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Market-specific sunk export costs:

The impact of learning and spillovers

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Abstract

Firms may face sunk costs when entering an export market. Previous studies have focused on global or country-specific sunk export costs. This study analyses the importance of *market*-specific sunk export costs (defining 'market' as a product-country combination). We also study how market-specific export costs can be affected by various kinds of learning and spillover effects. We use firm-level panel data for Norwegian seafood exports distributed on products and countries. The results lend support to the hypothesis of market-specific sunk costs. We also find evidence of learning and spillover effects, particularly within the same product group.

Keywords: Market-specific sunk export costs, learning to export, export spillovers, extensive and intensive margin, firm-level panel data, correlated random effects probit

JEL Classification: F10, F14, C33

1 Introduction

Recent years have seen the emergence of a literature which incorporates 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 firms with equal marginal production costs). Several empirical studies find evidence of sunk export costs by analysing export persistence in firm-level data (Roberts and Tybout, 1997; and Bernard and Jensen, 2004). These studies focus on firms' decisions of whether or not to export as such and hence on global sunk export costs.[1]

As Melitz and Redding (2015) underline, the nature of trade costs is potentially important but remains "under-explored" (p. 14).[2] If sunk export costs are country and/or product specific, firms will typically serve different sets of markets, and persistence will be country and/or product specific. Therefore, country and product-specific sunk export costs may influence aggregate trade patterns. A few studies find evidence of country-specific sunk export costs, but, to our knowledge, no studies have investigated the importance of sunk costs of exporting a particular product to a particular country.[3] We refer to such costs as 'market specific'. Analysing only the export decision as such or the decision to export to a particular country misrepresents sunk export costs when they are market specific.[4]

The first aim of this article is to study the importance of market-specific sunk export costs. This is done in a new dataset of particular interest due to its high level of detail: we have 11 years of customs declaration panel data covering *all* Norwegian seafood exporters, the countries they export to, and the products they export. We do not therefore have to rely on survey data as do many other studies. Norway is one of the world's largest exporters of seafood, with an annual export value of 35.7 billion

[1] In the presence of such costs temporary export-promotion policies or macro-shocks (such as exchange-rate fluctuations) may have persistent effects on aggregated trade flows (Baldwin, 1988; Baldwin and Krugman 1989; Dixit, 1989). Generally there is evidence of positive effects from export promotion policies. See Hiller (2012) for an overview of the literature.

[2] They write: "The implications of different microfoundations for trade costs in models of firm heterogeneity remain under-explored, including whether trade costs are sunk, fixed or variable."

[3] Meinen (2015) estimates the importance of country-specific sunk costs. Moxnes (2010) and Morales *et al*. (2011) investigate the role of country-specific versus global sunk export costs. Evidence in Gullstrand (2011) suggests that country-specific sunk export costs vary with firm characteristics.

[4] See Chaney (2008), Bernard *et al.* (2011), and Arkolakis and Muendler (2010) for (static) theoretical models of country- and/or product-specific sunk export costs. In the presence of such costs, only the large and most productive firms find it profitable to export many products to many countries. Das *et al.* (2007) discuss export promotion policies in the presence of fixed and sunk costs, but they do not incorporate market-specific effects.

NOK in 2007 (approx. 6.09 billion USD). The industry is highly internationalized, with exports of a wide range of products to almost 200 countries. Approximately 90 per cent of all Norwegian seafood production is exported.[5] The sector is therefore an interesting case for a study of international sales activity.

Our second aim is to study whether learning and spillovers effects lead to reductions in market-specific export costs.

Schmeiser (2012) develops a theoretical model where learning about exporting from export experience in other countries reduces a firm's entry costs to a given country, denoting it 'learning to export'. In this article we allow for a range of learning effects like this: intra- and inter-country as well as intra- and inter-product. If this type of learning is important, it will have consequences for export promotion policies: benefits from such policies can be larger than expected because export promotion can boost export to other countries or of other products than were initially targeted.

Krautheim (2012) presents a theoretical model where knowledge acquired by other exporters in a particular destination country may spill over to potential exporters and reduce their costs of exporting to that country. In this paper we investigate such spillover effects in destination countries. We study spillovers both within and between products. Earlier empirical evidence is mixed regarding spillovers that reduce global sunk export costs.[6] If, on the other hand, market-specific spillovers are important, then policies aimed at exploiting spillovers could benefit from encouraging exports to certain markets rather than exports in general. Furthermore, firms targeting the same market could benefit from organizing themselves in 'exporting societies'.

We find evidence of several different learning and spillover effects. Other recent studies have also found indications of market- or country-specific learning and spillovers, but these studies differ from ours in the type of variables included and the econometric method applied (see section 5.3 for an overview).

[5] Figure based on information from the Norwegian Seafood Council.
[6] 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.

Most other studies have focused on either learning or spillovers. We include both in the same regression, as it is conceivable that both effects could influence export costs at the same time. We also include in the same regression discrete variables on firms' lagged *presence* in markets, capturing the extensive margin, and continuous variables on firms' lagged export *value* to markets, capturing the intensive margin. We find that learning and spillover effects are stronger along the extensive margins than the intensive margins.

Furthermore, most other studies of learning and spillovers at the country and/or product level focus on how learning and spillovers may affect *sunk* export costs and include only *entrants*, i.e. firms that did not export the product to the country the previous year. We believe that learning and spillovers can also affect *fixed* export costs. For example, costs related to filling out customs declaration forms are largely fixed, but can be reduced over time as the firm gains experience. We therefore also include firms that exported the product to the country the previous year (*continuing exporters*). By including interaction variables, we allow the effects to be different for the two types of firms. We know of no other paper that distinguishes between entrants and continuing exporters like this. The results indicate that not only sunk, but also fixed export costs are affected, and there is no general indication of stronger effects for entrants than for continuing exporters. Consequently, it is important to include both groups in order to capture the full effect from learning and spillovers.

The remainder of this article is organized as follows: The next section presents the theoretical background for the estimation equation. Section 3 gives a more detailed presentation of the export data and the sample used for regression analyses. Section 4 offers a description of the econometric method applied. Results are presented in section 5, with concluding remarks offered in section 6.

2 Theoretical background

We follow 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. Whereas Roberts and Tybout (1997) only consider the exporting decision as such, we consider firms' export participation with one or more products to one or more destination countries. Our variables are

therefore given in four dimensions: firm (*i*), product (*v*), destination country (*j*), and time (*t*). Furthermore, we allow for market-specific *fixed* in addition to *sunk* export costs in the analysis, and we allow both to be affected by learning and spillover effects. This is described in detail below.

If there are no sunk costs, firm *i* will export product *v* to country *j* in period *t* as long as variable profits in period *t* are larger than fixed export costs, M_{ivjt}. Sunk export costs (G_{ivjt}) occur only when the firm enters the market, not if it is already present there. Following Roberts and Tybout (1997), the firm's decision of exporting to a given market is given by:

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

y_{ivjt} takes the value of 1 if firm *i* exports product *v* to a country *j* in period *t* and 0 otherwise. π_{ivjt} is firm *i*'s maximised expected profits from selling product *v* in country *j* in period *t* net of sunk and fixed export costs. It is the solution of a Bellman equation, where the firm takes into account that its export decision today will affect the entire path of future expected profits.[7] The equation shows that the decision to export to a given market today depends on previous export status, y_{ivjt-1}. A firm that exported to the market the previous year would be more likely to export this year than a firm that did not because the former has already paid the sunk export costs, G_{ivjt-1}. Consequently, in the presence of market-specific sunk export costs, we would observe persistence in market specific exports.[8] 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 (see section 4).

[7] In the online appendix we provide details of the dynamic profit-maximizing problem. We assume constant marginal costs in order to treat each firm's export volumes in each market independently. Furthermore, we assume that the price received by firm *i* for product *v* in country *j* is independent of export activities in other markets. And we assume that any effects of other firms' export on the price received by firm *i* are external. In the online appendix we also describe how the profit function can be constructed on the basis of standard *CES* preferences, monopolistic competition and constant marginal costs. In that case, the firm's operating profits is proportional to sales in each market.

[8] Note that for simplicity we assume that the full sunk cost recurs if the firm exits the market one year and then re-enters later. Other authors, such as Roberts and Tybout (1997), Bernard and Jensen (2004), Gullstrand (2011), and Meinen (2015), 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 their theoretical formulation. Roberts and Tybout (1997) find that most of the sunk cost must be repaid after one period of exit.

We depart from Roberts and Tybout (1997) in allowing learning and spillovers to affect G_{ivjt} and M_{ivjt}. The effects are modelled by allowing G_{ivjt} and M_{ivjt} to depend on learning effects from the firm's own experience and spillovers from other firms' experience. In addition, G_{ivjt} and M_{ivjt} consist of fixed elements (G^0 and M^0) that are common for all firms and independent of learning and spillovers. We further depart from Roberts and Tybout (1997) in distinguishing the effects on G_{ivjt} from those on M_{ivjt}. While effects on sunk costs are present only for entrants (for which $y_{ivjt-1}=0$),[9] effects on fixed costs are present for both entrants and continuing exporters (for which $y_{ivjt-1}=1$), as both will benefit from reduced M_{ivjt}. In other words, sunk costs are important for the decision to enter markets, whereas fixed costs also influence the decision to stay in a market. Taking this into account, the export decision can be formulated as:

$$\pi_{ivjt} \geq \left(1-y_{ivjt-1}\right)\left(G^0 - G_j^L y_{iv'jt-1} - \mathbf{G^L y_{ij't-1}} - \mathbf{G^S y_{i'jt-1}}\right)$$
$$+\left(M^0 - M_j^L y_{iv'jt-1} - \mathbf{M^L y_{ij't}} - \mathbf{M^S y_{i'jt-1}}\right), \quad i \neq i' \quad j \neq j' \quad v \neq v'$$

The effect of market-specific sunk costs is given by $G^0 y_{ivjt-1}$.[10] We allow for various types of learning effects to affect G_{ivjt} and M_{ivjt}: $y_{iv'jt-1}$, $v' \neq v$, is an indicator variable denoting the firms' presence in the same destination country with any other product. G_j^L and M_j^L hence denote the reductions in market-specific sunk and fixed costs due to firm *i*'s experience from exporting other products to the same country (consequently they can reflect country-specific sunk and fixed costs in addition to learning). The vector $\mathbf{y_{ij't-1}}$, $j' \neq j$, contains variables for the activities of firm *i* in other countries. The vectors $\mathbf{G^L}$ and $\mathbf{M^L}$ thus denote the reductions in market specific sunk and fixed costs due to firm *i*'s

[9] If $y_{ivjt-1}=1$, then $G_{ivjt}=0$, so no variables can reduce G_{ivjt} further.

[10] If the firm learns through its own export activities in the same market, we should have included $-M^0 y_{ivjt-1}$ at the right hand side of the equation. However, this effect cannot be separated from the effect of market-specific sunk costs (denoted by $G^0 y_{ivjt-1}$). Effectively, these reductions in fixed costs due to learning are sunk costs. Both effects are captured by y_{ivjt-1} in the regression analysis (see section 4). Timoshenko (2015), however, distinguishes between sunk costs and learning by imposing different functional forms of the two in her regressions.

learning from own export experience in other countries. Similarly, we also allow for various types of spillover effects: the activities of other firms in the same destination country (within and across products) are denoted with the vector $\mathbf{y_{i'jt-1}}$, $i' \neq i$. $\mathbf{G^S}$ and $\mathbf{M^S}$ are therefore vectors for reductions in market-specific sunk and fixed costs due to spillovers in the destination country. Re-arranging, the export decision can be formulated as:

$$1) \quad \begin{aligned} &\pi_{ivjt} - G^0 - M^0 \geq -G^0 y_{ivjt-1} - G_j^L \left(1 - y_{ivjt}\right) y_{iv'jt-1} - \mathbf{G^L} \left(1 - y_{ivjt}\right) \mathbf{y_{ij't-1}} \\ &-\mathbf{G^S} \left(1 - y_{ivjt-1}\right) \mathbf{y_{i'jt-1}} - M_j^L y_{iv'jt-1} - \mathbf{M^L y_{ij't-1}} - \mathbf{M^S y_{i'jt-1}}, \quad i \neq i' \quad j \neq j' \quad v \neq v' \end{aligned}$$

3 Data

The export data cover the full universe of Norwegian seafood exports disaggregated on firms, products, countries, and time. They are provided by Statistics Norway. An advantage of our data is that they are not based on a sample, but contain all firms that export. In addition, they are based on what firms actually do, thus we do not have not rely on survey answers as do many other studies.

Our data have another great advantage over many other studies: in addition to containing firms that export their own production, they also contain pure trading companies that buy all the seafood they export from other producers. We have reason to believe that these pure traders constitute around 30 per cent of all seafood exporters (Melchior and Medin, 2002). Their export decisions are therefore an important part of the total picture. They are also likely to create spillovers and engage in learning because their speciality is trade transactions as such.

Unlike earlier studies of sunk export costs, we do not have data on firm characteristics such as production or factor productivity. Other empirical studies of sunk export costs often find such characteristics important for entry into the export activity. Nevertheless, they are probably less important for our study because, as explained below, we concentrate on market-specific export entry, not global export entry. We also proxy for differences in the ability to export by correcting for unobserved heterogeneity, by including firm dummies, and by using information about firms' export behaviour (see section 4 for the first and section 5.5 for the two latter).

Most other studies have focused on firms in the manufacturing sector, and we believe we make an important contribution by investigating whether sunk costs, learning and spillovers are also present in another sector, namely seafood. Yet a fair question is whether the results from our study can be generalised. Admittedly, seafood has some specific characteristics. For one thing, some seafood product groups are necessarily quantity-restricted, as fishing rights for caught fish are distributed by quotas. In the accompanying online appendix we argue that our results are also valid when the quantity of a given export volume across countries is restricted, but that they may be underestimated. In addition, important product groups in our data are farmed fish, and these are not quantity-restricted to the same extent as caught fish. Furthermore, many manufacturing sectors are also characterised by varying degrees of quantity restrictions. 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 veterinary standards, to be present also for seafood exporters. However, Melchior (2003) shows that the sunk costs of exporting are far lower for seafood than for IT products. If anything then, our results should be expected to underestimate the general impact of market-specific sunk and fixed costs.

Table 1 shows some summary statistics of the whole data vs. the sample used for regression. In a given year, one observation represents export of one product from one firm to one country; this we refer to as an *export market channel*. As can be seen from the table, the number of observations in the data is huge and in fact prohibitively large for data computation purposes.

Table 1 Summary statistics of the whole dataset vs. the sample

	No of firms[1]	No of products[1]	No of countries[1]	No of observations per year [5]	Period covered	% coverage of total export	% coverage of markets where exports are positive
Whole dataset	1 242	376 [2]	196	37 112 704 [6]	1996–2007	100	100
Sample	116 [4]	18 [3]	144	38 952 [7]	1997–2007 [8]	49	66

Note: The export data are given in four dimensions: firm, country, product and year. [1]Numbers refer to the whole period covered. [2] Products at 8 digit hs level. [3]Aggregated product groups. [4]Includes only firms that export at least one product during all sample years. [5]In a given year, one observation represents the export status of one firm exporting one product to one country. [6] = no of firms x no of products x no of countries. [7]= no of firm-product combinations x no of countries. No of firm-product combinations =268 and not 116 x 18, as only firm-product combinations with positive export during the whole sample period are included. [8]The first year is used to construct lagged variables.

We therefore aggregated the 8-digit HS-level products into 18 groups containing fairly homogeneous products in terms of product characteristics and exporting conditions.[11] Some countries are also dropped from the analysis as export data were merged with data for countries from several other databases with various coverage (see section 5.5). Furthermore, it is not adequate to include all the remaining observations in the regression analyses:

We include only firm-product group observations with positive export all years during the sample period, as our purpose is to study firms' export to specific markets, not firms' export as such. Several different kinds of sunk costs can accrue when starting to export: global, product, country, and market specific. By focusing on the last (and also on the second but last), we can disregard starting to export as such or starting to export within new product groups. Hence, we can analyse market-specific sunk export costs separately (and also country-specific ones), without running the risk of incorrectly interpreting them as global or product-specific sunk export costs.

[11] These groups are: Whitefish (fresh whole, fresh fillet, frozen whole and frozen fillet), Farmed salmon/trout (fresh whole, fresh fillet, frozen whole and frozen fillet), Clipfish/stockfish/salted whitefish, Pelagic (fresh whole, fresh fillet, frozen whole and frozen fillet), Salted herring, Shellfish and similar (fresh, frozen and conserved), and Smoked salmon. In the aggregation, we also dropped some products for various reasons. The dropped products were classified into 7 residual product groups. One residual group was dropped because the products have a much higher processing level than the rest (Manufactured products). Two other residual groups were dropped because products are very heterogeneous and thereby difficult to classify (Meal/oil/industry products and Miscellaneous products). We expect sunk costs for these three product groups to differ considerably from those for the rest. The remaining four groups were dropped because the deviations between 6- and 8-digit hs-levels of these groups are severe. (Caught whole salmon/trout, fresh and frozen; and Farmed fresh whitefish, whole and filet.) Exports of these products are marginal. We need 6- and 8-digit levels to fairly correspond due to the merge with import data from the Comtrade database, where products are given at the 6-digit level (see section 5.5).

There are three additional advantages of reducing the sample in this way. Firstly, we do not risk incorrectly interpreting sunk production costs as sunk export costs. If a firm starts exporting as such or starts exporting new product group, we cannot know whether this is due to production start-up or export start-up since we do not have information about firms' production. Secondly, we get a more homogeneous sample, and we reduce bias from omitted variables and unobserved heterogeneity. Thirdly, it allows us to deal with acquisitions: if one firm acquires another it is reasonable that the price includes, and therefore reflects, the already-paid sunk costs. Thus, these costs are reflected in an observation of increasing market coverage due to acquisitions. Firms that are acquired by other firms represent exits in the dataset and are not included in our sample.

Compared to the whole dataset, the sample is biased towards larger firms that export more products to more countries. Although the number of firms is highly reduced in the sample, it still covers around half of the total of Norwegian seafood export value during the period and about two-thirds of all markets where exports were positive. Obviously, this is not a representative sample of all exporting firms, but since our focus is on market- (or country-) specific entry, our aim is to study the behaviour of permanent exporters (i.e. firms with positive export from at least one product group during the whole sample period), and not that of all firms. In the present study, the entire population of permanent exporters, small as well as large, producers as well as pure trading companies are included, as are most countries in the world.[12]

A first glance at the data gives some indications of market-specific sunk export costs. In the presence of such costs, we should expect firms to export to a limited number of markets and stay in the same markets year after year (see discussion on persistence in section 2). On average, only 5.5 per cent of all export market channels are positive each year, and most firms only sell a few products in a few countries. There is also persistence: the entry as well as the exit rates amount to approximately 25 per

[12] Many studies of sunk costs apply samples that are biased towards more successful firms or markets. Often, only firms that are operational during the whole sample period are included, and several studies do not include small firms (e.g. Roberts and Tybout, 1997; Bernard and Jensen, 2004). Further, some studies include only the most important importing countries (Moxnes, 2010).

cent.[13] Furthermore, firms and export values tend to concentrate in a few countries and markets. In the regression analysis we include variables that control for market attractiveness (see section 5.5). As will be shown, evidence of persistence and clustering in a limited number of markets remains. See Maurseth and Medin (2012) for a more thorough presentation of preliminary evidence.

4 Empirical strategy

In line with several other studies (e.g. Roberts and Tybout, 1997) we specify a reduced form of the latent variable $\pi_{ivjt}^{n} - G^{0} - M^{0}$ from eq. 1. We approximate the profit function with an expression containing exogenous variables along one or more of the four dimensions *firm* (*i*), *product* (*v*), *country* (*j*), and *time* (*t*), summarized with the vector **z.** Based on eq. 1 we thereby specify the binary choice equation as:

$$2 \qquad y_{ivjt} = \begin{cases} 1 \quad \text{if } 0 \le \alpha_0 y_{ivjt-1} + \alpha_1 (1 - y_{ivjt-1}) y_{iv'jt-1} + \alpha_2 y_{ivjt-1} y_{iv'jt-1} \\ \qquad + \boldsymbol{\alpha_3} (1 - y_{ivjt-1}) \mathbf{y_{ij't-1}} + \boldsymbol{\alpha_4} y_{ivjt-1} \mathbf{y_{ij't-1}} \\ \qquad + \boldsymbol{\alpha_5} (1 - y_{ivjt-1}) \mathbf{y_{i'jt-1}} + \boldsymbol{\alpha_6} y_{ivjt-1} \mathbf{y_{i'jt-1}} + \mathbf{z}_{ivjt} \boldsymbol{\eta} + e_{ivjt} \\ 0 \quad \text{otherwise} \end{cases}$$

Above, e_{ivjt} denotes noise.

We hence have a model where the dependent variable lagged one period is among the explanatory variables. Its coefficient is α_0. A positive α_0 implies that having exported to the market in the previous year increases the probability of exporting to the same market this year, and it is interpreted as the sunk cost parameter of serving that single market (but, as indicated in footnote 10 it may also capture learning from own experience in the market in question). In Roberts and Tybout (1997), this was the variable of prime interest. Here, we are also interested in the other αs which reflect learning (α_1–$\boldsymbol{\alpha_4}$) and spillover ($\boldsymbol{\alpha_5}$ and $\boldsymbol{\alpha_6}$) effects described in section 2.

Most other studies of learning and spillovers at the country and/or product level focus on *entrants*, i.e., firms that did not export the product to the country the previous year. These studies thereby assume

[13] With the observed percentage of positive export market channels, these rates should be 94.5 per cent if firm-product combinations chose countries randomly.

that learning and spillovers only affect sunk costs. However, if fixed costs are also affected, we should include firms that did export the product to the country the previous year, i.e. the *continuing exporters.* Only by including both types of firm will we capture the full effect of learning and spillovers (see section 2). In eq. 2 we do precisely that. In addition, we allow for the effect on the two types of firms to differ by interacting the learning and spillover variables with categorical variables for *entrants* ($1-y_{ivjt-1}$) and for *continuing* exporters (y_{ivjt-1}). Effects for entrants may be interpreted as combined effects on fixed costs and sunk costs. These are captured by α_1, $\boldsymbol{\alpha_3}$ and $\boldsymbol{\alpha_5}$. These coefficients are, respectively, for the effects of experience of exporting different products in the same country, the experience of exporting to different countries, and spillovers from other firms in the same country. The two latter are vectors as they capture the effect of either exporting the same product or of exporting other products. Effects for continuing exporters may be interpreted as effects solely on fixed costs and are captured by α_2, $\boldsymbol{\alpha_4}$ and $\boldsymbol{\alpha_6}$. Their interpretations are analogous to those for entrants.

The αs in eq.2 denote the effects from presence in different markets (the extensive margin). We also include learning and spillover variables along the intensive margin (export value in different markets). For simplicity, only the variables along the extensive margin are shown in eq. 2 (but both types are part of the regression analysis). More details on the various variables are given in the discussion of the regression results in section 5. Furthermore, the appendix contains a table with exact definitions of all variables included in the regression, including the content of the vector **z**.

Unobserved heterogeneity is likely to create persistence in the dependent variable. For example, firms may differ in their ability to export to a specific market e.g. due to knowledge possessed by their employees. If this is not corrected for, α_0 will be overestimated. To handle this problem, we estimate eq. 2 using a random effects probit model. This is in accordance with most other studies of sunk export costs.[14] In that model, unobserved heterogeneity is modelled at the firm-product-country level, thus the error term is given by $e_{ivjt} = \varepsilon_{ivj} + u_{ivjt}$. ε_{ivj} captures unobserved heterogeneity that is time-invariant

[14] See e.g. Roberts and Tybout (1997), Clerides *et al*. (1998), Bugamelli and Infante (2002), Campa (2002), Bernard and Jensen (2004), and Gullstrand (2011).

and specific to the firm-product-country combination. Remaining noise is captured by u_{ivjt}. There may also be unobserved heterogeneity at other levels. To correct for this, we also include firm, year, product, and year-product dummies.

An important problem is the *initial conditions* problem (see Heckman, 1981 and Wooldridge, 2012 p. 626–627). The problem concerns how to treat the first observation of the lagged dependent variable. Simply including y_{ivj0} as an explanatory variable for y_{ivj1}, implies treating y_{ivj0} as exogenous and hence assuming it to be uncorrelated with ε_{ivj}. This is unlikely to be the case. We have argued above that factors such as export ability (captured by ε_{ivj}) are likely to affect y_{ivjt} for $t \geq 1$. Similarly, they must be expected to influence y_{ivj0}. However, if y_{ivj0} and ε_{ivj} are correlated, the estimate of α_0 will be biased. Several solutions have been proposed in the literature. Here we use a variant of the method proposed by Wooldridge (2005):[15] We include as auxiliary explanatory variables for every year in the regression the within means of all time-variant variables in eq. 2 (except y_{ivjt}), $\overline{\mathbf{x}}_{\mathbf{ivj}}$, together with y_{ivj0}.[16] Then we run a standard random effects probit regression.[17] Using this approach implies considering the unobserved heterogeneity as:

$$\varepsilon_{ivj} = \lambda_0 + \lambda_1 y_{ivj0} + \boldsymbol{\lambda}_2 \overline{\mathbf{x}}_{\mathbf{ivj}} + \mu_{ivj}$$

where λ_1 and $\boldsymbol{\lambda}_2$ are coefficients to be estimated. μ_{ivj} is remaining noise which is assumed *iid* $N[0, \sigma_\mu^2]$. We estimate eq. 2 using the random effects Wooldridge method as described above. This model (WREP) is the preferred one as it corrects for the initial conditions problem. However, for comparison

[15] An advantage of the Wooldridge method is that it also allows us to correct for another potential source of bias in α_0 originating in the possible violation of the assumption of no correlation between the other explanatory variables (apart from y_{ivj0}) and ε_{ivj} that lies behind a standard random effect probit model. The model thus corrects for potential serial correlation in u_{ivjt} caused by any such correlation (see Chamberlain, 1984; and Mundlak, 1978). Another advantage of the Wooldridge model is that it reduces the variance of the unobserved heterogeneity, σ^2_ε. As pointed out by Heckman (1981), a large σ^2_ε may overestimate the effect of the lagged dependent variable.

[16] We also tried the variant proposed in Rabe-Hesketh and Skrondal (2013), including also the initial period explanatory variables, $\mathbf{x}_{\mathbf{ivj0}}$, as additional regressors. Results were almost identical to those reported here.

[17] The within means of learning and spillover variables are interacted with y_{ivj0} and $(1- y_{ivj0})$, in accordance with Wooldridge (2005).

we also estimate a standard random effects probit estimation (REP), and a WREP regression that also includes country dummy variables (WREP country).

5 Results

The main results from the preferred model, WREP, and the comparison models, REP and WREP country, are presented in tables 2, 3 and 4 (see section 4 for descriptions of the models). The three tables, therefore, report results from the *same* regressions. Table 2 reports results on variables that reflect market-specific sunk costs and learning, whereas table 3 reports results for the spillover variables. Results for other explanatory variables are reported in the Table 4.[18] In comparing the magnitude of the coefficients of the WREP model with those of the REP model, the coefficients should be scaled with the models' estimate of $\sqrt{1-\rho}$.[19] The estimated ρs are also reported in Table 1. It is evident that the WREP approach is important for dealing with unobserved heterogeneity. By applying the WREP model instead of REP, the estimate of ρ is substantially reduced, from 0.278 to 0.047. This demonstrates that the Wooldridge model reduces possible bias of α_0 due to large σ_ε.

In addition to the coefficients and their standard errors, we report average partial effects (APEs) for the WREP model. These are calculated using coefficients scaled with $\sqrt{1-\rho}$, as described in Wooldridge (2012, p. 628).[20]

[18] The online appendix reports results for the time independent averages in the WREP models.
[19] ρ is the proportion of total variance contributed by the constant cross-period variance due to unobserved heterogeneity. It is given by $\rho=\sigma^2/(\sigma^2+1)$, where $\sigma=\sigma_\varepsilon$ in the REP model and $\sigma=\sigma_\mu$ in the WREP model (see Wooldridge, 2005; Arulampalam and Stewart, 2009).
[20] For dummy variables, the APEs indicate the average of the difference in the predicted probability as the dummy changes from 0 to 1. The percentage change is evaluated relative to the predicted probability when the dummy is set equal to 0. The other variables are evaluated relative to the average predicted probability of serving an export market, which is equal to 5.4 per cent.

Table 2 Regression results, sunk costs and learning

	WREP		REP	WREP country
	Coeff.	APE	Coeff.	Coeff.
market export status	1.124 ***	0.07064	1.802 ***	1.112 ***
	(0.053)		(0.053)	(0.052)
market export value	0.017 ***	0.00056	0.024 ***	0.018 ***
	(0.003)		(0.004)	(0.003)
country export status, other products. (1-y)	0.173 ***	0.00584	0.735 ***	0.154 ***
	(0.024)		(0.021)	(0.024)
country export status, other products. y	0.543 ***	0.02404	0.35 ***	0.540 ***
	(0.035)		(0.031)	(0.035)
export intensity, same country, other products. (1-y)	-0.001 *	-0.00004	-0.001	-0.001 *
	(0.001)		(0.000)	(0.001)
export intensity, same country, other products. y	-0.002 ***	-0.00006	-0.002 ***	-0.002 ***
	(0.001)		(0.001)	(0.001)
number of other countries, same product. (1-y)	0.03 ***	0.00100	0.044 ***	0.031 ***
	(0.002)		(0.002)	(0.002)
number of other countries, same product. y	0.016 ***	0.00053	0.031 ***	0.016 ***
	(0.003)		(0.002)	(0.003)
average export intensity, other countries, same product. (1-y)	-0.003 *	-0.00011	0.001	-0.003 *
	(0.002)		(0.002)	(0.002)
average export intensity, other countries, same product. y	-0.003	-0.00008	0.001	-0.003
	(0.003)		(0.002)	(0.003)
number of other countries, all products. (1-y)	0.001	0.00005	-0.014 ***	0.002
	(0.002)		(0.002)	(0.002)
number of other countries, all products. y	0.002	0.00007	-0.017 ***	0.002
	(0.002)		(0.002)	(0.002)
average export intensity, other countries, all products. (1-y)	0.001	0.00004	0.000	0.001
	(0.002)		(0.002)	(0.002)
average export intensity, other countries, all products. y	0.001	0.00002	-0.001	0.001
	(0.002)		(0.002)	(0.002)
rho	0.047 ***		0.278 ***	0.028 ***
	(0.007)		(0.009)	(0.006)

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 million NOK. 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. For the WREP country model, the numbers are -27041 and 0.170, respectively. Average predicted probability of exporting a product to a country (APP) is 5.4 per cent in the WREP model.

5.1 Sunk costs and learning

5.1.1 Market-specific sunk costs

The effect of sunk export costs is captured by the variable *market export status* (the indicator variable for the firm-product-country observation the period before). The estimated α_0 is positive and significant in all regression models, lending support to the hypothesis of market-specific sunk costs.

The probability of serving a market increases with lagged export status in that market. As expected, the coefficient is overestimated in the REP model, where it is equal to 1.53 when scaled appropriately.[21] This underlines the importance of adequately correcting for unobserved heterogeneity, as is done in the WREP model, where the scaled estimated coefficient is 1.10. According to the APE from the WREP model, the probability of exporting to a market increases by 7.1 per cent points, or more than 180 per cent (from 3.9 to 11.0 percentage points) if the firm exported to the market the previous year as compared to if it did not. As a comparison, Moxnes (2010) found that, on average, the probability of exporting is roughly six times higher if the firm exported to the country last year. It is no surprise that the effect of previous export experience is larger in his analysis than in ours: He includes only the five most important export destinations. Furthermore, country specific effects are likely to be larger than market specific ones (see footnote 23). Our results seem quite robust. We experimented with excluding the 5 per cent smallest or largest firms, without this altering the results much.[22]

5.1.2 Market-specific learning

As noted in section 4 and footnote 10 it is not possible to distinguish the effect of market-specific sunk export costs from the effect of market-specific learning. Thus the positive coefficient for *market export status* may also indicate that the firms' export costs have been reduced through learning. We analyse additional learning from export intensity in the market separately by including the *market export value.* Its estimated effect is positive and significant, but small compared to *market export status*. Comparing the APEs, the estimates indicate that, in order for *market export value* to match the effect from the mere presence in the market, market-specific exports must be about NOK 125 million. As a comparison, median export value from a firm to a market is only NOK 0.36 million.

[21] As explained in the introduction to this section, when comparing the coefficients we must multiply them with the estimates of $\sqrt{1-\rho}$, which are equal to 0.976 in the WREP model, 0.850 in the REP model and 0.986 in the WREP country model.

[22] We also ran separate regressions for various product categories. Lagged export status was significant for most categories. An exception is Fresh white fish. Furthermore, it was highest for Clipfish/stockfish/salted whitefish – not surprising, as this is a more heterogeneous product group where quality differences are important.

5.1.3 Country- versus market-specific sunk costs.

The variable *country export status, other products* equals 1 if firm *i* exported other products to country *j* in the last period and 0 otherwise. For entrants (i.e. when interacted with $1-y_{ivjt-1}$), the coefficient is given by α_1, and may capture the effect of country-specific sunk costs that come in addition to market-specific sunk costs. For example, costs related to setting up of a sales office or acquiring information about a country's business culture and legislation are specific to the country rather than to the market. If the firm exported other products to country *j* in the last period, then G_j^L is already paid, making it less costly to start exporting product *v*. α_1 is positive and significant. If this effect is not taken into account, it will erroneously be captured as market-specific effects.[23]

5.1.4 Country-specific learning

Firms may learn about exporting a given product to a given country from their experience of exporting other products to the same country. For example, knowledge about a country's culture acquired by exporting one product may facilitate the export of other products to the same country.[24] In addition to capturing country-specific sunk export costs, the variable *country export status, other products* also captures learning effects like these. For entrants, it is not possible to distinguish them from country-specific sunk costs. They are both captured by α_1. α_2 captures learning effects for continuing exporters. Also estimates of α_2 are positive and significant. The APEs indicate that having exported another product to a country in the previous year increases the probability of entering the country with a new product this year by 11.5 per cent (from 5.2 to 5.8 per cent points). The probability of continuing to export a particular product to the country increases by 49.0 per cent (from 4.9 to 7.3 per cent points). Medin and Melchior (2002) also present qualitative evidence on such intra-country learning: from

[23] Comparable regressions where we excluded the *country export status, other products* (interacted with dummy for entry as well as continuance) resulted in estimates of α_0 which were greater than those reported in Table 1. The importance of country-specific sunk costs also becomes evident when we run regressions on the country dimension only. Such regressions yield larger coefficients for the lagged dependent variable as compared to our baseline firm-product-country regressions.

[24] A related notion is economies of scope: Consider a firm that pays for undertaking a market analysis for frozen fillet of cod. The costs may be lower if it has already undertaken a market analysis for frozen whole cod, because a more limited analysis is then sufficient. Consequently, the costs of exporting a product to a country decline with the number of other products exported. Such mechanisms are described in e.g. Arkolakis and Muendler (2010). Country-specific sunk or fixed costs represent a type of economy of scope.

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 the country.

As for market 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 costs of exporting product *v* to country *j*. The effect is captured by the variable *export intensity, same country, other products*. Our results indicate no additional effects, as the coefficients are negative (partly significant). This 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 probability of exporting a given product.

5.1.5 Learning from export experience in other countries

As emphasised in the model by Schmeiser (2012), 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 can make it easier to export to a given country.[25] The coefficient vectors for these effects are $\boldsymbol{\alpha_3}$ (entrants) and $\boldsymbol{\alpha_4}$ (continuing exporters) in eq. 2. The effects are 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 general effects, captured by the variable *number of other countries, all products*, and additional intra-product effects, captured by the variable *number of other countries, same product*. Again, there may also be learning effects from export intensity in other countries.

The results show positive effects of having product-specific experience from other countries: the estimated coefficients for *number of other countries, same product* are positive and significant for

[25] Again, there can be economies of scope in the sense that average export costs of a product to a country decline with the number of countries the firm exports to, e.g. because a marketing analysis undertaken in one country can give information about demand in other, similar countries.

entrants as well as continuing exporters. The APEs indicate the effects from increasing the number of other countries a firm exported a product to last year by 1. This leads to an increase in the probability of starting to export by 0.1 per cent points, or 1.9 per cent (when evaluated relative to the APP, see footnote 21; and an increase in the probability of continuing to export by 0.053 per cent points, or 1.0 per cent of the APP.[26] The results indicate the presence of intra-product learning effects across countries. Yet these effects are considerably smaller than the intra-country effects.

There is no evidence of learning across product groups from other countries, as the estimated coefficient for the *number of other countries, all products* is not significant. Neither does there seem to be any additional learning effects along the intensive margins, either within product groups (captured by *average export intensity, other countries, same product*), or in general (captured by *average export intensity, other countries, all products*).

Do our learning variables capture actual learning, or could there be other explanations for the results? One possibility is that the variables capture exporting ability rather than learning. We correct for unobserved heterogeneity and include several variables to control for this (see section 4 and 5.5). Another possibility is that increasing returns that reduce marginal costs in production are erroneously taken for learning effects. However, decreasing returns or quantity restrictions would work in the opposite direction. The revealed learning effects presented here are net of such effects.

5.2 Spillovers from other exporters

Firms' export experience in a country generates knowledge that may spill over to other firms and reduce their 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. The coefficient vectors for these effects are $\boldsymbol{\alpha_5}$ (entrants) and $\boldsymbol{\alpha_6}$ (continuing exporters) in eq. 2. The regression results are reported in table 3.

[26] 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.

Table 3 Regression results - spillovers

	WREP		REP		WREP country	
	Coeff.	APE	Coeff.		Coeff.	
number of other firms, same product. (1-y)	0.022 *** (0.002)	0.00072	0.044 *** (0.001)		0.023 *** (0.002)	
number of other firms, same product. y	0.017 *** (0.002)	0.00055	0.034 *** (0.002)		0.015 *** (0.002)	
average export intensity, other firms, same product. (1-y)	0.025 *** (0.005)	0.00081	0.057 *** (0.004)		0.036 *** (0.003)	
average export intensity, other firms, same product. y	0.03 *** (0.007)	0.00099	0.065 *** (0.006)		0.036 *** (0.005)	
number of other firms, all products. (1-y)	0.004 *** (0.001)	0.00014	0.003 *** (0.000)		0.004 *** (0.001)	
number of other firms, all products. y	0.002 * (0.001)	0.00006	0.001 (0.001)		0.002 ** (0.001)	
average export intensity, other firms, all products. (1-y)	0.006 (0.005)	0.00019	0.010 *** (0.003)		0.004 (0.005)	
average export intensity, other firms, all products. y	-0.011 ** (0.006)	-0.00037	-0.004 (0.004)		**-0.008** (0.006)	
country value, other firms, same product. (1-y)	-0.001 *** (0.000)	-0.00003	-0.002 *** (0.000)		-0.001 *** (0.000)	
country value, other firms, same product. y	-0.001 *** (0.000)	-0.00003	-0.002 *** (0.000)		-0.001 *** (0.000)	
country value, other firms, all products. (1-y)	0.000 *** (0.000)	-0.00001	0.000 *** (0.000)		0.000 *** (0.000)	
country value, other firms, all products. y	0.000 (0.000)	0.00000	0.000 (0.000)		0.000 (0.000)	

See note for table 2.

Along the extensive margin general spillover effects are captured by the variable *number of other firms, all products*, while additional intra-product effects are captured by *number of other firms, same product*. Estimated coefficients are positive and significant. The APEs show that an additional firm exporting a product to a country increases the probability of another firm exporting the same product to the same country by approximately 1 per cent of APP (for entrants as well as for continuing exporters). There is also some evidence of spillovers across products, but effects are smaller. It should be noted that these revealed spillover effects are net of any competition effects, which would tend to reduce the coefficients. The results are in line with findings in Medin and Melchior (2002), where interviews with Norwegian seafood exporters showed that firms considered it advantageous if there were other Norwegian exporters present in a market.

Regarding spillovers along the intensive margin, we find evidence of intra-product spillovers (captured by *average export intensity, other firms, same product)*, but not of general spillovers (captured by *average export intensity, other firms, all products*). We also included the total value of other firms' export of the same or all products as possible sources of spillovers (*country value, other firms, same/all products*), but most estimated coefficients are negative and significant. We interpret this as dominating competition effects.

One risk is that our spillover variables capture market attractiveness rather than actual spillovers. To control for this, we included several indications of market attractiveness (see section 5.5 and the appendix). In addition, we ran a separate regression with country dummy variables included to investigate the sensitivity of the results (third set of results in table 1). The results for the spillover variables (and also other variables) remained very similar in the two regressions, indicating that these results do not reflect country characteristics. The only exception is *average export intensity, other firms, all products* for continuing exporters (highlighted with bold letters in the table) where the estimated negative coefficient from the main analysis is insignificant in the regression with country dummies.

5.3 Comparison with other studies

Summing up, the results on learning from own export experience seem to indicate that such effects are strongest within the same country. A firm's presence with a product in a country seems to stimulate the export of other products to that country. There are also learning effects within product groups across countries, but no effects across products *and* countries. Learning from own export experience in other countries takes place through the extensive margin (number of other countries to which the firm exports), not the intensive margin (the firm's average export value to other countries). There is some evidence of learning from own export intensity in the same market, but effects are small.

We find strong indications of intra-product spillovers along the extensive margin (number of other firms exporting a particular product to the same destination country) as well as the intensive margin (their average export value). There is also some evidence of spillovers across products along the

extensive margin (number of other firms exporting any product to the country), but not along the intensive margin. We find no evidence of spillovers from total export value of other firms to the country. All in all, most learning and spillover effects seem to take place through the extensive margin (presence in markets) rather than the intensive margin (market export value).

We find evidence of learning and spillovers for continuing exporters as well as for entrants. Whereas effects for entrants capture reductions in both sunk and fixed export costs, effects for continuing exporters capture reductions in fixed export costs only. Our results therefore imply that learning and spillovers not only reduce sunk export costs, but also fixed export costs.[27] Furthermore, there is no general indication of stronger effects for entrants than for continuing exporters. Most other studies of market-specific learning and/or spillovers include only entrants in the analysis, and they differ from ours in the econometric method applied.[28] Our results show that continuing exporters should also be included in order to capture the full effect from learning and spillovers.

Some other studies have also documented learning effects from exporting to particular countries or markets. Some, among them Schmeiser (2012), Eaton *et al.* (2008), Lawless, (2009) and Albornoz *et al*. (2012), find that export expands through gradual entrance, possibly caused by learning. Others find that export experience in other countries or markets increases the probability of exporting to a particular country or market (see Lawless, 2013; Morales *et al*., 2014; Castagnino, 2011; Alvarez *et al.*, 2013; Fabling *et al*., 2011; Gullstrand, 2011; Meinen, 2015; and Chaney, 2014). Most other studies that look for spillovers that affect country- or market-specific export costs are affirmative. Requena Silvente and Castillo Giménez (2007), Koenig (2009), and Lawless (2013) find that spillovers affect country-specific export costs; while Alvarez *et al.* (2013), Koenig *et al*. (2010), and Fabling *et al*. (2011) find that spillovers affect market-specific sunk export costs.

[27] The effects could also reflect reductions in variable export costs. However, since we only study the decision to export, not how much to export, studying variable trade costs is less relevant here.
[28] The only exceptions we know of are Gullstrand (2011) and Meinen (2015), but they do not distinguish between effects for entering and continuing exporters within the same regression as we do. Moreover, they only focus on learning, not spillovers.

The above-mentioned studies define learning and spillover variables somewhat differently than we do and do not include such a rich variety of different effects. Few of them include both learning and spillovers in the same regression, and few discuss effects along both the extensive and intensive margins.

5.4 Internalised learning and spillover effects

We have, like most of the studies referred to here, assumed that learning as well as spillover effects are external to firms. It may be, however, that learning effects are internal. A firm may want to start exporting to a market not only because it believes that this market is profitable, but also because it knows that it will learn from exporting and therefore takes into account that entry into other markets later will become easier (for example by reducing uncertainty). In this case, a firm's entries across markets are interdependent. Schmeiser (2012) argues that firms first enter large and close countries with characteristics similar to their domestic market. The issue is also discussed in Albornoz *et al.* (2012), who 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 as such since we include only firm-product observations that are positive all years of the sample period. When learning effects are particularly important for the *first* export destination, possible problems of assuming that learning effects are external to the firm are not important in our investigation. Furthermore, if learning is internalised into the firms' decision problem, it is not clear whether the resulting interdependence would alter our results since the sequence of entry into new markets could well be the same.

It is also possible (but perhaps to a lesser degree) that spillover effects are internalized: firms may take into account that their export decisions make it more likely that other firms will follow. A firm may, for instance, choose countries or markets where spillovers are less likely to materialise (in order to prevent other firms from benefitting from its knowledge) – or markets where spillovers are more likely to materialise (in order to benefit from mutual spillover effects). Krautheim (2012) argues that spillovers tend to magnify gravity and distance effects in aggregate trade patterns. This follows from clustering effects that we have identified as significant effects in this article. Krautheim also argues

that these effects are likely to materialise at the extensive and not at the intensive margin. We find support for this view for inter-product spillovers: they are present along the extensive margin but absent or negative along the intensive margin. Regarding intra-product spillovers, however, there is no support for Krautheim's view in our study: they are present along both the extensive margin and intensive margins.

5.5 Other independent variables

Our regressions include a range of other explanatory variables. Table 4 reports regression results. Here we offer only a short description of these. All variables are listed in the appendix.

Table 4 Regression results – other variables.

	REP		REP		WREP country	
	Coeff.		Coeff.		Coeff.	
leader, market	0.076	***	0.250	***	0.070	***
	(0.015)		(0.014)		(0.014)	
leader, country	0.037	***	0.067	***	0.036	***
	(0.006)		(0.005)		(0.06)	
leader, product	0.009	***	0.007	***	0.009	***
	(0.003)		(0.003)		(0.03)	
size	0.012		-0.023		0.012	
	(0.015)		(0.015)		(0.015)	
appreciation	0.000		0.000		0.000	
	(0.000)		(0.000)		(0.000)	
gdp	0.095		0.109	***	0.147	
	(0.200)		(0.007)		(0.201)	
gdp per capita	0.150		0.010		0.086	
	(0.200)		(0.014)		(0.203)	
gdp growth	0.012	***	0.006	**	0.012	***
	(0.003)		(0.002		(0.003)	
regulatory quality	0.008		0.149	***	-0.001	
	(0.046)		(0.027)		(0.047)	
rule of law	-0.008		0.069	**	0.004	
	(0.057)		(0.033)		(0.058)	
control of corruption	0.113	***	-0.123	***	0.108	*
	(0.042)		(0.026)		(0.042)	
import adjusted	0.043	***	0.011	**	0.042	***
	(0.014)		(0.005)		(0.014)	
EU	-0.024		-0.184	***	-0.023	
	(0.106)		(0.036)		(0.098)	
USA	-0.039		-0.190	***		
	(0.057)		(0.073)			
FTA	-0.055		-0.003		-0.056	
	(0.056)		(0.034)		(0.055)	
FTAEEA04	0.163		0.019		0.156	
	(0.115)		(0.045)		(0.108)	
FTAEEA07	0.161		0.288	***	0.143	
	(0.138)		(0.062)		(0.133)	
distance	-0.130	***	-0.162	***		
	(0.023)		(0.025)			

See notes for table 2.

Other studies on sunk export costs often find that firm characteristics reflecting productivity, such as firm size, are important for the export decision (see, e.g., Roberts and Tybout, 1997). Our data lack firm characteristics beyond those related to export. Since we concentrate on market-specific export entries, not global export, data on firm characteristics are probably less important than in studies of export decisions as such. Nevertheless, it is a concern that our results on persistence, learning, and spillovers may capture unobserved firm-level differences in ability to export rather than the presumed effects. We therefore compensate for the lack of such characteristics in various ways. Firstly, to capture time-varying effects, we use the information embedded in the export data. Firms' total export value is used as a proxy for firm *size*. The firm's specific competitive advantage is proxied for by variables reflecting the firm's relative position among Norwegian firms in the market, country, and, for the product, *leader market*, *leader country*, and *leader product*. Secondly, to capture time-invariant effects we include random effects at the firm-product-country level, as described in section 4. Ideally, we should have included fixed rather than random effects. This would have corrected for all time-invariant unobserved heterogeneity in all combinations of the three dimensions. However, this is not possible in a non-linear model with a lagged dependent variable like ours (see discussion in Bernard and Jensen, 2004). Therefore, we include firm dummies. [29] These approaches ensure that we can control for fixed firm effects and firm dynamics, such as, e.g., firms on a growing curve.

Another concern is that our results on persistence, learning, and spillovers may capture market attractiveness rather than the presumed effects. We include several variables to correct for country characteristics. Data for log of GDP, log of 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).[30] Log of import (from all countries) of product *v* to country *j* is taken from the COMTRADE database.[31] Taken together, these variables capture demand and demand

[29] We would have liked to include firm-product and firm-country dummies, but this would have yielded a prohibitively large number of independent variables for data computational purposes.
[30] WDIs for the Faroe Islands lack GDP growth data for the whole period and GDP for 1997, so we use data from the Statistics Faroe Islands instead. Growth data are based on current USD. WDIs lack data for GDP for Brunei for the year 2007, so we have estimated that. WDIs for Qatar lack growth data for the years 1996–2000, so we have supplemented with growth data from the IMF.
[31] 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

differences for each product within and between countries. We also include changes in the country-specific exchange rates, taken from the CIA World Factbook. The governance qualities of a country may influence its attractiveness as a market. We include three measures of good governance provided by the World Bank from the Worldwide Governance Indicators (WGI): *regulatory quality*, *rule of law*, and *control of corruption*.[32] Trade costs are proxied for by log of distance.[33] We also include several dummies reflecting market differences: (i) products, to capture supply and demand side differences across products; (ii) product-year, to capture production and demand cycles; (iii) regions;[34] (v) EU countries; (vi) the USA;[35] and (vii) countries with which Norway has a free trade agreement.[36] Of the above-mentioned variables, only the *leader* variables, *import adjusted*, *gdp growth*, *control of corruption* and *distance* proved to be significant. All have the expected signs.

Although our analysis includes many standard gravity variables capturing differences between countries, a concern in interpreting the results is that persistence in market-specific export, learning, and spillovers may be due to unobserved characteristics of countries. We therefore ran a sensitivity analysis including country dummies as described in section 4. Results, reported in the last column of tables 2, 3 and 4, are very similar to those from the main regression.

6 Conclusions

In this article we have investigated the importance of sunk export costs by examining persistence in firms' export behaviour. Unlike earlier studies, which have focused on global or country-specific sunk export costs, we have concentrated on the costs to already established exporters of entering a particular market. We find that exporting to a particular market the previous period increases the probability of

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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 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.

[32] Data for the Faroe Islands and Greenland are lacking in the WGIs, so we have set figures for these countries equal to those for Denmark.

[33] Great-circle distances in kilometres based on coordinates for the capitals (Gyldendal, 1970).

[34] Europe, Asia, Africa and the Americas.

[35] Anti-dumping duties have been imposed on Norwegian exports of salmon in the US market.

[36] Separates dummies are included for the European Economic Area (EEA), and 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.

exporting to the same market in the current period by more than 180 per cent as compared to not having exported to the market. We interpret this as an indication of market-specific sunk export costs.

Furthermore, we have investigated how market-specific export costs are affected by learning and spillovers. We have looked for a wide range of learning and spillover effects, intra- and inter-product as well as intra- and inter-country. Our evidence indicates that firms learn about exporting to a particular country from their export experience both in the country in question as well as other countries. Learning effects appear to be strongest for presence within one and the same country: the export of another product to a given country in the previous year increases the probability of starting to export a given product to that country this year by 11.1 per cent and continuing to export by 49.6 per cent. Our results further indicate that learning effects are present within product groups across countries, but absent across countries and products.

We also provide evidence of spillovers. We focus on spillovers in the destination country, and our results indicate that presence of other Norwegian exporters in a given country last period increases the probability of a given firm exporting to that country this period. We find clear indications of intra-product spillovers and also some indications of spillovers across products. There is no evidence of spillovers from total Norwegian export value to a country. Most learning and spillover effects take place through the extensive margin (presence in markets) rather than through the intensive margin (market export value).

Learning and spillovers effect continuing exporters as well as entrants, thus these effects not only reduce sunk, but also fixed export costs. Consequently, both types of firms should be included in the analysis in order to capture the full effects from learning and spillovers.

Appendix

Appendix table Independent variables

Independent variable	Description
Market export status	Lagged export status (y_{ivjt-1}). 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.
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*.
Country export status, other products	A dummy equal to 1 if firm *i* exported other products to country *j* last year ($y_{iv'jt-1}$). Reflects the importance of country-specific sunk costs and learning from own experience of exporting other products to country *j*.[1]
Export intensity, 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*.1
Number of other 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.[2] Part of the vector $\mathbf{y_{ij't-1}}$.
Average export intensity, other countries, same product	Export value of product *v* from firm *i* to other countries (excluding country *j*), divided by *number of other countries, same product*. A learning variable corresponding to *number of other countries, same product*.[2]
Number of other countries, all products	Number of other countries (not including country *j*) firm *i* exported any product last year. Reflects learning from experience from exporting to other countries.[1 2] Part of the vector $\mathbf{y_{ij't-1}}$.
Average export intensity, other countries, all products	Export value of all products from firm *i* to other countries the previous year, divided by *number of other countries, all products.* A learning variable corresponding to *number of other countries, all products*.[1 2]
Number of other 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.[3] Part of the vector $\mathbf{y_{i'jt-1}}$.
Average export intensity, other firms, same product	*Country value, other firms, same product* divided by *number of other firms, same product*. A spillover variable corresponding to *number of other firms, same product*.[3]
Number of other firms, all products	Number of other Norwegian firms (not including firm *i*) that exported any product to country *j* the previous year. Reflects country-specific spillovers from other exporters.[3] Part of the vector $\mathbf{y_{i'jt-1}}$.
Average export intensity, other firms, all products	*Country value, other firms, all products*, divided by *number of other firms, all products*. A spillover variable corresponding to *number of other firms, all products*.[1 3]
Country value, other firms, same product	Export value from other Norwegian firms (excluding firm *i*) of product *v* to country *j* the previous year. An additional spillover variable.[3]
Country value, other firms, all products	Export value from other Norwegian firms (excluding firm *i*) to country *j* the previous year. An additional spillover variable.[1 3]
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. [1]
Leader, product	Export value of product *v* from firm *i* to all countries, divided by total Norwegian exports of product *v*. Lagged one year. [2]
Size	Log of firm *i's* export value. A proxy for firm size. Lagged one year.[1 2]
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*. Great circle distance in km.
Import	Log of import of product *v* in country *j*. In 1000 current NOK. Missing observations are replaced by mean.
Regulatory quality	Perceived quality of a government's regulatory quality, normally distributed for country ranking.
Rule of law	Perceived quality of rule of law, normally distributed for country ranking.
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 fillets of whitefish.
Dfirm	Dummy equal to 1 for all firms, except one.
Dyearproduct	Dummy equal to one for all year - product combinations, except fresh fillets of whitefish 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 EU member countries in 2004 with which Norway previously had free trade agreements.
DFTAEEA07	Dummy for new EU member countries in 2007 with which Norway previously had free trade agreements.

Note: values are in millions NOK (learning and spillover variables) or 1,000 NOK (other variables). Learning and spillover variables are interacted with *market export status* and (1- *market export status*).

[1] Include all 25 product groups, not just the 18 groups included in the sample

[2] Include all countries in the data, not just sample countries

[3] Include all firms in the data, not just sample firms

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