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LABOUR PRODUCTIVITY AND FOREIGN DIRECT INVESTMENT IN IRISH MANUFACTURING INDUSTRY: A DECOMPOSITION ANALYSIS*

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Abstract:

Overall labour productivity in the Irish manufacturing sector increased by 158 per cent between 1991 and 1999. This growth in labour productivity coincided with strong growth in employment during the same period, in stark contrast to the experience of other European countries. This paper examines the components of this labour productivity growth in the period 1991-1999, using a decomposition analysis based on plant level data. In order to account for the large presence of foreign plants we carry out our analysis separately for foreign and domestic plants, as well as for four ownership subgroups, four sectoral subgroups, and two time sub-periods. Our results show that although the main drivers of average labour productivity growth in all groups arise *within plant* and from *plant entry*, there are marked differences in the relative sizes of these effects across the ownership/sector/time-period.

Keywords: Foreign Direct Investment, Labour productivity, decomposition, Irish manufacturing industry

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1 Introduction

During the past decade, the Irish economy has been characterised by high rates of economic growth and low unemployment rates relative to other European Union (EU) and OECD countries. The increase in the real Gross Domestic Product (GDP) reached double-digits in the period 1995-2000 compared to growth rates of between 2 and 3 per cent in the EU and OECD countries. The success in achieving high growth rates of output and employment has been accompanied by substantial increases in the general labour productivity level of the economy, due to higher growth rates obtained in output relative to the growth in employment levels.

Overall labour productivity in the Irish manufacturing sector increased by 158 per cent from 1991 to 1999. This growth in labour productivity has coincided with growth in both employment and output levels during the same period, in stark contrast to the experience of other European countries.[1] Although growth patterns in employment and output at aggregate level are important in examining productivity growth, it is increasingly recognized that these changes mainly take place in individual plants. In recent years there has been a growing body of research into the productivity growth at the plant level, with the increasing interest in industry dynamics and the greater availability of data at plant level. Many of these studies examine the origins of productivity growth, by using total factor or labour productivity at the plant level. They conclude that plant performance is heterogeneous and that net changes observed in aggregate data are marked by large increases at some plants and decreases at others. Theoretical explanations behind this heterogeneity include innovation and creative destruction (Schumpeter, 1942), passive learning (Jovanovic, 1982) and active learning (Erickson and Pakes, 1995).[2]

[1] See Scarpetta *et al.* (2000)
[2] See Foster et al (1998) for a review.

This paper examines the factors that affect the growth of labour productivity in the Irish manufacturing sector using a decomposition analysis. Section 2 reviews the methods used to analyse the decomposition of productivity growth in the literature, and summarizes the results from studies across a range of developed and developing countries. Section 3 outlines the methodology adopted in the decomposition analysis of labour productivity growth in Irish manufacturing and the data used in the analysis.

A distinguishing feature of the Irish manufacturing sector is the large presence of foreign plants - in 1999 foreign plants accounted for 85 per cent of net output and 49 per cent of employment in the sector. In the light of this factor, Section 4 presents ownership decomposition results for both foreign and domestic plants, as well as for four different nationality groups. It also presents results separately for 1991-1995 and 1995-1999, because of the very different growth rates in labour productivity in these two sub-periods. This analysis also serves to test the robustness of overall results to different time periods.

A key part of the focus of Irish policy has been the restructuring of manufacturing out of traditional and into high tech sectors. In Section 5 we present results for four (OECD) sectoral groups in order to examine the contribution of different factors at a more disaggregated sector level. Finally, Section 6 contains a brief summary and some conclusions.

2 Decomposing Productivity Change

Studies within the literature that investigate the role of resource allocation in labour productivity change begin with a decomposition analysis that expresses the aggregate productivity in a given sector by a weighted average of each plant's productivity in that sector, i.e.,

$$P_t = \sum_{it} S_{it} P_{it} \qquad (1)$$

where P_t is an aggregate productivity measure, which can be labour productivity (LP) or total factor productivity (TFP) for the sector at time t; S_{it} is the share of plant i in the

given sector at time t; and P_{it} is a productivity measure of an individual plant i at time t. In the literature, employment is typically used in weighting LP and output share is used to weight TFP.[3]

In an early empirical study Baily, Hulten and Campbell (1992) explore heterogeneity among plants to see how productivity of individual plants changes within an industry, which plants account for the productivity growth, and how important entry and exit are to productivity growth in the industry. Their decomposition analysis begins with a calculation of total factor productivity (TFP) of each plant. The level of productivity in an industry in year t is the expressed, as an index:

$$\ln TFP_t = \sum_i S_{it} \ln TFP_{it} \qquad (2)$$

where S_{it} is the share of the i-th plant in industry output in current dollars.

Baily *et al.* (1992) decompose the industry productivity growth into the contributions of the continuing plants (C), the entrants (N) and the exiting plants (X) using

$$\Delta \ln TFP_t = \underbrace{\sum_{i \in C} (S_{it-k} \Delta \ln TFP_{it})}_{within} + \underbrace{\sum_{i \in C} \ln TFP_{it} \Delta S_{it}}_{between} + \underbrace{\sum_{i \in N} S_{it} \ln TFP_{it}}_{entry} - \underbrace{\sum_{i \in X} S_{it-k} \ln TFP_{it-k}}_{exit} \qquad (3)$$

The contribution of continuing plants can be divided into two parts. The first term is the ***within-effect***, which evaluates the contribution of productivity growth in the continuing plants holding their shares constant in the base year. The second term, which is denoted as the ***between-effect,*** measures the contribution of changes in the shares of plants, holding productivity measure constant in the base year. This value will be positive if there is an increase in the shares of high-productivity plants or a decrease in the shares of low-productivity plants. The last two terms give the contribution of entering and exiting plants to overall productivity growth.

[3] The notation used in this paper follows the corresponding studies that are reviewed.

Using data from the Longitudinal Research Database (LRD) for the years 1972,1977 and 1982 they examine the decomposition of productivity growth in US manufacturing industry for the 1972-77, 1977-82 and 1982-87 periods. They find that for the 1972-77 and 1982-87 periods, within plant productivity determines the performance of the overall growth, whereas for the 1977-82 period the between-effect accounts for most of the overall productivity growth. The entry and exit terms play only a minor role and the values are small.[4] They find that in the periods of growth in the manufacturing sector there is a small negative effect of entry and exit, whereas in the recession periods they observe a small positive contribution from entry and exit.[5]

Griliches and Regev (1995) in their analysis of the productivity growth in the Israeli manufacturing industry propose an alternative method of decomposition. They include the deviation of plant level productivity from the industry average over the base and end years in the between, entry and exit terms.[6] Their decomposition method is given as

$$\Delta P_t = \underbrace{\sum_{i \in C} \bar{S}_i \Delta p_{it}}_{within} + \underbrace{\sum_{i \in C} \Delta S_{it} (\bar{p}_i - \bar{P})}_{between} + \underbrace{\sum_{i \in N} S_{it} (p_{it} - \bar{P})}_{entry} - \underbrace{\sum_{i \in X} S_{it-k} (p_{it-k} - \bar{P})}_{exit} \qquad (4)$$

where a bar over a variable indicates the average of the variable over the base and end years, p is plant productivity, P is sector productivity and S is the plant share in the industry.[7] They use labour productivity as their productivity measure and employment as their share measure. Griliches and Regev (1995) find that most of the labour productivity in the Israeli manufacturing sector over the 1979-88 period occurs within plant.

[4] They report the contribution of entry and exit together as a net entry effect.

[5] Although they do not include average industry productivity in their decomposition method, they interpret the results of the net entry effect in the growth period due to the entrants being below average productivity. Likewise they argue that in the recession period, there was less entry and more exit of low productivity plants leading to a positive net entry contribution.

[6] It is also argued in later studies that this method is less sensitive to random measurement errors in variables such as employment.

[7] Although Griliches and Regev (1995) include average productivity in the between, entry and exit terms, they do not compare their method to that of Bailey *et al.* (1992). A comparison of the two methods can be found in Foster, Haltiwanger and Krizan (1998) as outlined below.

Foster, Haltiwanger and Krizan (1998), following Baily *et al.* (1992) and Griliches and Regev (1995), apply their decomposition method to the measurement of labour productivity. They argue that the Baily *et al.* method of decomposition could lead to a negative net entry effect, even when the entrants are more productive than exiters. They suggest that this may not reflect the true net entry contribution, if the market share of entrants is very low and the market share of exiters is very high. They further suggest that the Griliches and Regev (1995) method obscures the *within-* and *between-effects.* In order to overcome these problems, they propose a modified version of both decompositions given as:

$$\Delta P_t = \underbrace{\underbrace{\sum_{i\in C} S_{it-k}\Delta P_{it}}_{within-firm} + \underbrace{\sum_{i\in C}(P_{it-k}-\overline{P_{t-k}})\Delta S_{it}}_{between-firm} + \underbrace{\sum_{i\in C}\Delta S_{it}\Delta P_{it}}_{cross-effect}}_{continuing-firms} + \underbrace{\sum_{i\in N} S_{it}(P_{it}-\overline{P_{t-k}})}_{entering} - \underbrace{\sum_{i\in X} S_{it-k}(P_{it-k}-\overline{P_{t-k}})}_{exiting} \qquad (5)$$

where P_t is defined as labour productivity in industry, S_{it} is a plant's share of employment at time t and P_{it} is a plant's labour productivity at time t.

In this decomposition, for the between, entry and exit terms, Foster et al. (1998) use the deviation of individual plants' productivity from the base year industry average instead of using the average of base and final year values as proposed by Griliches and Regev (1995).

In Equation 5 the *within-effect* captures the contribution from labour productivity changes within existing plants, holding employment shares constant at their base period level. This term removes the contribution to the productivity growth of changes in employment shares, giving a pure interpretation of productivity change within the existing plants.

The *between-effect* measures the contribution from changes in employment shares, holding constant the labour productivity level of each plant, relative to the group average in the base period. Disney et al (2003) argue that a positive contribution from the *between-effect* suggests that market selection is generating faster growth among more

productive establishments. This term will be positive for (a) plants that have above-average labour productivity in the base period and gain employment share and (b) for plants that have below average productivity and lose employment share during the period. Correspondingly, it will have a negative effect on overall productivity growth if plants with below (above) average labour productivity in the base period gain (lose) employment share.

The *cross-effect* is a covariance term from the specification of the within and between plant effects and it takes account of the interaction of changes in employment shares and labour productivity. If this value is positive then it reflects gains in productivity from plants, which are both gaining market share and increasing their productivity, or from plants whose productivity levels decrease along with their market share. On the other hand if this value is negative and average productivity growth is positive, it shows that on the average, continuing plants increase their productivity levels while downsizing.

The entry and exit of plants involves a movement of resources including capital and labour. If plants that enter are more productive, on average, than plants that are already in operation, this contributes positively to labour productivity growth. If the plants that exit have lower labour productivity than those that continue to operate, this again improves the average labour productivity.

Using Census of Manufactures plant level data for the US manufacturing industry Foster *et al*. first examine the aggregate productivity change over the ten-year period 1977 to 1987. In their analysis they use both multifactor productivity and labour productivity[8]. For shares, they use plant-level gross output with multifactor productivity measure, and both plant-level employment and gross output with labour productivity measure although they argue that for labour productivity, the appropriate share measure is employment. For the period 1977-1987, their analysis shows that the within component accounts for 48 per cent and 74 per cent of average industry productivity for the multifactor productivity and

[8] They calculate labour productivity both on a *per worker* and a *per hour* basis.

labour productivity per worker measures respectively[9]. Net entry accounts for 26 per cent and 29 per cent of the average industry change for multifactor and labour productivity measures respectively. They also carry out their analysis in five-year periods for 1977-82, 1982-87 and 1987-92 to test the robustness of their results for a shorter time horizon. They find that cyclical variation in productivity growth plays a dominant role in the overall pattern. Their analysis also shows that the ***net entry*** contribution is greater in cyclical downturns and ***within-plant*** contribution is large and positive for high productivity growth periods.[10]

Recent studies have followed these studies on the US manufacturing sector, using previously unavailable plant level panel data for a variety of other countries.

Ahn (2000), using plant level data on the Korean manufacturing sector for the period 1990-1998, analyses the micro dynamics of entry, exit and productivity growth. He uses the Baily *et al.* decomposition method in which ***between*** and ***cross-effect*** terms are combined. Ahn uses TFP as the productivity measure and presents results for 1990-95 and 1995-98 periods separately; he points out that the 1995-98 period was marked by a downturn in Korean manufacturing industry. The results for 1990-95 show that ***within*** plant effects account for about 60 per cent of manufacturing productivity growth, while this effect is actually slightly negative during the 1995-98 period.[11] The effect of entry and exit on aggregate productivity growth is more than 40 per cent for 1990-95 and around 65 per cent for 1995-1998. This effect is consistent with the Foster *et al.* findings that net entry term has a greater effect in downturns.[12] Overall the study shows that the entry and exit effects were the most important factors contributing to the productivity growth in Korean manufacturing sector over the period 1990-1998, playing a particularly important role in the recession period of 1995-98.

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[9] The values of some individual components in the decomposition analysis can be greater than 100 per cent due to possible negative contribution of other components.

[10] Foster *et. al.* also present results for eight 4-digit industries in the auto repairs sector to examine the effects of different factors of productivity decomposition in a service industry.

[11] This is consistent with output declining at plant level while employment stays constant.

[12] He also presents results for thirteen 2-digit sectors; these show that within-effect is important in six of the industries and that the entry and exit effects play a major role in seven industries.

A recent OECD (2001) study, that is part of an ongoing project on plant-level data, analyses labour productivity decompositions for eight countries.[13] The periods of the analysis differ due to data availability across countries, but in general the results cover the period between 1985 and 1995. The study analyses both labour productivity and, where available, multifactor productivity growth.[14] They find that for all countries in the analysis, labour productivity growth is largely accounted for by gains within individual plants, where the *within* component accounted for three-quarters of or more of productivity growth. The results show that the *between-effect* varies significantly across countries and over time, but is generally small and in some cases even negative.[15] The net contribution of the entry and exit of plants is positive in most countries, with the exception of West Germany,[16] and accounts for between 10 per cent and 40 per cent of productivity growth. They also find that in cases where the net entry effect is positive and the coefficient is large, exits made most of the contribution, i.e., the closure of inefficient plants.

In years of expansion, the *within* plant effect makes a stronger contribution to overall productivity growth, while in slowdowns the contribution is mostly from the exit of low-productivity plants. The contribution of entry is significantly influenced by the horizon over which productivity is measured, the contribution becoming greater the longer the horizon considered. They argue that this is due to the increased share of activity for entrants in the end year over the time period examined. This contrasts the results of studies on US data, where analyses on longer time periods find a higher contribution of entry than those using shorter time periods.[17] Although the components of the decomposition analysis differ significantly across countries, the OECD study finds that in the industries that are more closely related to information and communication

[13] The countries included are Canada, Finland, France, Germany, Italy, Netherlands, Portugal, United Kingdom and the United States.
[14] Due to data availability they carry out the decomposition of multifactor productivity analysis only for Finland, France, Italy, Netherlands and the UK.
[15] Since this study uses the Griliches and Regev (1995) decomposition method, between-effect results are mixed since they reflect both between and cross terms from Foster *et. al*. (1998) method.
[16] Data for Germany refer to West Germany.
[17] See Baily *et al*. (1992), Haltiwanger (1997) and Foster *et al.* (1998)

technologies, the entry component makes a stronger contribution to labour productivity growth.[18]

In the case of multifactor productivity growth, the OECD results show that the *within* plant contribution is smaller than for labour productivity growth, with the *between* plant and *net entry* effects being more important. Combining these two results on labour and multifactor productivity decompositions, the OECD study concludes that incumbent plants, in a number of European countries, increased their labour productivity by mainly substituting capital for labour. [19]

Baldwin and Gu (2002) examine the contribution of plant turnover to labour productivity growth in the Canadian manufacturing sector over the three periods, 1973-79, 1979-88 and 1988-97, using Annual Surveys of Manufacturers. They measure labour productivity of a plant as real gross output per worker.[20] They use the decomposition methods proposed by Foster et al (1998) and Griliches and Regev (1995).[21] Their results show that productivity growth within continuing plants is the predominant source of labour productivity growth in Canadian manufacturing, where the *within*-plant component of the decomposition ranges from 40 per cent to 100 per cent of aggregate productivity growth. They find that the *between-effect,* which explains the shift towards more productive plants, accounts for 30-70 per cent of labour productivity growth in the 1973-79 period but has a negligible effect after that. The *net entry* effect contributes 25 per cent of productivity growth in the 1973-79 period, but this contribution declines after that.[22] The results of the decomposition of productivity growth in 22 manufacturing industries at 2-digit level show that plant turnover, i.e., entry and exit effects, contribute positively to

[18] Although the study does not give results for the individual sectors, *electrical and optical equipment* sector in the US, *office, accounting and computing machinery* sector in the UK and *precision instruments* industry in France, Italy and Netherlands are cited as examples for the importance of net entry.
[19] They support this with results from studies showing that in many European countries high labour productivity growth was accompanied by reduced employment.
[20] They also report results using value added per worker, which are similar.
[21] In addition to the main two methods used in the literature, they use two alternative methods proposed by Baldwin and Gorecki (1991) and Baldwin (1995). They argue that entering plants replace exiting plants and suggest two methods where they replace the average productivity of an industry with that of exiting plants' average productivity in both Foster *et al.* (1998) and Griliches and Regev (1995) methods.
[22] It is 20 per cent in 1979-88 and to 15 per cent in 1988-97.

labour productivity growth in nearly all of the industries, though *within-effect* is the dominant contributor. They also carry out a decomposition analysis for domestic and foreign-controlled plants separately.[23] Results show that the growth of the *within-plant* component is considerably higher in the foreign sector after 1979. It accounts for 40 per cent of overall *within* growth in the 1970s and this rises to over 55 per cent of the total in the 1990s. They also show that foreign plants are an important source of net entry, representing 60 per cent of the contribution from the total net entry effect.

Disney, Haskel and Heden (2003), using UK Census of Production data, analyse the determinants of productivity growth in UK manufacturing industry. Their data set covers the period 1980-1992. By using the decomposition methods suggested by Foster et al. (1998) and Griliches and Regev (1995), they examine the contribution of *within, between, cross, entry* and *exit* effects on the overall productivity growth in UK manufacturing. They measure both labour and total factor productivity and use employment and gross output alternatively as shares in the decomposition analysis. They find that net entry accounts for around 50 per cent of productivity growth for both labour productivity and total factor productivity measures. They also find that *cross* and *between* terms are important when they use TFP, whereas the *within* term is important for labour productivity.[24] They argue that the stronger *within* contribution to labour productivity growth of continuing firms is driven by capital-labour substitution.[25] On the other hand they find similar *entry* and *exit* effects, irrespective of the use of TFP or labour productivity. They also consider three sub-periods, 1980-82 and 1989-92 as recession periods and 1982-89 as a boom period. Their results show that *within-effect* is more important in the boom period, with *net entry* being less important.[26]

Overall, results from studies on decomposition of productivity growth in the manufacturing sectors in different countries show that the *within-effect* is the most

[23] To our knowledge this is the only study in the literature that examines decomposition of productivity growth for foreign and domestic plants separately.
[24] It accounts for 48 per cent of productivity growth in their study.
[25] They also argue that much of the difference could be due to measurement error in the construction of the capital variable in measuring TFP.
[26] The short recession period makes the interpretation of results sensitive. The authors also note that the recession period of 1980-82 saw very high productivity growth, making the results harder to interpret.

important factor in determining the overall change in labour productivity growth, although this effect is smaller when explaining the change in total factor productivity growth. In comparing results from different countries one has to be alert to differences in data sources, time periods and more, importantly, different decomposition methods used in these studies. These differences make simple direct comparisons difficult.

3 Decomposing Labour Productivity Change in Irish Manufacturing

3.1 Approach of Decomposition

The Irish manufacturing industry has experienced exceptional economic performance during the 1990s, both in terms of increasing output and employment levels. Although employment creation and increased output thorough exports has been the priority for industrial policy for many decades, recently the focus has shifted towards labour productivity. In this section we explain how we propose to examine the changes in labour productivity using the decomposition methods outlined in Section 2.

Foreign plants, mainly drove the growth in the employment and net output levels in Irish manufacturing industry in the 1990s. They accounted for 85 per cent of total manufacturing net output and 49 per cent of total manufacturing employment in 1999. Thus, in addition to the overall results, we present results for foreign and indigenous plants separately and also for four different nationality groupings, among foreign plants.
In order to check the sensitivity of our results for selected time periods, we also decompose labour productivity growth separately for 1991-95 and 1995-99. The latter half of the 1990s, from 1995, shows persistent output and employment growth for both foreign and domestic plants, whereas in the first half of the period many domestic plants experienced both increases and decreases in employment in different years.[27]

[27] Overall labour productivity grew by 38 per cent during the 1991-95 period, with increases of 6 per cent and 45 per cent for domestic and foreign plants, respectively. In the second half of the 1990s, during the 1995-99 period, the labour productivity of domestic and foreign plants increased by 29 per cent and 96 per cent, respectively giving rise to a 87 per cent overall increase.

An overall examination of Irish manufacturing industry, in terms of decomposing labour productivity growth, gives an understanding of the different factors that contribute to this growth, but it can miss the structural differences that exist in different individual industries that make up the overall. For example, although foreign plants account for 85 per cent of total manufacturing net output in 1999, as can be seen from Table 1, this share differs considerably across individual 2-digit sectors ranging from 17 per cent in Other Non-Metallic Minerals to 98 per cent in Chemicals. We can see the same structural difference in terms of the share of employment, with foreign plants accounting for 49 per cent of total manufacturing employment overall, though this value ranges from 15 per cent in Other Non-Metallic Minerals industry to 89 per cent in the Radio, Television and Communications sector. Hence it is necessary to carry out a more detailed examination of labour productivity growth at sectoral level. We carry out this analysis by dividing the individual industries into four main groups, according to OECD classification, namely, high-tech, medium high-tech, medium-low tech and the low-tech industries.

3.2 Methodology and Data

We use the Foster *et al.* (1998) method in our analysis of the decomposition of labour productivity growth in the Irish manufacturing sector over the period 1991-1999, since it is the most comprehensive method in terms of analysing the effects of changes in continuing plants and the contribution of entering and exiting plants. In addition to the comprehensiveness of this method, our analysis benefits from having a data set that is free of the complexities of changing sampling procedures, as it is based on the full population of manufacturing plants.

The data used for our analysis come from the Irish Census of Industrial Production (CIP).[28] This census is carried out annually by the Central Statistics Office of Ireland and covers **all** industrial local units with 3 or more persons engaged. As such it is the only fully representative survey of plants in Ireland. The variables on which data are collected are those standard for such Censuses – output (gross and net), sales, employment, wages,

[28] These confidential data can were accessed and analysed under "safe-setting" conditions at the Central Statistics Office.

capital additions, sectoral and regional classification as well as nationality of ownership. In the CIP, the classification by nationality of ownership is determined by the nationality of the owners of 50 per cent or more of the share capital.[29] The analysis is for the period 1991-99, and covers an average of 4,600 companies, of which more than 3,800 are Irish-owned.[30]

Labour productivity is measured as the ratio of net output to total employment in each plant, where value added figures are expressed in real terms using the producer price indices published by the CSO.[31] Following Haskel and Barnes (2000), we removed all observations where either net output or employment data were missing or had a zero value, in order to deal with missing or spurious observations.[32] Also the top and bottom percentiles of the net output were dropped to remove potential outliers.[33] In addition to examining *within, between, cross, entry* and *exit* effects on overall productivity growth for all plants, we carry out the decomposition separately for foreign and domestic plants because of the importance of foreign plants in Irish manufacturing industry. Although it is possible to examine the contribution of different factors for foreign and domestic plants in the same equation, this approach can cause problems in the Irish manufacturing industry where general labour productivity levels in individual industries are biased upwards with the transfer pricing activities of foreign plants. The model we use in our analysis takes the following form:

$$\Delta P_t = \underbrace{\sum_{i\in C} S_{it-k}\Delta P_{it}}_{\text{within-firm}} + \underbrace{\sum_{i\in C}(P_{it-k}-\overline{P_{t-k}})\Delta S_{it}}_{\text{between-firm}} + \underbrace{\sum_{i\in C}\Delta S_{it}\Delta P_{it}}_{\text{cross-effect}} + \underbrace{\sum_{i\in N} S_{it}(P_{it}-\overline{P_{t-k}})}_{\text{entering}} - \underbrace{\sum_{i\in X} S_{it-k}(P_{it-k}-\overline{P_{t-k}})}_{\text{exiting}} \quad (6)$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}_{\text{continuing-firms}}$$

[29] FDI policy in Ireland does not require minimum domestic equity participation as is the case in many developing countries, and most FDI is in the form of green-field investment with 100% foreign ownership, although CIP does not provide any information on actual foreign ownership levels in individual plants.

[30] Plants that changed nationality during the study period were removed from the analysis; this amounted to less than 1 per cent of total number of plants.

[31] The classification system of manufacturing industries in these indices is the NACE 70 where sector codes are different than NACE Rev. 1 classification system that the CIP adopted in classifying plants to different industries after 1991. We mapped the available information at 2-digit and where possible at 3-digit level between the NACE 70 and NACE Rev. 1 classifications.

[32] This led to a decrease of 169, 163 and 158 in the number of observations for 1991, 1995 and 1999 respectively. This decrease in the number of observation is less than 2 per cent of total number of observations in each year.

[33] Removing the top and bottom percentiles of the net output variables resulted in a loss of 80 observations in 1991, 88 observations in 1995 and 92 observations in 1999.

where i is the i-th plant and t is the time period, C, N and X correspond to continuing, entering and exiting plants respectively. Since our analysis adds another dimension in which we examine the decomposition of labour productivity for different nationality groups, the industry averages that we use in calculating between, entry and exit terms in the decomposition refer to the corresponding groups' mean values of productivity in the industry. So, for example, when calculating the contribution of different components to overall productivity growth in Irish plants, we calculate the industry averages as the average productivity of Irish plants in the corresponding sector. This allows us to compare the individual plant productivity levels from the corresponding sector average for each nationality group.

4 Decomposition of Productivity Growth by Ownership

4.1 Overall Decomposition, 1991-1999

Table 2 presents the results for labour productivity decomposition using Equation 6. Labour productivity growth over the period 1991-1999 was 158 %. The results for all manufacturing plants indicate that continuing plants and those new entrants whose productivity is above the industry average, have contributed significantly to this labour productivity growth. *Within* and *entry effects* accounted for 55 per cent and 29 per cent of overall growth, respectively. The *cross-effect*, showing the contribution of plants with above industry productivity and employment growth is also positive, reflecting the positive trend of both employment and productivity growth in the manufacturing sector during the period.

4.2 Ownership Decomposition, 1991-1999

Next we turn to examine labour productivity growth for foreign and domestic plants separately.[34] Table 2 shows the much higher growth rate in productivity in foreign

[34] Although labour productivity levels of foreign plants are very much affected by the transfer pricing activities of these plants, we do not expect transfer pricing to have any impact on the decomposition of labour productivity in foreign plants.

compared to domestic plants, i.e., 185 per cent and 37 per cent respectively. Productivity growth of Irish plants comes mainly from the *within* (73 percent) and *net entry* (29 percent) effects. The results for foreign plants also show a similar pattern, but the *within* productivity contribution is much lower (55 per cent) for foreign plants. For both domestic and foreign plants the net entry effect arises mainly from the entry of above average productivity plants.[35] The *between-term* effect, which shows the market share reallocations between continuing plants, is more important for domestic compared with foreign plants, reflecting the structural change within the domestic part of the manufacturing industry during this period.

Since the composition of direct foreign investment changed over the 1990s, with increased extra-EU investment and much less intra-EU investment, it is insightful to look at the differences in their productivity growth rates and the contributing factors. The UK dominates intra-EU investment in Ireland, and the US accounts for almost all of the extra-EU investment.[36] To reflect this, we decompose intra- and extra-EU investment in Irish manufacturing industry into four categories – UK, Other-EU, US and Other Non-EU.

The most striking result in Table 3 is the extent to which the productivity growth of US plants exceeds that of the other nationality groups. The *within-plant* effects differ in magnitude three-fold across nationality groups, with a high of 73 per cent for the UK, which is identical to that of domestic plants. The *net entry* term's contribution also varies even more widely across nationality groups, reaching a high of 76 per cent (Other Non-EU).[37] Although it has a similar effect (30 per cent) for UK and US plants, the entry term accounts for all of it for US plants whereas the exit of less productive plants contributes significantly to the UK net entry term.[38] Uniquely, the *cross effect* term for US plants is

[35] The exit of less productive plants contributes positively to foreign plants whereas, for domestic plants the exit of more productive plants brings a negative contribution to overall productivity growth.
[36] The differences between the different nationality groups in Irish manufacturing industry are. outlined in Ruane and Görg (1997). UK plants are mainly engaged in traditional sectors, whereas US plants are mostly in high-tech industries. This forms the basis for our grouping of different nationality of plants.
[37] The only negative effect coming from the entry term is in the Other-EU category but its contribution is negligible.
[38] This difference is not surprising given that there are many more UK plants in traditional sectors.

positive, reflecting the expansion of US plants that showed increased productivity levels.[39] We also see that in Other EU and Other Non-EU plants there is a relatively larger *between-effect*, reflecting the greater employment share reallocation between plants in these two groups.

4.3 Ownership Decomposition, 1991-1995, 1995-1999

Foster *et al.* (1998) argue that the time horizon used in productivity decomposition studies can have an effect on the relative contribution of each of the components. To test whether our results are dependent on the time-period selected, we carry out separate decomposition analyses for the periods 1991-95 and 1995-99. Another factor in the choice of these two periods is the growth rates of net output and employment in the Irish manufacturing sector. Table 4 presents percentage changes of net output and employment for both domestic and foreign plants in Irish manufacturing industry for the 1991-95 and 1995-99 periods. Although the whole 1991-1999 period has shown substantial growth in terms of output and employment, the second half of the 1990s saw a greater increase in values, except for employment in foreign plants. Employment levels in Irish plants actually decreased between 1992 and 1994, which were described as the "jobless growth years" in some studies.[40]

Tables 5 and 6 show the decomposition of labour productivity growth by nationality groups for the 1991-95 and 1995-99 periods respectively. Comparison of the two tables reveals that, for both foreign and domestic plants, most of the labour productivity growth occurred after 1995. While the growth rates in productivity in Irish plants were less than in foreign plants, the inter-period differences in growth rates were even more marked, with labour productivity trebling in Irish plants and doubling in foreign plants. These higher second period growth rates must be seen in the context of substantial employment growth for both domestic and foreign plants in the 1995-99 period compared to virtually

[39] The negative cross effect coefficient for other groups, including Ireland, implies that some of their productivity growth occurred in plants that were downsizing.
[40] See Guiomard(1995)

no change in the 1991-95 period.[41] The productivity growth differed across nationalities, and it is clear that the US productivity growth dominates the foreign-owned sector in the second period. The rate of productivity growth of all other foreign groups was broadly similar to that of domestic industry in this period.

Next we turn to examine the decomposition of labour productivity changes and attempt to ascertain these factors behind the different growth rates for the two periods. In Table 5 we see that in the 1991-95 period, in line with the results from the 1991-99 period, the *within* effect is the most significant contributor to labour productivity growth for both domestic and foreign plants and the foreign plants drive the overall results in the decomposition analysis. The *entry* term is negligible overall and negative for Irish plants, in contrast to the strong positive contribution for the whole period in Table 2. We also see that for Irish plants, exit of below average productivity plants was the main positive contributor to the net entry term.

Table 6 presents the results of the labour productivity decomposition analysis for 1995-99 period. *Within* and *entry* terms are the most important contributors to overall labour productivity growth, with foreign plants one again dominating the overall pattern of results. For foreign plants, comparison of the results for the two periods reveals that the *cross term* had a positive effect in the first period of the analysis, whereas this effect was negative, on average, in the second half of the period. This shows that foreign plants were more successful in improving their productivity and increasing their employment levels in the first half of the 1990s than in the second half of the period. The higher effect of *between* and *entry* terms in the second period than in the first period reflects the fact that more efficient plants were able to gain greater market share in terms of employment and that entrants were more productive in the 1991-1995 period than in the 1995-1999 period. The negative cross term in the second half of the period and its positive effect in the first period for US plants, shows that continuing US plants with increasing productivity were able to increase their employment shares in the first half of the analysis whereas, their

[41] In effect both foreign and domestic plants on average were able to increase their productivity levels and employment levels in the 1995-99 period.

shares declined in the second half of the period. This can be explained by the much higher contribution of entry of above average productivity plants in this group in the period.

5 Sectoral Decomposition

In this section, we divide the manufacturing sector into four main groups, based on the OECD classification of plants at the two/three digit level: high tech, medium high tech, medium low tech, and low tech. We undertake a decomposition analysis for each of these sectoral groups and we present results separately for foreign and domestic firms.

High-Tech Sectors:

We can see from Table 7 that in the high-tech sectors, overall *cross* and *net entry* effects are more substantial than the *within-effects* reported for aggregate manufacturing in Tables 2 and 3. The positive contribution of *cross* effect, which is much higher in foreign plants than in domestic ones, suggests that much of the productivity growth occurred in plants that were upsizing. This effect was higher in US and Other-EU plants, implying that these have been more successful in combining increased productivity with increased employment levels. The *net entry* effect plays an important role for both indigenous and foreign plants and that virtually all of the *net entry* effect derives from the entry of above average productivity plants.[42]

Overall, results for the high-tech sector show that as opposed to the dominance of *within* effect in the aggregate results, the *entry* term is relatively more important role in this sector. This is in line with the results from the OECD (2001) study, which shows that entry plays a more important role in determining the labour productivity growth in sectors related to information and communication technology.

[42] It is relatively more important for Irish plants.

Medium-High-Tech Sectors:

The most striking result from Table 8 is that overall productivity decreased for Other Non-EU plants during the period, in contrast to substantial increases in other categories. This decrease has been mainly due to the *between*-effect,[43] which reflects the fact that the employment share of the plants that were above average productivity declined in this category during the period. In the medium-high tech sectors overall productivity growth mainly comes from the *within* and *net entry* terms, and results from Table 8 show that foreign plants determine the overall average given their high presence in these sectors.

For domestic plants the main contributing factor to productivity growth in terms of *net entry* comes mainly from the exit of below average productivity plants. For all different groups of foreign plants, the *between-effect* makes a positive contribution towards their corresponding overall productivity growth, showing that the market shares of above-average productivity plants increased; this effect is highest for the Other-EU category. In UK plants the *net entry* effect accounts for nearly all of the productivity growth, whereas for US plants, *within-plant* and *entry* of above average productivity plants are both important.

Medium-Low-Tech Sectors:

Table 9 shows that labour productivity growth has been higher in domestic plants than in foreign plants in Medium Low-Tech sectors in the 1991-99 period. In contrast to the domination of foreign plants in the overall figures for the high-tech and medium-high tech sectors, domestic plants drive the overall results in this category. The *within*-effect is much higher for foreign plants whereas the *net entry* driven by the entry factor is higher for domestic plants. The negative sign of the *cross-effect* in this sector reflects the fact that productivity growth is coming from downsizing plants. The *between* term

[43] When overall productivity growth is negative the interpretation of the effects of different factors in the decomposition analysis changes. So a positive sign in this case would be contributing to this decline in productivity whereas a negative sign will be acting in the opposite direction, in other words improving productivity.

contributes positively to overall growth for UK and Other-EU plants whereas it has a negative effect for US and Other Non-EU plants. This reflects the fact that above average productivity plants in the former group increased their employment share whereas in the latter group the employment shares of above average productivity plants decreased.[44]

Low-Tech Sectors:

Table 10 presents results for the low-tech sector where ***within***-effects and ***cross***-effects were the main factors driving overall productivity growth. In this sector we again observe that foreign plants dominate the pattern of the contribution of different factors to overall productivity growth. Here the sign of ***cross***-effect is negative only for UK and Other-EU plants, reflecting the fact that productivity growth came from plants that were downsizing in this category. On the other hand the positive and significant contribution of the ***between***-effect in US and Other Non-EU plants shows that these two groups enjoyed both productivity and employment growth in the low-tech sectors. In contrast to the other OECD sectors, ***entry*** does not play a significant contributory role to US productivity in this sector. In Other-EU plants, the ***within***-plant effect is actually negative, but this is offset by the huge ***between***-effect, suggesting that the decline in the within plant productivity is offset by the increase in the market share of above-average productivity plants. In this category we also see the downsizing in the high productivity plants form the negative ***cross***-effect. The main contributing factor in the productivity growth in Other Non-EU plants mainly come from the ***entry*** of above average productivity plants and the expansion in the employment levels of high productivity plants.

Overall:

Overall, results for the four OECD sectors show that the ***within***-effect contributes most to overall labour productivity growth in all but one sector, namely high-tech sector in which the ***net entry*** (driven mainly by the entry of high productivity plants) and ***cross***-term effects contribute most. In the other three categories the results show that ***within*** and ***entry*** terms, in line with the empirical results from other studies, account for most of the

[44] In US plants in the medium-low-tech sector, as is the case in the previous two sectors, the within and entry effects account for most of the overall productivity growth.

productivity growth. There are differences across nationality groups and these are more prominent between foreign and domestic plants across different sectors. Foreign plants dominate the overall average in all but one sector, medium-low tech sector where we also see that domestic plants' productivity increase has been greater than that of foreign plants. The *cross* term is negative for all nationality groups in medium-high and medium-low sectors, showing that continuing plants, on the average, increased their productivity levels by downsizing.

6 Conclusion

Studies that examine the origins of productivity growth (using both total factor and labour productivity) at plant level find that plant performance is heterogeneous and that net changes observed in aggregate data are marked by large differences in productivity performances across plants.

Overall labour productivity in the Irish manufacturing sector increased by 158 per cent between 1991 and 1999, in addition to strong employment growth in contrast to other European countries. In order to investigate the microeconomic productivity dynamics that took place in Irish manufacturing industry during the 1990s, this paper utilized a labour productivity decomposition approach. Our analysis showed that the key determinant of productivity growth arise from *within-plant* gains in continuing plants and the entry of new plants with above-average productivity. The dominance of *within* and *entry* effects on overall productivity growth is in line with Irish industrial policy; it has focused on improving performance among continuing plants and selectively encouraging entry of high-productivity plants into Irish manufacturing industry.

Recognising the large presence of foreign plants in the Irish manufacturing industry, we carried out labour productivity decomposition analysis separately for both foreign and domestic plants, as well as four different nationality groups of plants. Results showed that although *within* and *entry* components are the main drivers of average labour productivity

growth in all groups, there are marked differences between the size of the effects across the groups, reflecting their different patterns of investment and production.

In order to see the sensitivity of our decomposition results to the time period we investigated the changes for the 1991-95 and 1995-99 periods separately. The results showed that in the first half of the period *within* plant productivity was the main contributor to overall average productivity growth for both foreign and domestic plants, whereas results from the second period reflect the trend from the overall results where both *within* and *entry* components played important roles. This undoubtedly reflects the importance of the establishment of new high-productivity plants in the latter 1990s.

Finally we examined the micro dynamics of labour productivity in Irish manufacturing industry using the OECD four-group classification of sectors. The analysis showed that *within*-effect contributes most to overall labour productivity growth in all but one sector, namely, the high-tech sector in which the *net entry* (mainly driven by the entry effect) and *cross term* effects contributed most. This shows that in the high-tech sector, the entry of above average productivity plants and employment expansion in some of the high productivity plants have been the main drivers of the productivity growth. This is consistent with the finding for the information and communications technology sector reported in the OECD study.

Overall, the Irish results are similar to those for other country studies. Our analysis goes further than many of the other studies in carrying out decompositions at more disaggregated levels (i.e., by ownership and sector). These additional decompositions point to the marked differences between results when data was disaggregated, reflecting the fact that aggregate productivity decompositions hide systematic heterogeneity in the manufacturing sector.

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Tables

Table 1 Significance of Foreign Plants in the Irish Manufacturing Sector, 1999				
	Total Net Output		Total Employment	
	Sectors as % of Total	Foreign as % of Sector	Sectors as % of Total	Foreign as % of Sector
Food, Drink and Tobacco	10.9	66	10.3	26
Textiles and Clothing	0.6	50	3.6	35
Wood and Wood Products	0.2	34	0.9	19
Paper and Paper Products	0.3	32	0.7	19
Publishing and Printing	11.2	86	5.5	34
Pharmaceuticals	7.5	92	5.5	82
Chemicals	39.5	98	9.6	80
Rubber and Plastics	0.5	46	3.5	40
Other non-metallic Minerals	0.3	17	1.3	15
Basic and Fabricated Metals	0.7	37	3.1	24
Machinery and Equipment	1.2	60	5.4	46
Office Machinery and Computers	11.7	98	14.4	88
Electrical Machinery	1.9	80	8.3	70
Radio, Television and Communications	7.9	97	9.7	89
Medical, Precision and Optical	4.3	91	11.6	85
Motor Vehicles and Transport	0.7	71	4.2	54
Manufacturing n.e.c.	0.7	40	2.4	27
Total Manufacturing	100	85	100	49

Table 2: Labour Productivity Decompositions, 1991-1999							
	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net Entry
All	158%	55	6	7	29	-2	32
Irish	37%	73	8	-10	32	3	29
Foreign	185%	55	5	10	28	-2	31

Table 3: Labour Productivity Decompositions for Foreign Plants by Nationality, 1991-1999							
	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net Entry
Foreign	185%	55	5	10	28	-2	31
UK	55%	73	10	-13	20	-10	30
Other EU	71%	63	25	-1	-3	-15	12
US	185%	55	3	14	29	0	29
Other Non-EU	91%	25	15	-15	50	-26	76

Table 4 Percentage Changes in Net Output and Employment in Irish Manufacturing Sector, 1991-99		
	Net Output	Employment
All		
1991-95	55%	12%
1995-99	111%	13%
1991-99	227%	26%
Irish		
1991-95	12%	6%
1995-99	40%	9%
1991-99	57%	15%
Foreign		
1991-95	73%	20%
1995-99	131%	18%
1991-99	300%	41%

Table 5: Labour Productivity Decompositions, 1991-1995							
	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net Entry
All	40	92	8	1	0	1	-1
Irish	8	108	10	-15	-7	-4	-3
Foreign	46	87	8	6	0	1	-1
UK	24	133	-3	-67	20	-17	38
Other EU	34	84	10	-5	4	-7	11
US	40	89	-4	18	2	5	-3
Other Non-EU	53	82	16	-7	6	-3	9

Table 6: Labour Productivity Decompositions, 1995-1999							
	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net Entry
All	84	64	24	-22	29	-6	35
Irish	27	57	4	-3	38	-5	43
Foreign	95	62	29	-24	24	-8	33
UK	25	92	8	4	1	5	-3
Other EU	28	121	-15	-8	32	30	2
US	104	68	30	-30	24	-8	32
Other Non-EU	25	10	19	3	40	-28	68

Table 7- Labour Productivity Decompositions by OECD Sectoral Classification, High-Tech 1991-1999

	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net entry
All	98	10	10	40	38	-2	41
Irish	89	28	-1	7	66	0	66
Foreign	101	10	10	37	39	-4	43
UK	606	1	-2	3	96	-1	98
Other EU	104	79	11	11	-1	0	-1
US	74	12	7	52	26	-3	29
Other Non-EU	159	-21	2	5	104	-10	114

Note: The sectors in the high-tech category are Pharmaceuticals, Office Machinery and Computers and Radio, Television and Communications.

Table 8- Labour Productivity Decompositions by OECD Sectoral Classification, Medium-High Tech 1991-1999

	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net entry
All	222	66	5	-9	34	-4	38
Irish	18	59	2	-3	37	-5	42
Foreign	262	65	5	-9	35	-3	39
UK	266	14	1	-13	93	-4	97
Other EU	76	72	4	0	16	-9	24
US	317	69	2	-9	35	-4	38
Other Non-EU	-15	-120	435	-164	-15	36	-50

Note: The sectors in the medium-high-tech category are Chemicals (excluding Pharmaceuticals), Machinery and Equipment, Electrical Machinery and Medical, Precision and Optical.

Table 9- Labour Productivity Decompositions by OECD Sectoral Classification, Medium-Low Tech 1991-1999

	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net entry
All	33	91	0	-32	36	-4	40
Irish	38	73	0	-21	48	-1	48
Foreign	22	127	7	-53	9	-10	19
UK	62	114	22	-56	12	-7	19
Other EU	12	107	52	-72	14	1	13
US	14	67	-9	-8	31	-19	50
Other Non-EU	57	150	-2	-52	-2	-6	4

Note: The sectors in the medium-low-tech category are Rubber and Plastics, Other Non-Metallic Minerals, Basic and Fabricated Metals, Motor Vehicles and Transport and Manufacturing n.e.c.

Table 10- Labour Productivity Decompositions by OECD Sectoral Classification, Low Tech 1991-1999

	Labour Productivity Growth	Within	Between	Cross	Entry	Exit	Net entry
All	109	66	7	17	10	1	10
Irish	35	76	20	-4	14	5	9
Foreign	180	69	-1	30	1	-1	2
UK	24	93	7	-9	11	1	10
Other EU	81	-5	198	-184	51	-39	90
US	173	67	-4	37	-1	-1	1
Other Non-EU	257	28	-3	27	53	4	49

Note: The sectors in the low-tech category are Food, Beverages and Tobacco, Textiles, Wood and Wood Products, Paper and Paper Products and Printing and Publishing.

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