Market specific fixed and sunk export costs: The impact of learning and spillovers

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Abstract

Firms may face substantial fixed sunk costs when entering an export market. While previous studies have focused on global or country specific sunk export costs, in this study we analyse the importance of market specific sunk export costs (defining 'market' as the market for a given product in a given country). In addition, we investigate the impact of market specific versus country specific sunk export costs. We also distinguish between sunk and fixed costs by analysing the decisions to enter new markets separately from the decision to stay in existing markets. Market specific fixed and sunk export costs are affected by various kinds of learning and spillover effects. A firm may learn about exporting from intramarket experience or from intermarket experience across products or countries. Moreover, knowledge about exporting may spill over from other firms in the export countries, within and between products categories. We use firm-level panel data for Norwegian seafood exports distributed on products and countries. The results support market specific sunk costs, learning and spillovers.

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1. Introduction

Recent years have seen the emergence of a literature which incorporates fixed or sunk export costs in models of international trade. This literature shows that, in the presence of such costs, not all firms export (see Melitz, 2003, or also Medin, 2003 for a model with homogeneous firms), or that not all firms export to all countries (see e.g., Helpman *et al.*, 2008 and Chaney, 2008). Generally, models with fixed or sunk export costs predict that only the most productive firms export; and that more productive firms export more products to more countries.
Additionally, several empirical papers have used firm-level data to study the existence of sunk export costs. In the presence of such costs, the expected profits of exporting today will be higher if the firm exported during the last period, because the sunk cost has already been paid. Consequently, sunk costs create persistence in the export behaviour of firms. The results from these studies unambiguously support the sunk cost hypothesis (see e.g., Roberts and Tybout, 1997 and Bernard and Jensen, 2004). In practice, firms typically expand internationally by entering into new markets one by one, indicating that part of the sunk export cost is market specific. Only analysing the export decision as such will then misrepresent such costs, because it cannot distinguish entry into one export market from entry into several markets.

Some recent contributions concentrate on how firm-level export develops in different markets along extensive and intensive margins (see e.g., Mayer and Ottaviano, 2008 or Bernard *et al.*, 2011a for surveys). Yet, only a few studies have investigated the importance of country specific sunk export costs (see e.g., Moxnes, 2010; Gullstrand, 2011, Morales *et al.*, 2011 and Meinen, 2012).[1] Moxnes (2010) demonstrates that both country specific *and* global sunk export costs should be taken into account: otherwise, estimates of the effect of the latter will be biased. Evidence in Gullstrand (2011) suggests that country specific sunk export costs vary with firm characteristics. Morales *et al.* (2011) estimate the magnitude of country specific sunk export costs. In this paper we extend the analysis to investigate *market* specific sunk export cost, defining 'market' as the market for a particular product in a particular country. We apply a random effects probit model and investigate whether previous presence in a particular export market increases the probability of exporting to that market in the cur-

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[1] Ottaviano and Martincus (2011) and Blanes *et al.* (2008) investigate the importance of the region specific sunk export costs in two and three regions, respectively.

rent period. To our knowledge, this is the first paper to do so. We find evidence of both market specific and country specific sunk costs, and show how the former may be overestimated if the latter is not taken into consideration.

Other factors that may increase the probability of export are learning and spillovers (see e.g., Cleredis *et al.*, 1998). Firstly, we hypothesize that there is learning by exporting Schmeiser (2012) develops a theoretical model where learning about exporting from other countries reduces firms' entry costs to a given country. We hypothesise that a firm's export costs to a particular market can be reduced due to export experience in that particular market as well as from export experience in other markets. For instance, demand patterns may be similar across countries; and a firm that exports to Germany may use the knowledge it has acquired about German demand when exporting to France. Similarly, country specific knowledge may facilitate introduction of new products. Having exported a specific product to Germany, may reduce the costs of starting exporting other products to Germany. Hence, firms with experience in other markets may face lower export costs to a particular market than firms with no such experience. In this paper we allow for a range of learning effects, both intra- and intercountry, and intra- and interproduct. [2]

Secondly, we hypothesise that knowledge acquired by other exporters may spill over to potential exporters and reduce their export costs. Various studies have investigated whether such spillovers reduce global export costs, and the evidence is mixed.[3] Recently, several authors have found support for the hypothesis that spillovers reduce country or market specific export costs.[4] Unlike most of these recent studies we investigate learning and spillovers in a dynamic framework that includes lagged export status among the explanatory variables.

Most studies on spillovers hypothesise that spillovers occur in the home country, from other exporters.[5] In accordance with the theoreti-

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[2]   Some studies have used aggregated trade flows to investigate the impact of experience acquired in other export markets. See e.g. Nicita and Olarreanga (2000) or Evenett and Venables (2002). Some papers also study how learning affects the probability of export to a particular country or market using firm-level data See e.g. Fabling *et al.* (2011); Alvarez *et al.* (2010); Lawless (2011); Morales *et al.* (2011); Castagnino (2011) and Meinen (2012). These papers employ different learning variables from ours, and do not include such a rich variety of different effects. None of these distinguish between entering and continuing exporters within the same regression, as we do, and some focus on entering firms only. Most of them also differ from ours in the econometric methods applied.

[3]   See e.g. Clerides *et al.* (1998) and Bernard and Jensen (2004) for dynamic frameworks; and Aitken *et al.* (1997); Greenaway *et al.* (2004); and Barrios *et al.* (2003) for static frameworks.

[4]   Requena and Castillo (2007), Koenig (2009) and Lawless (2011) find that spillovers affect *country* specific export costs; while Alvarez *et al.* (2010), Koenig *et al.* (2010) and Fabling (2011) find that spillovers affect *market* specific sunk export costs.

[5]   An exception is Lawless (2011), who finds that if there is a high number of national firms exporting to a country, this increases the probability that a firm will enter that country.

cal model in Krautheim (2012) we investigate spillovers from other exporting firms in the destination markets rather than in the home country, assuming there to be 'exporting societies' in the destination countries. As for learning, we distinguish between inter- and intraproduct spillovers.

As opposed to most other studies on learning and spillovers we include both discrete variables on firms' lagged *presence* in markets, capturing the extensive margin, and continuous variables on firms' export lagged *value* to markets, capturing the intensive margin. We find that the extensive margin induces more learning and spillover effects than the intensive margin.

We allow exporting firms to face both fixed and sunk costs. These costs occur independently of exported volume, given that firms export, but sunk costs are entry costs that occur only once. Sunk costs introduce persistence in export behaviour, since staying in a market that is already served by a firm does not require additional sunk costs. Fixed costs on the other hand, occur for each period and impact on the decision to stay in a market as well as on the decision to enter markets. Within the same regression, we distinguish firms that enter new markets from firms that continue exporting in existing markets. We allow learning and spillover effects to reduce both fixed and sunk costs. This enables us to investigate how learning and spillovers affect sunk and fixed costs differently. To our knowledge, this study is the first to do so.

We use a panel dataset of total firm-level Norwegian seafood exports in the period from 1996 to 2007. Norway is one of the world's largest exporters of seafood, with an annual export value of 35.7 billion NOK (2007) (approx. 7.28 billion USD). The industry is highly internationalized, with exports of a great range of products to 196 countries (during the sample period).

Rather than investigating just the probability of global export or export decisions for a given product, we are able to investigate the probability of market specific export, i.e. firm i's exports of product v to country j. The regression analysis supports the hypothesis of market specific fixed and sunk export costs, learning and spillovers (see section 4). To motivate the analysis we will take a brief look at some preliminary evidence (see section 3 for details).

In the presence of market specific sunk costs or learning, we should expect firms to stay in the same markets year after year. Although entry and subsequent exit are not uncommon in our data, there is much

more persistence in market specific export than if firms chose export markets and countries randomly.

In the presence of market specific sunk or fixed export costs, firms will export to a limited number of markets, because they have to pay a fixed cost every time they enter a new market. Helpman *et al.* (2008) and Chaney (2008) present extensions of the Melitz (2003) model, with multiple asymmetric countries and country specific fixed export costs.[6] These models predict that small and less productive firms export to a few countries only. Bernard *et al.* (2011) further extend the Melitz (2003) model to multi-product firms, where firms face both country- and market specific fixed export costs. Large and more productive firms supply a wider range of products to each country than smaller firms. In section 3.2.2 we show that patterns in our data are in accordance with the above-mentioned theories: Large firms in our data export more products and to more countries than do smaller firms.
In the presence of spillovers from other exporters, we should expect firms to cluster in the same countries and markets. Having many Norwegian firms in a given market reduces the entry costs to that market and makes it profitable for more firms to export there. In section 3.2.3 we show that most firms in our data do in fact export to countries where also many other Norwegian firms export.

The focus in the present paper is twofold: (i) to investigate the existence of market specific sunk export costs, and (ii) to investigate whether market specific fixed and sunk export costs are reduced by learning and spillover effects.

The regression results presented in section 4 show that the preliminary evidence on persistence and clustering holds, even after controlling for other possible explanations by including standard gravity variables and firm and product characteristics.

The remainder of this paper is organized as follows: the next section presents the theoretical background for the estimation equation. Section 3 gives a more detailed presentation of the dataset we use, and other data used in the analysis. Results are presented in section 4, with concluding remarks offered in section 5.

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[6]   These models are static in the export decision and therefore do not distinguish between fixed and sunk costs.

2. Theoretical background

This section presents the theoretical background for our the empirical investigation. It follows Roberts and Tybout (1997) in modelling firms' export decisions in the presence of sunk export costs. They construct a multi-period model of firms' export participation decisions. We consider export to a given market rather than exports in general or exports to a given country, and we allow for both sunk and fixed costs.

We introduce several learning and spillover effects. In our model here, a firm may learn from its export experience, both in the particular export market and in other export markets. Further, spillovers occur from other firms in the destination country. In contrast to previous studies, we allow learning and spillovers to impact both on sunk costs and on fixed costs. The effects are identified by distinguishing between the decisions to enter new markets versus staying in existing markets.

2.1 Profits from exporting

Consider *market specific export:* i.e. firm i's export of product v to country j. There are many firms that export one or more products to one or more countries. For each firm i in period t, the term $\pi^*_{ivjt}(\boldsymbol{p}_{vjt}, \boldsymbol{v}_{ivjt})$ denotes extra profits from exporting product v to country j. These are gross profits not adjusted for sunk cost of entering markets or for fixed costs for operating in a market. The vector $\boldsymbol{p}_{vjt}$ consists of variables that are exogenous for firms. It reflects product, country and time specific factors. $\boldsymbol{v}_{ivjt}$ is a vector of factors that are firm specific. It includes firm size, experience and market position.

We assume constant marginal costs. This allows us to treat each firm's export volumes in each market independently of each other. We also assume that the price received by firm i for product v in country j is independent of export activities in other markets ($v' \neq v$ and/or $j' \neq j$). We assume that any effect of other firms' export on the price received by firm i is external. In the appendix we describe how a profit function can be constructed on the basis of standard *CES* preferences and constant marginal costs. In that case, the profit function is proportional to sales values in each market. Without sunk and fixed export costs, firm i will export product v to country j if $\pi^*_{ivjt} > 0$.

Each firm also faces fixed costs of exporting any product v to any country j, M_{vjit}, and sunk costs of entering a market, G_{vijt}. These are assumed to depend on a set of learning and spillover effects described in detail below. If there are no sunk costs, firm i will export product v to country j in period t if $\pi^*_{ivjt} > M_{ivjt}$. We will use the notation $\pi'_{ivjt} = \pi^*_{ivjt} + M_{ivjt}$. Sunk costs, G_{ivjt}, occur only when the firm enters the market, not if the firm is already present there.

2.2 Market specific sunk export costs

Future prices and costs, and hence profits in any future period, s, π'_{ivjt+s}, are uncertain to the firm. If there are market specific sunk export costs, the decision to export to the market today hinges on expected future profits. If the firm exits the market one year and then re-enters later, the full sunk cost recurs.[7] We define the variable y_{ivjt} taking on the value of 1 if firm i exports product v to a country j in period t and 0 otherwise.

With market specific sunk export costs, the single period profit from exporting product v to county j becomes:

$$1.1 \qquad \pi_{ivjt}\left(y_{ivjt}\right) = \left[\pi'_{ivjt} - \left(1 - y_{ivjt-1}\right)G_{ivjt}\right]y_{ivjt}$$

From eq. 1.1 is it seen that in the presence of market specific sunk export costs, previous export status will affect today's profit from exporting. Consequently, once in the market, the firm may find it profitable to continue exporting even if this yields negative profits in single periods, because expected profits of exporting to the market in the future may be positive. [8] The firm hence faces a dynamic maximization problem, which cannot be analysed by maximizing π'_{ivjt} at time t. Since future profits are uncertain, at time t the firm instead chooses the infinite sequence of values $y^+_{ivjt} = \{y_{ivjt+s} | s \geq 0\}$ that maximizes the expected present value of current and future profits.

Firm i's optimal export strategy is the y_{ivjt} that satisfies the Bellman equation:

$$1.2 \qquad V_{ivjt} = \max_{y^+_{ivjt}}\left(\pi_{ivjt} + \delta E_t\left(V_{ivjt+1}\left(\Omega_{it}\right) | y_{ivjt}\right)\right)$$

E_t is an expectations operator conditioned on firm i's information set at time t, Ω_{it}, and δ is the discount rate in each period. Consequently V_{ivjt} is the value of the optimal strategy for firm i's export strategy for

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[7] This assumption is made for simplicity. Other authors, such as Roberts and Tybout (1997), Bernard and Jensen (2004), Gullstrand (2011) and Meinen (2011), discuss the possibility that only part of the sunk costs recurs if the firm re-enters the market. Some authors also include exit costs in the theoretical formulation. It is a simplification without many consequences to disregard these.

[8] See Baldwin (1988), Dixit (1989) and Baldwin and Krugman (1989).

product v in country j in period t. A firm chooses to export in period t if the expected value of exporting is larger than the expected value of not exporting. Using (1.1), we get that export in this period will be positive ($y_{ivjt}>0$) if:

1.3

$$\pi'_{ivjt} + \delta\left[E_t\left(V_{ivjt+1}(\Omega_{it})\mid y_{ivjt}=1\right) - E_t\left(V_{ivjt+1}(\Omega_{it})\mid y_{ivjt}=0\right)\right] \geq \left(1-y_{ivjt-1}\right)G_{ivjt}$$

The equation shows that in the presence of market specific sunk export costs, the decision to export in period t depends on export status in period t-1. In the regression analysis, the effect of lagged export status on today's export decision is interpreted to indicate the importance of market specific sunk export costs.

2.3 Learning and spillovers

The model includes several learning and spillover effects that may influence firm i's decision to export product v country j.[9] Firm i may learn from past presence with the same product in the same country ($y_{ivjt-1}=1$) and from past presence with other products in the same country ($y_{iv'jt-1}=1$). Further, it may learn from the number of other markets it exports product v to ($\Sigma y_{ivj't-1}$) and from the number of other market it exports all products to ($\Sigma y_{ij't-1}$). In addition there may be positive spillovers from the number of other exporters in country j, both for exporters of product v ($\Sigma y_{i'vjt-1}$) and for exporters of all products ($\Sigma y_{i'jt-1}$) $i'\neq i$, $v'\neq v$ and $j'\neq j$. There may also be additional learning and spillover effects from high *export value* in other markets or from other firms. Section 4 and appendix 1 present a thorough description of all learning and spillovers effects investigated in the regression analysis.

Several other studies have hypothesised that learning and/or spillovers affect sunk export costs.[10] We distinguish between effects on sunk costs and on fixed costs. Effects on sunk costs are present only for entrants, when past export experience is 0. (If $y_{ivjt-1}=1$, then $G_{ivjt}=0$, so no variables can reduce G_{vijt} further.) Effects on fixed costs are present for both entrants and firms that exported to the market the previous period. (M_{ivjt} can be further reduced even if entry is already undertaken.) In other words, sunk costs are important for the decision to enter markets while fixed costs also influence the decision to stay in a mar-

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9   Two recent theoretical contributions incorporate learning and spillovers in general equilibrium models of firms' decisions to export to different countries. In Krautheim (2012), country specific fixed export costs are reduced due to spillovers from domestic exporters in the destination market. In Schmeiser (2012), learning from own export experience in other countries reduces sunk entry costs to a particular country.

10   See e.g. Cleredis *et al.* (1998), Bernard and Jensen (2004), Álvarez *et al.* (2010), Koenig (2009), Koenig *et al.* (2010), Lawless (2011) and Fabling *et al.* (2011), for spillovers; and Alvarez *et al.* (2010), Gullstrand (2011) Lawless (2011), Morales *et al.* (2011), Castagnino (2011) and Meinen (2012) for learning.

ket. Consequently, we attempt to distinguish between the combined effect on fixed and sunk costs and on fixed costs alone by interacting learning and spillover variables with a categorical variable for the firm's presence in the market the year before (lagged export status). In other words, we include both entrants and firms that exported to the market last year and the same regression, but, in contrast, other studies, we allow learning and spillovers to affect two kinds of firms differently.

The left-hand side of eq.1.3 describes expected profits net of entry costs. Now define expected profits net of entry costs and fixed costs as:

$$\pi_{ivjt}^{n} = \pi_{ivjt}^{'} - M_{ivjt} + \delta\left[E_{t}\left(V_{ivjt+1}\left(\Omega_{it}\right)|\ y_{ivjt} = 1\right) - E_{t}\left(V_{ivjt+1}\left(\Omega_{it}\right)|\ y_{ivjt} = 0\right)\right]$$
$$= \pi_{ivjt}^{*} + \delta\left[E_{t}\left(V_{ivjt+1}\left(\Omega_{it}\right)|\ y_{ivjt} = 1\right) - E_{t}\left(V_{ivjt+1}\left(\Omega_{it}\right)|\ y_{ivjt} = 0\right)\right]$$

We now have that

$$y_{ivjt} = \begin{cases} 1 & \text{if } \pi_{ivjt}^{n} \geq \left(1 - y_{ivjt-1}\right)G_{ivjt} + M_{ivjt} \\ 0 & \text{otherwise} \end{cases}$$

We allow G and M to depend on firm i's experience from other markets and on spillovers from other firms. The firm decides to export if:

$$\pi_{ivjt}^{n} \geq \left(1 - y_{ivjt-1}\right)G_{ivjt} + M_{ivjt} = \left(1 - y_{ivjt-1}\right)\left(G^{0} + G^{L}y_{it-1}^{*} + G^{S}y_{i't-1}^{*}\right) +$$

$$\left(M^{0} + M^{L}y_{it-1}^{*} + M^{S}y_{i't-1}^{*}\right), \quad i \neq i'$$

Above, G^{0} and M^{0} denote market specific sunk and fixed costs that are independent of learning and spillovers from other markets. Nevertheless, it may be that the firm learns through own export activities in the same market, and therefore that the fixed costs of serving that market (M^{0}) decrease with the firm's experience in the same market. It is not possible to separate out this effect. Both market specific sunk costs and market specific learning create persistence in market specific exports, and both effects are captured by y_{ivjt-1} in the regression analysis.

G^{L} and M^{L} denote the reduction in sunk and fixed costs that is due to firm i's experience from other markets (learning effects). These are specified to occur if firm i exported to any other market in the previous period. Firm i's activities in other markets are indicated by the vector y_{it-1}^{*}. This vector consists of indicators for presence in the same country or for presence in other countries with the product in question or with other products. Consequently, G^{L} and M^{L} are coefficient vec-

tors. Other firms' activities are denoted with the vector $y^*_{i't-1}$, $i' \neq i$. G^S and M^S are therefore coefficient vectors for reductions in sunk and fixed costs because of spillovers. The firm therefore chooses to export if:

1.4
$$\pi^n_{ivjt} - G^0 - M^0 \geq -G^0 y_{ivjt-1} + G^L \left(1 - y_{ivjt}\right) y^*_{it-1} + G^S \left(1 - y_{ivjt-1}\right) y^*_{i't-1} + M^L y^*_{it-1} + M^S y^*_{i't-1}$$

G^L, G, M^L and M^S relate to G and M as follows:

$$G_{ivjt} = G^0 - G^L_{iv'j} y_{iv'jt-t} - G^L_{ivj'} \sum_{j=1} y_{ivj't-1} - G^S_{ij'} \sum_{j=1} y_{ijt-1} - G^S_{i'vj} \sum_{i=1} y_{i'vjt-1} - G^S_{i'j} \sum_{i=1} y_{i'jt-1}$$

$$M_{ivjt} = M^0 - M^L_{iv'j} y_{iv'jt-t} - M^L_{ivj'} \sum_{j=1} y_{ivj't-1} - M^L_{ij'} \sum_{j=1} y_{ijt-1} - M^S_{i'vj} \sum_{i=1} y_{i'vjt-1} - M^S_{i'j} \sum_{i=1} y_{i'jt-1}$$

$v \neq v'$, $j \neq j'$, $i \neq i'$

We will pay special attention to the variable $G^L_{iv'j}$. This is a variable that indicates the extent to which export experience in a country for other products will be beneficial for starting to export a new product to the same country. One interpretation of this variable is that it captures country specific learning. Another is that it reflects country specific sunk export costs, which may accrue in addition to pure market specific sunk export costs. For example, costs related to establishing a sales office may be specific to the country and not to the market. In this case, having exported another product to the country the year before reduces sunk costs of starting to export a new product to the same country, because the country specific part of the entry cost is already paid for. Not taking this effect into account will give upward biased estimates of the effect of market specific sunk export costs.[11]

As was the case for market specific sunk export costs and learning, it is not possible to separate the effect of country specific sunk export costs from country specific learning. $G^L_{iv'j}$ denotes the effect of both, and in the regression analysis $y_{iv'jt-1}$ will capture both effects. $M^L_{iv'j}$ reflects learning effects on market specific fixed export costs.

2.4 The regression equation
In line with several other studies (see e.g., Roberts and Tybout, 1997) we specify a reduced form of the latent variable $\pi^n_{ivjt}-G^0-M^0$. Therefore we do not specify the profit function but approximate it with an

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[11] Moxnes (2010) studies country specific versus global sunk export costs. He argues that not including country specific export participation in the analysis will overestimate the effect of global sunk export costs. Further, Meinen (2011) argues that export experience from another country may reduce country specific sunk export costs if these have a global component.

expression in exogenous firm, product, country and time variables and combinations of the four dimensions. Thus, we write

$$\pi_{ivjt}^{n} - G^{0} - M^{0} = \mathbf{z}_{ivjt}\boldsymbol{\eta} + e_{ivjt}$$

The vector $\mathbf{z}$ consists of variables that are specific to the firm, the product or country or any combination of the three. These are captured by dummy variables and by other variables as described in section 4. e_{vijt} denotes noise. If the left-hand side of the above equation is positive, net of sunk and fixed costs, the firm chooses to export to this market (product-country combination). Based on eq. 1.4 we therefore specify the binary choice equation as:

1.5

$$y_{ivjt} = \begin{cases} 1 & \text{if } 0 \leq \alpha_0 y_{ivjt-1} + \alpha_1\left(1 - y_{ivjt-1}\right)y_{iv'jt-1} + \alpha_2 y_{ivjt-1}y_{iv'jt-1} + \alpha_3\left(1 - y_{ivjt-1}\right)y_{ij't-1}^{*} \\ + \alpha_4 y_{ivjt-1}y_{ij't-1}^{*} + \alpha_5\left(1 - y_{ivjt-1}\right)y_{i'jt-1}^{*} + \alpha_6 y_{ivjt-1}y_{i'jt-1}^{*} + \mathbf{z}_{ivjt}\boldsymbol{\eta} + e_{ivjt} \\ 0 & \text{otherwise} \end{cases}$$

We hence have a model where the dependent variable lagged one period is among the explanatory variables. The coefficient for this lagged dependent variable, α_0, denotes the effects on the costs of exporting given that the firm was present in the same market the year before. A positive α_0 implies that having exported to the market last year increases the probability of exporting there this year and it is interpreted as the sunk cost parameter of serving that single market (but again – it may also capture learning from own experience in the market in question).

In eq. 1.5 we also include several other variables interacted with a categorical variable for whether the firm is an entrant ($1-y_{ivjt}$) or a continuing exporter (y_{ivjt}). Effects for entrants are interpreted as combined effects on fixed costs and sunk costs. These are captured by α_1 α_3 and α_5. Effects for continuing exporters are interpreted as effects on fixed costs and are captured by α_2 α_4 and α_6 correspondingly. Alternative interpretations are discussed below.

We pay particular attention to α_1. α_1 denotes the effects of experience from exporting other products to the same country on the costs of entering the country with a particular product. It is interpreted as the effects on market specific fixed and sunk costs from serving other markets in the same country. It will increase the probability that the firm starts exporting to a given market (note the interaction with ($1-y_{ivjt-1}$). It captures country specific sunk costs (or country specific learning). Not including it in the analysis will result in upward biased estimates

of α_0. α_2, on the other hand, denotes the reduction in market specific fixed costs from having export experience with other products in the same country. We interpret it as country specific learning. It will increase the probability that the firm continues to export to a given market (note the interaction with y_{ivjt-1}).

α_3 and α_4 denote the reduction in market specific sunk and fixed costs from experiences from other countries, i.e. learning effects. As indicated above, $y^*_{ij't-1}$ is a vector of varying indicators of experience from other countries. It captures the number of countries to where the firm exports product v and the number of countries to where the firm exports all products as well.

$y^*_{i'jt-1}$ is a vector of indicators of the number of other firms exporting the same or different products to the country, thus α_5 and α_6 capture spillover effects..In the analysis we also include variables of export *value* that correspond to the learning and spillover variables described above. These variables are intended to capture additional learning and spillover effects from firms' intensive margin. For simplicity, these variables are not included in the equations, but are described in detail in section 4 and in appendix 1. Krautheim (2012) argues that spillovers in the destination markets are a function of the number of other exporters present there, rather than the export value. By allowing for spillovers from both the extensive and intensive margins we are able to test for various effects: the number of exporters, their average export value as well as the total value of exports may induce spillovers. The probability that firm i exports product v to country j in period t is therefore given by the probability regression equation:

1.6

$$P\left(y_{ivjt}=1\right)=f\begin{pmatrix} \alpha_0 y_{ivjt-1}, \alpha_1\left(1-y_{ivjt-1}\right)y_{iv'jt-1}, \alpha_2 y_{ivjt-1}y_{iv'jt-1}, \alpha_3\left(1-y_{ivjt-1}\right)y^*_{ij't-1}, \\ \alpha_4 y_{ivjt-1}y^*_{ij't-1}, \alpha_5\left(1-y_{ivjt-1}\right)y^*_{i'jt-1}, \alpha_6 y_{ivjt-1}y^*_{i'jt-1}, \mathbf{z}_{ivjt}\boldsymbol{\eta} \end{pmatrix}$$

2.4.1 Alternative interpretations of the effects on fixed and sunk costs

Our formulation is pragmatic, developed for the dataset at hand. Learning and spillovers are allowed to impact on both fixed and sunk export costs. This is our strategy for distinguishing between effects on entering firms and continuing exporters. Other interpretations are also possible. For example, there may be learning and spillover effects for production costs, so firms with high export values could have higher entry rates and persistence in the markets they serve. We control for this with size effects and with firm dummies. Further, learning and spillovers may also influence variable export costs. We believe that

the distinction between fixed and variable export costs is not important in this context, since we analyse only the decision to export to a market, not how much the firm exports.

Our approach differs from some other contributions in how we interpret the effect of interaction variables between learning/spillover variables and lagged export status (i.e. the effect for continuing exporters). If the coefficients for our learning and spillover variables for continuing exporters are positive, we interpret this as supporting the hypothesis that learning and spillovers reduce fixed costs.

An alternative interpretation could be that sunk costs are greater for certain types of firms. If our learning and spillover variables reflect characteristics of firms rather than actual learning and spillovers, and sunk export costs vary according to these characteristics, then positive coefficients for continuing exporters can reflect the fact that sunk costs are higher for firms with those characteristics. In such cases, persistence, and hence the probability of continuing to export, should be higher for the firms with the characteristics in question. Such an interpretation is in line with how some other studies, which do not distinguish between sunk and fixed export costs, interpret coefficients for interaction variables between lagged export status and firm (and possibly country) characteristics (see e.g., Bugamelli and Infante, 2003, Máñez *et al.* 2008 and Gullstrand, 2011).

We will illustrate the distinction by an example: Let l be the variables that are interacted with lagged export status. In Gullstrand (2011) l contains, among other things, firms' productivity, and Gullstrand finds a negative coefficient. He concludes that sunk export costs are less important for more productive firms. However, in line with our interpretation, Gullstrand's findings may well indicate that more productive firms have higher fixed costs in exporting (not less important sunk costs). Both interpretations may be correct, but we believe that distinguishing between sunk and fixed export costs, as we do, makes the analysis richer.

Further, in our model, where l is intended to capture learning and spillover effects rather than firm and market characteristics, we believe that our interpretation is more adequate. This is because we do have reason to believe that sunk and fixed costs vary indirectly via learning and spillovers, but we do not have reason to believe that sunk costs vary directly according to the characteristics reflected in l in our analysis.[12] For example, l includes the number of other markets the

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[12] Nevertheless, in line with Gullstrand's interpretation, learning and spillovers may potentially reduce persistence: If there are cumulative learning and spillovers effects that reduce sunk cost, exit and subsequent re-entry becomes less costly. (Note, however, that we ab-

firm exports to, and we find a positive effect for continuing exporters. Using Gullstrand's interpretation, this should indicate that firms that export to many markets face greater market specific sunk export costs. We find such an interpretation counterintuitive and therefore choose to interpret the positive coefficient as reductions in fixed costs due to learning.[13]

2.5 Econometric issues

An important econometric problem with estimating eq. 1.6 is α_0. There is most likely unobserved heterogeneity between firms, products and countries that can potentially affect a firm's probability of exporting a given product to a given market. There may be differences in, for example, employee skills. If a firm has a German-speaking employee it may be more likely to export to Germany. Further, personal networks may influence which products a firm exports to which countries.[14]

Such heterogeneity is likely to create persistence in the dependent variable. If it is not corrected for, α_0 will be overestimated. The unobserved heterogeneity may also be correlated with the other explanatory variables, in which case the coefficients for these variables will be inconsistently estimated.[15]

There are various possible estimation strategies for correcting for this heterogeneity. One commonly used method in studies of sunk export costs is to apply a probit estimation with firm specific random effects (see e.g., Roberts and Tybout, 1997; Clerides *et al*., 1998; Bugiamlli and Infante, 2002; Bernard and Jensen, 2004; Gullstrand, 2011; and Meinen, 2012). Another method is to compare linear probability models with and without firm specific fixed effects with an estimation of first differences (see Bernard and Wagner, 2001; Bernard and Jensen, 2004; and Gullstrand, 2011). We follow the method applied in most studies: a random effects probit model.[16]

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stract from such cumulative effects since we include only one lag of learning and spillover variables in our econometric specification.) When we observe increased persistence, we interpret this as effects on fixed costs net of potential counteracting effects through sunk costs.

[13] For one variable, however, we find Gullstand's interpretation relevant. See section 4.1.3

[14] Medin and Melchior (2002) found that employees' special skills and personal networks were important for which countries Norwegian seafood exporters chose to export to.

[15] See Heckman (1981), Roberts and Tybout (1997) and Bernard and Jensen (2004) for discussions.

[16] Random effects cannot be applied in a logit model. Neither can fixed effects when the lagged dependent variable is among the explanatory variables (Card and Sullivan, 1988). Inclusion of fixed effects in a probit model gives rise to the *incidental parameter* problem (see Heckman, 1981). The advantage of random effects is that, in contrast to fixed effects, they can be included in a probit model.

In this study, the unobserved heterogeneity is at the firm-product-country specific level. This heterogeneity can be formulated by assuming that the error term consists of two terms:

$$e_{ivjt} = \varepsilon_{ivj} + u_{ivjt}$$

where ε_{ivj} captures elements that are time-invariant and firm-product-country specific. Remaining noise is captured by u_{ivjt}.

An important problem is the *initial conditions* problem (see Heckman, 1981). The problem concerns how to treat the first observation of the lagged dependent variable. Export experience is likely to be correlated with unobservable characteristics. However, simply including y_{ivj0} as an explanatory variable for y_{ivj1}, implies treating y_{ivj0} as exogenous and hence uncorrelated with the unobservable characteristics. This is not likely to be true.

Several solutions have been proposed in the literature. Heckman (1981) proposes using the dataset's pre-sample exogenous variables to estimate the first observation and then including the estimated first observation in the regression model. This methodology has been applied in several studies of persistence in firms' export decisions (see e.g., Roberts and Tybout, 1997 or Moxnes, 2010). Wooldridge (2005) suggests capturing the correlation between unobserved heterogeneity and y_{ivj0} by including y_{ivj0} together with all observations for all years of the time-variant exogenous variables as auxiliary explanatory variables for every year in the regression, and then running a standard random effects probit regression. We use this methodology but choose to include the within means of the time-variant exogenous variables instead of all observations, in order to make the computational task manageable. The Wooldridge method then consists in considering the unobserved heterogeneity, ε, as the expression:

$$\varepsilon_{ivj} = \lambda_0 + \lambda_1 y_{ivj0} + \lambda_2 \bar{\mathbf{x}}_{ivj} + \mu_{ivj}$$

Above $\bar{\mathbf{x}}_{ivj}$ now denotes the vector of the within mean of all time-variant right hand variables in eq. 1.7, λ_i the vector of coefficients to be estimated and μ_{ivj} is an unobserved individual effect which is assumed *iid* $N[0,\sigma^2_\mu]$. Our learning and spillover variables are constructed with interactions with dummy variables for entrance ($1-y_{vijt-1}$) or continuance (y_{vijt-1}) in markets. Following Wooldridge (2005), we interact the within means of these variables with ($1-y_{vijt0}$) and (y_{vijt0}). The regression equation becomes:

1.7

$$P\big(y_{ivjt}=1\big)=f\left(\begin{array}{c}\alpha_0 y_{ivjt-1},\alpha_1\big(1-y_{ivjt-1}\big)y_{iv'jt-1},\alpha_2 y_{ivjt-1}y_{iv'jt-1},\alpha_3\big(1-y_{ivjt-1}\big)y^*_{ij't-1},\\[2mm]\alpha_4 y_{ivjt-1}y^*_{ij't-1},\alpha_5\big(1-y_{ivjt-1}\big)y^*_{i'jt-1},\alpha_6 y_{ivjt-1}y^*_{i'jt-1},\mathbf{z}_{ivjt}\boldsymbol{\eta},\lambda_0,\lambda_1 y_{ivj1},\overline{\mathbf{x}}_{ivj}\boldsymbol{\lambda_2}\end{array}\right)$$

An advantage of using the Wooldridge method is that it also corrects for potential serial correlation in u_{ivjt} caused by ε_{ivj} being correlated with the explanatory variables (see Chamberlain, 1984 and Mundlak, 1978).Another advantage is that it reduces the variance of the unobserved to heterogeneity, σ^2_ε. As pointed out by Heckman (1981), a large σ^2_ε may overestimate the effect of the lagged dependent variable. We perform random effects probit estimation of eq. 1.7. Stewart (2006) and Akay (2011) test the above approach and compares it with other approaches (in particular that proposed by Heckman, 1981). They conclude that the Wooldridge method performs as well as and sometimes better than the Heckman solution for time series longer than 5–8 periods.

We use the random effects Wooldridge regression as our baseline regression, but we compare the results with the ordinary random effects probit regression. The Wooldridge methodology implies that several of our variables are included as well as their within means. This is important when interpreting the results.

We interact learning and spillover variables with dummy variables indicating entrance or continued export activities (the lagged dependent variable). Ai and Norton (2003) argue that marginal effects of interaction terms in nonlinear regression analyses are not equal to the estimated marginal effect. We believe that this critique is not crucial for our purposes, since our interaction effects are with dummy variables that serve to distinguish observations between groups of firms (entrants versus continuing exporters) rather than for analysing changes in the interaction terms. This issue is further discussed in Greene (2010) and Kolasinski and Siegel (2010).

3. Data and descriptive statistics

We use a panel dataset of total Norwegian seafood exports for the years 1996 to 2007, provided by statistics Norway. Export is disaggregated on firms, products and countries. Over the whole period, the most important export destinations in terms of export value are Denmark, Japan, France, Great Britain and Russia; the most important exported products are Fresh Whole Salmon/Trout, Stockfish/Clipfish and Frozen Whole Pelagic Wish.

Most other studies focus on manufacturing firms, and an important question is whether the results from our study can be generalised to other sectors. Admittedly, seafood has some peculiarities as compared to other products. For one thing, some seafood product groups are necessarily quantity restricted, as fishing rights for caught fish are distributed by quotas. We do not believe that this is a serious objection regarding the general implications of our findings. In appendix 2 we show that that our analysis is also relevant for the distribution of a given export volume across countries. In addition, important product groups in our data are farmed fish, and these are not quantity restricted to the same extent as caught fish. Further, many manufacturing sectors are also characterised by varying degrees of quantity restrictions.

Another issue is that much seafood constitutes more homogeneous product groups than manufactured products. Some findings indicate that sunk and fixed export costs are more important for heterogeneous products than for homogeneous ones (Rauch, 1999). We expect sunk costs, e.g. related to adjustment to different product and veterinarian standards, to be present also for seafood exporters. Nevertheless, Melchior (2003) shows that the sunk costs of exporting are dozens of times higher among Norwegian IT exporters than among seafood exporters. If anything, then, our results underestimate the general impact of market specific sunk and fixed costs.

Firms in our data export in total 376 product groups at eight digit HS-level to 196 countries. Expanding the data to cover all possible markets, we get 376x196=74 824 markets. On average 496 firms are active each year during the sample period, yielding an average of 37,112,704 observations each year. This is prohibitively large for data computation purposes. Nevertheless, it is not adequate to include all observations in the regression analysis. Our purpose is to study firms' exports to specific markets, not firms' global exports. Therefore we reduced the data in various ways.

3.1 The full dataset versus the sample used for regression analysis

3.1.1 Firms and products

Many of the 8-digit HS-level products are similar. We therefore aggregate them into 25 groups that are fairly homogeneous in terms of production and exporting conditions.[17] This also have the advantage of reducing the number of observations into a more manageable one. Three of the groups differ substantially from the others, so we have dropped them from the sample used for regression analysis.[18] Further, we merge export data with data for country- and product-level import from the COMTRADE database, where products are on 6-digit HS-level. This is necessary for including countries' total import of the product groups in the regressions. Aggregations of 6- and 8-digit HS-level products do not fully correspond. For four of our groups the deviation is severe, so we exclude them from the sample used for regression analysis.[19] Only the remaining 18 product groups are therefore included.

One disadvantage of our data is that we do not have information about firm production, mergers or acquisitions. If a firm enters into export activity or starts exporting a new product, we cannot know whether this is due to production start-up or to export entry. Not wishing to incorrectly interpret sunk production costs for sunk export costs, we include only those firms that export all years throughout the sample period (in total 146 firms). Furthermore, we include only those firm-product combinations that that are positive all years.[20] This further reduces the number of firms to 116.

There are three additional advantages of reducing the data in this way: Firstly, it reduces bias from omitted variables. We lack data for firm characteristics other than destination- and product specific export. Empirical studies of sunk export costs often include a set of firm characteristics such as age, number of employees etc., which has proven important for entry into the export activity. Such characteristics are

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[17] These groups are Conserved Fish, Whitefish (fresh whole, fresh fillet, frozen whole and frozen fillet), Farmed Fresh Whitefish (whole and fillet), Farmed Salmon/Trout (fresh whole, fresh fillet, frozen whole and frozen fillet), Caught Whole Salmon/Trout (fresh and frozen), Clipfish/Stockfish, Meal/Oil/Industry, Pelagic (fresh whole, fresh fillet, frozen whole and frozen fillet), Salted Herring, Shellfish, and similar (fresh, frozen and conserved), Smoked Salmon, and Miscellaneous.

[18] In two of these groups, products are much more heterogeneous than in the others (Meal/Oil/Industry and Miscellaneous), and the last group consists of products with a much higher level of manufacturing than the other groups (Conserved Fish).

[19] Export of these product groups is marginal. These groups are: Caught Salmon/Trout (fresh and frozen) and Farmed Whitefish (whole and filet).

[20] An alternative method could be to include firm-product observations that are positive at least one year during the sample period. Results from the regression analysis are robust to which of the two methods we apply.

probably less important for our study since our focus is on market specific export entry, not global export entry. Nevertheless, by considering only continuous exporters and continuous firm-product combinations, we get a more homogeneous sample and reduce bias from omitted firm-level and firm-product-level variables.[21]

Secondly, by including only continuous exporters we believe we have dealt with acquisitions. If one firm acquires another firm it is reasonable that the price includes, and therefore reflects, already paid sunk costs. Thus, these costs are reflected in an observation of increasing market coverage due to acquisitions. Firms that are taken over represents exits in the dataset and are therefore not included in the sample.

Thirdly, and perhaps most importantly, there are several different kinds of potential sunk costs of entering into the export activity: both global and product specific costs may accrue, in addition to market and country specific sunk costs. By restricting ourselves to continuous firm-product combinations, we can separate out global sunk export costs and product specific sunk export costs from the regression analysis – without the risk of incorrectly interpreting such costs for market- or country specific sunk export costs.

3.1.2 Countries

Export data are merged with data for countries from several databases: Data for GDP and GDP per capita (in current NOK), and GDP growth (in fixed US dollars, three-year moving average) are provided by the World Bank, from the World Development Indicators (WDI).[22] Three indicators of good governance (regulatory quality, rule of law and control of corruption) are provided by the World Bank, from the Worldwide Governance Indicators (WGI).[23] The geographical distance is great circle distance (in kilometres) based on coordinates for the capitals as found in Gyldendal, 1970. Data for country specific exchange rates are provided by CIA World Factbook. Data for country- and product-level import come from the from the COMTRADE database.[24] Compared to our export data, 52 countries are missing from the above-mentioned databases.

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[21] In the regression analysis we account for the remaining unobserved heterogeneity by including random effects at the firm-product-country level, as well as firm, product, and product-year dummies.

[22] WDIs for the Faroe Islands lack GDP growth figures for the whole period and GDP for 1997, so figures for the Faroes have been provided by the Statistics Faroe Islands. Growth figures are in current US dollars. WDIs for Brunei lack GDP for the year 2007, and we therefore estimate that figure. WDIs for Qatar lack growth figures for the years 1996–2000, so we have supplemented with growth figures from the IMF.

[23] Data for the Faroe Islands and Greenland lack from the WGIs, so we have set figures for these countries equal to those ones for Denmark.

[24] A problem with the COMTRADE data is that some countries fail to report import of certain products in certain years, even if import was positive. It is not possible to distinguish these missing observations from observations that are in fact zero. In the case where import of product v to country j was positive at least one year during the sample period, we

3.1.3 The sample

The first year of the period (1996) is used to construct lagged variables, and the sample therefore spans the period 1997 to 2007. Following the methods described above, the sample now contains 116 firms, 18 products, 144 countries, 268 firm-product combinations, and 2,592 markets. There are 38,592 observations each year. One observation represents export of one product from one firm to one country, and we refer to this as an *export market channel*. On average, only 5.46 per cent of these are positive each year.

Comparing the sample to the whole dataset shows that continuous exporters are much larger than occasional exporters: although the number of firms is highly reduced in the sample, it still covers 49 per cent of the total export value. On the other hand, the average number of positive export market channels is reduced considerably, from 7,863 in the whole dataset to 2,109 in the sample. The average value of an export market channel in the sample is twice that in the whole dataset (6,732 as against 3,795 million NOK).

Continuous exporters also export to more markets than occasional exporters do: even though the sample contains an average of only 23 per cent of all exporters in a given year, it still covers 66 per cent of all markets that Norwegian firms exported to. On average over the sample period, the number of markets with at least one Norwegian exporter present was 741 if we consider only sample firms and markets, as against 1,116 if we consider all firms and markets in the dataset.

Consequently, our sample is biased towards larger firms that export more products to more countries.

3.2 Preliminary evidence

Our analysis is closely related to the analyses of extensive and intensive margins of trade that have been popular in recent literature (see e.g., Chaney, 2008 or Bernard *et al.*, 2007). The extensive margin of trade refers to the number of exporters (and potentially their number of export products and destinations), while the intensive margin of trade refers to the value of one firm's export (potentially distributed across products and countries). This section presents characteristics of our sample along the different extensive and intensive margins, with special attention to variables indicating the existence of sunk export costs, learning and spillovers.

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replace the zero observations with the mean of the positive observations from the years these were reported. If import of product v to country j was zero all years, these remain zero. Nevertheless, results from the regression analysis are robust to alternative methods, such as treating all missing observations as zero.

3.2.1 Persistence

Do firms export the same products to the same countries year after year, or do they switch in and out of markets frequently? Persistence in export as such is a well known phenomena. In this section, we show that there is also considerable persistence in export at the firm-country level as well as at the even more disaggregated firm-product-country level. This may indicate country or market specific sunk costs or learning – if these are present we should expect firms to stay in the same countries or markets, since entry and exit are costly.

One way of investigating export market persistence is to look at entry and exit rates of export market channels. In the sample we include only firm-product combinations that are positive throughout the sample period (116 firms, 18 products, and 268 combinations of the two). Consequently, market specific entry and exit rates will show how many of the 268 firm-product combinations that switch in and out of the 144 sample countries each year. In other words, entry and exit rates reflect the variation in our dependent variable. The number of market specific entries varies over the sample period from 23 per cent to 30 per cent of the number of positive export market channels in the year in question. The average entry rate is 26 per cent. Exits rates vary between 22 per cent and 27 per cent of the number of positive export market channels in the year preceding the exit. The average exit rate is 25 per cent. This variation is much lower than what we would expect if firm-product combinations chose countries randomly: in that case we would see entry and exit rates of 94.5 per cent, since, on average, only 5.5 per cent of all export market channels are positive each year.

Most other studies have examined firms' entries and exits in and out of the export activity. In these studies rates tend to be lower – which is not surprising, since the decision to enter/exit the export activity covers only a small part of the total entry/exit process.[25] If we concentrate firms' entries and exits in and out of *countries* instead of *markets,* we find, that these rates are lower: on average both rates amount to 12 per cent.[26]

In a study of various entry and exit rates among Norwegian seafood exporters based on the same data for years 1996–2004, Melchior (2006) finds that, while global entry and exit rates were only 4 per cent, country specific rates were around 33 per cent, product specific rates around 18 per cent, and market specific rates some 55 per cent.[27]

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[25] Examples of global entry/exit rates in other studies are 6 per cent in Bernard and Wagner (2001), and 12.6 per cent in Bernard and Jensen (2004)

[26] Country specific entry and exit rates in Moxnes (2010) lie between 11 and 17 per cent.

[27] Figures are based on the whole dataset, not just the sample of continuous exporters as in our case.

An alternative way of looking at persistence is to calculate the Kaplan-Meier survival function, which shows how many of the export channels that were positive in year one continued to be positive in subsequent years. In Figure 1 we have calculated the survival functions for market specific export (firm-product-country dimension) and for country specific export (firm-country dimension). Note that year 1 in the Figure 1 refers to the year when the firm enters. Since a firm may enter and exit a market (country) several times in the course of the sample years, we have treated each period of positive market (country) specific export from a given firm as one observation. The case of a firm that enters, exits, and then re-enters is hence treated as two different observations in calculating the survival functions. Also note that our sample suffers from left-censoring: we do not observe the year of entry for export channels that are positive in the year 1996. When calculating the survival functions, we therefore include only observations that enter in 1997 or later. This biases the sample towards less persistent firms: the share of positive export market channels is reduced from 5.5 to 3.9 per cent, whereas the share of positive export country channels is reduced from 8.2 to 4.5 per cent. As a consequence, the persistence evidenced in Figure 1 underestimates persistence in our data: all firms that exported in 1996 are excluded from the analysis in order to avoid problems with left-censoring. This includes firms that exported to a market in all the years covered.

Figure 1 shows that, despite the low probability of exporting to a particular market, as much as 52 per cent of positive firm-market combinations that start exporting one year continue to be positive the subsequent year. The corresponding figure for firm-country combinations is 57 per cent.[28] After 12 years, 10 per cent of the export *market* channels survived, while16 per cent of the export *country* channels survived.

Entry and exit rates as well as survival functions show that firm-country persistence is higher than firm-product-country persistence. This is not surprising, as the latter is part of the former. Nevertheless, it indicates that both market- and country specific sunk export costs may accrue. In the regression analysis we attempt to distinguish between the two, and show how the former may be overestimated if the latter is omitted.

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[28] Eaton *et al.* (2008) find that, among Colombian exporters, only about one third of both firms and firm-country combinations are still exporting the year after entry. Békés and Muraközy (2012) explore temporary trade within a theoretical model where firms can choose between high variable trade costs and low sunk costs versus the opposite in order to explain temporary trade channels.

Figure 1 Kaplan-Meier survival estimates, firms in markets and in countries
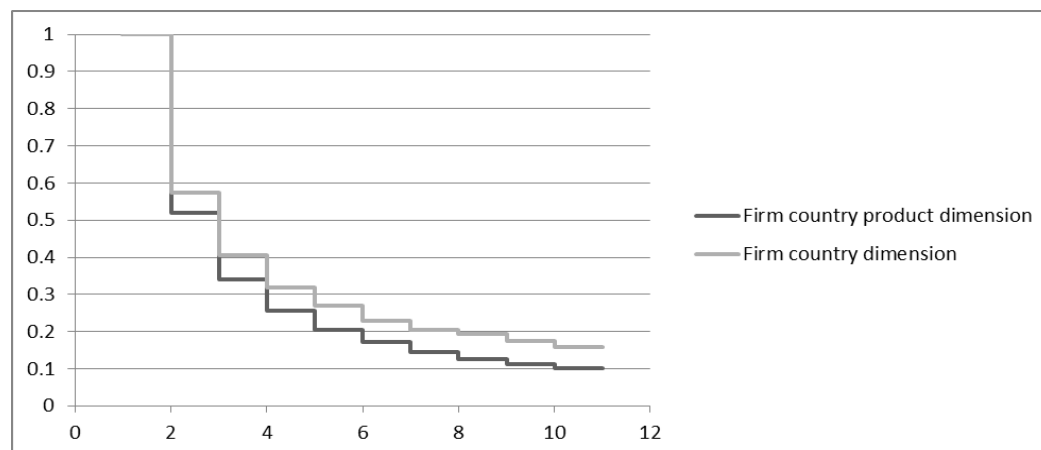
3.2.2 Characteristics of firms related to learning variables

In the presence of market specific sunk export costs, we should expect firms to export to a limited number of markets. Traditional trade theory, with monopolistic competitive firms and CES preferences that disregards sunk export costs, predicts that all firms export to all countries as long as variable trade costs are not prohibitive. This is strongly rejected by our data: only 5.46 per cent of all export market channels in our sample are positive, and most firms sell only a few products to a few countries.

If a firm learns from own export experience in other markets, the probability that it will export to a given market increases with the number of other markets to which that firm has exported. In the regression analysis we will check for such effects. Table 1 presents characteristics of firms, along the extensive and intensive margins that are related to the learning variables included in the regression analysis. Figures are for the year 2000, which is an 'average' year in terms of the number of export markets per firm and the average value of an export market channel. We construct learning variables based on all countries to which a firm exports and all products a firm exports, since learning might occur from a firms' occasional as well as continuous export. Therefore, except for the last column, figures in Table 1 include all 25 products and 196 countries, but only the 116 firms in our sample. Figures in the last column include all 196 countries, but only the 268 firm-product combinations in the sample.

Table 1 Characteristics of firms in the sample, year 2000

	Intensive margins		Extensive margins			
	Firm export value (NOK mill.)*	Export value of a firm to a market (NOK mill.)*	No. of markets a firm exports to*	No. of countries a firm exports to*	No. of products a firm exports*	Average no. of countries a firm exports a product to**
5 percentile	1.5	0.005	1	1	1	1
Median	40	0.36	20	9	6	6
Mean	143	4.7	31	13	6.7	7.1
95 percentile	623	21	93	38	15	18.2
Correlation with firm export value	1	0.0764***	0.8079***	0.7232***	0.4953***	0.5676***

* Figures are based on the 116 sample firms, but include all 25 products and 196 countries.

** Figures are based on the 268 sample firm-product combinations, but include all 196 countries. The variable is calculated by taking the average number of countries per product for each firm. The column shows how this variable varies across firms in the sample.

*** Significant at the 1% level.

Figure 1 clearly demonstrates that the distribution of firms is highly skewed: there are many small firms and a few large ones. On average, firms export for NOK 143 million to 31 markets, but the median export value is only NOK 40 million. The median number of markets per firm is 20. Moreover, most firms sell only a small amount in each market. The average value of an export market channel is NOK 4.7 million, whereas the median is only NOK 360 thousand. This skewness is further underlined by the fact that in 2000, the 5 per cent largest firms in terms of export value accounted for 41 per cent of exports and 30 per cent of all positive export market channels in the sample.

In the regression analysis we will distinguish between intra- and inter-country and intra- and inter-product learning. The number of markets per firm (column 3) can be high either because the firm exports to many countries (column 4), or because it exports many products (column 5). Again, the distribution is skewed: on the 95 percentile, a firm exports 15 products to 38 countries; but on average, firms export only 6.7 products to 13 countries. Further, 11 per cent of the firms export only one product, and 7 per cent export to one country only.

The last row in Table 1 presents correlation coefficients between the different variables and firm export value, which we use as a proxy for firm size. All coefficients are positive and highly significant. Hence, it

is the small firms that tend to export few products to few countries. There is also a positive, albeit much smaller, correlation between sales in each market and firm size. In Figure 2 in section 3.2.3, we will show that the small firms on average sell to markets where there are many other Norwegian exporters. However, there is much more variation among the small firms than the large ones: There are some small firms that export many products, or export to many countries. Some small firms also have particularly high export to certain markets or are pioneers in markets where there are few other Norwegian exporters.[29]

3.2.3 Clustering and characteristics of markets related to spillover variables

Can knowledge about exporting spill over from other Norwegian firms in a destination country and reduce a firm's costs of exporting to that country? In the regression analysis we will address this question, but in this section we present some preliminary evidence by demonstrating how firms in our data are distributed across countries and markets. In the presence of spillovers, we should expect firms to cluster in the same countries or markets. Despite the large number of countries that import Norwegian seafood, a high share of the export value is concentrated in a few large countries: in year 2000 the 5% top countries that imported most Norwegian seafood accounted for 53 % of total export of Norwegian seafood. As expected, these countries also have a high number of Norwegian exporters present (164 on average). The same is true for markets: as much as 67 per cent of total Norwegian seafood export is concentrated in the top 5 per cent markets, and on average there are 34 Norwegian exporters present in these markets. Consequently, the data clearly demonstrates that firms cluster in the same countries and markets.

Also Figure 2 shows that firms in our data tend to export to the same countries. The figures are from the year 2000. Each observation represents one firm, and firms are ranged along the horizontal axis by the number of countries to which they export. The vertical axis shows the average number of Norwegian exporters present in the portfolio of each firm's export destinations. Less than 4 per cent of the firms export to countries where there is an average of fewer than 50 other Norwegian exporters present. Further, there are on average 132 other Norwegian exporters present in an average firm's portfolio of destination countries. We can conclude that there is considerable clustering.

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[29]   Other empirical studies find patterns similar to those described above (see Mayer and Ottaviano, 2008 for a survey of European firms or Bernard et al., 2009 for US firms): Most exporters tend to be small and export to a few markets. A few very large exporters, which also export to numerous markets account for a large share of total export value.

Nevertheless, there are some firms that seek to be pioneers in countries and markets where few other firms export. What characterizes these pioneers? A consequence of the Helpman *et al.* (2008) and Chaney (2008) models is the existence of a hierarchy of countries: The larger (and hence more productive) a firm is, the more countries it exports to. If the firm is productive enough to export to the k+1 most popular country, it will export to the k'th most popular country as well.[30] Consequently, these models predict that it is the larger firms that tend to be pioneers in less popular countries.

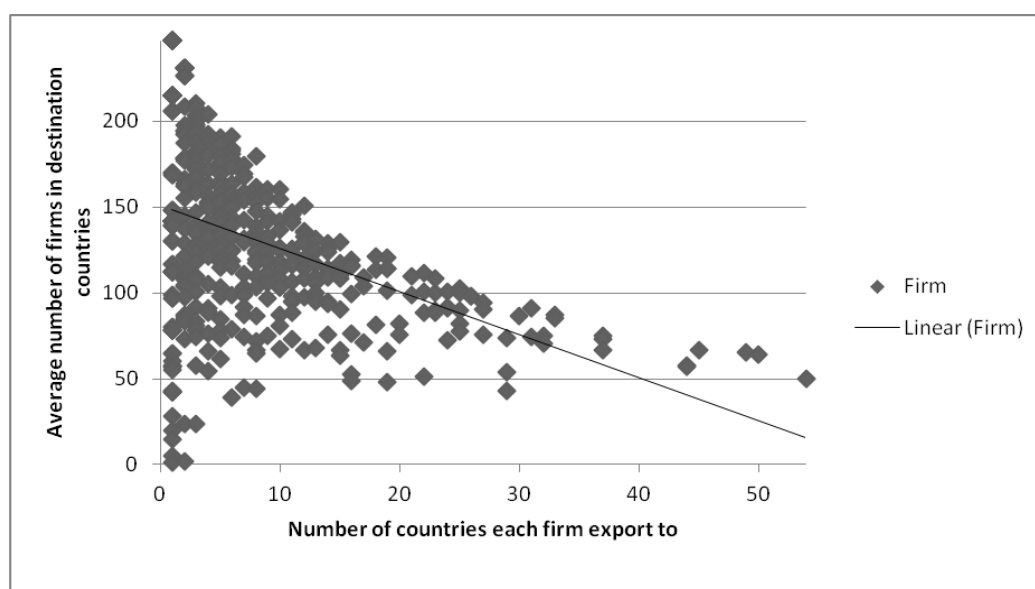**Figure 2** Average number of firms in each firm's portfolio of destination countries. Year 2000.

Figure 2 shows that the firms in our data that export to few countries tend to choose countries where there are many other Norwegian firms present. Firms that export to few countries are also small, so if we instead range firms by size, we get a similar pattern. Among the firms that exported to only one country (22 per cent of all firms), only one exported to a country where there were no other Norwegian exporters. Only two firms exported to a country with fewer than 15 other exporters present. As the number of countries to which a firm exports increases, the average number of exporters presents in its destination countries decreases. Our data thus give some support for the hierarchy hypothesis. There is, however, considerable variation among the

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[30] Some evidence of hierarchies is found among French exporters in Eaton *et al.* (2011), among Colombian exporters in Eaton *et al.* (2008), and among Irish exporters in Lawless (2009). Firms that export to a small number of countries tend to sell to the most popular ones. Nevertheless, the evidence is not conclusive: not all firms adapt to the hierarchy, and not all firms follow the same hierarchy.

smallest firms: there are some small firms that export to countries where there are few other Norwegian exporters present.

Table 2 presents characteristics of countries and markets in our sample along the intensive and extensive margins in the year 2000. Country characteristics (the first three columns) include those of the 144 sample countries with positive import of Norwegian seafood (118 countries in 2000). Spillover variables in the regression analysis include all firms and firm-product combinations, as do country characteristics in Table 2. The reason for this is that spillovers might come from occasional exports as well as continuous ones. The fourth and fifth columns in Table 2 present market characteristics, not country characteristics. Figures include those sample markets with positive import in the year 2000 (in total 837), and all firms.

Table 2 Characteristics of countries and markets in the sample, year 2000

	Country characteristics			Market characteristics	
	Intensive margin	Extensive margins		Intensive margin	Extensive margins
	Norwegian export value to a country (NOK mill.)*	No. of products a country imports*	No. of firms that export to a country*	Norwegian export value to a market (NOK mill.)**	No. of firms that export to a market**
Min	0.002	1	1	0.001	1
Median	11	6	8	0.9	3
Mean	263	8.8	31	35	7.7
Max	4224	23	247	2209	75

*The figures include those of the 144 sample countries that had positive import of Norwegian seafood in the year 2000 (total 118), but include all firms that exported Norwegian seafood in the year 2000 (total 484) and all 25 products.
** Figures include those sample markets with positive import of Norwegian seafood in the year 2000 (total 837), but include all firms that exported Norwegian seafood in the year 2000 (total 484).

The table shows that the distribution of exporters per country or market is skewed: most countries and markets have few Norwegian exporters present. In the regression analysis we distinguish between intraproduct spillovers (firms that export the same product to the same country), and interproduct spillovers (firms that export any product to the same country). The average number of Norwegian firms in each market is only 7.7, which is less than one quarter of the average number of firms in a country (31). However, in some markets Norwegian exporters are heavily represented: for example, 75 Norwegian firms export Stockfish/Clipfish to Italy, and 71 firms export Fresh Whole

Whitefish to Denmark. On the other hand, in as much as 15% of the countries and 33 per cent of the markets there was only one Norwegian exporting firm.

4. Results

We estimate several variants of the regression eq. 1.7. For comparison purposes we also report results from random effects probit models (REP). The regression equations include lagged export status and several learning and spillover terms. The learning and spillover effects are interacted with indicators for lagged export status (y_{ivjt-1}) to capture effects on the probability of staying in a market (fixed costs) and indicators for lagged absence in a market ($1-y_{ivjt-1}$) to capture effects on the probability of entering a market (fixed and sunk costs). In addition, the vector **z** contains a range of firm specific, product specific and country specific variables (and combinations of the three), both time-independent and time-varying.

Main results are presented in Tables 3. The table reports coefficients and estimated marginal effects evaluated at the mean of the explanatory variables and the respective standard deviations.

In our data, the probability of serving an export market is on average very low. The predicted probability of positive export channels is 5.34 per cent. Therefore, marginal effects are calculated at the lower tail of the distribution, where it is necessarily relatively flat. The marginal effects should therefore be interpreted with care. Nevertheless, we compute them in order to get an idea of the economic impact of the explanatory variables.[31]

The table only report results that reflect sunk and fixed costs and corresponding learning and spillover variables. Results for other explanatory variables are reported and discussed in the appendix to this paper. This also goes for the coefficients for the time- independent averages of the explanatory variables included in the Wooldridge random effects probit model (WREP).

It should be noticed that for comparing the coefficients of the WREP model with those of the REP model, the coefficients should be scaled with the models' estimate of of $\sqrt{1-\rho}$, where ρ is the proportion of total variance contributed by the constant cross-period variance. It is given by $\rho=\sigma^2_\varepsilon/(\sigma^2_\varepsilon+1)$ (see e.g., Wooldridge, 2005 or Arulampalam and Stewart, 2009). Also the estimated ρs are reported in table 3. From that table it is evident that the WREP approach is important for deal-

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[31] Marginal effects for dummy variables indicate the change in the predicted probability of export as the dummy changes from 0 to 1 while all other explanatory variables are held at their population mean and the unobserved heterogeneity (μ_{ivj}) is set to 0.

ing with unobserved heterogeneity. By applying the WREP model, ρ is substantially reduced from 0.278 in the REP model to 0.046. This demonstrates that the Wooldridge model reduces possible bias of α_0 due to large σ_ε, i.e. variance due to unobserved heterogeneity on the firm-product-country-level (see section 2.5 for discussion).

Table 3 Regression results – learning and spillovers

	WREP Coeff.		REP Coeff.		WREP M.effects		REP M.effects	
market export status	1.124	***	1.802	***	0.0467	***	0.0928	***
	(0.053)		(0.053)		(0.00667)		(0.00987)	
market export value	0.017	***	0.024	***	0.00017	***	0.000	***
	(0.003)		(0.004)		(0.00004)		(0.00002)	
country export status, other products. (1-y)	0.173	***	0.735	***	0.00213	***	0.00859	***
	(0.024)		(0.021)		(0.00043)		(0.00071)	
country export status, other products. y	0.543	***	0.35	***	0.011	***	0.0024	***
	(0.035)		(0.031)		(0.00172)		(0.00036)	
firm export value, same country, other products. (1-y)	-0.001	*	-0.001		-0.00001	*	0.000	
	(0.001)		(0.000)		(0.00001)		(0.00000)	
firm export value, same country, other products. y	-0.002	***	-0.002	***	-0.00002	***	-0.00001	***
	(0.001)		(0.001)		(0.00001)		(0.00000)	
number of countries, same product. (1-y)	0.03	***	0.044	***	0.0003	***	0.00018	***
	(0.002)		(0.002)		(0.00004)		(0.00001)	
number of countries, same product. y.	0.016	***	0.031	***	0.00016	***	0.00013	***
	(0.003)		(0.002)		(0.00003)		(0.00001)	
average firm value, other countries, same product. (1-y)	-0.003	*	0.001		-0.00003	*	0.000	
	(0.002)		(0.002)		(0.00002)		(0.00001)	
average firm value, other countries, same product. y	-0.003		0.001		-0.00003		0.000	
	(0.003)		(0.002)		(0.00003)		(0.00001)	
number of countries, all products. (1-y)	0.001		-0.014	***	0.00001		-0.00006	***
	(0.002)		(0.002)		(0.00002)		(0.00001)	
number of countries, all products . y	0.002		-0.017	***	0.00002		-0.00007	***
	(0.002)		(0.002)		(0.00002)		(0.00001)	
average firm value, other countries, all products. (1-y)	0.001		0.000		0.00001		0.000	
	(0.002)		(0.002)		(0.00002)		(0.00001)	
average firm value, other countries, all products. y	0.001		-0.001		0.00001		0.000	
	(0.002)		(0.002)		(0.00002)		(0.00001)	
number of other firms, same product. (1-y)	0.022	***	0.044	***	0.00022	***	0.00018	***
	(0.002)		(0.001)		(0.00003)		(0.00001)	
number of other firms, same product. y	0.017	***	0.034	***	0.00017	***	0.00014	***
	(0.002)		(0.002)		(0.00003)		(0.00001)	
average country value, other firms, same product. (1-y)	0.025)	***	0.057	***	0.00025	***	0.00024	***
	(0.005)		(0.004)		(0.00005)		(0.00002)	
average country value, other firms, same product. y	0.03	***	0.065	***	0.0003	***	0.00027	***
	(0.007)		(0.006)		(0.00008)		(0.00003)	
number of other firms, all products. (1-y)	0.004	***	0.003	***	0.00004	***	0.00001	***
	(0.001)		(0.000)		(0.00001)		(0.00000)	
number of other firms, all products. y	0.002	*	0.001		0.00002	*	0.000	
	(0.001)		(0.001)		(0.00001)		(0.00000)	
average country value, other firms, all products. (1-y)	0.006		0.010	***	0.00006		0.00004	***
	(0.005)		(0.003)		(0.00005)		(0.00001)	
average country value, other firms, all products. y	-0.011	**	-0.004		-0.00011	*	-0.00002	
	(0.006)		(0.004)		(0.00006)		(0.00002)	
country value, other firms, same product. (1-y)	-0.001	***	-0.002	***	-0.00001	***	-0.00001	***
	(0.000)		(0.000)		(0.00000)		(0.00000)	
country value, other firms, same product. y	-0.001	***	-0.002	***	-0.00001	***	-0.00001	***
	(0.000)		(0.000)		(0.00000)		(0.00000)	
country value, other firms, all products. (1-y)	0.000	***	0.000	***	0.000	***	0.000	***
	(0.000)		(0.000)		(0.00000)		(0.00000)	
country value, other firms, all products. y	0.000		0.000		0.000		0.000	
	(0.000)		(0.000)		(0.00000)		(0.00000)	
rho	0.047	***	0.278	***				
	(0.007)		(0.009)					

Note: Standard deviations in parentheses. (1-y) and y denote interacted with entrance and continuance, respectively. *, ** and *** correspond to significance at the 10%, 5% and 1% levels. Number of observations is 424,512. Value variables are in NOK million. Year dummies, product dummies, firm dummies, regional dummies and product-year dummies were included in the regressions but are not reported. Random effects are for firm-product-country. The number of firm-country-product observations is 38,592. Log-likelihood and sigma for WREP are -27 294 and 0.221. Log-likelihood and sigma for REP are -31,670 and 0.620.

4.1 Sunk costs, learning and spillovers

4.1.1 Market specific sunk costs

The effect of sunk export costs is captured by the variable *market export status,* which is equal to y_{ivjt-1}. The estimated coefficient is α_0. The coefficient for *market export status* is positive and significant in both regression models, which gives support to the hypothesis of market specific sunk costs. This holds true for our baseline regression, the Wooldridge random effects probit model (WREP), as well as for the random effects probit regression (REP). As expected, the coefficient is considerably higher for the REP model than it is for the WREP model. Scaled with $\sqrt{(1-\rho)}$, the coefficient for the WREP model is 1.1 and for the REP model 1.53. This underlines the importance of adequately correcting for unobserved heterogeneity. Both results imply that the probability of serving a market increases with lagged export status in that market.

The marginal effect is calculated as almost 5 per cent points in the WREP model. This is considerably lower than the results reported in studies of global sunk export costs. Roberts and Tybout (1997) find that if the firm exported in the preceding year, the probability of export in the current year increases by 60 per cent points. Bernard and Jensen (2004) find that the corresponding figure lies between 20 and 60. Our results are qualitatively in line with these, but the calculated effects are much smaller. However, the results should be compared with the overall probability of serving a market, which is 5.34 per cent. An increase in probability of 5 per cent points therefore represents an increase of almost 100 per cent.

The results in the above studies concern the probability of engaging in export activity as such. Gullstrand (2011) reports insignificant and very small effects in a model similar to ours for country specific export (not product specific). For a limited sample of high-income countries, he finds larger, positive and significant effects. Also Moxnes (2010) finds positive and larger effects, although for a much smaller sample of countries (the five most important export destinations). The probability that at firm exports to a country is on average 6 times higher if the firm exported to that country in the preceding year. Since our dependent variable is exports of a given product to a given country, and we include 144 countries, it is hardly surprising that our estimates are lower.

Our results seem to be quite robust. We experimented with running regressions for small and large firms separately. It is noteworthy that excluding the largest firms from the regressions, which account for 13.2 per cent of total exports and 13.3 per cent of the total number of

positive export market channels, did not alter the results much. We also ran separate regressions for different product categories. For the product categories the results we obtained differed somewhat. Lagged export status seems more important for frozen than for fresh seafood, and particularly for whitefish. This may reflect need for freezing capabilities in the receiving country, or other product specific differences in sunk costs.

4.1.2 Market specific learning

The most obvious learning effect is perhaps that a firm learns about exporting a certain product to a certain country from own export experience in that particular market. As discussed in section 2.3, it is not possible to distinguish the effects of market specific sunk export costs from the effects of market specific learning. Thus the positive coefficient for *market export status* may also indicate that the firms have learnt from own experience in the market in question. For instance, the firm may learn about demand in the market, which is likely to reduce the firm's fixed costs of conducting market analyses over time. Hence $dM_{vijt}/d\, y_{vijt-1}<0$ and the estimated coefficient is expected to be positive.

There may also be an additional learning effect from export intensity in the market. It seems plausible that the firm learns more about demand the more it exports, in which case $dM_{vijt}/ds_{vijt-1}<0,$ where s_{vijt-1} denotes the firms' export value to the market in the previous year. This effect is analysed separately by including the variable *market export value* in addition to *market export status*. The effect of export value on a given market is also positive and significant, but small compared to export status. Export value is given in NOK million (corresponding to about USD 0.11 million in 2000). Thus, in order to double the effect of mere presence in a market, a firm must increase its exports by about NOK 300 million. As a comparison, median export value from a firm to a market is only NOK 0.36 million (see Table 1).

4.1.3 Alternative interpretation of market export value

We interpret the effect of *market export value* as a learning effect. Alternatively, we could interpret it as an additional effect of sunk costs for different firms, in line with how Gullstrand (2011) and others interpret interaction effects between firm characteristics and lagged export status (see section 2.4.1).[32]

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[32]   Since lagged export status is zero when lagged export value is zero, inclusion of this variable is also interacted with lagged export status.

Sunk export costs may differ among firms of different size. For example, large firms may face lower entry costs than small firms, perhaps because of higher efficiency in the process of information gathering.[33] On the other hand, it could be argued that sunk export costs are higher for large firms than for small ones, perhaps because large firms choose to invest more in distribution networks, which in turn enables them to sell more in each market. Arkolakis (2010) extends the Chaney (2008) model and assumes firm specific endogenously determined fixed export costs that increase with the number of consumers that a firm attempts to reach. In this model only the largest, most productive, firms find it profitable to reach almost all consumers in a given country. The model explains why small firms sell less in each market than do large firms, which is in accordance with our data (see section 3.2.2).

Interpreted this way, the positive coefficient for *market export value* may indicate that market specific sunk costs are higher for firms that have large market specific export values. This may lend support to Arkolakis' hypothesis. Strictly speaking, to test that hypothesis we should examine interactions between *firm size* and lagged export status (as e.g., Bugiamelli and Infante, 2003 and Gullstrand, 2011 do), instead of *market export value*. However, Table 1 in section 3.2.2 showed that the correlation between firm export value (our proxy for firm size) and market export value is positive, albeit quite low (0.08). Hence, some firms may be small and still have large export value to certain markets. A possible explanation for this is that some firms have higher productivity in exporting to certain markets, rather than having higher overall productivity. Consequently, large market export value may reflect that the firm has high productivity in exporting to the market in question. Following Arkolakis' reasoning, these firms should then be expected to invest more in finding customers in the markets where they have high productivity. In this case, the relevant variable to test would be *market export value*, and not *firm size*.

4.1.4 Country specific sunk export costs and country specific learning

The variable *country export status, other products* equals 1 if firm *i* exported other products to country *j* last period and 0 otherwise. If part of the sunk export cost is country specific rather than market specific, this variable may capture the effect of country specific sunk costs. For example, costs related to acquiring information about a country's business culture and legislation are specific to that country rather than to the market.[34] If the firm exported other products, but not

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[33] Bugamelli and Infante (2003), Máñez *et al.* (2008) and Gullstrand (2011) find that the impact of sunk export costs decrease with firm size.

[34] Information gathering is indeed believed to be an important part of sunk export costs (see Roberts and Tybout, 1997).

product v, to country j in the last period, then part of G is already paid, making it less costly to start exporting product v.

When this variable is interacted with lagged absent export status in the given market ($1-y_{vijt-t}$), we interpret the effect as country specific sunk export cost (or country specific learning). See sections 2.3 and 2.4 for discussion.

On the other hand, *country export status, other products* may also reflect country specific learning: Firms may learn about exporting a given product to a given country from their export experience with other products in the same country. Finding customers is one example of how experience with exporting a product can reduce the sunk or fixed costs of exporting another product. A firm that exported product v to country j in the last period may have established contacts with several customers in that country. Those same customers may be interested in another product (v'), and so the costs related to finding customers for v' will be lower. As for market specific sunk export costs and market specific learning, it is not possible to distinguish country specific sunk export costs from country specific learning. Consequently, the variable *country export status, other products* may capture both effects.

Its coefficient is positive and significant. This is the case both when the firm was not in the market in the previous year (interact ($1-y_{ivjt-1}$)) and when it was in the market in the previous year (interacted with y_{ivjt-1}). The probability of entry increases by 0.02 per cent points, or 3.9 per cent, and the probability of continuing export a given good increases by about 1 per cent points, or 21 per cent, if the firm exported other goods to the same country the year before.

We would like to emphasise these country specific effects. They come in addition to the market specific effects reported above. Note that in our baseline regression, the WREP model, the effect on continuance is larger than the effect on entrance. Medin and Melchior (2002) also present qualitative evidence on such intra-country learning: From interviews with Norwegian seafood exporters, they found that different products were often sold to the same customers and that costs of introducing a new product in a country were significantly lower if the firm exported other products to that country.

Also for country experience, there may be an additional learning effect from export intensity. In this case, firm i's export value of other products to country j should reduce its sunk and/or fixed costs of exporting product v to country j. The effect is captured by the variable *firm export value, same country, other products*. Again we distinguish

between the combined effects on fixed and sunk costs (interacted with $(1-y_{vijt-t})$ and on fixed costs only (interacted with y_{vijt-1}).

Our results indicate negative (and partly significant) effects. This effect is more pronounced for the probability of staying in a market than for starting to export a new product (interacted with $(1-y_{ivjt-t})$. These effects may indicate that firms tend to remain specialised in their export markets, given high export values. One reason for such specialisation effects may come from the supply side: firms may have limited production capacity, so that the *export value* of other products does not increase the probabilities of starting or continuing to export a given product.

4.1.5 Markets versus country specific sunk costs.

The results on country specific export status are important. If these effects are not taken into account, they will be captured as market specific effects. In Table 4 we report results for lagged lagged export status from comparable regressions (i.e. when we have adjusted the coefficients with $\sqrt{(1-\rho)}$) where we excluded the *country export status, other products* (interacted with dummy for entry as well as continuance). The results indicate that the coefficients for lagged export status are greater when country specific effects are not taken into account. Exclusion of country specific effects is therefore an important misspecification that results in overestimation of market specific sunk costs.

Table 4 Results when country export status are excluded (compared with inclusion)

Description	WREP.		REP.	
Market export status without country experience	1.402	***	1.743	***
Market export status with country experience	1.098	***	1.532	***

Note: Similar regressions as those reported in Tables 3a and 3b were run without the variables indicating country export status (for entrance or continuance in a market). Other results from these regressions are available from the authors upon request.
***Significant at the 1% level

The importance of country specific sunk costs also becomes evident when we run regressions on the country dimension only. Such regressions give larger coefficients for the lagged dependent variable as

compared to our baseline firm-product-country regressions (results are available upon request).

4.1.6 Learning from export experience in other countries

Firms may also learn about exporting to a specific market from their own experience in other countries. Demand patterns, customs procedures and competition legislation may be similar across countries, so export experience in other countries may make it easier to export to a given country. The effect is likely to increase with the number of other countries to which the firm exports.

Some effects, like learning about demand patterns, may be product specific, while others, like learning about business culture, may be more general. We therefore distinguish between the number of other countries the firm exports product *v* to (captured by the variable *number of countries, same product*), and the number of other countries to which the firm exports all products (captured by the variable *number of countries, all products*). Again, there may be additional learning effects from export intensity in other countries. We distinguish between average export value of product *v* to other countries (captured by the variable *average firm value, other countries, same product),* and average export value of all products to other countries (captured by the variable *average firm value, other countries, all products).*

The results show positive effects of having product specific experience from other countries: the variable *number of other countries, same product,* is positive and significant both for entrants and continuing exporters.[35] Note however, that the effect is much smaller than the intra-country learning effect described in section 4.1.4. Still, if a firm increases its exports of a given product to one country, the probability of entering a new country with the same product increases by 0.03 per cent points, or 0.56 per cent.[36] As a comparison the median number of countries a firm exports a product to is 6 (see Table 1).

We do not find similar effects, however, from a firm's export intensity in other markets. The coefficients for *average firm value, other countries, same product* is not significant for the probability of starting to export to a given country. In our baseline regression, the WREP model, the coefficient is negative and weakly significant for the probability of starting exporting.

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[35] These results confirm the qualitative results from interviews with Norwegian seafood exporters in Medin and Melchior (2002). They found evidence on learning from experience in other countries, but the effect was less important than experience within the same country.

[36] Considering that we include in the analysis as much as 144 countries, of which many have only one or a few Norwegian exporters present, this figure is not as small as it may appear.

Similarly, our models do not give support for learning effects across product groups from other countries. The variable *number of countries, all products* has insignificant positive values for the WREP model, and negative (and sometimes significant) coefficients in the REP model. Again these effects may indicate that firms are specialised in their product choices, and they may indicate potential capacity constraints on the firms' supply side. The results are qualitatively the same for the probability of starting to export and for the probability of continuing exporting. For the variable *average firm value, other countries, all products,* there are no significant results.

Summing up, the results on learning from own export experience seem to indicate that such effects are strongest within one and the same country. While the firm's presence with a product in a country seems to induce learning about exporting another product to that country, we find no learning effects from high export value of products in the country. Results further indicate that learning effects are weakly present within product groups across countries, and absent between countries and products. Learning from own export experience takes place through the extensive margin (number of other countries to which the firm exports), and not through the intensive margin (average export value to other countries).

Also other studies have documented learning effects from exporting. Some studies, such as Schmeiser (2012), Eaton *et al.* (2008), Lawless, (2009) and Albornoz *et al.* (2012) find that export expands through gradual entrance, possibly caused by learning. Lawless (2011), Morales *et al.* (2011), Castagnino (2011), Alvarez *et al.* (2010), Fabling *et al.* (2011), Gullstrand (2011) and Meinen (2012) all find that export experience in other countries or markets increases the probability of exporting to a particular country or market. These studies define learning variables in a somewhat different manner than we do, and do not include such a rich variety of different effects. Some concentrate on entering firms only. None of these distinguish between entering and continuing exporters within the same regression as we do. Most of them also differ from ours in the econometric methods applied.

4.1.7 Spillovers from other exporters

Firms that export to a specific country gain information about that country on factors like exporting procedures, business culture, demand patterns, legislation and distribution networks. Such knowledge may spill over to other firms, reducing their sunk or fixed export costs. Spillover effects are likely to be stronger the larger the number of other exporters in the country. Some spillovers, such as information about demand, may be product specific, whereas others, such as information about business culture, may be more general. In the first case, export

costs of a given firm decrease with the number of other Norwegian firms exporting the same product (captured by the variable *number of firms, same product*). In the second case, the costs will decline further with the number of other Norwegian firms exporting other products (captured by *number of firms, other products*). As in the case of learning, spillovers may be stronger the larger the export intensity of other firms to the country: a firm's costs of exporting product *v* to country *j* may decrease with the average value of other firms' export of product *v (*captured by the variable *average country value, other firms, same product)* and with the average value of exports of all products (captured by the variable *average country value, other firms, all products).*

In addition there may be positive spillovers from total export of Norwegian seafood to the country in question. The more Norwegian seafood in the market, the better known is this product group, and this may reduce marketing costs and increase demand.[37] Increased exports to a market may also improve distribution and retail services in that market. Again, the effect may be specific to a given product (captured by the variable *country value, other firms, same produc*t) or general, across products (captured by the variable *country value, other firms, other products).*

As in the case of learning, we distinguish these spillover effects between effects on the probability of starting to export to a market (*1-y_{vijt-1}*=1) and continuing to export to a market (y_{vijt-1}=1).

We find evidence of positive spillovers. The number of other firms selling the same product in the same country has a positive and significant effect both on the probability of starting exporting to a given market and on the probability of staying in a market. This is interesting since the presence of other firms could potentially also indicate more fierce competition in a market. Obviously, clustering effects in export markets are larger than such centrifugal effects. This is in line with finding in Medin and Melchior (2002), where interviews with Norwegian seafood exporters revealed that firms consider it an advantage that there are other Norwegian exporters present in a market.
Also, the effect of *number of other firms, all products* is positive as regards starting to export to a market (interacted with (*1-y_{ivjt-1})*. So is the effect for continuing to export in our main model (WREP), but the results indicate lower significance.

In addition to the mere presence of other firms, also the export intensity of other firms has positive and significant effects on the probability of starting to export a product in a country and on the probability that the firm will remain in the market. This is evident from the positive

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[37]   This effect can also be seen as learning among consumers.

and significant coefficients for the variables denoted by *average country value, other firms, same product,* whether interacted with previous presence of the firm in a market or with a firm establishing exports in the market. According to our estimates, the effect of one additional firm selling the same product in a country corresponds to the effect of an increase in the average export value of other firms of about NOK 1 million for the probability of starting to export, and to about NOK 2 million for the probability of continuing to export. As a comparison, the median number of firms in a market is 3, while the median value of Norwegian exports to a market is 0.9 million NOK (see Table 2).

However, we do not find clear evidence of intraproduct spillovers from other firms' export intensity in the country. The coefficients on *average country value, other firms, all products* in the Wooldridge model indicate no effect on the probability that a firm will start export activity (interacted with $1 - y_{ivjt-1}$) and negative effects on the probability of continuing exporting (interacted with y_{ivjt-1}).

The total value of Norwegian exports of the same products from other firms has negative and significant effects, both for the probability of starting and for the probability of continuing exporting. We interpret this as a dominating competition effect. By contrast, total export value of all products has positive and significant effects on the probability of starting to export, but no significant effect on continued export.

Summing up, we find strong indications of intraproduct spillovers along the extensive (number of firms exporting a particular product to the country) and intensive (their average export value) margins. There is also some evidence of interproduct spillovers along the extensive margin (number of firms exporting any product to the country), but not along the intensive margin. There is little evidence of spillovers from total Norwegian export value to country.

Our results are in line with the theory of network spillovers presented in Krautheim (2012), which predicts spillovers to be a function of the number of other exporters. Other studies concentrate on the impact of concentration of export activity within a region or industry in the exporting firm's home country. Regarding spillovers that affect global export costs, results are mixed (see e.g., Clerides *et al.*, 1998; Bernard and Jensen, 2004; Aitken *et al.*, 1997; Barrios *et al.*, 2003; and Greenaway *et al.*, 2004). Evidence regarding spillovers that affect country or market specific export costs, on the other hand, are clearer: Requena and Castillo (2007), Koenig (2009), and Lawless (2011) find that spillovers affect country specific export costs; while Alvarez *et al.* (2010), Koenig *et al.* (2010) and Fabling *et al.* (2011) find that spillovers affect *market* specific sunk export costs. Koenig *et al.* (2010) also

distinguish between fixed and variable export costs in two separate regressions, and find that only the former are affected by spillovers.

4.1.8 Entrants versus continuing exporters

Table 3 shows that the effects of a certain variable on entering and continuing firms mostly have the same sign, so learning and spillovers variables seem to affect entering and continuing firms in a similar manner. There is no clear pattern regarding which type of firm exhibits greater effects. For the two variables indicating intra- and inter-product spillovers from the extensive margin (*number of other firms, same product*; and *number of other firms, other products*), and for the valuable indicating intraproduct learning from the extensive margin (*number of countries same product*) the effects are greater for entrants than for continuing exporters. For the variables indicating country specific sunk export costs or learning from export of other products to the same country (*country export status, other products*; and *firm export value, same country, other products),* the effect is greater for continuing exporters. This holds true also for the variable indicating intraproduct spillovers from the intensive margin (*average country value, other firms, same product*).

4.1.9 Alternative explanations

The variables described above capture many different effects, not all of which necessarily reflect learning or spillovers. There may be unobservable characteristics of firms, countries or products that affect the probability of exports. If these change over time, they are not captured by the time-invariant unobserved heterogeneity discussed in section 2.5. A firm that employs a German-speaking person one year may, for instance, have a higher probability of exporting to Germany the next year. Nevertheless, this is a criticism that applies also to other studies on learning and spillovers in exports, and the present paper is no different in that respect.

We have assumed, like most studies of export decisions cited in this paper, that both learning and spillover effects are external to firms. It may be, however, that learning and (to a lesser extent) spillover effects are endogenous. Firms may want to try exporting to a market not only because it believes that market is profitable, but also because it learns from exporting and therefore takes into account that entry into other markets will become easier. In this case, firms' entrance across markets is not independent. This is discussed in Krautheim (2012) and Albornoz *et al.* (2012). The latter analyse sequential exporting and argue that firms internalise learning effects, especially for the first market they enter. We have not modelled the decision to enter into export activity, since we include only firm-product observations that

have positive observations each year. If learning effects are particularly important for the *first* export decision, we have reduced the problem of assuming that learning effects are external to the firm. Furthermore, if learning is internalised into the firms' decision problem, it is not clear that the resulting interdependence would change our results since the sequence of entry into new markets could well be the same.

Furthermore, it may be that firms take into account that their export decisions make it more likely that also other firms will follow. In that case, spillovers between firms are taken into account. Firms may, for instance, try to choose countries or markets where spillovers are less likely to materialise (in order to avoid competition) – or markets where spillovers are more likely to materialise (in order to benefit from mutual spillover effects). Again it is not clear whether such internalised spillover effects would alter the sequence of market entrances.

Finally, presence of other firms in a market or a country does not necessarily imply positive spillovers. Other firms may also represent competition with the firm in question. High export value from other firms or the presence of many firms could mean more competition in the relevant markets. When coefficients are positive, we interpret the results as indicating spillovers that are so strong that they outweigh the effects of competition.

4.2 Other independent variables

We included a range of other explanatory variables in our regressions. These are reported in the appendix to this paper.

4.2.1 Dummy variables

As discussed in section 2.5, ideally but not possible in our model, we should correct for unobserved heterogeneity by including fixed effects on the firm-product-country combination. This would have corrected for all time-invariant unobserved heterogeneity. An alternative approach would be to include dummies on the following combinations of variables: firm-product, firm-country, and country-product, in addition to random effects on the firm-product-country combination. This, on the other hand, would yield a large number of independent variables, prohibitively large for data computational purposes. We therefore choose to include dummies along the dimensions where we have few other independent variables to account for heterogeneity:

We include product-year dummy variables to capture cycles both on the production side that reflect comparative advantages (fish farming is due to time specific shocks, as is wild fish catching); and we include

firm-dummy variables to correct for unobserved heterogeneity at the firm-level, such as productivity differences. We include year dummies to correct for temporary shocks that have an equal effect across all products, firms and countries. To correct for product differences we also include a product dummy. Further, several factors, like culture and demand patterns, may be similar inside a region. We therefore divide the countries into four regions and include region specific dummies.[38] We include dummy variables for EU countries, for countries of the European Economic Area (EEA), for countries that Norway has free trade agreements with, and for the USA.[39] We also include dummy variables for countries that became EU members in 2004 and in 2007 (FTAEEA04 and FTAEEA007). Norway had generous free trade agreements with these countries (for seafood) that became void when they joined the EU.

4.2.2 Other variables

To correct for the firm's specific competitive advantage, we include variables that reflect the firm's position in the market, the country and for the product among Norwegian firms: *leader market, leader country and leader product* These variables equals the ratio of the firm's market or country specific export value to the average export value of Norwegian firms in the market (i.e. the firm's market share) or the firm's total share of Norwegian seafood exports These variables are lagged one year.

As a proxy for productivity, firm size is often included in studies of sunk export costs, and is generally found to be positively related the probability of exports (see e.g., Roberts and Tybout, 1997; Bernard and Jensen, 2004; Lawless, 2011; Koenig *et al*. 2010; Gullstrand, 2011). Lacking data for productivity, production or capital stock, we use the log of the firm's total export value. The variable is lagged one year and is called *size*.

We include the variable *import adjusted,* defined as log of import (from all countries) of product *v* to country *j*, as explanatory variable. It captures demand and demand differences for each product within and between the countries included in the regressions.[40]

We also include changes in the *country specific* exchange rates, *appreciation.*

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[38]   The four regions are Europe, Asia, Africa and the Americas.
[39]   We include a separate dummy for the USA since anti-dumping duties are imposed on Norwegian exports of salmon in the US market.
[40]   In some versions of our regressions we also included total Norwegian exports and Norway's export share (in the world market) of each product. These were included to reflect Norway's comparative advantages and time-varying supply characteristics. Results varied (and they are available upon request). The results presented here are when product-year dummies were included; these variables capture time-varying product specific effects.

In the gravity literature of international trade, GDP is commonly used as a measure of market size, and distance as a measure of transport costs.[41] We therefore include log of GDP, *gdp, ,* and log of GDP per capita, *gdp per capita,* in order to control for different demand patterns in wealthy versus poor countries. In addition we include three-year moving averages of growth rates in GDP. As is standard, we also included (log of) *distance* to capture transportation costs.

The governance qualities of a country may influence its attractiveness as a market. We include three measures of governance indicators: indicators of regulatory quality, rule of law and control of corruption. The first of these indicates the ability of governments to formulate and implement regulations that permit and promote private-sector development. The second reflect perceptions of the quality of contract enforcement, property rights, the police and the likelihood of crime and violence. Control of corruption indicates low levels of corruption and good control with corrupt practices.

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[41]   See Feenstra *et al.* (2001) for a survey.

5. Conclusions

In this paper we have investigated the importance of sunk export costs by looking at persistence in the export behaviour of firms. As opposed to earlier studies, which focus on global or country specific sunk export costs, we have concentrated on the costs of entering a particular market (defining 'market' as the market for a given product in a given country). We find that having exported to a particular market the previous period doubles the probability of export in the current period. This we interpret as evidence of the existence of market specific sunk export costs.

We distinguish between market specific sunk and fixed export costs by analysing the decision to enter new markets separately from the decision to stay in existing markets. While the probability of starting export activities is related to sunk and fixed costs combined, the probability of staying in export markets are related to fixed costs only. We have investigated how such market specific sunk and fixed export costs are affected by learning and spillover variables. We have looked for a wide range of learning spillover effects, intra- and interproduct as well as intra- and intercountry. These effects may occur along both the extensive margin and along the intensive margin. Several new effects are identified.

Our evidence indicates that firms learn about exporting to a particular market from own exporting experience in the market in question as well as from own exporting experience in other markets. Learning effects appear to be strongest for presence within one and the same country: having exported another product to that country the previous period increases the probability of entering the country with a new product this period by 3.9 per cent and the probability of continuing to export a particular product to the country by 21 per cent. Whereas a firm's *presence* in the country seems to induce learning, we found no learning effects from high export *value* of other products of the country. Our results further indicate that learning effects are weakly present within product groups across countries, but absent between countries and products. Learning from own export experience takes place through the extensive margin (number of other countries the firm exports to), and not through the intensive margin (average export value to other countries).

We also provide evidence on spillovers from the presence of other Norwegian exporters. As opposed to most other studies, which con-

centrate spillovers in the home country, we focus on spillovers in the destination country. Our results indicate that an increased number of other exporters in a given country increases the probability of export to that country. We find strong indications of intraproduct spillovers along both the extensive margin (number of firms exporting a particular product to the country) and the intensive margin (their average export value). There is also some evidence of interproduct spillovers along the extensive margin (number of firms exporting any product to the country), but not along the intensive margin (their average export value). There is little evidence of spillovers from total Norwegian export value to country.

Learning and spillover variables seem to affect entrants and continuing exporters in a similar manner. For some variables, the effects are largest for entering firms, whereas for others, the effects are greatest for continuing exporters.

Appendix 1

In the text we proposed that the profit function $\pi^*_{ivjt}(p_{vjt}, v_{ivt})$ could be represented as proportional to sales in a given market, independently of sales of other products in a country or of the same product in other countries. Here we present a simple model set up that gives such a profit function. We assume that the firm faces iso-elastic demand functions in each market from standard CES preferences with elasticity of substitution $\sigma > 1$. Thus firm i's demand for a variety v sold in country j can be written as:

A1
$$q_{ivj} = W_{vj} p_{ivj}^{-\sigma}$$
$$W_{vj} = \mu_{vj} Y_j P_j^{\sigma-1}$$

Above, q_{ivj} denotes demanded quantity, W_{vj} denotes product-country specific demand level and p_{ivj} denotes the price charged by firm i for product v in country j. W_{vj} depends on (potential) country specific preferences for product v, μ_{vj}, country j's income level, Y_j, and an overall price index in country j, P_j, taken as exogenous for firm i.

Assume that firm i produces under constant marginal costs. For exports of product v to country j, these are given by:

A2
$$c_{ivj} = \tau_{vj} w / a_{iv}$$

Above, c_{ivj} denotes firm, product and country specific marginal costs. These depend on variable transportation costs, τ_{vj}, marginal production costs, w, and a firm-product specific productivity parameter a_{iv}. Profits for firm i from exporting are given by:

A3
$$\Pi_i = \sum_j \sum_v \pi^*_{ivj}\left(\mathbf{p}_{vj}, \mathbf{v}_{iv}\right) - \mathbf{C}_{ivj}$$

Above, $\pi^*_{ivj}(p_{vj}, v_{iv})$ represents extra running profits from exporting good v to country j. It depends on product-country characteristics, $\mathbf{p}$, that are exogenous for the firm and firm-product characteristics, $\mathbf{v}$. The vector $\mathbf{C}$ denotes fixed and sunk costs (in this appendix we suppress the time dimension so that fixed and sunk costs are treated similarly) that could be firm specific, firm-product specific, firm-country specific and firm-product-country specific. This vector therefore captures all sunk/fixed costs discussed in the text, as well as others. In the empirical specification in the text we focused on firm-country and

firm-product-country specific sunk and fixed costs. The profit function can now be written:

A4 $\quad \Pi_i = \sum_j \sum_v \left(p_{ivj} q_{ivj} - \dfrac{\tau_{vj} w}{a_{iv}} q_{ivj} \right) - \mathbf{C}_{ivj}$

The first-order condition for profit maximizing sales of product v in country j is:

$$\dfrac{d \Pi_i}{dq_{ivj}} = p_{ivj} \dfrac{\sigma - 1}{\sigma} - \dfrac{\tau_{vj} w}{a_{iv}} = 0$$

The firm charges a price that is a mark-up, $\sigma/(\sigma-1)$, over marginal costs:

$$p_{ivj} = \dfrac{\sigma}{\sigma - 1} \dfrac{\tau_{vj} w}{a_{iv}}$$

Extra running profits from exporting product v to country j are therefore:

$$\pi_{ivj}^* = \left(p_{ivj} q_{ivj} - \dfrac{\tau_{vj} w}{a_{iv}} q_{ivj} \right) = \left(\dfrac{1}{\sigma - 1} \dfrac{\tau_{vj} w}{a_{iv}} \right) q_{ivj} = \dfrac{1}{\sigma} (sales)$$

Extra running profits are therefore proportional to sales. The exact formulation is:

A5
$$\pi_{ivj}^* = \left(\dfrac{1}{\sigma - 1} \dfrac{\tau_{vj} w}{a_{iv}} \right) q_{ivj} = \left(\dfrac{1}{\sigma - 1} \dfrac{\tau_{vj} w}{a_{iv}} \right) p_{ivj}^{-\sigma} \mu_{vj} Y_j P_j^{\sigma - 1} = \left(\dfrac{1}{\sigma - 1} \right)^{1 - \sigma} \sigma^{-\sigma} \left(\dfrac{\tau_{vj} w}{a_{iv}} \right) \mu_{vj} Y_j P_j^{\sigma - 1}$$

As seen, these profits π^*_{ivj} depend on variables exogenous to the firm (captured by the vector $\mathbf{p}_{vj}$ and variables that are product and firm specific (captured by the vector $\mathbf{v}_{iv}$). Therefore we write the profit equation in the text as $\pi^*_{ivj}(\mathbf{p}_{vj}, \mathbf{v}_{iv})$.

We have modelled fish exports as traditional monopolistic competition markets where firms have (limited) market power and constant marginal costs. As a consequence, supply is assumed to be perfectly flexible. This may be a realistic assumption for fish farming industries – but not for wild fish, which is caught according to quotas that are determined by the government and are issued in fixed supply. For a firm with fixed supply, our model requires only minimal adjustments.

To illustrate this, we focus on a one product that sells to two countries only. Consequently subscript j now refers to country j (j=1,2). We simplify by setting w=1 and a=1, so that marginal costs are:

$$c_j = \tau_j$$

Profits are:

$$\Pi = \sum_j \left(p_j q_j - \tau_j q_j\right) - \mathbf{C}_j$$

The corresponding profit-maximization problem is a constrained one, since the sum of exports to the two countries cannot exceed the total quota, Q. The Lagrangian for the maximization problem is:

A6 $$L = \sum_j \left(p_j q_j - \tau_j q_j\right) - \mathbf{C}_j - \lambda\left(\sum_j q_j - Q\right)$$

The first-order conditions are

A7
$$\frac{\partial L}{\partial q_j} = p_j\left(\frac{\sigma - 1}{\sigma}\right) - \left(\tau_j + \lambda\right) = 0$$
$$\sum_j q_j = Q$$

As compared to our unconstrained maximization problem, the problem corresponds to adding a constant (shadow price of quotas) to the marginal cost. The shadow price in turn depends on export costs and income levels in the two countries.

Appendix 2

Independent variables

Independent variable	Description
market export status	Lagged export status. A dummy equal to 1 if firm i exported product v to country j. It reflects the importance of market specific sunk exporting cost or learning.
country export status	A dummy equal to 1 if firm i exported other products to country j last year. Reflects the importance of country specific sunk costs and learning from own experience of exporting other products to country j.
number of countries, same product	Number of other countries (not including country j) firm i exported product v to last year. Reflects learning from experience in other countries.
number of countries, all products	Number of other countries (not including country j) firm i exported all products to last year. Reflects learning from experience from exporting to other countries.
number of firms, same product	Number of other Norwegian firms (not including firm i) that exported product v to country j the previous year. Reflects market specific spillovers.
number of firms, all products	Number of other Norwegian firms (not including firm i) that exported all products to country j the previous year. Reflects country specific spillovers from exporters.
market export value	The firm's export value of product v' to country j' the previous year. Reflects additional learning effects from being deep in the market, and corresponds to *market export status*
firm export value, same country, other products	The export value of other products (not including product v') from firm i to country j' the previous year. A learning variable corresponding to *country export status*.
average firm value, other countries, same product	Average value of export of product v from firm i to other countries (excluding country j) the previous year. A learning variable corresponding to *number of countries, same product*.[42]
average firm value, other countries, all products	Average value of export of all products from firm i to other countries (not including country j) the previous year. A learning variable corresponding to *number of countries,*

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[42] This variable is equal to the export value of product v from firm i to other countries, divided by number *of countries, same product*

	all products.[43]
average country value, other firms, same product	Average export value of product *v* from other firms (not including firm *i*) to country *j* the previous year. A spillover variable corresponding to *number of firms, same product.*[44]
average country value, other firms, all products	Average export value of other products from other firms (not including firm *i*) to country *j* the previous year. A spillover variable corresponding to *number of firms, all products.*[45]
country value, other firms, same product	Export value from other Norwegian firms (not including firm *i*) of product *v* to country *j* the previous year. An additional spillover variable.
country value, other firms, all products	Export value from other Norwegian firms (not including firm *i*) to country *j* the previous year. An additional spillover variable.
leader, market	Export value of product *v* from firm *i* to country *j*, divided by Norway's export value of product *v* to country *j*. Lagged one year.
leader, country	Export value of all products from firm *i* country *j*, divided by Norway's total export value to country *j*. Lagged one year.
leader, product	Export value of product *v* from firm *i* to all countries, divided by total Norwegian exports of product *v*. Lagged one year.
size	Log of firm *i's* export value. A proxy for firm size. Lagged one year.
gdp	Log of GDP. In 1000 current NOK.
gdp per capita	Log of GDP per capita. In 1000 current NOK.
growth in gdp	3-year moving averages of growth rates in GDP (fixed UD$).
appreciation	Growth in the exchange rate between NOK and the local currency.
distance	Log of distance from Norway to country *j*. In km.
import	Log of import of product v in country *j*. In 1000 current NOK. Missing observations are replaced by mean.
governance indicator, regulatory quality	Perceived quality of a government's regulatory quality, normally distributed for country ranking.

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[43] This variable is equal to the export value of all products from firm *i* to other countries, divided by *number of countries, other products.*

[44] This variable is equal to *country value, other firms, same product* divided by *number of firms, same product.*

[45] This variable is equal to *country value, other firms, all products,* divided by *number of firms, all products.*

governance indicator, rule of law	Perceived quality of rule of law, normally distributed for country ranking.
governance indicator, control of corruption	Perceived control of corruption, normally distributed for country ranking.
Dyear	Dummy equal to 1 for all years except, 2007.
Dregion	Dummy equal to 1 for all regions, except Africa.
Dproduct	Dummy equal to 1 for all products, except fresh fillet of white fish.
Dfirm	Dummy equal to 1 for all firms, except one.
Dyearproduct	Dummy equal to one for all year - product combinations, except fresh fillet of white fish in 2007.
DUSA	Dummy equal to 1 for USA.
DEU	Dummy equal to 1 for EU member countries.
DFTA	Dummy equal to 1 for countries with which Norway has free trade agreements.
DEEA	Dummy equal to 1 for EFTA countries.
DFTAEEA04	Dummy for new member countries in EU in 2004 with which Norway previously had free trade agreements.
DFTAEEA07	Dummy for new member countries in EU in 2007 with which Norway previously had free trade agreements.

Appendix 3. Other explanatory variables

In the main text we report and discuss results for lagged export status and for the learning and spillover variables. In this appendix we report and discuss results from the other variables included as well as the results for the time independent means of the variables included in the WREP model. Also the estimated ρ and the estimated coefficients for lagged export status and lagged export value of the product for reference purposes. The results tables are included as Tables A3.1 and A3.2.

We include product-year dummy variables, firm-dummy variables year dummies, product dummy and region-specific dummies.[46] We do not report the results for the above dummy variables, but they are available upon request.

A1 Leader
The estimated coefficients of the three leadership variables, *leader market, leader country and leader product* are all positive and significant. Leaderships in the market, the country and for the product (in the previous period) have positive effects on the probability of exporting a product to a market. This is as expected. Note that the estimated effects seem to be larger for the market, smaller for the country and smallest for leadership in a given product.

A2 Firm size
The variable *firm size* (log of the firm's total export value) is not significant. This contradicts with earlier studies, where firm size is found to significantly increase the probability of export. This result reflects the inclusion of our dummy variables. Firm dummies reflect firm characteristics, and product-year dummy variables reflect product dynamics. Hence our firm size variable reflects only firm size dynamics that can not be attributed to product specific dynamics. The results therefore reflect that firm export growth (when we have controlled for other variables) mainly occurs through expansion in existing export channels rather than through entrance in new markets. This is in line with theory (see e.g. Lawless (2009).[47] The WREP model and the REP model controls for individual specific (i.e. firm-product-country) random effects. The WREP model also controls for correlation between

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[46] The four regions are Europe, Asia, Africa and America.
[47] Lawless (2009) concludes that (p. 247) "... we would expect to see export growth at the firm level come more from adding to sales in existing markets than form sales in new markets.".

the individual specific effects and (i) initial export status and (ii) time independent effects from the other explanatory variables. Without such controls, inclusion of the firm and product-year dummy variables results in negative and significant coefficients for size in the standard pooled probit model. This underlines the importance of adequately correcting for unobserved heterogeneity.

A3 World trade
We include the variable *import* which is defined as log of import (from all countries) of product *v* to country *j*, as explanatory variable. It captures demand and demand differences for each product within and between the countries included in the regressions. The coefficient is positive and significant in the two models.[48]

A4 Exchange rates
An appreciation of Norwegian kroner relative to the currency of country *j* has no significant effect on the probability of export. Results from other studies are mixed: Bernard and Jensen (2004) find a weak effect of the industry specific exchange rate. Campa (2002) finds a significant effect of changes in the firm-specific exchange rate, where each firm's exchange rate is calculated according to its export markets. Clerides *et al.* (1998) also find an effect in some cases. Meinen (2012) and Gullstrand (2011) find no effect of country specific exchange rates. However, Gullstrand (2011) finds a negative effect of country specific exchange rate variation.

A5 Market size and transport costs
The variable measuring market size, *gdp*, is not significant in the WREP regressions, but turns up with the expected sign in the REP model. Income level, measured by *gdp per capita,* is insignificant. The fact that market size becomes insignificant is because we also include the countries' total import of the seafood product in question. Furthermore, country specific time-invariant averages of this variable are included in the WREP regression. Note however, that *gdp* also turns out insignificant in its time invariant average version (see table A3.2). Growth of gdp (*growth, gdp*) has positive and significant coefficients, however. Export presence is more prevalent in markets with high growth rates. This may possibly reflect positive expectations about profitability in emerging markets.

Further, the effect of *distance* is negative and significant, as expected, in the two models. These results correspond to results found in the

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[48]   In some versions of our regressions we also included total Norwegian exports and Norway's export share (in the world market) of each product. These were included to reflect Norway's comparative advantages and time varying supply characteristics. Results varied (and they are available upon request). The results presented here are when product-year dummies were included and these variables capture time varying product specific effects.

gravity literature of international trade (see Feenstra *et al.*, 2001). Since distance is time invariant, its mean is not included among the auxiliary time independent variables in the WREP model.

A6 Governance indicators

The two indicators of good governance (*Regulatory Quality* and *Rule of Law*) have insignificant coefficients in the WREP model (but positive and significant in the other models). The reason for this result may be that these indicators are highly persistent across countries over time. Their time invariant means have positive, but not significant coefficients in the WREP model. *Control of Corruption*, is negative and significant in the REP model, but positive and significant in the WREP model. Again, the difference between REP model and the WREP model on the other side can be explained with the fact that time-invariant averages of this indicator is included in the WREP model. In this case, the economic interpretation is interesting. *Control of corruption* has a negative and significant coefficient in the REP model. *Ceteris paribus* therefore, corruption does not seem to discourage Norwegian seafood exporters. From the Wooldridge regressions, however, the time variation for the *Control of Corruption* variable has a positive and significant effect. The coefficient of the time-invariant mean is negative and significant. Thus, when controlling for time invariant mean and when taking into account initial conditions, it seems that corruption deters Norwegian exporters. One potential explanation is that unobserved firm-market characteristics that affect firms' abilities to handle corruption are correlated with the initial value of the dependent variable. This interpretation implies that many firm-market combinations have good abilities to handle corruption. When initial conditions are controlled for, the isolated effect of corruption is negative (giving a positive coefficient for *Control of Corruption*). Again, our results indicate the importance of adequately correcting for unobserved heterogeneity.

A7 Trade policy relevant dummy variables.

The trade policy dummies included in the regressions are generally insignificant. Both the USA and EU have imposed trade reducing restrictions on imports of Norwegian seafood. This is so in particular for farmed salmon and trout. Still the results are insignificant in the WREP model (but we obtain negative and significant results in the REP model). Also, note that the signs are the opposite for the countries for which Norway had free trade agreements prior to their EU membership (and partly significant in the case of the REP model)**.**

Table A3.2 Other regression results

	WREP Coeff.		St. dev	REP Coeff.		St.dev	WREP M.effects		St.dev	REP M.effects		St.dev
market export status	1.124	***	0.053	1.802	***	0.053	0.04670	***	0.00667	0.09280	***	0.00987
market export value	0.017	***	0.003	0.024	***	0.004	0.00017	***	0.00004	0.00000	***	0.00002
leader, market	0.076	***	0.015	0.250	***	0.014	0.00076	***	0.00017	0.00103	***	0.00009
leader, country	0.037	***	0.006	0.067	***	0.005	0.00037	***	0.00008	0.00028	***	0.00003
leader, product	0.009	***	0.003	0.007	***	0.003	0.00009	***	0.00003	0.00003	***	0.00001
size	0.012		0.015	-0.023		0.015	0.00012		0.00015	-0.00009		0.00006
appreciation	0.000		0.000	0.000		0.000	0.00000		0.00000	0.00000		0.00000
gdp	0.095		0.200	0.109	***	0.007	0.00095		0.00201	0.00045	***	0.00004
gdp per capita	0.150		0.200	0.010		0.014	0.00151		0.00202	0.00004		0.00006
growth, GDP	0.012	***	0.003	0.006	**	0.002	0.00012	***	0.00003	0.00002	**	0.00001
Government indicator Regulatory qual.	0.008		0.046	0.149	***	0.027	0.00008		0.00047	0.00062	***	0.00012
Government indicator Rule of law	-0.008		0.057	0.069	**	0.033	-0.00008		0.00057	0.00028	**	0.00014
Government indicator Control of corr.	0.113	***	0.042	-0.123	***	0.026	0.00113	**	0.00044	-0.00051	***	0.00011
Import adjusted	0.043	***	0.014	0.011	**	0.005	0.00043	***	0.00015	0.00000	**	0.00000
EU	-0.024		0.106	-0.184	***	0.036	-0.00037		0.00052	-0.00060	***	0.00017
USA	-0.039		0.057	-0.190	***	0.073	-0.00024		0.00102	-0.00063	***	0.00011
FTA	-0.055		0.056	-0.003		0.034	-0.00053		0.00053	-0.00001		0.00014
FTAEEA04	0.163		0.115	0.019		0.045	0.00202		0.00174	0.00008		0.00020
FTAEEA07	0.161		0.138	0.288	***	0.062	0.00201		0.00212	0.00185	***	0.00058
distance	-0.130	***	0.023	-0.162	***	0.025	-0.00131	***	0.00027	-0.00067	***	0.00011
Rho	0.047			0.278								

Note: *, ** and *** correspond to significance at the 10%, 5% and 1% levels. Number of observations is 424,512. Value variables are in NOK million. Year dummies, product dummies, firm dummies, regional dummies and product-year dummies were included in the regressions but are not reported. Random effects are for firm-product-country. The number of firm-country-product observations is 38,592. Log-likelihood and sigma for WREP are -27 294 and 0.221. Log-likelihood and sigma for REP are -31,670 and 0.620.

Coefficients for time-independent means of variables included in the WREP regressions

Description	Coeff.		St.dev
market export status	-0.09100		0.06830
market export value	-0.02230	***	0.00255
country export status, other products. Interact (1-y)	-2.77500	***	0.07830
country export status, other products. Interact y	-2.07800	***	0.07530
firm export value, same country, other products. Interact (1-y)	0.00062		0.00088
firm export value, same country, other products. Interact y	-0.00019		0.00093
number of countries, same product. Interact (1-y)	0.01030	***	0.00314
number of countries, same product. Interact y	-0.00297		0.00391
average firm value, other countries, same product. Interact (1-y)	0.00844	**	0.00352
average firm value, other countries, same product. Interact y	0.00550		0.00393
number of countries, all products. Interact (1-y)	-4.19700	***	0.07730
number of countries, all products . Interact y	-4.19800	***	0.07730
average firm value, other countries, all products. Interact (1-y)	-0.03460	**	0.01480
average firm value, other countries, all products. Interact y	-0.03590	**	0.01480
number of other firms, same product. Interact (1-y)	0.01030	***	0.00242
number of other firms, same product. Interact y	-0.01110	***	0.00261
average country value, other firms, same product. Interact (1-y)	0.03140	***	0.00684
average country value, other firms, same product. Interact y	0.00702		0.00863
number of other firms, all products. Interact (1-y)	-0.00502	***	0.00099
number of other firms, all products. Interact y	-0.00382	***	0.00106
average country value, other firms, all products. Interact (1-y)	-0.00141		0.00531
average country value, other firms, all products. Interact y	-0.01260	*	0.00708
country value, other firms, same product. Interact (1-y)	-0.00104	***	0.00025
country value, other firms, same product. Interact y	0.00056	*	0.00029
country value, other firms, all products. Interact (1-y)	0.00010	*	0.00006
country value, other firms, all products. Interact y	0.00017	**	0.00007
leader, market	0.69100	***	0.02230
leader, country	-0.01980	**	0.00861
leader, product	-0.01220	**	0.00500
appreciation	-0.00001		0.00007
gdp	-0.06100		0.20000
gdp per capita	-0.16300		0.20000
growth, GDP	-0.00700		0.00534
Government indicator Regulatory quality	0.06830		0.05520
Government indicator Rule of law	0.08600		0.06750
Government indicator Control of corruption	-0.20500	***	0.05220
Import adjusted	-0.03730	**	0.01460
EU	-0.07640		0.11100
FTA	0.07860		0.06650
FTAEEA04	-0.23000	*	0.12800
FTAEEA07	0.07120		0.14900

Note: Distance and USA dummy, which are time-invariant: and firm size, which is captured by firm dummies, are not included.

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