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Working Paper No. 297

May 2009

# Exporting and Ownership Contributions to Irish Manufacturing Productivity Growth

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*Abstract*: This paper combines a literature identifying the sources of productivity growth with a literature exploring differences between the characteristics of exporters and non-exporters to examine the contributions of exporters and non-exporters to aggregate labour productivity growth in the Irish manufacturing sector between 1998 and 2004. Using the Breunig and Wong (2007) decomposition technique, we uncover the contributions to aggregate labour productivity of continuing, entering and exiting firms based on exporting and ownership status. We find that within-firm productivity growth of exporters drives overall productivity growth, with significant differences apparent between productivity growth rates of foreign and domestic owned establishments.

*Keywords*: Exporters; productivity; decomposition; reallocation; manufacturing,

*JEL Classifications*: D24 F10 J24

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† The authors are grateful to the Central Statistics Office (CSO) of Ireland for the provision of data used in this study. To facilitate the research conducted the CSO gave the authors controlled access to anonymised micro data; this access is provided for in the Statistics Act, 1993 and was at all times within the CSO's premises under stringent conditions. Special thanks to Mr Kevin Phelan of the CSO for assistance with the data and also to Dr Stefanie Haller of the ESRI. We are grateful for financial support for this research from the Irish Research Council for the Humanities and Social Sciences.

# Exporting and Ownership Contributions to Irish Manufacturing Productivity Growth

## 1. Introduction

In recent years there has been an abundance of empirical literature exploring the link between exporting and productivity using firm-level data. Much of this has focused on the characteristics of exporters relative to non-exporters (for example, Bernard and Jensen, 1995 and 1999; Bernard and Wagner, 1997; Ruane and Sutherland, 2005) and on the *ex ante* and *ex post* performance of exporters. These studies have shed some light on firm heterogeneity in international trade (see Melitz, 2003) and have fed into the debate on whether higher exporter productivity at firm level is due to self-selection (higher-productivity firms deciding to export) or learning-by-exporting.[1] However, as pointed out by Harris and Li (2008), there appears to be little attention in the literature to the significance of exporters to overall productivity growth, in other words, on the scale of the contribution that exporters make to productivity performance.

Many countries directly promote export activity on the basis that exporting provides expanded market opportunities and generates benefits to exporters from exposure to knowledge and innovation spillovers that can arise through interacting with foreign markets. At the very least, exporting allows manufacturers to specialise in a range of products and to increase their scale of production (Aw, Chung and Roberts, 2000). This is particularly important for small economies where the size of the domestic market may prevent firms from achieving minimum efficient scale (Hansson and Lundin, 2004), and hence the potential for productivity improvements through exporting are likely to be greater.[2] Other potential benefits for export promotion may be generated through the number, quality and longevity of jobs as exporters are regarded as "good firms" (Bernard and Jensen, 1999).

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[1] For extensive literature reviews on this subject see Greenaway and Kneller (2007) and Wagner (2007).
[2] Exporting may not be so important for firms where the domestic market is large and scale efficiencies have already been achieved, such as Canada, the UK, and especially the US, where most of the empirical work to date on exporter productivity has been undertaken.

In this paper we contribute further to the literature by exploring the exporter contribution to productivity growth using a new technique that allows a dynamic decomposition of elements underlying this growth in the Irish manufacturing sector. The decomposition technique, developed by Breunig and Wong (2007), allows us to distinguish how productivity growth over a given time period can be attributed to exporters and non-exporters, and the extent to which exporter contributions arise in continuing, entering and exiting firms.[3] In a development on existing papers, we distinguish between foreign-owned establishments (FOEs) and domestic-owned establishments (DOEs), since we expect their export patterns to differ.[4] In addition, we explore the impact of the business cycle on the pattern of contributions to productivity growth. We use a plant[5] level data set constructed from the Irish annual Census of Industrial Production for the period 1997 to 2004 to explore the following five questions:

(i) How much do exporters contribute overall to total productivity growth?
(ii) How important are continuing firms relative to new exporters to that growth?
(iii) How do the dynamics of exporter productivity growth differ between domestic and foreign-owned firms?
(iv) Do the exporting firms that cease production have lower productivity on average than those which continue?
(v) Is there evidence of a business cycle dimension to labour productivity growth?

In support of the literature that suggests that exporters have higher productivity than non-exporters, we find that exporters are indeed the major drivers of labour productivity growth in Irish manufacturing, and most of the productivity growth is due to the increased intra-firm productivity growth of continuing exporters. We find that both continuing and FOEs contribute significantly to productivity growth. In contrast, entering DOEs, both

[3] It represents an improvement on the two traditional methods of productivity decomposition, namely, Griliches and Regev (1995) and Foster, Haltiwanger and Krizan (2001)
[4] This distinction is particularly important in the Irish context, since Irish manufacturing is dominated by a large export-oriented FOE sector which has developed under government support for an export-led growth strategy for over 40 years – these FOEs are encouraged to locate in Ireland as a base for exporting to the European market.
[5] The terms plant, firm, and establishment are used interchangeably throughout this paper to describe a local unit, that is, a manufacturing production unit.

exporters and non-exporters, have below average labour productivity. In the case of all DOEs and FOE exporters, we find that firms ceasing production have lower average productivity, resulting in a consistently positive exit effect.

This paper proceeds as follows: Section 2 sets the context of this research by discussing some of the recent theoretical and empirical literature on the relationship between exporting and productivity. Section 3 presents some empirical background and describes the data set and variables. In Section 4 the new decomposition technique by Breunig and Wong (2007) is outlined, and set in the context of the two traditional decomposition methods, Griliches and Regev (1995) and Foster, Haltiwanger and Krizan (2001). The analysis covers the period 1998 – 2004, and sub-analyses for the periods 1998-2001 and 2001-2004 are also undertaken. The results of our Breunig and Wong (2007) decompositions of labour productivity growth are presented in Section 5 together, with the Griliches and Regev (1995) and Foster, Haltiwanger and Krizan (2001) results used as robustness checks. Section 6 concludes.

## 2. Literature

Recently new dynamic models of international trade incorporating firm heterogeneity have been developed (for example, Melitz, 2003), based on the industrial organisation literature on firm dynamics (for example, Hopenhayn, 1992). These models provide solid micro foundations to underpin the recent empirical findings on firms' export heterogeneity. Their focus is on the decisions of firms, with *ex-ante* unknown productivity, which face a fixed or sunk cost associated with entry into an industry and face further costs (fixed and variable) if, following successful entry, they decide to export. These latter trade costs are seen as significant, resulting in the self-selection of only the most productive firms into the export market. The models show how exposure to trade leads to resource reallocations from less efficient to more efficient firms and industries over time. These models also provide a framework for empirical studies that seek to explain the relationship between trade and productivity at firm level.

Policy in many countries promotes export activity on the basis that exporting firms are 'good' firms possessing superior performance characteristics relative to non-exporters. In the past decade there has been an increasing empirical literature on the productivity and

other characteristics of exporters compared to non-exporters. The general findings of these studies are that exporting firms are likely to be substantially larger than non-exporters, in terms of employment and shipments (e.g. Bernard and Jensen, 1995, 2004; Hansson and Lundin, 2004). Compared to non-exporters, they are also more likely to have larger capital stocks (Bernard and Jensen, 1995 and Clerides, Lach and Tybout, 1998); pay higher wages (Bernard and Jensen, 1995); use more human capital (Bernard and Wagner, 2001) and face fewer financial constraints (Greenaway et al, 2005). Extensive empirical research has also shown that exporters are more productive *ex ante* than non-exporters, suggesting that they self-select into the export market. There are mixed results on the *ex post* productivity performance of exporters, i.e., on whether 'learning by exporting' is important.[6] Exporting firms are generally found to be larger, pay higher wages, employ more advanced technologies and have higher productivity than non-exporters.

There are two papers that have explored differences between exporters and non-exporters in Ireland. Girma, Görg and Strobl (2004) examine the performance differences between exporters and non-exporters in Irish manufacturing using non-parametric stochastic dominance techniques. Using a large cross-section plant-level data set for the year 2000, [7] they find that domestic exporters do not outperform non-exporters on the three measures of performance examined: sales per employee, value-added per employee and net profit per employee. Ruane and Sutherland (2005) use an eight-year panel data set to explore the performance characteristics of domestic exporters and non-exporters in Irish manufacturing.[8] In contrast to Girma *et al* (2004), they find that exporters are the superior performers across seven performance characteristics.

Within the existing literature there has been some attempt to quantify the contribution of exporting to aggregate productivity growth, drawing on the general approach to

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[6] See Greenaway and Kneller (2007) and Wagner (2007) for extensive surveys of the recent empirical literature on productivity and exporting.

[7] This data set covers manufacturing plants with at least 10 employees. The data are collected by the Irish policy development agency, Forfás, as part of its *Annual Business Survey of Economic Impact*.

[8] Their data come from the Central Statistics Office Annual Census of Industrial Enterprises for the period 1991 to 1998

productivity decomposition analyses developed during the 1990s.[9] For example, Baldwin and Gu (2003), using data from the Canadian Annual Survey of Manufactures for the period 1973-1997, decompose labour productivity growth in manufacturing to determine the importance of exporters. They focus on the contributions of continuing and entering firms relative to the average productivity of exiting plants. Continuing plants are grouped on the basis of export status and export intensity, while new plants are divided into exporters and non-exporters. They find that the most important contributors to aggregate labour productivity growth are continuing exporters, accounting for 74 per cent of aggregate productivity growth, with new plants that export accounting for 18 per cent of the growth between 1990 and 1996. In effect, little productivity growth comes from non-exporting firms and the contributions of continuing and new exporting firms increased over time.[10] One limitation of this paper is that the direct contributions of exiting firms to aggregate productivity growth are omitted from the analysis.

Bernard and Jensen (2004), using data from the US Census Bureau's Annual Survey of Manufactures for the period 1983-1992 find that, within the same industry, shipment and employment growth rates are higher for exporters while productivity growth rates are not significantly higher than for non-exporters.[11] They separate continuing plants, i.e. only plants that exist in years $t$ and $t$+1, into four groups: export stopper, exporter throughout, export starter, and non-exporter. They focus on the *within* plant and *reallocation* effects, where the latter is defined as the product of the change in output share and average total factor productivity (TFP) at plant level. They find that *within* firm effects account for 58 per cent of TFP growth of continuing plants in the manufacturing sector, while the remainder is due to *reallocations*. Exporters are the main drivers, accounting for 81 per cent of the *within* firm effect and virtually all of the *reallocation* effect. An important limitation of their study, in terms of productivity dynamics, is that it is limited to

[9] The most commonly used methodologies are by Griliches and Regev (1995) and Foster, Haltiwanger and Krizan (2001).
[10] They find that the contributions of continuing non-exporters are small (3.6 per cent) while those of new non-exporting plants and continuing plants that exit the export market contribute negatively.
[11] This finding is consistent with the idea that the scale and development of the US market is such that it is possible for firms to reach global productivity levels without exporting.

continuing firms, i.e., it excludes the contributions of entering and exiting plants, both exporters and non-exporters.

This same limitation applies to the study by of Swedish firms by Hansson and Lundin (2004). Using data covering all Swedish manufacturing firms employing at least 50 persons for the period 1990-99, they decompose TFP and labour productivity growth of continuing firms into within firm, within industry and between industry effects for both domestic and export components. They find that 78 per cent of labour productivity growth is attributable to the *within* firm productivity effect, 55 and 23 per cent for the export and domestic component components, respectively. They also find that *reallocation* effects from increasing export shipments have a positive effect on productivity growth. However, this is offset by the negative reallocation contributions resulting from changes in domestic shipments.

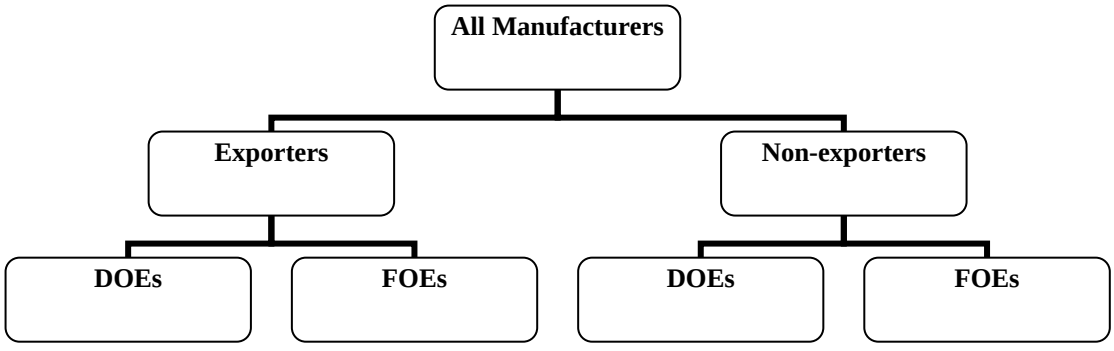
While there is some micro evidence on trade-induced aggregate productivity growth available for Canada (Baldwin and Gu, 2003), the US (Bernard and Jensen, 2004) and Sweden (Hansson and Lundin, 2004), Harris and Li (2008, p.220) point to "the paucity of evidence worldwide on aggregate productivity growth in the context of international trade". To address this they present a comprehensive study of the contribution of exporters and non-exporters to aggregate labour productivity and TFP growth across manufacturing and non-manufacturing sectors in the UK.[12] They follow the Foster, Haltiwanger and Krizan (2001) decomposition technique, which takes account of *within*, *between* and *cross* effects of continuing firms as well as the contributions of entering and exiting firms.[13] Overall they find that exporters are responsible 78 per cent of labour productivity growth in the manufacturing sector, 48 per cent of which is attributable to improved intra-firm productivity among continuing exporter firms. In the UK manufacturing sector they find that entering exporters contribute negatively but on a small

[12] Aggregate labour and total factor productivity changes are determined using geometric mean definitions, e.g., $\Delta \ln At = \ln A_t - \ln A_{t-k}$ where $A_t$ denotes aggregate labour productivity.
[13] Harris and Li use a weighted FAME dataset to investigate the contributions of exporters to aggregate productivity growth between 1996 and 2004.

scale to productivity growth while the contribution of exiting exporters and non-exporters contribute is positive.

Our paper adds to the emerging literature on the importance of exporting to aggregate productivity growth by investigating the contributions of continuing, entering and exiting firms by exporting status in the Irish manufacturing sector. Moreover, unlike previous studies, we distinguish between the contributions of foreign and domestic firms as performance dynamics are expected to differ by ownership. Helpman, Melitz and Yeaple (2004) show that only the most productive firms become MNEs, consequently we would expect FOEs to enter with a productivity advantage over DOE entrants. Furthermore, we use a new decomposition technique developed by Breunig and Wong (2007) [BW] to conduct this analysis. In addition, for comparative and robustness purposes, we also apply the Griliches and Regev (1995) [GR] and Foster, Haltiwanger and Krizan (2001) [FHK] decomposition techniques to our dataset. Figure 1 presents a schematic representation of the approach taken in the decomposition analysis. At each of three levels, we determine the contributions of continuing, entering and exiting plants: (i) we decompose the productivity change for manufacturing as a whole; (ii) we conduct a further decomposition by dividing firms into exporters and non-exporters, and (iii) we further decompose these two groups on the basis of ownership –foreign owned or domestic owned.

Figure 1 Schema of Decomposition of Labour Productivities by Exporter and Ownership Status




Note: We determine the contributions of continuing, entering and exiting plants, separately, at each stage.

## 3. Data

Ireland is one of the most open economies in the world in terms of international trade. Its current trade/GDP ratio is 75 compared with an OECD average of 45 and EU 15 average of 50. In terms of foreign direct investment (FDI), Ireland is also highly globalised economy,[14] hosting large numbers of FOEs in the manufacturing sector that have contributed significantly to the sector's growth in the last 20 years.[15] Most FDI in Irish manufacturing is export-platform investment, reflecting the fact that the local European markets rather than the small Irish domestic market is primary market attraction to inward FDI. For example, in 2006 exports accounted for 95.5 per cent the total sales of these companies. (IDA, 2007, p.26) As a consequence of the small size of the Irish economy and the importance of FDI, it is important to decompose the contributions to aggregate manufacturing productivity growth by ownership status.

Ireland's real GDP growth rates were particularly high between 1994 and 2000, averaging 8.9 per cent per year.[16] During this period, exports were seen as the key drivers of growth. In 2001 there was a slowdown in the world economy associated with, *inter alia,* a large increase in the price of oil, difficulties in the global ICT sectors, and the events of September 11. While the Euro area grew at an average rate of approximately 3 per cent per annum in 1998-2000, GDP growth slowed to less than 1 per cent in 2002 and 2003. Over the same period Ireland's growth fell from an average of 9 per cent per year for 1998-2000 to an average of 6.1 per cent in 2001-2002, and an average of 4.5 per cent in 2003-2004.[17] For domestic firms in particular, the source of demand growth switched from exports to domestic demand over the two periods. To explore the impact of the business cycle on the contributions of exporters and non-exporters by ownership status, we look separately at two sub-periods, 1998-2001 and 2001-2004.

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[14] In the period 2002-2004, Ireland was ranked as the most globalised nation in the A.T. Kearney/Foreign Policy Globalisation Index and has maintained a high ranking in subsequent years.
[15] The UN World Investment Report (2004) shows Ireland has inward FDI stock levels of 126 per cent of GDP compared with levels of 36.3, 31.7 and 21.7 per cent of GDP for the UK, EU and World, respectively.
[16] It was during this period that the economy began known as the *Celtic Tiger*.
[17] Growth figures are from the OECD (2008).

The data for this paper are drawn from the Irish Central Statistics Office annual Census of Industrial Production (CIP).[18] An important benefit of this data set is that it is census data covering all industrial production units employing 3 or more persons; as such it is free of the issues that arise with other data sets which employ sampling procedures. Our analysis covers all plants operating in industrial sectors 151-366 using the 3-Digit NACE Rev.1 classifications. The CIP includes variables on outputs and inputs such as gross and net output, employment, wages as well as exporting activities and nationality of ownership.[19]

Although the CIP covers all local units with three or more employees it should be noted that a small number of firms were absent from the Census for various spells in the period 1998 to 2004. This usually occurred because a firm either became too small (less than three employees) to respond to the Census, or was re-classified out of the manufacturing sector into another sector, e.g., the services sector. In order to overcome this discontinuity of observations, which would undermine the analysis in the light of the dynamic nature of our decompositions, plants with any discontinuous years have been excluded from this analysis. When employment and/or output data were missing for one year the missing observations were filled using the average of the preceding and subsequent years' observations. However, when employment and/or output data were missing for two or more consecutive years or where there were insufficient observations these plants were dropped. After our data cleaning was completed, we had 13,892 observations on an average of 4,559 firms.[20]

In the absence of capital stock data for Irish manufacturing, we are restricted to exploring labour productivity growth. We follow Harris and Li (2008) and base our calculation of labour productivity on the changes in real gross output per worker. As we do not have information on firm specific prices we cannot account for any variation in the prices charged by entering or exiting firms relative to those firms that continue operating in each

[18] This is confidential data which can only be accessed and analysed, with permission, under "safe-setting" conditions in situ at the Central Statistics Office.
[19] The CIP does not contain information on the share of foreign ownership within individual plants but most FDI in Irish manufacturing is in the form of 100 per cent green-field investment.
[20] This amounts to 92 per cent of total observations for the period.

period. We calculate revenue values for real gross output by deflating the nominal values reported in the CIP by the relevant index from the CSO's Producer Price Index, with 2000 as the base year. If a firm charges a higher (lower) price than the average industry price, then our calculated real gross output, and hence the labour productivity, will be overstated (understated), *ceteris paribus*.[21]

## 4. Decomposition Methodology

As noted above, to calculate the contribution of exporters to productivity growth, decomposition techniques are used. The level of aggregate labour productivity ($A_t$) may be defined as the sum of the share weighted levels of labour productivity for each firm as follows:

$$A_t = \sum_i \theta_{it} a_{it}\,, \tag{1}$$

where $\theta_{it}$ and $a_{it}$ denote the labour share input (in terms of numbers of workers) and the labour productivity (real gross output per worker) respectively, for each firm $i$ in year $t$.

The change in aggregate productivity is then measured as the difference in the level of labour productivity between two time periods, $t$-$k$ and $t$, as

$$\Delta A_t = \sum \theta_{it} a_{it} - \sum \theta_{it-k} a_{it-k} = A_t - A_{t-k} \tag{2}$$

where $\Delta A_t$ is the change in aggregate labour productivity between $t$ and $t$-$k$. Equation 2 is the starting point for recent decomposition methods, including the Griliches and Regev (1995); Foster, Haltiwanger and Krizan (2001), and Baldwin and Gu (2003). However, Fox (2003) and Petrin and Levinsohn (2008) highlight problems with this starting point, noting that Equation 2 is measures more than pure productivity change because it combines productivity change and input share change.

[21] For further discussion of this issue see, for example, Foster, Haltiwanger and Syverson (2008).

Fox (2003) proposes including a Bennet (1920) indicator to overcome the measurement problem associated with the failure of Equation 2 to meet the basic property of monotonicity in aggregation. The Bennet (1920) indicator in Equation 3 operates by keeping input shares unchanged between the two periods, i.e., it weights the productivity change by the average of the shares between the two periods.

$$\Delta A_t^B = \sum_{i=1} \left(\frac{1}{2}\right)(\theta_{it} + \theta_{it-k})\Delta a_{it} \tag{3}$$

We adopt the recently developed decomposition method of Breunig and Wong (2007) [BW] to decompose the dynamics of aggregate labour productivity growth in the Irish manufacturing sector. This is an extension of the technique proposed by Fox (2003) which is set out in Equation (4). This equation overcomes the measurement problem (outlined above) and interpretation problems (outlined below) arising from decompositions based simply on Equation 2.

$$\Delta A_t^F = \overbrace{\sum_{i\in C} \theta_{it-k}\Delta a_{it}}^{within} + \overbrace{\sum_{i\in C}\left(\frac{1}{2}\right)\Delta\theta_{it}\Delta a_{it}}^{between} + \overbrace{\sum_{i\in E}\left(\frac{1}{2}\right)\theta_{it}a_{it}}^{entry} - \overbrace{\sum_{i\in X}\left(\frac{1}{2}\right)\theta_{it-k}a_{it-k}}^{exit} \tag{4}$$

where $\Delta a_{it}$ is the change in firm $i$'s labour productivity between $t$ and $t$-$k$ and similarly $\Delta\theta_{it}$ is the change in firm $i$'s labour input share between $t$ and $t$-$k$. *C, E* and *X* denote three sub-groups of firms, namely continuing, entering and exiting firms, respectively. Continuing firms are present in both $t$ and $t$-$k$. Entering firms are present in $t$ but not in $t$-$k$ and exiting firms are observed in $t$-$k$ and not in $t$.

While the Fox decomposition in Equation 4 captures the contributions of continuing firms to pure aggregate labour productivity growth, Breunig and Wong (2008) hold that there is a potential problem with the interpretation of the entry and exit terms. Specifically, the entry effect can be negative, even if entrants are more productive than exiting firms, if their labour shares are much lower. To overcome this problem they deviate each term in

Equation (4) by an arbitrary scaling factor, $\alpha$,[22] where, following Balk (2003), the simple average aggregate industry labour productivity between the two periods, *t-k* and *t,* is used.[23] Breunig and Wong (2007) refer to Equation (5) as the extended-Fox decomposition but for simplicity we refer to it as the BW method.

$$\Delta A_t^{BW} = \overbrace{\sum_{i\in C}\theta_{it-k}\Delta a_{it}}^{within} + \overbrace{\sum_{i\in C}\left(\frac{1}{2}\right)\Delta\theta_{it}\Delta a_{it}}^{between} - \overbrace{\sum_{i\in C}\left(\frac{1}{2}\right)\Delta\theta_{it}(\alpha)}^{pure\ share} + \overbrace{\sum_{i\in E}\left(\frac{1}{2}\right)\theta_{it}(a_{it}-\alpha)}^{entry} - \overbrace{\sum_{i\in X}\left(\frac{1}{2}\right)\theta_{it-k}(a_{it-k}-\alpha)}^{exit} \quad (5)$$

The *within* term captures pure intra-firm labour productivity improvements at continuing firms as the term uses initial labour input shares as weights. The *between* component captures the between-firm cross effect - it measures the interaction between input share movements and labour productivity changes. This term can be interpreted as a measure of *reallocation* as it captures the productivity gains arising from the expansion (contraction) of labour shares at firms with high (low) productivity growth. The *pure* share component measures the contribution to aggregate productivity growth arising from labour share changes of continuing firms. Breunig and Wong (2008, p. 9) state that the "pure share change term does not have any intrinsic economic meaning", and is a statistical "artefact" from the derivation of true entry and exit effects in this decomposition. The final two terms show the contributions from entry and exit respectively.

We use the BW method to determine the contributions of continuing, entering and exiting plants to aggregate labour productivity growth in the Irish manufacturing sector. We decompose labour productivity change for each 3-digit NACE industry. Aggregate labour

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[21] When Equation 4 is deviated by $\alpha$ the first two terms for continuing firms are unchanged as $\Delta a_{it} = (a_{it} - \alpha) - (a_{it-k} - \alpha)$.

[22] Since $\sum_{i\in C\cup E}\theta_{it} = \sum_{i\in C\cup X}\theta_{it-k} = 1$, the additional terms $\frac{1}{2}(a)\left[\left(\sum_{i\in C}\theta_{it-k} + \sum_{i\in X}\theta_{it-k}\right) - \left(\sum_{i\in C}\theta_{it} + \sum_{i\in E}\theta_{it}\right)\right]$ sum to zero.

productivity growth is then calculated by dividing Equation 5 by each industry's average labour productivity over periods *t* and *t*-k, that is, by the scaling factor, $\alpha$. Our results are then aggregated using time average industry employment shares in total manufacturing employment as weights. The contributions of continuing, entering and exiting plants are determined in the sequence set out in Figure 1 and the decompositions are carried out for the whole period, 1998-2004, as well as for two sub-periods 1998-2001 and 2001-2004.

For comparison purposes and a robustness check we also apply also estimate the GR and FHK decompositions. The criticisms of these methods by Fox (2003) and Petrin and Levinsohn (2008) would lead us to expect aggregate productivity growth to be overestimated using these techniques. Equation 2 can be re-arranged to yield Equation 6, the GR method. Aggregate labour productivity growth can be calculated by dividing Equation 6 by the average aggregate labour productivity over periods *t* and *t-k*.

$$\Delta A_t^{GR} = \overbrace{\sum_{i \in C} \overbrace{\overline{\theta}_{it-k} \Delta a_{it}}^{within}}^{} + \overbrace{\sum_{i \in C} \overbrace{\Delta \theta_{it} (\overline{a}_{it} - \alpha)}^{between}}^{} + \overbrace{\sum_{i \in E} \overbrace{\theta_{it} (a_{it} - \alpha)}^{entry}}^{} - \overbrace{\sum_{i \in X} \overbrace{\theta_{it-k} (a_{it-k} - \alpha)}^{exit}}^{} \quad (6)$$

where $\Delta a_{it}$ is the change in firm *i*'s labour productivity between *t* and *t-k*, similarly $\Delta \theta_{it}$ is the change in firm *i*'s labour input share between *t* and *t-k* and a bar over a variable indicates a time average over *t* and *t*-k and, as in Equation 5, $\alpha$ is the average level of aggregate labour productivity over periods *t* and *t-k*.

An alternative re-arrangement of Equation 2 yields Equation 7, the FHK (2001) decomposition[24]:

[24] Note that we use the arithmetic mean definition for the change in labour productivity, unlike Harris and Li (2008) who conduct a similar analysis using the geometric mean definition. According to Breunig and Wong (2008) the former method is preferred as it reflects the assumption that the lower bound productivity level is zero and is more appropriate for productivity decompositions where the productivity of entering/exiting plants is truncated in their entering/exiting year.

$$\Delta A_t^{FHK} = \overbrace{\sum_{i\in C}\theta_{it-k}\Delta a_{it}}^{within} + \overbrace{\sum_{i\in C}\Delta\theta_{it}(a_{it-k}-A_{t-k})}^{between} + \overbrace{\sum_{i\in C}\Delta\theta_{it}\Delta a_{it}}^{cross} + \overbrace{\sum_{i\in E}\theta_{it}(a_{it}-A_{t-k})}^{entry} - \overbrace{\sum_{i\in X}\theta_{it-k}(a_{it-k}-A_{t-k})}^{exit} \quad (7)$$

where all variables are as previously defined. In the FHK method aggregate labour productivity growth is calculated by dividing each component of Equation 7 by the level of aggregate labour productivity in *t-k*.

The *within* component measures the change in labour productivity that occurs within a firm arising from changes in output while holding employment constant at the base period, *t-k*, level. This measure is broadly comparable across all three decomposition techniques. The GR *between* component in Equation 6 measures the contribution of continuing firms to aggregate labour productivity change arising from changes in labour input shares between firms using the *average* labour productivity of each firm relative to *average* aggregate manufacturing productivity over the period.

The FHK *between* component in Equation 7 measures the contribution of continuing firms to aggregate labour productivity change arising from changes in labour input shares between firms holding the labour productivity of each firm relative to aggregate manufacturing productivity constant at *t-k* levels. Each of these *between* measures broadly corresponds to the *pure share* component in the BW method. FHK interpret a positive result as indication that continuing firms with above average labour productivity in period *t-k* experience an increase in their employment shares while a negative result implies an inverse relationship between average labour productivity and changes in labour shares. They label this as a reallocation effect. The *cross* component in Equation 7 measures the interaction between changes in the labour productivities and the labour input shares of continuing firms; positive values show that productivity gains are derived from firms that increase (decrease) labour productivity and increase (decrease) labour shares.

The final two terms in Equations 6 and 7 measure the relative contributions to aggregate labour productivity growth arising from entering and exiting firms. As with the BW method, a negative value for entry implies that entering firms are less productive than the

average firm and thus contribute negatively to aggregate productivity growth; while a negative value for exiting firms implies that the exit of these less efficient firms results in an increase in aggregate labour productivity growth.

It is important to note the difference in the *between* effects of the FHK and BW methods. We follow BW's in labelling their *between* effect as a *reallocation* effect and, for clarity, label it so in our results; this contrasts with FHK who attribute the term *reallocation* effect to their *cross* effect. The BW *pure share* effect and the GR and FHK *between* effects are broadly similar although under BW the effect is negative and no intrinsic economic meaning is ascribed to it. An advantage of this decomposition technique is that it completely separates productivity changes from labour input share changes thus facilitating the calculation of true entry and exit effects. We use the GR and FHK techniques to provide comparison with, and also a robustness check on, the BW patterns of the contributions of continuing, entering and exiting firms to aggregate labour productivity growth of exporting and no-exporting firms by ownership type. [25]

## 5. Decomposition Results

Table 5 provides details of the construction of each type or sub-group of firm for the three time intervals. Continuing firms account for the greatest number (shares) of firms in each period. As expected, the numbers and shares of entering (exiting) firms are relatively higher (lower) in the high growth, i.e. pre-2001, sub-period.

[25] The GR method is preferred to the FHK by some, for example Balk and Hoogenboom-Spijker (2003), as it is less likely to contain measurement error. The FHK method appears to be a more comprehensive technique for analysing the contributions to aggregate productivity growth by continuing, firms as productivity changes are disaggregated into three separate effects (*within*-firm, *between*-firm and *cross* effects) compared with two (*within* and *between*) for GR.

Table 1 Construction of Sub-Groups

| Criteria | Sub-Groups | Number of Observations | | |
|---|---|---|---|---|
| | | 1998-2004 | 1998-2001 | 2001-2004 |
| Observed in *t* and *t-k* | Continuing | 2,919 | 3,685 | 3,582 |
| | | (47.10) | (65.51) | (62.02) |
| Observed in *t* but not *t-k* | Entering | 1,663 | 1,090 | 1,000 |
| | | (26.83) | (19.38) | (17.32) |
| Observed in *t-k* but not in *t* | Exiting | 1,616 | 850 | 1,193 |
| | | (26.07) | (15.11) | (20.66) |

Source: Own estimates based on Census of Industrial Production, 1998-2004.
Note: Figures in parentheses are time-period percentages.

In Section 5.1 we present our results using the BW (2007) decomposition method for the 1998-2004 period. The benefit of this method is that it completely separates productivity changes from labour input share changes thus facilitating the calculation of true entry and exit effects. We report our results for the business cycle, i.e. for the pre- and post 2001 sub-periods, in Section 5.2. Finally, in Section 5.3, we compare the BW (2007) results with those obtained using the traditional GR (1995) and FHK (2001) methods for the 1998-2004 time period.

### 5.1 The BW Decomposition Results over

The decomposition analysis in Table 2 shows that overall aggregate productivity growth was approximately 18 per cent for this period, with continuing firms accounting for 74 per cent of the increase and 98 percent of the growth attributable to the *within* component. The *reallocation* component accounts for almost 6 per cent of aggregate productivity growth in the sector, indicating that labour shares increased (decreased) at high (low) productivity firms.[26] Both entering and exiting firms contributed positively to economic growth, with the major contribution coming from exiting firms.

[26] As per the discussion above, we ignore the *pure share* effect.

We now turn to explore the difference between exporters and non-exporters (Rows 2 and 5). The contrast between the low productivity growth amongst non-exporters and the strong productivity growth of exporters shows that exporters drive the overall productivity pattern, accounting for 90 per cent of the productivity growth between 1998 and 2004. For exporters and non-exporters, the *within* component dominates overall. The *reallocation* component is positive (7 percent) for exporters while for non-exporters it is small and negative.[27] In the case of exporters, both entry and exit contribute positively to productivity growth, with the latter effect dominating. In the case of non-exporters, exit also contributes positively to growth, but the entry effect is negative as entrants have below average productivity growth. Furthermore, we find that evidence of proportionately larger contributions coming from the exit of below average-productivity exiting (72 per cent) non-exporters compared to exiting exporters (15 per cent).

Table 2 BW Decompositions of Aggregate Labour Productivity Growth, 1998-2004

| | *Within* | *Reallocation* | *Share* | *Entry* | *Exit* | Total |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| **1. All** | 17.62 | 1.05 | 5.41 | 1.12 | -3.51 | 17.89 |
| **2. Exporters** | 16.18 | 1.27 | 4.92 | 1.48 | -2.55 | 16.56 |
| **3.** FOE | 12.09 | 1.83 | 2.54 | 1.69 | -1.24 | 14.32 |
| **4.** DOE | 4.09 | -0.57 | 2.38 | -0.22 | -1.31 | 2.24 |
| **5. Non-exporters** | 1.44 | -0.22 | 0.49 | -0.36 | -0.96 | 1.33 |
| **6.** FOE | 0.11 | -0.02 | -0.02 | 0.05 | 0.02 | 0.15 |
| **7.** DOE | 1.32 | -0.20 | 0.51 | -0.41 | -0.98 | 1.18 |

Source: Own estimates based on Census of Industrial Production, 1998-2004.
Notes: Labour productivity calculated using real gross output per worker.
Differences are due to rounding.

[27] In effect, for non-exporters labour shares increased (decreased) at firms which experienced decreased (increased) labour productivity over the period.

In terms of contributions to productivity growth, there is clearly a marked difference between exporters and non-exporters. There are also significant differences between FOEs and DOEs in both categories. In the case of exporters, 86 per cent of the productivity growth is attributable to FOEs. For continuing FOE exporters, the *within* component dominates (84 per cent), while the *reallocation* component accounts for 13 per cent of productivity growth, indicating positive labour reallocation effects. The *within* component accounts for a much greater share of the productivity growth for exporting DOEs and the *reallocation* component makes a large and negative contribution (-25 per cent) implying strong intra-firm productivity improvements but significant inefficiency in the inter-firm reallocations of labour within industries. The exit effects are positive for both FOEs and DOEs, assuming a much greater importance in the case of DOEs. The entry effect contributes positively to productivity growth for exporting FOEs (11 per cent), but negatively for exporting DOEs (-10 per cent). This contrast is not surprising given that, unlike their DOE counterparts, the FOEs are not true *de novo* entrants. We return to this issue below.

In the case of non-exporters, DOEs dominate, accounting for 88 per cent of the productivity growth.[28] The *within* effects are large and positive for FOEs and DOEs, while the *reallocation* effect is significant and negative for both groups.[29] Entering FOE non-exporters contribute positively to growth while DOE non-exporter entrants contribute negatively. In contrast, exiting FOE non-exporters contribute negatively to productivity growth while the contribution of exiting DOE non-exporters is positive.

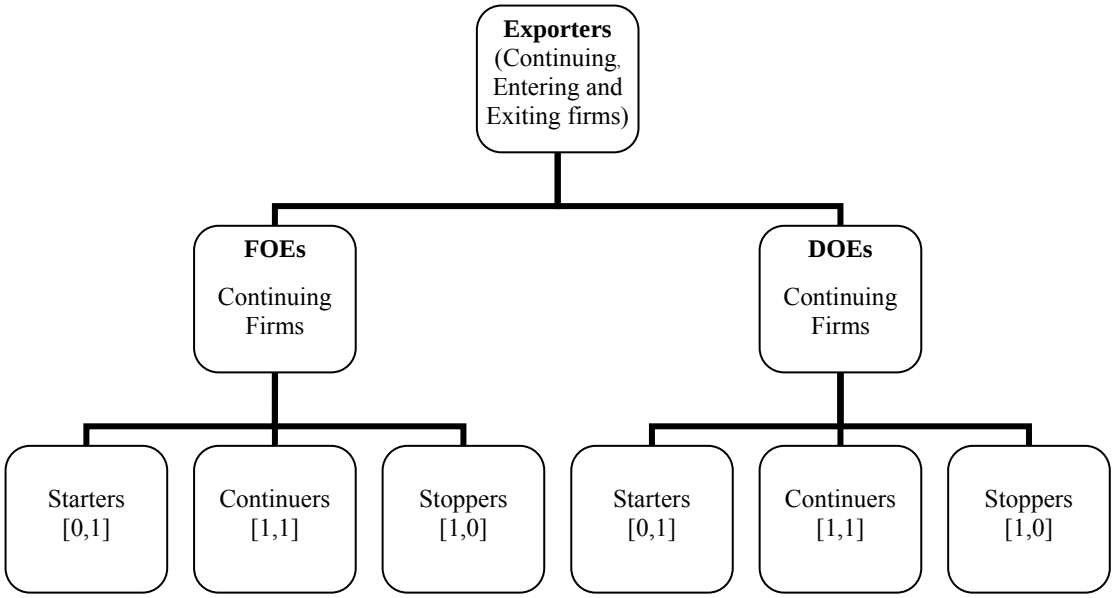
In the case of all DOEs, entry contributes negatively to productivity growth implying that these firms have below average productivity performance. This result does not support the theoretical predictions in recent trade theories (e.g. Melitz, 2003), that suggest that entering firms will have above average productivity, especially when exporting. The argument is that, as a result of the presence of sunk costs of entry to international markets, only the most productive firms will export. Our result may arise because in a small open

[28] In a sense they parallel the dominant role of FOEs in the case of exporters,
[29] It should be noted that the number of non-exporting FOEs is a very small, they account for 1 per cent of plants, and consequently these results must be viewed with caution.

economy firms are willing to take-on the additional risk, or perhaps short-term losses, associated with exporting in the hope of achieving scale economies which ultimately enhances productivity. However, when we focus on net entry, i.e. the sum of entry and exit effects, we find that there is positive net entry effect for all exporting and ownership types. The exit of firms contributes positively to aggregate labour productivity growth, accounting for 20 per cent of the overall growth. This result provides strong evidence in support of the theoretical hypotheses that the less productive firms exit resulting in reallocations of resources.

In Table 2 continuing firms were classified as exporters if they exported in at least one year in the period 1998-2004. In order to examine the exporting dynamics of the contributions of continuing firms to the labour productivity growth by ownership status, we conduct a further decomposition in which we classify exporters that are continuing firms into three types, namely, starters, continuers and stoppers, based on their exporting status over the time interval. Export starters are firms that are present in both years but are exporters in 2004 and not exporters in 1998. Export continuers are firms that export in both 1998 and 2004, while export stoppers are present in both years but export in 1998 and not in 2004. Figure 2 presents a schematic representation of this decomposition.

Figure 2 Schema of Decomposition of Exporters by Ownership Status and Exporter Type



In Table 3 we report the results of the dis-aggregation of continuing exporters, as per Figure 2 and for convenience we repeat the results outlined in Table 2 for all exporters and by ownership type. Continuing FOEs account for 69 per cent of the total exporter contribution and 79 per cent of the total FOE exporter contribution to productivity growth. Not surprisingly continuers dominate the *within* and *reallocation* effects, both of which are positive, while the contributions of FOE starters and stoppers are negligible.

Continuing DOE exporters account for just 7 per cent of the total exporter contribution and 52 per cent of the total DOE exporter contribution. As with FOEs, DOE continuers dominate the *within* and *reallocation* effects. In contrast to FOEs, DOE continuers and stoppers have negative *reallocation* effects - the *between* firm labour share changes move in the opposite direction to labour productivity changes. Starters contribute negatively (12 per cent) to the total continuing DOE contribution while stoppers contribute positively (3 per cent).

Baldwin and Gu (2003) conducted a broadly similar analysis for continuing Canadian plants in the period 1990 to 1996. Like us, they find that that the largest contributions to productivity growth were attributable to continuing exporters; they also find that continuing plants that started exporting contributed positively (10 per cent). We find that contributions of FOE starters are positive but negligible while those of DOE s are negative. This negative result for DOE starters is surprising and as before for entry it may be due to the willingness of these firms to take on additional risk in the form of the sunk costs associated with exporting in the hope of achieving productivity improvements due to expanded market opportunities.

Table 3 Contributions of Exporters to Labour Productivity Growth by Ownership Status, 1998-2004

| | *Within* | *Reallocation* | *Share* | *Entry* | *Exit* | Total |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| **Exporters** | 16.18 | 1.27 | 4.92 | 1.48 | -2.55 | 16.56 |
| **FOE** | 12.09 | 1.83 | 2.54 | 1.69 | -1.24 | 14.32 |
| **Continuing FOEs:** | | | | | | 11.35 |
| Starters [0,1] | 0.12 | 0.00 | 0.06 | | | 0.06 |
| Continuers [1,1] | 11.92 | 1.82 | 2.36 | | | 11.38 |
| Stoppers [1,0] | 0.02 | 0.02 | 0.12 | | | -0.08 |
| **DOE** | 4.09 | -0.57 | 2.38 | -0.22 | -1.31 | 2.24 |
| **Continuing DOEs:** | | | | | | 1.16 |
| Starters [0,1] | 0.29 | 0.00 | 0.43 | | | -0.14 |
| Continuers [1,1] | 3.70 | -0.54 | 1.90 | | | 1.26 |
| Stoppers [1,0] | 0.05 | -0.02 | -0.01 | | | 0.04 |

Source: Own estimates based on Census of Industrial Production, 1998-2004.
Notes: Labour productivity calculated using real gross output per worker.
Differences are due to rounding.

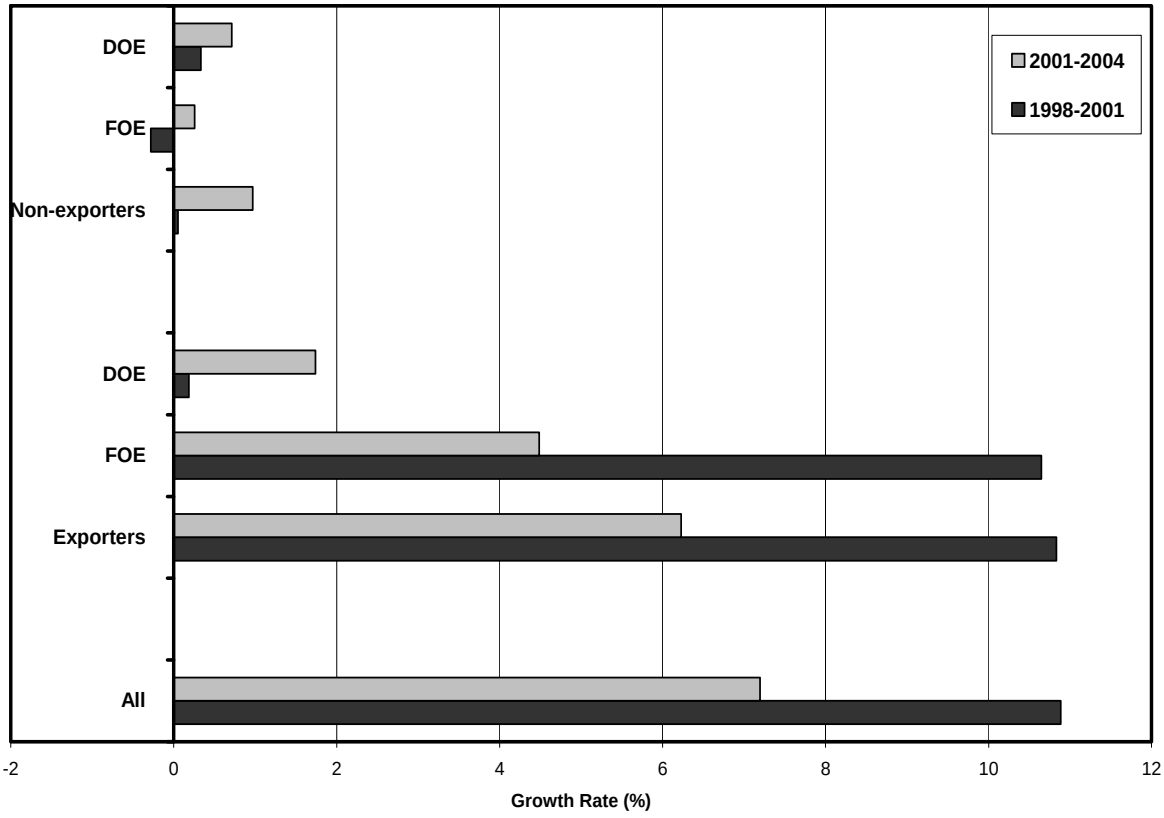
### 5.2 Business Cycle Decomposition Results

We noted above that there were significant differences in GDP growth rates in the late 1990s compared with the early 2000s. It was also a period over which the driving force in economic growth switched from exports to domestic demand, propelled by a rapid expansion in the domestic building sector. We use the BW decomposition technique to explore possible differences in manufacturing productivity growth over the business cycle by examining two sub-periods, 1998-2001 and 2001-2004; Figures 3 and 4 graph the results for the these periods.[30] In Figure 3 we see that overall aggregate productivity growth was much higher in the earlier period. The cross period difference was driven by a fall (43 percent) in the productivity of exporters between the two periods while that of

[30] Tables with detailed results are presented in Appendix 1.

non-exporters increased significantly, albeit from a low base. The decline in exporter productivity was driven by a drop of more than 50 per cent in the case of FOEs, partially compensated for by the significant increase in the productivity of DOEs. In contrast non-exporting FOEs and DOEs experienced large increases in productivity growth between the two periods. These results may reflect the difficulties faced by Irish-based exporters in the international downturn post-2001, while demand in the Irish economy remained relatively strong supporting non-exporters.

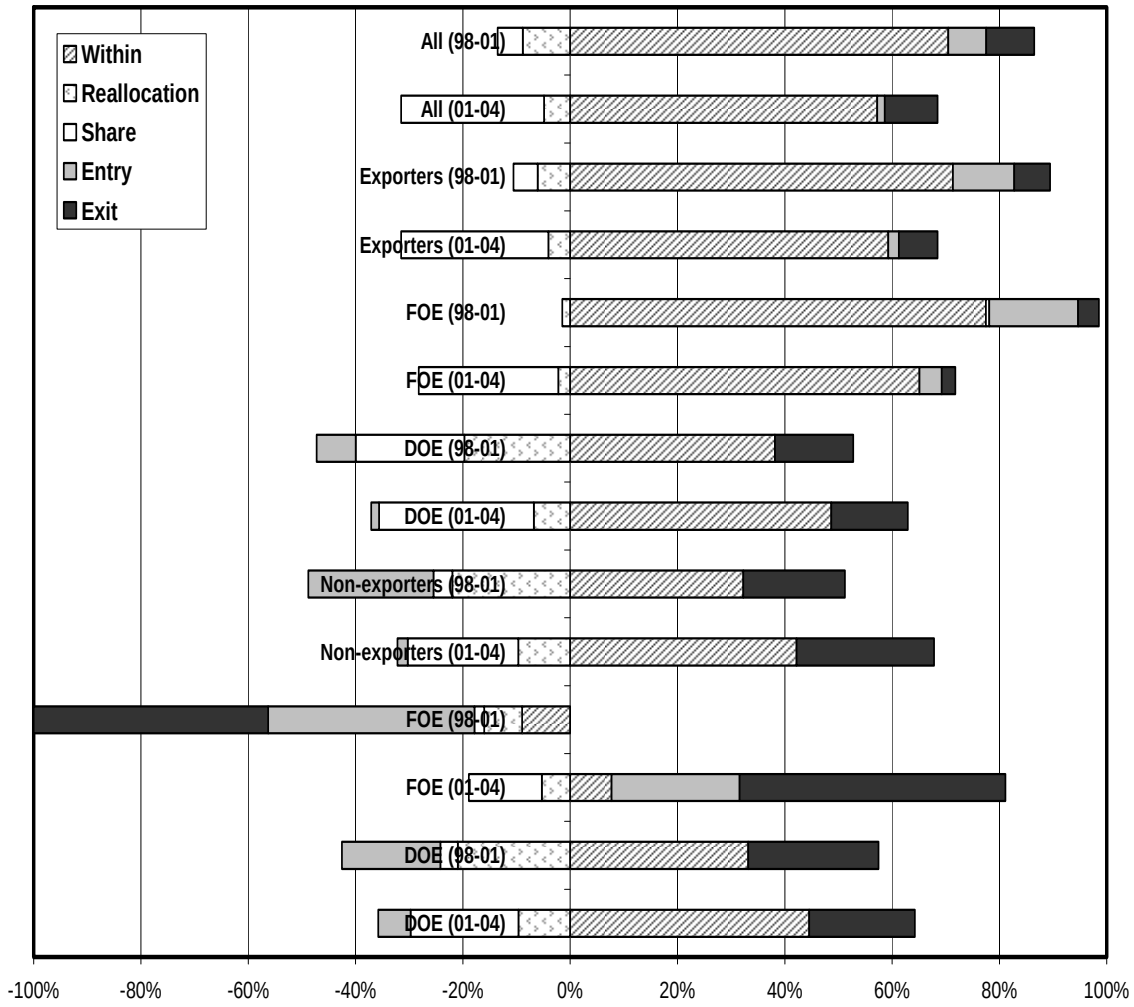
Figure 3 Labour Productivity Growth Rates for All Firms and by Export and Ownership Status 1998-2001;2001-2004




Looking at the contributions of continuing, entering and exiting firms to productivity growth over the sub-periods in Figure 4, we see that for continuing firms the *within* component is less important in the later sub-period for FOE exporters while it is more important for DOE exporters and all non-exporters. The *reallocation* contributions remained negative across the sub-periods but became less significant in the later period except for FOE exporters. Turning to the dynamics of the decompositions, as expected with a downturn in the business cycle, the contributions of entrants were unambiguously

smaller while the contributions for exiting plants, although less clear cut, were larger overall in the post-2001 period.

Figure 4 Comparisons of Component Shares by Sub-period for All Manufacturers and by Export and Ownership Status, 1998-2001 and 2001-2004




Note: The positive contributions for Exit result from the exit of below average productivity firms while the negative contribution indicates that above average productivity firms exit.

FOE non-exporters stand-out as the contributions of these firms was negative in the pre-2001 period and positive in the post-2001 period. This resulted from changes in the signs on the *within*, entry and exit components from negative to positive.[31] This could be seen

[31] As previously mentioned, the number of FOE non-exporters is very small so these results must be interpreted with caution.

as providing further support for the argument that increasing growth in domestic demand, despite the global downturn, may have facilitated productivity improvements particularly at continuing DOE exporters, who would sell a portion of their output on the domestic market, and at non-exporting continuing firms in this sub-period.[32]

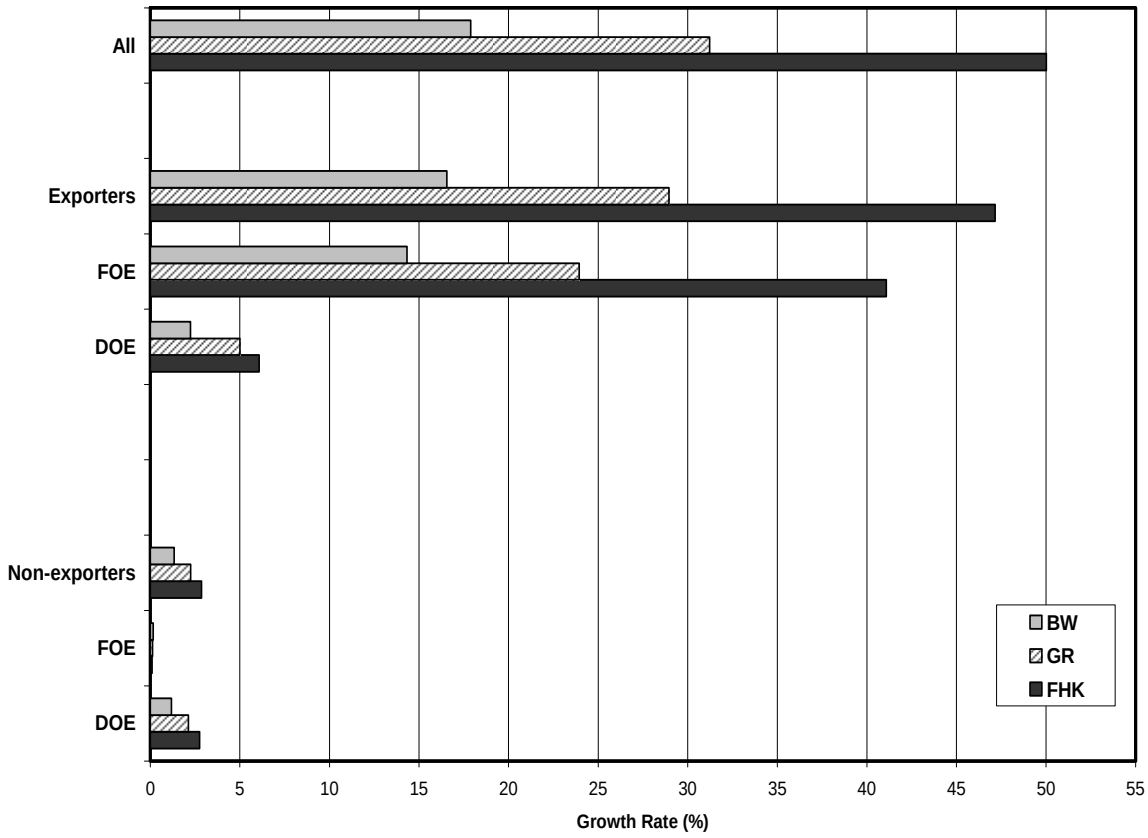
### 5.3 Comparing Methodologies

As discussed in Section 4, there are problems with the traditional measurement of the change in aggregate productivity using Equation (2) as the measure combines productivity and share changes. Although the GR and FHK methods tend to overestimate aggregate productivity growth, it is possible to compare the general patterns of contributions to aggregate manufacturing productivity growth overall and by exporting and ownership type for all three decomposition techniques – see Figure 5. As anticipated, the reported labour productivity growth is much lower using the BW (2007) method; however the patterns of contributions by exporting and ownership status are similar to the results obtained using the FHK and GR methods.[33] All three methods show that overall productivity growth was driven by exporters, with FOE exporters being overwhelmingly dominant. DOE exporters contribute positively substantially outperforming both foreign and domestic non-exporters.

Figure 6 presents a comparison of the dynamics of the contributions of exporters and non-exporters by ownership type for each of the three methods. The *reallocation* effect compares the BW *between* effect with the FHK *cross* effect and the *share* effect compares the BM *pure share* effect with the GR and FHK *between* effects. We can see that, while the magnitudes differ, the direction of the *within, reallocation, entry* and *exit* effects are generally the same across all methods for the 1998-2004 time interval.

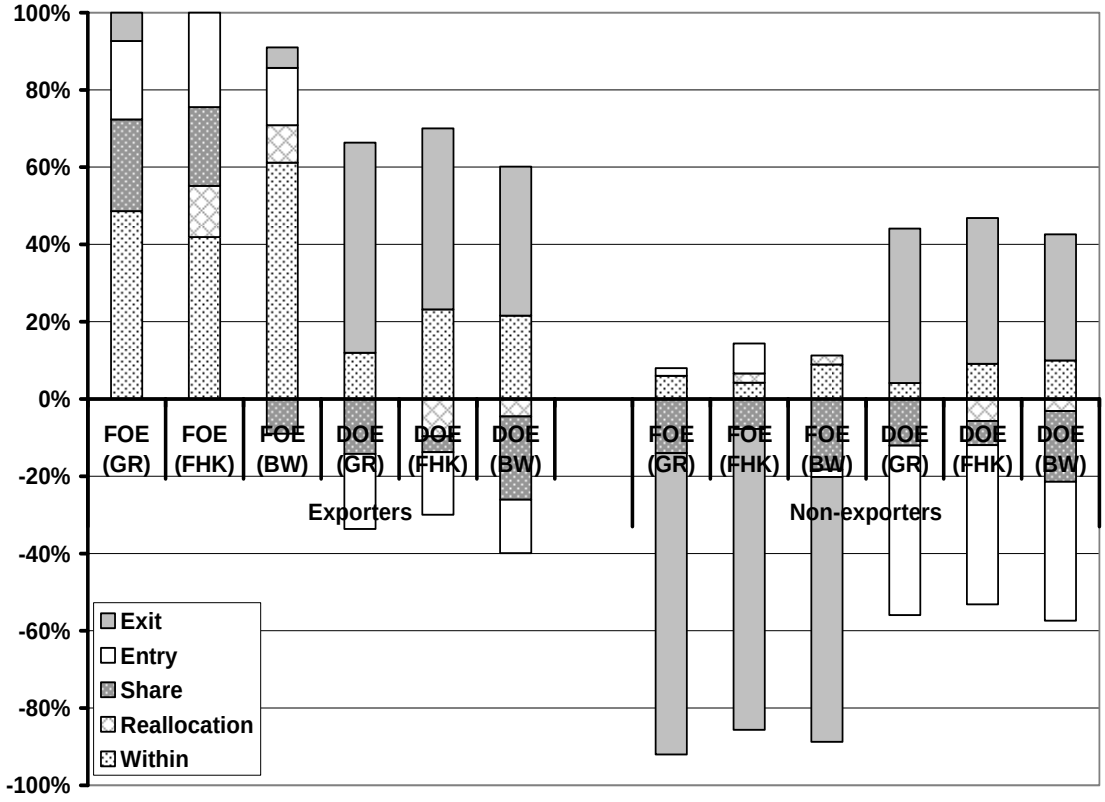
[32] Since FOE exporters sell most of their output outside Ireland, they were not affected by the upturn in domestic demand.
[33] Tables in Appendices 2 and 3 contain full details of the GR and FHK decompositions.

Figure 5 Comparisons of Labour Productivity Growth Rates for Three Decomposition Methods for All Firms and by Exporting and Ownership Status, 1998-2004




Source: Own estimates based on Census of Industrial Production, 1998-2004.

Figure 6 Comparisons of Dynamic Contributions to Labour Productivity Growth for Various Decomposition Methods for by Exporting and Ownership Status, 1998-2004




Source: Own estimates based on Census of Industrial Production, 1998-2004.
Note: The *reallocation* effect compares the BW *between* effect with the FHK *cross* effect.
The *share* effect compares the BM *pure share* effect with the GR and FHK *between* effects.

## 6. Conclusion

In this paper we used the Breunig and Wong (2007) decomposition technique to determine the microstructure of aggregate labour productivity growth in Irish manufacturing, using an unbalanced plant-level panel constructed from the annual Irish Census of Industrial Production for the period 1997-2004. The aim of the paper was to determine the contributions of continuing, entering and exiting firms by exporting and ownership status. The motivation for this study was the expanding literature exploring the link between productivity and exporting and most especially Harris and Li (2008) who used the Foster, Haltiwanger and Krizan (2001) decomposition method to explore the contributions of exporters and non-exporters to aggregate productivity growth in the UK.

For comparison and as a robustness exercise, we also conducted Griliches and Regev (1995) and Foster, Haltiwanger and Krizan (2001) decompositions. The results yielded different rates of productivity growth but the microstructure and pattern of contributions overall and by exporting activity and ownership type were similar to those for the Breunig and Wong decompositions.

Let us return to the questions we asked at the outset:

(i) *How much do exporters contribute overall to total productivity growth?* Total productivity growth is dominated by exporters, who account for 93 per cent of the productivity growth over the period 1998-2004.[34] Most of the contribution comes from intra-firm productivity improvements (the *within* component). This underscores the preoccupation of policy-makers with the contribution of exports to economic growth. Although due to methodological differences our results are not directly comparable previous studies (e.g. Baldwin and Gu (2003); Bernard and Jensen (2004); and Hansson and Lundin (2004) and Harris and Li (2008)) they add further to the evidence that exporters account for a larger share of productivity growth than non-exporters. Harris and Li (2008) whose approach is most like ours also find that most of the contribution comes from the *within* component.

(ii) *How important are continuing exporters relative to new exporters to that growth?* As one would expect, continuing firms that export dominate, being responsible for over 70 per cent of total labour productivity growth. The contributions of starters are small by comparison but not insignificant, accounting for 8 per cent of total productivity growth. These results are broadly comparable with the 74 percent for continuers and 18 percent for new plants found by Baldwin and Gu (2003) for Canadian plants?

(iii) *How do the dynamics of exporter productivity growth differ between domestic and foreign-owned firms?* FOEs in Ireland dominate the pattern of productivity growth. In

[34] The contributions are 99 per cent and 87 per cent in the pre- and post 2001 sub-periods, respectively

the case of both FOE and DOE exporters, continuers provide the main source of total productivity growth with the *within* component dominating. However, there are contrasting differences in the case of the *reallocation* and *entry* effects, which are positive and large in the case of FOEs, and negative and small in the case of DOEs – in effect these dynamics underpinning FOEs are favourable whereas those for DOES are unfavourable. For both groups, exiting firms contribute positively to labour productivity growth. As far as we know, this is the first paper to distinguish the productivity contributions of exporting and non-exporting plants by ownership type.

*(iv) Do the exporting firms that cease production have lower productivity on average than those which continue?* In the case of all FOE and of DOE exporters, exiting firms are relatively less efficient firms, thereby contributing positively to aggregate labour productivity growth. This finding supports the theory that less efficient firms cannot survive in international markets.[35] Harris and Li (2008) also find that exiting exporters contributed positively to labour productivity for the UK manufacturing sector as these firms were relatively less productive on average.

*(v) Is there evidence of a business cycle dimension labour productivity growth?* Total labour productivity grew more slowly in the post-2001 period and the driver of this change was the decline in the productivity of FOE exporters, which outweighed the increase in productivity of DOE exporters and non-exporters as well as FOE non-exporters. In terms of contributing to productivity growth, continuing firms were dominant in both periods, with entry contributing less in the second period while there was no consistent pattern to exit effects over time. These results appear to reflect the difficulties faced by Irish-based exporters in the global downturn post-2001, while increasing growth in domestic demand in this sub-period may have facilitated productivity improvements particularly at DOE exporters as well as at non-exporting firms. To our knowledge this is the first paper to distinguish the impact on the

[35] In the case for non-exporting FOEs, the exiting firms have above average productivity, thus contributing negatively to labour productivity growth. This suggests that Ireland may be losing FDI plants because of greater attractiveness of other locations.

contributions to productivity growth by exporting and non-exporting plants as well as by ownership type over the business cycle.

The analysis undertaken in this paper also suggests a number of areas for further research. For example it would be informative to use this framework to focus in on dis-aggregated industries to determine how productivity growth and dynamics vary across industries. The approach also lends itself to developing a similar framework to explore job creation, job destruction and labour reallocation issues.

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Appendix 1.1 BW Decompositions of Aggregate Labour Productivity Growth, 1998-2001

| | *Within* | *Reallocation* | *Share* | *Entry* | *Exit* | Total |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| **All** | 10.51 | -1.32 | 0.70 | 1.05 | -1.34 | 10.89 |
| | | | | | | |
| **Exporters** | 9.80 | -0.83 | 0.62 | 1.57 | -0.92 | 10.83 |
| FOE | 8.50 | -0.16 | -0.07 | 1.82 | -0.43 | 10.65 |
| DOE | 1.29 | -0.67 | 0.69 | -0.25 | -0.49 | 0.19 |
| | | | | | | |
| **Non-exporters** | 0.72 | -0.49 | 0.08 | -0.52 | -0.42 | 0.05 |
| FOE | -0.03 | -0.02 | 0.01 | -0.11 | 0.12 | -0.28 |
| DOE | 0.74 | -0.47 | 0.07 | -0.41 | -0.54 | 0.33 |

Source: Own estimates based on Census of Industrial Production, 1998-2004.
Notes: Labour productivity calculated using real gross output per worker.
Differences are due to rounding.

Appendix 1.2 BW Decompositions of Aggregate Labour Productivity Growth, 2001-2004

| | *Within* | *Reallocation* | *Share* | *Entry* | *Exit* | Total |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| **All** | 11.13 | -0.95 | 5.18 | 0.28 | -1.92 | 7.20 |
| | | | | | | |
| **Exporters** | 9.98 | -0.69 | 4.62 | 0.33 | -1.22 | 6.23 |
| FOE | 6.71 | -0.23 | 2.68 | 0.43 | -0.26 | 4.49 |
| DOE | 3.28 | -0.46 | 1.94 | -0.10 | -0.96 | 1.74 |
| | | | | | | |
| **Non-exporters** | 1.15 | -0.26 | 0.56 | -0.05 | -0.70 | 0.97 |
| FOE | 0.03 | -0.02 | 0.06 | 0.10 | -0.20 | 0.26 |
| DOE | 1.12 | -0.24 | 0.50 | -0.15 | -0.49 | 0.71 |

Source: Own estimates based on Census of Industrial Production, 1998-2004.
Notes: Labour productivity calculated using real gross output per worker.
Differences are due to rounding.

Appendix 2 GR Decompositions of Aggregate Labour Productivity Growth, 1998-2004

| | *Within* | *Between* | *Entry* | *Exit* | Total |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| **All** | 18.67 | 3.27 | 2.24 | -7.05 | 31.22 |
| | | | | | |
| **Exporters** | 17.45 | 3.44 | 2.94 | -5.13 | 28.95 |
| FOE | 13.93 | 4.14 | 3.37 | -2.51 | 23.95 |
| DOE | 3.53 | -0.70 | -0.43 | -2.61 | 5.01 |
| | | | | | |
| **Non-exporters** | 1.22 | -0.17 | -0.72 | -1.92 | 2.26 |
| FOE | 0.10 | -0.04 | 0.10 | 0.03 | 0.12 |
| DOE | 1.12 | -0.13 | -0.81 | -1.96 | 2.13 |

Source: Own estimates based on Census of Industrial Production, 1998-2004.
Notes: Differences are due to rounding.

Appendix 3 FHK Decompositions of Aggregate Labour Productivity Growth, 1998-2004

| | *Within* | *Between* | *Cross* | *Entry* | *Exit* | Total |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| **All** | 28.23 | 5.25 | 5.62 | 7.15 | -3.76 | 50.02 |
| | | | | | | |
| **Exporters** | 26.62 | 5.15 | 6.08 | 7.13 | -2.19 | 47.16 |
| FOE | 21.81 | 4.75 | 7.09 | 7.12 | -0.31 | 41.08 |
| DOE | 4.81 | 0.40 | -1.01 | 0.00 | -1.88 | 6.08 |
| | | | | | | |
| **Non-exporters** | 1.61 | 0.11 | -0.45 | 0.03 | -1.57 | 2.86 |
| FOE | 0.13 | -0.04 | -0.04 | 0.19 | 0.15 | 0.10 |
| DOE | 1.47 | 0.15 | -0.42 | -0.17 | -1.72 | 2.75 |

Source: Own estimates based on Census of Industrial Production, 1998-2004.
Note: Differences are due to rounding.

| Year | Number | Title / Author(s)<br>ESRI Authors / Co-authors *Italicised* |
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