UCD CENTRE FOR ECONOMIC RESEARCH

WORKING PAPER SERIES

2009

Importing, Exporting and Productivity in Irish Manufacturing

Fergal McCann, University College Dublin

WP09/22

November 2009

UCD SCHOOL OF ECONOMICS
UNIVERSITY COLLEGE DUBLIN
BELFIELD DUBLIN 4

Importing, exporting and productivity in Irish manufacturing

Fergal McCann[*§]

October 28, 2009

Abstract

The impact of international trade on firm productivity is tested by accounting for firms' import as well as export status for a large panel of Irish manufacturing firms. Two-way traders and exporters-only are found to be the most productive firms, with a significant gap between them and importers-only and non-traders. tfp is calculated using a modified version of the Olley and Pakes (1996) estimator, taking account of a four-category trade status. Selection of the most productive firms into exporting or importing is not found in any robust sense. Fixed effects, as well as Propensity Score Matching with Difference in Differences, are used to calculate productivity improvements from entering into international trade. These improvements are found to be highly contingent on export status, with import status being unimportant. The key finding of the paper is that the gains from trade, for Ireland at least, appear to lie on the export side. Interestingly, quitting trade leads to a mirror image effect to that of entry for all trade statuses.

JEL Classifications: F10, F14, L25
Keywords: Trade orientation, heterogeneous firms, productivity

[*]University College Dublin; Université Paris 1, Panthéon-Sorbonne

[†]I thank Dermot Leahy for supervision of my doctoral thesis, and Ron Davies for supervision of this paper which forms part of said thesis.

[‡]I thank Paul Walsh, Jim Markusen, Mark Roberts, Bee-Yan Aw-Roberts, Jan De Loecker, Marian Rizov, Matthew Gobey, Liam Delaney and Joan Monrás for helpful comments, along with participants at a UCD lunchtime seminar, the Spring Meeting of Young Economists 2009, Marmara University, Istanbul, a Forfás Productivity Research day and the European Trade Study Group annual conference, Rome, September 2009.

[§]I acknowledge the financial support of Science Foundation Ireland Research Frontiers Programme Grant MAT017 and Forfás Productivity Research Bursary 2009.

1 Introduction

An important body of empirical research in international trade has focused on the productivity premium enjoyed by exporting firms. Early papers, such as Bernard and Jensen (1999) examine whether these more productive exporting firms selected into exporting, or whether firms improved after becoming exporters. The former, "selection hypothesis" was motivated by the idea that there is a threshold level of productivity below which firms would not have the capability to enter international markets. This was formalized in Melitz (2003) in the form of fixed costs of entry to export markets which only the most productive firms could overcome. The latter, "learning hypothesis" suggests that exposure to international markets will lead to greater competition, higher standards, exposure to new and better technologies and an opportunity to avail of economies of scale, and thus productivity improvements for firms.

This paper contributes to the firm-level literature on the link between international trade and total factor productivity (*tfp*) by considering both importing and exporting as methods of international orientation. Whether or not more productive firms select into exporting or importing is tested using a random effects probit. The firm's import status is taken into account while testing for export selection, and vice-versa. The strong results usually found in the literature supporting selection into exporting are not found here. Neither is selection found on the import side. The related issue of conscious selection, proposed theoretically by Yeaple (2005) and tested empirically by *inter alia* Alvarez and López (2005), is also examined, with no significant results uncovered.

The productivity-enhancing, or learning effects from international trade are then analysed by Fixed Effects and a combination of Propensity Score Matching (PSM) and Difference in Differences (DD) techniques. The literature has often found only negligible support for learning effects from exporting (for a survey, see Wagner (2007) or Kneller (2007)). For Irish manufacturers, using a structurally estimated tfp variable that accounts for a four-category trade status variable, I find that becoming an exporter significantly increases tfp, both for firms that were previously non-traders and firms that were already importing. Firms that become importers, however, are found not to experience tfp increases.

The results of this study are not fully compatible with the majority of

research in the area. The consensus view seems to be that strong support has generally been found for the selection-to-exporting hypothesis, with less conclusive results on the learning effects of exporting. Examples of studies supporting the selection hypothesis include Clerides et al. (1998), Bernard and Jensen (1999), Delgado et al. (2002), Arnold and Hussinger (2004), Damijan et al. (2004), the International Study Group on Exports and Productivity (2007). Despite the perception that selection is the more robustly supported hypothesis, many studies find evidence for both learning and selection effects, including Clerides, Lach and Tybout (1998) for Morocco, Baldwin and Gu (2003) for Canada, Aw et al. (2000) for Korea and Taiwan, Liu et al. (1999) for Taiwan, Girma et al. (2004) for the UK, Greenaway and Kneller (2004a,b) for UK. Recent studies such as De Loecker (2007) for Slovenia, Bustos (2008) for Argentina, Van Biesebroeck (2005) for a panel spanning numerous African countries and Walsh and Rizov (2007) for the UK, have found support for learning effects from exporting using a more structural methodology. An explanation for the results of the three former papers may lie in the country under study in each. Firms in less developed countries are more likely to experience learning effects as, prior to entering exporting, their productivity may have been hampered by factors such as the size of the domestic market, poor infrastructure and credit provision. One could also posit that papers including the export decision in an Olley and Pakes (1996) (OP hereon) framework have better dealt with the firm-level dynamics of exporting and are, thus, more likely to find a learning effect.

The role of intermediate imports in tfp growth has received less attention when compared to the vast exporting literature. Halpern et al. (2005) for Hungary, Amiti and Konings (2007) for Indonesia, and Kasahara and Rodrigue (2008) for Chile, all employing OP-type estimation procedures, look specifically at the effect that importing intermediates has on productivity, and all find a positive "learning-by-importing" effect. This effect is attributed to an increased variety of inputs, the inferior quality of domestic intermediates, and the diffusion of improved technologies embedded in the imported intermediates (see Keller (2004) for a survey on international technology diffusion). Vogel and Wagner (2008) claim to be the first to test both the learning and selection effects for importing as in Bernard and Jensen (1999). They find support for selection but not for learning, using labour productivity as a dependent variable and refraining from using structural estimation techniques due to data constraints.

Studies that simultaneously analyse the import and export decision, as is the aim of this paper, are more rare. Kasahara and Lapham (2008) build a theoretical extension of Melitz (2003) incorporating importing and exporting where both activities are subject to fixed and sunk costs. Their empirical tests on Chilean data find higher fixed and sunk costs for exporting than importing. Altomonte and Békés (2009), using Hungarian data, include importing and exporting as additional state variables in a typical export-productivity structural framework such as that used by De Loecker (2007). They find that the inclusion of the importing decision lowers the exporter premium from 33% to 15%. This indicates that the initial export-productivity literature may have been overestimating the extent to which exporters are better performers. They find that two-way traders are the most productive firms, followed by importers only, then exporters only, and finally purely domestic firms. They find support for selection into both trading activities, and that the ex-ante productivity of firms that switch into importing is higher than that for exporting. Castellani et al. (2008) find an identical productivity ordering for Italian firms to that in Altomonte and Békés (2009), but focus more on the extensive margins due to availability of data at the product level. They find that the degree of geographical and sectoral diversification is positively correlated with firm size and productivity and present some indirect evidence suggesting selection into importing. Bernard et al. (2007) for US data, find two-way traders to be the top performers along all firm characteristics, while exporters and importers only are very similar in all categories. Muuls and Pisu (2009), for Belgian data, also find importers-only to have a higher labour productivity than exporters-only.

The tfp ordering of this paper differs from that found in Altomonte and Békés (2009), Castellani et al. (2008) and Muuls and Pisu (2009). As in these papers, non-traders are found to be the least productive. Conversely, however, exporters only are here found to be as productive as two-way traders, while importers-only have a similar productivity to non-traders. This result is slightly surprising in the context of previous evidence. An explanation may lie in the fact that Ireland already plays host to many high quality input-providing firms, meaning that sourcing from abroad need not imply any improvement in input[1]. See Li, Walsh and Whelan (2007) for a study of the industrial development of Ireland, with particular reference

[1]Ireland has sold itself internationally as an ideal location for supply chain management and as a high-quality host for parts of the international value chain. http://www.idaireland.com/business-in-ireland/supply-chain-managemnent/scm-activities/

to the role of high-quality domestic firms with linkages to the internationalised sector. The strong interventionist tradition in Irish industrial policy is also potentially important here. Enterprise Ireland (EI), the state support agency for indigenous exporters, has a long history of helping firms with market research, product development, information on local barriers and bureaucracy in the run-up to entry to the export market. Given this tendency, it may be less surprising that exporting is found to be far more strongly associated with high productivity than importing for Irish firms. Indeed, Besedina (2008) finds that when state agencies are supporting exporting firms, the exporter productivity premium is overstated. The fact that there is a strong state intervention in Irish exporting, combined with the fact that we cannot observe which firms are helped by Enterprise Ireland in the data, may mean that the export coefficients here are overestimates. Unfortunately, there is no way to test for this with the CSO data. The tradition of state intervention in Ireland may also explain why little evidence of selection of more productive firms into exporting is found here - perhaps it is the case that the help of EI has meant that entry to exporting is not associated with the same fixed costs as in other countries. This finding of no selection into exporting is in line with the Irish contribution to the International Study Group on Exports and Productivity (2007).

The lack of evidence on selection into importing may be explained in comparative terms by the fact that in less developed countries, such as Hungary and Chile, firms desiring imported intermediates may not have yet established a reputation for regular payment, have sophisticated credit access, or benefit from a lack of tariff and non-tariff barriers. One might expect that in Ireland, as an EU member and developed economy, importing an intermediate would not suffer from such drawbacks and, therefore, would not be associated with high fixed entry costs, thus mitigating against the need for an exceptionally high tfp level to facilitate entry. A robustness check shows that when UK imports are excluded, a selection effect into importing exists, indicating that there are negligible fixed costs to entry into the import market from the UK. This may be plausible given that the UK is Ireland's closest and historically its majority trading partner.

The results from tests of the learning hypothesis indicate that exporting is the trading activity that results in productivity improvement. Regardless of previous or contemporaneous import status, entry into exporting leads to improvements in tfp. There is no evidence of learning by importing for the full sample. The reasons outlined above regarding Ireland's high-quality

input-supplier network and its status as a developed economy may also help to explain this lack of an effect. The overall message is quite a strong one: for Irish firms, the benefits of trade accrue on the export side, with firms that become importers rarely experiencing any benefit. Exporting seems to lie above importing in a "productivity ordering". These findings have quite pointed implications for Irish industrial policy regarding firms' international orientation.

The rest of the paper is structured as follows: Section 2 outlines the data and descriptive statistics, Section 3 describes the estimation of the production function, Sections 4, 5, and 6 report empirical results, Section 7 outlines robustness checks, while Section 8 concludes.

2 Data, descriptive statistics

The data source used is the *Census of Industrial Production*, from the Central Statistics Office of Ireland. This is a mandatory plant and enterprise-level survey of all manufacturing firms in the Republic of Ireland with three employees or more. The time period covered is 1992-2005, which makes it a particularly interesting dataset as it covers the entire "Celtic Tiger" boom period in Ireland, as well as a small number of years preceding the boom[2]. Industry breakdown at the 2, 3 and 4 digit level is given in accordance with NACE Rev 1 from 1992-2001 and NACE Rev 1.1 from 2002-2005. The panel is unbalanced, with sample size hovering between 4,500 and 5,000 firms for each year.

For the purposes of much of the econometric analysis, firms will be broken down into four groups:

0=non-traders,
1=exporters-only,
2=importers-only,
3=two-way traders.

Table 1 documents the frequency of each type of firm in the data. Two-way traders are shown to be the most common type of manufacturing firm in Ireland. This is a rare finding in the literature. Studies such as Altomonte and Békés (2009) for Hungary, Bernard et al. (2007) for the US and Kasahara and Rodrigue (2008) for Chile all find a predominant amount of firms

[2]The general consensus is that the boom began in 1994 or 1995.

not engaging in international trade. The figures here are an indication of the heavily international orientation of Ireland's economy throughout the sample period 1992-2005. As expected, far more foreign-owned firms (88%) are two-way traders than Irish-owned firms (46%). The figure for indigenous firms engaging in two-way trade is still exceptionally high, however, at 43%.

Table 1: Frequency by trade status

Trade Status	0 non-trader	1 exporter	2 importer	3 two-way
Frequency (all firms)	21	7	23	49
Frequency (indigenous)	24	7	26	43
Frequency (foreign)	2	7	3	88

In Table 2 below the frequency of exporting and importing plants is outlined. 56% of all firms are engaged in exporting, while the figure is 72% for importing. As would be expected, over 90% of foreign-owned firms based in Ireland are involved in each trading activity. For indigenous firms, importing is again more frequently observed, with almost three-quarters of Irish-owned firms involved, against half of Irish firms involved in exporting[3]. This indicates that importing is the more common activity among firms in Ireland.

The status quo in the literature is that exporters are better than non-exporters across a range of firm characteristics. Here I exploit the four-category nature of the trade dummy to check whether a firm's import status is also an important indicator of firm performance.

Table 2: Frequency of Exporting and Importing firms

Non-Exporters vs Exporters		
Total Sample	44%	56%
Indigenous	50%	50%
Foreign	6%	94%
Non-Importers vs Importers		
Total Sample	28%	72%
Indigenous	31%	70%
Foreign	9%	91%

[3]The International Study Group on Exports and Productivity (2007) reports exporter participation rates ranging from 26.6% for Columbia to 83% for Sweden.

To do this the following regression is run:

$$x_{it} = \beta_\tau \tau_{it} + \beta_f f_{it} + \delta_t + \delta_i + e_{it} \quad (1)$$

Where x is a vector of firm characteristics, τ refers to trade status, f is a foreign ownership dummy, δ_t and δ_i are time and industry dummies. The coefficients on exporters only, importers only and two-way traders relative to non-traders are reported in Table 3. The early indications from the data are that exporting is much more heavily associated with positive firm performance than importing. This is a surprising finding when compared to Altomonte and Békés (2009) and Castellani et al. (2008) who find that among one-way traders importers-only are more productive than exporters-only, and Andersson et al. (2007) who also find a marginally higher premium for importing over exporting. Across sales, capital[4] and investment, exporters-only are marginally better performing than two-way traders, who have a large advantage over importers only. Across size (in employees) and wages per employee, two-way traders are top performers, followed closely by exporters only, with a significant margin differentiating both from importers-only.

Kasahara and Lapham (2008) attempt to quantify fixed and sunk costs to both exporting and importing. They find that these costs are higher for exporting than importing, implying that firms must be more productive to enter exporting. A tentative remark on fixed costs can be made by observing the patterns in Table 4. The share of non-exporters who import (53%) is larger than that for non-importers who export (25%). The share of exporting firms who are two-way traders (88%) is also larger than that for importing firms (68%). This goes against Bernard et al. (2007) who report that in the US data 41% of exporting firms also import, while 79% of importing firms also export. These findings, along with the rankings in Table 3, indicate that for Irish manufacturing there are likely to be higher fixed costs to entering exporting than importing.

[4]The CIP does not report capital stock figures. To get around this problem, changes in capital stock were regressed on differences in energy usage for each year at the NACE2 level, with the resulting parameter applied to levels of energy usage to get a proxy for capital stock.

Table 3: Regressions of trade dummies on firm characteristics

Trade Status	wage	sales	capital	investment	size
1 (Export only)	1,461	5.659m	730,740	283,345	20.88
2 (Import only)	321	1.333m	-498,363	34,372	2.29
3 (Two-way)	1477	5.297m	30,420	127,031	23.64
R^2	.3306	.058	.0526	.0415	.1099
Foreign ownership, industry and time dummies included					

Table 4: Trade Statuses broken down by export and import dummy

Trade Status	Non-Exp	Exp	Non-Imp	Imp
No Trade	47	n/a	75	n/a
Export	n/a	12	25	n/a
Import	53	n/a	n/a	32
Two-way	n/a	88	n/a	68

In the empirical analysis presented here, firms that either enter or exit a given trade status are needed for identification of selection and learning regressions. Transition of firms between trade statuses is outlined in Table 5 below. Each (*vertical, horizontal*) combination indicates each firm's status in a given $(t-1, t)$ pair. For example, there were 386 firms who moved from being a non-trader in a given year to being an exporter-only in the following year. The most frequent observations, marked in bold, are along the diagonal of the transition matrix, indicating that trading activities on the whole are persistent and subject to significant sunk costs. This is a finding that is consistent across most firm-level trade studies. The observations above the diagonal represent the firms that are under study in the majority of the papers mentioned in the introduction. These are firms that have entered into a trading activity. The amount of activity to the left and below the diagonal is surprising, as this represents firms leaving trading activities. Given the frequency with which firms leave trading activities, it seems pertinent to investigate the effect of exiting trade on firm performance too. Results of exit regressions will be reported in Table 14.

The bottom section of Table 5 gives the trade status of firms reported in 1992, which is the first year of the sample, along with the status of new-born firms whose first year appearing in the data is after 1992. A $(t-1, t)$ trade status pair can clearly not be observed for either of these categories. The total numbers of firms in these categories are almost identical, and exporters

and importers-only both appear with almost identical frequency in both groups. Among firms born during the sample period, however, there are more born non-traders, while among observations in 1992, the first year of the data, two-way trade is reported more frequently. This may be explained by the fact that firms reporting in 1992 are not necessarily born in 1992, so that firms born prior to 1992 are driving the higher incidence of two-way trade and lower incidence of non-traders. Given that for firms whose birth can be observed in the data there is a higher incidence of non-trade, one can posit that there are additional barriers to entering the market as a two-way trader beyond the barriers to entry that exist for all firms.

Table 5: Transition matrix of full sample

	Non-trade	Export	Import	Two-way
$t-1$		t		
Non-trade	**8,827**	386	1,354	569
Export	352	**2,394**	94	996
Import	1,746	136	**9,371**	1,716
Two-way	1,022	1,092	2,182	**23,657**
1992	586	235	1,080	2,572
Age=1	1,092	293	987	1,992

3 Production function estimation

The method used to estimate the firm-level production function is a modified version of that proposed by Olley and Pakes (1996). The modification is that firms' trade status is allowed to be a state variable, i.e. it affects the firms' productivity and decision-making process. Several papers have modified the OP procedure to include exporting, importing, or both, but none to my knowledge have included a four-category trade status. The estimation procedure, results of which are reported in Column (5) below, is outlined in detail in Appendix 1. Table 6 reports results from different versions of this modified OP procedure. Column (1) reports the coefficients from a standard OP estimation where productivity is a function of capital and investment only. Column (2) mimics De Loecker (2007) by allowing an export dummy to be an additional state variable. Column (3) similarly mimics Amiti and Konings (2007) by allowing an import dummy to be a state variable. Column (4) presents the estimator similar to that used by Altomonte and Békés (2009) where both an export and import dummy are included as

state variables. Columns (2) to (4) show that both trading activities, when entered independently of each other, have a negative sign in the Non-Linear Least Squares estimation of the final stage of the OP estimation. Column (5) reports this paper's modified estimation procedure, which is outlined in Appendix 1. This estimator will be used to back out the tfp variable used in the empirical section of the paper. The four-category "trade status" variable outlined in Section 2 is added as a state variable here. This now indicates that it is exporting-only that enters into the production function with a positive sign, with both importing-only and two-way trading having negative coefficients.

Table 6: Coefficients from modified OP estimators

	(1)	(2)	(3)	(4)	(5)
	OP(96)	DeL (07)	AK (07)	AB (09)	
l	.3504***	.3487***	.3494***	.3476***	.3466***
m	.5217***	.5211***	.5224***	.5219***	.5221***
k	.0476***	.0487***	.0493***	.0498***	.0505***
export		-.0538***		-.0239***	.0361***
import			-.0900***	-.0854***	-.0571***
two-way					-.1017***
time and industry dummies included in all regressions					
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$					

tfp can be backed out of these estimation procedures as:

$$tfp = y - \hat{\beta}_l l - \hat{\beta}_m m - \hat{\beta}_k k \tag{2}$$

Table 7 reports a ranking of tfp backed out of different estimation procedures. Regardless of the estimation used, it appears that exporters only and two-way traders are the most productive firms, while importers-only and non-traders are the least productive. There is a significant gap between the two pairs of firm types. When importing and exporting are included as individual dummy variables in columns (2) to (4), two-way traders are found to be the most productive firms. In all estimations where the importing dummy is included, non-traders are found to be more productive than importers-only. It is the tfp variable from Column (5), tfp_{trade}, that will be used in the following sections. Interestingly, when the four-category trade status variable is included as a state variable, tfp is higher for exporters-only than two-way traders. The difference is marginal, however, with both these

categories still far more productive than importers-only and non-traders. The results from this and the previous table indicate that accounting for trade status in this way, rather than as a pair of dummy variables, leads to a higher positive weighting being given to exporting and a more strongly negative weighting being given to importing than including both separately as dummy variables.

Table 7: Ranking of trade statuses by different tfp measures

Column	measure	mimics	ranking
(1)	tfp	Olley & Pakes (1996)	$two-way > ex > im > non$
(2)	tfp_{ex}	De Loecker (2007)	$two-way > ex > im > non$
(3)	tfp_{im}	Amiti & Konings (2007)	$two-way > ex > non > im$
(4)	tfp_{exim}	Altomonte & Békés (2009)	$two-way > ex > non > im$
(5)	tfp_{trade}		$ex > two-way > non > im$

4 Selection

In this section the selection hypothesis, i.e. that more productive firms select into export and import markets, is tested. The theoretical concept underpinning the selection hypothesis originates with the fixed entry costs of Melitz (2003). Only the most productive firms can overcome this entry cost and begin trading. To test this hypothesis empirically, all firms who are not engaging in the trading activity under analysis at a given time $t-1$ must be considered. Before moving on to the detailed breakdown by trade status that is the theme of this paper, the selection-to-exporting and selection-to-importing regressions that are more common to the literature will be run. From the results in Table 8, there is evidence of more productive firms selecting into importing, but no evidence of selection into exporting.

Table 8: Selection to exporting and importing

	export	import
tfp_{t-1}	$-.0752$	$.5029^{***}$
	(.1905)	(.1907)
tfp_{t-2}	$-.0158$	.0327
	(.1911)	(.1904)
$foreign$	$.3670^{***}$	$-.0680$
	(.1399)	(.1030)
age	$.0274^{***}$	$.0288^{***}$
	(.0080)	(.0075)
$skill$	.1725	.0807
	(.1338)	(.1401)
D.Time?	yes	yes
D.Industry?	no	yes
Obs	17577	9588
all regressions random effects probit		
Standard errors in parentheses		
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$		

The main contribution of this paper lies in identifying whether traditional selection effects may depend on the opposing trade status. Table 9 reports coefficients from the following regression:

$$Pr(\tau = x|\tau_{i,t-1} = y) = F(\Phi_{i,t-1} + \delta_s + \delta_t + e_{it}) \tag{3}$$

where the dependent variable is a dummy indicating a switch from trade status y to x from $t-1$ to t, Φ includes productivity, foreign ownership, age and skill intensity, and δ_s and δ_t are industry and time dummies[5]. The selection hypothesis is confirmed if a positive significant coefficient on previous period tfp is found. The results of Table 9 show no evidence whatsoever of *ex-ante* tfp predicting entry into any trade status. This is at odds with much of the literature, but may have explanations lying in Ireland's interventionist industrial policy as mentioned in the introduction. Enterprise Ireland (EI), the state body responsible for internationalisation of local firms, has a long and successful history of aiding firms in their entry into export markets. This state intervention may have reduced the traditional Melitz-style productivity cut-off for entry to export markets, so

[5]The omission of industry dummies in Columns (1) and (3) is caused by a computational problem. There appears to have been a surfeit of information in the explanatory vector which meant that Stata's solver could not arrive at a solution for these regressions. The omission of industry dummies remedied this problem. When industry dummies were included with time dummies omitted, Stata could not solve either, indicating that the inclusion of time dummies only was the best that could be done for these two specifications.

that lagged tfp does not show up as a significant predictor of entry into international markets. In fact, the only significant factors predicting entry are age and foreign ownership; older firms are significantly more likely to enter exporting from non-trade and to enter importing when already an exporter, while foreign affiliates are more likely to enter exporting while already an importer. As mentioned earlier, one potential explanation for the lack of an effect for importing may lie in the quality of indigenous input supplying firms in Ireland.

Table 9: Results of random effects probits testing selection hypothesis

	(1)	(2)	(3)	(4)
Switch	$0 \rightarrow 1$	$0 \rightarrow 2$	$2 \rightarrow 3$	$1 \rightarrow 3$
tfp_{t-1}	0.1349	0.2736	-0.058	-0.0107
	(0.515)	(0.2992)	(0.2868)	(0.4032)
tfp_{t-2}	-0.5432	-0.3323	0.0799	0.4446
	(0.5222)	(0.3012)	(0.29)	(0.3984)
$foreign$	-6.7365	0.1264	0.3206*	-0.1898
	(7,155.82)	(0.289)	(0.1742)	(0.1404)
age	0.0337*	0.0133	0.0051	0.0409**
	(0.019)	(0.0093)	(0.0125)	(0.0187)
$skill$	0.4538	-0.0592	0.1715	0.4278
	(0.3216)	(0.1867)	(0.2012)	(0.3044)
$Cons$	-0.3139	0.1893	-1.9116**	-3.9909***
	(1.8792)	(1.3275)	(0.8325)	(1.4909)
D.Time?	yes	yes	yes	yes
D.Industry?	no	yes	no	yes
Obs	5980	6527	6882	1809
Standard errors in parentheses				
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$				

A related but importantly different concept is that of conscious selection. The selection of more productive firms into trade proposed above is essentially an exogenous decision. In the original Melitz model, firms receive a random draw from a productivity distribution and then sort into trade based on the cut-off level of productivity needed to enter. It may be the case, however, that firms realise there is a certain productivity level required in order to enter into trade, and consciously improve in the run-up to entry with this in mind. This innovation was formalized theoretically by Yeaple (2005) who augments Melitz's random draw from a productivity distribution to give firms a choice over the type of workers and technology used, thus enabling firms to consciously improve in order to enter the export market. Alvarez and López (2005) propose testing the conscious selection

hypothesis by using lagged investment as a proxy for the firm's decision to improve in the periods preceding entry to exporting. Here, this involves including inv_{t-1} in Φ_{t-1} in Equation 3 above. The results again indicate that there is no significant evidence of conscious improvement in the run-up to entry into any trade status. Concerned that tfp and inv may be correlated, the regressions of Table 10 are run again with only inv included and tfp omitted. The omission of tfp changes nothing - lagged and twice lagged investment still have no significant effect on entry into any trade status. Table 8 is mimicked by running conscious selection regressions for all firms that enter exporting, regardless of import status, and all firms that enter importing, regardless of export status. These regressions also indicate that prior investment levels are not a significant predictor of entry into either trading activity.

Table 10: Random effects probits testing conscious selection hypothesis

	(1)	(2)	(3)	(4)
Switch	$0 \rightarrow 1$	$0 \rightarrow 2$	$2 \rightarrow 3$	$1 \rightarrow 3$
tfp_{t-1}	-0.0699	0.2188	-0.1357	-0.2972
	(0.5609)	(0.3203)	(0.3002)	(0.4541)
tfp_{t-2}	-0.2391	-0.4393	0.0464	0.4664
	(0.5688)	(0.3207)	(0.3009)	(0.449)
inv_{t-1}	0.0083	0.003	0.0061	0.0164
	(0.0103)	(0.0056)	(0.0062)	(0.0105)
inv_{t-2}	-0.013	0.0057	0.0041	0.0017
	(0.0101)	(0.0056)	(0.0067)	(0.0105)
$foreign$	-6.6586	0.1232	0.3134*	-0.1809
	(7,228.30)	(0.2895)	(0.1724)	(0.1402)
age	0.0337*	0.0135	0.004	0.0418**
	(0.019)	(0.0093)	(0.0124)	(0.0186)
$skill$	0.4445	-0.062	0.1667	0.4336
	(0.3217)	(0.1868)	(0.1997)	(0.3042)
$Cons$	-0.8043	0.4203	-1.0148	-2.4029
	(2.1066)	(1.437)	(0.8997)	(1.661)
D.Time?	yes	yes	yes	yes
D.Industry?	no	yes	no	yes
Obs	5980	6527	6882	1809
Standard errors in parentheses				
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$				

5 Learning

The learning hypothesis, i.e. that, upon entry into trade, firms improve their productivity at a faster rate than if they had remained solely domestically oriented, is tested in this section. There are many reasons given in the exporting literature for the productivity-enhancing effect of selling abroad. The domestic market may not offer opportunities for economies of scale to be exploited, which seems particularly plausible in a country of Ireland's size. The increased competition to which firms are exposed when selling abroad also forces them to improve their product and processes. Similarly, contact with foreign dealers and intermediaries involves a certain amount of knowledge transfer to the Irish firm in the form of higher standards. On the import side, an increased variety of input, along with an assumed higher quality of input found abroad, are commonly cited as productivity drivers associated with importing inputs (Amiti and Wei, 2006). Knowledge transfer and embedded technology is also seen as an important productivity-enhancing effect of importing (Keller, 2004). When attempting to estimate the productivity benefits of entering into trade, I first adopt a Fixed Effects (FE) and then for robustness a combination of Propensity Score Matching with a Difference in Difference estimator.

5.1 Fixed Effects

Adopting the FE estimator does not explicitly deal with endogeneity, but gives up less observations than GMM, and is considered useful as a first look at the productivity improvements from entering into international trade.

$$\Delta tfp_{i,t+s} = \alpha_0 + \beta_{xy} Switch_{xy,it} + \beta_4 Cont_{it} + + \delta_s + \delta_t + \epsilon_{it} \qquad (4)$$

where $\Delta tfp_{i,t+s}$ is the average change in total factor productivity s periods after the switch into x, $Switch_{xy}$ denotes a dummy which takes on 1 for a switch from y at $t-1$ to x at t and zero if a firm has trade status y at $t-1$ and t, $Cont$ is a vector of control variables which usually comprises capital, investment, age and a foreign ownership dummy and ϵ is the regression error. In Table 11, coefficients on $Switch_{xy,it}$, along with standard errors and number of observations are reported. The picture is quite clear: across four periods after a switch into exporting for non-importers there is a very large statistically significant increase in tfp. For firms that were already importers there is a smaller effect over three periods, and for firms that switch from non-trade directly to two-way trade, there is a small effect for one period and strangely a similar effect over four periods. Entering into

importing in fact decreases tfp for firms that were already exporting, while for a non-trader, entry into importing has no effect. This emphasises the role of exporting as a driver of productivity for Irish manufacturing firms, with particularly strong productivity-enhancing effects for firms that enter exporting having previously not been involved in international trade.

Table 11: Learning Effects of entry to trade on tpf, Fixed Effects

		(1)	(2)	(3)	(4)
Outcome = Δtfp_{t+s}		s=1	s=2	s=3	s=4
No trade	Export	.1375***	.0659***	.0319***	.0096
		(.0071)	(.0086)	(.0077)	(.0123)
		9203	5946	3892	2527
No trade	Import	-.0024	-.0023	-.0016	.0018
		(.0038)	(.0033)	(.0031)	(.0042)
		10171	6523	4266	2770
No trade	Two-way	.0174***	.0094	.0097	.0187**
		(.0058)	(.0071)	(.0109)	(.0087)
		9385	6042	3965	2583
Export	Two-way	-.0869***	-.0468***	-.0301***	-.0239***
		(.0058)	(.0053)	(.0063)	(.0065)
		3386	2024	1265	834
Import	Two-way	.0366***	.0178***	.0084**	.0066
		(.0032)	(.0035)	(.0037)	(.0076)
		11072	7057	4647	3045

Standard errors in parentheses
Observations reported underneath
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$
Coefficients on control variables suppressed for ease of exposition

5.2 Propensity Score Matching with Difference in Difference

As a method that better accounts for the potential endogeneity between tfp and trade, I use propensity score matching (PSM), followed by a Difference in Difference (DD) estimator to estimate the learning effects from entering trade. The procedure is intuitive: initially, all firms that enter into a given trade status are matched from the pool of firms who do not enter that trade status by a propensity score (Rosenbaum and Ruben, 1983). This propensity score is estimated as follows

$$Pr(Enter_{\tau} = x | \tau_{t-1} = y) = F(tfp_{t-1}, k_{t-1}, inv_{t-1}, foreign_{t-1}, \delta_i, \delta_t) \quad (5)$$

where $Enter_{\tau} = x|\tau_{t-1} = y$ denotes entry into trade status x given that the firm's trade status was y at time $t-1$, k and inv are the logs of capital

and investment, respectively, $foreign$ is an ownership dummy, and δ_i, δ_t are industry and time dummies. The inclusion of tfp in the propensity score is most crucial as it accounts for the endogenous selection of more productive firms into trading activities. Firms are matched by means of "nearest neighbour" matching to firms within the control group of firms that remain in trade status y at time t. The DD procedure first calculates the difference between tfp before and after entry to the trade status x for the treatment group, conditional on the right hand side variables of Equation 5. This difference in tfp cannot be fully attributed to entry to x, due to factors that could be contemporaneous with entry, so this first difference is then differenced with respect to the before and after difference of the matched control group, firms which remain in y. The DD estimator has in this step removed the effect of common shocks, providing a better estimate of the effect of entering x on tfp. What is estimating finally is the difference in tfp evolution between firms that leave y to enter x and firms that *ex-ante* had the same probability of entering x but in fact stayed in y. The key assumption to identify a "learning from trade" effect is that any unobservable left in the propensity score is uncorrelated with the decision to enter x. Common support is also imposed, so that any observations with a propensity score too far away from their nearest neighbour are dropped. These dropped firms never amount to more than five, indicating the matching procedure does not result in many outliers. Furthermore, for each regression a balancing test has been performed before and after the matching. The t-tests for the mean of tfp, k, inv and $foreign$ indicate in each regression that the matched and control groups do not have significantly differing means. Table 12 reports results from the matching DD estimator. Each figure reported corresponds to the average treatment effect on the treated (those entering into trade status x). The sample size of the treatment and control groups are reported below the coefficients. While, particularly for longer time periods, the number of firms switching into a given trade status is quite small (sometimes less than one hundred), the fact that at all times there is a relatively large control group from which to match (anything from two to twenty times as large as the treatment group) should add weight to the validity of the coefficients. One striking feature of Table 12 is the similarity between the matching results and the Fixed Effect results of Table 11, indicating that the learning effects estimated are reasonably robust to estimation methodology. The coefficients are generally marginally larger under matching than under Fixed Effects. The broad picture again emerges that exporting is an extremely important instigator of tfp improvement, while entry to importing in fact has a negative effect on tfp, particularly

if a firm is already an exporter. Entry to exporting for firms that were previously not trading results in 15, 6, 4 and 4 percent growth in tfp one, two, three and four periods after entry, respectively. Entry to exporting and importing simultaneously, along with entry to exporting for firms already importing, results in between one and three percent improvements in tfp, significant up to four years after entry. The almost zero effect of entering importing for non-traders, combined with the particularly strong negative effect for firms already exporting, indicates again that the traditional hypotheses used to explain productivity improvements from importing seem not to hold for Ireland.

Table 12: Learning effects of entry to trade on tfp using PS Matching

		(1)	(2)	(3)	(4)
Outcome = Δtfp_{t+s}		s=1	s=2	s=3	s=4
No trade	Export	.1534***	.0615***	.0444***	.0358***
		(.0067)	(.0061)	(.0054)	(.0056)
		386	169	86	45
		8583	5626	3012	1961
No trade	Import	-.0030	-.0053*	-.0022	-.0021
		(.0035)	(.0026)	(.0024)	(.0025)
		1352	746	450	285
		8808	5752	3787	2467
No trade	Two-way	.0268***	.0220***	.0138***	.0131***
		(.0060)	(.0048)	(.0041)	(.0042)
		567	264	153	98
		8598	5638	3708	2392
Export	Two-way	-.0887***	-.0416***	-.0295***	-.0165***
		(.0056)	(.0040)	(.0036)	(.0039)
		990	611	411	275
		2390	1400	839	521
Import	Two-way	.0361***	.0186***	.0098***	.0082***
		(.0033)	(.0025)	(.0023)	(.0024)
		1715	976	627	407
		9057	5819	3699	2405

Standard errors reported in parentheses
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$
Number of treated, followed by controls, reported underneath

To get a sense of what is uncovered by allowing learning-by-exporting to depend on import status and vice-versa, it is instructive to quickly report results from regressions that adopt the exact same methodology as above, but do not differentiate by the trade status not under study. This allows the reader to make a comparison between the Irish data and the data used in the multitude of firm-level studies on trade and productivity. In the first row of Table 13, results are reported for all firms that did not export

at $t-1$, regardless of import status, and learning effects for firms that enter exporting at t are examined. The same is done for importing in the second row. This learning-by-exporting regression would significantly underestimate the effect that exporting has on firms that begin to export from a position of having never traded before. Similarly, the productivity decreases that occur to exporters who begin to import are underestimated by simply looking at all firms that enter importing at once, while the fact that entering importing has an almost zero effect for previous non-traders is also masked. The heterogeneous responses of different firm types to entry to trade is an important facet that is often left untouched in the literature.

Table 13: Learning-by-exporting and importing

	(1)	(2)	(3)	(4)
Outcome = Δtfp_{t+s}	s=1	s=2	s=3	s=4
Exporting	.0514***	.0166***	.0065***	.0041***
	(.0028)	(.0016)	(.0012)	(.0010)
	2805	2449	2135	1874
	20728	17157	14278	11936
Importing	-.0262***	-.0059***	-.0029*	-.0031***
	(.0029)	(.0017)	(.0014)	(.0012)
	3005	2506	2091	1711
	11944	9562	7757	6177
Standard errors reported in parentheses				
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$				
Number of treated, followed by controls, reported underneath				

6 Quitting trade

The observations below and to the left of the diagonal in Table 5 represent firms that have left a given trading activity from period $t-1$ to t. Their frequency, often greater than those firms entering trade, suggests that the phenomenon of firms exiting trade is something worth studying. It is an interesting policy question to ask whether the benefits that firms experience from engaging in trade (in particular exporting, as the previous section has shown) "stick" once firms exit from trade, or whether firms do indeed regress upon exit. I apply precisely the same Propensity Score Matching methodology as in the learning regressions, with firms that exit a given trading activity matched with firms that continue in that trade activity by foreign ownership, capital, tfp and time and industry dummies:

$$Pr(Quit_{\tau} = x | \tau_{t-1} = y) = F(tfp_{t-1}, k_{t-1}, inv_{t-1}, foreign_{t-1}, \delta_i, \delta_t) \quad (6)$$

where $Quit_\tau = x|\tau_{t-1} = y$ is a dummy indicating that a firm engaged in trade status x at time $t-1$ and quit to enter status y at time t and controls are as in Equation 5. The results of the propensity score matching, combined with Difference in Difference estimator are reported in Table 14. Each coefficient represents the average percentage change in tfp over the time period specified after quitting activity x.

Table 14: Effect of quitting trade on tfp, Matching DD estimator

		(1)	(2)	(3)	(4)
Outcome = Δtfp_{t+s}		s=1	s=2	s=3	s=4
Export	No trade	-.1159***	-.0609***	-.0479***	-.0313**
		(.0076)	(.0062)	(.0051)	(.0063)
		352	179	97	58
		2382	1356	770	481
Import	No trade	.0103***	.0058***	.0001	-.0003
		(.0034)	(.0025)	(.0023)	(.0022)
		1737	1038	688	461
		9335	6052	3979	2516
Two-way	No trade	-.0319***	-.0178***	-.0111***	-.0120***
		(.0044)	(.0032)	(.0027)	(.0025)
		1019	612	391	262
		23321	17714	8835	6345
Two-way	Export	.0979***	.0435***	.0284***	.0204***
		(.0048)	(.0044)	(.0038)	(.0042)
		1087	465	256	133
		23571	17926	13263	9370
Two-way	Import	-.0394***	-.0212***	-.0130***	-.0099***
		(.0032)	(.0024)	(.0022)	(.0022)
		2175	1213	763	501
		23607	17923	13894	10842

Standard errors reported in parentheses
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$
Number of treated, followed by controls, reported underneath

A striking mirror image of Table 12 emerges: for the vast majority of switches, the effect of quitting is almost inversely identical to the effect of entering. These results indicate that there may be an important role for policy in ensuring firms continue to export: quitting exporting is associated with statistically and economically significant losses in tfp. These decreases are marked for firms that leave exporting to become non-traders, with an initial loss of 11 percent of tfp. The decreases are less severe for firms that quit both exporting and importing simultaneously, and for firms that quit exporting but remain importing. The decreases in tfp may be explained by a returns to scale story; firms that leave exporting suddenly have a far

more restricted market available to them and may be forced up their average cost curves and thus to a lower level of tfp. The results also indicate that quitting importing is good for firms' tfp. This may be due to the fact that Ireland is a relatively developed economy in which there is a large pool of suitable supplier firms, indicating that sourcing inputs from these local firms may in fact be the optimal sourcing strategy. As in Section 5, Fixed Effects were also run, with similar results.

6.1 Technology downgrading?

Following from the finding that quitting exporting leads to productivity losses, I investigate whether this loss in productivity is associated with a sort of "technology downgrading". Here I contrast with Bustos (2008) who finds that trade liberalization drives Argentinean firms to upgrade their technology. To check whether there is indeed technology downgrading in the aftermath of an exit from a trading activity, Equation 6 is run, but the log of investment, rather than *tfp*, is included as the outcome variable. The measure of investment is the best proxy in the Irish data for technology-enhancing behaviour of firms. A negative coefficient on investment would indicate that leaving a given trading activity did indeed lead to a decrease in firms' investments, which could be evidence of technology downgrading. I find that firms that leave two-way trading to become either exporters-only or importers-only decrease their investment in the years following their exit from the respective trade category. This result is not in line with the technology downgrading hypothesis, given that one should expect that only the switches that are associated with productivity decreases are also those associated with technology downgrading. This is the case for the switch from two-way trading to importing only. However, technology downgrading is also seen for firms quitting importing, which in fact has a positive coefficient in Table 14. One potential explanation for this inconsistency is that investment in physical capital is included in the investment measure, which means that the figure is not solely capturing investments that improve the technological capacity of the firm. Thus, this investigation does not yield any conclusive evidence of technology downgrading after exit from trade.

7 Robustness checks

To complete the empirical analysis, attempts were made to identify all potential weaknesses and points of uncertainty associated with the regression

results from Tables 8 to 14. In the following paragraphs each concern, and attempt to assuage it, will be described in turn.

(1) *Are the results driven by foreign-owned firms, who are on average more productive, more export-oriented and more import-oriented than Irish firms?*

- Response - We should not expect this *a priori* to be a huge worry when we are looking at firms entering trade. The main reason for this is that when multinationals set up in a country, particularly Ireland, they are likely to enter as a two-way trading firm, having already overcome the fixed costs of entry into multinationality which are thought to be greater than those to exporting (Helpman, Melitz and Yeaple, 2004) and importing. Indeed, the vast majority of foreign-owned firms in the sample (88 percent) are two-way traders. In the framework of Table 5, they appear almost uniquely in the bottom right-hand corner, i.e. they are persistent two-way traders, firms that were two-way traders at $(t-1)$ and are two-way traders at t. Given this fact, they should not affect the results of regressions testing effects of entry into and exit from trading activities. To ensure that there are no foreign-driven effects picked up in the results in sections 4-6, the regressions of Tables 8-14 were re-run for the subsample of indigenous firms only. As expected, the sample sizes change very little, with more than 90 percent of firms that made each switch in Tables 8-14 turning out to be Irish owned. The coefficients on all selection and conscious selection regressions are similar and insignificant, as in Tables 8, 9 and 10. For learning regressions, the negative effect of entering importing is now insignificant, while all other switches have similar effects in magnitude and significance. The fact that omission of foreign firms eliminates the negative effect of importing is a further result hinting at the possibility that foreign firms may be benefiting more than others from the high-quality input supplier network purportedly in place in Ireland.

(2) *Does the usage of tfp_{trade}, in which the four category trade status variable is included as a state variable in the tfp algorithm, accentuate the coefficients?*

- Response - As can be seen from Table 6, the positive effect of exporting and the negative effect of importing are felt most strongly in the

final column, where the four-category trade status variable is included as a state variable. It is tfp_{trade}, from this estimation, that is used in Tables 8-14. To check whether the usage of tfp_{trade} leads to overly positive results associated with exporting and overly negative results associated with importing, I run all regressions in Tables 8-14 with a number of alternative *tfp* measures:

(a) tfp_{imex}, which includes two separate dummy variables for importing and exporting instead of the four-category trade status variable in the OP estimation. This is the estimation procedure proposed by Altomonte and Békés (2009). For learning regressions under Fixed Effects and Propensity Score Matching, identical signs and significance levels to those reported in Section 5 for tfp_{trade} are found, but with lower coefficients. For example, the move from non-trade to exporting, which has a reported coefficient of 15, 6, 5 and 4 percent for 1, 2, 3 and 4 periods' average tfp improvement, respectively, is found to have coefficients of 8, 4, 2 and 1 percent under tfp_{imex}. This pattern is repeated for all switches apart from the switch from non-trade to importing, and for quitting regressions, with the absolute value of coefficients marginally smaller but similarly significant in almost all cases. As in Section 4, no evidence of selection is found when tfp_{imex}, is used.

(b) tfp_{ex}, which mimics exactly the strategy of De Loecker (2007), including export status as a state variable. Using this *tfp* measure, we see again that all three switches (0 to 1, 2 to 3 and 0 to 3) in which exporting is added lead to statistically significant *tfp* increases for all four periods. The coefficients are lower than those under tfp_{trade}; for example the switch from non-trader to exporter leads to 6, 3, 1 and 1 percent increases over one, two, three and four year periods, respectively. Interestingly, now that importing is not accounted for in *tfp* estimation, all coefficients for the switches from 0 to 2 and for 1 to 3 are insignificant. The mirror images of learning coefficients are generally found for quitting regressions, as is the case in the main body of the paper.

(c) tfp_{im}, which mimics the algorithm of Amiti and Konings (2007), including import status only as a state variable. This gives rise to much lower coefficients for learning by exporting, now lying at approximately one percent. Learning by importing, for previous non-exporters, has a significant negative coefficient of roughly one percent for three pe-

riods, which is a larger decrease than that in the main body of the paper. The heavy negative coefficient on learning by importing for firms already exporting (1 to 3), now disappears.

(d) tfp_{op}, which is the baseline algorithm of Olley and Pakes (1996), in which no trade variables are accounted for in the estimation. Using this measure, there is significant evidence of learning by exporting, for both the 0 to 1 and the 2 to 3 switches. The coefficients are again much lower, hovering between 1 and 2 percent. The negative values that have been found for learning by importing, both for the 0 to 2 and the 1 to 3 switch, are all insignificant and minuscule under this specification.

- The conclusion that can be drawn from this set of robustness checks is that learning by importing is never positive, but the heavily negative coefficient on the switch from exporter-only to two-way trader in the main body of the paper does not hold in estimations where the four-category trade status is replaced by something else in the *tfp* algorithm. Learning by exporting is a robust finding across all specifications, but coefficients are higher when exporting is accounted for in the tfp estimation algorithm, and higher again if both exporting and importing are accounted for. The results in the main body of the paper paint the picture perfectly accurately, but should be seen as an upper bound for learning by exporting coefficients.

(3) *Does the UK matter?*

- Response - It is possible that there may be something different about trading with the UK, given that many of these observations may include trading that is essentially local, particularly with trading partners in Northern Ireland. Under this circumstance, neither the fixed entry costs of importing nor the technology transfer embodied in imported intermediates are likely to exist for imports from the UK. To check if this is indeed the case, I create a new dummy variable which takes a 1 only if the firm is an importer from the EU, US or Rest of World, and 0 if the firm is a non-importer or a UK importer. All regressions are run from Tables 8 to 14 again using this new import variable. Interestingly, selection of more productive firms into importing is now found, indicating that imports from the UK are indeed not subject to the traditional fixed entry costs, whereas imports from further overseas are. On the learning side, there are no negative learning coefficients, and indeed, a one period productivity increase for firms

that switch from non-importers to being importers from EU, US or Rest of World can be seen. This indicates again that the technology-enhancing aspect of imported goods may exist more in these products from further away. So in summary, as well as the productivity measure used, there is reason to believe that UK imports bias downwards all coefficients related to importing, due to the fact that they are not subject to fixed entry costs, and may be identical to products available in the Republic of Ireland.

The same thing was done for non-UK exports, but no significant difference in the pattern of results was uncovered. This indicates that as an export market, the UK is characterised by the same productivity-enhancing effect as other overseas markets for Irish firms. Similarly, the exclusion of the UK does not change the results for selection, indicating that Irish firms do not indeed overcome fixed entry costs to export markets in the traditional Melitz (2003) fashion. This may give a little more weight to the idea that it is government support to exporters that drives the lack of a selection effect.

The conclusion to be taken from these robustness checks is that learning by exporting is a very strong and robust finding for Ireland. Accounting for bias introduced by foreign firms, productivity measurement, and the UK as source of inputs or destination of exports has no effect on the significance of learning by exporting, both for firms that were non-importers or importers. The only change is that the coefficient reported in the paper is somewhat of an upper bound, with many robustness checks finding coefficients half the size of those in the paper, and sometimes lower. The other important conclusion is that the negative effect of learning by importing for firms that were previously exporting is very much a lower bound. Across many robustness checks, this negative coefficient becomes minuscule and often insignificant. A positive effect of learning by importing, for either exporters or non-exporters, is very nearly never found. The robustness checks simply indicate that the negative coefficient is not stable, and that most likely it can be concluded that there is no real effect of importing on productivity. Another important lesson is that for Irish firms, imports from the UK may warrant treatment as a separate entity, in that non-UK imports are subject to fixed costs that more productive firms overcome upon entry.

8 Conclusion

This paper aimed to test the sources of the productivity advantage of firms engaged in international trade. Following a well-established line of literature, the selection and learning hypotheses were tested for both exporting and importing. tfp is estimated in a structural fashion, modifying the Olley and Pakes (1996) algorithm to account for a firm's trade status: non-trader, exporter only, importer only or two-way trader. The key finding of the paper is that exporting matters a lot for productivity, with importing having a negligible effect in comparison. The selection hypothesis is rejected for Irish firms: no evidence is found that *ex-ante*, firms that enter into either trade activity are more productive than those who remain domestically active. A potential explanation for this finding is the long interventionist tradition in Irish industrial policy, whereby firms are aided in their attempts to enter into export markets. This may artificially have helped firms who would not have been productive enough in a Melitz-style *laissez-faire* world to enter international markets. Firms that enter into export markets are found to experience significant positive gains in tfp terms, significant up to four years after entry. This holds regardless of import status, although the largest gains are for firms that enter into exporting from a previous status of non-trader. Non-exporting firms that enter into importing are found to experience no change in productivity as a result, while exporters that enter into importing in fact decrease tfp. This is a surprising result, but does not hold up to robustness checks. It may be explained in part by Ireland's status as a well-developed economy with a renowned reputation for local high-quality input suppliers. The traditional hypotheses put forward for productivity gains from importing, such as higher quality inputs available abroad, may not hold in the Irish case, where firms may benefit equally from sourcing intermediates at home. Similarly, firms that have already experienced the tfp benefits of being an exporter may not have anything to learn from the process of importing an intermediate. The final finding of the paper, that exiting a trade status has an almost equal and inverse effect to that of entering, suggests a role for policy in encouraging firms to continue to export. This "exit effect" presents an interesting topic for further research.

References

Ackerberg, D., Caves, K., Frazer, G., 2006. Structural identification of production functions. Mimeo, University of Toronto.

Altomonte, C., Békés, G., 2009. Trade complexity and productivity. IEHAS Discussion Papers 0914, Institute of Economics, Hungarian Academy of Sciences.

Alvarez, R., López, R.A., 2005. Exporting and performance: evidence from Chilean plants. Canadian Journal of Economics 38 (4), 1384-1400.

Amiti, M., Konings, J., 2007. Trade liberalization, intermediate inputs and productivity: Evidence from Indonesia. American Economic Review 97 (5), 1611-1638.

Andersson, M., Johansson, S., Loof, H., 2007. Firm performance and international trade. CESIS Working Papers, No. 99.

Andersson, M., Loof, H., 2008. Imports, productivity, and the origin markets - the role of knowledge-intensive economies. CESIS Working Papers, No. 146.

Arellano, M., Bond, S. 1991. Some tests of specification for Panel Data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies 58(2), 277-97.

Arnold, J.M., Hussinger, K., 2004. Exporting behaviour and productivity in German manufacturing: a firm-level analysis. Review of World Economics 141 (2), 219-243.

Aw, B.Y., Chung, S., Roberts, M.J., 2000. Productivity and turnover in the export market: Micro-level evidence from the Republic of Korea and Taiwan (China). The World Bank Economic Review 14, 65-90.

Baldwin, J.R., Gu, W., 2003. Export-market participation and productivity performance in Canadian manufacturing. Canadian Journal of Economics 36, 634-657.

Baldwin, R. 2006. Globalisation: the great unbundling. Contribution to the project "Globalisation Challenges for Europe and Finland", Secretariat of the Economic Council of Finland.

Baltagi, B.H., 2001. Econometric analysis of Panel Data, 2nd Edition, John

Wiley.

Bernard, A.B., Jensen, A.B., 1995. Exporters, jobs and wages in U.S. manufacturing: 1967-1987. Brookings Papers on Economic Activity: Microeconomics. 67-119.

Bernard, A.B., Jensen, J.B., 1999. Exceptional exporter performance: Cause, effect, or both? Journal of International Economics 47, 1-25.

Bernard, A.B., Jensen, J.B., Redding, S.J., Schott, P.K., 2007. Firms in international trade. Journal of Economic Perspectives 21 (3), 105-130.

Bernard, A.B., Wagner, J. 1997. Exports and success in German Manufacturing. Weltwirtschaftliches Archiv / Review of World Economics 133, 134-157.

Bernard, A.B., Wagner, J., 2001. Export entry and exit by German firms. Weltwirtschaftliches Archiv / Review of World Economics 137, 105-123.

Besedina, E., 2008. Exporting and productivity under endogenous trade policy: Theory and evidence from Ukraine. Paper presented to European Trade Study Group, Warsaw 2008.

Blalock, G., Gertler, P.J., 2004. Learning from exporting revisited in a less developed setting. Journal of Development Economics 75, 397-416.

Bustos, P., 2008. Trade liberalization, exports and technology upgrading: Evidence on the impact of MERCOSUR on Argentinean firms. Mimeo, Universitat Pompeu Fabra.

Castellani, D., Serti, F., Tomasi, C., 2008. Firms in international trade: Importers and exporters heterogeneity in the Italian manufacturing industry. LEM Papers Series 2008/04.

Clerides, S.K., Lach, S., Tybout, J.R., 1998. Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico and Morocco. Quarterly Journal of Economics 113, 903-947.

Damijan, J.P., Polanec, S., Prasnikar, J., 2004. Self-selection, export market heterogeneity and productivity improvements: Firm-level evidence from

Slovenia. Katholieke Universiteit Leuven, LICOS Discussion Paper 148/2004.

De Loecker, J., 2007. Do exports generate higher productivity? Evidence from Slovenia. Journal of International Economics 73, 69-98.

Delgado, M.A., Farinas, J.C., Ruano, S., 2002. Firm productivity and export markets: a non-parametric approach. Journal of International Economics 57 (2), 397-422.

Girma, S., Görg, H., Strobl, E., 2004. Exports, international investment and plant performance: evidence from a non-parametric test. Economics Letters 83, 317- 324.

Greenaway, D., Kneller, R., 2004a. Exporting and productivity in the United Kingdom. Oxford Review of Economic Policy 20, 358-371.

Greenaway, D., Kneller., R. 2004b. Industry differences in the effect of export market entry: Learning by exporting? University of Nottingham, GEP Research Paper 04/33.

Halpern, L., Koren, M., Szeidl, A., 2005. Imports and productivity. CEPR Discussion Paper 5139.

International Study Group on Exports and Productivity, 2007. Exports and productivity: Comparable evidence for fourteen countries. ZEW Discussion Paper 07-069.

Kasahara, H., Lapham, B., 2008. Productivity and the decision to import and export: theory and evidence. CESIfo Working Paper, No. 2240.

Kasahara, H., Rodrigue, J., 2008. Does the use of imported intermediates increase productivity? Plant-level evidence. Journal of Development Economics 87, 106-118.

Keller, W., 2004. International technology diffusion. Journal of Economic Literature 42 (3), 752-782.

Kneller, R., 2007. Exports and productivity, in: Forfás (Ed.) Perspectives on Irish Productivity, 366-384.

Li, Q., Walsh, P.P., Whelan, C., 2007. Building export capabilities by promoting inter-firm linkages: Ireland's industrial policy revisited. Working 103 Papers 200740, Geary Institute, University College Dublin.

Liu, J.T., Tsou, M.W., Hammitt, J.K., 1999. Export activity and productivity: Evidence from the Taiwan Electronics industry. Weltwirtschaftliches Archiv / Review of World Economics 135, 675-691.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71, 1695-1725.

Muuls, M., Pisu, M. 2009. Imports and exports at the level of the firm: Evidence from Belgium. The World Economy 32 (5), 692-734.

Olley, S.G., Pakes, A., 1996. The dynamics of productivity in the Telecommunications Equipment industry. Econometrica 64 (6) 1263-1297.

Roodman, D., 2006. How to do xtabond2: An introduction to "Difference" and "System" GMM in Stata. Center for Global Development Working Paper Series, No. 103.

Rosenbaum, P. R., Rubin, D. B., 1983. The central role of the propensity score in observational studies for causal effects. Biometrika 70, 41-55.

Van Biesebroeck, J., 2005. Exporting raises productivity in sub-Saharan African manufacturing firms. Journal of International Economics 67 (2), 373-391.

Vogel, A., Wagner, J., 2008. Higher productivity in importing firms: Self-selection, learning from importing, or both? University of Luneburg Working Paper Series No. 106.

Wagner, J., 2007. Exports and productivity: A survey of the evidence from firm-level data. World Economy 30 (1), 60-82.

Walsh, P.P., Rizov, M., 2007. Productivity and trade orientation in UK manufacturing. IZA Discussion Papers, 2808.

Yeaple, S.R., 2005. A simple model of firm heterogeneity, international trade, and wages. Journal of International Economics 65 (1), 1-20.

Appendix 1 - Productivity estimation procedure

The firm's production function in logs is set up as follows:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \eta_{it} \tag{7}$$

Where y_{it} is log of gross output, k_{it} is log of capital input, l_{it} is log of labour input and m_{it} is log of material inputs. ω_{it} and η_{it} are unobservable to the econometrician. The difference between the two unobservables is vital to the rest of the model: ω_{it} represents shocks that are potentially observable to the firm when it makes its production decisions at time t, such as managerial ability, expected down-time of machinery or expected changes in the manufacturing environment and is often referred to as the "productivity shock". η_{it} represent shocks that are unobservable both to the firm and econometrician when the firm makes its production decision at time t. Note that the constant is subsumed into the ω_{it}.

The well-known endogeneity problem in the estimation of 7 is that the firm's optimal choice of m, l and k will generally be correlated with the firm's observable productivity shock w_{it}. This renders OLS biased, and attempts such as instrumental variables and GMM techniques to deal with this have been subject to weak instrument criticisms. The OP methodology places structure on the firm's behaviour and movement through discrete time. They assume that productivity evolves exogenously through a first-order Markov Process, and assume labour to be a non-dynamic input. Capital, on the other hand, is a dynamic input, which accumulates through investment, represented as follows:

$$k_{it} = \kappa(k_{i,t-1}, i_{i,t-1}) \tag{8}$$

Economically this seems to be a sensible imposition, as it may take a full period from deciding to invest in capital to the capital being usable in the plant. This helps solve the endogeneity problem for capital: if k_{it} is decided at $t-1$, it must be uncorrelated with evolutions in ω between $t-1$ and t. OP show how under assumptions investment is a *strictly increasing* function of current productivity[6]:

$$i_{it} = f_t(\omega_{it}, k_{it}) \tag{9}$$

[6]note that this investment function will in general contain all state variables of the firm.

I augment this equation to allow for the fact that the firm's trade status may be an important determinant of the firm's investment decision:

$$i_{it} = f_t(\omega_{it}, k_{it}, \tau_{it}) \tag{10}$$

where τ_{it} is the four-category trade status variable being used throughout this paper.
With the OP assumptions of monotonicity of the investment function, i_{it} can be inverted to give

$$\omega_{it} = f_t^{-1}(i_{it}, k_{it}, \tau_{it}) \tag{11}$$

This inverse function controls for ω_{it} in the production function. The inclusion of τ allows for heterogeneity in the inverted investment function conditional on the firm's trade status. Substituting Equation 11 back into 7 gives

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + f_t^{-1}(i_{it}, k_{it}, \tau_{it}) + \eta_{it} \tag{12}$$

In this version, consistent estimates of $\hat{\beta}_l$ and $\hat{\beta}_m$ are obtained. $\hat{\beta}_k$ is not obtained, however, as k_{it} is collinear with the composite non-parametric function $\Phi_t(i_{it}, k_{it}, \tau_{it}) = \beta_k k_{it} + f_t^{-1}(i_{it}, k_{it}, \tau_{it})$. An estimate of this composite term, $\hat{\Phi}_{it}$ is obtained from this first stage, however.

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \Phi_t(i_{it}, k_{it}, \tau_{it}) + \eta_{it} \tag{13}$$

In Stage 2, the probability of survival is estimated. This is similar to the standard OP procedure, except that the probability of survival, $\hat{P}$, will depend on the firm's trade status.

$$Pr(\chi_{i,t+1} = 1|I_t) = Pr(\chi_{i,t+1} = 1|\omega_{it}, \underline{\omega}_{i,t+1(k_{i,t+1})}) = \hat{P}_{it}(i_{it}, k_{it}, \tau_{it}) \tag{14}$$

Where $\underline{\omega}_{i,t+1}$ is a productivity level in $(t+1)$ that causes the firm to be indifferent between continuing and exiting. This is a function of capital due to the fact that more capital-intensive firms are assumed to be able to survive a more severe productivity shock.
Stage 3 of OP proceeds with the estimated $\hat{\beta}_l$, $\hat{\beta}_m$ and $\hat{\Phi}_{it}$ from stage 1, along with the estimated $\hat{P}_{it}$ from Stage 2.
It identifies a consistent coefficient on capital. It is calculated using a non-linear least squares estimator on the following equation:

$$y_{i,t+1} - \beta_l l_{i,t+1} - \beta_m m_{i,t+1} = \beta_0 + \beta_k k_{i,t+1} + g((\hat{\phi} - \beta_k k_{it}), \hat{P}_{i,t+1}) + \eta_{it} \tag{15}$$

where in calculating both Φ and $\hat{P}$, trade status has been controlled for. Finally this gives rise to a consistent estimation of the production function coefficients, β_l, β_m and β_k. Given Φ and $\hat{\beta}_k k$, tfp can be backed out as $\omega_{it} = \hat{\Phi} - \hat{\beta}_k k_{it}$.