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The Role of Knowledge in Lowering Barriers to Internationalisation

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By

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Abstract

Using a merged data set for Scotland comprising the Scottish Global Connections Survey (GCS) and the Annual Respondents Database (ARD), we demonstrate that exporters and those engaged in outward FDI have a productivity advantage over those firms that do not internationalise (both pre- and post-entry). We then consider the factors that determine which firms in Scotland operate in overseas markets, and specifically the role of knowledge-based assets in overcoming barriers to internationalisation. This allows us to consider whether firms that export are 'better' and would experience higher productivity even if they did not export, and thus if the post-entry positive impact of exporting on productivity is upward biased because of the self-selection of such firms into overseas markets. We find that such firms are indeed better, but when we use a 'matching estimator' approach we still find a post-entry productivity advantage which can be attributed to a 'learning-by-exporting' effect. Because the information in the GCS-ARD is limited with respect to firms' assets, we also consider another source of information (Community Innovation Survey data) that allows us to understand better the importance of knowledge assets in determining internationalisation. Various policy conclusions are then considered based on our findings.

Keywords: Knowledge-based assets Globalisation Firm-level data Productivity

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1. Introduction

The volume of international commerce has surged dramatically within the last two decades (e.g., the OECD estimates that world exports of goods and services increased by nearly 350% between 1990 and 2008), partly encouraged by deregulation, such as the abolition of exchange controls and the erosion of barriers to cross-border investment, and partly by the easing of trade restrictions through both WTO and regional institutions like the European Community. With greater globalisation, typified by falling trade costs, there is greater scope for individual businesses to enter export markets, invest directly in overseas activities (such as production facilities and/or collaborative arrangements link to production, distribution and R&D), or increasingly use imported intermediate goods and services.

Moreover, engagement in exporting and/or outward foreign direct investment (FDI) is generally perceived as being beneficial to individual firms and the economy as a whole. The benefits brought about by ‘going international’ are varied, as pointed out by Bernard and Jensen [1], including faster growth of shipments and productivity, diversification of risk, increased innovation, better investment opportunities leading to improved survival prospects and gains for workers in terms of higher pay and better future employment opportunities. The reasons for such benefits revolve around arguments (and evidence) put forward in the literature that firms that internationalise have to overcome barriers to exporting (sunk costs), and therefore invest in resources and capabilities (i.e. absorptive capacity) that provide them with the ability to compete effectively in overseas markets. Thus they achieve higher productivity levels as a prelude to exporting (or engaging in outward FDI). Consequently, there is a self-selection process whereby firms that enter export markets do so because they have higher productivity prior to entry; thus there is a general ’sorting’ of the most-to-least productive firms that is highly correlated with different forms of internationalisation. However, this then raises the issue of whether exporting itself leads to further benefits through “learning” in global markets. The empirical evidence found for many countries provides significant support for the ‘self-selection’ hypothesis but much less support for the ‘learning-by-exporting’ hypothesis (see Greenaway and Kneller [2] Table 1, and Greenaway and Kneller [3] Table 3, for a summary of the evidence).

Given this importance of increased firm internationalisation within a rapidly expanding global economy, this paper uses a merged data set for Scotland, comprising the Scottish Global Connections Survey (GCS) and the Annual Respondents Database (ARD), to demonstrate (in section 3) that exporters and those engaged in outward FDI have a productivity advantage over those firms that do not internationalise (both pre- and post-entry). We then consider the factors that determine which firms in Scotland operate in overseas markets, and specifically the role of knowledge-based assets in overcoming barriers to internationalisation. This allows us to consider whether firms that export are ‘better’ and would experience higher productivity even if they did not export, and thus if the post-entry positive impact of exporting on productivity is upward biased because of the self-selection of such firms into overseas markets. We find that such firms are indeed better, but when we use a ‘matching estimator’ approach we still find a post-entry productivity advantage which can be attributed to a ‘learning-by-exporting’ effect. Because the information in the GCS-ARD is limited with respect to firms’ assets, section 4 also considers another source of information (Community Innovation Survey data) that allows us to understand better the importance of knowledge assets in determining internationalisation. Policy conclusions are then considered in section 5 based on our findings. However, the next section begins by briefly examining the extant literature on the role of resources in determining internationalisation, and links between exporting and productivity, before considering the empirical evidence for Scotland.

2. Overview of the Literature

We begin with a discussion of the recent microeconomics literature on the exporting-productivity nexus whereby exporting is positively associated with firm performance. While this literature shows that firms with the highest levels of productivity are able to break down the sunk costs of entry into overseas markets, and thus there is a general 'sorting' of the most-to-least productive firms that is highly correlated with different forms of internationalisation, it generally has less to say on what leads to higher productivity. In contrast, the mainly strategic management literature related to the resource-based view of the firm and its subsequent development puts more of an emphasis on those factors that determine productivity; namely, the role of knowledge assets.

Recent (theoretical) developments of economic models of exporting have emphasised firm heterogeneity (i.e. productivity differences) and stressed the importance of sunk (entry) costs as determinants of exporting.[1] These models were motivated to encompass and explain firm-level empirical facts that have been observed in the last two decades (e.g. in the U.S. dating back to the pioneering work of Bernard and Jensen [2,8]): 1) exporting is concentrated amongst a very small number of firms who nevertheless are large and account for the preponderance of trade undertaken (Bernard *et al.*, [9]); and 2) compared with non-exporting indigenous firms, such exporters, *cet. par.*, have a greater probability of survival, much higher growth, are more productive, more capital-intensive, pay higher wages, employ better technology and more skilled personnel.[2]

In a seminal article, Melitz [11] extends Krugman's [12] model to accommodate firm-level differences in productivity in order to analyse the intra-industry effects of trade. It is shown that as a consequence of increasing exposure to trade, the most productive firms are induced to participate in export markets while less productive firms continue to serve the domestic market only; whereas the least productive firms drop out of the market. It follows that trade-induced reallocations towards more efficient firms will eventually lead to aggregate productivity gains. Other more recent international trade models incorporating firm-level heterogeneity also include Bernard *et al.* [13] based on Ricardian differences in technological efficiency; Helpman *et al.* [14] explicitly comparing exporting and outward FDI as alternative modes of entry; Yeaple [15] focusing on heterogeneous competing technologies, trade costs and labour skills; Bernard *et al.* [16] drawing on heterogeneous productivity; and Aw et al. [17,18,19] adding a new dimension of R&D to the export-productivity debate.

Bernard and Jensen [20] model the decision to export allowing for firms to have different characteristics (which impact on their profitability)[3] and for them to face (sunk) entry costs into foreign markets.[4] The latter potentially include the cost of information about demand conditions abroad (e.g. market research), or the cost of establishing a distribution system, or the need to modify products for different markets and to comply with institutional arrangements and regulations (including differences in the 'culture' of the way business is carried out). It is also assumed that such non-recoverable entry costs recur in full if the firm exits the export market for any amount of time. Ultimately, firms only internationalise if the

[1] This literature was initially developed by Dixit [4], Baldwin [5] and Baldwin and Krugman [6]; and the existence of sunk costs was confirmed by Roberts and Tybout [7].

[2] Nevertheless, Eaton et al. [10] have also documented some empirical irregularities in terms of patterns of international trade using data from French manufacturing firms.

[3] These include size, labour composition, productivity, product mix and ownership structure.

[4] They also recognised that other exogenous factors affect profitability and thus the decision to export or not, such as exchange rate movements, other shocks to demand, indirect and direct subsidies to exporters and potential spillovers from the presence of other nearby exporters. However, it is firm heterogeneity and sunk costs that dominate (especially in empirical applications of this type of model).

present value of their profits (affected by their characteristics) exceeds these fixed costs of entry. Moreover, this study also examines whether firm entry into export markets (and continuing to export with/without increasing export intensity) is due to certain plants being more export-orientated because of their attributes and/or because of the presence of sunk costs. In principle, Bernard and Jensen's model can differentiate between these competing determinants of exporting; nevertheless, in practice the proxy used in empirical work for measuring sunk costs is usually less well defined, while unobserved plant heterogeneity has to be accounted for which can also contaminate the empirical proxy used to measure sunk costs. Their results suggest that, in line with expectations, both heterogeneity and sunk costs are found to be important determinants of internationalisation.

Others have examined the link between tariff reduction and firm-level exporting using similar approaches, which show that only the most productive plants enter export markets to overcome trade barriers (Bernard *et al.* [13]; Melitz [11]; Baldwin and Gu [21]). As barriers fall, export intensity rises and (the most productive) non-exporters now internationalise (since production costs fall as imports become cheaper and competitiveness rises with lower tariffs). Evidence is documented in Baldwin and Gu (*op. cit.*) who consider the impact of tariff reductions on Canadian manufacturing between 1984-1996. Their results show that cuts in tariffs both increase the probability of internationalising for all plants and more particularly for those with the highest levels of relative labour productivity. The results also show that larger, younger and more productive plants are more likely to export.

Further empirical evidence on the factors that determine whether firms export is provided in Bernard and Jensen [22] for the US and Greenaway and Kneller [23] for the UK. Lagged export status (i.e. whether the plant exported in the previous period) is used as a proxy for sunk costs, and is always highly significant as a determinant of exporting. Bernard and Jensen (*op. cit.*) for the US also find that spillover effects are not present, and that state export promotion has a slightly positive effect (but statistically insignificant). However, size, wage (representing human-capital intensity) and productivity have important influences on the probability of exporting, with larger, productive plants being much more likely to export. Greenaway and Kneller (*op. cit.*) for the UK find similar results, although the impact of total factor productivity (henceforth TFP) on the probability of exporting is not statistically significant, while industry agglomeration effects (associated with spillovers) are important in the case of the UK.[5]

In addition to the predominant roles of productivity, general empirical findings show that the determinants of a firm's entry decision include trade liberalisation (Baldwin and Gu [21]), sunk entry costs (Bernard & Jensen [20]; Girma *et al.* [28]; Das *et al.* [29]) and some firm-level characteristics such as size (Aw and Hwang [30]; Roberts and Tybout [7]; Bleaney and Wakelin [25]; Gourley and Seaton [27]); experience including *ex ante* success (Bernard and Jensen [1]; Greenaway and Kneller [23]; Kneller and Pisu [31]); export spillovers (Aitken *et al.* [32]; Greenaway *et al.* [33]); and foreign networks (Sjoholm [34]).

Thus the relationship between international trade and productivity growth is crucial to understanding a firm's export orientation. Research on this exporting-productivity relationship was initially empirically driven as it is universally found in the literature that exporting is positively associated with firm performance (see Greenaway and Kneller [2,3]; Rodriguez and Rodriguez [35]; and Wagner [36] for comprehensive surveys and evidence). The causal direction of this link is an important issue – whether causality runs from exporting

[5] Other studies for the UK using panel data provide similar results, confirming the importance of sunk costs and productivity, but also the role of resources, innovation and human-capital factors that all positively impact on the decision to export (*c.f.* Wakelin [24]; Bleaney and Wakelin [25]; Roper and Love [26]; and Gourlay and Seaton [27]).

to productivity, from productivity to exporting, or in both directions (i.e. a feedback relationship). These issues are often examined empirically by testing two competing (but not mutually exclusive) hypotheses, viz. self-selection and learning-by-exporting. Given that there is almost universal evidence substantiating the self-selection proposition (i.e. higher productivity leads to export-market entry – see Greenaway and Kneller [3] Table 1), we shall focus here on the learning effect of exporting (i.e. the second hypothesis).

The 'learning-by-exporting' hypothesis postulates that export-oriented firms experience an acceleration in productivity growth following entry. If this is not true, this has important policy implications: if better firms do self-select into export markets, and exporting does not further boost productivity, then export subsidies could simply be a waste of resources (involving large-scale dead weight and possibly even displacement effects given that firms that export usually sell to domestic markets as well[6]). This 'learning-by-exporting' proposition has, generally, received less support in the literature. Many early empirical studies raised doubts about the causality running from exporting to productivity, since they find that productivity growth does not increase post entry, notwithstanding that exporting firms on average experience significantly higher growth in terms of employment and wages (Aw and Hwang [30] for Taiwan; Bernard and Jensen [8] for the US; Bernard and Wagner [38] for Germany; Clerides *et al.* [39] for Columbia, Mexico and Morocco; Delgado *et al.* [40] for Spain). For example, applying a novel non-parametric analysis of productivity distributions for Spanish firms, Delgado *et al.* [40] fail to find significant differences between new exporters and continuing exporters, when analysing productivity growth post-entry. Analogically, exporters are found to be no different from non-exporters, although limited learning effects could be found among younger exporters.

Consequently, many of the theoretical models developed in recent years have generally ignored any 'learning-by-exporting' effect, and instead concentrated on the implications of self-selection for overall aggregate productivity growth.[7] One exception is Clerides *et al.* [39] who developed a model that resulted in lower costs for exporters both as a result of pre-entry selection (to overcome barriers to exporting) and of learning that occurred during exporting. Nevertheless, their empirical evidence failed to support the presence of learning effects post-entry. Most recently though, as a breakthrough in the theoretical modelling of the learning effect of exporting, Aw et al. [18] developed a model of knowledge accumulation and exporting and for the first time their model was able to predict positive export-led profitability growth within firms. They further went on to show that this learning effect was reinforced by the endogenous relationship between R&D and exporting.[8] These results were subsequently validated by their data for electronics producers in Taiwan.

Despite the early empirical studies (mentioned above) that found little empirical evidence of a learning-by-exporting effect, positive learning effects for firms engaged in exporting have been identified, particularly where different econometric methodologies are adopted that principally take account of selectivity effects (e.g. Kraay [41]; Castellani [42]; Hallward-Driemeier *et al.* [43]; Pavcnik [44]; Baldwin and Gu [45]; Girma *et al.* [28]; van Biesebroeck [46]; Lileeva and Trefler [47]; Fernandes and Isgut [48]; De Loecker [49]; and Harris and Li [50]). Additionally, Crespi *et al.* [51] have found that exporters in the UK engage in relatively

[6] Robust empirical evidence shows that exporters tend to sell very small fractions of their output abroad (Roberts *et al.* [37]).
[7] For example, Bernard *et al.* [16] state in their Footnote 10 that they assume away any 'learning-by-exporting' effect since this matches previous empirical findings.
[8] Therefore, it is reasonable to argue that benefits from export-market entry may not be automatic: in order to achieve post-entry productivity gains, exporters need to invest in more R&D and human capital to acquire more foreign technologies and enhance their absorptive capacity.

more learning from clients, and that this subsequently leads to higher productivity growth.[9] More recent empirical testing of the leaning-by-exporting theory has adopted the model by Olley and Pakes [52] to obtain firm-level estimates of productivity using a production function approach, with productivity (in part) determined by past exporting experience leading to learning effects (*c.f.* Pavcnik [44]; van Biesebroeck [46]; Fernandes and Isgut [48]; De Loecker [49]). These studies show a strong 'learning-by-exporting' effect for countries like Columbia, Slovenia and several sub-Saharan countries. In addition, there is also a strand of literature documenting evidence on the co-existence of selection and learning effects; for instance, Baldwin and Gu [45] for Canadian manufacturing, Kraay [41] for Chinese firms; Greenaway and Yu [53] for the UK chemical industry; and finally, Girma *et al.* [23] for UK manufacturing firms.

While this mainly economics literature considers that learning pre- and post-entry into international markets is important, leading to higher productivity that allows firms to overcome barriers and potentially gain further productivity increases once exporting, there is less discussion of what enables such learning, and thus which firms are likely to gain and loose from globalisation. In an open economy, we can expect the role of knowledge and absorptive capacity to be particularly crucial in the growth of internationalising firms in that there is a stronger need for them to acquire, apprehend and assimilate new knowledge/information in order to compete and grow in global markets where they have little or no previous experience (Autio, et. al. [54]).

From a resource-based perspective,[10,11] the pursuit of firm-specific resources provides the principle stimuli of a firm's decision to trade and invest in international markets. For instance, on the international stage, these distinctive firm-specific (and often intangible) assets include cost advantages (the ability to acquire factors of production at a lower cost), the control of superior production technology, specialised know-how about international production, technological opportunities, brand names, extensive international contacts and networks, better distribution channels, superior technological and marketing expertise, etc., all of which contribute to the capacity to exploit economics of scale and scope. These advantages conferred by resources and capacities can greatly enhance firms' international competitiveness and consequently bring about a higher rate of return on sales/assets and profitability, particularly in global markets characterised by a variety of market imperfections such as asymmetric information, capital immobility and the like.

The use of intangible assets (which can be defined broadly as knowledge embodied in intellectual assets) is, however, more general than just the link to internationalisation.[12] There

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[9] As Crespi *et al.* [51] state "… a possible explanation of why our results in favour of the 'learning-by-exporting' hypothesis might be stronger than those found in most of the previous exporting-productivity studies is that the impact of learning effects might have been hidden by the noise in productivity measures when directly learning measures are not available" (p. 621).

[10] The resource-based view (RBV) of the firm was initially put forth by Penrose [55], and subsequently developed by others such as Wernerfelt [56], Barney [57,58] and Teece and Pisano [59]. The thrust of this viewpoint lies in the established assumption that 'better' firms possess intangible productive assets that they are able to exploit to derive competitive advantages.

[11] For more elaboration on the significance of resources in the international entrepreneurship literature, see Bloodgood *et al.* [60] and Bell *et al.* [61].

[12] As well as specific assets linked to trade and investment in international markets set out above, others have provided a more general list – for example, Eustace [62] argues that: "Intangibles such as R&D and proprietary know-how, intellectual property, workforce skills, world-class supply networks and brands are now *the* key drivers of wealth production, while physical and financial assets are increasingly regarded as commodities. … Today, a firm's intangible assets are often *the* key element in its competitiveness. Increasingly, the capacity to combine external and internal sources of knowledge to exploit commercial opportunities has become a distinctive competency".

are significant difficulties in measuring these assets (both from an accounting – or balance sheet – perspective, and in terms of the rate of return or productivity impact of such assets), both from a theoretical and empirical standpoint. Indeed, it is not always clear exactly what should be included in such intangible assets (IA) and whether all the activities being measured are additions to this stock of knowledge, or if some expenditure produces other outcomes (for example, not all advertising equates with establishing brand equity; not all training is firm-specific). Attempts have been made to produce estimates of the stock of IA at the economy level (e.g. Corrado *et. al*. [63]), and micro-level (e.g., Bontempi and Mairesse [64]) but there are still issues of what exactly should be included and what should not, as well as obtaining the necessary data with which to construct estimates of the stock of IA. Thus, the general consensus would appear to be that: "… currently, there is no standardized and consistent firm- or economy-wide measure of investment into the creation of enterprise intangible capital, either as a whole or by component" (Webster and Jensen [65]).

Others take a different approach in that instead of measuring the stock of IA, they relate these assets to firm-specific capabilities (Teece and Pisano [59]; Pavitt [66]) which largely define the dynamic capabilities that determine the firm's competitive advantage. Fosfuri and Tribo [67] summarise the work of Teece and his collaborators as follows: "dynamic capabilities are embedded in organisational processes and routines, and allow a firm to quickly adapt to changing market conditions, to reconfigure its resource base, to enable morphing and adaptation and ultimately to achieve an edge over competitors" (p. 173). Fundamentally, Teece and other proponents of the resource-based view of the firm argue that such competencies and capabilities by their very nature cannot easily be acquired, replicated, diffused, or copied – they therefore cannot easily be transferred or built-up outside the firm. This in part comes from the key role that learning plays both in enabling the firm to align its resources, competencies and capabilities, and in allowing the firm to internalise outside information into knowledge; and the way the firm learns is not acquired but it is determined by its unique 'routines', culture and its current position (stock of knowledge).

Thus, processes of knowledge generation and acquisition *within* the firm (i.e. internal knowledge generation) are essentially organisational learning processes (Reuber and Fisher [68]; Autio, *et. al.* [54]). The processes of incremental learning are important sources of both codified and tacit knowledge which may have great competitive impact. Although firms could develop and acquire much of the knowledge internally (through their own resources and routines), few (and especially SMEs) virtually possess all the inputs required for successful and sustainable (technological) development. Therefore, the fulfilment of firms' knowledge requirements necessitates both the acquisition *and* internalisation/exploitation of knowledge from external sources[13] (Rosenkopf and Nerkar [70]; Almeida *et. al.* [71]), with the result that such absorption of external knowledge increases the firm's stock of knowledge-based intangible assets.[14] Furthermore, firms with greater absorptive capacity can extract greater benefits from similar stocks of external (and internal) knowledge, and therefore gain a competitive advantage over their rivals.

The relationship between internal and external knowledge sourcing is complex in nature. Much of the theoretical literature concerned with transaction cost economics and property rights considers the choice between internal development and external sourcing ('make or

[13] Zara and George [69] called such acquisition potential absorptive capacity, with exploitation leading to realised absorptive capacity

[14] Of course, while a higher absorptive capacity can add to the stock of knowledge assets, it is also stressed in the literature (starting with Cohen and Levinthal [72]) that "a firm's absorptive capacity depends on its existing stock of knowledge" (Escribano et. al. [73]). Thus, the relationship between the (static) concept of the stock of intangible assets and its (dynamic) counterpart – absorptive capacity – is endogenous.

buy') and the conditions that may favour one route rather than the other, or not to proceed with a particular development at all (Coase [74]; Williamson [75]). The resource based view of the firm stresses competences and internal capabilities as key elements in determining firm performance, while more recently the commonality between the firm's internal knowledge and external search has been stressed as necessary for successful knowledge transfer; they are complementary activities (e.g., Arora and Gambardella [76]). Thus it is appropriate to consider these factors in relation to the processes of knowledge acquisition, transfer and conversion.

In developing the original concept, Cohen and Levinthal [77] argued that since the ability to internalise and apply external knowledge is enhanced by a firm's internal capabilities, spending on R&D (enhancing the stock of knowledge capital) was an adequate proxy for absorptive capacity.[15] However, the more recent literature has widened this to both consider the importance of other (antecedent) factors such as the firm's search strategy to identifying external knowledge (e.g., Grimpe and Sofka [80]); its strategic posture, collaborative experiences, and related technological capabilities (e.g. Bierly et. al. [81]); it prior knowledge base and social integration mechanisms (e.g., Vega-Jurado et. al. [82]). How and where firms search for external knowledge can be considered in terms of 'breadth and depth' (Lausen and Salter [83]; Van Wijk et. al. [84]), where there is a (potentially U-shaped) trade-off between the need for a wide search to ensure important knowledge is not missed, and the need to focus to ensure that knowledge related to the firm's core competencies can be exploited. Grimpe and Soka [80] argue that low-tech firms gain more from search patterns that targets market knowledge (from customers and competitors), while high-tech firms benefit from technological knowledge (from universities and suppliers). In addition, Fabrizio [85] argues that in addition to the role of searching in terms of potential absorptive capacity, firms with internally developed research capabilities will be able to internalise more knowledge (i.e. realise more benefits) if they are also engaged in external research collaborations (particularly with universities), because a greater breadth of knowledge is then accessible and the firm gains access to the tacit complementary knowledge that is available from external partners. In addition, through their (prior) "… collaborative experiences, firms institutionalise learning mechanisms … and establish organisational routines that enable future learning to be more efficient and effective" (Bierly et. al. [81] p. 487).

Strategic posture is argued to influence a firm's capacity for learning, with this being captured by the overall entrepreneurial (as opposed to conservative) orientation of the organisation – its innovativeness, proactiveness and risk-taking. These factors institutionalise the pursuit of learning and minimise resistance to change through promoting internal openness and knowledge sharing (Bierly et. al. [81]). The prior knowledge base of the firm depends on its accumulated experience with searching for knowledge, the individual skills of employees, and engaging in R&D (Vega-Jurado et. al. [82]). Several authors have stressed the importance of highly educated and technically qualified staff, who are more receptive to assimilating and transforming available external knowledge (e.g. Cohen and Levinthal [72]; Mowery and Oxley [86]; Keller [87]; Veugelers [78]; and Vinding [120]). Moreover, strong social integration systems within the firm encourage interaction and thus (tacit) knowledge sharing, especially in the transformation and exploitation stages of internalising external knowledge. Vega-Jurado et. al. [82] argue that stronger social integration systems are generally associated with practices such as job rotation, quality circles, and problem solving approaches; it is also likely that firms who have significantly invested in human capital (e.g.

[15] For example, Veugelers [78] and Coombs and Bierly [79] among others point out that intramural R&D strengthen the firm's technological trajectory in a given knowledge field, and thus make it more receptive to relevant external knowledge.

through employing and then training graduates) will have better developed integration systems.

Thus, and given the above, the literature proposes several different measures of absorptive capacity, and many argue that no single proxy is superior to all others. As will be discussed below, we also have taken a broad view (in part based on data availability) that includes measures such as the R&D capital stock, and whether R&D is intramural and/or extramural, and whether it involves collaboration; innovativeness; knowledge sourced from Higher Education institutes; and human capital (as proxied by the proportion of graduates in the workforce).

Given these arguments it is possible to conclude that when a firm internationalises, it must have sufficient resources and capabilities through absorbing new knowledge to overcome the initial (sunk) costs of competing in international markets in order to organise for foreign competition, thus facing the dual challenge of overcoming rigidities and taking on novel knowledge (Eriksson et al. [88].[16] In this sense, we could expect the development of absorptive capacity to be a necessary condition for the successful exploitation of new knowledge gained in global markets (e.g., Rodriguez and Rodriguez [35]; Riap et. al. [89]).

3. Exporting and Productivity in Scotland

In this section evidence is presented on whether exporters (and those firms engaged in outward FDI) have a productivity advantage both pre- and post-entry into overseas markets. Panel data for Scotland, covering 2002-2005, is used comprising the Scottish Global Connections Survey (GCS) merged into the Annual Respondents Database (ARD).[17] The former is a survey conducted by the Scottish Government each year, in which firms are asked to provide detailed information on international activities (mainly exporting); the ARD is developed from the Annual Business Inquiry carried out by the UK Office for National Statistics each year, in which detailed financial information on production is collected at the level of the plant and firm, for use in such areas as producing national GDP statistics.

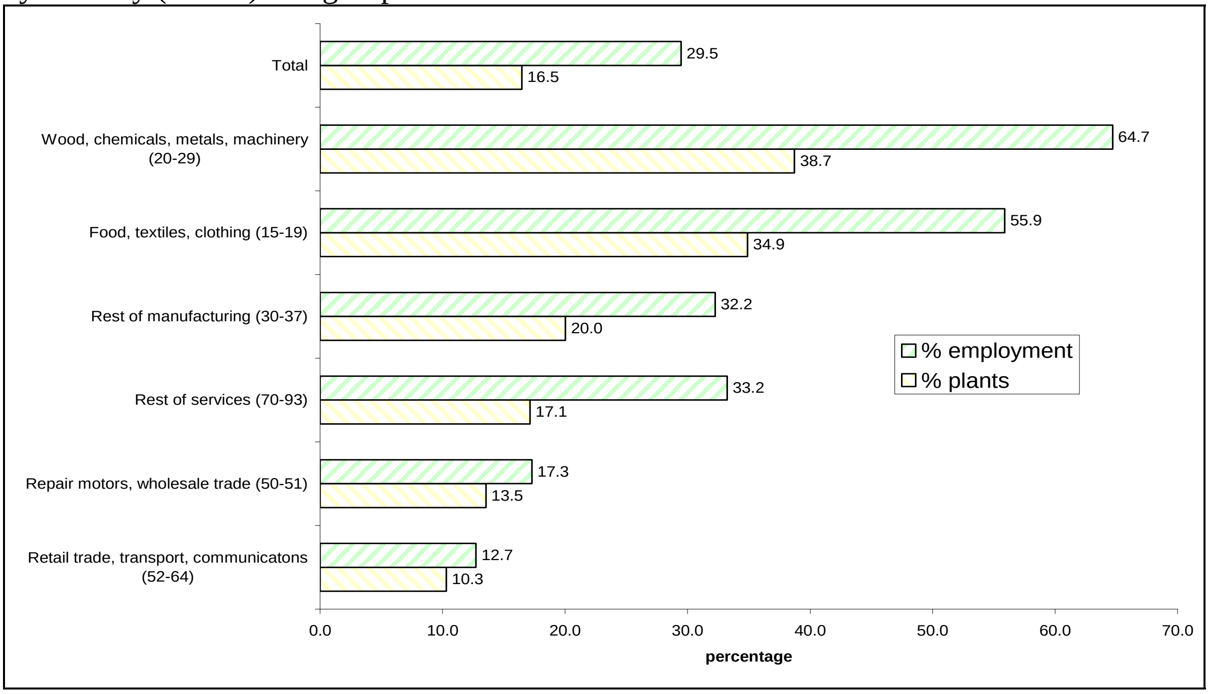
The GCS-ARD data used in this study (with suitably constructed weights) indicates (Figure 1) that on average between 2002-2005 some 16.5% of plants in the market-based sector of Scotland were engaged in exporting outside the UK (employing around 29.5% of employees).[18] There were significant variations across industry sub-groups, with generally much higher level of exporting in manufacturing sectors. Generally plants engaged in exporting were larger (as evidenced by the difference in the percentage number of plants involved vis-à-vis the numbers of employees covered).

[16] Additionally, given the discussion above of ‘learning-by-exporting’, it is reasonable to argue that benefits from export-market entry may not be automatic: in order to achieve post-entry productivity gains, exporters need to invest in more R&D and human capital to acquire more foreign technologies and enhance their absorptive capacity.

[17] Information on the GCS is available in http://www.scotland.gov.uk/Topics/Statistics/export-statistics/gcs-introduction; information on the ARD is available in, for example, Harris [90]. Details of merging are provided in the appendix. Note, data can only be accessed via the ONS VML, resulting in a number of restrictions (including confidentiality tests before results are released) – see http://www.ons.gov.uk/about/who-we-are/our-services/vml/about-the-vml/vml-overview.

[18] Note, the ARD does not cover certain market sectors (such as agriculture and most financial services), while other sectors (covering mining and extraction, utilities and construction) are omitted through lack of data on certain key variables (e.g. capital stocks); therefore these are excluded from the subsequent analysis.

Figure 1: Average percentage of plants (and employment) that exported, Scotland 2002-2005, by industry (SIC92) sub-groups



Source: weighted GCS-ARD database

The variables available in the GCS-ARD database are set out in Table 1. Information is available at plant (i.e. local unit) level, comprising output and factor inputs, various characteristics of the plants (e.g. ownership, location), and certain aggregated variables calculated using the dataset (e.g. information on industry concentration and agglomeration). In addition, data from the Business Enterprise R&D (BERD) micro-database has been merged into the GCS-ARD on to indicate whether the plant was engaged in R&D; note, BERD data only covers the main enterprises undertaking R&D in the UK (some 12,000 p.a. out of a total of some 1.7 million).[19] Table 2 breaks down the GCS-ARD data into those plants undertaking exporting at any time during 2002-2005, separately from those not selling abroad, and compares the mean values of the variables across these two sub-groups. As expected, exporters are larger (cf. output and factor inputs), more likely to spend on R&D, be engaged in outward FDI, and generally operate more from urban and non-Assisted areas (with the exception of Edinburgh). They are also more likely to be US-owned, but less likely to be EU-owned (while differences for the other foreign-owned category are not statistically significant). Interestingly, exporters were more likely to be single-plant enterprises (although this is at least in part the result of industry differences in exporting and the preponderance of single-plant firms). Lastly, exporters are more likely to operate in areas with higher agglomeration levels, greater diversification, and in industries with higher levels of concentration.

[19] Later, we use data from the Community Innovation Survey which has a more general definition of R&D and wider coverage of which firms spend on such activities.

Table 1: Variable definitions used in GCS-ARD panel dataset for 2002-2005

Variable	*Definitions*	*Source*
Real gross output	Plant level gross output data deflated by 2-digit ONS producer price (output) indices. Data are in £'000 (2000 prices)	ARD
Real intermediate inputs	Plant level intermediate inputs (gross output minus GVA) deflated by 2-digit ONS producer price (input) indices (non-manufacturing only has a single PPI). Data are in £'000 (2000 prices)	ARD
Employment	Number of employees in plant.	ARD
Capital	Plant & machinery capital stock (£m 1995 prices) plus real value of plant and machinery hires (deflated by producer price index) in plant. Source: Harris and Drinkwater ([91], updated) and Harris [92].	ARD
Export	Dummy variable coded =1 if plant exported	GCS
Outward FDI	Dummy variable coded =1 if plant belonged to Scottish MNE	GCS
Single-plant	Dummy coded 1 when plant comprises a single-plant enterprise	ARD
US-owned	Dummy coded 1 if US-owned	ARD
EU-owned	Dummy coded 1 if EU-owned	ARD
Other foreign-owned	Dummy coded 1 if other foreign-owned	ARD
R&D stock dummy[a]	Dummy variable =1 if plant had positive R&D stock based on undertaking intramural and/or extramural R&D since 1997	BERD
Assisted Areas	Dummy variable = 1 if plant located in assisted area	ARD
Region	Dummy variable = 1 if plant located in particular Scottish region	ARD
Industry	Dummy variable = 1 depending on 1992 SIC of plant (used at 2-digit level).	ARD
Industry agglomeration	% of industry output (at 5-digit SIC level) located in local authority district in which plant is located – MAR-spillovers[20]	ARD
Herfindahl	Herfindahl index of industry concentration (3-digit level).	ARD
Diversification	% of 5-digit industries (from over 650) located in local authority district in which plant is located – Jacobian spillovers	ARD

[a] R&D stocks were computed using perpetual inventory method with 30% depreciation rate for the largest components of R&D spending (intra-mural current spending and extra-mural R&D). See Harris et. al. [99] for details of methods used.

In order to determine if plants that internationalise experience a productivity advantage, we have estimated a production function so as to model the determinants of total factor productivity (TFP).[21] Similar to Griliches [100], this is based on estimating a dynamic-form of the Cobb-Douglas production function using (unbalanced) panel-data:

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[20] MAR-spillovers (Marshall [93], Arrow [94], and Romer [95]) are related to minimisation of transport and transaction costs for goods, people, or ideas, when firms within a specific industry locate near other firms along the supply chain (be they customers or suppliers); locate near other firms that use similar labour; and/or locate near other firms that might share knowledge (Ellison, *et. al*. [96]). MAR-spillovers are associated with industrial specialisation and are to a large extent an intra-industry phenomenon (where this covers firms belonging to a particular industry, or closely related industries). Spillovers can also result from urbanisation externalities due to the size and heterogeneity (or diversity) of an (urban) agglomeration. These are labelled Jacobian spillovers (Jacobs [97,98], and they result when different industries benefit from economies of scope (rather than scale).

[21] TFP is measured as the level of output that is *not* attributable to factor inputs (employment, intermediate inputs and physical capital). It measures the contribution to output of all other influences, capturing such determinants as technological progress and/or changes in efficiency (where the latter also captures the under-utilising of factor inputs unless this is taken into account when measuring these inputs). Thus, such a measure of TFP is equivalent to a combination of the residual from equation (1) and the time trend, *t*, which represents technological change. Harris [90] provides a detailed explanation of how this approach is preferable to other

Table 2: Weighted mean values of variables, Scotland, 2002-2005

	Non-exporters[a]	Exporters
ln gross output	-0.763	-0.476
ln intermediate inputs	-1.286	-0.909
ln employment	1.994	2.301
ln capital	-3.139	-2.148
R&D stock dummy	0.003	0.065
Single plant enterprise	0.047	0.175
US-owned	0.024	0.038
EU-owned	0.072	0.059
Other foreign-owned	0.036	0.040
Outward FDI	0.025	0.175
Assisted Area	0.598	0.539
Strathclyde	0.420	0.449
Rest of Scotland	0.401	0.343
Edinburgh	0.118	0.110
Aberdeen	0.061	0.098
ln Industry agglomeration	-0.999	-0.911
ln Diversification	0.299	0.436
ln Herfindahl	-4.415	-4.180
Unweighted no. of obs.	14,377	2,407

[a] *T*-tests of differences in the mean values between sub-groups are significant at 5% level (or better) for all variables except 'Other foreign-owned' and Edinburgh. Source: weighted GCS-ARD database

$$\ln Y_{it} = \beta_0 + \sum_{j=1}^{5} \pi_{1j} x_{jit} + \sum_{j=1}^{4} \pi_{2j} x_{ji,t-1} + \pi_4 \ln Y_{i,t-1} + \phi_x X_{it} + \eta_i + t_t + (1-\rho) e_{it} \quad (1)$$

where the subscripts *i* and *t* represent the *i*-th plant and the *t*-th year of observation, respectively;
Y represents real gross output;
x_1 represents the logarithm of intermediate inputs;
x_2 represents the logarithm of capital (stock + hires);
x_3 represents the logarithm of total employment, *e*;
x_4 represents whether R&D stock of knowledge was non-zero (coded 1) or zero;[22]
x_5 represents a time trend to take account of technical progress, *t*;
X is a vector of variables determining TFP (comprising all the other variables in Table 1), and includes industry and region dummies; and
the composite error term has three elements with the fixed-effect term η_i affecting all observations for the cross-section plant *i*; t_t affects all plants for time period *t*; and e_{it} affects only plant *i* during period *t*.[23]

estimators of productivity, and in particular why a one-step model is preferred rather than estimating a production function (or using a growth equation approach) involving just output and factor inputs in stage 1 to obtain (mis-specified) estimates of TFP for use in a stage 2 analysis of the determinants of TFP.

[22] Since for most plants the R&D stock is zero, we prefer to include this variable as a dummy rather than having to deal with the problem of including both *ln*(R&D + 1) ad a dummy coded 1 of the R&D stock is zero. We did try this alternative approach but obtained inferior results.

To allow for potential endogeneity of factor inputs and output, equation (1) was estimated using the Generalised Method of Moments (GMM) systems approach available in STATA 9.2 (Arellano and Bond [101]). This is sufficiently flexible to allow for both endogenous regressors (through the use of appropriate instruments involving lagged values – in levels and first differences – of the potentially endogenous variables in the model[24]) and a first-order autoregressive error term.[25] Note, all data were also weighted to ensure that the samples are representative of the population of Scottish firms under consideration.[26]

Table 3: Weighted systems GMM production function, Scotland,2002-2005[a] (equation 1)

	$\hat{\beta}$	*z*-value
ln intermediate inputs$_t$	0.864***	13.00
ln employment$_t$	0.273***	2.74
ln capital$_t$	0.108***	4.51
R&D stock dummy$_t$	0.231*	1.76
t	0.030***	4.98
Export$_t$	0.455***	3.78
Outward FDI$_t$	0.324*	1.89
Single plant enterprise$_t$	0.108*	1.83
US-owned$_t$	0.745***	7.33
EU-owned$_t$	0.215***	3.46
Other foreign-owned$_t$	-0.188***	-4.46
Assisted Area$_t$	0.181***	5.94
Rest of Scotland$_t$	0.068***	2.84
Edinburgh$_t$	0.239***	6.13
Aberdeen$_t$	0.149***	3.48
ln Industry agglomeration$_t$	-0.070***	-4.61
ln Diversification$_t$	0.246***	5.38
ln Herfindahl$_t$	0.074***	4.91
Intercept	-1.186***	-4.56
Industry dummies	yes	
AR(1) z-statistic	-3.44***	0.01
AR(2) z-statistic	1.47	0.10
Hansen test $\chi^2(13)$	18.85	0.13
No. of Obs.	16,784	

[a] Note the 2-step GMM system estimator in STATA9.2 is used (i.e. "xtabond2")
$^{***}/^{**}/^{*}$ significant at the 1%/5%/10% level Source: weighted GCS-ARD database

[23] Note, if e_{it} is serially correlated such that $e_{it} = \rho e_{it-1} + u_{it}$ then u_{it} is uncorrelated with any other part of the model, and $|\rho|<1$ ensures the model converges to a long-run equilibrium (i.e. the variables in the model are cointegrated).

[24] Output, intermediate inputs, labour, capital, R&D, exporting and outward FDI are treated as endogenous.

[25] Using the GMM systems approach the model is estimated in both levels and first-differences. This is important, since Blundell and Bond [102] argue that including both lagged levels and lagged first-differenced instruments leads to significant reductions in finite sample bias as a result of exploiting the additional moment conditions inherent from taking their system approach.

[26] A discussion of the importance of weighting the data is provided in Harris [90,103].

Table 3 provides the results for all Scottish industries when equation (1) is estimated using the full-sample data.[27] Lagged variables were insignificant, and therefore dropped, with the key results of interest being the parameter estimates linked to the dummy variables that take on a value of 1 when the plant exported, belonged to a Scottish company engaged in outward FDI, or undertook R&D. Our results show that Scottish exporters had a significant productivity advantage (*cet. par.* around 58% higher TFP),[28] while plants belonging to Scottish MNE's were some 38% more productive. The small number of plants engaging in R&D had a 26% productivity advantage, although this was only significant at the 10% level.[29] Thus, we find evidence that post-entry into overseas markets, there was a strong 'learning' effect for firms both exporting and engaging in outward FDI activities.

Other results reporting in Table 3 include: higher levels of TFP for US- and EU-owned plants, but not those plants owned by other foreign countries. This suggests that the former were engaged in technology exploitation (of their comparative advantages/assets), while plants from the rest of the world were more likely to be engaged in technology sourcing (i.e., they have inferior technology and acquire plants in Scotland to gain access to technology – see Love [104] and Driffield and Love [105] for a discussion). Single-plant enterprises have a productivity advantage, as do those operating in Assisted Areas (the latter *may* suggest that government assistance, mostly through RSA capital grants, has a positive impact). Plants located in Edinburgh have a large productivity advantage vis-à-vis Strathclyde (the benchmark region), followed by Aberdeen and the rest of (semi-rural) Scotland. Lastly, plants operating in areas with higher industry agglomeration appear to experience negative spillover effects that lower productivity, although those operating in diversified sub-regions do gain from positive spillovers – hence we find Jacobian spillovers dominate over MAR-type spillovers in Scotland.

Using these results from estimating (1), we can rearrange the equation and obtain estimates of TFP for each plant (see footnote 21). Figure 2 plots the distribution of TFP for Scottish plants operating during 2002-2005, showing that exporters and plants belonging to outward FDI firms had productivity levels that generally dominated the productivity distribution for non-internationalised plants, although there is evidence that those exporters with the lowest levels of TFP (on the lower left-hand tail of the distribution) did worse, and the best non-international plants (on the upper right-hand tail) were as good as plants that operated overseas. We can formally test if the rank ordering of productivity distribution of one sub-group of plants lies to the right of another sub-group using a two-sided Kolmogorov-Smirnov statistic (see Stevens [106]); if so, there is shown to be first-order stochastic dominance between such (random) variables, which is a stricter test than simply comparing average productivity levels across sub-groups. A K-S statistic of 0.13[30] was obtained, when testing the null hypothesis that the difference between the two distributions is favourable to exporters over non-exporters (suggesting that exporters have a distribution to the right of the rejected sub-group), which is significant at better than the 1% level. However, we also obtain a K-S

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[27] Note, the model estimated passes diagnostic tests for autocorrelation and the Hansen test that the over-identifying restrictions are valid.

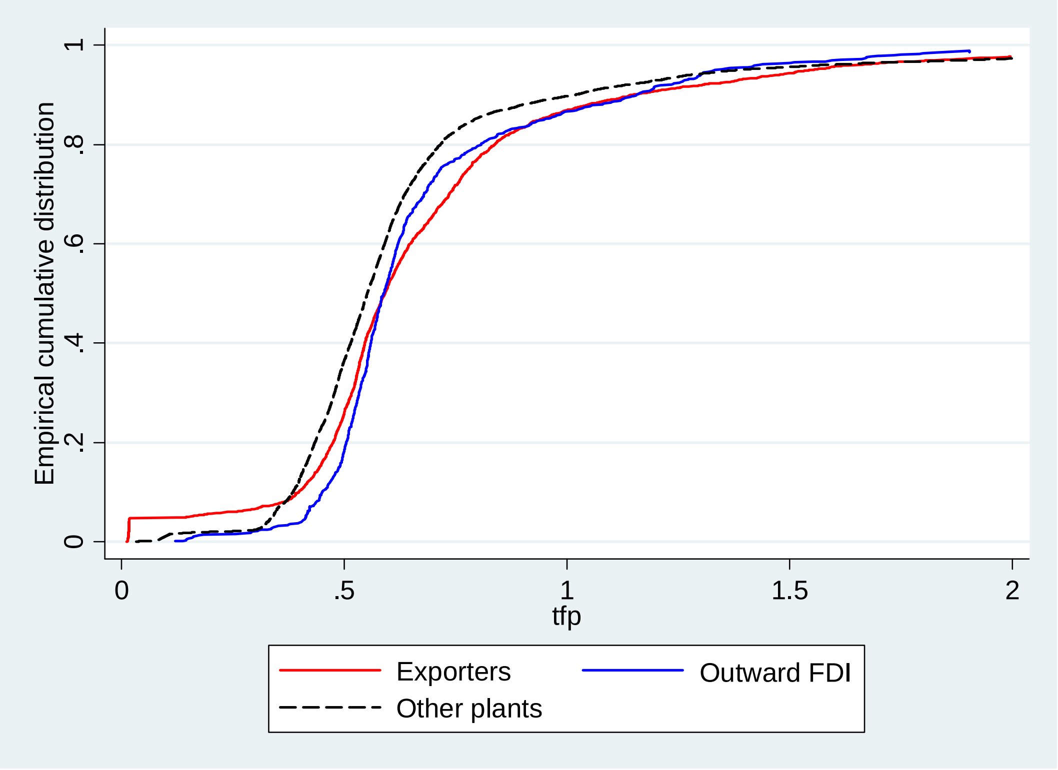
[28] Note, since the dependent variable is logged, the marginal effect is $\exp(\hat{\beta}) - 1$.

[29] Note the role of this variable is not just about technological improvements through the development of product and process innovations; in addition, the 'two faces of R&D' concept introduced by Cohen and Levinthal (1989) applies, whereby R&D has a direct impact on TFP through innovation, and an indirect impact in that R&D provides the firm with absorptive capacity so that it can internalise the benefits to be gained from technology transfer.

[30] This value measures the greatest difference between the two sub-groups, and a positive value means that a sub-group (here non-exporters) lies to the *left* of the opposing sub-group (by definition of the way differences are calculated).

statistic of -0.05 (significant at the 1% level) when testing the null hypothesis that the difference between the two distributions is favourable to non-exporters over exporters. These apparently conflicting results occur because there is a cross-over in the two productivity distributions in the lower left-hand tail, with initially (at the lowest levels of TFP) non-exporters dominating exporters.[31]

Figure 2: Distribution of TFP across plants, Scotland 2002-2005



Source: based on calculations using results from equation (1) and Table 3

We now turn to a consideration of the factors that determine which plants in Scotland operate in overseas markets. This allows us to consider whether pre-entry plants that export become 'better' in order to overcome barriers exporting, and in the process experience higher productivity that would persist even if they did not export; if this is so, the post-entry positive impact of exporting on productivity reported in Table 3 is likely to be upward biased because of the 'self-selection' of such firms into overseas markets. More formally, if the time-path of productivity post-entry is (potentially) endogenous to the plant having certain characteristics that ensure its better performance whether it exports or not, there will be an upward biased sample selectivity effect.

To take account of this potential selectivity bias there are several approaches that are available, including instrumental variables, difference-in-difference estimators and matching (cf. Blundell *et. al.* [107]; Harris [90]). Here we have chosen the matching approach, since we lack variables in our dataset that determine whether a plant exports but have no direct impact

[31] The K-S test involving plants belonging to outward FDI firms against all other plants results in a test statistic of 0.18 (significant at the 1% level) when testing the null hypothesis that the difference between the two distributions is favourable to non-outward FDI plants over outward FDI plants; and a test statistic of -0.02 (significant at the 0.58 level) when testing the null hypothesis that the difference between the two distributions is favourable to outward FDI plants over non-outward FDI plants. Thus, plants belonging to firms in Scotland engaging in outward FDI tend to dominate the TFP distributions of all other firms.

on productivity (i.e., the lack of a set of (weak) instruments that would be needed to identify the propensity to export separate from any effect on TFP). Essentially there is a need to match every plant involved in exporting with another plant that has (very) similar characteristics but does not sell overseas. Thus, under the matching assumption exporting- and non-exporting plants have the same (observable) attributes that impact on productivity except that one sub-group receives the treatment (it exports) and the other does not; put another way, the outcome that would result in the absence of exporting is the same in both cases. Thus the non-exporting, matched sub-group constitutes the correct counterfactual for the missing information on the outcomes that exporting plants would have experienced, on average, if they had exported.

Different approaches can be used to match plants, from using simple propensity score matching algorithms (Rosenbaum and Rubin [108]), where such scores are obtained from a probit/logit regression approach, to covariate matching estimators (that use complicated algorithms to match plants who export with non-exporting plants). There are a number of issues with this matching process, including the need for a rich dataset set that includes all relevant variables (X_i) that impact on productivity and all variables that impact on whether the plant exports or not (Z_i). In principle, matching is done on the set of variables $W = (X, Z)$, so that any selection on unobservables is assumed to be trivial and does not affect outcomes in the absence of exporting. In terms of the practical issues faced in any empirical design of matching plants using the propensity score approach Bryson *et. al.* [109], Imbens [110], Zhao [111] and more recently Caliendo and Kopeinig [112] provide a detailed and useful discussion.

The first major issue is which variables should enter the (probit/logit) model from which propensity scores, P_{it}, are obtained. The literature in this area show that omitting important variables can result in serious bias in the propensity scores used to obtain the control group; indeed it is argued by many that all the relevant variables in $W = (X, Z)$ should be included. Clearly, variables affected by treatment (such as productivity) should not be included contemporaneously, but only included (where justified) pre-entry (i.e. at $t - 1$ or earlier), and then only when its value at $t - 1$ has not been influenced by the anticipation of overseas market entry (Caliendo and Kopeinig [112]). Variables in W that are not significant should be omitted (to reduce the risk of inefficient estimates of the propensity score), and it has been suggested by some (e.g. Heckman and Navarro-Lozano [113]) that variables in Z that have only a weak impact on the outcome variable (e.g. productivity) should also be omitted to avoid inconsistency. Indeed Bhattacharya and Vogt [114] provide evidence to show that indeed variables in Z that effectively act as instruments (i.e., they determine whether a plant exports or not, but are not correlated with the outcome variable – here TFP) should be omitted from the propensity score.

A second major issue concerns the estimation of the propensity score model. The data available here is panel data, which involves an expectation that fixed effects are important, i.e. the probit model can be written as:

$$P_{it} = W_{it}\alpha + \mu_i + u_{it}; \qquad u_t \sim N(0,1) \tag{2}$$

where fixed effects μ_i have been included. Such fixed effects are potentially correlated with the explanatory variables ($\mathbf{x}_{it}$, $\mathbf{z}_{it}$)[32] and this leads to the “incidental parameters problem”

[32] The alternative commonly used panel data estimator is to assume random effects (i.e. the terms μ_i are incorporated into the error terms in the model, and thus are assumed to vary independently of the explanatory variables). Random effects therefore by-passes the incidental parameters problem by integrating out the individual effects. The random effects approach is applicable if the panel data comprise N firms drawn randomly from a large population (e.g. the typical approach in household panel studies) such that the μ_i are randomly

(Neyman and Scott [115][33], which has been shown to lead to biased estimates of the model parameters (α). This is especially problematic for the probit estimator which involves a non-linear approach.

The problem essentially arises because in estimating equation (2) using maximum likelihood methods the unobserved μ_i are replaced by inconsistent sample estimates [i.e. $\hat{\mu}_i(\alpha)$] which are conditional on the other parameters in the model (i.e., the α). As Fernandez-Val and Vella [117] put it: "… since estimation of model parameters cannot be separated from the individual effects in these models, the estimation error of the individual effects contaminates the other parameter estimates" (p. 5). There have been several approaches suggested in the literature to overcome this problem and thus produce consistent (and thus unbiased) fixed effect probit estimators.[34] For example, Fernandez-Val and Vella propose correcting the bias in the probit fixed effects estimator, but in practical terms the approach has not yet reached the stage that it is available in standard econometric packages such as STATA. An alternative is to use the simple approach suggested by Wooldridge [118] which in practical terms means estimating (2) as a cross-sectional probit model for each period *t*, and then calculating the propensity scores for each plant *i*, and stacking the results by *i* and *t* in order to obtain a control group. Hence, in this study we have used the Wooldridge [118] approach to obtain propensity scores, which are then used year-by-year to match plants based on the nearest-neighbour, one-to-one common-support approach available in PSMATCH2 in STATA. Only variables that are significant in equation (2) are used, and then only if they are also correlated with output (the dependent variable in equation 1).

For illustrative purposes, Table 4 presents the results from estimating equation (2) using stepwise regression, by pooling the cross-section time-series dataset and thus ignoring the fixed effects term. The results obtained are very similar to the results obtained from estimating (2) using cross-sectional data year-by-year, and they show that exporting in the past and belonging to a firm that has undertaken outward FDI in the past (i.e., proxies for sunk costs) are important determinants of the likelihood of exporting in time *t* (e.g., there is a 40% higher probability of exporting in *t* if the plant exported in *t* – 1). Plants that undertook R&D and with higher TFP in *t* – 1, and which were US-owned (and thus with access to superior technology) were also more likely to export, while EU-owned plants had a lower probability of exporting. Capital-intensive plants in *t* – 1 were also more likely to export (given the signs on the capital and employment variables), as were (cet. par.) single plant enterprises. Plants operating in industries with higher agglomeration effects were also more export orientated, while belonging to a more concentrated industry lowered the likelihood of selling abroad. In summary, there is evidence that pre-entry plants become 'better' through undertaking R&D and other learning activities that boost TFP, as well as having to overcome sunk costs. However, the set of variables that proxy for knowledge assets is limited – hence the analysis presented in the next section.

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distributed across plants. The fixed effects approach is more appropriate here when focussing on a specific set of *N* plants which are not randomly selected from the population, and to which we would expect there to be a time invariant individual effect associated with each plant.

[33] See Lancaster [116] and Fernandez-Val and Vella [117], amongst others, for further discussion of this issue.

[34] Note the alternative of using a random effects probit estimator is not an option if fixed effects is the more appropriate model (see footnote 32) and if the regression model determining productivity is to be estimated using a fixed effects approach. Clearly, using a random effects selection model (assuming individual effects are random) and a fixed effects regression model is not consistent. Similarly, it is not appropriate to use the fixed effects *logit* estimator because the regression approach assumes that the error terms in the model are normally distributed (and the logit estimator of course imposes a logistic distribution).

Table 4: Weighted probit model of determinants of exporting in Scotland, 2002-2005

	$\partial\hat{p}/\partial x$	*z*-value	$\overline{X}$
$Export_{t-1}$	0.400^{***}	7.85	0.091
Outward FDI_{t-1}	0.124^{***}	3.14	0.043
R&D stock $dummy_{t-1}$	0.081^{***}	2.76	0.011
ln TFP_{t-1}	0.019^{*}	1.83	-0.643
US-$owned_t$	0.320^{***}	3.27	0.004
EU-$owned_t$	-0.019^{*}	-1.88	0.130
Single plant $enterprise_t$	0.068^{**}	2.37	0.034
ln $employment_{t-1}$	-0.006^{**}	-2.43	2.285
ln $capital_{t-1}$	0.004^{**}	2.46	-2.943
ln Industry $agglomeration_t$	0.018^{***}	4.33	-1.009
ln $Herfindahl_t$	-0.024^{***}	-5.03	-4.326
Rest of $Scotland_t$	-0.018^{**}	-2.21	0.365
Industry dummies	yes		
No. of Obs.	4,607		
Pseudo R^2	0.43		
Log pseudo-likelihood	-889.96		
$\hat{p}$	0.15		

Source: weighted GCS-ARD database

Having obtained a matched sample of exporting and non-exporting plants, equation (1) is (re)estimated using the matched data to test whether exporting still enhances productivity. This combination of matching and parametric estimation is argued (e.g. Blundell and Costa Dias [119]) to improve the results obtained from this type of non-experimental evaluation study, as other impacts on the outcome variable are explicitly controlled for. Table 5 presents the results obtained for both the model estimated on the full data set (cf. Table 3) and when only using matched data. The latter comprised only 1,989 observations where there was common support and one-to-one matching,[35] and while many of the parameter estimates take on a similar value (compared to the results using the full data set) many are now not statistically significant, showing how using the full dataset results in more efficient estimates (albeit biased upwards with respect to the ‘learning-by-exporting’ effect). With respect to whether the ‘learning-by-exporting’ effect remains in the matching model, plants that exported had a TFP advantage of 31.5% while plants belonging to firms involved in outward FDI had a 49.5% higher level of TFP. Thus there is strong evidence that when the model is estimated using only those plants with similar characteristics (based on the results in Table 4), plants engaged in internationalisation continue to benefit from higher productivity levels.

4. Determinants of exporting using *CIS* data

In the last section, using GCS-ARD panel data showed that plants that sold to overseas markets had a significant productivity advantage both pre- and post-entry. There was evidence that pre-entry plants become ‘better’ through undertaking R&D and other learning

[35] Note, the propensity scores were obtained using lagged values of many variables (Table 4) which meant the loss of plants where there were only one observation in the database.

activities that boost TFP, as well as having to overcome sunk costs; and post-entry being in export markets continued to enhance productivity levels presumably through having the ability (and higher absorptive capacity) to access better foreign technology and the need to remain efficient in such highly competitive markets. However, the information in the GCS-ARD is limited with respect to firms' assets, and therefore in this section we consider another source of information (Community Innovation Survey data) that allows us to understand better the importance of knowledge assets in determining internationalisation.

Table 5: Weighted systems GMM production function, Scotland,2002-2005[a]

	Full model		Matching model	
	$\hat{\beta}$	z-value	$\hat{\beta}$	z-value
ln intermediate inputs$_t$	0.864***	13.00	0.809***	4.89
ln employment$_t$	0.273***	2.74	0.180	0.85
ln capital$_t$	0.108***	4.51	0.085**	2.07
R&D stock dummy$_t$	0.231*	1.76	-0.005	-0.05
t	0.030***	4.98	0.023	1.05
Export$_t$	0.455***	3.78	0.274*	1.93
Outward FDI$_t$	0.324*	1.89	0.402**	2.05
Single plant enterprise$_t$	0.108*	1.83	0.102	0.97
US-owned$_t$	0.745***	7.33	0.815**	2.42
EU-owned$_t$	0.215***	3.46	0.212	1.12
Other foreign-owned$_t$	-0.188***	-4.46	-0.288	-1.58
Assisted Area$_t$	0.181***	5.94	0.073	1.14
Rest of Scotland$_t$	0.068***	2.84	-0.027	-0.54
Edinburgh$_t$	0.239***	6.13	0.052	0.64
Aberdeen$_t$	0.149***	3.48	0.177**	2.10
ln Industry agglomeration$_t$	-0.070***	-4.61	-0.020	-0.69
ln Diversification$_t$	0.246***	5.38	0.016	0.25
ln Herfindahl$_t$	0.074***	4.91	0.053	1.36
Intercept	-1.186***	-4.56	-0.050	-0.07
Industry dummies	yes		yes	
AR(1) z-statistic	-3.44***	0.01	-3.93***	0.00
AR(2) z-statistic	1.47	0.10	0.46	0.65
Hansen test χ^2(13/19)	18.85	0.13	21.21	0.32
No. of Obs.	16,784		1,989	

Source: weighted GCS-ARD database

The CIS data used comes from the fifth survey undertaken in 2007 (known as CIS5), covering innovation activities in 2004-2006.[36] Based on the unique Reporting Unit code for each enterprise, this data has been merged back into the ARD dataset for 2005 (as 2006 data is not yet available), in order to add other information (mostly on enterprise characteristics) not available in CIS, and also to ensure a more accurate coverage is obtained across the

[36] See http://www.dius.gov.uk/science/science_and_innovation_analysis/cis for details.

Table 6: Variable definitions used in CIS-ARD merged dataset for 2006

Variable	**Definitions**	**Source**
Export	Whether the establishment sold goods and services outside the UK (coded 1) or not in 2006	CIS5
Size	Number of employees in the establishment, broken down into 5 size-bands, i.e. 0-9, 10-19, 20-49, 50-199 and 200+	CIS5
Size of graduates workforce	Proportion of employees educated to degree level or above in the establishment, broken down into 5 bands, i.e. no graduates, 0-5% graduates, 5-20% graduates, 20-75% graduates, and 75%+ graduates	CIS5
Age	Age of establishment in years	ARD
Employment	Current employment for establishment in 2006	ARD
Capital	Plant & machinery capital stock (£m 1995 prices) plus real value of plant and machinery hires (deflated by producer price index) in plant. Source: Harris and Drinkwater ([91], updated) and Harris [92].	ARD
Capital Intensity	Capital to employment ratio	ARD
Labour productivity	Establishment turnover per employee in 2006	CIS5
Single-plant enterprise	Whether the establishment was a single-plant enterprise	ARD
Knowledge sourced from HEIs	Whether HEIs was used as information source for the establishment's innovation activities; or firm co-operated with HEIs at regional, national or international level	CIS5
Foreign ownership	Whether the establishment was owned by foreign enterprises	ARD
Product innovations	Whether the establishment introduced new or significantly improved goods/services during 2004-2006	CIS5
Process innovations	Whether the establishment introduced new or significantly improved processes for producing/supplying products during 2004-2006	CIS5
Blue sky innovations	Whether product/process innovations introduced was new to market/industry	CIS5
Patents	Whether the establishment used patents to protect innovation	CIS5
International cooperation	Cooperated on innovation activities with partners outside UK 2004-2006	CIS5
Knowledge sourcing strategies	Whether the establishment used the following strategies in sourcing R&D[a] (coded 1): 1 "Not used"; 2 "Make only"; 3 "Buy only"; 4 "Co-operate only"; 5 "Make & Buy"; 6 "Make & Co-operate"; 7 "Buy & Co-operate"; 8 "Make & buy & co-operate"	CIS5
Agglomeration	% of industry output (at 5-digit SIC level) located in travel-to-work area in which establishment is located	ARD
Diversification	% of 5-digit industries (from over 650) located in travel-to-work area in which establishment is located	ARD
Herfindahl	Herfindahl index of industry concentration (5-digit level)	ARD
Industry	Whether the establishment was located in a particular industry SIC (2-digit)	CIS5
GO regions	Whether the establishment was located in a particular GB region	CIS5
Weight	Population weights based on the ratio between population employment and sample employment	CIS5

[a] 'Make' = intramural R&D; 'Buy' = extramural R&D; 'Co-operate' = cooperate with outside institutions in innovation activities.
[b] Each dummy variable is coded 1 if the barrier is of medium-to-high importance to the establishment as constraints on innovation activities

regions of the UK.[37] The variables available from this data source are defined in Table 6, while in Table 7 these data are sub-divided into those British enterprises that exported in

[37] CIS data is collected at the Reporting Unit (RU) level, where a RU may cover a number of plants (or Local Units), some of which may be located in different regions. All the attributes of the RU are assigned to just the region in which the RU has its headquarters (which is often the region with the largest plant, but not always). Thus, plants belonging to regions outside the RU region are ignored to the extent that any innovation activities (e.g. undertaking R&D) are assumed then not to occur in those plants. This tends to bias the regional distribution of innovation activities (by giving more emphasis to those regions with proportionately more 'headquarters' RU's). Thus, our preference is to merge CIS data back into the ARD at the plant level, and then aggregate back up to the RU level *and* regions, so allowing multi-region RU's to be represented in all the regions they operate in. Weights are then calculated (stratified by region, 1-digit SIC codes and 4 employment size-bands) to ensure

Table 7: Weighted mean values of variables, CIS-ARD dataset for 2006

	Non-exporters[1]	Exporters
Size of enterprise		
10-19 employees	0.218	0.177
20-49 employees	0.164	0.187
50-199 employees	0.120	0.182
200+ employees	0.309	0.429
Enterprise characteristics		
ln Labour productivity	4.407	4.709
ln Capital Intensity	-5.134	-4.827
ln Age	1.721	1.823
Single-plant enterprise	0.470	0.366
Foreign ownership	0.102	0.232
ln Herfindahl	1.407	0.485
ln Diversification	2.374	2.484
ln Agglomeration	-0.333	-0.111
Human capital		
No graduates	0.384	0.114
1-5% graduates	0.168	0.174
5-20% graduates	0.184	0.293
20-75% graduates	0.112	0.222
75% + graduates	0.152	0.196
Knowledge-sourcing strategies		
Knowledge sourced from HEIs	0.180	0.377
International co-operation	0.035	0.158
Make only	0.099	0.252
Buy only	0.057	0.044
Co-operate only	0.010	0.011
Make & buy	0.087	0.220
Make & co-operate	0.009	0.029
Buy & co-operate	0.003	0.005
Make & buy & co-operate	0.013	0.038
Process innovations	0.113	0.253
Product innovations	0.190	0.437
Blue sky innovations	0.025	0.086
Unweighted no. of observations	12,741	6,095

[1] *T*-tests of differences in the mean values between sub-groups are significant at 5% level (or better) for all variables except '1-5% graduates', 'Co-operate only', and 'Buy & co-operate'.

the CIS data is representative of the total population of RU's operating in the region. In practical terms, this means that the 13,200 matched CIS-ARD observations at the RU level (which exclude certain industries not covered in both datasets, and exclude Northern Ireland which is not in the ARD for Great Britain) convert into 18,836 matched CIS-ARD observations at the RU-region level. The extra 5,600 observations comprise RU's operating in more than one region.

2006 vis-à-vis those that did not. This shows that exporters were larger, with higher labour productivity, higher capital intensity, they were older, less likely to be multi-plant enterprises, more likely to be foreign-owned, operate in more agglomerated and diversified areas, and less concentrated industries.

As to variables associated with absorptive capacity and intangible assets (see section 2), various hypotheses on the components of absorptive capacity have been put forward in the literature (particularly, in strategic management studies), such as human capital, external network of knowledge and HRM practices as in Vinding [120], and potential and realised absorptive capacity as re-conceptualised by Zahra and George [69]. R&D-related variables are most commonly used as proxies (e.g. Cohen and Levinthal [72]; Arora and Gambardella [121]; Veugelers [78]; Cassiman and Veugelers [122]; Belderbos *et. al.* [123]). Here we take a practical approach based on the concept of absorptive capacity as developed in the literature, matched to the data available to us. Thus the last two sub-groups in Table 7 comprise our attempt to capture the internal and external knowledge creation processes within the firm, with an expectation that with higher levels of human capital (as proxied by the use of graduates in the workforce) the firm will have higher absorptive capacity; knowledge sourced from higher education institutes (HEI's) and through international cooperation on innovation activities with partners outside the UK is also expected to be positively related to absorptive capacity (cf. Fabrizio [85]).

The other variables included cover R&D and innovations. R&D spending is defined here as intramural R&D, acquired external R&D or acquired other external knowledge (such as licences to use intellectual property), and we combine this with information on whether the establishment has cooperated with outside institutions on innovation activities to create indicators of 'make', 'buy' and 'co-operate' on R&D. Cassiman and Veugelers [124] have proposed that when firms combine both internal and external knowledge acquisition in their innovative strategy, this is indicative of their absorptive capacity since for a firm to take advantage of knowledge acquired externally, it needs to develop internally to facilitate a smooth assimilation of the external expertise. Indeed, Veugelers [78] found that "cooperation in R&D has no significant effect on own R&D unless the firms have an own R&D infrastructure, in which case cooperation stimulates internal R&D expenditures. These results support the idea that indeed absorptive capacity is necessary to be able to capitalise on the complementarities between internal and external know-how" (p. 312). As Mowery and Rosenberg [125] concluded: "co-operative research programs alone are insufficient….more is needed, specifically the development of sufficient expertise within these firms to utilize the results of externally performed research". In terms of differences between exporters and non-exporters, Table 7 shows that not only are exporters more likely to undertake some form of R&D and/or cooperation on innovation (60% versus 27.8% for non-exporters), but in relative terms exporters are less likely to rely solely on a 'buy only' approach (7.3% of total activities versus 20.5% for non-exporters). As to innovations produced in 2004-2006, exporters are more than twice as likely to have innovated than non-exporters (69% versus 30%), and were some 3.4 times more likely to have produced an innovation which was 'novel'.

Using this CIS-ARD data, Table 8 reports the results from estimating a (weighted) probit model of the determinants of which plants exported in 2006. Two models were estimated using a stepwise approach (starting with entering all the variables in Table 6), with the second model based on the final model for Great Britain but with every variable that entered Table 6 also being initially included as a composite variable multiplied by the Scotland dummy variable. This was done to allow Scotland to differ from Great Britain, but without estimating a model just using Scottish observations (which would have reduced the number of observations to only 1500). Concentrating on the GB-Scottish results, larger enterprises

Table 8: Weighted probit model of determinants of exporting in Great Britain, 2006.

	GB model		*GB-Scottish model*		
	$\partial\hat{p}/\partial x$	*z*-value	$\partial\hat{p}/\partial x$	*z*-value	$\overline{X}$
Size of enterprise					
10-19 employees	0.237***	7.79	0.228***	7.43	0.199
-"- × Scotland	–	–	0.137**	2.43	0.013
20-49 employees	0.308***	10.23	0.310***	10.28	0.170
50-199 employees	0.362***	11.96	0.364***	12.03	0.146
200+ employees	0.358***	13.52	0.356***	13.34	0.348
-"- × Scotland	–	–	0.043	1.63	0.028
Enterprise characteristics					
Foreign owned	0.051***	3.94	0.051***	3.88	0.140
ln Labour productivity	0.034***	6.48	0.034***	6.45	4.406
ln Capital Intensity	0.012***	3.88	0.014***	4.31	-5.037
-"- × Scotland	–	–	-0.025***	-3.28	-0.380
ln Herfindahl	-0.026***	-8.70	-0.026***	-8.74	1.176
ln Diversification	0.008***	2.90	0.007**	2.52	-0.248
-"- × Scotland	–	–	-0.047***	-3.17	0.168
ln Agglomeration × Scotland	–	–	0.035***	2.76	-0.057
Human capital					
No graduates	-0.110***	-7.89	-0.110***	-7.91	0.291
5-20% graduates	0.052***	3.84	0.052***	3.84	0.216
20-75% graduates	0.119***	6.61	0.118***	6.58	0.150
75% + graduates	0.048***	3.15	0.049***	3.19	0.164
Knowledge-sourcing strategies					
Make only	0.156***	10.46	0.150***	9.70	0.152
-"- × Scotland	–	–	0.069*	1.69	0.012
Make & buy	0.122***	7.52	0.123***	7.54	0.132
Make & co-operation	0.128***	3.32	0.126***	3.27	0.016
Make & buy & co-operation	0.145***	4.34	0.146***	4.34	0.023
Knowledge sourced from					
HEIs	0.050***	4.43	0.051***	4.50	0.242
International co-operation	0.119***	5.93	0.119***	5.91	0.074
Process innovations	-0.063***	-5.01	-0.064***	-5.10	0.160
Product innovations	0.056***	4.59	0.057***	4.65	0.278
Blue sky innovations	0.125***	4.29	0.125***	4.28	0.041
Industry & region dummies	Yes		Yes		
No. of observations	18,489		18,489		
Pseudo-R^2	0.29		0.29		
Log pseudo-likelihood	-8226.03		-8204.12		
$\hat{p}$	0.25		0.25		

Source: CIS-ARD dataset for 2006

were more likely to engage in exporting (especially the very largest Scottish enterprises which were some 40% more likely to export vis-à-vis the 1-9 benchmark employment group). In terms of the characteristics of the establishment, foreign-owned firms were more likely to export, as were those establishments with higher labour productivity. Higher capital intensity was positively related to exporting, but not in Scotland. Establishments operating in more diversified areas had a lower probability of exporting in Scotland, although agglomeration was positively related to exporting (but in Scotland only). Lastly, the greater industry concentration, (cet. par.) the less likely were establishments to export.

Turning to the role of human capital, establishments with greater reliance on graduates as employees were more likely to export (vis-à-vis the benchmark group, 1-5% graduate employment), although the relationship is something of an inverted U-shape. As to the impact of R&D, only when this involved intramural R&D was there a positive impact on the probability of exporting (since only then is there increased absorptive capacity), with the largest effect in Scotland being associated with a ‘make only’ approach. Knowledge sourced from HEI’s increased the likelihood of exporting by about 5%, while establishments that engaged in international co-operation on innovation were some 12% more likely to export. Product innovations increased the probably of exporting, while ‘novel’ innovations increased exporting by over 12%. Process innovations reduced the probability of exporting (by 6.4%), suggesting that product innovations are concentrated more at the early stage of the product life cycle, and are associated with exporting; while at later stages when the firm is maximising sales of a more mature product process innovations are more likely important and exporting activities are curtailed.

In all, these results confirm the importance of absorptive capacity and the role of knowledge assets in determining which establishments are most likely to export; for example, a foreign-owned establishment in Scotland employing 200+, having a graduate workforce of between 20-75%, engaging in just intra-mural R&D, cooperating with an HEI and producing a novel innovation is (cet. par.) over 96% more likely to export. Of course, there are few of these types of establishments around, but those that do exist have high levels of absorptive capacity, a high propensity to export, and high levels of TFP.

5. Summary and Conclusions

This paper has used the merged Scottish Global Connections Survey (GCS) and the Annual Respondents Database (ARD) to demonstrate that exporters and those engaged in outward FDI have a significant productivity advantage over those firms that do not internationalise (both pre- and post-entry). Consequently, there is a need for more firms to become involved in such activities, as this will improve aggregate Scottish productivity and growth levels.

Given that there is also the need for a better understanding of the factors that determine which firms in Scotland operate in overseas markets, and specifically the role of knowledge-based assets in overcoming barriers to internationalisation, we have tried to measure the importance of such assets in determining the propensity to export. Because the information in the GCS-ARD is limited with respect to firms’ assets, the last section used Community Innovation Survey data that allowed us to understand better the importance of knowledge assets in determining internationalisation. Several proxies for different aspects of absorptive capacity (measuring the importance of human capital, R&D, university-firm linkages, international cooperation, and innovation activities) were all found to be important determinants of whether exporting takes place or not.

Various policy conclusions follow from our findings. Given that current thinking with respect to the government case for helping firms to export has moved beyond just considering ‘market failures’ as mostly information needs, and thus potentially indicative of resource-gaps faced by (especially smaller) firms, rather there are potential capability-gaps that need to be addressed. Most export promotion agencies (e.g., Scottish Development International) offer a similar set of ‘products’ to help firms to internationalise, which mostly concentrate on increasing export volumes (e.g., help with attending trade missions, exhibitions, and obtaining market intelligence). However, what is now recognised is that policies need to have a stronger element linked to improving productivity. For example, EU [126] argues that “… successful and sustainable internationalisation will require an internationalisation strategy and the acquisition of a series of capacities, abilities and resources prior or at the first steps of internationalisation”. These experts are making a direct and clear link between internationalisation and competitiveness whereby boosting internationalisation requires integrating policies for competitiveness and growth. To improve competitiveness requires improvements in productivity; and to increase firm-level productivity requires that the firm have the necessary intangible assets that will allow them to create new knowledge from the resources they possess, and add to this stock of knowledge through ensuring a sufficient level of absorptive capacity.

This study suggests therefore that to improve absorptive capacity, and thus exporting and productivity, requires an increase in those activities that build up the stock of knowledge-based assets (such as human capital, innovation activities and R&D, cooperation) – and therefore these are the resources that government agencies must consider in any strategy designed to boost exporting, and not just the provision of information to aspiring firms.

Appendix

Merging the GCS into the ARD

The GCS is undertaken each year to gather information on the internationalisation activities of Scottish firms. A postal survey is administered by Scottish Government statisticians, with questionnaires sent to a stratified sample of market-based firms operating in Scotland.[38] We have access to these 'raw' GCS completed questionnaires.[39] The data for 2002-2005 has been merged into the Annual Respondents Database (ARD)[40], which comprises the equivalent to the population of firms in the Inter-Departmental Business register (IDBR) that are available for sampling by the ONS as part of the Annual Business Inquiry conducted by Government each year. Merging initially took place at the local unit (or plant) level, since both datasets have information on the reporting units of respondents (and the ARD has data on each local unit belonging to a reporting unit – see Harris [90] for details). Using employment data available for each Scottish local unit in the ARD (covering some 157-173 thousand enterprises each year), we were able to weight the 2,700-3,500 p.a. respondents to the 2002-2005 GCS by employment-size and industry to provide population estimates.[41] This is a similar approach to that used by the Scottish Government statisticians.

[38] The survey sample is extracted from the Inter Departmental Business Register (IDBR) and includes all industries with the exception of public administration, private households with employed persons and extra-territorial organisations. Sampling takes place at reporting unit level and reporting units are asked to provide information on the combined Scottish activity of all their local units. The sample is stratified by industry (4 digit SIC) and 5 employment size-bands (Scottish employment). There were almost 3,000 known and potential exporters identified using information provided by Highland's & Islands Enterprise (HIE), participating Local Enterprise Companies (LECs) and previous survey data. Known and potential exporters are weighted in order to have a greater chance of being sampled than non-exporters or companies whose export status was unknown. Companies are then selected at random from the strata. Those with 100 or more employees were automatically sampled regardless of their export status and all known/potential exporting companies were sampled regardless of their size. This resulted in a sample of 8,778 reporting units. In most years a response rate of around 35 per cent is achieved.

[39] Note, we do not have information that allows us to identify respondents, and the data are held in the secure ONS Virtual Microdata Laboratory (VML), which has strict rules concerning access to the data and what type of information can be extracted (in particular the results of any analysis based on the GCS must pass stringent disclosure tests administered by the ONS).

[40] For information on the ARD see, for example, Harris [90].

[41] Four employment size-bands were used (1-12; 13-27; 28-82; 83+ employees) and 6 industry groups. The latter were constructed to ensure that every employment size-band × industry group contained at least 10 local units (for which there is available financial information in the ARD), to ensure we did not construct weights based on too little information.

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