WORKING PAPER SERIES

NO. 69

THE DETERMINANTS OF EXPORT PERFORMANCE: PANEL DATA EVIDENCE FOR IRISH MANUFACTURING PLANTS

STEPHEN ROPER and JAMES H LOVE

NORTHERN IRELAND

ECONOMIC RESEARCH CENTRE

The Determinants of Export Performance: Panel Data Evidence for Irish Manufacturing Plants

December 2001

Stephen Roper* and James H Love**

*Northern Ireland Economic Research Centre,
46-48 University Road, Belfast, BT7 1NJ
Fax: + 44 (0) 28 9043 9435
e-mail: s.roper@qub.ac.uk

**Aston Business School, Aston University,
Birmingham B4 7ET
Fax: +44 (0) 121 333 3474
e-mail: j.h.love@aston.ac.uk

Over the years a large number of individuals have been involved in the collection of the dataset on which this paper is based. Particular thanks are due, however, to Nola Hewitt-Dundas (NIERC) and Julie Anderson (NIERC). Data collection was financed by the Royal Irish Academy and the Industrial Research and Technology Unit, Belfast. Staff in the development agencies in both Dublin and Belfast generously provided access to sampling frames and expertise. Additional thanks are due to Maureen O'Reilly and Catherine Glass (NIERC) for providing access to the exports data for Northern Ireland and to Jessica Doyle and Lisa Bradley for high quality research assistance. This paper was written as part of the NIERC research programme on Innovation and Industrial Change.

Abstract

The dramatic GDP and export growth of the Republic of Ireland over the last decade forms a marked contrast with that of its nearest neighbour Northern Ireland. In the Republic of Ireland, export volume growth averaged 15.5 per cent pa from 1991-99 compared to 6.3 per cent from Northern Ireland. Using data on individual manufacturing plants throughout Ireland this paper considers the determinants of export performance in the two areas.

Larger, externally-owned plants with higher skill levels are found to have the highest export propensities in both areas. Other influences (plant age, R&D etc.) prove more strongly conditional on location, plant size, and ownership. Structural factors (e.g. ownership, industry) explain almost all of the difference in export propensity between larger plants in Northern Ireland and the Republic of Ireland but only around half of that between smaller plants. Significant differences are also evident between plants in terms of their sources of new technology. For indigenously-owned plants, in-house R&D is important. For externally-owned plants, R&D conducted elsewhere in the group - typically outside Ireland - proves more significant. Both this external dependency and lower than expected export propensity on the part of small plants in Northern Ireland represent significant policy challenges for the future.

The Determinants of Export Performance: Panel Data Evidence for Irish Manufacturing Plants[1]

1. Introduction

The dramatic GDP and export growth of the Republic of Ireland over the last decade forms a marked contrast with that of its nearest neighbour Northern Ireland. In the Republic of Ireland, export volume growth averaged 15.5 per cent pa from 1991-99 compared to 6.3 per cent from Northern Ireland. Average real GDP growth from 1991 to 2000 in the Republic of Ireland was 7.1 per cent pa compared to 2.7 per cent pa in Northern Ireland[2]. By 1997, this meant that GDP per capita in Northern Ireland continued to lag 18 per cent below the EU average while that in the Celtic Tiger economy of the Republic of Ireland was 102 per cent of the EU average [3]. What factors can explain these stark differences in performance given that Northern Ireland and the Republic of Ireland share a common geographical situation, i.e. both are 'peripheral' to the main European markets?

Much speculation has, of course, already surrounded the causes of the 'Celtic Tiger' phenomenon in the Republic of Ireland (e.g. Gray, 1997; Sweeney, 1998; Barry, 1999; Murphy 2000) with the general consensus focusing on the vital role of FDI and the growth of the externally-owned, high-tech sector (e.g. McCarthy, 1999; Ruane and Görg, 1997; Roper and Frenkel, 2000)[4]. Other factors, have also been implicated, however, as explanations for differential trade performance. Barry and Bradley (1997), for example, emphasise the importance of market orientation and industrial

[1] The terms 'Ireland' and 'Irish' are used here to relate to the whole island of Ireland. The terms 'Northern Ireland' and the 'Republic of Ireland' are used where more specific geographical reference is necessary.

[2] Sources: Republic of Ireland, GDP volume growth average measure, Table 13, Budgetary and Economic Statistics, March 2001, Department of Finance; Northern Ireland, NIERC/OEF Regional Economic Outlook, Spring 2001.

[3] Marked disparities exist, however, between regions within the Republic of Ireland. GDP per capita is around 112 per cent of the EU average in the Southern and Eastern region but only 75 per cent in the Border, Midlands and Western region. Source: Statistics in Focus, General Statistics, Theme 1 – 1/2000, Eurostat.

[4] Murphy (2000) describes the situation as follows: 'Ireland's transformation, one primarily caused by multinationals, was facilitated by the phenomenon of globalisation … Globalisation enabled Ireland to move from the periphery towards the centre of the new global economy. Now Ireland is the second largest exporter of packaged software in the world after the US … From having virtually no major

sector to the success of the Republic of Ireland economy. From a different perspective, Greenhalgh (1990) and Buxton et al. (1991) consider the potential effects of non-price competitiveness, with Thirwall (1986), suggesting that it was failure to keep pace with rising quality standards in international markets that was a major factor in the UK's poor trade performance through to the 1980s. More recently, attention in this area has focussed on the comparative trade performance of UK and German manufacturing firms (e.g. Wakelin, 1998; Anderton, 1999, 1999a; Roper and Love, 2001), suggesting that that non-price qualities – proxied by innovation and/or R&D indicators - are a potentially important explanation of differences in trade performance.

Promoting export development has also been an important strand of industrial policy in both Northern Ireland and the Republic of Ireland through direct measures focussing on marketing, and indirect measures focussing on improving firms' international competitiveness (Seringhaus and Rossen, 1990) [5],[6]. Policy in both areas has focussed particularly on developing the export potential of indigenously-owned and smaller firms reflecting policy-makers' concerns that Ireland has become over-reliant on the export activities of MNE subsidiaries' (Bell, 1997, p. 168)[7].

The remainder of the paper is organised as follows. Section 2 provides the context, by profiling the development of export growth in Northern Ireland and the Republic of Ireland since 1991. Section 3 outlines a simple conceptual model of export propensity, drawing together on previous 'neo-endowment' and technology-based models (Wakelin, 1998). Section 4 then describes the panel data used and our empirical approach. Section 5 outlines the main empirical results, and section 6 concludes with a summary and policy discussion.

---

export industries (Guinness and Irish whiskey representing two exceptions) Ireland has become a significant platform for US hgih-tech companies competing in the European market' (p. 4).

[5] Bell (1997), p. 148-149 quotes the definition of export promotion suggested by Seringhaus (1986), viz: 'all public policy measures that actually or potentially enhance exporting activity either from a firm, industry or national perspective'.

[6] From 1991-98 direct export promotion in the Republic of Ireland was the primary responsibility of An Bord Tráchtála (or the ITB). In 1998 the ITB merged with Forbairt the agency responsible for the development of indigenous firms and innovation and the agency responsible for business training to form Enterprise Ireland. In Northern Ireland, trade promotion is primarily the responsibility of Trade International which is part of the IDB although the small business agency LEDU would also encourage export development.

2. Irish Exports Growth During the 1990s

The 1990s witnessed rapid growth in the volume of manufacturing exports from both Northern Ireland and the Republic of Ireland (Figure 1). The more dramatic growth of export sales from the Republic of Ireland was accompanied by marked changes in the composition of exports as the externally dominated, high-tech sector expanded rapidly (Table 1). From 1991-98, for example, foreign-owned firms accounted for 95 per cent of the growth in industrial exports from the Republic of Ireland and at least 75 per cent of total export growth (Forfás, 2000, p. 9). Manufacturing firms' export propensity in the Republic of Ireland also rose markedly over this period 'rising from an average of 73 per cent in 1991 to 83 per cent in 1998 … export propensity was highest in the chemicals and electronic and optical equipment sectors at 97 and 93 per cent respectively' (Forfás, 2000, p. 23). As a result, exports of chemicals etc. (including pharmaceuticals) in the Republic of Ireland grew from 19.5 per cent of total export sales in 1991 to 35.8 per cent by 1999. Similarly, electrical and optical equipment, which includes the manufacture of computers and components, rose from 31.5 per cent of total exports sales in 1991 to 43.9 per cent by 1999 (Table 1).

While the rapidly expanding externally-owned sector in the Republic of Ireland increased its export sales and re-oriented the Republic of Ireland's industrial base towards faster growing regions and goods with higher income elasticities (Barry and Bradley, 1997), doubts remain about the international competitiveness of indigenously-owned Republic of Ireland firms (e.g. Wrynn, 1997). For example, exports of indigenously-owned firms in the Republic of Ireland grew more slowly over the 1991-98 period than over previous 1986-91 period (Forfás, 2000, p. 25)[8]. As a result, the share of the Republic of Ireland's industrial exports made by indigenously-owned firms fell from 26 per cent of the total in 1991 to 12 per cent by 1998 (Forfás, 2000, p. 9). This is also reflected in the sectoral composition of exports

[7] For example, specific policy initiatives are described in Mackinnon (1997) and Demick and O'Reilly, (2000)

[8] Using data derived from the Census of Industrial Production, Forfás (2000) estimates the export growth of indigenous Irish firms at 12.3 per cent pa between 1986 and 1991 and 4.4 per cent between 1991 and 1998. Commenting on this difference the report notes that 'the relatively poor measured export performance of the indigenous sector in the 1990s … may in part reflect the accelerating internationalisation of the Irish economy, with high numbers of Irish firms being acquired by foreign firms and investors. It may also be possible that indigenous firms have substituted domestic for foreign export sales to exploit faster demand growth in the home market'.

from the Republic of Ireland. The food and drink sector, for example, accounted for a quarter of exports in 1991 but only a tenth by 1999 (Table 1). Other, more traditional, sectors (notably textiles and clothing) saw their export sales fall in both real terms, and as a share of total export sales (Table A3).

As in the Republic of Ireland, externally-owned firms are also important in the Northern Ireland manufacturing sector. In 1996, for example, 18.3 per cent of employment, 29.8 per cent of value added and 24.6 per cent of net capital expenditure in Northern Ireland manufacturing was by firms owned outside the UK[9]. Other studies have suggested that a similar proportion of manufacturing activity in Northern Ireland may be accounted for by firms owned in other UK regions (e.g. Murshed et al., 1993, p. 54). In contrast to the Republic of Ireland, however, the Northern Ireland externally-owned manufacturing sector is longer established, includes firms in more mature industries and has a much larger UK-owned component (e.g. Crone, 1998)[10]. As a result, its export growth has been more like that of the indigenously-owned sector, and changes in the composition of Northern Ireland exports have been less dramatic than those in the Republic of Ireland (Table 1). The same fundamental trends are evident, however, in the Northern Ireland exports figures; expanding export sales of electrical and optical equipment and declines in the export shares of the more traditional textile and food-based sectors (Table 1). In general terms, however, and in complete contrast to the situation in the Republic of Ireland, the composition of industrial exports from Northern Ireland in 1998 resembled closely that of 1991.

[9] Source: Tables 6 and 11, Manufacturing Production and Construction Inquiries – Summary Volume, PA 1002, National Statistics 1996.
[10] More recent investment into Northern Ireland has been dominated by software, networked services and back office activity (Crone, 2000)

3. Conceptual Model

Two main conceptual approaches exist to modelling the determinants of export performance (Wakelin, 1998): 'neo-endowment' models in which firms' competitive advantage is based on factor endowments and, 'technology-based' models in which competitive advantage derives from the quality of firms' products or services. Studies in the neo-endowment tradition argue that factor-based advantages may be important if the firm has either a natural monopoly of a particular factor or is, for example, located in a particular region where a factor is plentiful. Extending the more traditional range of factors included in such models beyond labour and capital to include different dimensions of human and organisational resources, emphasises the parallels between this type of explanation and resource-based models of company competitiveness. The argument then becomes one of identifying the types of productive resources that determine firms' competitive advantage in export markets. In terms of firms' internal resources, Wakelin (1998a) identifies positive links between export performance and average capital intensity among UK firms, while Sterlacchini (1999) identifies a positive relationship between the technological level of firms' capital stock and the export propensity of small Italian businesses. Roper and Love (2001) also emphasise the potential benefits of being part of a multi-plant group, finding that in the UK, at least, group-members were likely to have higher export propensity than similar single-plant businesses. Another common finding is a positive but non-linear relationship between export propensity and plant size, a variable which may itself be acting as a proxy for the strength of firms' resource base (Kumar and Siddharthan, 1994; Wagner, 1995; Bernard and Wagner, 1997; Wakelin, 1998a; Bernard and Jensen, 1999; Sterlacchini, 1999; Roper and Love, 2001)[11].

Technology-based models of export performance focus primarily on firms' investments or achievements in implementing new technologies or the development of new products or processes. This capability will depend both on the internal strengths of the plant, where applicable its links to other group companies and on the support available from the regional or national innovation system within which the firm is operating (Nelson, 1993; Metcalfe, 1997). The presence of an R&D function

within a plant, for example, may stimulate innovation through the type of technology-push process envisaged in linear models of innovation. R&D staff may also, however, contribute to firms' creativity as part of multi-functional groups, or may allow firms to utilise extra-mural networks or information sources more effectively (Veugelers and Cassiman, 1999; Love and Roper, 2001). Braunerhjelm (1996), for example, provides evidence from Sweden that R&D expenditures and investment in skilled labour both have a positive effect on firms' export intensity, while more conventional cost factors have no effect. For plants which are part of multi-plant groups, access to group-wide R&D resources may also be important sources of new technology and product innovation. The Irish operations of US software multi-nationals, for example, are strongly dependent on the transfer of technology from software development centres within the US (Coe, 1997).

Taking into account of the findings of previous studies in both the neo-endowment and technology-based traditions, our model of export propensity will include a number of indicators of plants' operating and organisational characteristics. In particular, we allow for the ownership characteristics of plants located in Ireland and, where appropriate, for the presence elsewhere within the group of related R&D facilities. Given the differences in policy and economic performance between Northern Ireland and the Republic of Ireland we also allow for plant location. This suggests a basic model of the form:

$$X_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 C_{it} + \beta_3 L_i + \beta_4 S_i + \varepsilon_{it} \qquad (1)$$

Where: X_{it} is the export propensity (i.e. the share of exports in total sales) of plant i in period t, R_{it} is a set of indicators of plants' internal resource endowments, C_{it} is a set of plants' other characteristics, L_{it} is an indicator of potential locational effects and S_{it} is a vector of sectoral indicators.

[11] The findings of Bernard and Wagner (1997) and Bernard and Jensen (1999) suggest that large and strong plants/firms tend to become exporters, rather than exporting enhancing performance.

4. Data and Estimation Methods

The data used is taken from the 2nd and 3rd surveys in the Irish Innovation Panel (IIP), a series of surveys of innovation activity by Irish manufacturing plants with 10 or more employees (Roper et al, 1996; Roper and Hewitt-Dundas, 1998; Roper and Anderson, 2000)[12]. Each survey was undertaken by post using a sampling frame provided by the economic development agencies in Northern Ireland and the Republic of Ireland. The second IIP survey was conducted between November 1996 and March 1997, covered plants' innovation activity during the 1994-96 period, and had a response rate of 32.9 per cent (Roper and Hewitt-Dundas, 1998). The third IIP survey, covering the 1997-99 period, was undertaken between October 1999 and January 2000 and achieved an overall response rate of 32.8 per cent (Roper and Anderson, 2000). 344 plants responded to both the 2nd and 3rd IIP surveys, with a further 1,119 plants responding to one of the two surveys (Table 2). Single observations included in the unbalanced panel relate to plants which responded to only one of the surveys either because of non-response or because the plant was newly opened or had closed at the other survey date. In terms of employment in the target group (i.e. manufacturing plants with more than 10 employees) the IIP panel covers 32.2 per cent in 1996 and 36.4 per cent in 1999[13].

As part of each of the surveys, plants were asked about their export propensity and also provided a range of background information on the plant itself (Table 3). Export propensity is measured by the proportion of plants' sales made outside the UK and Ireland, i.e. sales in continental Europe and beyond. This measure was chosen for two

[12] One unfortunate feature of the IIP in terms of the current analysis is a change in the definition of the 'export propensity' variable after the first survey. In 1993, plants were asked to indicate the proportion of their sales which were *exported* whereas in the latter two surveys plants were asked to indicate the proportion of their sales made *outside the UK and Ireland*.

[13] The target population was estimated from the Census of Industrial Production for the Republic of Ireland (Table 3) for 1996. For 1999 the target population was estimated using total manufacturing employment (Source: Table 45 Budgetary and Economic Statistics, Dept of Finance) and the 1996 proportion of total employment in the target group. For Northern Ireland, data for 1993 is available from the Size Analysis of UK Business, 1993, Table 10. For subsequent years total manufacturing employment is taken from the Northern Ireland Annual Abstract, 2000, Table 8.5 and adjusted using the 1993 proportion of manufacturing employment in plants with less than 10 employees. Sample coverage in Northern Ireland (and the Republic of Ireland) was in: 1996, 35.6 per cent (30.8 per cent); 1999, 49.2 per cent (31.1 per cent).

main reasons. First, given the context for this study (i.e. covering Northern Ireland, a region of the UK and a national economy, the Republic of Ireland) this definition has the advantage of avoiding any ambiguity over the definition of exports. Secondly, it provides a common basis for comparison between the export performance of Northern Ireland and Republic of Ireland plants. The disadvantage of this measure is that it excludes sales made by Northern Ireland and Republic of Ireland companies in each others home markets and in Great Britain. The former exclusion is perhaps the least objectionable given the different relative sizes of the Northern Ireland and Republic of Ireland markets. The latter is more difficult but is justified on the basis that for Northern Ireland firms, GB is part of the UK home market whereas for Republic of Ireland firms it represents an export market. Including sales in GB in the analysis would therefore lead to an uneven comparison between the apparent export competitiveness of Northern Ireland and Republic of Ireland plants. In terms of the chosen measure - export sales outside the UK and Republic of Ireland - export propensity among Republic of Ireland plants averaged 30-35 per cent compared to 16-18 per cent among Northern Ireland plants (Table 3).

The form of the dependent variable (i.e. export propensity) as a percentage of total sales suggests that the appropriate estimator is Tobit. The structure of the Irish Innovation Panel with small T and relatively large N suggests the difficulty of estimating the number of parameters required by a fixed effects model, however, and where appropriate a random effects structure is therefore preferred (see, for example, Hamerle and Ronning, 1995, pp. 412-413). Let X_{it}* be a latent (i.e. unobserved) variable then our model specification is:

$$\begin{aligned} X_{it}^{*} &= \beta_0 + \beta_1 R_{it} + \beta_2 C_{it} + \beta_3 L_i + \beta_4 S_i + \varepsilon_{it} \\ X_{it} &= \begin{cases} X_{it}^{*} & if \quad X_{it}^{*} > 0 \\ 0 & if \quad X_{it}^{*} \leq 0 \end{cases} \\ \varepsilon_{it} &= \alpha_i + u_{it} \end{aligned} \qquad (2)$$

where we assume that $u_{it} \sim N(0, \sigma^2_u)$, $\alpha_i \sim N(0, \sigma^2_\alpha)$ and that u_{it} and α_i are mutually uncorrelated, i.e. $E(\alpha_i \alpha_j) = 0$ and $E(u_{it} u_{js}) = 0$ if $i \neq j$ and $s \neq t$. This means that $\sigma^2_\varepsilon = \sigma^2_\alpha + \sigma^2_u$, and implies that for any given time period the latent variables X_{it}* are independent. For given any i (i.e. specific plant), however, the X_{it}* are correlated over

time with correlation parameter $\gamma = \sigma^2_\alpha / \sigma^2_\varepsilon$. This correlation is constant through time and higher where the 'individual effect' α_i has greater variation, i.e. there is more (unobserved) heterogeneity among plants (Hamerle and Ronning, 1995, p. 434).

In terms of the application of this model to the Irish Innovation Panel two alternative strategies are possible: using the full unbalanced panel or using the sub-sample of plants which responded to both of the two surveys. Baltagi (1995, pp. 156-57) reports the results of Monte Carlo experiments relating to this issue and concludes that extracting a balanced panel can lead to significant loss of efficiency. Our preferred approach is therefore to estimate the Tobit model of equation (2) using the unbalanced panel. This is done using the Tobit estimator for panel data implemented in LIMDEP 7.0 (Greene, 1995)[14].

The first group of determinants of export propensity included in equation 2 relates to the strength or otherwise of plants' internal resource base. Central to this is whether the plant conducts informal R&D in house, has an organised R&D department or, where applicable, has access to R&D conducted elsewhere in the group. Essentially similar proportions of plants in Northern Ireland and the Republic of Ireland undertake informal R&D (27-28 per cent), but larger proportions of Republic of Ireland plants both have formal R&D departments and access to R&D conducted elsewhere (Table 3). Previous studies provide strong evidence that R&D capability contributes to plants' export competitiveness. We expect, therefore, that for any given set of plant characteristics, the effect of R&D on exporting is likely *ceteris paribus* to be positive. Essentially similar arguments suggest that we would also expect to observe a positive relationship between variables representing the quality of plants' human resource base and export performance.

Plant size is also generally expected to have a positive relationship to export propensity as larger plants have more resources with which to enter foreign markets. Wakelin (1998a) argues, for example, that this may be particularly important if there are fixed costs to exporting such as information gathering or economies of production

[14] The Tobit estimator in Limdep uses an ML approach which Baltagi (1995) reports performs well in terms of MSE for the estimation of the components of error variance even when panels are severely unbalanced.

and/or marketing which may benefit larger firms disproportionately. Scale may be important in overcoming such initial cost barriers but may then be less significant in determining the extent of firms' export activity. Support for this assertion comes from the non-linear relationship between plant size (employment) and export propensity found by Kumar and Siddharthan (1994), Willmore (1992), Wakelin (1998a) and Sterlacchini (1999), each of which identifies an inverted-U shape relationship. We therefore include both plant size and its square in the estimated models, and expect to find a quadratic relationship with export propensity.

Other relevant plant characteristics include business age, whether or not the plant is locally or externally-owned, and the type of production being undertaken. Business maturity in the Irish electronics sector, for example, has been shown by Görg and Ruane (2000) to lead to stronger local linkages and greater local sourcing. Similar arguments may be applicable to the relationship between plant-vintage and export propensity. Older plants may have had time to establish and expand their distribution networks and also to establish a market position in export markets. We might therefore expect a positive coefficient on the plant age variable. Ownership may also be an important indicator of a plant's export potential if it is able to take advantage of group resources for branding, marketing or distribution. As indicated earlier, the export sales of the Republic of Ireland's externally-owned sector has increased much more rapidly than that of indigenously-owned plants over the last decade (Forfás, 2000). This, and the strong export orientation of much inward-investment to both Northern Ireland and the Republic of Ireland, suggests we would expect a positive relationship between external-ownership and export propensity. In aggregate, this effect is likely to be stronger in the Republic of Ireland given the much larger proportion of externally-owned plants (Table 3).

In terms of plants' production activities, we include two indicators relating to small and large batch production. Small batch production may be associated with either a product differentiation strategy or a focus on niche markets. Large batches are more likely to reflect commodity production for broader geographical markets and may therefore be more strongly associated with exporting. We therefore expect a negative relationship between small batch production and export propensity and a positive relationship between large batches and exporting. These effects are likely to be

equally important in both Northern Ireland and the Republic of Ireland as the profile of production activities of plants in both areas is broadly similar (Table 3).

5. Empirical Analysis

We first consider the determinants of export propensity for the whole sample. This highlights significant differences between the export propensity of plants located in Northern Ireland and the Republic of Ireland, indigenously and externally-owned plants and plants of different sizes. Results for these sub-samples are outlined in Sections 5.2, 5.3 and 5.4.

5.1 Whole Sample Results

Table 4 reports standard Tobit estimates and the random effects Tobit models for export propensity among all plants in the 2nd and 3rd IIP surveys[15]. The estimated coefficients are generally well defined with strong regularity in sign and significance between the standard Tobit and random effects estimators.

The first notable feature of the estimated coefficients of the Tobit models is the strong positive effect on export propensity of the strength of plants' internal resource base. As expected, plants with a high proportion of graduate employees had higher export propensity, as did plants with an in-house R&D capability (Table 4). Both R&D conducted informally and a more structured R&D department contributes to increased export propensity, with more structured R&D activity having a larger positive effect. This may reflect the more systematic exploitation of R&D resources in a structured setting, or the likelihood that plants with formally organised R&D departments are actually making larger R&D investments. Notably, for the sample as a whole, access to R&D conducted elsewhere has an insignificant effect on export propensity. This positive result for R&D reflects that found in other studies in the technology-based tradition which also suggest a strong positive relationship between non-price quality and plants' export competitiveness (e.g. Wakelin, 1998; Anderton, 1999, 1999a).

[15] Initial experimentation also involved models including indicators of innovation and sectoral, locational and supply-chain spillovers following Roper and Love (2001). These variables proved universally insignificant in the estimation and are therefore omitted from the results reported.

Plant size - which we interpret as a general indicator of the strength of plants' resource base - also proves important, and we observe the expected quadratic relationship between export propensity and employment (see also Kumar and Siddharthan (1994), Willmore (1992), Wakelin (1998a) and Sterlacchini (1999), Roper and Love (2001)).

Other plant characteristics also prove important in determining export propensity. External-ownership in particular has a strong positive effect, perhaps reflecting the position of Ireland, and in particular the Republic of Ireland, as a production base from which US high-tech firms serve the European or EU markets (Roper and Frenkel, 2000). The significance of the 'large-batch' variable is also suggestive of a similar interpretation. Other plant characteristics prove less significant with the plant age variable also taking an unexpected negative sign. The suggestion - although relatively weak in statistical terms - is that plant longevity is linked to reduced rather than increased export propensity. This runs contrary to arguments that suggest that older plants are more likely to have better developed export market positions or distribution networks which might increase export propensity. An alternative explanation is that plant age may be reflecting the market orientation of different waves of inward investment and plant establishment in Ireland, with more recently established plants having a stronger global market orientation. In terms of the Republic of Ireland at least, this may also related to the scale and significance of recent flows of inward investment.

Plants' location also proves an important determinant of export propensity. As we might expect from the contrast between average export propensity in Northern Ireland and the Republic of Ireland (Table 3), plants in the Republic of Ireland have significantly higher export propensity than similar plants in Northern Ireland. This might reflect differences in, say, the operating environment in Northern Ireland and the Republic of Ireland. If export marketing support was more effective in the Republic of Ireland, for example, this might raise Republic of Ireland plants' export propensity *ceteris paribus*. Similarly, Republic of Ireland plants may enjoy a better international image than Northern Ireland plants with positive consequences for export propensity. Either of these effects would be primarily additive, augmenting the export propensity of any given plant which would be predicted on the basis of its internal characteristics. More fundamental, behavioural differences between Northern

Ireland and Republic of Ireland plants, however, may also be evident if, instead, the factors influencing export propensity in the two areas are different. This latter possibility is explored in more detail in subsequent sections for sub-samples distinguished by location, ownership, and plant size.

5.2 Locational Contrasts

Interest in potential differences between the Northern Ireland and Republic of Ireland sub-samples stems from the very different pattern of export growth in the two areas, and the significance of the regional dummy in the aggregate equations (Table 4). Table 5 reports separate Tobit models for each area. As in the aggregate models (i.e. Table 4), coefficients are generally well defined with some uniformity of sign and significance. Indeed, in terms of the group of internal resource indicators the results for both areas are very similar (Table 5). More marked differences are evident in terms of the impact on export propensity of other plant characteristics (e.g. age, external ownership etc). In Northern Ireland, for example, we observe the expected age effect, with older plants having higher export propensity *ceteris paribus*. In the Republic of Ireland, the opposite is true, with higher export propensity among younger plants. One possibility is that this contrast reflects the diverse industrial history of the two areas. In Northern Ireland, there has been relatively little inward investment by Republic of Ireland standards over the last decade and the estimated coefficients are consistent with steady development by plants of their export market position and export propensity. Such organic developments are also likely to have taken place in the Republic of Ireland but their effect is perhaps dominated by the massive scale of highly export-oriented inward investment. This is also suggested by the very much larger and statistically stronger positive coefficient on the variable denoting external ownership in the Republic of Ireland model (Table 5).

To illustrate the implications for export propensity of the equations in Table 5, and the differential characteristics of plants in Northern Ireland and the Republic of Ireland, Figure 2 gives predicted export propensities for plants of different sizes in each area. As would expect, export propensity in both areas increases with employment, with marginally stronger scale effects in Northern Ireland than in the Republic of Ireland. More interesting, however, is that the Tobit models suggest that on average export

propensity in Northern Ireland is around 20 pp below that in the Republic of Ireland for plants with around 100 employees, a deficit which falls to around 10 pp for plants with 600-700 people.

5.3 Indigenously and Externally-Owned Plants

Forfás (2000) and other commentators on economic development in the Republic of Ireland have emphasised the importance of inward investment in the Celtic Tiger phenomena, and the very different export growth of indigenously and externally-owned plants. Another potentially interesting decomposition of the sample, is therefore to consider whether the determinants of export propensity are markedly different for indigenous and externally-owned businesses. Table 6 reports separate Tobit models for the export propensity of indigenously and externally-owned firms. From these models it is readily apparent that significant differences do exist between the estimated coefficients for the two groups of firms, suggesting the inadequacy of the simple dummy variable indicator included in the aggregate equations (i.e. Table 4).

Marked differences exist, for example, between indigenously and externally-owned plants in terms of those elements of plants' internal resource base which have most influence on export propensity. The most significant factor for externally-owned plants, for example, is R&D conducted elsewhere in the group, with informal R&D having a statistically insignificant effect and only a relatively weak plant size effect. For the export propensity of indigenously-owned firms, however, both informal and formal R&D prove significant as does plant size - which we interpret as general indicator of strength of plants' resource base. Skill levels are an important determinant of export propensity for both groups of plants, but have a stronger influence in indigenously-owned businesses. This suggests a picture of indigenously-owned plants competing in international markets on the basis of their internal competencies, while externally-owned plants derive their international competitiveness not so much from their internal capabilities but from R&D conducted elsewhere. This configuration of plants' sources of international competitiveness reflects closely that in other accounts of the Irish - particularly the Republic of Ireland - manufacturing sector. Yearly (1995), for example, highlights the strong dependence of many externally-owned

manufacturing plants in Ireland on R&D conducted elsewhere. One consequence, highlighted by Wrynn (1997), is the dual nature of the Irish manufacturing sector, with externally-owned firms reliant on technology transfer from elsewhere and the weaker technological base of indigenously-owned Irish plants.

Other plant characteristics prove largely unimportant for the export propensity of indigenously-owned plants. For example, there is no evidence that more recently established indigenously-owned plants have higher export propensity than older plants. This contrasts strongly with the results for externally-owned plants which suggests that more recently established plants are likely to have greater export propensity. This is a disappointing result, suggesting as it does that increasing globalisation of international markets has had little effect on the market orientation of indigenously-owned plants in Ireland.

Another notable contrast between the results for indigenously-owned and externally-owned businesses relates to location. The export propensity of indigenously-owned plants located in Northern Ireland and the Republic of Ireland does not differ significantly *ceteris paribus* (Table 6). Externally-owned plants in Northern Ireland, however, have significantly lower export propensity than their Republic of Ireland counterparts even after allowing for sectoral and age effects (Table 5). The implication is that the determinants of export propensity of indigenously-owned plants are essentially similar throughout Ireland, with no identifiable difference in export competitiveness. Externally-owned plants in the Republic of Ireland, however, clearly differ from their Northern Ireland counterparts in a way which boosts their export propensity. As in the models for the whole sample this contrast may reflect either internal, organisational or environmental factors not captured elsewhere. One potentially significant organisational factor, for example, is the nationality of ownership of externally-owned plants. As indicated earlier, the vast majority of inward investment to the Republic of Ireland has been from the US, while more externally-owned Northern Ireland-based plants are owned by GB-based multi-plant or multinational businesses (e.g. Crone, 1998). If this latter group were more focussed on serving a GB rather than a European market this would generate the observed result.

Figure 3 illustrates the predicted export propensity for externally-owned and indigenously-owned plants of different sizes. Again, as we would expect, export propensity rises with plant size, an effect which is much stronger for indigenously-owned firms. The predicted export propensity of small indigenously-owned plants is negligible, but is around 20 per cent of the sales of small externally-owned plants. As the export propensity of indigenously-owned plants rises faster with employment, however, predicted export propensity among the two groups of firms is equal in plants with around 550 employees. In practice, however, this result is somewhat difficult to interpret as relatively few plants in either group are of this size.

5.4 Small and Larger Plants

From a policy perspective another interesting distinction is that between the factors which determine export propensity in small and larger plants. Promoting exporting among small firms has been a particular focus of policy in both areas and is central to the objectives of InterTradeIreland (one of the new cross-border bodies established as part of the Good Friday Agreement). Table 7 reports Tobit models of export propensity for small plants (i.e. those with less than 50 employees) and larger plants.

In common with the models discussed earlier, both small and larger businesses with higher skill levels tend to have higher export propensity *ceteris paribus* (Table 7). Intriguing differences are observed, however, in the relationship between R&D and export competitiveness for the two groups of plants. For small plants, both informal and more formally organised in-house R&D activity have positive benefits for export propensity; for larger plants only formalised R&D activity has any significant effect. The suggestion is that, for small firms at least, even informal R&D can have significant commercial benefits in terms of increasing exports. In policy terms this result is important in that there may be an unwillingness to support informal R&D activity in small firms where this cannot be clearly identified by firms' accounting systems. This result also suggests the potential importance of informal R&D activity to our understanding of the competitiveness of small firms. This is important because innovation surveys, in particular, have a well documented tendency to under-estimate the true level of any R&D and developmental activity conducted informally (e.g. Kleinknecht, 1987; Kleinknecht, 1989; Kleinknecht et al., 1991).

Other differences between the determinants of export propensity of small and larger plants largely reflect those already identified. For example, externally-owned plants in both plant sizebands have higher export propensity than indigenously-owned businesses (Table 7). Export propensity in small plants, however, proves more dependent on the size and age of the plant than that in larger businesses. Younger and larger small plants tend also to be more export intensive, ceteris paribus, effects which are insignificant once plants have more than 50 employees. Some difference is identified in terms of the impact of location on plants' export propensity, with location only important in the case of larger businesses. As larger plants also tend to be externally-owned, this result is likely to reflect a similar point made earlier for externally-owned businesses.

6. Conclusions

Our analysis of the determinants of Irish manufacturing plants' export propensity suggests three results applicable to all business types. First, plants with more highly skilled workforces - particularly more graduate employees - tend to be more successful in export markets. Secondly, in common with other national studies, we find that larger plants in Ireland tend to export a larger proportion of their sales. The increase in export propensity is, however, less than proportionate to plant size. Thirdly, externally-owned plants export a larger proportion of their output than similar indigenously-owned plants.

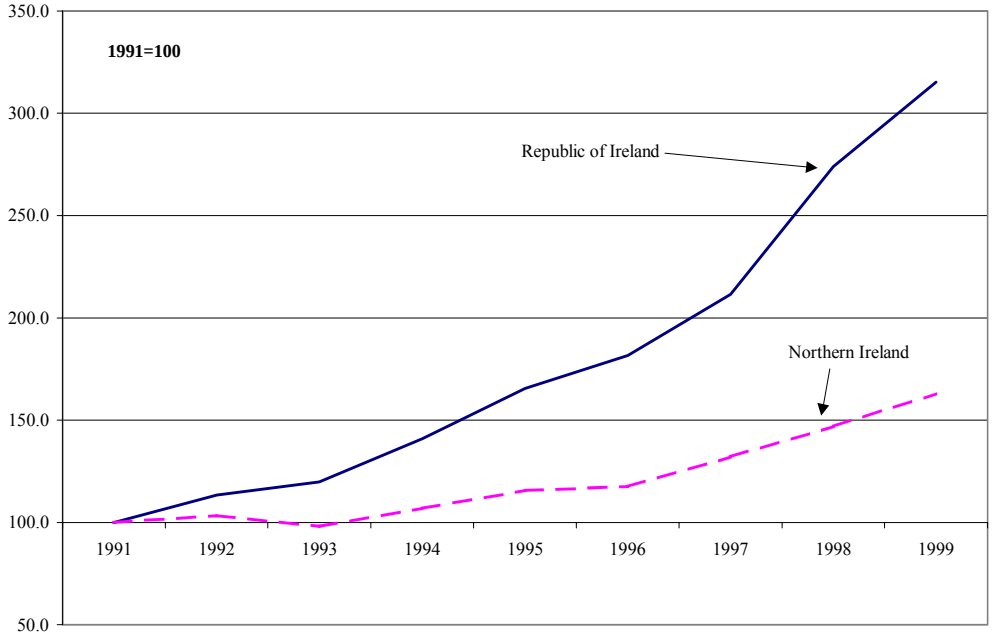
The impact of other influences on plants' export propensity depends strongly on the plants' location, its size and its ownership. Older plants, for example, tend to export more in Northern Ireland but have lower export propensity in the Republic of Ireland. External ownership is also much more strongly linked to increased export propensity in the Republic of Ireland than in Northern Ireland. Given the very different export growth in the two areas it is interesting to explore whether differences in export propensity are structural or behavioural in nature, i.e. whether they can explained by differences in sectoral structure/ownership etc. To this end, Figure 4 reproduces the predicted export propensity of Northern Ireland and Republic of Ireland plants from Figure 2. To examine the effect of industrial structure etc, we also plot an additional series based on the estimated export propensity model for Northern Ireland (Table 5) and plant characteristics in the Republic of Ireland. The difference between this structurally adjusted line and that for Northern Ireland is the structural effect. The difference between the structurally adjusted line and that for the Republic of Ireland is due to differences in the behavioural relationship which determines export propensity in the two areas. This decomposition implies very different results for smaller and larger plants. For small plants in Northern Ireland, predicted export propensity is around 20pp lower than that in the Republic of Ireland, of which around half is behavioural and half structural. In other words around half of the predicted difference in the export propensity of small plants can be explained by industrial structure etc. The remaining shortfall (around 10 pp) is due to differences in the way plants in Northern Ireland and the Republic of Ireland approach export sales. For larger plants

the story is radically different with almost no behavioural effect and almost all of the difference in export propensity explained by industrial structure etc.

Important differences are also evident between groups of plants in terms of their sources of new technology and in particular the impact of R&D on export propensity. For indigenously-owned plants, in-house R&D - both inside and outside a formal R&D department - is significant. For externally-owned plants, R&D conducted elsewhere in the group proves more important. These empirical results are important from three standpoints. First, from a policy point of view they emphasise the importance of R&D and associated developments to export competitiveness and growth. Secondly, in terms of our understanding of the Irish manufacturing sector, they provide - perhaps for the first time - some firm empirical evidence of the dependency of many externally-owned plants on intra-group technology transfers (Yearly, 1995; Wrynn, 1997). Thirdly, in terms of the differences between small and larger plants, they emphasise contrasts between the different types of R&D activity which influence export propensity. Small plants' export propensity, for example, is positively influenced by both informal and formally organised R&D activity; for larger plants, however, only more formally organised R&D is helpful.

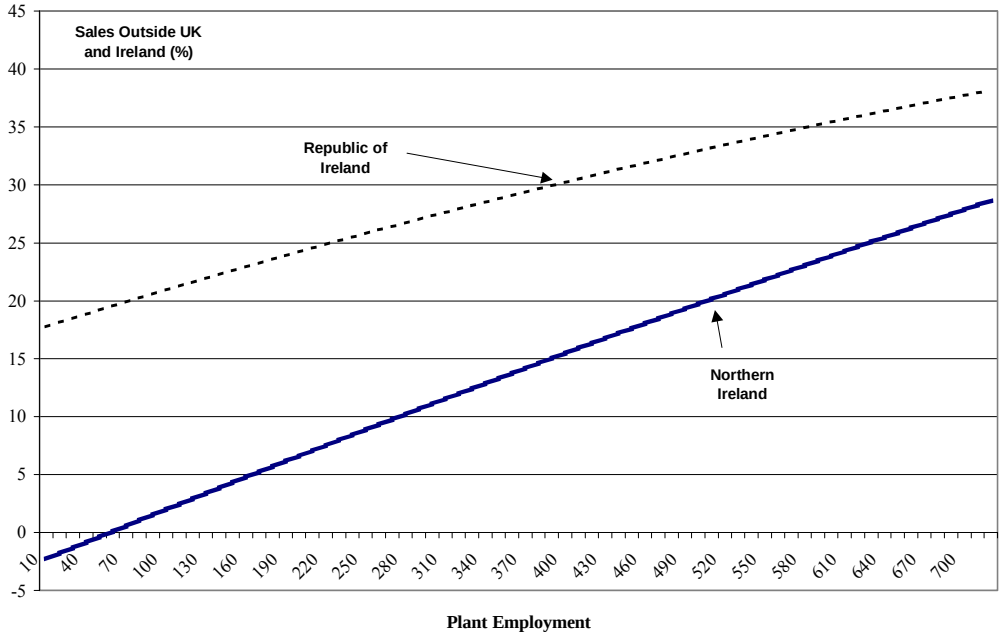
In policy terms, this study emphasises again the positive relationship between an aspect of business performance (i.e. export propensity), workforce quality and research and development. It also highlights, however, the continuing dependency of externally-owned plants in Ireland on inward technology-transfer and lower than expected export propensity on the part of small plants in Northern Ireland. Both issues present significant policy challenges for the future.

Figure 1: Real Exports Growth in Northern Ireland and the Republic of Ireland Since 1991



Sources: See Annex

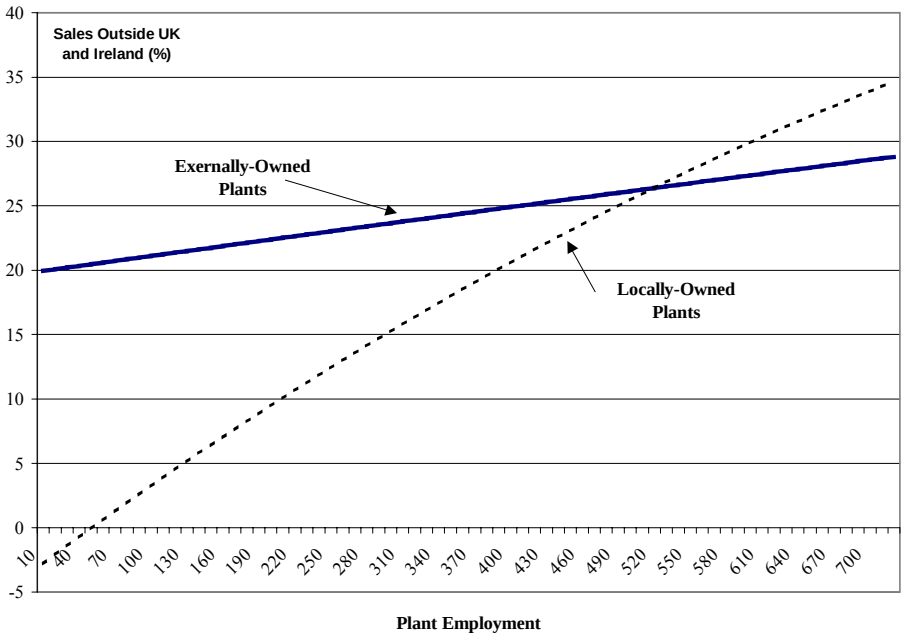
Figure 2: Predicted Export Propensity By Plant Size: Northern Ireland and the Republic of Ireland



Note: Predicted values relate to sales outside the UK and Ireland only, and were constructed using estimated parameters in Table 5. Variable values are set to the mean for Northern Ireland and the Republic of Ireland.

Source: Irish Innovation Panel, Table 5.

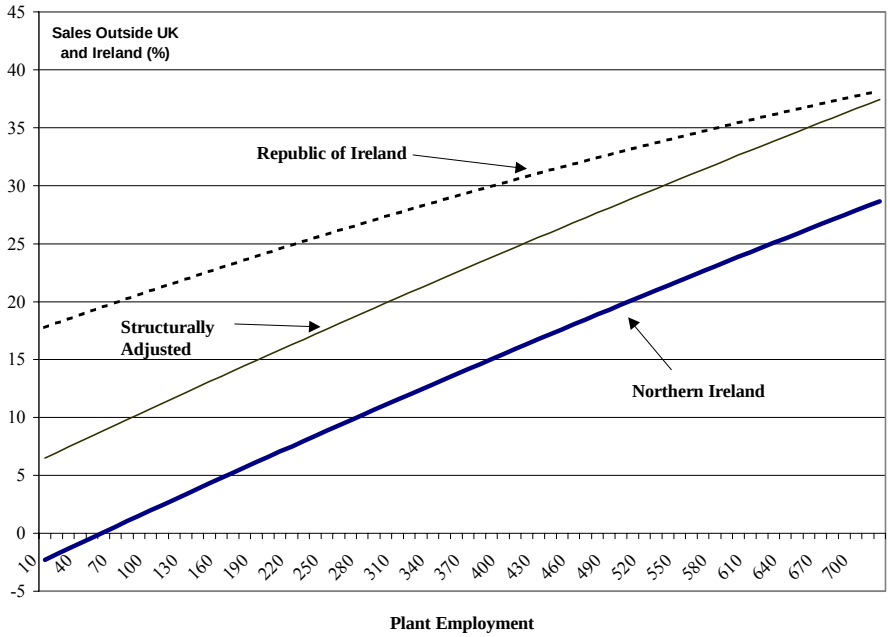
Figure 3: Predicted Export Propensity of Locally and Externally-Owned Plants



Note: Predicted values relate to sales outside the UK and Ireland only, and were constructed using the estimated parameters reported in Table 6. Variables are set to the mean for externally-owned and locally-owned plants.

Source: Irish Innovation Panel, Table 6.

Figure 4: Predicted and Structurally Adjusted Export Propensity By Area



Note: For details of derivation of Northern Ireland and Republic of Ireland series see note to Figure 2. Structurally adjusted line is the result of estimated relationship for Northern Ireland (Table 5) and average plant characteristics in the Republic of Ireland.

Table 1: Manufacturing Export Growth and Composition: 1991-99

	1991	1993	1995	1997	1999
A. Republic of Ireland (%)					
Food, Drink and Tobacco	25.3	25.6	22.6	13.8	10.4
Textiles, Clothing and Leather	6.9	5.4	4.4	3.4	2.0
Chemicals & Man-made Fibres	19.5	22.2	21.7	29.2	35.8
Basic Metals & Fabricated Metal Products and other Machinery and Equipment	10.0	7.2	6.6	6.1	4.3
Electrical & Optical Equip.	31.5	34.1	40.0	43.2	43.9
Transport Equipment	1.4	1.0	0.9	1.1	1.2
Other Manufacturing inc. R & P and Coke and Petroleum Products	5.6	4.5	3.7	3.2	2.4
Total Manufacturing (%)	100.0	100.0	100.0	100.0	100.0
Total Manufacturing £IRm 1995	**14012**	**16782**	**23199**	**29619**	**44177**
B. Northern Ireland					
Food, Drink & Tobacco	30.7	29.3	26.9	25.1	26.3
Textiles, Clothing & Leather	17.2	17.9	17.1	16.3	11.5
Chemicals & Man-made Fibres	9.0	8.3	8.1	6.9	5.3
Basic Metals & Fabricated Metal Products and other Machinery and Equipment	7.9	11.4	11.5	10.5	9.4
Electrical & Optical Equip.	8.1	9.5	11.2	13.3	17.6
Transport Equipment	14.8	11.3	11.6	14.5	16.4
Other Manufacturing inc. R & P and Coke and Petroleum Products	12.2	12.5	13.6	13.4	13.5
Total Manufacturing (%)	100.0	100.0	100.0	100.0	100.0
Total Manufacturing (£m Stg 1995)	**5039**	**4936**	**5824**	**6652**	**8207**

Notes and Sources: See Annex 1.

Table 2: Structure of Irish Innovation Panel

Surveys	Northern Ireland		Republic of Ireland		All Plants	
	Plants	Obser-vations	Plants	Obser-vations	Plants	Obser-vations
2nd and 3rd	146	403	198	549	344	952
2nd only	147	252	261	436	408	688
3rd only	273	273	438	438	711	711
Total	566	928	897	1423	1463	2351

Source: Irish Innovation Panel

Table 3:Descriptive Data

	Republic of Ireland		Northern Ireland	
	1996	1999	1996	1999
Number of Observations	459	636	293	419
Export Propensity (% sales)	**35.3**	**30.7**	**15.5**	**17.8**
Internal Resource Indicators				
Workforce with degree (mean %)	9.2	9.2	6.6	7.4
Informal R&D Only (% plants)	26.6	27.5	28.0	27.7
R&D Dept In Plant (% plants)	25.5	26.6	17.0	18.5
R&D Elsewhere In Group (% plants)	37.8	29.7	18.5	19.0
Plant Size (Employment)	153.6	114.6	124.4	113.5
Other Plant Characteristics				
Age Of Plant (Years)	27.5	25.6	36.5	31.5
Externally-Owned (% plants)	40.6	29.8	10.7	13.2
Small Batch Production (% plants)	43.7	39.3	48.1	40.7
Large Batch Production (% plants)	38.7	26.9	32.0	29.0
Industry Indicators (% plants)				
Food, Drink	19.4	16.2	18.1	17.9
Textiles, Clothing	9.2	8.0	16.7	15.5
Wood and Wood Prods	5.5	3.6	7.9	5.0
Paper and Printing	7.4	6.3	6.5	7.2
Chemicals etc	10.2	8.0	4.1	3.3
Metals, Fabrication	9.4	11.5	6.8	10.3
Mechanical Engineering	5.7	8.0	10.9	6.7
Electronics, Optical	18.3	16.4	5.5	7.2
Transport Equipment	3.7	2.8	3.4	4.3
Other Manufacturing	11.3	19.2	20.1	22.7

Note: Export propensity relates to sales outside the UK and Ireland.
Source: Irish Innovation Panel

Table 4: Tobit Models of the Export Propensity of Irish Manufacturing Plants

	Basic Tobit		Random Effects Tobit	
	Coeff.	t-stat	Coeff	t-stat.
Constant	-17.084	(-4.54)	-16.780	(-4.57)
Internal Resource Indicators				
Workforce With Degree (%)	0.416	(3.77)	0.390	(3.36)
Informal R&D Only	10.219	(3.82)	10.373	(4.1)
R&D Dept In Plant	17.550	(5.89)	17.903	(5.7)
R&D Elsewhere In Group	4.669	(1.48)	4.516	(1.45)
Plant Size (Employment)	0.026	(3.27)	0.025	(3.36)
Plant Size (Employment)2	-0.035	(-2.00)	-0.034	(-1.64)
Other Plant Characteristics				
Age Of Plant (Years)	-0.057	(-1.41)	-0.058	(-1.77)
Externally-Owned	31.368	(9.38)	31.173	(9.33)
Small Batch Production	2.308	(0.99)	2.693	(1.11)
Large Batch Production	6.059	(2.47)	6.234	(2.47)
Northern Ireland Plant	-6.998	(-2.85)	-7.227	(-3.07)
Industry Dummies				
Food, Drink	2.571	(0.65)	2.617	(0.76)
Textiles, Clothing	21.021	(4.92)	20.754	(4.97)
Wood and Wood Prods	-8.017	(-1.28)	-7.721	(-1.16)
Paper and Printing	-8.409	(-1.43)	-8.548	(-1.4)
Chemicals etc	28.396	(5.51)	28.511	(5.53)
Metals, Fabrication	5.255	(1.15)	4.366	(1.04)
Mechanical Engineering	16.906	(3.5)	15.853	(3.22)
Electronics, Optical	25.582	(6.01)	25.622	(6.16)
Transport Equipment	18.696	(2.92)	18.433	(2.83)
σ_ε	37.451	(38.38)		
σ_u			37.345	(24.15)
σ_α			3.735	(0.43)
N	1327		1322	
Log Likelihood	-4489.70		-4484.48	

Source: Irish Innovation Panel

Table 5: Tobit Models for Export Propensity of Northern Ireland and Republic of Ireland plants

	Republic of Ireland		Northern Ireland	
	Coeff	t statistic	Coeff	t statistic
Constant	-13.650	(-2.94)	-28.244	(-5.23)
Internal Resource Indicators				
Workforce With Degree (%)	0.270	(2.13)	0.827	(4.07)
Informal R&D Only	7.802	(2.37)	17.073	(3.97)
R&D Dept In Plant	13.683	(3.94)	22.602	(4.20)
R&D Elsewhere In Group	3.414	(0.89)	7.498	(1.40)
Plant Size (Employment)	0.036	(3.23)	0.048	(2.98)
Plant Size (Employment)^2	-0.100	(-2.59)	-0.061	(-2.17)
Other Plant Characteristics				
Age Of Plant (Years)	-0.225	(-3.86)	0.092	(1.73)
Externally-Owned	36.309	(9.21)	11.484	(1.89)
Small Batch Production	2.760	(0.97)	0.039	(0.01)
Large Batch Production	8.235	(2.81)	-0.516	(-0.12)
Industry Dummies				
Food, Drink	10.169	(2.06)	-8.950	(-1.42)
Textiles, Clothing	27.050	(4.78)	11.235	(1.82)
Wood and Wood Prods	-8.712	(-1.07)	-8.242	(-0.91)
Paper and Printing	-12.656	(-1.69)	2.649	(0.30)
Chemicals etc	32.756	(5.55)	4.055	(0.39)
Metals, fabrication	-2.781	(-0.49)	21.312	(2.96)
Mechanical Engineering	14.925	(2.46)	17.225	(2.34)
Electronics, Optical	24.623	(4.95)	24.882	(3.11)
Transport Equipment	23.165	(2.94)	3.928	(0.37)
σ_ε	36.217	(31.89)	35.935	(21.49)
N	837		490	
Log Likelihood	-2999.81		-1460.89	

Note: Both equations are standard Tobit models. The individual component of the error in the random effects model was insignificant (Northern Ireland, t statistic = 0.328; Republic of Ireland, t statistic = 0.223). Omitted industry dummy variable relates to Other Manufacturing nes.
Source: Irish Innovation Panel

Table 6: Tobit Models of Export Propensity of Indigenously and Externally-Owned Plants

	Externally-Owned		Indigenously-Owned	
	Coeff.	t statistic.	Coeff	t statistic
Constant	-13.770	(-2.23)	-22.276	(-5.39)
Internal Resource Indicators				
Workforce With Degree (%)	0.331	(2.16)	0.550	(4.06)
Informal R&D Only	2.929	(0.69)	13.958	(4.80)
R&D Dept In Plant	8.375	(2.00)	25.234	(7.11)
R&D Elsewhere In Group	11.995	(3.20)	-2.134	(-0.58)
Plant Size (Employment)	0.013	(1.75)	0.069	(4.64)
Plant Size (Employment)2	-0.007	(-0.40)	-0.224	(-3.50)
Other Plant Characteristics				
Age Of Plant (Years)	-0.133	(-1.84)	-0.026	(-0.61)
Small Batch Production	-0.643	(-0.18)	1.143	(0.44)
Large Batch Production	7.208	(2.03)	2.519	(0.91)
Northern Ireland Plant	-20.428	(-4.92)	-3.634	(-1.42)
Industry Dummies				
Food, Drink	2.453	(0.38)	8.600	(2.12)
Textiles, Clothing	14.304	(1.76)	20.087	(4.52)
Wood and Wood Prods	-4.989	(-0.45)	-1.759	(-0.28)
Paper and Printing	-18.247	(-1.61)	-5.428	(-0.94)
Chemicals etc	33.436	(4.95)	22.553	(3.30)
Metals, fabrication	22.110	(2.65)	3.037	(0.62)
Mechanical Engineering	35.052	(4.24)	11.312	(2.20)
Electronics, Optical	35.213	(6.15)	21.739	(4.09)
Transport Equipment	30.795	(3.40)	11.410	(1.48)
σ_ε	35.387	(27.46)	36.732	(32.41)
Number of Observations	485		1080	
Log Likelihood	-2084.59		-3318.06	

Note: Both equations are standard Tobit models. The individual component of the error in the random effects model was insignificant (externally-owned, t statistic = 0.249; indigenously-owned, t statistic = 0.317). Omitted industry dummy variable relates to Other Manufacturing nes.
Source: Irish Innovation Panel

Table 7: Tobit Models of Export Propensity of Small and Larger Irish Plants

	Large Plants		Small Plants	
	Coeff.	t statistic	Coeff	t statistic
Constant	-1.198	(-0.22)	-47.388	(-4.16)
Internal Resource Indicators				
Workforce With Degree (%)	0.547	(3.67)	0.473	(3.29)
Informal R&D Only	1.705	(0.46)	10.743	(2.97)
R&D Dept In Plant	8.180	(2.33)	17.761	(3.33)
R&D Elsewhere In Group	1.567	(0.44)	7.768	(1.30)
Plant Size (Employment)	0.009	(1.11)	1.792	(2.39)
Plant Size (Employment)2	-0.003	(-0.19)	-186.853	(-1.50)
Other Plant Characteristics				
Age Of Plant (Years)	-0.028	(-0.61)	-0.151	(-2.03)
Externally-Owned	21.990	(5.78)	34.727	(5.51)
Small Batch Production	5.441	(1.78)	2.015	(0.58)
Large Batch Production	6.179	(2.07)	-0.287	(-0.07)
Northern Ireland Plant	-12.398	(-3.78)	-1.929	(-0.47)
Industry Dummies				
Food, Drink	2.712	(0.51)	-4.759	(-0.83)
Textiles, Clothing	18.982	(3.28)	14.442	(2.23)
Wood and Wood Prods	-7.496	(-0.78)	-5.598	(-0.72)
Paper and Printing	-14.042	(-1.67)	-11.255	(-1.21)
Chemicals etc	37.365	(5.88)	3.327	(0.32)
Metals, fabrication	9.991	(1.42)	-3.537	(-0.59)
Mechanical Engineering	29.602	(4.15)	3.929	(0.52)
Electronics, Optical	27.524	(5.12)	16.448	(1.96)
Transport Equipment	30.310	(3.75)	-4.462	(-0.38)
σ_ε	34.376	(30.41)		
σ_u			30.010	(13.74)
σ_α			24.383	(7.83)
N	631		692	
Log Likelihood	-2574.83		-1854.00	

Note: Small Plants are those with 50 or less employees. The equation for larger plants is the standard Tobit model as the individual t-component of the error in the random effects model was insignificant (t statistic=0.326). For smaller firms the model reported includes random effects. Omitted industry dummy variable relates to Other Manufacturing nes.
Source: Irish Innovation Panel

Annex: Northern Ireland and Republic of Ireland Exports Data

For the Republic of Ireland nominal exports data is available from 1991 is published in Trade Statistics, (CSO, Dublin) on the basis of the SITC (Rev 3). For Northern Ireland data based on the 2-digit SIC 1980 and sic 1992 have been published in 'Made in Northern Ireland Sold to the World' (various dates, NIERC, Belfast). A consistent time-series for all Northern Ireland manufacturing was published in Appendix 2 of the 1997/98 to 98/99 report. Consistent data for industrial groups was provided by Maureen O'Reilly and Catherine Glass (NIERC)[16]. The main issue in making any Northern Ireland-Republic of Ireland comparisons is matching SIC and SITC based series. (In addition, the Republic of Ireland exports data is reported for calendar years whereas the Northern Ireland exports series relate to financial years). The approximate matches used are given in Table A1. The resulting nominal series are given in Table A2 with Northern Ireland data in £m. and Republic of Ireland data in £IRm. Nominal series were deflated using export price deflators taken from Table 1, Trade Statistics August 2000, CSO Dublin and Table 1.21 (series BQKR), Economic Trends Annual Supplement 2000, National Statistics. Real export series (in 1995 prices) are given in Table A3.

Table A1: Sectoral Definitions Using SIC and SITC Codes

	Republic of Ireland	Northern Ireland
	SITC (Rev 3) Codes	SIC 92 Codes
Food, Drink & Tobacco	01-12, 29, 41-43	15-16
Textiles, Clothing & Leather	21, 26, 61, 65, 82-85	17-19
Chemicals & Man-made Fibres	27, 51-56, 59	24
Basic Metals & Fabricated Metal Products and Other Machinery & Equipment	28, 67-9, 71-74	27-29
Electrical & Optical Equipment	75-77, 87, 88	30-33
Transport Equipment	78, 79	34-35
Other Manufacturing (including Coke & Petroleum products n.e.s, Wood & Wood Products, Paper & Printing, Other Non-Metallic Mineral Products)	23, 32-34, 57, 58, 62, 24, 63, 81, 25, 64, 66	23, 25, 36-37, 20, 21-22, 26

[16] Note that in the Northern Ireland exports reports 'exports' are taken as sales outside the UK. Here we use the term 'exports' to refer to any sales outside Northern Ireland whether to GB or elsewhere. This is called 'external sales' in the Northern Ireland exports reports.

Table A2: Nominal Export Series for Northern Ireland and the Republic of Ireland: 1991-99

	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. Republic of Ireland Export Sales (£IR million)									
Food, Drink and Tobacco	3322	4000	4220	4638	5252	4612	4119	4449	4752
Textiles, Clothing and Leather	906	938	889	1015	1027	1025	1016	1049	922
Chemicals & Man-made Fibres	2,565	3,086	3,662	4,631	5,038	6,575	8,705	14,081	16,362
Basic Metals & Fabricated Metal Products	1,310	1,230	1,191	1,382	1,528	1,616	1,824	1,871	1,984
And other Machinery and Equipment									
Electrical & Optical Equip.	4,138	4,305	5,621	6,715	9,283	10,341	12,861	16,612	20,074
Transport Equipment	181	174	168	189	203	234	324	558	562
Other Manufacturing inc. R & P and	736	800	747	820	867	899	948	998	1110
Coke and Petroleum Products									
Total Manufacturing	**13157**	**14532**	**16497**	**19389**	**23199**	**25301**	**29797**	**39620**	**45767**
B. Northern Ireland Export Sales (£Stg million)									
Food, Drink & Tobacco	1283	1323	1372	1401	1566	1483	1588	1657	1939
Textiles, Clothing & Leather	718	755	837	898	999	1040	1031	967	847
Chemicals & Man-made Fibres	376	417	387	427	471	450	438	399	393
Basic Metals & Fabricated Metal Products	330	360	536	646	670	641	668	705	691
And other Machinery and Equipment									
Electrical & Optical Equip.	338	368	445	530	653	767	842	1025	1297
Transport Equipment	619	638	528	612	673	751	917	1017	1206
Other Manufacturing inc. R & P and	508	542	585	704	792	834	849	916	997
Coke and Petroleum Products									
Total Manufacturing	**4172**	**4402**	**4689**	**5217**	**5824**	**5967**	**6333**	**6686**	**7370**

Table A3: Real Export Series for Northern Ireland and the Republic of Ireland: 1991-99

	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. Republic of Ireland (£IR95 million)									
Food, Drink and Tobacco	3538	4376	4293	4723	5252	4640	4094	4311	4587
Textiles, Clothing and Leather	964	1026	905	1034	1027	1031	1010	1017	890
Chemicals & Man-made Fibres	2731	3376	3725	4716	5038	6614	8653	13645	15793
Basic Metals & Fabricated Metal Products and other Machinery and Equipment	1395	1346	1211	1407	1528	1626	1813	1813	1915
Electrical & Optical Equip.	4407	4710	5718	6838	9283	10403	12785	16097	19377
Transport Equipment	193	190	171	192	203	235	322	541	543
Other Manufacturing inc. R & P and Coke and Petroleum Products	784	875	760	835	867	904	942	967	1071
Total Manufacturing	**14012**	**15899**	**16782**	**19744**	**23199**	**25454**	**29619**	**38391**	**44177**
B. Northern Ireland (£Stg95 million)									
Food, Drink & Tobacco	1549	1565	1444	1445	1566	1472	1668	1835	2159
Textiles, Clothing & Leather	867	893	881	927	999	1032	1083	1071	943
Chemicals & Man-made Fibres	454	494	408	441	471	447	460	442	438
Basic Metals & Fabricated Metal Products And other Machinery and Equipment	399	426	564	667	670	635	702	781	769
Electrical & Optical Equip.	408	435	468	547	653	761	885	1135	1444
Transport Equipment	748	755	556	632	673	745	964	1126	1343
Other Manufacturing inc. R & P and Coke and Petroleum Products	614	641	615	726	792	827	892	1014	1110
Total Manufacturing	**5039**	**5209**	**4936**	**5384**	**5824**	**5920**	**6652**	**7404**	**8207**

References

Anderton B (1999) 'UK trade performance and the role of product quality, innovation and hysteresis: some preliminary results', *Scottish Journal of Political Economy*, 46, 570-595

Anderton B (1999a) 'Innovation, product quality, variety, and trade performance: an empirical analysis of Germany and the UK, *Oxford Economic Papers*, 51, 152-167.

Baltagi B H (1995) *'Econometric analysis of panel data'*, Wiley.

Barry F (1999) '*Understanding Ireland's Economic Growth'*, Macmillan, London.

Barry F and Bradley J (1997) 'FDI and Trade: The Irish Host-Country Experience', *Economic Journal*, 107, November 1798-1811.

Bell J (1997) 'The Role of Export Promotion Organisations' in '*Competing From the Periphery'*, Fynes, B and Ennis, S (Eds.), Oaktree Press, Dublin.

Bernard A B and Jensen J B (1999) 'Exceptional export performance: cause, effect, or both?' *Journal of International Economics***,** 47, 1-25.

Bernard A B and Wagner J (1997) 'Exports and success in German manufacturing' *Weltwirtschaftliches Archiv*, 133, 134-157.

Braunerhjelm P (1996) 'The relation between firm-specific intangibles and exports', *Economics Letters*, 53, 213-219.

Buxton T, Mayes D and Murfin A (1991) 'UK Trade Performance and R&D', *Economics of Innovation and New Technology*, 1, 243-256

Coe N (1997) 'US Transnationals and the Irish Software Industry', *European Urban and Regional Studies*, 4, 3, 211-230.

Crone M (1998) 'Inward Investment and External Ownership in Northern Ireland Manufacturing: Historical Trends and Recent Developments', mimeo, NIERC.

Crone M (2000) 'Computer Services and Software Employment in the UK and Ireland', 1991-97, NIERC Report No 16.

Demick D H and O'Reilly A J (2000) 'Supporting SME Internationalisation: A Collaborative Project for Accelerated Export Development', Irish Marketing Review, 13, 1, 34-45.

Forfás (2000) 'International Trade and Investment Report, 2000', Report by Forfás to the Trade Advisory Forum and the Foreign Earnings Committee, December, Dublin.

Görg H and Ruane F (2000) 'An Analysis of Backward Linkages in the Irish Electronics Sector', *The Economic and Social Review*, 31, 3, 215-235.

Gray A (1997) '*International Perspectives on the Irish Economy'*, Indecon, Dublin.

Greenhalgh (1990) 'Innovation and Trade Performance in the UK', *Economic Journal*, 100, 105-118.

Hamerle A and Ronning G (1995) 'Panel Analysis for Qualitative Variables', in *Handbook of Statistical Modeling for the Social and Behavioural Sciences*, Arminger G, Clogg C C and Sobel M E (eds.), Plenum Press, New York.

Kleinknecht A (1987) 'Measuring R&D in Small Firms: How Much are we Missing?', *Journal of Industrial Economics*, 36, 253-256.

Kleinknecht A (1989) 'Firm Size and Innovation: Observations in Dutch Manufacturing Industries', *Small Business Economics*, 215-222.

Kleinknecht A, Poot T P and Reijnen O N (1991) 'Formal and Informal R&D and Firm Size: Survey Results from the Netherlands', in *Innovation and Technical Change*, Acs, Z J and Audretsch, D B (eds), Harvester Wheatsheaf, Hemel Hempstead.

Kumar N and Siddharthan N S (1994) 'Technology, Firm Size and Export Behaviour in Developing Countries', *Journal of Development Studies*, 32, 288-309.

Mackinnon I (1997) 'Using Young Blood to Revive Export Business', *People Management*, 3, 16, 40-41.

McCarthy J (1999) '*Foreign Direct Investment: An Overview'*, Central Bank of Ireland, Autumn, p. 55-65.

Metcalfe S (1997) 'Technology Systems and Technology Policy in an Evolutionary Framework', in *Technology, Globalisation and Economic Performance*, Archibugi D and Michie J (eds), Cambridge University Press.

Murphy A E (2000) '*The Celtic Tiger – An Analysis of Ireland's Economic Growth Performance'*, Robert Schuman Centre for Advanced Studies EUI Working Paper 2000/16.

Nelson R R (1993) '*National Innovation Systems: A Comparative Analysis'*, Oxford University Press.

Roper S and Anderson J (2000) '*Innovation and E-Commerce – A Cross-Border Comparison of Irish Manufacturing Plants'*, NIERC Research Report 17.

Roper S and Hewitt-Dundas N (1998) '*Innovation, Networks and the Diffusion of Manufacturing Best Practice'*, NIERC Research Report 14, April, NIERC, Belfast.

Roper S and Frenkel A (2000) 'Different Paths to Success? The Electronics Industry in Israel and Ireland', *Environment and Planning C*, 18, 651-665.

Roper S and Love J H (2001) 'Innovation and Export Performance: Evidence from UK and German Manufacturing Plants', *Research Policy*, Forthcoming

Roper S, Ashcroft B, Love J H, Dunlop S, Vogler-Ludwig K and Hofmann H (1996) 'Product Innovation and Development in UK, German and Irish Manufacturing Firms', NIERC/Fraser of Allander Institute.

Ruane F and Görg H (1997) 'The Impact of Foreign Direct Investment on Sectoral Adjustment in the Irish Economy', *National Institute Economic Review*, 2, 76-86.

Seringhaus F H R (1986) 'The Impact of Government Export Marketing Assistance', *International Marketing Review*, 3,2, 55-65.

Seringhaus F H R and Rossen P J (1990) '*Government Export Promotion: A Global Perspective'*, Routledge, London.

Sterlacchini A (1999) 'Do innovative activities matter to small firms in non-R&D-intensive industries? An application to export performance', *Research Policy*, 28, 819-832.

Sweeney P (1998) '*The Celtic Tiger – Ireland's Economic Miracle Explained'*, Oak Tree Press, Dublin.

Thirwall A (1986) *Balance of Payments Theory and the UK Experience*, Macmillan, London.

Veugelers R and Cassiman B (1999) 'Make and buy in innovation strategies: evidence from Belgian manufacturing firms', *Research Policy*, 28, 63-80.

Wagner J (1995) 'Exports, firm size, and firm dynamics', *Small Business Economics*, 7, 29-39.

Wakelin K (1998) 'The role of innovation in bilateral OECD trade performance', *Applied Economics*, 30, 1335-1346

Wakelin K (1998a) 'Innovation and Export Behaviour at the Firm Level', *Research Policy*, 26, 829-841.

Willmore L (1992) 'Transnationals and Foreign Trade: Evidence from Brazil', *Journal of Development Studies*, 28, 314-335.

Wrynn J (1997) 'Foreign Direct Investment to a Peripheral Country – The Case of Ireland' in Fynes, B and Ennis, S (eds) '*Competing From the Periphery'*, Oaktree Press, Dublin.

Yearly S (1995) 'From One Dependency to Another: The Political Economy of Science Policy in the Irish Republic in the Second Half of the Twentieth Century, *Science, Technology and Human Values*, 20, 2, 171-196.