.4, -2.7, and -3.4, respectively. These translate into markups of 17, 41, 56, and 42 percent, respectively. For our firm sample, this means that export markets are all, especially North America, much more profitable per unit sold than the domestic market. This is important to have in mind when interpreting the estimated export cost parameters in the next subsection.

Second, consider the parameters α_0, α_1, and β_k estimated from equation (16). α_0 and α_1 govern the evolution of productivity. Given that we model productivity as a simple AR(1) process, it is not surprising that productivity is highly persistent ($\hat{\alpha}_1 = 0.867$). The estimated intercept is close to zero and highly statistically insignificant ($\hat{\alpha}_0 = -0.00744$). β_k is the effect of capital stock on marginal costs. A negative estimate ($\hat{\beta}_k = -0.0111$) means that firms with higher capital stocks enjoy lower marginal costs (though this is not statistically significant for our sample).

5.2 Dynamic Estimates

The bottom panel of Table 4 presents means and standard deviations of the posterior distributions for each parameter. Consider first the parameters γ_i for $i = 0, 1, 2, 3, 4$ governing the dynamic process of export demand, see equation (5). Recall that these are not allowed to vary across regions. γ_1 is the autocorrelation parameter, and an estimate of 0.791 means that export demand is highly persistent over time. This reflects that export statuses as well as export revenues for continuing exporters are persistent over time. γ_2 is the effect of past EPS purchase on present demand in that particular region. An estimate of 0.0303 means that purchasing EPS increases demand by around 3 percent in the following year. As this parameter is identified from the effect of EPS on export revenue for continuing exporters (that is along the intensive margin), it is reasonable to compare this with corresponding reduced-form estimates. Using the same data, though applying a much larger sample of all Danish manufacturing firms, Buus et al. (2019) find that purchasing EPS boosts export sales by around 7 percent. γ_3 is the effect of past export participation on present demand in that particular region. An estimate of 0.0939 means that a continuing exporter enjoys a boost in demand by around 9 percent. Even though we did not identify any significant impact of past exporting on present productivity, we do find very strong region-specific leaning-by-exporting effects. Importantly, if the productivity evolution is truly characterized by learning-by-exporting effects, which we have just failed to identify, this effect will be incorporated in the estimate of γ_3. Basically, the large estimate reflects that exporters experience relatively large sales growth conditional on survival. γ_4 is the interaction effect between past purchase of EPS and export participation. The estimate is negative, but small in magnitude, reflecting that the separate effects are virtually independent.

Table 4: Parameter estimates

	General	Market specific			
		Domestic	Europe	North America	Asia
Static Estimates					
$1 + 1/\eta_j$ (demand elasticities)		0.854	0.710	0.640	0.703
		(0.246)	(0.253)	(0.337)	(1.283)
α_0 (intercept, productivity)	-0.00744				
	(0.10316)				
α_1 (AR coefficient, productivity)	0.867				
	(0.028)				
β_k (capital coefficient, marginal costs)	-0.0111				
	(0.0184)				
Dynamic Estimates					
γ_0 (intercept, demand)	-0.113				
	(0.008)				
γ_1 (AR coefficient, demand)	0.791				
	(0.007)				
γ_2 (EPS coefficient, demand)	0.0303				
	(0.0095)				
γ_3 (export coefficient, demand)	0.0939				
	(0.0081)				
γ_4 (interaction coefficient, demand)	-0.00444				
	(0.01756)				
γ^{Ej} (EPS fixed costs)			0.387	0.132	0.551
			(0.061)	(0.020)	(0.100)
γ^{Dj} (EPS sunk costs)			3.281	4.965	9.692
			(0.486)	(0.807)	(2.948)
γ^{Fj} (export fixed costs)			7.090	1.779	0.253
			(0.703)	(0.189)	(0.018)
γ^{Sj} (export sunk costs)			161.414	59.977	3.048
			(16.953)	(9.476)	(0.335)
δ_F (fraction, fixed costs)	0.139				
	(0.010)				
δ_S (fraction sunk costs)	1.087				
	(0.043)				
$\log \Phi^j$ (market size)			1.670	-0.061	-1.884
			(0.075)	(0.092)	(0.100)
$\log \sigma_\mu$ (standard deviation, demand)	0.132				
	(0.012)				

The top panel contains the results from the static estimation procedure. These are based on 538 firms. Bootstrapped standard errors clustered at the firm in parentheses. The bottom panel contains the results from the dynamic estimation procedure. These are based on 516 firms. The discrepancy is due to exclusion of productivity outliers: If a firm-year is below the 1st percentile or above the 99th percentile of the (firm-year level) productivity distribution, the entire firm is excluded. Standard deviations in parentheses.

Now, consider the estimated cost parameters, γ^{Ej}, γ^{Dj}, γ^{Fj}, and γ^{Sj} for $j = 1, 2, 3$, which are the region-specific estimates of the fixed and sunk costs of purchasing EPS and exporting, respectively. More precisely, these are the estimated means of the region-specific exponential distributions for fixed and sunk costs of purchasing EPS and exporting, respectively. Two introductory notes of caution. First, the estimates reflect the average costs *un*conditional on purchasing/exporting, whereas the average realized costs, that is conditional on purchasing/exporting, are lower in expectation. This is because firms that draw relatively low costs are more likely to select into purchasing/exporting. Second, the exponential distribution is heavily right-skewed, and the median is only around 2/3 of the mean. Therefore, the median purchasing/exporting firm pays a cost considerably lower than the cost estimates reported in Table 4. The estimated fixed costs of purchasing EPS, γ^{Ej}, vary across regions between around 130,000 DKK (North America) and 550,000 DKK (Asia). The estimated sunk costs of purchasing EPS, γ^{Dj}, are much larger than the corresponding fixed costs, varying between a factor 8 in Europe and a factor 38 in North America. The much larger sunk costs reflect that there are sizable start-up costs affiliated with selecting into EPS, possibly because firms purchase EPS as one initiative among others (that we do not model), or that many firms are simply not aware of the presence of EPS, in which case the large sunk costs reflects some degree of information frictions. The estimated fixed costs of exporting, γ^{Fj}, vary greatly across regions from around 250,000 DKK in Asia to 7.1 million DKK in Europe. The cost estimate for Europe is strikingly large and constitutes almost a quarter of the average exporter's revenue. The same pattern is true for the estimated sunk costs of exporting, γ^{Sj}, though to an even more extreme degree, varying from 3.0 million DKK for Asia to 161 million DKK for Europe. That the estimated sunk costs exceed the fixed costs is in line with comparable studies and not surprising, as this reflects large persistence in export status in all three regions. The estimated sunk costs are, however, very large in magnitude. Through the lens of the model, the very large costs of exporting to Europe are necessary in order to rationalize the fact that a large share of firms, more than 40 percent in the average year, do not export to Europe, even though this is very profitable for the participants, which is, to a large degree, reflected in the large estimated market size (Φ) for Europe.

Lastly, consider the estimated effects of EPS on fixed costs of exporting, δ_F, and sunk costs of exporting, δ_S. Recall that these, in contrast to the estimated fixed and sunk costs of exporting, are not allowed to vary across regions. Starting with the latter, the estimated value of δ_S is 1.087, meaning that EPS slightly *increases* the expected sunk cost of exporting. This is obviously surprising, as a stated purpose of EPS is to help firms enter new export markets, which, through the lens of the model, is achieved by lowering the sunk cost of exporting. The background for this counterintuitive result is, as was also discussed in section 4, that non-exporting firms that purchase EPS only rarely enter the region to which they purchased EPS. Turning to the effect on fixed costs of exporting, the estimated value of δ_F is 0.139, meaning that the average fixed cost of exporting falls to only 14 percent of the original value upon purchasing EPS. This result is almost as surprising as the latter, but of opposite sign: Purchasing EPS drastically reduces the expected fixed cost of exporting. This result is driven by the fact that exporters that purchase EPS only rarely exit the export market in the subsequent year.

Taken at face value these results reveal an interesting feature regarding the effect of EPS on export performance: Apart from generally boosting foreign demand, purchasing EPS benefits the firm through maintenance of *existing* export markets rather than through entry into *new* export markets.

5.3 Model Performance

Our objective is to asses the predictive ability of the model and to shed light on the importance of key mechanisms. To do that, we simulate the model by computing patterns of EPS purchase, export participation, and realized export revenue, taking the estimated parameters as given, and compare these with the data counterparts. Specifically, we treat the observed levels of capital, k_{it}, and estimated levels of productivity, $\hat{\omega}_{it}$, as data throughout the sample years and take initial values of EPS purchase, d^j_{i0}, export participation, e^j_{i0}, and simulated export demand, z^j_{i1}, as given, then simulate forward the sequences of $\left(d^j_{it}, e^j_{it}\right)$ for $t = 1, 2, 3, 4, 5$ and z^j_{it} for $t = 2, 3, 4, 5$.[15, 16] For each firm, we repeat the simulation 200 times and report averages over simulations.

Table 5 presents simulated sequences of average export participation rates, average EPS purchase rates, average export revenues (conditional on exporting), and total export revenues together with their data counterparts across regions. The model is able to replicate both the level of and growth in export participation in Europe and North America, whereas participation in Asia is slightly under-predicted. Turning to EPS purchase rates, the levels are matched less closely, but the model does replicate the region-specific trends: Increasing rates in North America and declining rates in Europe and Asia. Regarding export revenues, the objective is to match the evolution from 2011 to 2015 (the predicted levels in 2011 do not exactly match their data counterparts only because the predicted revenues are calculated conditional on predicted, not observed, export participation). Compared to export participation rates, the model does a worse job replicating the observed revenue patterns. This should come as no surprise as foreign demand is restricted to follow the same process across the three regions. The model is, by construction, not capable at capturing the fact that export revenues do not evolve similarly across regions.

Next, Table 6 presents the simulated transition rates together with the data counterparts across regions. The model closely captures the persistence in terms of export participation, especially for Europe and North America. In Asia, the model over-predicts the exit rate, which is why the overall export rate is under-predicted as mentioned above. Turning to purchase of EPS, the model does resemble the qualitative patterns: A large share of firms that both export and purchase EPS keep doing both, and most non-exporting firms that purchase EPS will do neither in the subsequent year. Quantitatively, the transitions are over-predicted in some regions while under-predicted elsewhere, reflecting that the effect on fixed costs of exporting—which is estimated to be substantial—is restricted to be the same across regions.

In order to evaluate the importance of the main mechanisms of interest—the effect of EPS on foreign demand and export costs, respectively—we re-simulate restricted versions of the model and compare the results to those just presented.

First, we shut down the effect of EPS on foreign demand, that is imposing $\gamma_2 = \gamma_4 = 0$. Table 7 shows simulated levels of export participation rates, EPS purchase rates, and average and total levels of export revenue *relative* to the results from the full model presented in Table 5. For example, the simulated export participation rate in Europe in 2011 drops by 1.53 percentage points relative to the full model, and the average export revenue, conditional on exporting, increases by 2.59 percent. Across regions, the picture is qualitatively the same. Enforcing EPS to be less beneficial, reduces both the EPS purchase rate, the export participation rate, and the total export revenue, as one would expect. The increase in average export revenue is due to a selection effect: The exiting firms are relatively small in terms of export

[15] $t = 0$ corresponds to the initial year (2010), $t = 1$ corresponds to our first model year (2011), and so forth.

[16] Alternatively, we could have relied on the fixed capital levels k_i and simulated the evolution of productivity based on the initial estimate $\hat{\omega}_{i0}$ using the AR(1) process. However, as the demand process, z^j_{it}, is our main interest, and as this process is effectively recovered from the sequences of observed capital and estimated productivity, we abstract from this additional layer of complexity. Still, we utilize the AR(1) structure when firms form expectations about next period's productivity level.

Table 5: Predicted export rates (%), EPS rates (%), and export revenues (M DKK)

	2010	2011	2012	2013	2014	2015
Europe						
Export participation rate						
Predicted	-	56.6	57.6	58.6	59.7	60.7
Actual data	55.8	55.2	57.9	60.9	62.0	59.7
EPS purchase rate						
Predicted	-	5.2	5.0	4.9	4.7	4.6
Actual data	5.2	3.3	3.5	4.5	4.1	3.9
Average export revenue						
Predicted	-	31.1	36.4	38.8	43.5	43.2
Actual data	27.0	31.7	39.0	28.0	28.3	29.7
Total export revenue						
Predicted	-	9,082	10,804	11,749	13,415	13,531
Actual data	7,786	9,042	9,230	8,787	9,067	9,156
North America						
Export participation rate						
Predicted	-	31.7	33.8	35.8	37.6	39.1
Actual data	30.0	31.2	35.5	36.2	37.6	36.4
EPS purchase rate						
Predicted	-	1.8	2.8	3.4	3.8	4.1
Actual data	0.8	1.6	1.0	1.0	0.8	1.9
Average export revenue						
Predicted	-	6.40	6.65	6.82	7.12	7.33
Actual data	4.30	6.53	5.96	5.99	6.44	6.85
Total export revenue						
Predicted	-	1,047	1,158	1,258	1,381	1,480
Actual data	667	1,051	1,091	1,120	1,249	1,288
Asia						
Export participation rate						
Predicted	-	28.3	28.3	28.0	27.7	27.3
Actual data	28.5	31.2	31.2	32.4	31.8	34.1
EPS purchase rate						
Predicted	-	1.9	1.4	1.3	1.1	1.0
Actual data	3.3	2.7	2.9	1.9	1.9	1.7
Average export revenue						
Predicted	-	7.87	5.66	4.34	3.81	3.22
Actual data	7.81	7.09	6.05	5.17	5.69	5.81
Total export revenue						
Predicted	-	1,146	824	627	543	454
Actual data	1,149	1,141	974	863	934	1,022

Table 6: Predicted transition rates (%)

Status in year *t*	Status in year *t* + 1			
	Neither	Only export	Only EPS	Both
Europe				
Predicted				
Neither	88.9	10.3	0.4	0.4
Only export	6.4	88.9	0.0	4.7
Only EPS	85.9	7.1	2.7	4.4
Both	0.0	60.1	0.0	39.9
Actual data				
Neither	87.6	11.4	0.6	0.5
Only export	7.4	88.6	0.0	4.0
Only EPS	75.0	25.0	0.0	0.0
Both	4.1	64.3	0.0	31.6
North America				
Predicted				
Neither	92.6	6.9	0.3	0.2
Only export	8.7	87.9	0.0	3.4
Only EPS	80.1	2.8	10.2	6.9
Both	0.0	24.2	0.0	75.8
Actual data				
Neither	91.5	8.2	0.2	0.1
Only export	12.6	85.3	0.0	2.1
Only EPS	100.0	0.0	0.0	0.0
Both	0.0	57.1	0.0	42.9
Asia				
Predicted				
Neither	92.3	7.4	0.2	0.1
Only export	21.2	76.9	0.0	2.0
Only EPS	90.1	6.2	2.3	1.5
Both	0.1	65.0	0.0	34.9
Actual data				
Neither	92.6	7.3	0.1	0.0
Only export	13.7	83.6	0.1	2.6
Only EPS	40.0	20.0	0.0	40.0
Both	1.6	42.6	0.0	55.7

Table 7: Restricted model predictions ($\gamma_2 = \gamma_4 = 0$)

	2011	2012	2013	2014	2015
Europe					
Export participation rate	-1.53	-2.63	-3.38	-4.18	-4.77
EPS purcahse rate	-1.21	-1.5	-1.53	-1.49	-1.48
Average export revenue	2.59	3.89	4.65	5.64	6.36
Total export revenue	-0.194	-0.843	-1.41	-1.76	-2.03
North America					
Export participation rate	-1.04	-1.77	-2.43	-2.91	-3.39
EPS purcahse rate	-0.57	-0.934	-1.18	-1.35	-1.52
Average export revenue	3.09	4.6	5.57	5.83	6.68
Total export revenue	-0.281	-0.864	-1.57	-2.37	-2.58
Asia					
Export participation rate	-0.213	-0.289	-0.376	-0.421	-0.44
EPS purcahse rate	-0.546	-0.536	-0.488	-0.398	-0.364
Average export revenue	0.743	0.655	0.804	0.837	0.806
Total export revenue	-0.013	-0.358	-0.529	-0.704	-0.738

Participation rates are reported in percentage point deviations from those reported in Table 5. Export revenues are reported in percentage deviations from those reported in Table 5.

value. The restriction imposes the largest change in Europe, where purchases of EPS is most common, and smallest in Asia, where purchases of EPS is (predicted by the full model to be) least common. Table 8 shows simulated transition rates relative to those produced by the full model and presented in Table 6. For example, among firms that neither exported to nor purchased EPS for Europe, 1.5 percent points more firms will continue this status in the subsequent year relative to the prediction produced by the full model. Overall, we observe, as expected, that fewer firms will select into EPS and export, and more firms will exit both. Note that the entire mass of exporters that exit EPS, except for a small share in Asia, keep exporting. The entire drop in the export participation rate, therefore, is driven by fewer entries and, further, more exits by exporter that did *not* purchase EPS in the baseline simulation. That is, the increased exit rate is caused by firms that simply anticipated to, at some point, purchase EPS in order to boost demand.

Second, we shut down the effect of EPS on fixed and sunk export costs, that is imposing $\delta_F = \delta_S = 1$. We expect a response qualitatively similar to the one just described. Table 9 resembles Table 7 and shows that removing the effect of EPS on fixed and sunk costs has massive and immediate implications for the export participation rates, especially in Europe and North America. The export participation rate in Europe drops by 23.0 percentage points (from 56.6 in the baseline scenario) in the first year, and the EPS purchase rate drops by 3.95 percentage points (from 5.2). In comparison, the drop in North America is smaller, though still large, whereas the drop in Asia is modest and only slightly larger than in the previous scenario. The huge effect in Europe stems from the fact that this region is characterized by relatively large fixed costs of exporting. Note that the large drop in the export participation rate is followed by a drop in total export revenue by "only" 4.15 percent, indicating that the exiting firms are small. Similarly, the average export revenue among the remaining exporters increases massively. Table 10 resembles Table 8 and shows the predicted transition rates relative to the baseline scenario. Again, the drop in export participation rates are driven

Table 8: Restricted model transitions ($\gamma_2 = \gamma_4 = 0$)

Status in year t	Status in year $t+1$			
	Neither	Only export	Only EPS	Both
Europe				
Neither	1.5	-1.0	-0.4	-0.1
Only export	1.5	-0.6	0.0	-0.9
Only EPS	2.4	0.1	-2.7	0.2
Both	0.0	6.8	0	-6.8
North America				
Neither	0.9	-0.6	-0.3	-0.1
Only export	1.4	-0.7	0.0	0.7
Only EPS	9.4	0.8	-10.2	0.0
Both	0.0	6.7	0	-6.7
Asia				
Neither	0.3	-0.1	-0.2	0.0
Only export	0.0	0.4	0.0	-0.4
Only EPS	-0.9	2.7	-2.3	0.5
Both	0.1	7.9	0.0	-7.9

Transition rates are reported in percentage point deviations from those reported in Table 6.

Table 9: Restricted model predictions ($\delta_F = \delta_S = 1$)

	2011	2012	2013	2014	2015
Europe					
Export participation rate	-23.0	-31.0	-35.9	-39.3	-41.8
EPS purcahse rate	-3.95	-4.25	-4.19	-4.07	-3.99
Average export revenue	61.4	98.0	125	145	157
Total export revenue	-4.15	-8.61	-13.2	-16.4	-19.9
North America					
Export participation rate	-12.9	-18.5	-22.3	-25.1	-27.1
EPS purcahse rate	-1.27	-2.24	-2.89	-3.36	-3.64
Average export revenue	60.4	96.2	121	132	141
Total export revenue	-4.75	-10.9	-17.1	-22.5	-25.7
Asia					
Export participation rate	-0.336	-0.374	-0.462	-0.505	-0.554
EPS purcahse rate	-1.32	-1.14	-0.992	-0.884	-0.801
Average export revenue	1.18	1.06	1.18	1.2	1.31
Total export revenue	-0.032	-0.305	-0.499	-0.664	-0.739

Participation rates are reported in percentage point deviations from those reported in Table 5. Export revenues are reported in percentage deviations from those reported in Table 5.

Table 10: Restricted model transitions ($\delta_F = \delta_S = 1$)

Status in year t	Status in year $t + 1$			
	Neither	Only export	Only EPS	Both
Europe				
Neither	7.5	-7.2	0.1	-0.4
Only export	16.8	-12.9	0.1	-4.0
Only EPS	4.3	-2.6	2.6	-4.3
Both	16.0	13.9	1.6	-31.5
North America				
Neither	4.7	-4.5	0.0	-0.2
Only export	16.2	-13.4	0.1	-2.9
Only EPS	4.3	-0.8	3.0	-6.5
Both	13.0	37.1	4.9	-55.0
Asia				
Neither	0.0	0.1	0.0	-0.1
Only export	-0.4	2.0	0.0	-1.6
Only EPS	0.7	0.6	0.1	-1.5
Both	5.6	22.4	0.1	-28.1

Transition rates are reported in percentage point deviations from those reported in Table 6.

both by fewer entries and more exits. In contrast to the previous scenario, even exporting firms that purchased EPS in the benchmark scenario start exiting. This indicates that the effect of EPS on fixed export costs is crucial for many exporters survival, in contrast to the effect on demand. Whereas these effects are vast and largely similar in Europe and North America, they are much less pronounced in Asia. Here, fixed export costs are much smaller, and the restriction, thus, makes less of a difference, and exporting firms that previously purchased EPS do not continue purchasing EPS but they do continue to export.

For completeness, we impose the combined restriction and completely remove the benefits from purchasing EPS, that is $\gamma_2 = \gamma_4 = 0$ and $\delta_F = \delta_S = 1$. Table 16 and 17 in Appendix A show the results. By construction, firms completely abandon EPS. The effects on export participation closely follow those just described.

5.4 Policy Experiments

In this subsection, we consider two policy experiments and their implications beyond the sample years. We first consider implications of cheaper EPS, then of more effective EPS in terms of boosting foreign demand.

In the previous subsection, we showed that the presence of EPS greatly affects the export participation rates, especially in Europe and North America. Motivated by this finding, we now consider the counterfactual impact of cheaper EPS over a ten year period. Specifically, we first take observed export participation rates, observed EPS purchase rates, estimated productivity, and estimated export demand in our last sample year (2015) as given, and use the model to simulate export participation rates and EPS purchase rates ten years forward.[17] We then re-estimate these sequences, but now impose a 25 percent reduction of fixed and sunk EPS purchase costs across all regions. We estimate the two scenarios 200 times and report the average difference in Table 11.

The top panel of Table 11 presents results based on the full model. For example, a 25 percent reduction in EPS costs will increase the EPS purchase rate for Europe by 1.61 percentage points in the first year after 2015, the export participation rate by 0.82 percentage points, and total export revenue by 0.05 percent. Generally, as expected, the discount will increase both the EPS purchase rate, the export participation rate, and total revenue. Further, as the fixed cost of EPS is smaller than the sunk cost, firms that select into EPS, due to the discount, will tend to continue their purchases, so that the increase in EPS purchases and, thus, the export participation rate and total export revenue will accumulate over time. Ten years into the future, the export participation rate has increased, relative to the scenario with no discount, by 2.93 percentage point in Europe, 5.03 in North America, and 0.31 in Asia, and total revenues have increased by 1.12, 3.33, and 0.29 percent, respectively. These differences reflect the difference in increased take-up rate of EPS.

The top panel of 12 shows predicted responses ten years after 2015 (corresponding to the furthest right column in Table 11) across eight firm size groups.[18] Across regions, the largest increase in the take-up rate of EPS is among the largest firms (the furthest right column). In the case of Europe and North America, this reflects the combination of two features. First, large firms are by far are the most likely to export. Second, EPS effectively reduces the large fixed costs of exporting, making EPS especially beneficial for continuing exporters. Further, notice that the largest firms do not constitute a correspondingly large share of the increase in export participation and export revenue. This highlights that large firms taking up EPS due to the discount would, to a large extent, have exported anyway, but purchase EPS to lower costs and increase profits. On the other hand, cheaper EPS lead smaller and medium-sized firms (size categories 1-5 in Europe and 1-6 in North America) to increase export participation *more* than the EPS take-up rate. In that sense, the return to lowering the costs of purchasing EPS in terms of increased export participation is much larger among smaller firms than among larger firms. In the case of Asia, where costs of exporting are relatively low, we observe a different picture. The largest firms are still responsible for the largest increase in the take-up rate of EPS, but they also constitute the largest increase in export participation and export revenue. Here, purchasing EPS is to a larger degree a strategy for existing exporters to boost demand, and this applies to both small and large exporters.

The middle and bottom panels of Table 11 and 12 present corresponding simulations based on restricted models in which EPS does not affect export demand ($\gamma_2 = \gamma_4 = 0$) and does not affect fixed and sunk costs of exporting ($\delta_F = \delta_S = 1$), respectively. In the case of no demand effect, the effect of cheaper EPS on export revenue is considerably smaller after ten years. Especially in Asia, where low export costs make the demand effect relatively more important, the effect on export revenue is virtually absent. In the case of no cost effect, the discount only modestly increases the EPS purchase rate. Further, the export participation barely changes, indicating that the (relatively few) firms that take advantage of the discount and purchase EPS are already exporters.

Among the Trade Council's most popular export promotion services are "Partner Search and Match Making". The explicit purpose of this EPS is to help exporters find buyers on export markets. We now consider a policy experiment,

[17]In contrast to the in-sample simulations conducted above, we cannot rely on observed level of capital nor the estimated sequence of productivity. Instead, we fix capital levels to the sample mean and use the AR(1) structure to simulate forward productivity based on the estimated 2015 level.

[18]Firms are categorized into size groups based on their average capital stock over the sample years, and firms, then, belong to the same category across years and regions. The eight size groups are chosen such that they consist of an equal number of firms and correspond to the capital stock grid points used for the dynamic estimation routine.

Table 11: Predicted responses to cheaper EPS across years

Years after 2015	1	2	3	4	5	6	7	8	9	10
Full model										
Europe										
Export rate	0.79	1.34	1.75	2.04	2.27	2.47	2.57	2.66	2.80	2.90
EPS rate	1.58	2.28	2.49	2.61	2.63	2.68	2.72	2.70	2.74	2.72
Total export revenue	0.05	0.21	0.42	0.49	0.68	0.79	0.88	0.94	1.02	1.12
North America										
Export rate	1.11	1.86	2.49	3.03	3.44	3.78	4.15	4.38	4.74	5.04
EPS rate	0.79	1.47	2.07	2.50	2.86	3.27	3.49	3.74	4.00	4.18
Total export revenue	0.15	0.47	0.96	1.42	1.76	2.20	2.53	2.66	2.90	3.33
Asia										
Export rate	0.04	0.14	0.20	0.24	0.27	0.25	0.28	0.28	0.29	0.30
EPS rate	0.51	0.71	0.64	0.62	0.60	0.59	0.56	0.55	0.55	0.57
Total export revenue	0.01	0.11	0.31	0.43	0.27	0.28	0.34	0.42	0.38	0.29
Restricted model ($\gamma_2 = \gamma_4 = 0$)										
Europe										
Export rate	0.99	1.55	1.86	2.16	2.44	2.67	2.81	2.97	3.04	3.15
EPS rate	1.21	1.61	1.65	1.66	1.62	1.65	1.78	1.72	1.76	1.72
Total export revenue	0.09	0.16	0.24	0.30	0.41	0.49	0.52	0.64	0.71	0.80
North America										
Export rate	1.26	2.11	2.69	3.15	3.56	4.00	4.29	4.53	4.75	4.89
EPS rate	0.58	1.13	1.55	1.89	2.11	2.25	2.38	2.45	2.54	2.58
Total export revenue	0.18	0.48	0.90	1.28	1.78	1.85	2.24	2.39	2.65	2.81
Asia										
Export rate	0.00	0.06	0.09	0.09	0.11	0.11	0.10	0.07	0.08	0.10
EPS rate	0.39	0.44	0.39	0.41	0.36	0.33	0.35	0.34	0.36	0.34
Total export revenue	0.00	0.00	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01
Restricted model ($\delta_F = \delta_S = 1$)										
Europe										
Export rate	0.04	0.02	0.02	0.03	0.03	0.02	0.03	0.04	0.05	0.04
EPS rate	0.40	0.35	0.26	0.24	0.26	0.20	0.21	0.19	0.23	0.22
Total export revenue	0.03	0.06	0.09	0.17	0.09	0.08	0.06	0.08	0.08	0.07
North America										
Export rate	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.00
EPS rate	0.31	0.30	0.26	0.22	0.19	0.18	0.18	0.19	0.17	0.19
Total export revenue	0.00	0.04	0.06	0.09	0.10	0.03	0.04	0.07	0.03	0.02
Asia										
Export rate	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
EPS rate	0.14	0.12	0.08	0.07	0.08	0.09	0.07	0.08	0.08	0.08
Total export revenue	0.00	0.02	0.03	0.11	0.02	0.01	0.03	0.03	0.03	0.03

Each cell contains the difference between model predictions *with* a 25 percent reduction of EPS fixed and sunk costs (γ^{Ej} and γ^{Dj} for $j = 1, 2, 3$) and model predictions *without* discount. Differences in export and EPS participation are reported in percentage points. Differences in export revenue are reported in percent.

Table 12: Predicted responses to cheaper EPS in 2025 across firm size groups

Size group	1	2	3	4	5	6	7	8
Full model								
Europe								
Export rate	2.98	3.03	2.88	3.01	2.99	3.02	2.66	2.62
EPS rate	1.94	2.18	2.06	2.26	2.52	3.16	3.44	4.22
Total export revenue	1.34	1.53	0.94	0.92	1.42	1.08	0.94	1.02
North America								
Export rate	4.36	4.52	4.60	4.83	4.62	5.12	5.91	6.35
EPS rate	2.04	2.59	3.15	3.25	3.57	4.36	6.12	8.48
Total export revenue	4.34	2.96	2.80	3.15	2.44	3.39	4.38	3.50
Asia								
Export rate	0.20	0.23	0.26	0.19	0.30	0.27	0.33	0.63
EPS rate	0.39	0.35	0.53	0.45	0.45	0.66	0.65	1.12
Total export revenue	0.29	0.14	0.25	0.28	0.17	0.25	0.29	0.45
Restricted model ($\gamma_2 = \gamma_4 = 0$)								
Europe								
Export rate	3.11	3.38	3.15	2.94	3.37	3.33	3.14	2.80
EPS rate	1.27	1.34	1.20	1.51	1.60	1.87	2.16	2.87
Total export revenue	1.29	0.90	1.20	1.03	1.03	1.08	0.66	0.19
North America								
Export rate	3.99	4.32	4.55	4.45	4.70	4.97	5.84	6.36
EPS rate	1.32	1.52	1.85	1.65	2.25	2.50	3.84	5.77
Total export revenue	2.45	3.87	2.22	3.07	2.44	3.31	2.96	2.60
Asia								
Export rate	0.02	0.04	0.12	0.09	0.13	0.08	0.05	0.23
EPS rate	0.30	0.21	0.30	0.28	0.27	0.43	0.43	0.58
Total export revenue	-0.10	-0.05	0.04	0.03	0.03	0.02	0.01	0.03
Restricted model ($\delta_F = \delta_S = 1$)								
Europe								
Export rate	0.01	0.02	0.07	0.05	0.02	0.04	0.07	0.06
EPS rate	0.16	0.21	0.22	0.19	0.23	0.20	0.34	0.26
Total export revenue	0.03	-0.02	0.25	0.09	0.07	0.07	0.06	0.06
North America								
Export rate	0.00	0.01	0.01	0.02	0.01	0.02	-0.02	0.00
EPS rate	0.16	0.20	0.18	0.16	0.20	0.16	0.20	0.24
Total export revenue	0.02	0.02	0.03	0.10	0.05	-0.01	-0.03	-0.02
Asia								
Export rate	0.03	-0.02	-0.04	0.01	0.01	-0.02	0.00	0.00
EPS rate	0.08	0.05	0.08	0.06	0.02	0.09	0.12	0.09
Total export revenue	0.05	0.01	0.00	0.00	0.02	0.03	0.02	0.04

Size groups are in terms of average capital stock through the sample years. Each cell contains the difference between model predictions *with* a 25 percent reduction of EPS fixed and sunk costs (γ^{Ej} and γ^{Dj} for $j = 1, 2, 3$) and model predictions *without* discount. Differences in export and EPS participation are reported in percentage points. Differences in export revenue are reported in percent.

Table 13: Predicted responses to stronger demand effect of EPS across years

Years after 2015	1	2	3	4	5	6	7	8	9	10
Full model										
Europe										
Export rate	1.75	2.95	3.88	4.56	5.09	5.57	5.83	5.99	6.26	6.39
EPS rate	1.47	1.97	2.04	2.13	2.07	2.09	2.14	2.14	2.13	2.09
Total export revenue	6.27	4.95	4.80	4.21	3.52	3.54	3.33	3.24	3.07	3.11
North America										
Export rate	1.27	2.15	2.87	3.51	3.93	4.28	4.69	4.91	5.25	5.51
EPS rate	0.81	1.36	1.80	2.04	2.22	2.46	2.60	2.73	2.86	2.99
Total export revenue	2.48	2.83	3.34	3.74	4.16	4.32	4.68	4.73	4.92	5.20
Asia										
Export rate	0.30	0.47	0.58	0.68	0.68	0.72	0.76	0.79	0.80	0.76
EPS rate	0.56	0.68	0.60	0.58	0.55	0.53	0.49	0.50	0.49	0.51
Total export revenue	8.37	6.87	6.93	4.81	2.95	2.33	2.22	2.58	2.00	1.60
Restricted model ($\delta_F = \delta_S = 1$)										
Europe										
Export rate	0.94	1.12	1.18	1.16	1.17	1.14	1.16	1.12	1.10	1.09
EPS rate	1.33	1.20	0.95	0.88	0.90	0.82	0.84	0.77	0.76	0.76
Total export revenue	6.91	5.36	4.54	3.75	2.85	2.61	2.06	1.86	1.62	1.42
North America										
Export rate	0.13	0.14	0.15	0.17	0.17	0.18	0.16	0.13	0.13	0.11
EPS rate	0.98	1.10	1.03	0.89	0.80	0.76	0.74	0.70	0.71	0.71
Total export revenue	2.46	2.52	2.33	2.13	1.99	1.35	1.21	1.07	0.80	0.66
Asia										
Export rate	0.28	0.40	0.45	0.49	0.48	0.48	0.54	0.54	0.55	0.53
EPS rate	0.53	0.41	0.32	0.30	0.31	0.31	0.27	0.28	0.29	0.28
Total export revenue	8.37	6.63	6.24	3.75	2.13	1.58	1.51	1.59	1.06	0.81

Each cell contains the difference between model predictions *with* a doubling of the effect of EPS on demand (γ_2) and model predictions *without* the doubling. Differences in export and EPS participation are reported in percentage points. Differences in export revenue are reported in percent.

Table 14: Predicted responses to stronger demand effect of EPS across firm size groups in 2025

Size group	1	2	3	4	5	6	7	8
Full model								
Europe								
Export rate	6.99	7.05	6.38	6.85	6.46	6.65	5.77	4.94
EPS rate	1.68	1.81	1.68	1.82	1.95	2.36	2.30	3.12
Total export revenue	3.44	3.68	3.11	3.11	3.16	3.61	2.74	2.78
North America								
Export rate	4.98	5.03	5.12	5.46	5.32	5.57	6.07	6.57
EPS rate	1.61	2.10	2.49	2.39	2.61	3.09	3.97	5.72
Total export revenue	5.42	3.77	4.61	4.84	4.01	4.80	6.90	6.46
Asia								
Export rate	0.48	0.43	0.65	0.67	0.57	0.77	1.09	1.44
EPS rate	0.34	0.32	0.54	0.39	0.38	0.66	0.56	0.92
Total export revenue	0.84	0.72	0.79	2.15	0.90	1.42	1.36	2.82
Restricted model ($\delta_F = \delta_S = 1$)								
Europe								
Export rate	0.62	0.78	0.95	1.02	1.10	1.16	1.44	1.70
EPS rate	0.67	0.65	0.71	0.62	0.69	0.80	0.98	0.97
Total export revenue	1.05	0.74	1.49	2.07	1.16	1.68	1.24	1.63
North America								
Export rate	0.09	0.02	0.10	0.07	0.08	0.14	0.16	0.24
EPS rate	0.49	0.74	0.75	0.54	0.69	0.66	0.79	1.04
Total export revenue	0.98	0.43	0.57	0.48	0.37	0.63	0.92	0.88
Asia								
Export rate	0.41	0.25	0.43	0.42	0.36	0.54	0.81	1.04
EPS rate	0.21	0.19	0.32	0.21	0.22	0.42	0.31	0.34
Total export revenue	0.51	0.49	0.39	0.95	0.54	0.91	0.71	1.27

Size groups are in terms of average capital stock through the sample years. Each cell contains the difference between model predictions *with* a doubling of the effect of EPS on demand (γ_2) and model predictions *without* the doubling. Differences in export and EPS participation are reported in percentage points. Differences in export revenue are reported in percent.

where the TC is more effective in terms of matching Danish exporters to foreign importers, but keeping the costs of purchasing EPS unchanged. In the model, we implement this experiment by doubling the effect of EPS on foreign demand, that is doubling γ_2.

The top panel of Table 13 shows that the increase in take-up rate of EPS after ten years is 2.09, 2.99 and 0.51 percentage points for Europe, North America, and Asia, respectively. Across all three regions, this response is lower than the response to cheaper EPS. However, the increase in export participation, 6.39, 5.51, and 0.76, *exceeds* the response to cheaper EPS. The same apply to the response in export revenue.

The top panel of Table 14 shows that more effective EPS increases export participation and export revenues across firm size categories. In Europe, small firms respond the *least* in terms of take-up rate of EPS, but the *most* in terms of export participation and export revenue. Among the smallest firms, e.g., the export participation increases by 6.99 percentage points. In North America, large firms constitute the largest response in all three dimensions, but the response by small firms in terms of participation and revenue are large when taking into account their much smaller increase in EPS take-up. As in the previous policy experiment, the responses in terms of participation and revenue in Asia is basically proportional to the response in EPS take-up across firm size groups.

The bottom panels of Table 13 and 14 present corresponding simulations based on a restricted model where EPS does not affect fixed and sunk export costs ($\delta_F = \delta_S = 1$). In the case of Europe and North America, these results stress that the positive effects on export participation and export revenue from a higher demand effect of EPS is to a large extent dependent on continued effectiveness of EPS in lowering fixed costs of exporting. For Asia, on the other hand, where the effect of EPS on demand is relatively more important, the increase in export participation due to more effective EPS is to a lesser extent dependent on the effect of EPS on export costs.

We finalize this section by comparing the outcomes of the two policy experiments, call them experiment I and II, respectively. Unsurprisingly, imposing lower costs of purchasing EPS (experiment I) and imposing EPS to be more effective in terms of increasing demand (experiment II), respectively, have the same overall consequences: Firms respond by purchasing more EPS, export more often, and, conditional on exporting, export more. In combination, this leads to higher total export revenues. Conducting a formal cost-benefit comparison between these two policy experiments is beyond the scope of this paper in its present form. Nevertheless, simply comparing the responses by firms still reveals interesting patterns.

Comparing the responses ten years into the future, in 2025, reveals that experiment II facilitates a *lower* response in terms of EPS take-up rate than experiment I, but a *larger* response in terms of export participation and export revenue. This conclusion applies across all regions and firm size categories. The crude explanation is that EPS, according to our estimated model, are quite inefficient in terms of facilitating export entries. In experiment I, EPS remains inefficient, whereas in experiment II, firms that purchase EPS will enjoy an immediate boost in demand if they enter a new export market in the following year. To be slightly more elaborate, firms responding to experiment I, by either actually buying EPS or planning to do so in the future, were, to a large extent, already exporting and would have continued to do so in any case. Those that started purchasing EPS enjoyed lower fixed costs of exporting and, thus, higher profits. But this does not induce higher participation. On the other hand, firms responding to experiment II are, to a larger extent, non-exporters for which higher demand, either realized by purchasing EPS or expected by potential future purchases, is sufficient to make export entry profitable. These exercises highlight that two seemingly equivalent approaches to boost export participation and revenue have quite different consequences. Our model provides a framework for evaluating these consequences.

6 Conclusion and Future Work

This paper presents a dynamic model of heterogeneous firms which endogenously choose to export and purchase destination-specific export promotion services. Our empirical methodology allows us to separately identify the effects of export promotion services on foreign demand and export costs. The model is estimated using a panel of Danish machinery producers. Counterfactual policy experiments are employed to assess the impact of changes in trade-policy on firm-level export participation and total export revenue across regions. The model is able to broadly match promotion purchases and exporting behavior for each region. The model captures the differential export behavior across firms which acquire promotion and those that do not.

Our estimates show that promotion modestly increases foreign demand by around 3 percent. Counterintuitively, export promotion does not affect (sunk) export entry costs, but dramatically reduces (fixed) export maintenance costs. Thus, export promotion is much more effective in terms of preserving existing markets rather than entering new ones. In-sample simulations show that export promotion plays a large role in supporting firms' export participation. In particular, this applies to regions where export costs are high. Furthermore, simulations show that the importance of export promotion reaches beyond firms that actually acquire promotion. This is because firms, especially exporting firms, *anticipate* that export promotion can be profitable to acquire in the future. Therefore, any proper evaluation of export promotion services, and firm-specific trade policies more broadly, must account for its value to non-investors in order not to undervalue it.

The counterfactual experiments confirm that making export promotion more attractive to firms, by either reducing the price or improving the effect on demand, induce higher export participation and increased export revenues, which are often stated objectives of policy-makers. However, our simulations clearly show that the benefits, from the policy-maker's perspective, from improving the effectiveness of promotion surpasses the benefits from lowering prices. Crudely, the reason is that lower prices induce firms that would have exported in any case to purchase promotion, simply to reduce export costs and boost profits. Instead, improved promotion services are more effective in terms of incentivizing non-exporters to enter new markets.

Though the current state of this project provides a useful framework to evaluate *qualitative* implications of policy experiments, several features of the model seem too restrictive to produce convincing *quantitative* predictions. First of all, the large estimated impact of promotion on fixed export costs and the crucial role this mechanism plays in rationalizing firms' export participation rate, especially in Europe, arouse concern. An immediate suggestion for improvement is to allow for these impacts to vary across regions. Though methodologically unproblematic, this requires more variation in the data than offered by our current sample. The problem is, as highlighted in Section 4, that few non-exporters that purchase promotion—none in North America—enter the given export market in the subsequent year. The solution might be to expand the sample. Other model restrictions are easier to loosen. For example, we currently restrict market sizes to be constant, implying that the model does not perform well in terms of matching the region-specific trends in total export revenue. Augmenting market sizes with market-specific trends would probably improve this match considerably.

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A Additional Tables

Table 15: Annual transition rates (%), dis-aggregated data

Status in year t	Status in year $t+1$			
	Neither	Only export	Only EPS	Both
Europe				
Neither	96.9	3.0	0.0	0.0
Only export	12.6	86.9	0.0	0.4
Only EPS	78.7	12.8	6.4	2.1
Both	7.4	71.6	3.7	17.3
Total	83.2	16.7	0.1	0.1
North America				
Neither	94.9	4.9	0.1	0.0
Only export	17.6	81.2	0.0	1.1
Only EPS	83.3	0.0	0.0	16.7
Both	4.8	61.9	4.8	28.6
Total	81.3	18.3	0.1	0.3
Asia				
Neither	97.3	2.6	0.0	0.0
Only export	23.1	76.4	0.0	0.5
Only EPS	47.1	29.4	11.8	11.8
Both	6.7	40.0	3.3	50.0
Total	90.9	8.9	0.1	0.2

Table 16: Restricted model predictions ($\gamma_2 = \gamma_4 = 0$ and $\delta_F = \delta_S = 1$)

	2011	2012	2013	2014	2015
Europe					
Export participation rate	-23.5	-31.5	-36.5	-40.0	-42.5
EPS purcahse rate	-5.15	-5.0	-4.87	-4.69	-4.58
Average export revenue	63.5	101	129	150	164
Total export revenue	-4.41	-9.14	-13.9	-17.2	-20.7
North America					
Export participation rate	-12.9	-18.5	-22.4	-25.1	-27.1
EPS purcahse rate	-1.84	-2.78	-3.38	-3.84	-4.11
Average export revenue	60.8	96.8	121	133	142
Total export revenue	-4.78	-11.0	-17.2	-22.7	-25.8
Asia					
Export participation rate	-0.587	-0.717	-0.875	-0.97	-1.03
EPS purcahse rate	-1.86	-1.42	-1.25	-1.09	-1.02
Average export revenue	2.07	2.16	2.45	2.59	2.66
Total export revenue	-0.053	-0.471	-0.743	-0.992	-1.16

Participation rates are reported in percentage point deviations from those reported in Table 5. Export revenues are reported in percentage deviations from those reported in Table 5.

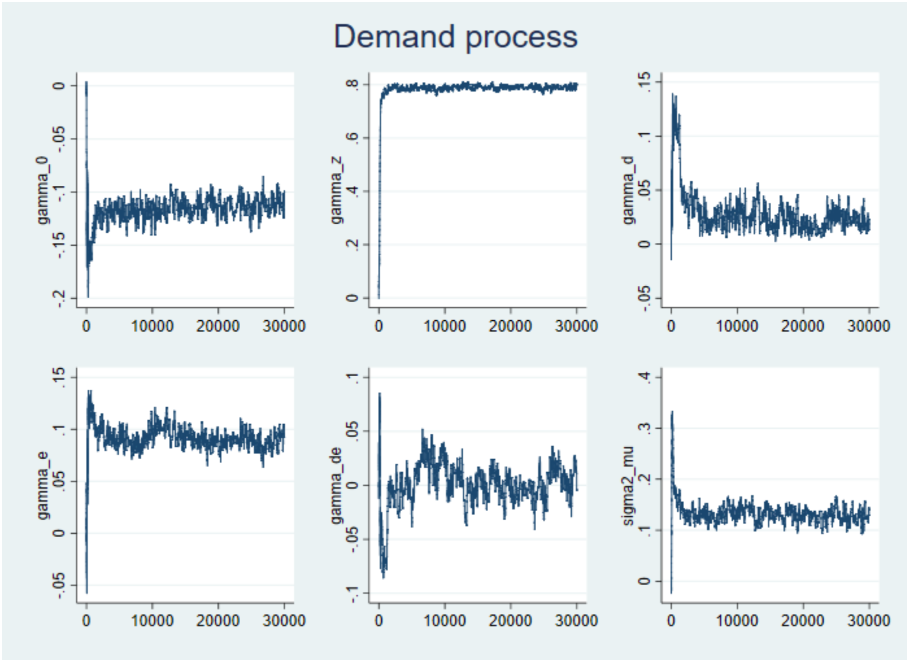
Table 17: Restricted model transitions ($\gamma_2 = \gamma_4 = 0$ and $\delta_F = \delta_S = 1$)

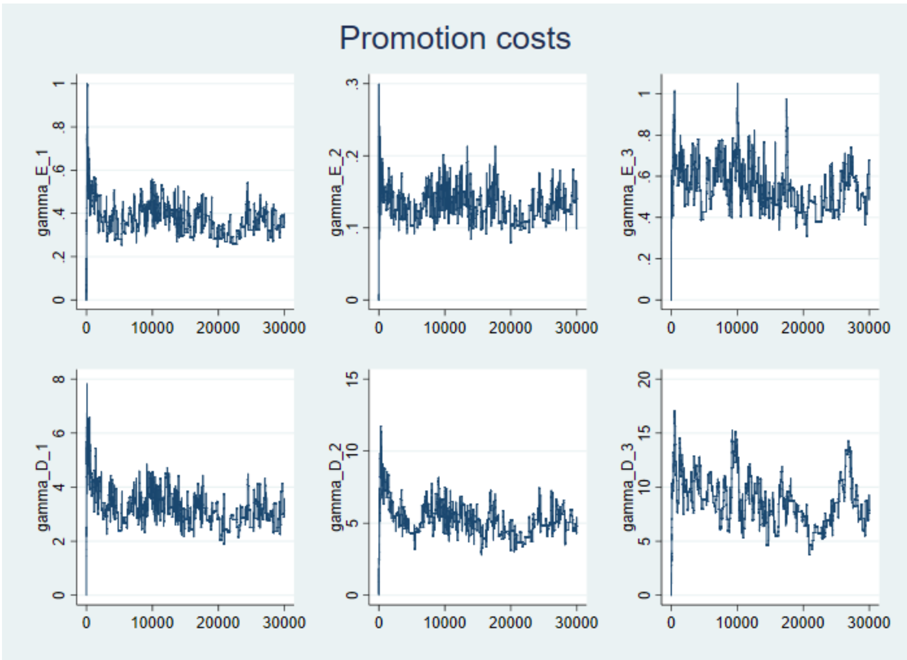
Status in year *t*	Status in year *t* + 1			
	Neither	Only export	Only EPS	Both
Europe				
Neither	8.1	-7.2	-0.4	-0.4
Only export	17.3	-12.5	0.0	-4.7
Only EPS	-	-	-	-
Both	-	-	-	-
North America				
Neither	5.0	-4.5	-0.3	-0.2
Only export	16.2	-12.8	0.0	-3.4
Only EPS	-	-	-	-
Both	-	-	-	-
Asia				
Neither	0.3	-0.1	-0.1	-0.1
Only export	-0.2	2.2	0.0	-2.0
Only EPS	-	-	-	-
Both	-	-	-	-

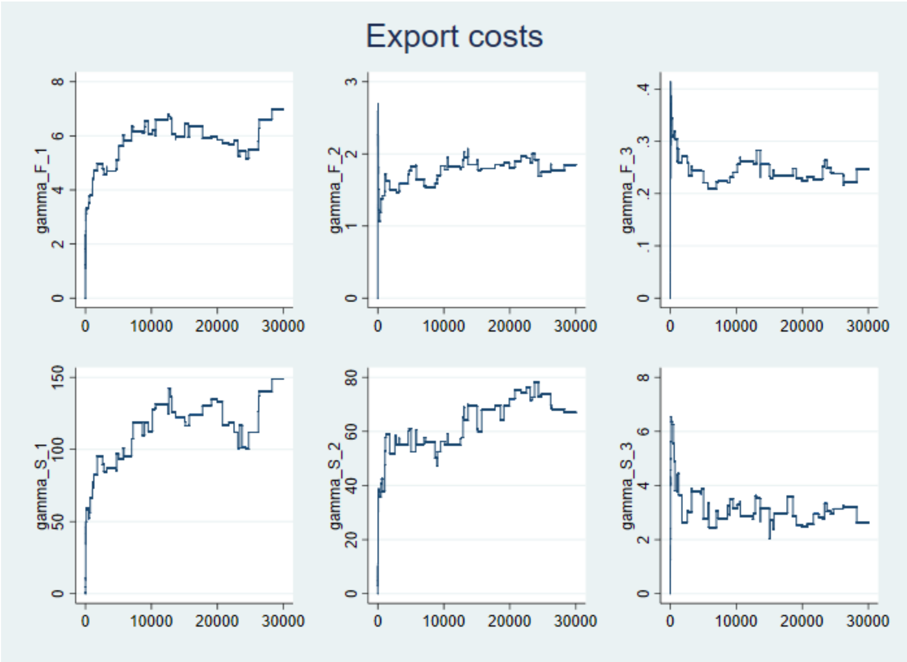
Transition rates are reported in percentage point deviations from those reported in Table 6. "-" indicates that the groups "Only EPS" and "Both" contain no firms.

B Markov Chains

B.1 Initialized in zero, large step sizes



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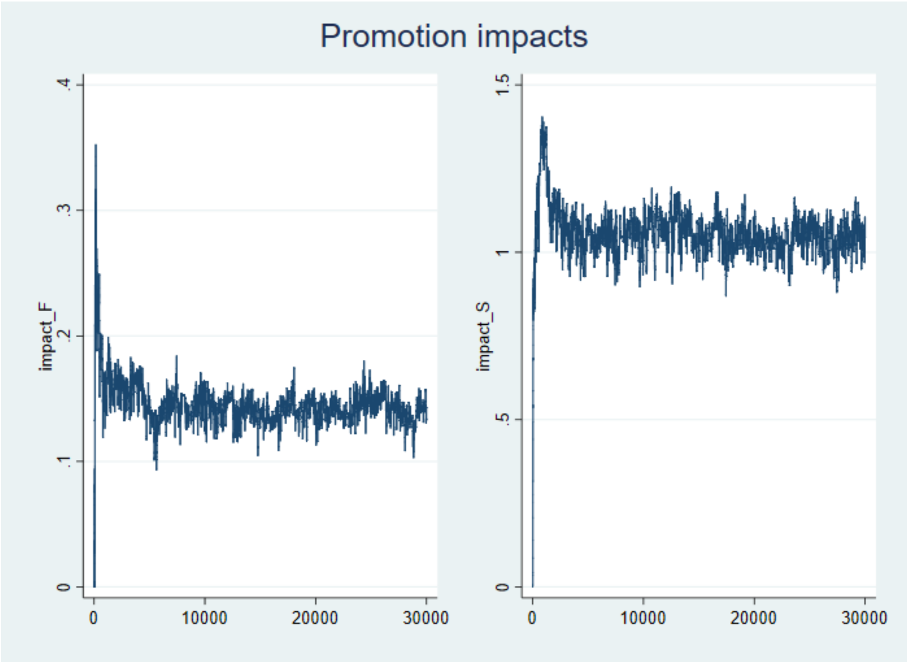
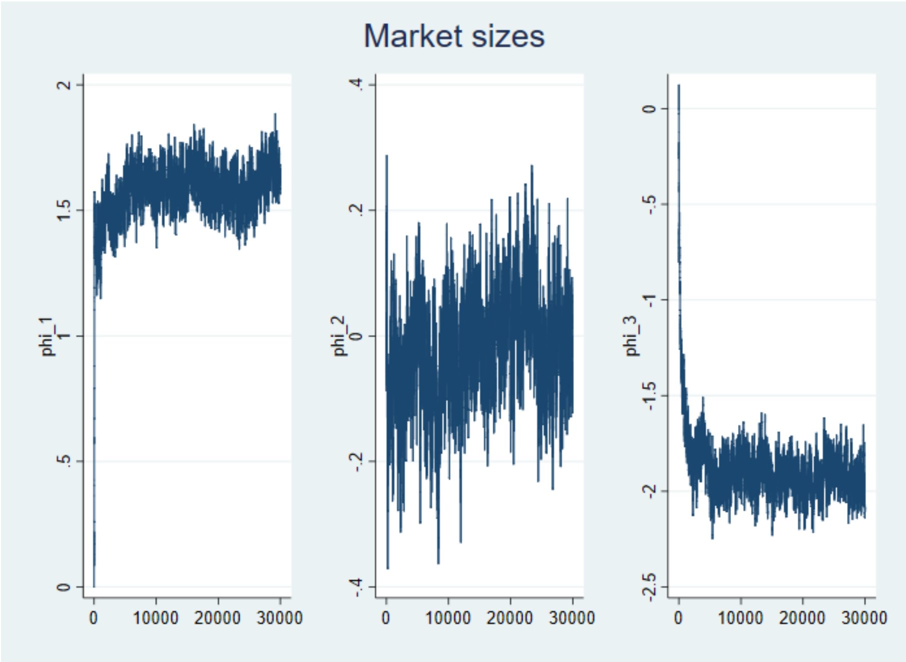
gamma_F_2
gamma_F_3
gamma_S_1
gamma_S_2
gamma_S_3


Promotion impacts
impact_F
impact_S


Market sizes
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phi_2
phi_3
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30000
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2
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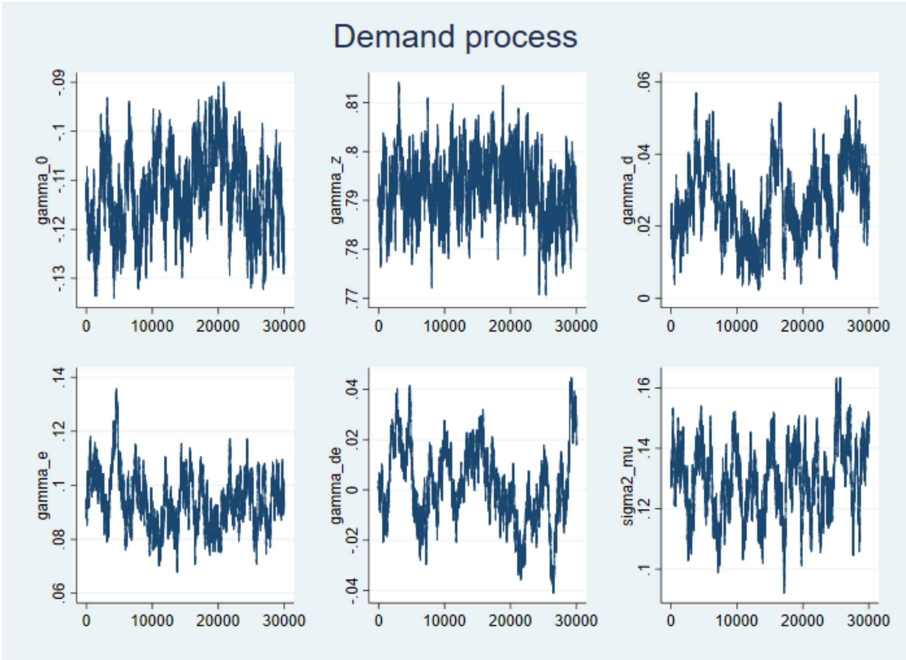
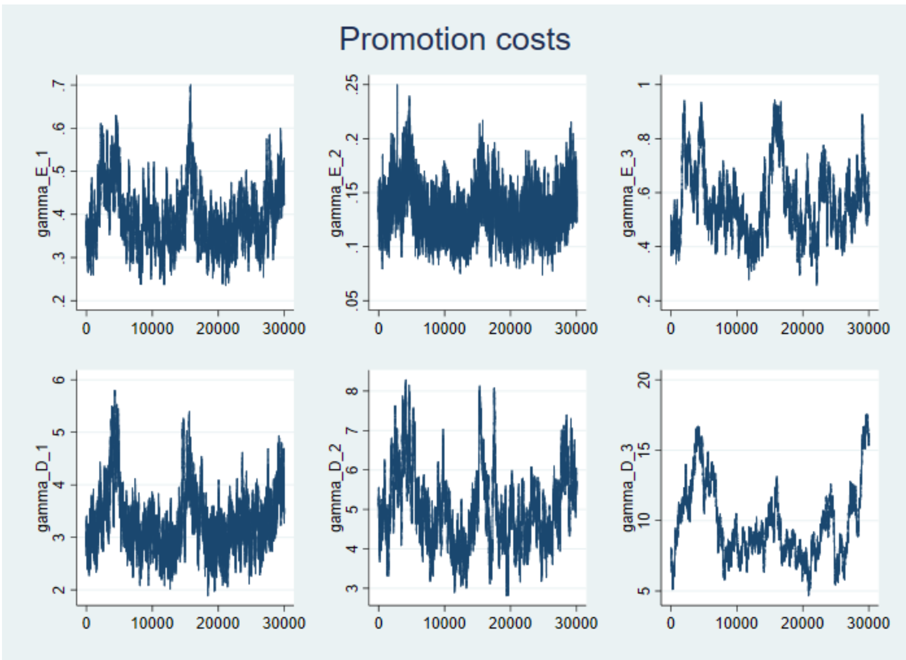
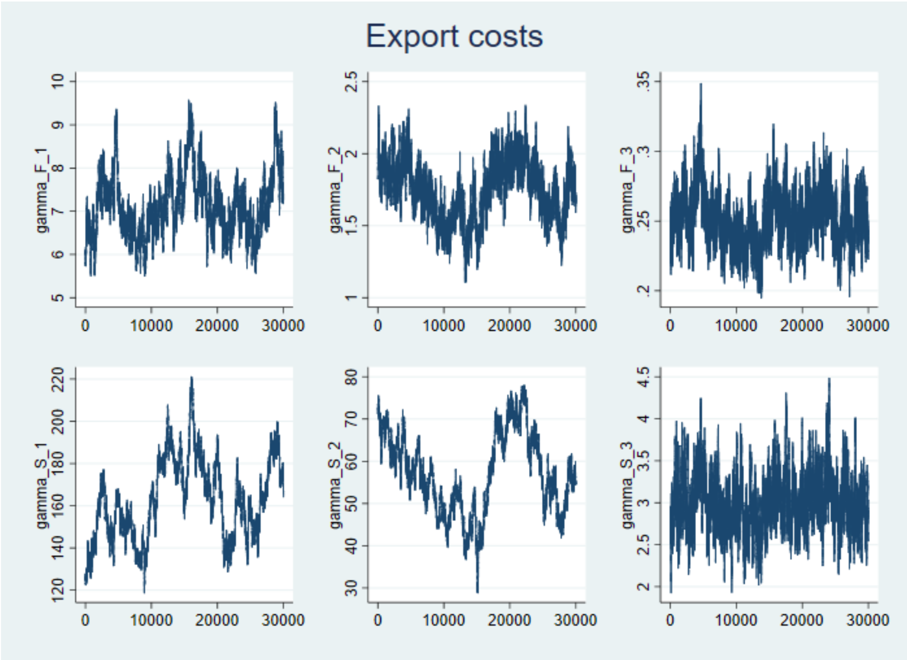
-.2
0
.2
.4
-2.5
-2
-1.5
-1
-.5
0

B.2 Starting values based on prior draws, small step sizes






Export costs
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gamma_F_2
gamma_F_3
gamma_S_1
gamma_S_2
gamma_S_3
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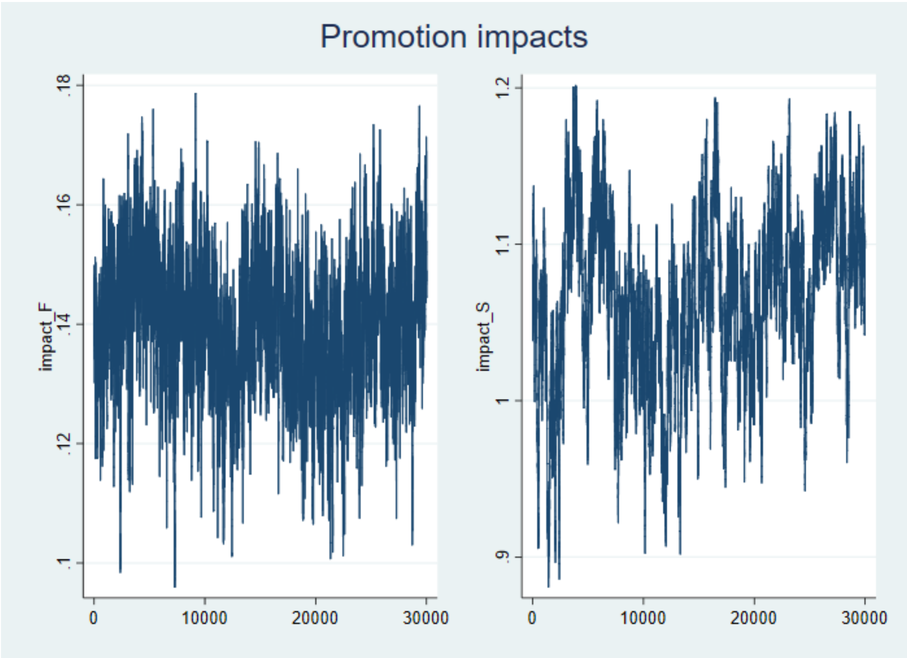
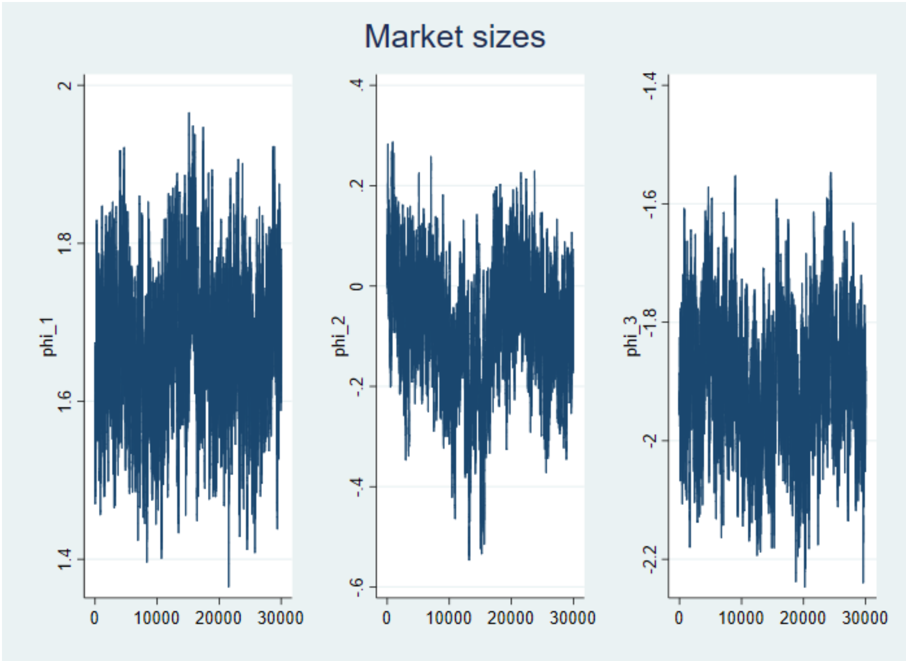
10000
20000
30000


Promotion impacts
impact_F
impact_S
0
10000
20000
30000


Market sizes
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phi_2
phi_3
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1.6
1.4
.4
.2
0
-.2
-.4
-.6
-1.4
-1.6
-1.8
-2
-2.2
0
10000
20000
30000