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MEASURING PRODUCTIVITY DISPERSION IN SELECTED AUSTRALIAN INDUSTRIES

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ABSTRACT

Productivity growth is a key determinant of improvements in living standards in the long run. However, analysis of productivity trends at the aggregate level does not capture the variation of firm and sub-industry productivity performance that underlies industry or aggregate productivity. By examining the differences in productivity performance of firms in particular industries (that is, productivity dispersion) we can enhance our understanding of the rich productivity dynamics of the economy and ultimately help to better inform policy advice. This paper – a collaboration between Treasury and the Australian Bureau of Statistics – uses firm-level data from the Business Longitudinal Analysis Data Environment (BLADE) to measure the dispersion in labour productivity for six Australian industries (Manufacturing; Construction; Retail Trade; Wholesale Trade; Professional, Scientific and Technical Services; and Administrative and Support Services). The study finds labour productivity dispersion to be persistent in the selected industries. Among the six industries, Manufacturing and Professional, Scientific and Technical Services exhibit the smallest labour productivity gap between businesses at the top and bottom quartiles. Contrary to international evidence, there is little evidence of widening labour productivity dispersion over time, with dispersion decreasing to varying degrees over 2001-02 to 2013-14. In particular, labour productivity dispersion declined significantly over the period in Retail Trade and Wholesale Trade. We also explore potential drivers of labour productivity dispersion and its relationship with aggregate labour productivity, and discuss avenues for further research.

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1. INTRODUCTION

There has been a well-documented slowdown in global productivity growth since the early 2000s. This slowdown is of concern to policy makers and researchers given productivity growth is a key determinant of improvements in living standards in the long run. Although Australia's labour productivity performance has been better than many other advanced economies (OECD, 2017), a deeper understanding of productivity dynamics and the heterogeneity of firms' productivity can help to inform the potential productivity-enhancing policies needed to continue to improve living standards.

This paper uses firm-level data from BLADE to measure the dispersion in labour productivity³ – that is, the width of the labour productivity-level distribution – among Australian firms in six industries.⁴ Productivity dispersion as a measure of heterogeneity of firm performance is relevant to the understanding of business dynamism, technology diffusion of frontier firms and resource reallocation (Bartelsman and Wolf, 2017). From this perspective, productivity dispersion studies are valuable inputs to the formulation of productivity-enhancing policies.

Prior to BLADE, studies on Australian firm performance primarily relied on survey data such as the Business Longitudinal Survey covering the 1994-95 to 1997-98 period or the Business Longitudinal Database focusing on small and medium enterprises (Hansell and Rafi, 2018). BLADE, a platform to integrate and link administrative with survey datasets, presents the most comprehensive Australian government's data holdings at business level.⁵ The extensive coverage of the Australian business population in BLADE offers a unique opportunity to examine productivity dispersion – a concept most relevant at disaggregated levels. Beyond this study, the rich content of BLADE offers a great potential for a stream of follow-up work in productivity analysis and for greater use of evidence-based policy-making.

This paper builds on a growing empirical body of productivity dispersion studies over the past two decades using firm-level data in a range of countries, both across industries and time. These studies, as do this paper, consistently find persistent dispersion in productivity performance among firms within a given industry albeit to varying degrees.

For example, a recent study in New Zealand found that the ratio of labour productivity levels between the top and bottom quartiles in selected industries in 2001 and 2012 ranged from around two in Construction to around 5½ in Manufacturing (Jaffe, Le and Chappell, 2016). Criscuolo, Haskel and Martin (2003) find the top (90th percentile) UK Manufacturing firms in 2000 were around five times as productive in terms of labour productivity as the least productive (10th percentile) firms. Other papers revealing similar results include Syverson (2011), Syverson (2003) and Bartelsman and Doms (2000). From a global perspective, Andrews, Criscuolo and Gal (2016) also find that the degree of productivity dispersion between firms at the global frontier in a given industry and the laggards has been increasing over time.

3 Throughout the paper, productivity and labour productivity are used interchangeably unless otherwise indicated.

4 See Section 3 for methodology. Note multifactor productivity (MFP) dispersion is left to future work due to the complexity of calculating firm-level MFP. Section 4 details the BLADE dataset, including discussion of the criteria for the selection of industries for the analysis and the industry coverage.

5 For details on the development of BLADE and information available within BLADE see Hansell and Rafi (2018).

The literature provides a number of potential reasons for the large and persistent productivity differences witnessed in empirical studies. Syverson (2004) notes that much of the research on productivity dispersion focuses on supply-side explanations such as management influences, capital vintage effects and R&D efforts; but other demand-side influences such as competitive markets (in particular product substitutability) also play a key role in explaining dispersion. For instance where there are barriers to competition or where products in a market are not easily substitutable, less-productive firms are able to survive and possibly grow (Martin, 2008; Syverson, 2003; Oulton, 1998). These supply and demand side explanations are also interlinked – a study by Bloom and Van Reenen (2007) finds intense competition in a firm's market is positively correlated with best-practice management.

Measurement issues could be another possible explanation for the persistence of productivity dispersion. For example, there can be a number of different products offered even within narrowly defined industries such that comparing like with like across firms is difficult. Some studies (Griffith, Haskel and Neely, 2006; Kauhanen and Roponen, 2010) attempt to account for this by looking at dispersion within different branches of a single firm, yet find persistent dispersion remains. As noted by Syverson (2011), the ubiquity of dispersion suggests there must be some real economic forces at work, rather than it simply being an artefact of measurement or odd chance.

Recent results from the OECD's MultiProd Project, which uses firm-level data from a large set of countries over the last two decades to examine productivity patterns, finds that the top 10 per cent of businesses in Australia are around 6½ and 7¾ times as productive as the bottom 10 per cent in manufacturing and non-financial services respectively (Berlingieri *et al.*, 2017). Note however that as OECD work is designed for international comparisons, the data manipulations and industry classifications used mean productivity dispersion results from the MultiProd Project may not be directly comparable with the results presented in this paper. Nonetheless, the MultiProd results support earlier analysis of surveyed Australian firms in the 1990s, which found that labour productivity levels of the top 10 per cent of firms were four times as high as the bottom 10 per cent (Bland and Will, 2001).

Consistent with the findings in empirical studies from around the world, the results in this paper (Section 5) show persistent productivity dispersion in the six Australian industries analysed: Manufacturing; Construction; Retail Trade; Wholesale Trade; Professional, Scientific and Technical Services; and Administrative and Support Services. While this is not surprising, as it confirms the international experience and also the intuitive impression that there will always be more and less productive firms within a given industry (for a variety of reasons as noted above), the findings are reassuring in terms of validating the usefulness and reliability of BLADE for this kind of exercise.

The more surprising and interesting aspect of this paper is its finding that in each industry analysed there is little evidence of widening labour productivity dispersion over time, with dispersion decreasing to varying degrees over 2001-02 to 2013-14. In particular, for both Retail Trade and Wholesale Trade labour productivity dispersion decreased significantly over the period. These findings are quite different to the international experience of generally increasing dispersion.

The paper examines whether the decreasing dispersion observed in Retail Trade and Wholesale Trade may be due to a lessening of market concentration as new entrants to the Australian market, particularly in Retail Trade, compete for market share with large, mature incumbent firms and increase product substitutability. Market concentration in these industries is found to be relatively low and, if anything, trending slightly upwards over the sample period, effectively discounting its importance as a potential explanation for declining productivity dispersion. A decline in business dynamism in these industries presents a more likely explanation for the declining dispersion. More broadly, micro firms are found to be more dispersed than larger firms, suggesting size as a reason for the presence of productivity dispersion within industries. A related factor of size may be maturity of the firm. Micro firms may have a larger share of entrants, whose performance is naturally more dispersed.

The paper also examines the relationship between labour productivity dispersion and labour productivity in the analysed industries, revealing industries with less productivity dispersion have higher levels of labour productivity.

2. WHY IS MEASURING PRODUCTIVITY DISPERSION IMPORTANT?

While studies such as Brown, Dinlersoz and Earle (2016) highlight that productivity dispersion in and of itself is neither necessarily good nor bad for aggregate productivity growth, measuring the degree of productivity dispersion in an economy's industries and understanding what drives the trends in dispersion – such as increasing innovation and experimentation or increasing resource misallocation – can help form a better understanding of the forces driving productivity growth at the aggregate level and the policies that can support it.

Just as aggregate productivity growth is determined by industry productivity growth, industry productivity growth is driven by its firms' productivity growth. Aggregate productivity can grow by either firms raising their own productivity level (known as the within-firm effect) or by the reallocation of resources to relatively more productive firms (known as the between-firm effect). For example, the between-firm effect can make a positive contribution to aggregate productivity growth by more productive firms increasing their labour share by growing larger, or through less productive firms shrinking or exiting the market.

One of the reasons put forward to explain the global slowdown in aggregate productivity growth is widening productivity dispersion between firms, even in narrowly defined industries, with the frontier pulling away from the laggards (Andrews, Criscuolo and Gal, 2016). This reinforces the scope for public policy to raise aggregate productivity growth through removing distortions to promote more efficient resource allocation and technology adoption.

A possible explanation for the widening productivity dispersion observed in international studies could be a breakdown in technology diffusion between frontier firms and laggards, with lower within-firm productivity growth from the laggards weighing on aggregate productivity growth. Another potential factor weighing on aggregate productivity growth is the ongoing survival of firms that would otherwise exit in a competitive market, which crowds out growth opportunities for more productive firms and therefore inhibits productivity-enhancing resource reallocation (Adalet McGowan, Andrews and Milliot, 2017). Research commissioned by the European Central Bank suggests that industry productivity growth in European countries is due more to within-firm productivity growth than the reallocation of resources from low productivity firms to high productivity firms (Lopez-Garcia, di Mauro and Altomonte, 2014).

Nevertheless, reducing constraints on resources being allocated more efficiently between firms in an industry has significant potential to increase industry and aggregate productivity growth. For example, the International Monetary Fund (IMF) finds that gains from reducing resource misallocation could add roughly one percentage point to annual real GDP growth, based on estimates for a sample of 54 developing countries and nine advanced economies (IMF, 2017). In another study, Hsieh and Klenow (2009) find China and India's manufacturing sectors could achieve total factor productivity gains of 30 to 50 per cent and 40 to 60 per cent respectively if resources were allocated as efficiently as in the US. The importance of resource allocation to aggregate productivity growth is discussed further in a number of other papers, such as Decker *et al.* (2016) and Andrews and Cingano (2012).

In Australia, at the whole of economy level, previous studies have shown that aggregate labour productivity growth is overwhelmingly driven by within-industry productivity growth as opposed to the reallocation of labour between industries (Campbell and Withers, 2017). As such, better understanding of what is happening within particular industries is critically important given the degree of productivity dispersion between firms in an industry – and how resources are allocated between these firms – is likely to have a significant effect on aggregate productivity growth in Australia.

Indeed, analysis of the six industries covered in this paper reveals above-average (below-average) labour productivity dispersion in a narrowly defined industry is associated with a below-average (above-average) level of labour productivity (see Section 5). While the level of and changes in industry productivity dispersion do not necessarily create a policy concern (as some degree of productivity divergence may be a reflection of industry evolution) they may have important policy implications.

For example, where a breakdown in diffusion and therefore rising productivity dispersion is identified, policies should aim to improve the transfer of technologies between firms. Policies that promote innovation may increase productivity dispersion, but likely by lifting performance at the top end of the productivity distribution. In this case greater dispersion may drive, rather than provide a drag on, aggregate productivity growth.

Alternatively, where dispersion is influenced by a misallocation of resources such as the persistence of unproductive firms in the market – a symptom of weak market selection – policies aiding the restructuring of unproductive firms and addressing barriers to entry and exit may be more fruitful to lift aggregate productivity growth (Adalet McGowan, Andrews and Milliot, 2017). Reforms that promote competition (Oulton, 1998; Martin, 2008) and increase business dynamism (such as changes to insolvency laws to make it easier for low-productivity firms to exit) can help with productivity convergence among firms in a given industry. Further, as the tax system in particular plays a key role in how resources are allocated across the economy, the IMF (2017) notes that countries can reduce resource misallocation by ensuring firms' decisions are made for business and not tax reasons.

Additionally, given the positive relationship between labour productivity and wages, labour productivity dispersion also has implications for wage inequality (See Dunne *et al.*, 2002; Berlingieri, Blanchenay and Criscuolo, 2017). Widening productivity dispersion may be associated with widening wage inequality, lending a social policy perspective to this analysis.

3. METHODOLOGY

LABOUR PRODUCTIVITY

Labour productivity is calculated by simply dividing a measure of output, typically value added, by a measure of labour input. In this analysis full-time equivalent (FTE) is used as the labour input measure. FTE is a measure derived from Pay-as-you-go (PAYG) data. This is outlined in Hansell, Nguyen and Soriano (2015).

$$LP_{jt} = \frac{Output_{jt}}{FTE_{jt}}$$

where j and t denote firm and time subscripts, respectively.

OUTPUT MEASURE

In this paper, value added is the primary output measure used. Firm-level value added (calculated as gross output less intermediate inputs) represents an individual firm's contribution to the economy and in theory, this should aggregate to GDP as aggregated final demand is equal to aggregate value added for the overall economy. Dispersion in value added based labour productivity therefore represents varying firm contributions to the economy per worker. This gives the dispersion measure an intuitive appeal as it reflects the variation under aggregate productivity statistics.

Gross output based labour productivity is also employed in firm-level research. Gross output based productivity has a different interpretation to value added based measures, as gross output represents a firm's output sold in the market. Dispersion in gross output labour productivity therefore reflects the dispersion in the sales per worker of firms. However, the gross output based labour productivity measure could mask varying intermediate usage across firms, and therefore be sensitive to substitution between factor inputs and intermediate inputs, notably through outsourcing. It is often argued gross output is not a good indicator of a firm's efficiency (Schreyer and Pilat, 2001). The value added measure is more meaningful and generally favoured for estimating labour productivity (Cobbald, 2003).

While the main results in this paper are calculated using value added based labour productivity, for completeness and as a robustness check, gross output based results are presented in Appendix A. It should be noted that both measures are revenue-based labour productivity, given the absence of firm-level prices needed to calculate quantity based labour productivity. This means changes in productivity levels presented in this paper are in terms of nominal labour productivity (dollars per FTE).

MEASURE OF PRODUCTIVITY DISPERSION

Productivity dispersion is a measure of how productivity differs between firms within a given industry, which is related to the width of productivity distribution. Three main statistics are typically employed to measure dispersion: the standard deviation, interquartile range and the 90-10 differential. Other measures, such as the difference between a fixed number of frontier firms and the rest (Andrews, Criscuolo and Gal, 2016) or 90-50 differential (Berlingieri, Blanchenay and Criscuolo, 2017) have also been used. Of the main measures, the standard deviation is sensitive to outliers, which are often present in firm level data sets.

The analysis presented in this paper uses the interquartile range (rIQR) and 90-10 differential (r90-10), to measure dispersion, given they are both robust to outliers. In essence, the rIQR measure shows how much more productive a business at the 75th percentile of the labour productivity distribution is than a business at the 25th percentile. Similarly, r90-10 reveals the number of times that a business at the top tenth percentile is more productive than a business at the bottom tenth percentile. Both of these measures of dispersion are comparable across industries and over time.

Industry aggregation

Calculating productivity dispersion measures at the highest level of disaggregation is important, as it ensures that dispersion measures reflect differences in the efficiency in undertaking similar productive activities rather than differences in the nature of the activities themselves.

Measures of productivity dispersion (rIQR and r90-10) are compiled at the 4-digit industry level, being the most disaggregated level available in the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006. These measures are then aggregated to higher industry classification levels to present an overview of dispersion across six selected industries.

Let $rIQR_{it}$ be the interquartile range for a 4-digit industry i and time period t . The aggregated rIQR for period t is calculated as the average interquartile range across 4-digit industries $rIQR_t = \sum_i w_{it} rIQR_{it}$ where w indicates weight. The aggregated interquartile range for the entire period is calculated as $rIQR = \frac{1}{T} \sum_t rIQR_t$ where T indicates the number of years. The aggregation of r90-10 is computed in a similar manner.

Two weighting schemes are used in aggregation. An unweighted average rIQR is obtained by assigning equal weight to each industry and time-specific $rIQR_{it}$, and a weighted average is obtained by using the number of businesses in a 4-digit industry at a given period as weights. The weighted average is preferred since it takes into account heterogeneity in industry size, but for completeness both weighted and unweighted averages are presented in the Results section.⁶

Negative value added

An individual firm could, in a given year, generate a negative value added (that is, where the firm's sales revenue is less than its intermediate input costs). For example, a new firm that has no knowledge of its input costs may underestimate these costs resulting in selling at a loss in early years. If enough firms in an industry have negative value added in a given year the value added of the firm at the lower quartile (or 10th percentile) is negative. In this case a measure of 'how many times more productive' the most productive firms are compared to the least productive firms would have no reasonable interpretation, being a negative number. Additionally, that industry's inclusion into the aggregate measures would lower the aggregated dispersion measure, despite the industry being heavily dispersed.

⁶ Weighting by labour share was explored, but this resulted in no real difference in the trends in dispersion measures for all industries (and for all industries excluding Manufacturing and Administrative & Support Services, virtually no differences in levels). A comparison of the results of labour share weights and number of firms weights are presented in Appendix B.

To resolve this, two treatments to calculate dispersion measures are explored. The first is to transform negative value added firms in the productivity distribution by giving these firms a log labour productivity of zero. The transformation preserves the productivity ranks of firms, which enables valid measures of 10th percentile and lower quartile to be computed. Industries that have a lower quartile or 10th percentile of zero are then excluded before aggregating up to the 1-digit industry. At the 4-digit ANZSIC level this results in only four industries (around 1½ per cent of all 4-digit industries) being excluded for the IQR analysis but 139 industries (around 51 per cent) being excluded for the 90-10 differential analysis. Nearly all 4-digit industries in Retail Trade and Wholesale Trade have a negative value added in the 10th percentile. Therefore estimates for 90-10 differential value added dispersion are not calculated for these industries.

The second treatment option is to drop from the sample firms with negative value added and calculate dispersion measures for industries based only on firms with a positive contribution to the economy.

The findings presented in the Results section will focus on the first method, which is called the transformation method, while the results for when firms with negative value added are dropped are presented in Appendix A. For all industries, the trends in the dispersion appear robust to treatment methods.

4. DATA

BUSINESS LONGITUDINAL ANALYSIS DATA ENVIRONMENT (BLADE)

Data were sourced from the Business Longitudinal Analysis Data Environment (BLADE) – formerly known as the Expanded Analytical Business Longitudinal Database (see ABS, 2015).⁷ BLADE integrates administrative data from the Australian Taxation Office with survey data from the ABS, for all active businesses in the Australian economy from 2001-02 to 2013-14. BLADE uses the ABS Business Register to link businesses using their Australian Business Number.

DATA SOURCES

Output information was from tax administration data sourced from the Business Activity Statement (BAS) and employment information from Pay-as-you-go summary (PAYG) data. From these sources the following key financial aggregates are available: total sales; GST on sales; GST on expenditure; capital expenditure; non-capital expenditure; and total salary, wages and other payments. Additionally, a full-time equivalent (FTE) measure is provided through BLADE.

Data sourced from the BAS has significant coverage of businesses in Australia as it has information on every business required to pay GST. Further, given the simplicity of these statements it also has fewer missing values than data sourced from the more complicated Business Income Tax statements. Information sourced from PAYG summaries cover any employing business.

The resulting dataset therefore contains all businesses required to issue a payment summary or required to pay GST.

NARROWING THE DATASET

Units with missing sales and employment information were dropped, leaving a firm-level panel dataset covering 13 years containing approximately 13 million observations across 19 industry ANZSIC divisions. As the dataset contains only employing businesses, it does not contain sole traders. It also does not contain businesses that have never had a turnover more than \$75,000 as this is the cut-off for GST registration and therefore requirement to submit a BAS. Value added is then calculated for the remaining businesses.⁸

7 BLADE was initially created to enable Australia's participation in the OECD's Dynamics of Employment (DynEMP) and Micro Drivers of Productivity (MultiProd) projects as well as to provide a solid evidence base for productivity analysis, policy development and evaluation of its stakeholders. BLADE has been developed by ABS in partnership with the Department of Industry, Innovation and Science (DIIS) who also provided financial support.

8 Following the System of National Accounts definition, value added is calculated by subtracting non-capital expenditures excluding GST on expenditures from gross output (which is calculated at basic prices, taking the total sales on goods and services and deducting GST on sales).

Industry selection

The analysis focused on six industries: Manufacturing; Construction; Retail Trade; Wholesale Trade; Professional, Scientific and Technical (PST) Services; and Administrative and Support Services. These industries have a relatively large number of businesses. Together, businesses in these industries account for around half of the total sample of observations from the cleaned BAS-BLADE data.

In addition, after aggregation the BLADE output data for the six industries compare favourably in both level and growth terms to published National Accounts data, supporting the data quality of these industries in BLADE. In addition, high data quality for these industries was also confirmed in the BLADE data assessment performed previously by the ABS when developing BLADE, where industry value added, input and output levels as well as growth rates were compared with the published National Accounts figures (Hansell and Berry, 2017).

Industry size

Industries with few firms can have erratic movements in dispersion due to a few players. An industry size threshold of 50 businesses was imposed, consistent with Bartelsman and Wolf (2017), and industries were dropped if the number of businesses fell below this threshold at any year in the sample. This resulted in 44 industries (at the 4-digit level) being excluded from the sample: 41 industries in Manufacturing and one industry in each of Wholesale Trade, PST Services and Administration and Support Services.

SUMMARY STATISTICS

As shown in Table 1 below, Construction has the largest number of businesses followed by PST Services and Retail Trade. For the average firm relatively higher value added outputs as well as FTE estimates are observed in both the Manufacturing and Wholesale Trade industries. The lowest FTE is observed in the Construction industry. In terms of the average intermediate usage (that is, estimated from non-capital purchases and by looking at the ratio of value added to gross output), higher intermediate usage of around 84 and 86 per cent are observed for Wholesale Trade and Retail Trade, respectively.

**TABLE 1: SUMMARY STATISTICS FOR AVERAGE FIRM
(AVERAGED FROM 2001-02 TO 2013-14) FOR THE SELECTED SIX INDUSTRIES**

Industry	Count of businesses	Average Gross Output (\$ million)	Average Value Added (\$ million)	Average FTE
Manufacturing	60,148	6.0	1.5	18.4
Construction	158,423	1.1	0.3	5.7
Wholesale Trade	47,014	7.0	1.1	12.9
Retail Trade	91,151	3.3	0.5	10.4
PST Services	126,621	1.1	0.4	6.9
Administrative and Support Services	38,746	1.5	0.7	14.0

5. RESULTS

PRODUCTIVITY DISPERSION IN NARROWLY-DEFINED INDUSTRIES

Table 2 below shows weighted averages (by number of firms) of 4-digit labour productivity dispersion ratios aggregated across the period of 2001-02 to 2013-14. Charts comparing dispersion based on employment share weights and number of firm weights are presented in Appendix B.

TABLE 2: WEIGHTED RIQR AND R90-10, 2001-02 TO 2013-14

Division	rIQR	r90-10
Manufacturing	2.6	12.4
Construction	3.1	10.0
Wholesale Trade	4.9	n.a*
Retail Trade	3.5	n.a*
PST Services	2.6	10.1
Administrative and Support Services	2.8	9.6

Note: 1-digit dispersion measure is average of 4-digit dispersion measures weighted by business counts.

* Not available due to number of firms with negative value added.

Divisional weighted rIQR and r90-10 are formed from dispersion at the 4-digit level, where weights are proportional to the number of business in the 4-digit industries. Overall, businesses at the 75th percentile are about 2½ to five times as productive as those at 25th percentile while businesses in the 90th percentile are about 9½ to 12½ times as productive as those in the 10th percentile, depending on industry being examined.

Among the six industries, Manufacturing and PST Services exhibit the smallest productivity gap between the top and bottom quartiles. Note that r90-10 measures are not available for Wholesale Trade and Retail Trade on a value added basis due to the large number of firms with negative value added in these industries. As such, the charts and discussion in this paper largely focus on the rIQR.

Table 3 below shows the aggregated unweighted averages of 4-digit productivity dispersion ratios. A comparison of weighted (Table 2) and unweighted dispersion (Table 3) can be informative about the relationship between dispersion and industry size. The differences between weighted and unweighted dispersion measures reflect differences in the dispersion of large and small-sized 4-digit industries. For instance, the unweighted rIQR measure for Wholesale Trade is significantly higher than the weighted average. This implies the unweighted dispersion is influenced by industries characterised by a small number of businesses and a high dispersion ratio.

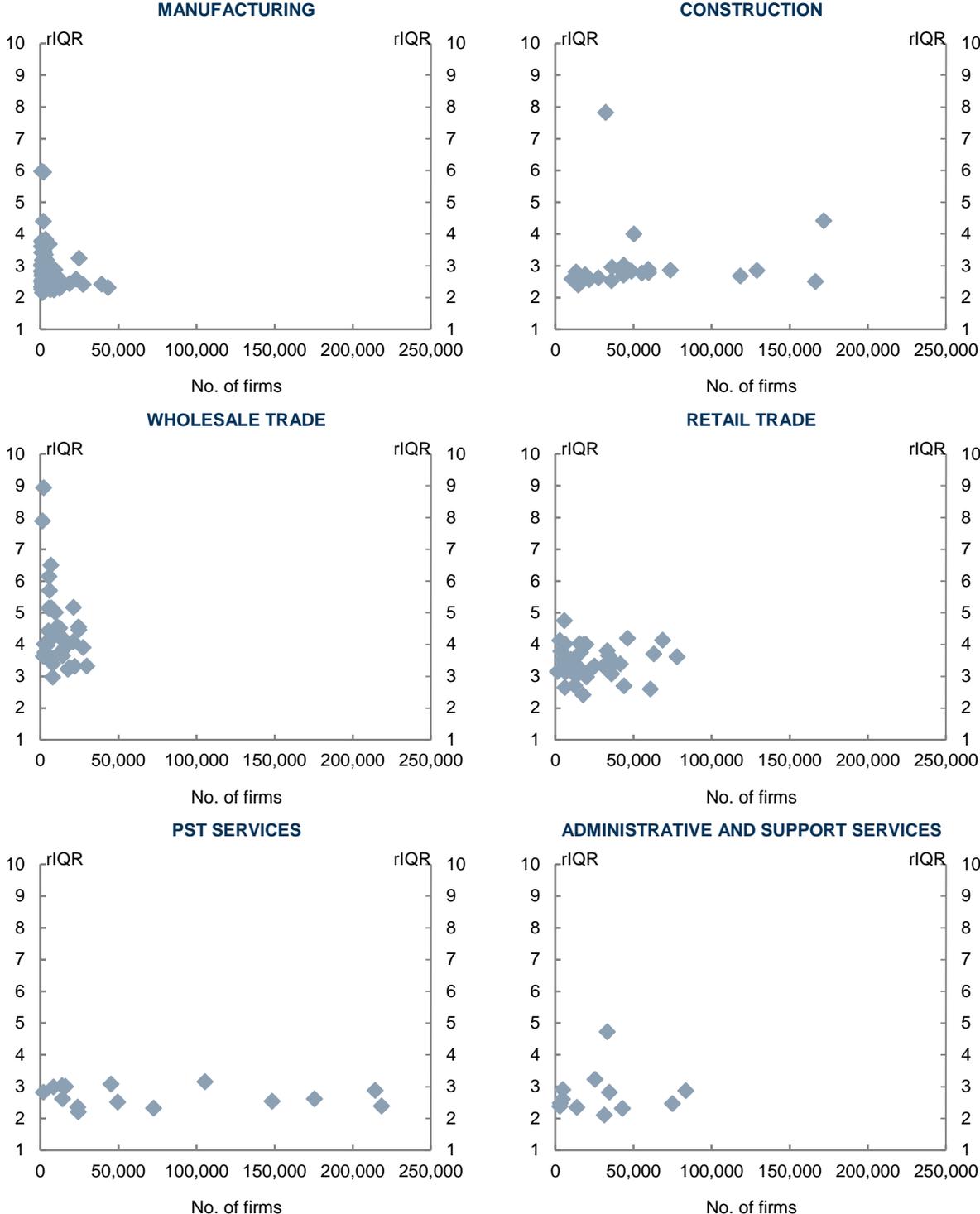
TABLE 3: UNWEIGHTED RIQR AND R90-10, 2001-02 TO 2013-14

Division	rIQR	r90-10
Manufacturing	2.8	14.2
Construction	3.1	10.3
Wholesale Trade	6.0	n.a*
Retail Trade	3.5	n.a*
PST Services	2.6	12.2
Administrative and Support Services	2.7	10.9

* Not available due to number of firms with negative value added.

Dispersion results, averaged across 2001-02 to 2013-14, for all 4-digit industries can be found in Figure 1 below.⁹ Each marker represents a 4-digit industry within each 1-digit industry division.

FIGURE 1: DISPERSION OF 4-DIGIT INDUSTRIES BY NUMBER OF FIRMS, 2001-02 TO 2013-14



Source: BLADE.

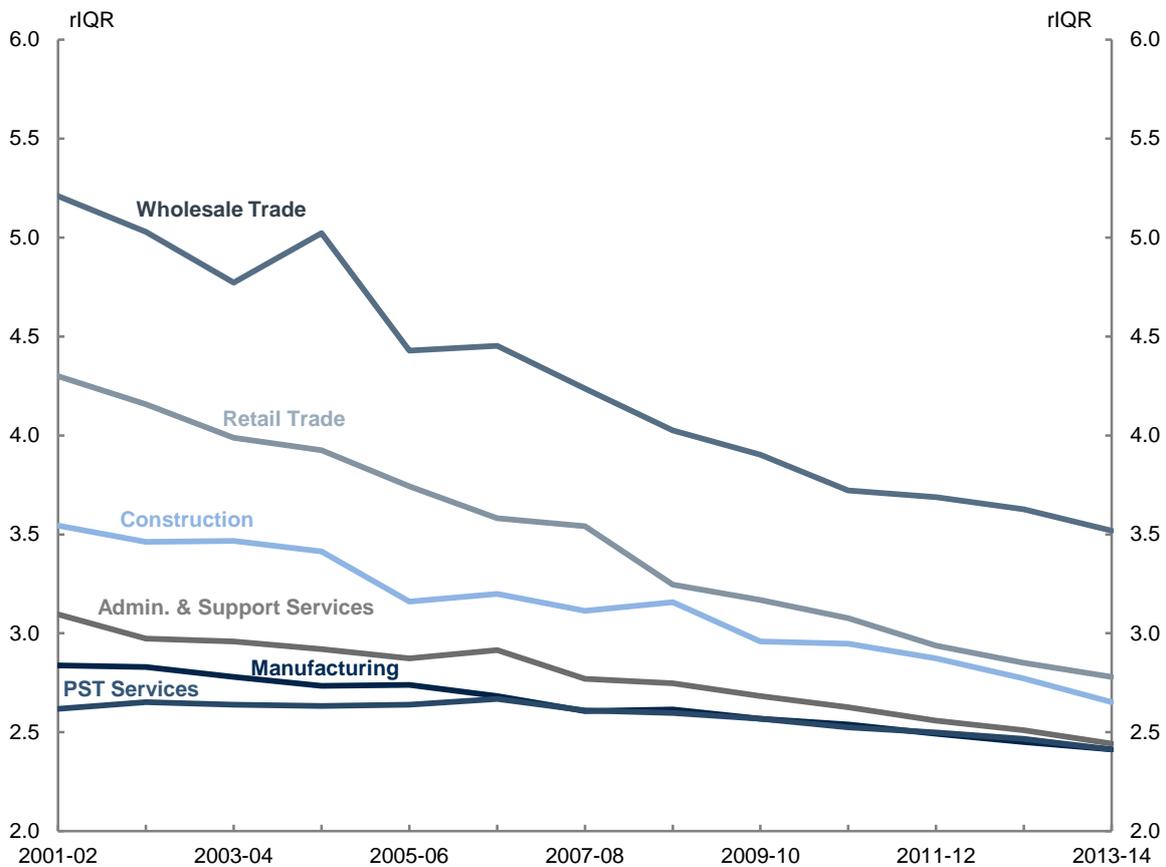
9 Firms in ANZSIC Class 3606 (Liquor and Tobacco Product Wholesaling) have been removed from the analysis in the charts in this paper due to the industry causing a large spike in the IQR ratio in 2004. A chart with Liquor and Tobacco Product Wholesaling firms included is provided in Appendix C.

Figure 1 shows industries characterised by a large number of businesses tend to show fairly low productivity dispersion. For example, Printing (ANZSIC Class 1611) and Bakery Product Manufacturing (ANZSIC Class 1174) have the largest business count in Manufacturing and are among the least productivity-dispersed industries. This is consistent with the theory that high productivity dispersion in an industry tends to be correlated with low product substitutability and vice versa (see Syverson, 2004; Syverson, 2003).

PRODUCTIVITY DISPERSION OVER TIME

Figure 2 shows year-by-year labour productivity dispersion for six selected Australian industries over 2001-02 to 2013-14.

FIGURE 2: PRODUCTIVITY DISPERSION OVER TIME (WEIGHTED)



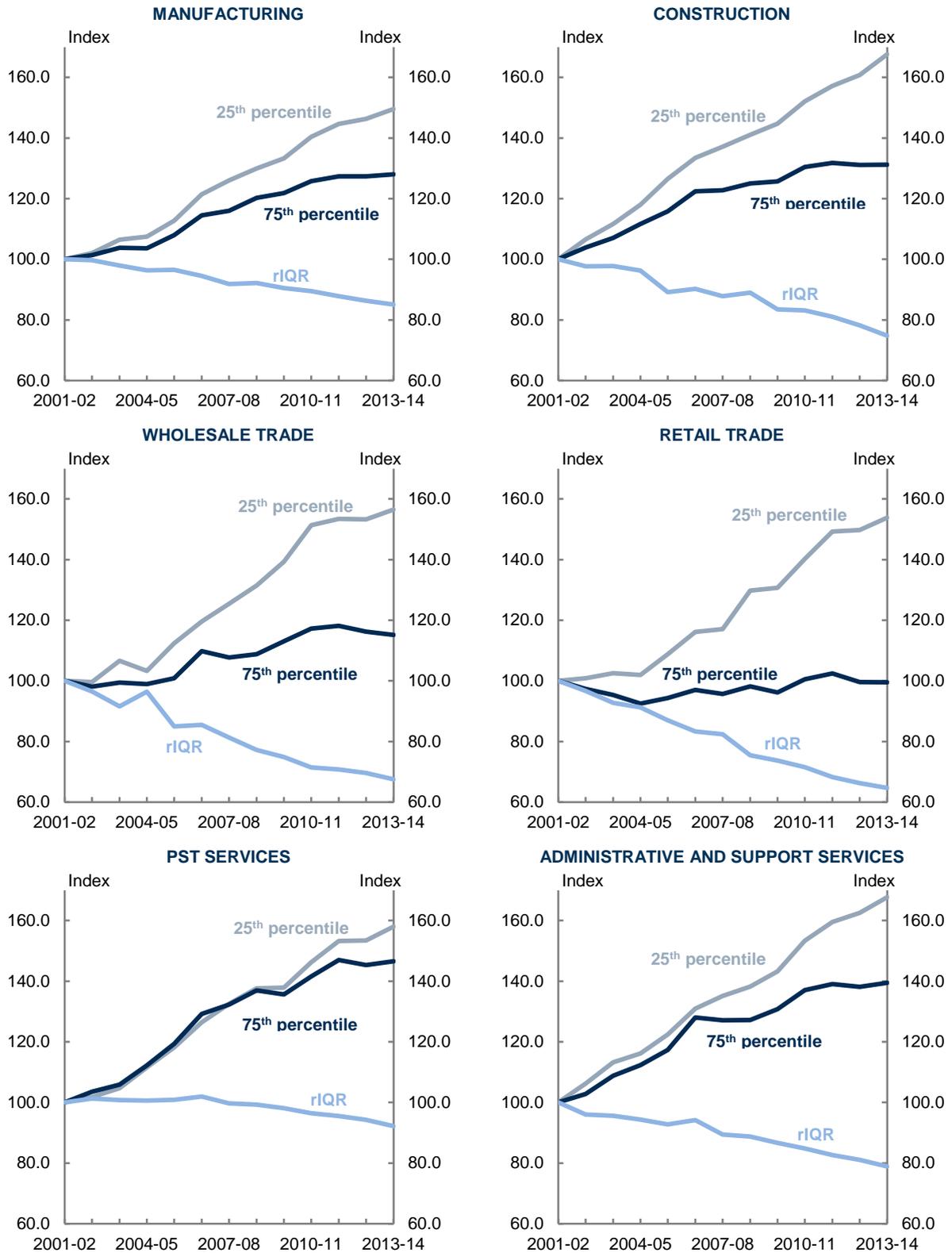
Source: BLADE.

Trends in dispersion

The pattern of dispersion across time differs between industries. However, in all six of the selected industries productivity dispersion exhibits a downward trend, to varying degrees. Most of the decline in dispersion occurs by 2010-11 before flattening out. Downward trends are strongest in the two margin industries, Retail and Wholesale Trade, followed by Construction, Administrative and Support Services and Manufacturing, which exhibit clear yet weaker downward trends. Labour productivity dispersion is relatively stable for PST Services, but decreasing nonetheless. These downward trends in dispersion are due to productivity levels for the bottom quartile growing faster than the top quartile.

To illustrate the catchup of the bottom quartile in each industry causing the narrowing of dispersion ratios, the growth in labour productivity levels of the top and bottom quartiles are charted in Figure 3 below. Both quartiles, along with the rIQR, are indexed to 100 in 2001-02.

FIGURE 3: NOMINAL LABOUR PRODUCTIVITY LEVELS BY QUARTILE AND RIQR (WEIGHTED)



Source: BLADE.

Drivers of changes in productivity dispersion in Wholesale Trade and Retail Trade

Read in conjunction with the gross output based results (Appendix A), where dispersion is effectively flat for all industries over the sample, the decline in the value added productivity gap implies that lower quartile firms are becoming relatively more efficient in their use of intermediate inputs. There could be a number of reasons behind this, such as a growing capability of smaller, less productive firms to join international value chains previously more accessible to larger, more productive firms; or an increasing online presence by these firms reducing their overheads.

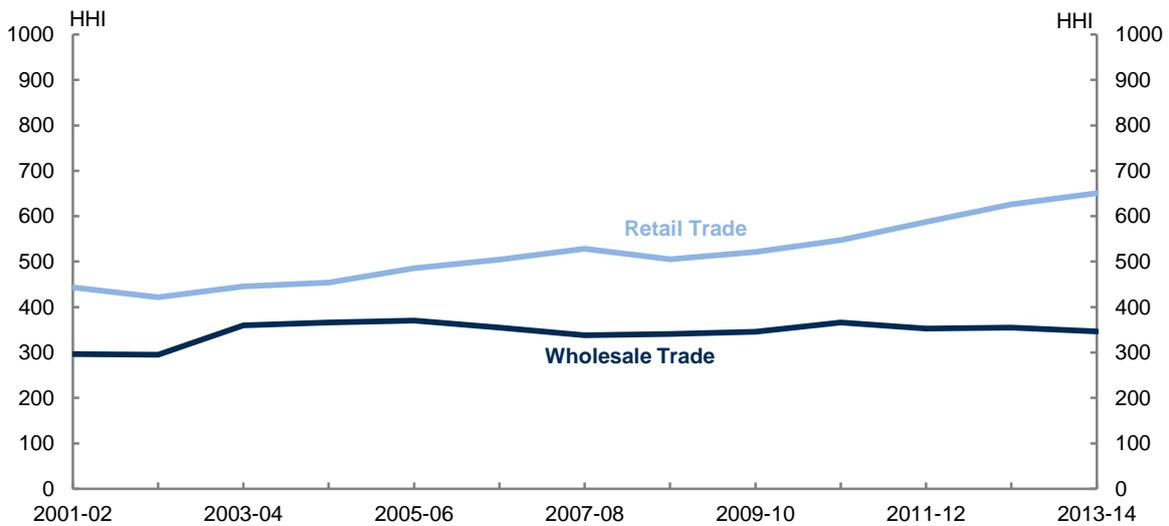
To better understand industry dispersion and its evolution, it is necessary to undertake more detailed work to examine potential factors such as entry and exit rates of firms, labour reallocation, changes in industry structure, concentration or competition, productivity persistence and productivity catchup of young or new firms. These are research areas that can be further investigated in future projects with business-level data from BLADE.

While much of that work is beyond the scope of this paper, the significant decline in productivity dispersion in Retail Trade and Wholesale Trade warrants investigation, even only at a relatively rudimentary level. A measure of market concentration – the Herfindahl-Hirschman Index (HHI) – is calculated for these industries to test whether the declining productivity dispersion could be related to changing industry concentration, acknowledging that concentration may be a somewhat imperfect proxy for competition and product substitutability (a market can be more competitive even as it becomes more concentrated – an indicator of this could be falling margins).

The HHI, constructed by summing the square of each firm's market share, approaches zero when a market is occupied by a large number of firms of relatively equal size and reaches its maximum of 10,000 points when a market is controlled by a single firm. The HHI increases both as the number of firms in the market decreases and as the disparity in size between those firms increases. The U.S. Department of Justice and the Federal Trade Commission (2010) considers a market with a HHI of less than 1,500 to be a competitive marketplace, a HHI of 1,500 to 2,500 to be a moderately concentrated marketplace, and a HHI of 2,500 or greater to be a highly concentrated marketplace.

Using firm's market share information from BLADE, the HHI were constructed for Wholesale and Retail Trade for each year of the 2001-02 to 2013-14 period. The HHI reveals that on average market concentration in the Retail and Wholesale Trade 4-digit industries is low. Both industries have an average HHI well below 1,000 over the 13-year time period, with the HHI increasing at a moderate rate from around 400 to around 650 in Retail Trade and fluctuating within a relatively narrow band of around 300 to around 400 in Wholesale Trade.

**FIGURE 4: MARKET CONCENTRATION (HHI) –
RETAIL TRADE AND WHOLESALE TRADE**

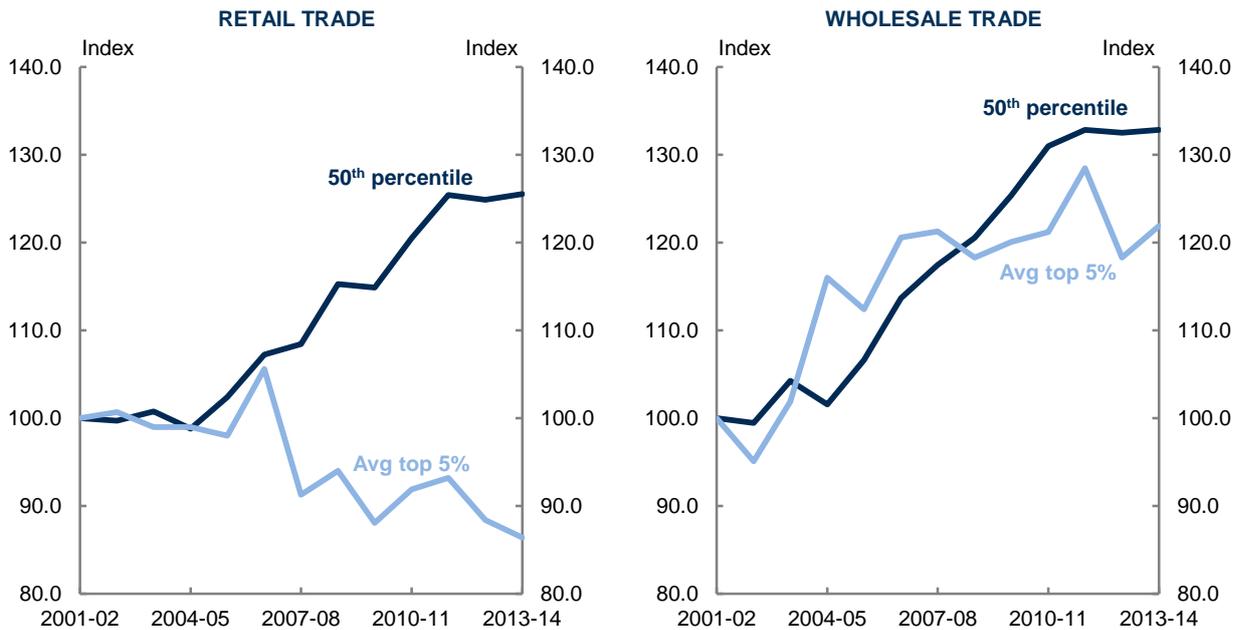


Source: BLADE.

While these HHI results suggest changes in market concentration do not provide a compelling explanation for the decline in productivity dispersion in Retail and Wholesale Trade, further work examining a potential tightening of margins in these industries due to smaller independent or family-owned firms being replaced by fewer, larger firms is necessary to gain a full picture of this relationship.

The employed measures of dispersion may mask what is happening at the very top of the productivity distribution. In some industries, there may exist a clustering of very large, very productive firms – changes in their level of productivity would be well beyond the cutoff of measures such as the rIQR. However, charting the growth in the average productivity levels of the top 5 per cent of firms in each year against the median firm (those at the 50th percentile) in Retail and Wholesale Trade does not provide any evidence of acceleration in the productivity performance of the domestic frontier from the rest (Figure 5). While the average productivity levels of the top 5 per cent are several times higher than that of the median firm, from 2001-02 to 2013-14 the median firm has outperformed the top 5 per cent in both industries in terms of cumulative productivity growth.

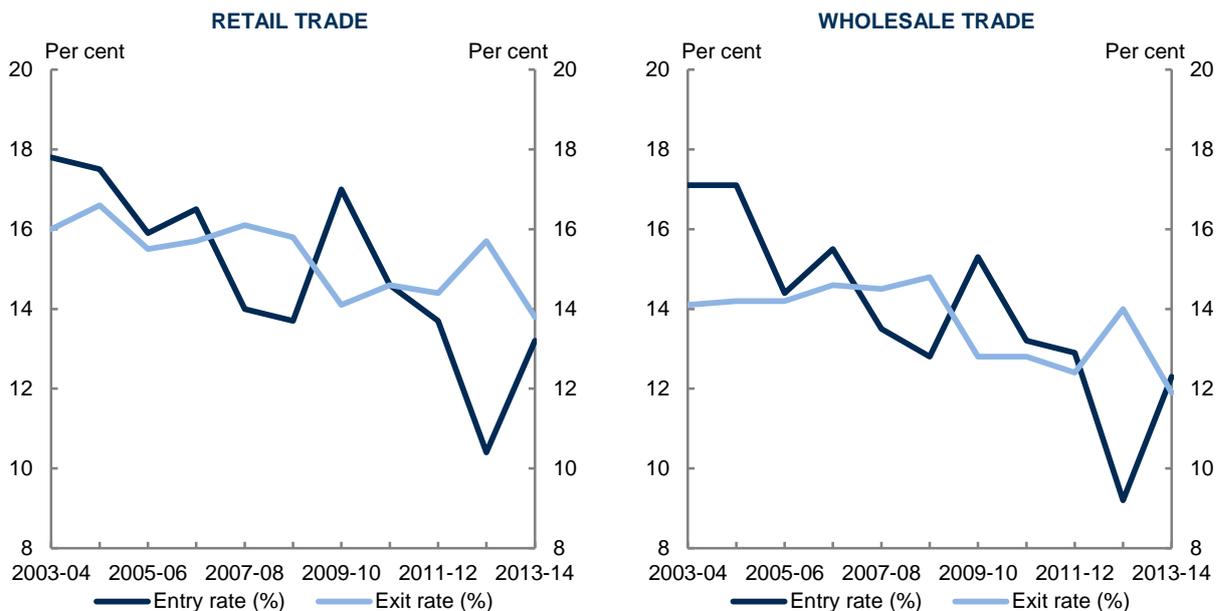
FIGURE 5: NOMINAL LABOUR PRODUCTIVITY LEVELS OF 50TH PERCENTILE V AVERAGE OF THE TOP 5 PER CENT – RETAIL TRADE AND WHOLESALE TRADE



Source: BLADE.

A further test to identify a potential factor behind declining productivity dispersion in Retail and Wholesale Trade is to examine entry and exit rates for businesses in these industries. Decker *et al.* (2016) note that entering firms do not know their type prior to entry (that is, they do not know how productive they will be) and are also more likely to be engaged in experimental innovation activity – both of which tend to increase productivity dispersion. A recent study by Foster *et al.* (2018) also shows that rising entry rates are associated with increased productivity dispersion. Entry and exit rates for the Retail Trade and Wholesale Trade industries are shown below in Figure 6.

FIGURE 6: ENTRY AND EXIT RATES



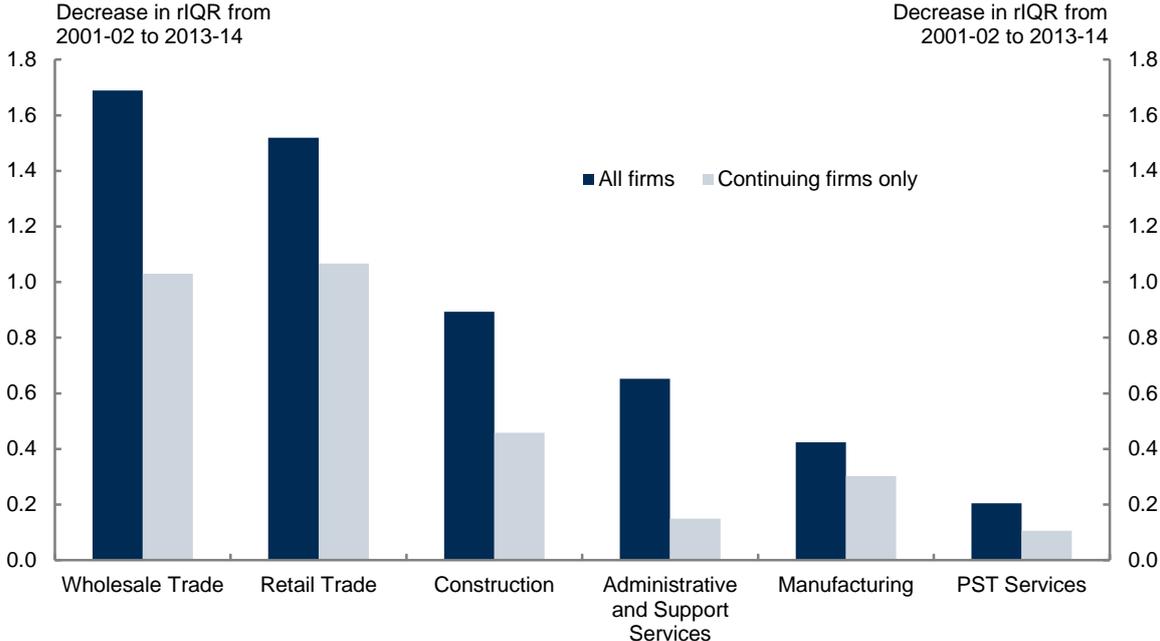
Source: ABS Cat. No. 8165.0 (Counts of Australian Businesses, including Entries and Exits).

Figure 6 shows falling rates of both entry and exit for firms in the Retail and Wholesale Trade industries over the period from 2003-04 to 2013-14. In both industries the decline in exit rate appears to be less significant than in entry rate. This would seem consistent with the slight increase in market concentration for Retail Trade shown in Figure 4 – if the output produced by fewer entering firms cannot absorb the lost output from exiting firms then this output would be picked up by incumbent firms who increase their market share.

The decline in both entry and exit rates may signal stalling business dynamism. The downward trend in productivity dispersion may be influenced by mature firms making up a greater proportion of these industries, since the productivity levels of mature firms have been found to be much less dispersed than young firms (Decker *et al.*, 2016).

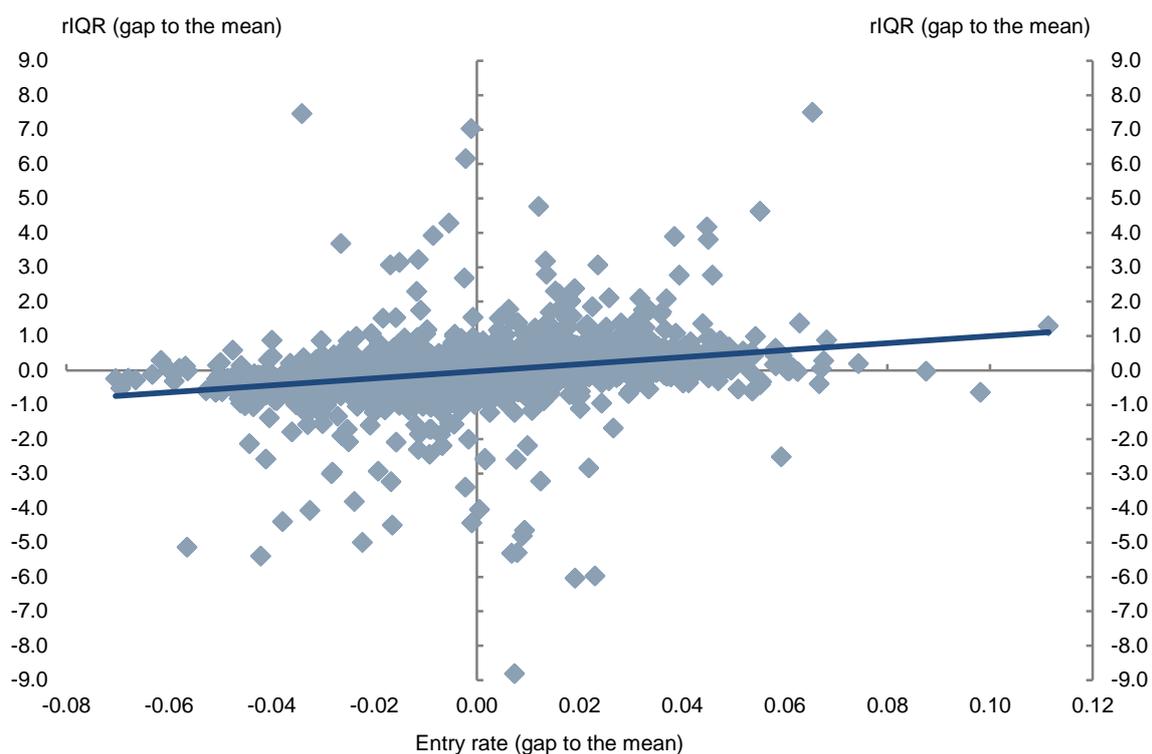
A comparison between the total decrease in the rIQR of each industry from 2001-02 to 2013-14 when all firms are included with the decrease in the rIQR when only continuing firms are included suggests that reduced dynamism is contributing to reduced productivity dispersion. Figure 7 below shows that for all industries, the decline in dispersion over the sample is smaller when only including continuing firms in the analysis. When entering and exiting firms are added to the analysis the decline in dispersion is greater, implying it is a contributing factor to the overall decline in dispersion.

FIGURE 7: COMPARISON OF RIQR (WEIGHTED) DECREASE FROM 2001-02 TO 2013-14 BETWEEN ALL FIRMS AND CONTINUING FIRMS ONLY, BY INDUSTRY



Source: BLADE.

While a deeper analysis of the relationship between business dynamism and productivity dispersion in Australia using firm-level data is an area for further work, there does appear to be a significant relationship between an industry’s firm entry rate and its productivity dispersion level. Figure 8 relates the level of rIQR to the firm entry rate at the 4-digit industry-year unit of observation.

FIGURE 8: RESIDUAL 4-DIGIT INDUSTRY PRODUCTIVITY DISPERSION AND ENTRY RATES, 2002-03 TO 2013-14

Source: BLADE.

Figure 8 reveals an above-average (below-average) entry rate in a 4-digit industry is associated with above-average (below-average) 4-digit industry productivity dispersion (rIQR). A regression, controlling for industry and year fixed effects, confirms this relationship is statistically significant at the 5 per cent level. The corresponding results for the exit rate are not significant. The regression results are provided in Appendix D.

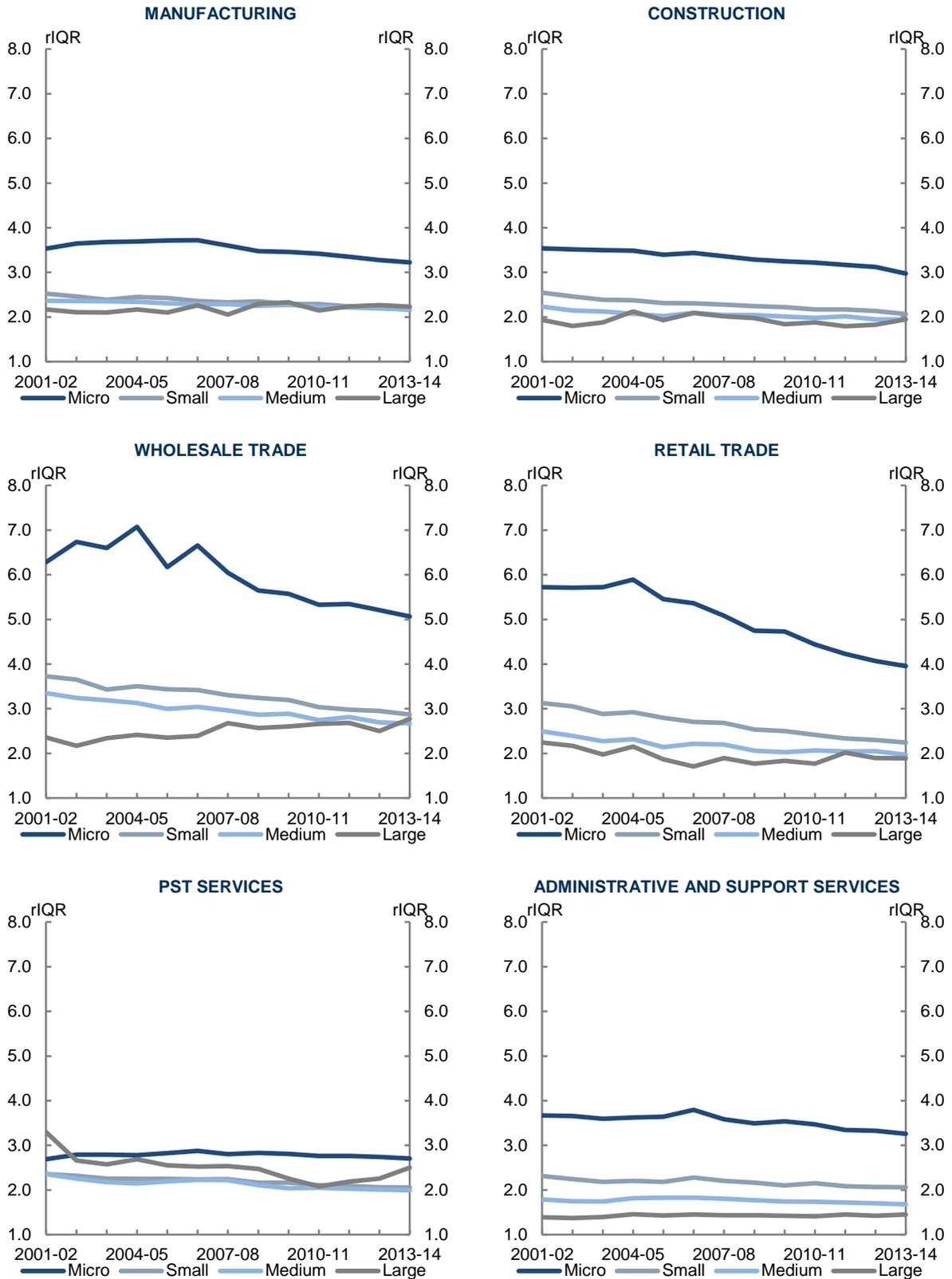
PRODUCTIVITY DISPERSION ACROSS FIRM SIZE

An additional factor worth considering is firm size. Economies of scale suggest larger firms face advantages simply from being larger, mainly through lower per unit costs. This would manifest in higher productivity. Dispersion in productivity at any given time might therefore partly reflect a difference between large and small firms. From the BLADE sample, firms are classified as micro units, small units, medium units and large units if they employ 1-4, 5-19, 20-199 and over 200 employees respectively.

Figure 9 illustrates productivity dispersion by firm size for the selected industries and confirms that micro units exhibit the largest dispersion in productivity performance. This is true across all industries although the productivity of micro units is most dispersed in Wholesale Trade and Retail Trade (which has become less dispersed in most recent years). The decline in dispersion for small, medium and large units in Retail Trade is much more modest.

With regards to division impact, the sharp fall in dispersion for micro units in Wholesale and Retail Trade appears to be a driver for the aforementioned strong downward trend in overall dispersion in those industries. As most new entrants start as micro firms, this provides further support to the notion that the declining entry rate in these industries could be narrowing the width of the productivity distribution.

FIGURE 9: PRODUCTIVITY DISPERSION BY BUSINESS SIZE

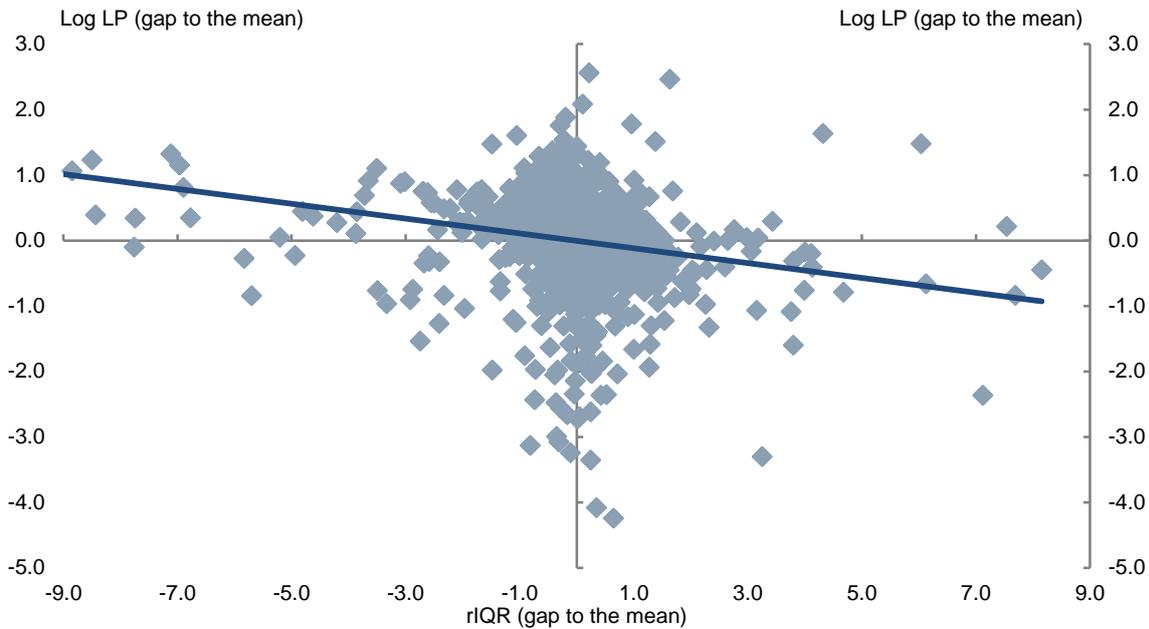


Source: BLADE.

RELATIONSHIP WITH LABOUR PRODUCTIVITY LEVELS

To highlight the importance of productivity dispersion analysis, it is useful to examine the relationship in this dataset between an industry's productivity dispersion (rIQR) and its average labour productivity level (weighted by employment share). Figure 10 relates the level of log labour productivity to the rIQR at the 4-digit industry-year unit of observation.

FIGURE 10: RESIDUAL 4-DIGIT INDUSTRY LOG LABOUR PRODUCTIVITY AND PRODUCTIVITY DISPERSION, 2001-02 TO 2013-14



Source: BLADE.

Figure 10 reveals above-average (below-average) productivity dispersion (rIQR) in a 4-digit industry is associated with a below-average (above-average) level of log labour productivity. A regression, controlling for industry and year fixed effects, confirms this relationship is statistically significant at the 1 per cent level. A one unit decrease in an industry's rIQR is associated with a 0.52 per cent increase in the industry's average labour productivity. The regression results are provided in Appendix D.

6. CONCLUSION

Analysis of the BLADE dataset reveals that selected Australian industries appear to be similarly dispersed in terms of labour productivity performance as other countries. Results from this study are consistent with other empirical studies over a number of years. There are differences in the degree of dispersion among different industries – for example the ratio between the most and least productive firms in Wholesale Trade is significantly greater than the equivalent ratio in Manufacturing – but even in the least dispersed industries the top firms are at least twice as productive as the bottom firms.

In terms of the trend in dispersion, Australia appears to differ from the international experience in that labour productivity dispersion is declining. Since 2001-02 and particularly in margin industries – Wholesale Trade and Retail Trade – value added based labour productivity dispersion has been declining significantly (especially until around 2010-11). While changes in market concentration do not appear to be driving decreasing labour productivity dispersion in Wholesale Trade and Retail Trade, lower business dynamism (in particular decreasing entry rates) in these industries may provide one explanation for the declining trend in dispersion in these industries.

More broadly, labour productivity dispersion among smaller firms is greater than that among larger firms – and industries with a higher number of firms are generally less dispersed than those with only a few firms. Interestingly, the patterns in declining labour productivity dispersion are driven by micro, small and medium firms. This is consistent with declining dynamism driving decreasing labour productivity dispersion, as most entering firms start small.

The persistence of dispersion in the six industries suggests that improving allocative efficiency and the productivity growth of low productivity firms can help lift aggregate productivity growth. This paper finds industries in Australia that have lower labour productivity dispersion experience higher aggregate labour productivity performance, which suggests that other factors may also be relevant. For example, forthcoming Treasury research (Andrews and Hansell, 2018) shows that within-industry labour reallocation was noticeably productivity-enhancing over the course of the 2000s, which is consistent with the observed decline in labour productivity dispersion.

Further work is necessary to better understand the nature and implications of the observed decline in labour productivity dispersion. At this stage, it is premature to assign a technological explanation to the decline in labour productivity dispersion, given that it could also be driven by differential patterns in tangible capital deepening and mark-up behaviour at the firm level (in addition to reallocation). In this regard, this paper introduces the usefulness of BLADE and its application in policy relevant issues, and uncovers a stream of potential follow-up work in this area. An important next step in understanding productivity dispersion is to calculate firm-level MFP and examine dispersion in MFP and capital deepening, which will be aided by Treasury sponsored work¹⁰ (in collaboration with the ABS) to estimate reliable capital stocks and MFP estimates at the firm level using BLADE . To make more progress on the issue of technology diffusion in Australia, future Treasury research will exploit these new MFP estimates to examine how Australian firm's productivity performance has fared relative to that of firms at the global technological frontier (see Andrews, Criscuolo and Gal, 2015 & 2016).

¹⁰ By Professor Kevin Fox (The University of New South Wales).

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APPENDIX A

GROSS OUTPUT BASED LABOUR PRODUCTIVITY RESULTS

TABLE A1: WEIGHTED RIQR AND R90-10, 2001-02 TO 2013-14 (GROSS OUTPUT)

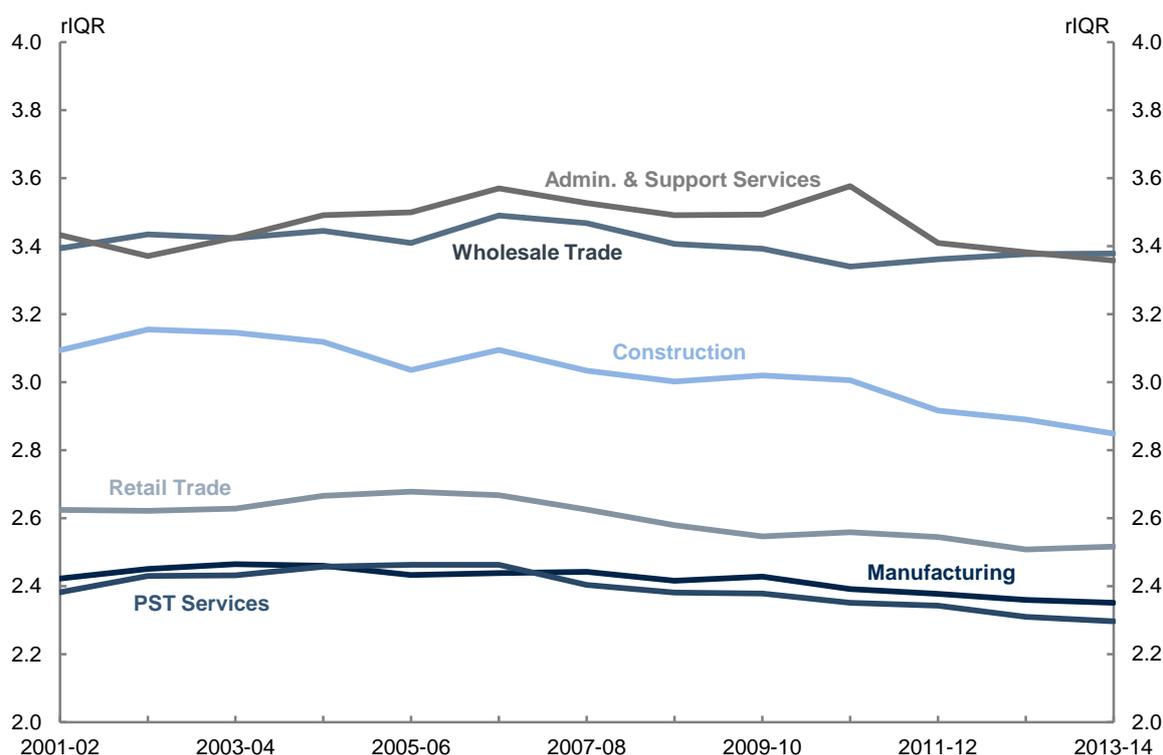
Division	rIQR	r90-10
Manufacturing	2.4	5.5
Construction	3.0	7.2
Wholesale Trade	3.4	5.5
Retail Trade	2.6	5.1
PST Services	2.4	6.3
Administrative and Support Services	3.5	8.6

Note: 1-digit dispersion measure is average of 4-digit dispersion measures weighted by business counts.

TABLE A2: UNWEIGHTED RIQR AND R90-10, 2001-02 TO 2013-14 (GROSS OUTPUT)

Division	rIQR	r90-10
Manufacturing	2.6	6.1
Construction	3.0	7.5
Wholesale Trade	3.8	5.5
Retail Trade	2.6	4.9
PST Services	2.5	6.2
Administrative and Support Services	3.4	7.8

**FIGURE A1: PRODUCTIVITY DISPERSION OVER TIME
(WEIGHTED, GROSS OUTPUT BASED)**



Source: BLADE.

For gross output, all six industries have relatively stable dispersion with little variation across time. There appears to be some cyclical, with dispersion in Retail Trade, Wholesale Trade, PST Services and Administrative and Support Services increasing slightly prior to 2008 and decreasing thereafter – though this is unlikely to be significant, given the limited variation in gross output based productivity dispersion.

In comparison to the declining dispersion observed using a value added based measure of labour productivity, the gross output based results suggest while there has been little change in sales per worker between higher and lower productivity firms, the less productive firms have become relatively more efficient in terms of their use of intermediate inputs.

ROBUSTNESS TO TREATMENT OF NEGATIVE VALUE ADDED

Tables A3 and A4 report dispersion results when negative value added observations are dropped from the analysis, as opposed to negative value added transformation presented in Table 2 and Table 3. For all divisions, the trends in dispersion appear robust to treatment method. For example, Wholesale Trade and Retail Trade still show strong downward trends in value added productivity dispersion. A dispersion measure of around 2½ still appears to be the lower bound at the 4-digit industry level, suggesting some level of dispersion in firm productivity is natural. Findings on dispersion between firms of similar sizes are also robust, with for the most part, large firms being less dispersed than micro units.

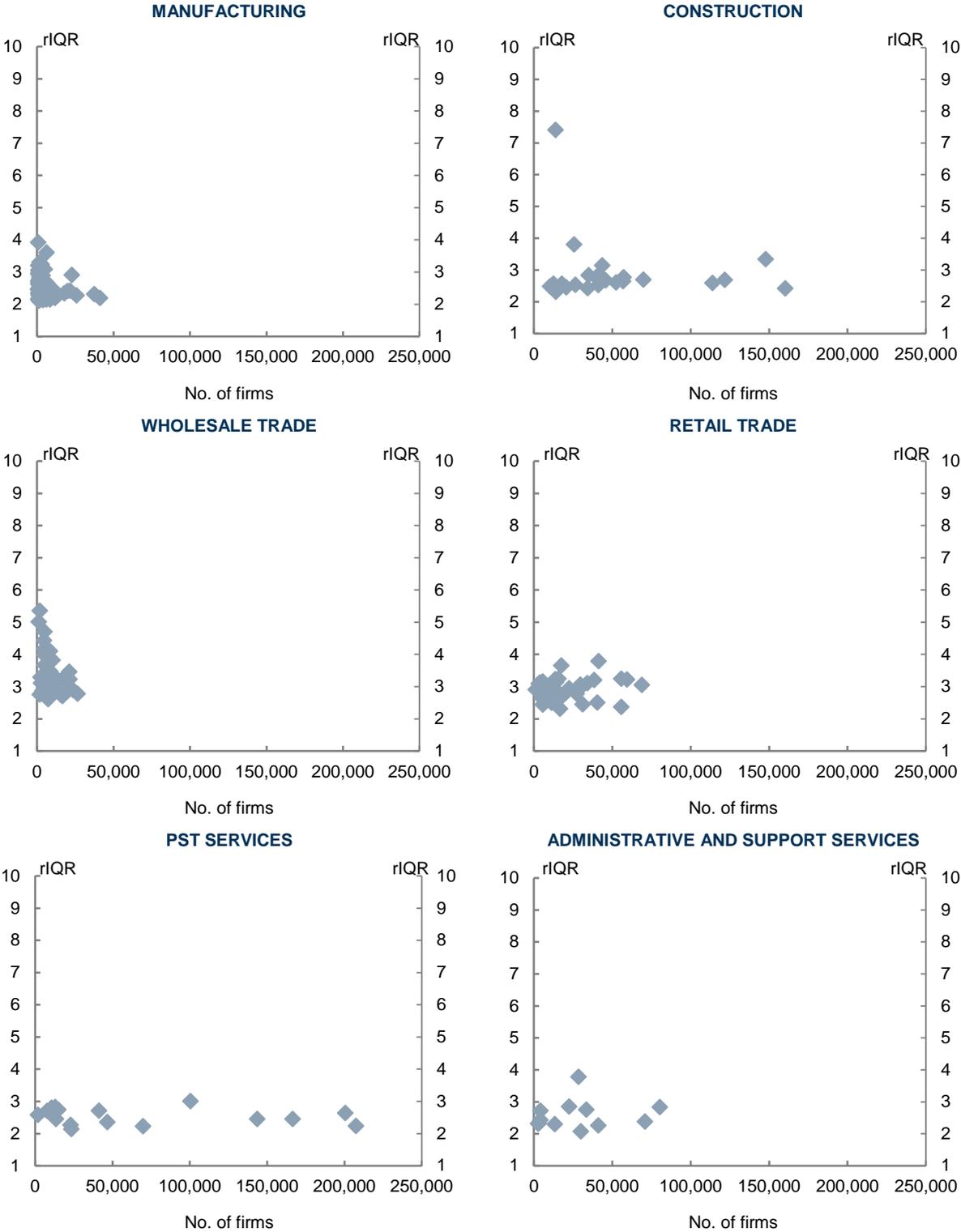
**TABLE A3: WEIGHTED RIQR AND R90-10, 2001-02 TO 2013-14
(NEGATIVE VA DROPPED)**

Division	rIQR	r90-10
Manufacturing	2.4	6.9
Construction	2.8	8.8
Wholesale Trade	3.2	12.5
Retail Trade	3.0	10.9
PST Services	2.4	6.7
Administrative and Support Services	2.6	9.2

**TABLE A4: UNWEIGHTED RIQR AND R90-10, 2001-02 TO 2013-14
(NEGATIVE VA DROPPED)**

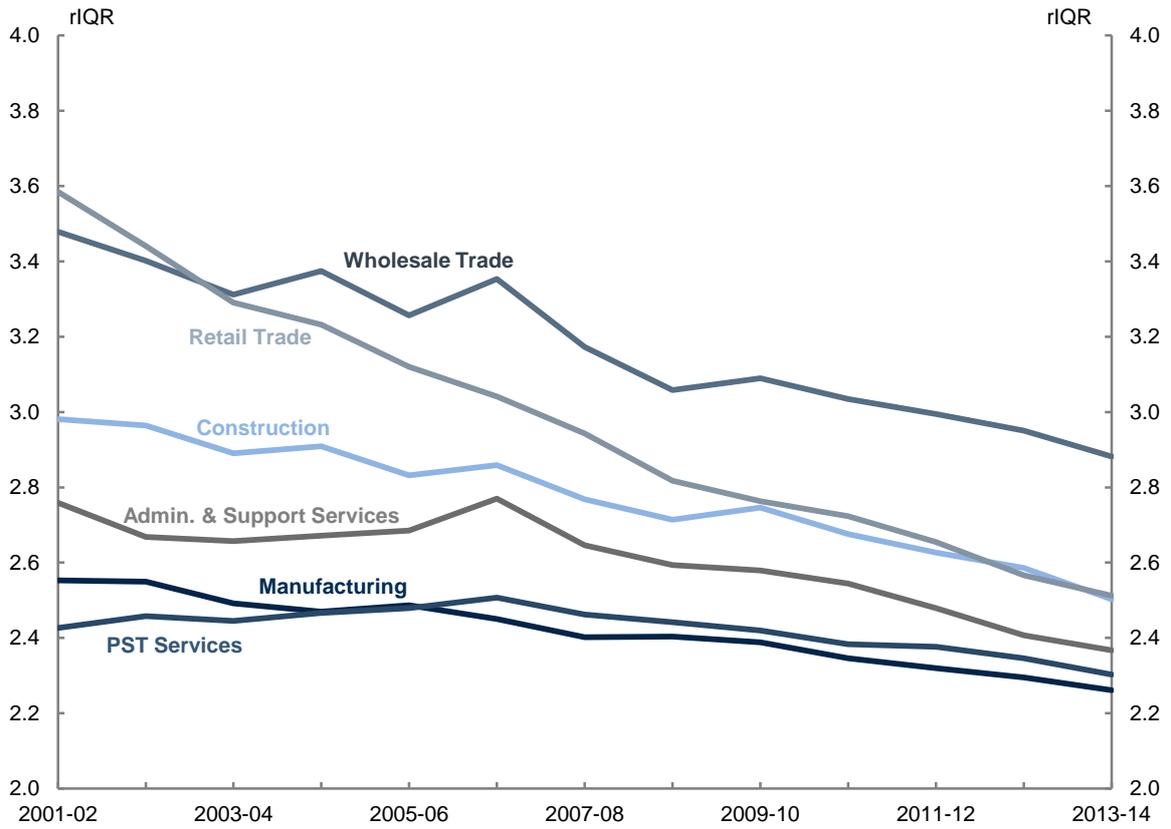
Division	rIQR	r90-10
Manufacturing	2.5	7.5
Construction	2.9	9.9
Wholesale Trade	3.4	14.4
Retail Trade	2.9	10.8
PST Services	2.5	7.3
Administrative and Support Services	2.6	9.1

**FIGURE A2: DISPERSION OF 4-DIGIT INDUSTRIES BY NUMBER OF FIRMS
(AVERAGED FROM 2001-02 TO 2013-14, NEGATIVE VA DROPPED)**



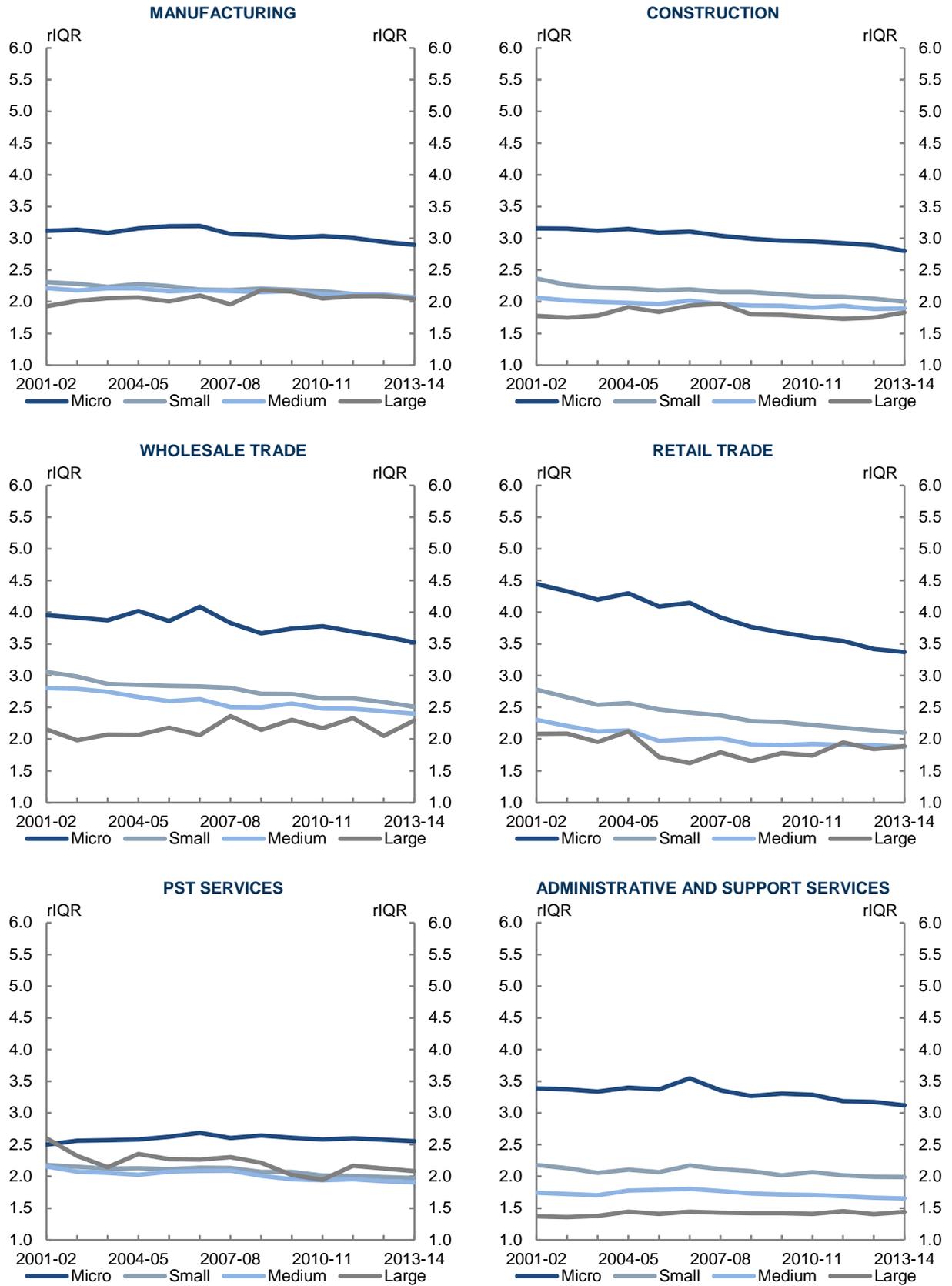
Source: BLADE.

**FIGURE A3: WEIGHTED DISPERSION OVER TIME AT 4-DIGIT ANZSIC LEVEL
(NEGATIVE VA DROPPED)**



Source: BLADE.

FIGURE A4: DISPERSION BY FIRM SIZE (NEGATIVE VA DROPPED)

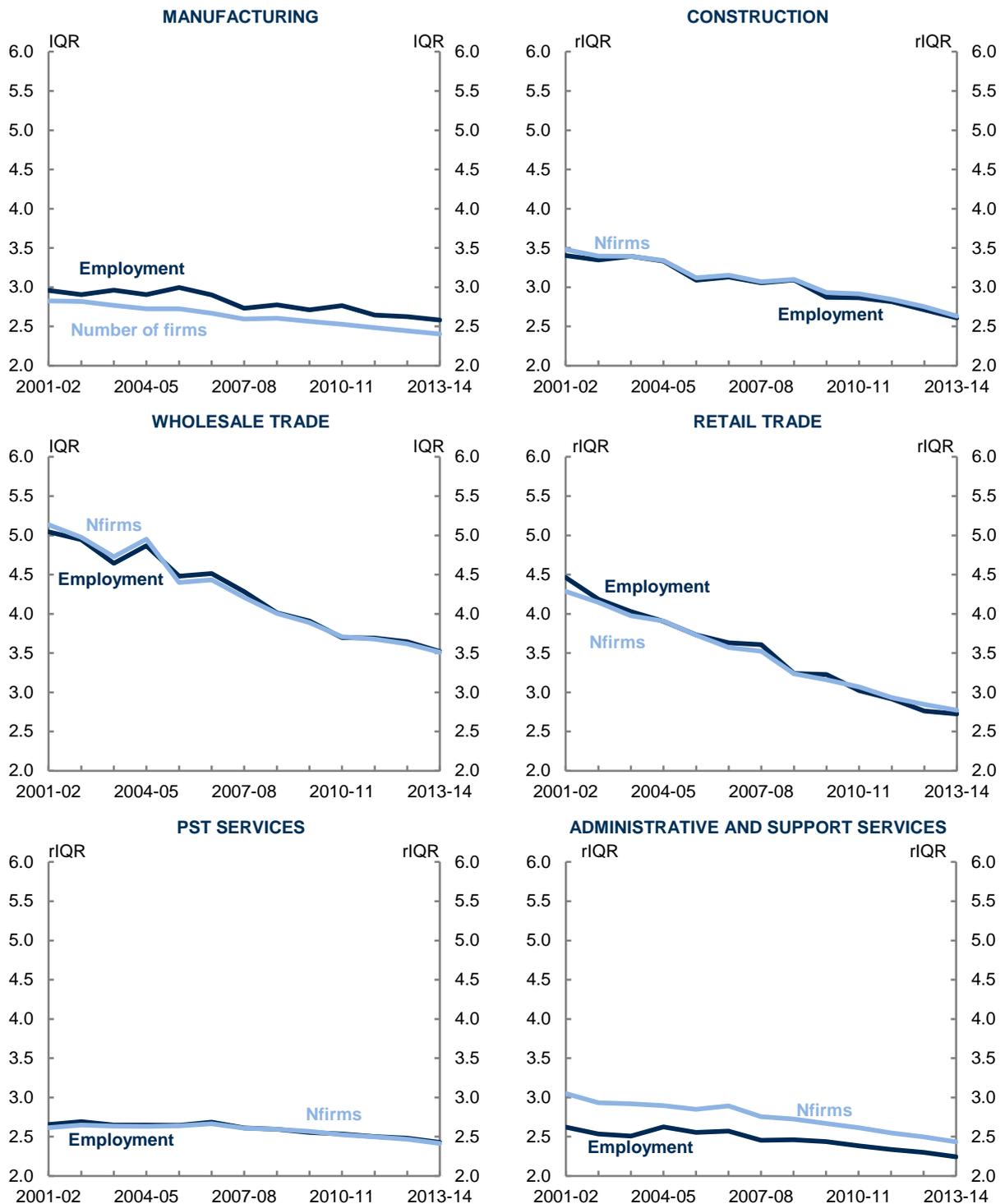


Source: BLADE

APPENDIX B

LABOUR SHARE WEIGHTING

FIGURE B1: WEIGHTING COMPARISON OF DISPERSION OVER TIME AT 4-DIGIT ANZSIC LEVEL (NEGATIVE VA TRANSFORMED, NUMBER OF FIRMS AND LABOUR SHARE WEIGHTS)



Source: BLADE.

**TABLE B1: DISPERSION AT 4-DIGIT ANZSIC LEVEL, 2001-02 TO 2013-14
(NEGATIVE VA TRANSFORMED, WEIGHTED BY LABOUR SHARE)**

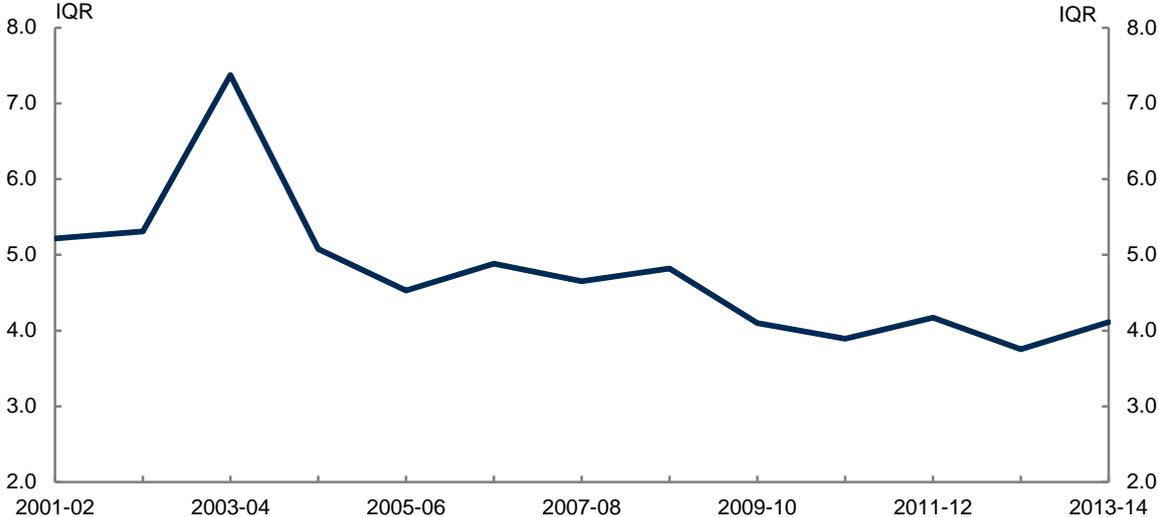
Division	rIQR	r90-10
Manufacturing	2.8	14.4
Construction	3.0	10.4
Wholesale Trade	4.7	n.a*
Retail Trade	3.5	n.a*
PST Services	2.6	9.9
Administrative and Support Services	2.5	8.9

* Not available due to number of firms with negative value added.

APPENDIX C

WHOLESALE TRADE WITH ANZSIC 3606 INCLUDED

FIGURE C1: PRODUCTIVITY DISPERSION OVER TIME (NEGATIVE VA TRANSFORMED, WEIGHTED BY NUMBER OF BUSINESSES)



Source: BLADE.

APPENDIX D

REGRESSIONS OF PRODUCTIVITY DISPERSION ON ENTRY RATE AND EXIT RATE

Tables D1 and D2 relate the level of rIQR to the firm entry rate and exit rate respectively, at the 4-digit industry-year unit of observation. The model equations are given by:

$$rIQR_{it} = \beta_0 + \beta_1 \text{Entry rate}_{it} + \gamma'4\text{-digit Industry} + \delta'Year + \epsilon_{it} \quad (1)$$

$$rIQR_{it} = \beta_0 + \beta_1 \text{Exit rate}_{it} + \gamma'4\text{-digit Industry} + \delta'Year + \epsilon_{it} \quad (2)$$

which, estimated using fixed effects becomes:

$$r\ddot{I}Q\ddot{R}_{it} = \beta_1 \text{Entry}\ddot{r}ate_{it} + \delta'Y\ddot{e}ar + \ddot{\epsilon}_{it} \quad (3)$$

$$r\ddot{I}Q\ddot{R}_{it} = \beta_1 \text{Exit}\ddot{r}ate_{it} + \delta'Y\ddot{e}ar + \ddot{\epsilon}_{it} \quad (4)$$

where $r\ddot{I}Q\ddot{R}_{it}$, $\text{Entry}\ddot{r}ate_{it}$ and $\text{Exit}\ddot{r}ate_{it}$ are the time demeaned values of the rIQR, entry rate and exit rate respectively.

For both regressions, each variable is purged of industry and year fixed effects to facilitate a within-industry interpretation and to abstract from time-varying shocks and industry factors. For the entry rate a robust positive relationship emerges, whereby an above-average (below-average) entry rate in a 4-digit industry is associated with above-average (below-average) 4-digit industry productivity dispersion (rIQR). The coefficient estimate implies that a 1 percentage point decline in an industry's entry rate is associated with a decline in the industry's rIQR of 0.058. The results for the exit rate were not significant.

**TABLE D1: ENTRY RATES: LINKS WITH PRODUCTIVITY DISPERSION
(4-DIGIT INDUSTRY, 2002-03 TO 2013-14)**

	Productivity dispersion (rIQR)
Entry rate	5.8452** (2.8706)
Industry Fixed Effects	YES
Year Fixed Effects	YES
Observations	2,730
AdjR2	0.6411

Note: Robust standard error in parentheses.

*** denotes statistical significance at the 1% level.

** significance at the 5% level.

* significance at the 10% level.

ns = not significant.

Source: BLADE.

**TABLE D2: EXIT RATES: LINKS WITH PRODUCTIVITY DISPERSION
(4-DIGIT INDUSTRY, 2002-03 TO 2013-14)**

	Productivity dispersion (rIQR)
Exit rate	-1.7002 ^{ns} (2.6863)
Industry Fixed Effects	YES
Year Fixed Effects	YES
Observations	2,730
AdjR2	0.6403

Note: Robust standard error in parentheses.
 *** denotes statistical significance at the 1% level.
 ** significance at the 5% level.
 * significance at the 10% level.
 ns = not significant.
 Source: BLADE.

REGRESSIONS OF INDUSTRY PRODUCTIVITY LEVEL AND GROWTH ON PRODUCTIVITY DISPERSION

Table D3 relates, respectively, the level of log labour productivity and the growth in labour productivity to the rIQR, at the 4-digit industry-year unit of observation. The model equations are given by:

$$\ln LP_{it} = \beta_0 + \beta_1 rIQR_{it} + \gamma'4\text{-digit Industry} + \delta'Year + \epsilon_{it} \quad (5)$$

$$Growth LP_{it} = \beta_0 + \beta_1 rIQR_{it} + \gamma'4\text{-digit Industry} + \delta'Year + \epsilon_{it} \quad (6)$$

which, estimated using fixed effects becomes:

$$\ln \ddot{L}P_{it} = \beta_1 rI\ddot{Q}R_{it} + \delta'Y\ddot{e}ar + \ddot{\epsilon}_{it} \quad (7)$$

$$Growth \ddot{L}P_{it} = \beta_1 rI\ddot{Q}R_{it} + \delta'Y\ddot{e}ar + \ddot{\epsilon}_{it} \quad (8)$$

where $\ln \ddot{L}P_{it}$, $Growth \ddot{L}P_{it}$ and $rI\ddot{Q}R_{it}$, are the time demeaned values of log labour productivity, the growth rate of labour productivity and the rIQR respectively.

For both regressions, each variable is purged of industry and year fixed effects to facilitate a within-industry interpretation and to abstract from time-varying shocks and industry factors. For log labour productivity level a robust negative relationship emerges, whereby above-average (below-average) productivity dispersion (rIQR) in a 4-digit industry is associated with a below-average (above-average) level of log labour productivity (significant at the 1 per cent level). The coefficient estimates imply that a decrease in an industry's rIQR of 1.0 is associated with a 0.52 per cent increase in the industry's average labour productivity. The results for labour productivity growth were not significant.

TABLE D3: PRODUCTIVITY DISPERSION: LINKS WITH INDUSTRY PRODUCTIVITY LEVEL AND GROWTH (4-DIGIT INDUSTRY, 2001-02 TO 2013-14)

	Log LP	Growth LP
Productivity dispersion (rIQR)	-0.0052*** (0.0008)	-0.00036 ^{ns} (0.00038)
Industry Fixed Effects	YES	YES
Year Fixed Effects	YES	YES
Observations	2,958	2,732
AdjR2	0.8927	0.2391

Note: Robust standard error in parentheses.

*** denotes statistical significance at the 1% level.

** significance at the 5% level.

* significance at the 10% level.

ns = not significant.

Source: BLADE.