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Patterns of Firm-Level Productivity in Ireland

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Abstract: Although Ireland is a high productivity country, it has not been immune from the global productivity slowdown, with the pace of growth on a downward trend throughout the 2000s. To identify the determinants behind the aggregate productivity growth in Ireland we use a firm-level panel dataset from the CSO to study productivity patterns and trends distributed by percentile, sector, ownership, as well the efficiency of resource allocation. Our results show a widening of the productivity gap between the most and least productive firms, consistent with cross-country results from the OECD. Results also confirm that aggregate productivity statistics are heavily dominated by a small number of foreign owned firms, leaving Ireland's productivity prone to firm-specific shocks, while also disguising the performance of domestic sectors and firms. Lastly, allocative efficiency, a key driver of productivity, does not appear particularly strong amongst domestic sectors of the economy.

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I INTRODUCTION

A country's ability to increase its living standards over time depends to a large extent on its ability to improve its output per worker, in other words its productivity level. Indeed, disparities in living standards are largely reflected in the different levels of productivity across countries. For example, Hall and Jones (1999), find that output per worker, the traditional measure of labour productivity, is 35 times greater in the United States than in Niger. Disparities in productivity growth were magnified by the Great Recession of 2008, with many countries experiencing a substantial contraction in their aggregate output (OECD, 2014). In the UK, labour productivity has remained weak following the recession, with firm-level evidence suggesting it is 17 percentage points below its pre-recession trend (ONS, 2017).

Advanced economies have experienced a trend decline in productivity growth in recent years, a phenomenon that predates the financial crisis (OECD, 2015; 2016). This 'productivity puzzle', so-called as it comes despite rapid technological advancement, is one of the factors behind the global low growth environment. Should productivity growth remain sluggish it will continue to act as a drag on real wage growth (and hence in living standards) in the years to come. The underlying reasons for the slowdown are complex and research aimed at understanding the global slowdown has shifted the focus towards firm-level dynamics, with a number of projects turning to this method as microdata become more freely available (Bartelsman *et al*., 2004; 2005; 2009; Andrews *et al*., 2015; Berlingieri *et al.*, 2017).

The accepted channels for aggregate productivity growth include innovation and productivity growth amongst firms at the productivity frontier, a diffusion of technology from frontier firms to the rest of the economy, and a reallocation of resources (i.e. capital and labour) from the least productive to the most productive firms through competition (Andrews *et al*., 2016). Empirical evidence based on a number of OECD countries suggests there is no slowdown in innovation at the frontier – indeed, firm-level analysis has shown strong productivity growth amongst the firms at the global frontier throughout the 2000s (Berlingieri *et al*., 2017). However, the same study showed that amongst laggard firms – firms in the lower productivity deciles – there has been limited productivity growth, and no evidence of catch-up. These findings suggest that it may be a breakdown in the diffusion mechanism causing the different productivity patterns across frontiers and laggards, as well as a possible misallocation of resources, driving the aggregate productivity slowdown.

This paper therefore seeks to understand what is happening at the firm level in Ireland to see if the same trends are occurring across the productivity distribution, and how this may explain aggregate productivity growth. We assess the implications of Ireland's particular industrial structure, driven by a high level of FDI, for its productivity patterns. Through use of comparable cross-country results, we analyse

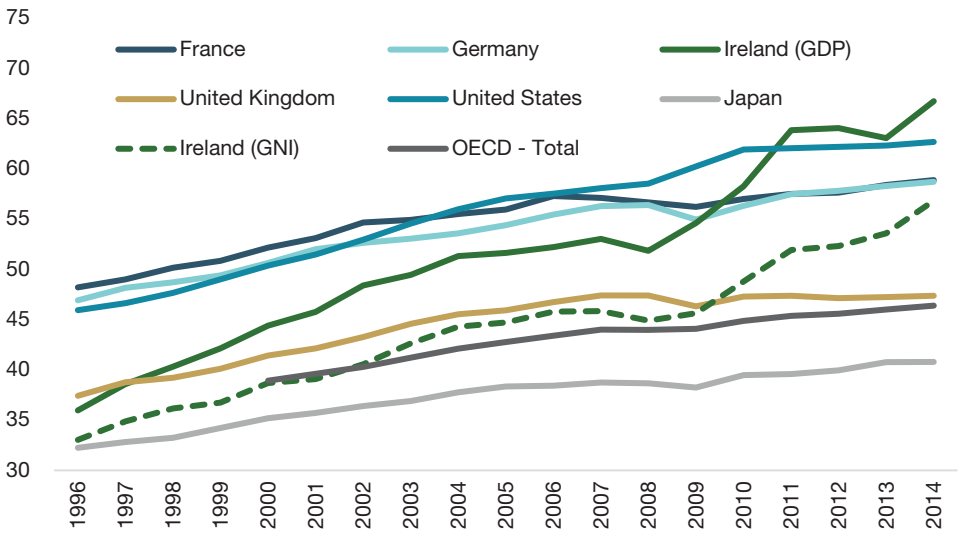
how this impacts the level of productivity dispersion and the efficiency with which resources are allocated across firms in the economy.

The remainder of the paper is structured as follows. Section II provides context on productivity in the Irish economy and the need to look at firm-level data. Section III discusses the datasets used. Section IV examines how this productivity is distributed across firms and the pattern of this dispersion over time. Section V decomposes this by sector, before Section VI provides measures on the efficiency of resource allocation; and finally, Section VII concludes.

II IRELAND'S RECENT PRODUCTIVITY PERFORMANCE

Throughout the 1990s and 2000s Ireland had one of the highest levels of labour productivity among EU Member States, and was close to – and in some years possibly above – the international productivity frontier (Figure 1). Indeed, Ireland's strong growth in the mid-1990s is consistent with the theory of economic catch-up and convergence put forward by Baumol (1986) and DeLong (1988) among others, whereby economies that start off with low levels of productivity tend to experience faster growth rates as they catch up to the frontier.

Figure 1: Labour Productivity: GDP Per Hour Worked (USD – 2010 PPPs)

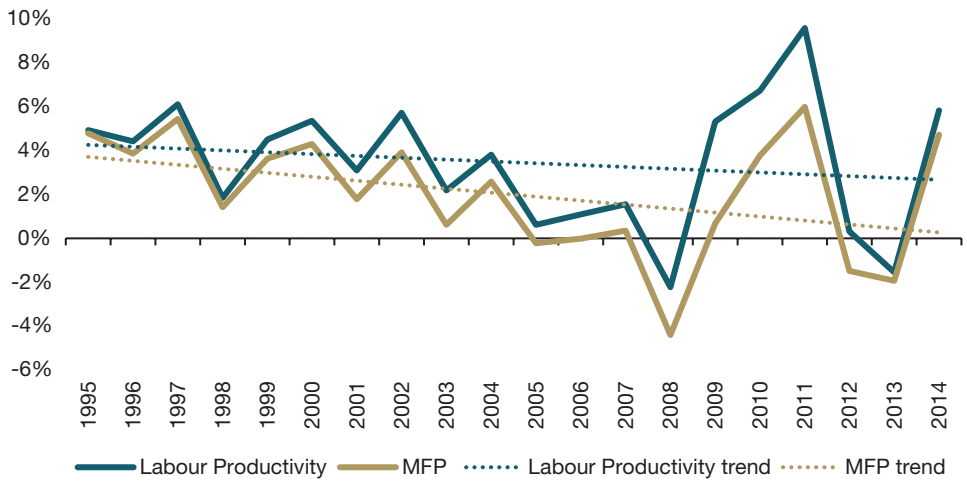


Source: OECD Productivity Statistics 1996-2014.
Note: Dashed line displays Labour Productivity on a GNI per hour worked basis for Ireland.

However, despite a high level and catch-up, Ireland has not been immune to the global slowdown in productivity growth. Productivity growth estimates for Ireland

(Figure 2) show a downward, and at times negative, pace of productivity growth over the period 1995-2014. Moreover, the slowdown in labour productivity growth is consistent with patterns in another widely used measure of productivity, known as Multifactor Productivity (MFP),[1] a proxy for technical change measuring the efficiency with which given inputs are used together in production.[2]

Figure 2: Productivity in Ireland, Year-on-Year Growth 1995-2014



Source: OECD productivity database 1995-2014.

A note of caution is needed when measuring Irish productivity. On a GNI basis, which strips out some – though not all – of the impacts of the foreign owned sector, Ireland's labour productivity (prior to the 2015 level shift) was lower than the GDP based estimate, though still above the UK, Japan and the OECD average (Figure 2). This suggests that standard productivity measures for Ireland are significantly inflated by the activities of parts of the multinational sector. Aggregate productivity being distorted in this way may disguise the productivity performance of domestic sectors and firms which could be stagnant or falling over time.

In part, this is an FDI story, with productivity levels in foreign-owned enterprises typically far in excess of domestic firms. However, it is also a function of the highly concentrated nature of the Irish economy whereby a small number of sectors and firms, most of which are foreign owned, are responsible for a disproportionately large share of output and value added, and therefore

[1] See Hulten (2001) for a short background of MFP, the concept of which is described elsewhere in the literature as total factor productivity (TFP) or the "Solow residual".

[2] Solow (1957) and Swan (1956) were the pioneers of the MFP measure, before Olley and Pakes (1996), Levinsohn and Petrin (2003) and Wooldridge (2009) proposed ways to overcome problems of simultaneity and selection bias when estimating MFP.

productivity.[3] Therefore, more granular analysis is needed to understand the underlying features of aggregate productivity in Ireland as well as the ultimate drivers of productivity growth.

Empirical evidence has found substantial variation across firms' productivity, even within the same industries (Dosi *et al*., 2010). For example, in the US manufacturing sector, productivity in the 90th percentile firm was on average 1.9 times higher than the 10th percentile firm, implying that given the same inputs, the 90th percentile firm makes nearly twice as much output as that of the 10th percentile firm (Syverson, 2004). One potential explanation behind the growing productivity dispersion may be due to differences in the rates of adoption of new technology (Caselli, 1999).

Such large dispersion in firm productivity suggests that analysing total economy or industry productivity will not offer the full picture as, for example, any two industries may display the same productivity on average but have very different underlying distributions. This is important as low average productivity can be explained by too few firms operating at the frontier, indicating a lack of innovation, or too many firms at the bottom due to weak market selection. Both scenarios require very different policy responses, and microdata based research is therefore essential to help decipher the types of firms operating at the national – and possibly global – frontier in Ireland, and those that lag behind.

Such firm-level evidence, coupled with the fact that productivity growth rate has recently slowed down, motivates a number of research questions. Is this trend persistent, or have we seen the end of the productivity growth rates experienced in previous years? What might the drivers of this trend be? And to what extent is this growth influenced by multinationals? Through the use of Irish firm-level data, this paper analyses what types of firms operate at the national frontier, how productivity is distributed across firms, how the dispersion of productivity evolved over time, and how resources are allocated across firms in order to answer such questions.

III DATA

The productivity data used in this paper were generated by using the OECD MultiProd model.[4] The model uses a harmonised methodological framework to generate micro-aggregated statistics that do not breach confidentiality requirements, thereby allowing cross-country comparisons by the OECD. The model uses national administrative data or production surveys, along with a Business Register, to construct statistics representative of the whole population of firms.

[3] CSO data show that sectors dominated by foreign multinationals accounted for 40 per cent of gross value added in 2016. These are NACE sectors 18.2, 20, 21, 26, 27, 32.5, and 58-63. See CSO (2017b).

[4] A full description of the model can be seen in Berlingieri *et al.* (2017), "The MultiProd project: A Comprehensive Overview", OECD Science, Technology and Industry Working Papers, No. 2017/04, OECD Publishing, Paris.

The key input variables are gross output, value added, employment, investment and labour costs on a yearly basis, which are refined by year of birth, NACE economic sector, foreign ownership and size. Labour productivity is generated on a value-added basis, while multifactor productivity (MFP) estimates are also generated.[5] The MFP measures presented herein are a gross output based 'Solow index number'.[6] This measure gives the ratio of (gross) output to a weighted[7] sum of inputs (capital, labour, intermediates), generally assuming constant returns to scale. However, while MFP measures are preferable to labour productivity in that they control for differences in capital intensity across firms, they can be more prone to measurement error issues.

Productivity measures are estimated, in levels and growth rates, at the broad industry level (manufacturing, utilities, non-financial market services, and non-market services) and at the detailed sector level. A number of measures of allocative efficiency are also produced, along with measures of granularity and concentration, and employment dynamics. All monetary variables in current prices are then transformed into real 2005 US dollars, in purchasing power parity terms, using the OECD STAN database.[8]

Given that comparable cross-country productivity estimates were not available for Ireland, we produce productivity data for Ireland following the MultiProd methodology. To do this we use three firm-level datasets for the key input variables by the Central Statistics Office (CSO) – the Census of Industrial Production (CIP), the Annual Services Inquiry (ASI) and the Business Register (BR).[9] The CIP contains data on firms in the manufacturing, utilities, mining and quarrying industries, while the ASI covers firms in market and non-market services, excluding financial services.[10] The average number of annual observations is 10,300, of which 2,500 are industrial firms and 7,800 are service firms.

The Business Register collects information on the entire population of firms for a limited number of demographic variables, and is used to reweight the surveyed data in order to construct statistics representative of the whole population of firms, thus improving the comparability of the results with those of MultiProd countries. Additionally, it enables a more efficient treatment of entry and exit of firms over

[5] For a more comprehensive discussion on MultiProd MFP methods see Section 2.3 of Berlingieri *et al.* (2017).

[6] Although not reported here, the MFP measure generated using the Wooldridge GMM method is also produced by MultiProd. Its correlation with the Solow residual results reported herein are 0.73 and 0.54 for manufacturing and services respectively.

[7] The weights used are cross-country-year median factor shares for each industry from the OECD STAN (STructural ANalysis) database.

[8] At the time of writing, 18 countries have been successfully included in the MultiProd database (namely, Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Hungary, Italy, Indonesia, Japan, Luxembourg, Netherlands, Norway, New Zealand, Portugal and Sweden).

[9] See CSO (2016b; 2016c; 2016d).

[10] In the rest of the paper, non-financial market services, for simplicity, are referred to as services.

the period, while it can assign more precise industry codes in the case of changes in the industry classification at the firm level, or changes in the whole industry classification system.

To give an idea of the coverage of the sample provided, Table 1 shows that around 4 per cent of the entire population of firms as reported in the Business Register are represented by the combined CIP/ASI sample each year, with these firms accounting for around 40 per cent of employment. This sample is then made

Table 1: RMF Data Coverages

Number of firms						
	Manufacturing (CIP)		*Services (ASI)*		*Business Register*	
Year	*Full sample*	*RMF*	*Full sample*	*RMF*	*Total population*	*RMF Representa-tiveness % ((1)+(2))/(3)*
		(1)		*(2)*	*(3)*	
2006	4,620	3,563	91,292	8,461		
2007	5,812	4,301		8,867		
2008	15,955	2,670	175,188	10,679	244,195	5.5
2009	16,285	2,249	179,965	8,583	244,428	4.4
2010	16,050	2,521	182,787	7,205	242,692	4.0
2011	16,132	1,917	183,863	6,750	240,880	3.6
2012	16,385	1,838	188,364	6,870	244,394	3.6
2013	16,540	1,679	188,475	6,551	243,571	3.4
2014	16,497	1,661	185,531	6,546	238,249	3.4
Number of employees						
	Manufacturing (CIP)		*Services (ASI)*		*Business Register*	
Year	*Full sample*	*RMF*	*Full sample*	*RMF*	*Total population*	*RMF Representa tiveness % ((1)+(2))/(3)*
		(1)		*(2)*	*(3)*	
2006	233,298	163,356	823,900	331,488	1,242,765	39.8
2007	243,204	171,737		392,927	1,332,136	42.4
2008	240,946	152,567	1,041,980	432,050	1,511,920	38.7
2009	218,279	141,537	960,348	420,560	1,345.461	41.8
2010	202,301	137,997	926,542	391,906	1,270,475	41.7
2011	201,695	140,520	925,658	366,207	1,259,326	40.2
2012	199,193	136,661	939,243	361,649	1,264,769	39.4
2013	200,991	134,771	961,338	353,833	1,288,017	37.9
2014	210,545	132,451	989,230	327,660	1,334,291	34.5

Source: CIP, ASI and BR.

Note: Research Microfiles (RMFs) are the raw firm-level microdata provided by the CSO containing potentially confidential data.

representative by MultiProd through use of the entire population of firms from the BR to construct sample weights for estimating key output statistics.

IV PRODUCTIVITY DISPERSION

A recurring finding from firm-level productivity analysis is the large and persistent dispersion in productivity between firms, even within narrowly defined industries. Furthermore, despite the recent global productivity slowdown, a small group of frontier firms have experienced consistent rates of productivity growth, while other firms have experienced much lower productivity growth over the same period. Four key questions regarding productivity dispersion in Ireland emerge:

- How is productivity distributed across sectors and firms?
- How much dispersion exists between frontier and laggard firms?
- How does productivity dispersion differ across sectors, countries, and over time? and
- How much of the dispersion in productivity is driven by differences in productivity within sectors as against differences between sectors?

4.1 Distribution Across Firms

The distribution of productivity across firms in both manufacturing and services sectors in 2014 is presented in Figure 3. Under the labour productivity measure,[11] both manufacturing and services sectors show a long right-hand tail in their distribution, especially in the case of manufacturing, which is reflective of the presence of extremely high-productivity firms.[12] The productivity distribution of manufacturing firms depicts a large number of 'modal firms' (i.e. firms with very similar productivity levels) co-existing with a small number of super-productive firms in the tail, who are likely to be multinationals. Labour productivity across services firms, while equally heterogeneous, seems to be distributed across a broader range of values, which may reflect both their less standardised nature compared to goods and the difficulty of measuring output in the sector (Sorbe *et al*., 2018).

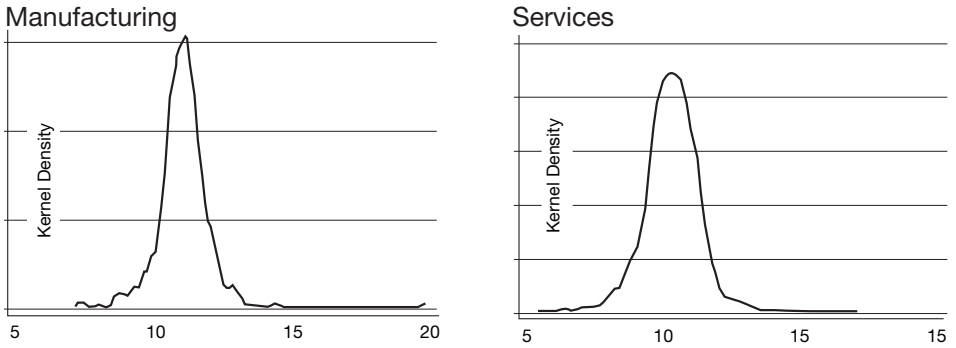
4.2 Distribution Across Sectors

Figure 4 reports the (unweighted) average of firm-level labour productivity of each sub-sector, relative to the unweighted mean of the sector as a whole. This may shed light on what sub-sectors are driving the dispersion across the broad sectors. As the

[11] Only results for labour productivity are presented in this section due to the availability of internationally comparable results, though the findings using MFP are consistent and available upon request.

[12] Though not shown here, both distributions have longer tails than in 2006 and 2010, indicating an increasing presence of extremely high productivity firms.

Figure 3: Labour Productivity Distributions for Manufacturing and Services, 2014



Source: Authors' calculations based on MultiProd using CSO data.

ratios are expressed in logs, the value on the horizontal axis corresponds to the percentage difference between the productivity level of an individual sub-sector, and the unweighted average across the sector it belongs to. A value higher (lower) than zero indicates that the sub-sector is relatively more (less) productive than the average across the sector, with a value of zero indicating that the sub-sector has the same productivity level as the sector average.

For manufacturing, the Pharmaceutical sector is by far the most productive, with an average firm-level labour productivity that is about 170 per cent larger than the manufacturing average. Chemicals and computer products are also well above the manufacturing industry average, being 60 per cent and 43 per cent more productive. This ranking of the top five sub-sectors in manufacturing is consistent with results reported for a benchmark group of countries from MultiProd, suggesting that these sub-sectors may have inherent features which make them productive.[13] In the case of services, the most productive sector relative to the industry average is Scientific R&D (76 per cent more productive). On the other hand, the Hotel and restaurant sub-sector is 48 per cent below the average, and in line with the benchmark group of countries as the least productive services sector.[14,15]

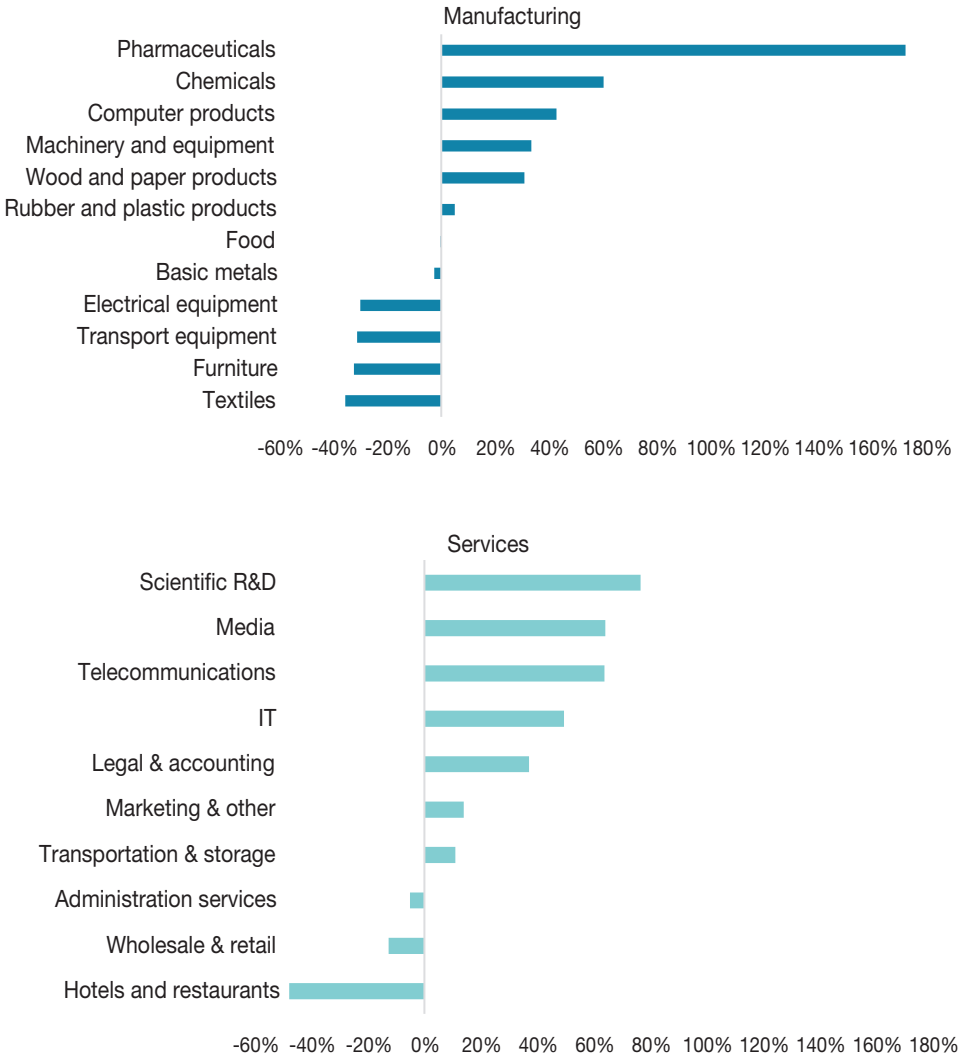
Given that these highly productive sectors are likely to be those with a high foreign presence, as a final look at sectoral differences Figure 5 sets out the sectoral foreign firm labour productivity premium. The chart also notes the average foreign firm employment multiple, as a measure of relative size. The results show that

[13] See OECD (2017).

[14] Both manufacturing and services labour productivity at two-digit industry level are broadly consistent with the CSO figures published in the CIP and ASI (full samples) as well as National Accounts (see Appendix A.1).

[15] The results for manufacturing and services under the MFP measure are also consistent with the MultiProd benchmark group (see Appendix A.5).

Figure 4: Relative Productivity by Two-Digit Industries (2006-2014 average) – Labour Productivity

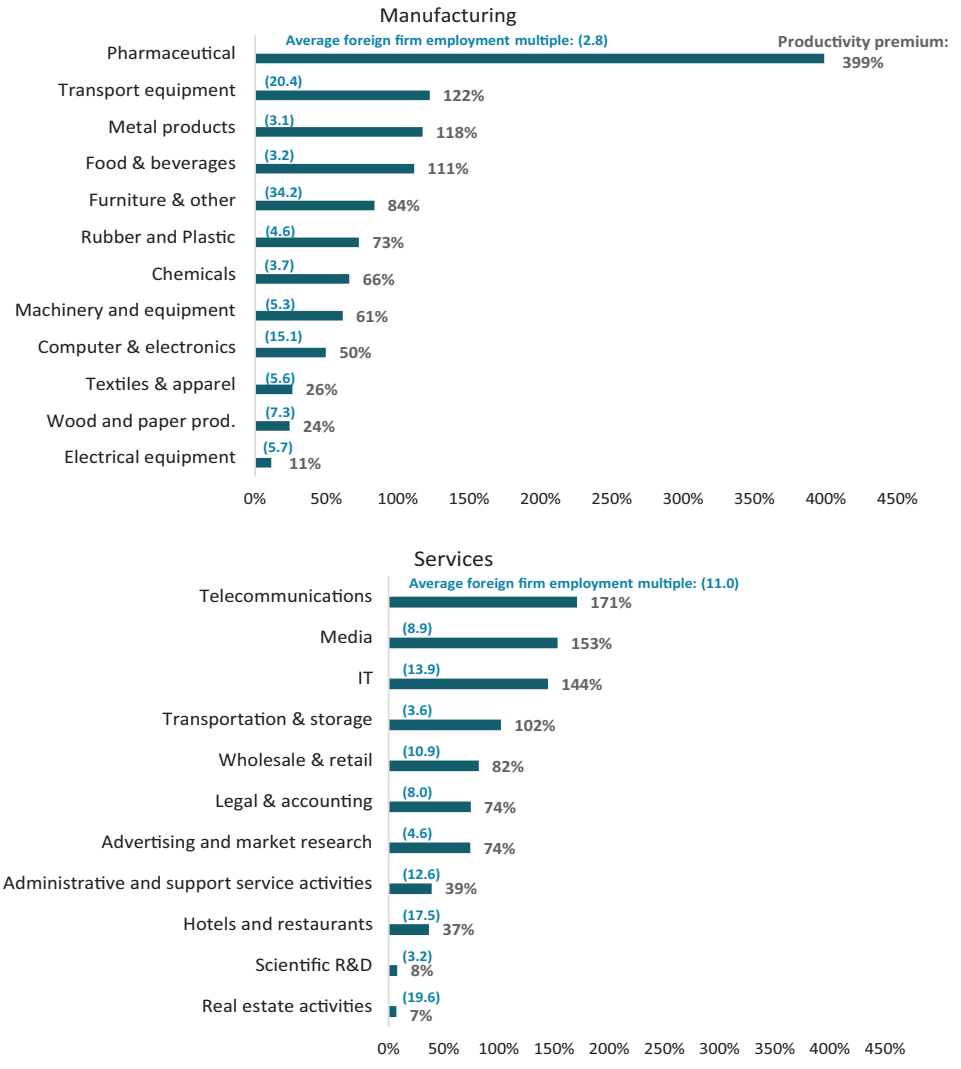


Source: Authors' calculations based on MultiProd using CSO data.

across all sectors, foreign firms are more productive and larger than domestic firms.[16] For instance, in the Pharmaceutical sector foreign firms have a 399 per cent productivity premium over domestic firms, and on average have 2.8 times as many persons engaged as domestic firms.

[16] The positive premium observed for labour productivity also exists for MFP, with the exception of the Textiles sector.

Figure 5: Within-sector Foreign Firm (Log) Labour Productivity Premium and Employment Differential (2014)



Source: Authors' calculations based on MultiProd using CSO data.
Note: The bars represent the foreign firm productivity premium (the horizontal axis) calculated as the percentage different weighted productivity in foreign firms and domestic firms. Average foreign firm employment multiple reported in brackets.

4.3 Frontier vs. Laggard Firms and International Comparisons

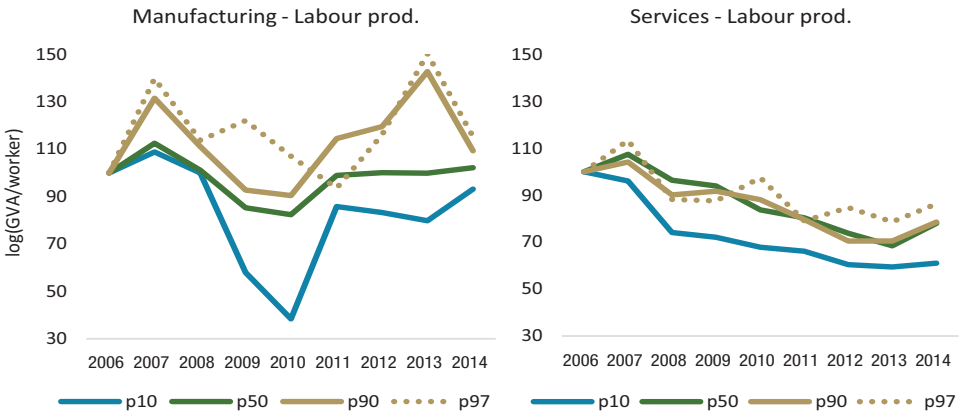
In order to understand the performance of different groups of firms causing the above-described heterogeneity, Figures 6 illustrates some selected percentiles of the labour productivity and MFP distributions over time, namely the 10th percentile

(laggard firm), 50th percentile (median firm), and both 90th and 97th percentiles (frontier firm).[17]

For manufacturing firms, Figure 6 illustrates a decline in labour productivity across all deciles after 2007, coinciding with the onset of the crisis.[18] Even though this pattern reverses from 2010, the recovery has been skewed towards the most productive firms, with a clear widening in the productivity gap between frontier firms and the rest by the end of the period. While year-on-year growth rates are somewhat volatile,[19] overall top performers are roughly 10 percentage points above their productivity level in 2014 compared with 2006, with the median firm productivity in 2014 just above its pre-crisis level of 2006, and the bottom performing firms still lagging. These trends are very similar for the MFP measure. Overall both measures indicate a widening in the productivity gap between the 'best' and the 'rest'.

In services, labour productivity levels declined post-2007 across all cohorts of firms, and still remained well below their 2006 level (between 15 and 40 per cent)

Figure 6: Trends for Top, Median and Bottom Decile of (Log) Labour Productivity Distribution



Source: Authors' calculations based on MultiProd using CSO data.
Note: 2006 normalised to 100. P10 = 10th percentile, P50 = 50th percentile, P90 = 90th percentile, P97 = 97th percentile.

[17] Sensitivity analysis carried out by the authors indicates a reasonable degree of consistency in the overall path for different definitions of the frontier (i.e. top 10th, 5th and 3rd percentiles of firms) in labour productivity measures.

[18] Transfer pricing could potentially have an impact on labour productivity statistics through the impact on output data. However, given that many of the foreign multinationals that engage in transfer pricing are likely to be extremely productive, located above even the 97th percentile, this is unlikely to affect the percentiles presented.

[19] The spike observed in the 90th and 97th percentiles in 2013 is partly due to developments in the Pharmaceutical sector.

at the end of the period. As with manufacturing, a widening in the labour productivity gap can be observed, although for slightly different reasons. While in the manufacturing sector frontier firms have seen a faster recovery in productivity growth after the crisis, in the services sector frontier firms have seen a slower decline in productivity growth as compared to laggards.[20]

Overall, Ireland's trends for the top, median and bottom deciles of labour productivity growth in manufacturing are relatively close to those observed in the cross-country analysis carried out by the OECD (Figure 1 displays these deciles for the median of a number of OECD countries, excluding Ireland). However, in the case of Ireland, productivity growth declined much faster, and the recovery was slower than other countries. This is not surprising given the relatively deeper recession experienced by the Irish economy during that period. In the case of services though, Irish labour and multifactor productivity, across all deciles, has not yet returned to pre-crisis levels, unlike the median OECD country, where recovery has occurred.

Table 2: Labour Productivity Dispersion by Country, 2011

Country	*Labour productivity 90:10 ratio*	
	Manufacturing	*Services*
Australia	6.5	7.8
Austria	7.1	11.2
Belgium	5.0	5.7
Chile	20.1	34.1
Denmark	4.3	7.1
Finland	3.2	4.0
France	3.9	6.1
Hungary	16.3	26.8
Indonesia	22.4	–
Italy	5.3	7.5
Japan	3.5	4.0
Netherlands	7.4	19.7
New Zealand	6.3	8.1
Norway	5.6	8.8
Portugal	6.6	14.2
Sweden	4.3	6.4
OECD average	6.6	9.2
Ireland	7.9	9.3
Ireland (97-10)	13.2	18.4

Source: Authors' calculations based on MultiProd using CSO data.
Note: Cross-country comparators from Berlingieri *et al*. (2017).

[20] Again, these trends are consistent under the MFP measure.

To put the 'productivity gap' into perspective, the 90:10 ratio in Ireland is compared to the group of countries in the MultiProd network in Table 2.[21] The first point of interest is that there is significant productivity dispersion between the frontier and laggard firms across all countries. Second, dispersion is on average higher in services than manufacturing, which is as expected given there tends to be more heterogeneity in services. For Ireland, the labour productivity dispersion ratio of 7.9 in manufacturing for Ireland in 2011 implies that firms at the top of the distribution can produce more than eight times as much value added per worker as firms in the bottom decile of the country's manufacturing sector,[22] and similarly nine times in services. This is close to the average ratios across countries, suggesting that despite the possible distortionary influence of FDI on aggregate productivity, Ireland's productivity gap is not an outlier. However, much larger ratios obtained when looking at dispersion between the 97th and 10th percentiles which may give a better idea of the gap between the low productivity firms in Ireland compared to the large multinational firms that are likely located in these upper percentiles.

V PRODUCTIVITY DISPERSION DECOMPOSITION

The previous sections have reported the productivity dispersion of the broad manufacturing and services sectors. This section shows that it is the dispersion within two-digit industry that is generating most of the overall dispersion. The overall dispersion in productivity in each broad sector can be decomposed into productivity variation within (two-digit) industries, capturing how much a firm's individual productivity differs from the broad sector (labour-weighted) average, and variation between sectors, capturing how much sectors vary from each other.

Total productivity variance (V_t) can be split into two components: a within-industry component (V_{Ft}) and a cross-industry component (V_{Xt}).

$$V_t = V_{Ft} + V_{Xt}$$

Within-industry variance is the weighted (by employment) average over all sectors j of the squared deviation of the firms' productivity from their sector (weighted) average labour productivity. δ_{jt} represents this deviation between the firm-level productivity and the sector weighted average (i.e. $P_{it} - \bar{P}_{jt}$). L_{jt} is the number of employees in sector j at time t while L_t is the total number of employees at time t.

$$V_{Ft} = \sum_j \frac{L_{jt}}{L_t} \delta_{jt}^2$$

[21] 2011 is the reference year used for cross-country comparison by the MultiProd project as per Berlingieri *et al.* (2017).

[22] This is calculated as the exponential of the log difference reported in the table.

The cross-industry component is the weighted average of the squared deviation of sector *j*'s average productivity ($\bar{P}_{jt}$) to the economy-wide productivity ($\bar{P}_t$).

$$V_{Xt} = \sum_j \frac{L_{jt}}{L_t} (\bar{P}_{jt} - \bar{P}_t)^2$$

The proportion of total productivity variance accounted for by the within-industry component (i.e. V_{Ft}/V_t) is presented in Table 3 for manufacturing and services, for Ireland and the comparator countries. The results for Ireland show that within-sector dispersion accounts for nearly 95 per cent of the overall labour productivity dispersion observed across firms in manufacturing, and 94 per cent in services. Therefore, the vast majority of the productivity dispersion comes from the variation in productivity between firms *within* the same two-digit sector, rather than differences in productivity between sectors, indicating that a large part of the productivity heterogeneity is firm- rather than sector-specific.

The within-sector dispersion in Ireland is amongst the largest across the group of MultiProd comparators, below only Australia in manufacturing, and Australia, Chile and Hungary in services. This suggests that the productivity heterogeneity in Ireland is wider than most countries, which may in part be due to the large number of multinationals located in the country, concentrated within certain sectors, who are much more productive than their domestic counterparts.

Table 3: Share of Labour Productivity Dispersion Accounted for by Within-Sector Variation, 2011

Country	*Manufacturing %*	*Services %*
Australia	98	99
Austria	86	90
Belgium	76	88
Chile	90	97
Denmark	84	63
Finland	65	76
France	63	85
Hungary	79	99
Indonesia	79	–
Italy	82	65
Japan	75	89
Netherlands	80	71
Norway	83	73
Portugal	62	76
Sweden	53	74
Ireland	94	94

Source: Authors' calculations based on MultiProd using CSO data.
Note: Cross-country results from Berlingieri *et al*. (2017).

VI FIRM SIZE AND PRODUCTIVITY

6.1 Productivity Concentration

In large economies it is generally assumed that uncorrelated micro shocks, on average, cancel each other out. In an economy like Ireland, where a small group of large firms dominate certain sectors, this is unlikely to be the case, suggesting that aggregate (productivity) variation is likely to be the result of (large) firm-level variation. Indeed, the so-called 'granular hypothesis' (Gabaix, 2011) suggests that aggregate (productivity) fluctuations are the result of microeconomic (firm-level) shocks rather than economy-wide shocks.[23] This section outlines the extent to which a small group of large firms contribute to productivity estimates.

The first concentration measure we look at is the market share (both in terms of value added and employment) of the top decile of firms as ranked by their gross output. The top 10 per cent of firms account for 87 per cent of value added and 73 per cent of employment in manufacturing (on average, from 2006 to 2014). In services, the contribution from the largest firms is higher than in manufacturing, with shares of approximately 96 and 87 per cent, respectively. Overall, value added and employment are more concentrated in Ireland than in other OECD countries for which comparable estimates exist.[24] These cross-country estimates are weighted averages across all countries and years, and show that about 79 per cent (78 per cent) of the total value in manufacturing (services) is produced by the firms in the top decile of sales. For employment, the firms in the top decile of sales employ 66 per cent (66 per cent) of total employment in manufacturing (services), (Berlingieri *et al.*, 2017). This suggests that Ireland's aggregate productivity may be more susceptible to firm-level shocks than other countries if these large firms are also the most productive.

Figure 7 shows the contribution of the most productive firms (those located between the 90th and 100th percentiles of the labour productivity distribution) to aggregate productivity in both manufacturing and services. The top 10 per cent of firms in manufacturing account for about 70 per cent of aggregate productivity over the period 2006-2014, and just under 80 per cent in 2014.[25] In services, however, the contribution of the most productive firms on aggregate productivity is lower than in manufacturing. The top 10 per cent most productive firms account for 46 per cent of aggregate productivity over the period, although showing a growing trend after the financial crisis from 37 per cent in 2008 to 56 per cent in 2014, which may suggest an improvement in the efficiency of resource allocation.

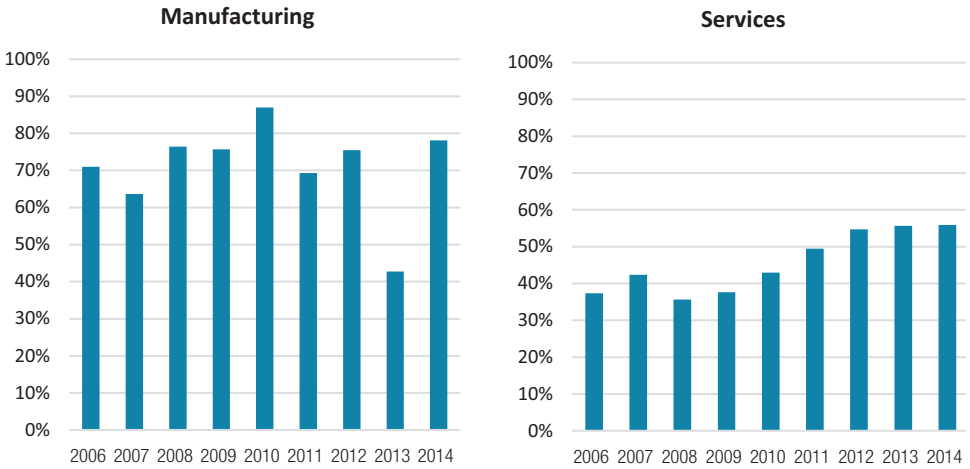
[23] See also Jovanovic (1987); Cochrane (1994); Durlauf (1993); and Nirei (2006).

[24] The countries included are Austria, Belgium, Denmark, Finland, Hungary, Norway, Portugal, over the period 1996-2012.

[25] The 2013 decline in aggregate manufacturing productivity was mainly driven by a drop in value added of a number of top performing pharmaceuticals and chemicals firms, a phenomenon known as the 'patent cliff', see Enright and Dalton (2014).

Overall, this illustrates the impact that a small number of firms are having on aggregate statistics such as value added, employment and ultimately productivity. Given the small number of these large firms, uncorrelated idiosyncratic shocks would not be expected to 'average out' over a large number of firms. In other words, productivity shocks within these players are likely to impact on aggregate productivity estimates to a large extent. A formal quantification of this strong relationship between firm size and productivity is provided next.[26]

Figure 7: The Contribution of the Most Productive Firms to Aggregate Productivity



Source: Authors' calculations based on MultiProd using CSO data.
Note: The bars represent the contribution of the top 10 per cent most productive firms to aggregate productivity.

6.2 Efficiency of Resource Allocation

The allocation of resources across firms can have a positive effect on aggregate productivity when there is a flow of inputs (capital and/or labour) from low- to high-productivity firms. Conversely, if factors are largely allocated to, or flowing towards inefficient firms, aggregate productivity will be adversely affected. A constant churn, or reallocation, of resources between firms in the same industry has been found in previous empirical research (Foster *et al*., 2002) where in addition to the entry of new firms and the exit of shrinking firms, productivity is driven by continuous upscaling and downscaling of incumbent firms. This churning can contribute to aggregate productivity growth, the extent of which depends on how effectively resources are reallocated across firms and sectors. Allocative efficiency has been found to vary considerably across countries (Bartelsman *et al*., 2004), as well as sectors (Arnold *et al*., 2011).

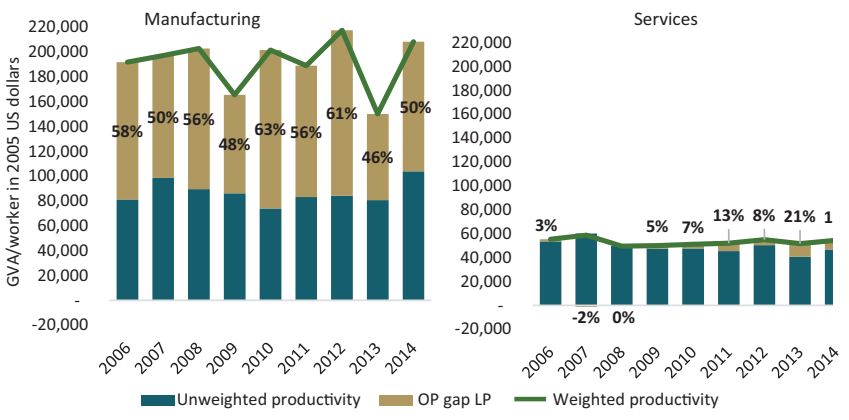
[26] Another measure to assess the extent of market concentration is the Herfindahl-Hirschman Index (HHI) and is presented in Appendix A.4.

Contributions to (weighted) aggregate productivity can be decomposed using the Olley-Pakes (1996) method into the contributions from (unweighted) within-firm productivity, and the efficiency of resource allocation, measured by the covariance between firm size and productivity. The latter term (known as the OP gap) is a measure of allocative efficiency, since it increases if more productive firms capture a larger share of resources in the sector. The formula is presented below, where P_t is the weighted industry level productivity at time t, N_t represents the number of firms in a sector, $\theta_{i,t}$ is the share of a firm i at time t, and $\bar{P}_t$ and $\bar{\theta}_t$ are sectoral averages. In the case of the value added-based measure of labour productivity, the weights used are simply labour shares. The first term on the right hand side of the equation represents unweighted productivity while the second term represents the OP gap.

$$P_t = \frac{1}{N_t}\sum_i P_{i,t} + \sum_i (\theta_{i,t} - \bar{\theta}_t)(P_{i,t} - \bar{P}_t)$$

Figure 8 plots the (weighted) aggregated productivity and its components, namely unweighted average productivity and the OP gap; plots are shown separately for manufacturing and services. In the manufacturing sector, more than half of aggregate labour productivity is accounted for by the allocative efficiency term (OP gap) over the whole 2006-2014 period. The remaining part of aggregate productivity in manufacturing is accounted for by within-firm productivity, which is effectively unweighted productivity. The size of the OP gap therefore captures how allocating resources among productive firms can boost productivity. The 2013 decline in weighted productivity was mainly driven by a drop in value added of large chemical and pharmaceutical enterprises, coinciding with the 'patent cliff' in

Figure 8: Resource Allocation: 'OP Gap', Weighted and Unweighted Productivity



Source: Authors' calculations based on MultiProd using CSO data.

those sectors.[27] This is a clear illustration of the dependence of aggregate productivity on a small number of highly productive sectors and firms.

On the whole, Ireland's OP gap in the manufacturing sector is relatively large and stable over time, indicating a fair degree of allocative efficiency as a high share of resources are already allocated to the most productive firms. However, as discussed in previous sections, large variations exist in firm productivity even within narrowly defined sectors. While the OP gap indicates that resource allocation is relatively efficient in the Irish manufacturing sector as a whole, these results are likely driven by particularly efficient sub-sectors.

In services, most of the aggregate productivity is accounted for by within-firm (unweighted) productivity over the period 2006-2014, with the overall allocation of resources playing a very small role. In fact, the OP gap was even negative during the crisis indicating an inefficient resource allocation during that period, indicative of an increase in market share by (and flow of resources towards) less productive firms.[28] After the crisis the OP gap started to grow, accounting for about 14 per cent of aggregate productivity in 2014. This tallies with Figure 7 and shows that resources are being redistributed more efficiently, meaning the more productive firms are growing in size.[29]

Ireland's resource allocation term in manufacturing is large when benchmarked against other OECD countries, with only Hungary and Chile reporting OP gaps of 50 per cent or more in 2011 (see Figure 13). However, given that this outcome is likely to be driven by the impact of a small number of very large firms, in certain foreign dominated sectors, we also present the OP gap for manufacturing with a small number of sectors dominated by foreign multinationals excluded from the analysis.[30] Relative to the full manufacturing sample, the exclusion of foreign dominated sectors results in a much lower OP gap, but a similar within-firm productivity. This result suggests that a substantial part of aggregate labour productivity (in manufacturing) is indeed driven by efficient allocation of resources within a small group of foreign dominated sectors.

Figure 9 shows that once these highly productive foreign-dominated sectors are removed, Ireland's productivity (both aggregate and components) is much more in line with those of other countries.[31] In fact, the OP gap is lower than in many

[27] See Enright and Dalton (2014).

[28] In fact, the OP gap has been found to be negative in a number of services sub-sectors such as Administrative and support service activities, Real estate activities, and Accommodation and food service activities. The low value of the OP gap in services may reflect the lower correlation between productivity and size in the service sector, as recently shown by Berlingieri *et al.* (2018).

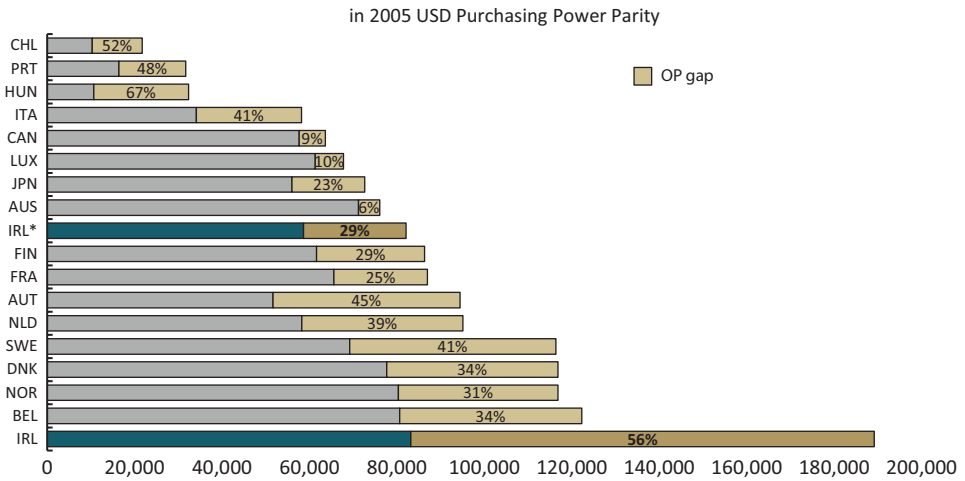
[29] Resource allocation analysis for services with foreign dominated sectors excluded are not presented here as the removal of foreign dominated sectors does not materially change the results.

[30] See CSO (2017b) for a list of foreign MNE dominated sectors.

[31] The results for manufacturing without foreign dominated sectors also remove the influence of firms who have located intellectual property in Ireland, which would inflate their productivity statistics, as shifts in intellectual property can distort value added-based measures.

countries, suggesting that the allocation of resources is much less efficient in the non-foreign dominated sectors of the economy.

Figure 9: Resource Allocation: OP Gap for Manufacturing Across Countries – 2011



Sources: Authors' calculations based on MultiProd using CSO data; Berlingieri *et al*. (2017).
Note: IRL* excludes MNE-dominated sectors.

VII CONCLUSION

This paper has used firm-level data to understand the dynamics driving Ireland's declining productivity trends, and the influence that Ireland's high level of FDI has had on aggregate productivity figures. Using a harmonised method we are able to then compare these results to those observed in OECD cross-country studies from the distributed microdata project MultiProd.

Ireland's productivity gap, the distance between high productivity 'frontier' firms and low productivity 'laggards', has widened over time in both manufacturing and services, although for different reasons. In manufacturing, after an initial fall in productivity coinciding with the Great Recession, we see that frontier firms have recovered to their pre-crisis levels while laggard firms have failed to do so. In services, firms at both ends of the productivity distribution declined over the period, although laggard firms saw a larger fall. Comparing these trends to cross-country results, productivity in manufacturing declined much faster while the recovery was slower for Ireland, unsurprising given the relatively deeper recession experienced by the Irish economy during that period. In the case of services, the cross-country results showed that a recovery to pre-crisis levels occurred, unlike the Irish results. We then compare the size of the productivity gap for Ireland to the cross-country

results. This is close to the average across countries, suggesting that despite the possible distortionary influence of FDI on aggregate productivity, Ireland's productivity gap is not an outlier.

Decomposing this productivity dispersion into variation within sectors and differences across sectors pinpoints the within-sector differences as the main driver of this overall variation, confirming that a large part of the productivity heterogeneity is firm- rather than sector-specific. The within-sector dispersion contribution for Ireland is amongst the largest across the group of comparators. This may in part be due to the large number of multinationals located in the country, concentrated within certain sectors and who are much more productive than their domestic counterparts. This suggests there may be greater scope for future productivity gains through diffusion, as encouraging linkages between high and low productivity firms in the same sector should be more feasible than those in unrelated sectors.[32]

We confirm the reliance of aggregate productivity on a small number of firms using a range of concentration measures. This suggests that any future trends in Irish aggregate productivity are highly dependent on these firms, and that any fluctuations to this over time are likely to be explained by micro (firm-level) shocks as opposed to economy-wide shocks. The efficiency of resource allocation is also deceptively high for Ireland due to these few firms. When foreign-dominated sectors are removed we find that Ireland's resources amongst domestic sectors and firms are much less efficiently allocated, and more in line with the OECD MultiProd comparison countries.

Although this paper makes clear the large contribution of large multinational enterprises to the Irish economy in terms of productivity, it also highlights that to ensure a more sustained aggregate productivity growth it is crucial to bridge the productivity gap between high productivity firms and those who are lagging behind. Although the size of this gap is not out of line with comparator countries, its growth should be of concern. However, the fact that the dispersion is mainly due to differences within sectors means that there is greater potential for policy to encourage linkages between the frontier and laggard firms, with benefits for long-term living standards via more efficient resource allocation among firms.

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[32] For example, this could occur through supply-chain linkages, the benefits of which are well established (see De Soyres and Gaillard, 2019).

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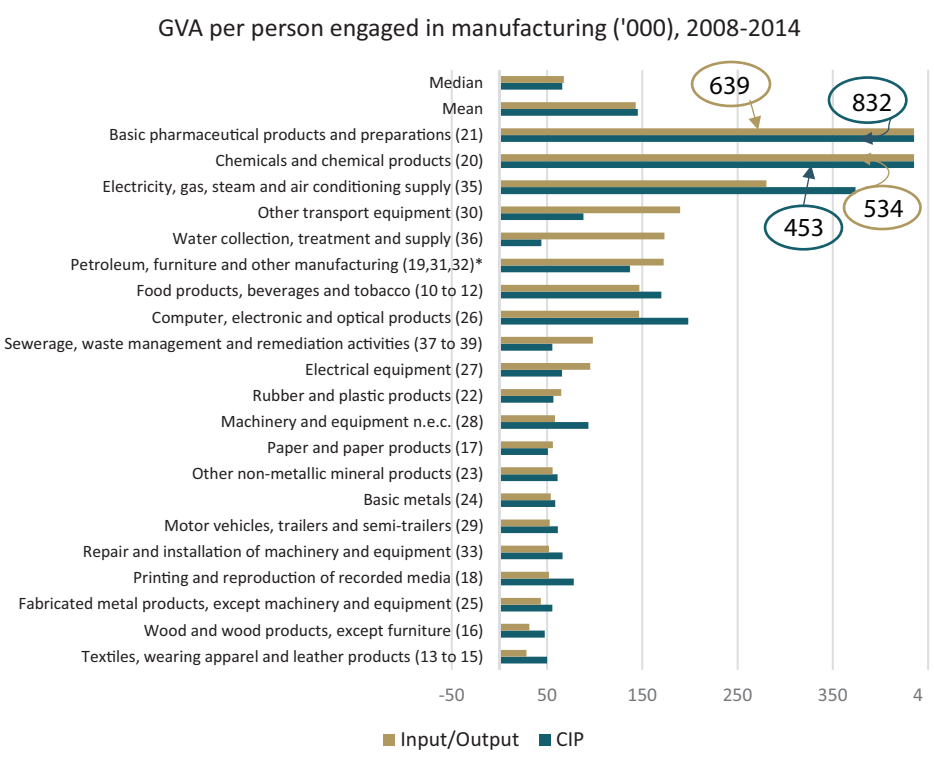
APPENDIX

A.1 Robustness Check vs. National Accounts

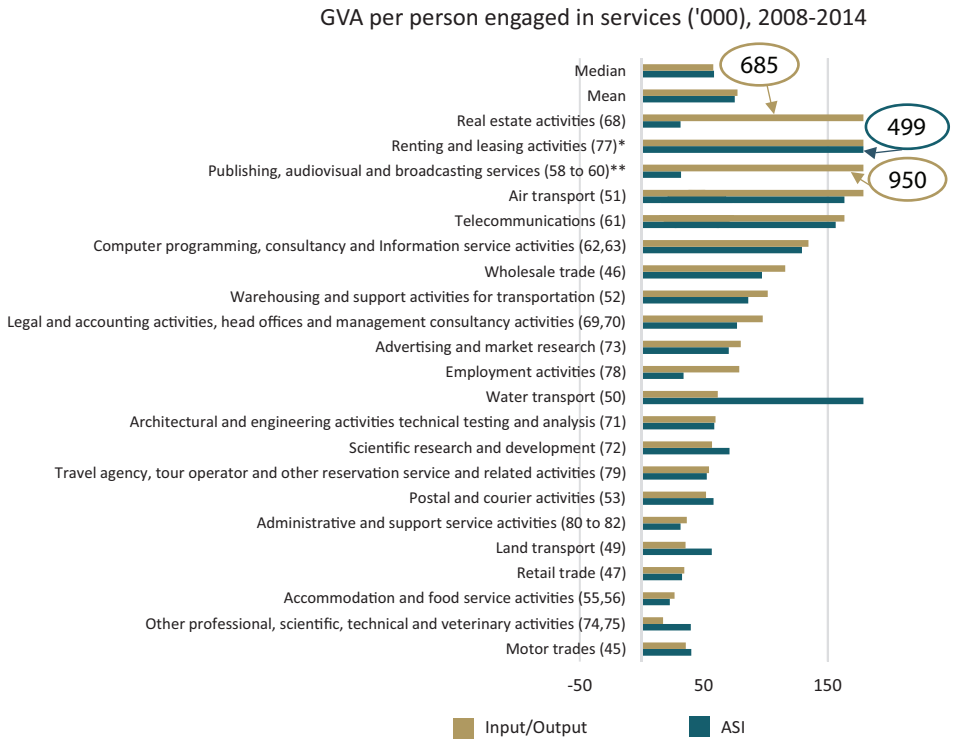
Figures A.1(a) and A.1(b) show that for both manufacturing and services, the production surveys used in MultiProd generate consistent results with the National Accounts. This is in part due to a coherency project that was carried out by the CSO, to ensure consistency between estimates from production surveys and those in the National Accounts.

Figure A.1 (a): Labour Productivity – Micro vs. Macro Measure



Source: CIP and Input/Output tables from National Accounts (CSO).
Note: Persons engaged for Input/Output sectors drawn from EHECS/QNHS (macro measure)
Persons engaged for CIP drawn from CIP survey responses (micro measure).
*Sub-sector 19 is removed from the CIP due to confidentiality.

Figure A.1 (b): Labour Productivity – Micro vs. Macro Measure



Source: ASI and Input/Output tables from National Accounts (CSO).
Note: Persons engaged for Input/Output sectors drawn from EHECS/QNHS (macro measure)
Persons engaged for ASI drawn from ASI survey responses (micro measure).
*The differences observed between source data for renting and leasing are due to the differential treatment of aircraft leasing activities, which has been completely removed from the MultiProd database.
**Sub-sectors 58 and 60 are removed from the ASI due to confidentiality.

A.2 Transformations to the Primary Data

- *Harmonisation of the pre- and post-2008 methodologies in the production surveys*. To ensure consistency with the National Accounts, the CSO revised the structural business statistics series back to 2008. The pre-2008 data in the longitudinal panel have therefore been transformed to ensure consistency with the treatment of R&D.
- The aircraft leasing sector was dropped in order to avoid distortions between the treatment of aircraft pre- and post-2008.
- The Mining and quarrying sector was also dropped as it contained less than the minimum number of observations MultiProd requires to run.

- Birth years can differ across sources for the same firm and there could be a level of replication of records for the same firm. Therefore, the earliest year on record for any firm regardless of source was taken as its birth year.

A.3 Capital Stock Estimation

For MFP estimation, firm-level capital stocks are calculated based on the perpetual inventory method (PIM) using annual firm-level investment. The PIM relies on an opening capital value for each firm, annual investment and depreciation. While the main MultiProd run begins in 2006 (the first year the Business Register is available), in order to generate an initial capital value for each firm, the closing value of a parallel run is used. The parallel run begins for each firm in the year of their first ever observation in either the CIP or ASI, which commenced in 1991 and 1999 respectively, and ends in the year 2006. For firms that join the production survey after 2006 their opening capital stock values are calculated as the average of two proxies, namely:

- Average firm investment in all years divided by the depreciation rate, as provided by the OECD STAN tables;
- Country-industry-year specific capital-labour ratio (K/L) from the same STAN tables, which is then multiplied by firm-level employment (L).

A.4 Alternative Measures of Concentration

The Herfindahl-Hirschman Index is calculated as the sum of the squared market shares (by gross output) of all firms in a given industry, representing a single measure of market concentration.[33,34] It ranges from 0 to 1, with higher levels of concentration having a higher HHI score.

Table A.3 presents the HHI in 2011 from Berlingieri *et al*. (2017) for a number of countries included in the MultiProd network, along with Ireland. The results show that Ireland recorded a HHI of 0.158 in 2011 in manufacturing, only slightly above Australia, and 0.220 in services, by far the highest score in services that year, and more than twice that of Switzerland, the next highest. Again, these results suggest that Ireland's aggregate statistics are more dependent on a small number of firms than in other countries.

[33] This measure of concentration has been calculated by the authors outside the MultiProd framework on the basis of the same CIP and ASI data.

[34] $HHI_j = \sum_i \left(\frac{S_{ij}}{S_j}\right)^2$

Table A.1: Herfindahl-Hirschman Index of Concentration, 2011

Country	*Manufacturing*	*Services*
Australia	0.155	0.036
Austria	0.063	0.016
Belgium	0.050	0.019
Canada	0.018	0.017
Chile	0.058	0.014
Denmark	0.041	0.027
Finland	0.057	0.013
France	0.007	0.005
Germany	0.014	0.011
Hungary	0.041	0.009
Italy	0.001	0.002
Japan	0.026	0.009
Netherlands	0.010	0.004
Norway	0.052	0.008
Portugal	0.016	0.008
Switzerland	0.041	0.044
Sweden	0.044	0.010
Ireland	0.158	0.220
Ireland (2008)	0.145	0.166
Ireland (2014)	0.157	0.214

Source: Berlingieri *et al*. (2017) and Ireland's CIP and ASI.

As a final concentration measure, the share of GVA accounted for by the 50 largest firms by gross output was also calculated from the microdata.[35] Overall, the 50 largest firms accounted for 50 per cent of GVA in 2008, growing to 56 per cent in 2014. Overall manufacturing (74 per cent) was more concentrated than services (44 per cent) over the period.

These findings from the microdata on the concentrated nature of the Irish economy are consistent with a range of other measures from publicly available sources:

- Companies that report to the CSO large cases unit, a unit that interacts with the [50-100] largest firms,[36] accounted for 80 per cent of turnover in 2015.[37]
- A small number of sectors dominated by foreign owned multinationals accounted for 40 per cent of gross value added in the economy in 2016.[38]

[35] Authors' calculations made outside the MultiProd framework on the basis of the CIP and ASI data.
[36] For confidentiality reasons, the CSO does not disclose the actual number of firms covered by its large cases unit.
[37] See CSO (2017a).
[38] See CSO (2017b).

- The Revenue Commissioners reported that the ten largest payers accounted for 40 per cent of net corporation tax receipts in recent years.[39]

A.5 Productivity Dispersion by Sector (MFP)

Figure A.2: Relative Productivity by Two-Digit Industries (2006-2014) – Log Multifactor Productivity

Source: MultiProd on the basis of CSO data.

[39] See Revenue Commissioners (2017).