Explaining Productivity Distribution in New Zealand Industries:

The effects of input quality on firm productivity differences

Hilary Devine, Tinh Doan
and Philip Stevens

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Author: Hilary Devine, Tinh Doan and Philip Stevens

Contact: Occasionalpapers@med.govt.nz

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Abstract

This paper examines the productivity dispersion within New Zealand industries. We look at the effect accounting for labour input quality has on explaining productivity dispersion. Many studies, across different economies, have observed the large differences in productivity within narrowly defined industries. The top performing firms can be many times more productive with the same inputs as the poorest performing firms (Syverson 2011). The productivity dispersion within several 4-digit industries has been found to be significantly larger (Devine et al 2011).

This paper argues that traditional volume measures of inputs may contribute to the large productivity dispersion we observe, as input quality is not taken into account. Productivity measures typically include both capital and labour, and while capital is usually measured in monetary units – providing a reasonable measure of quality – measures of labour are not as straight forward. Typically labour is measured as the number of workers or full time equivalents (FTEs). These volume measures do not provide a measure of quality that varies across firms. In this paper we use the wage bill of firms as a proxy measure of labour input quality. We examine whether incorporating this measure accounts for some of the productivity dispersion. The wage bill has several advantages over simple volume measures of labour, as it reflects the marginal price firms are willing to pay workers, and can capture unobservable characteristics that determine worker earning.

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JEL Classification: L11, L23, J21

Keywords: productivity dispersion, production function estimation, input quality

Table of Contents

List of Tables

List of Figures

Explaining Productivity Distribution in New Zealand Industries: *The effect of input quality on firm productivity differences*

1. Introduction

Many papers document large and persistent differences in productivity between firms, even within narrowly defined industries (e.g. Syverson, 2011; Bartelsman and Doms, 2000; Baily, Hulten and Campbell, 1992). Syverson (2011) in his survey paper reports productivity differences of firms in the 90th can be as large as 5 times as productive as firms in the 10th percentile, given the same levels of inputs. Labour productivity dispersion appears to large within New Zealand 4-digit industries with large 90/10 differences reported in Devine, Doan, Iyer, Mok and Stevens (2011).

The increasing availability of firm or plant level datasets has led to a large number of studies exploring the productivity differences across heterogeneous firms. There are two key areas of focus in this work. First, focuses on the measurement of productivity, the possible difference of inputs of capital and labour across firms (Fox and Smeets 2011, Collard-Wexler 2011, Bagger, Christensen and Mortensen 2011, Ornaghi 2006) and differences in outputs, (Foster, Haltiwanger and Syverson, 2008). The second area looks at determinants of productivity to explain the dispersion. The work covers a wide range: Syverson (2004) looks at increases in competition decreasing productivity dispersion, the effects of trade (Helpman 2006 , Melitz 2003, and Helpman, Melitz and Yeaple 2004), technology improvements (Faggio, Salvanes and Van Reenen 2007), regulation and institutions (Nicoletti and Scarpetta, 2003), productivity spillovers (Bloom, Schankerman and Van Reenen, 2007), effects of entry and exit (Foster Haltiwanger and Kirzan, 2002). However, from this large body of work there is still no clear consensus, either theoretical or empirical to explain the productivity dispersion we observe.

The focus of this paper is on the quality measurement of inputs, to explain the productivity dispersion within New Zealand industries. Mismeasurement of inputs due to lack of data or the incorrect specification may increase the error at both ends of the distribution. Previous work shows that the levels of labour quality in New Zealand are high in the OECD, with high levels of training and tertiary qualifications (MED, Treasury and Statistics New Zealand, 2011). However, levels of productivity are low within the OECD and falling (OECD 2011). We hope this paper will contribute to the work in this area, on both the measurement and interpretation of productivity.

In this paper we estimate production functions for separate industries using both volume measures of labour input (number of workers) and quality-adjusted measures (wage bill). The difference between using the two different measures is compared to determine whether the mismeasurement of inputs increases productivity dispersion. This paper draws on recent work by Fox and Smeets (2011) who conduct similar analysis for Danish industries. Fox and Smeets draw on a rich dataset, with worker characteristics including gender, education, labour market experience and firm tenure, allowing them to construct human capital variables included in their estimation of productivity. They find input quality does drive some of the productivity dispersion. However, the dispersion remains large indicating other factors also contribute to the spread.

The remainder of this paper is as follows. In the next section we will present findings from previous work as background to the paper. In section three and four we outline the method and data used. Section five presents the results and section 6 concludes.

2. Explaining productivity distribution and quality of labour inputs

As we alluded to above the literature on productivity and its measurement is vast and varied. The focus of this paper is on the effect of input quality measures on productivity dispersion we will focus on productivity distribution, why it is important and investigate the importance of input measures.

2.1. Productivity Distribution

As we mentioned above, large productivity differences are common across industries and firms. It remains a puzzle as to why the dispersion within very narrow industries or across firms is so large and persistent when we expect poor performers in a market to become unprofitable and eventually be selected out of the market. We assume new entrants are more productive as they come into the market with a new idea or innovation displacing the low productivity incumbents. This selection process increases the productivity of the market over time. The Schumpeterian process of ‘creative destruction’ can help explain what drives productivity growth, whereby there is a continual process of firm birth and death bringing new ideas process and technology into the market. Syverson (2004) demonstrates that productivity dispersion decreases in more competitive markets, where the selection process is evident.

Despite these selection mechanisms, productivity dispersion remains large and persistent across industries and countries (both developed and developing), irrespective of different competition levels and rates of entry and exit. An interesting question arises, is it the same firms that continue to under or over perform, do the top firms remain at the top of the productivity distribution and vice-versa? Devine et al (2011) looked at this across New Zealand industries finding there is persistence of firms remaining in the same place in the distribution over a three-year period. Typically entering and exiting firms have lower than average productivity compared to the incumbent but of the entering firms that do survive move up the productivity distribution, reaching or overtaking the incumbent (Devine, Doan, Iyer, Mok, Stevens, 2012 and Fabling, Grimes, Sanderson and Stevens, 2008). This persistence is consistent with similar studies conducted on UK datasets, both between firms and within firm distributions (Haskel and Martin 2002, and Griffith, Haskel and Neely, 2006, respectively).

Much of the literature in this area tries to explain these large differences in productivity. In some ways this is not surprising, as in any population there are differences between individuals. Therefore, it is more important to ask, why the productivity differences between firms is important? Is it simply a matter of differences in inputs across firms (Griliches 1957) or firm characteristics such as management or business practices or technology? Or is it necessary to some degree to allow a competitive market to function, a selection out of poor performers. Understanding how the poor performers differ from the top performer can influence how we think about the allocation of resources to the most productive. Haskel and Martin (2002) found that even when the least productive firms are brought up to the industry median level of production the increase in productivity is only small, as the low performers have a low market share, therefore their contribution to overall productivity is small.

Although the use of the wage bill in production functions is not new, in this paper we compare incorporating it as a proxy for input quality to determine if it contributes to productivity dispersion. It is possible that [at least some of] the productivity we report is an artefact of mismeasurement and by not taking into account of the full price or quality of an input, productivity is overestimated (Bagger, Christensen and Mortensen, 2011 and Fox and Smeets 2011). If we assume more productive firms can afford to pay for higher quality workers and the wage [or price] of an input acts to allocate resources within the market. More productivity firms can hire better workers. Alternatively if productivity is driven by other firm characteristics or business practices then inputs will not impact on productivity. Baily et al (1992) look at the productivity differences in wages, finding a link between efficiency differences and wages differences, but no causal impact with productivity. We look at labour input quality to determine if this drives productivity dispersion.

2.2. Labour Input Quality

This paper focuses on the quality of labour inputs in the production function. We focus on this for two reasons. Typically capital input is measured in monetary units, whereas labour inputs are measured by volume such as number of workers or FTEs or hours worked. Although capital measures are not exact on the measurement of utilisation and capturing the vintage or depreciation effect (Ornaghi 2006), they are reported in monetary values and therefore are more likely to capture the input quality than labour inputs. Labour inputs are difficult to quantify as they rely on a measure of skill of each individual worker, incorporating years of education and experience, but also intangible attributes like ability and motivation. With rich firm-individual progress, this work has expanded hugely.

Exploring the effect of labour quality measures could potentially effect productivity dispersion in New Zealand is interesting. New Zealand is reported as having high labour quality within the OECD. However, New Zealand also has low and falling rates of productivity, raising the question what contribution labour quality or education has for productivity. This paper we look at accounting for the quality of labour input drives productivity dispersion.

Previous work on labour quality in New Zealand by Szeto and McLoughlin (2008) has looked at measurement of labour quality in New Zealand, constructing a measure based on the composition of the labour force based on hours worked. They find labour quality increases with the revised measure and up to half of the labour productivity growth is due to the quality of labour, overestimates productivity growth. We use the wage bill as a proxy of labour quality rather than augment hours worked.

The advantages of the wage bill are that it captures labour quality if we assume the wage rate [price] is a good indicator of quality. The wage bill captures the unobservable characteristics of the worker. Hyslop and Mare (2008) look at worker fixed effects of New Zealand workers, to explore how earnings rate differ due to worker or firm characteristics. They find half of differences are due to worker fixed effects 25 percent is determined by demographics or workers and 10 – 25 percent are from firm effects. Fox and Smeets (2011) look at worker fixed effects in their model, finding it is not significant in their wage bill augmented production function, we do not include it in our formal analysis.

Thee is limited literature in this area, looking at the labour quality and productivity dispersion. Early papers such as Hellerstein and Neumark (2006) look at wage estimation from the production function, reporting a reduction in the dispersion through incorporation of the wage as a labour quality measure. Fox and Smeets (2011) with an employer-employee linked dataset create human capital variables that capture education and experience of employees. They use a Cobb-Douglas and Translog production functions to estimate any decrease in variance in productivity explained by incorporating various labour input quality measures including the wage bill. Their findings indicate the wage bill explains as much productivity dispersion as the human capital measures. A similar study of Norwegian firms looked at the labour quality in firms engaged in internationalisation and those who were not (Irarrazabal, Moxnes and Ulltveit-Moe (2010). Typically internationalising firms are more productive and have higher wages. They use similar human capital measures as Fox and Smeets (2011) to look at the productivity of internationalising firms. Finding inclusion of input quality explains 25 precent of productivity differences between internationalises and non-internationalises over stating productivity differences. An alternative method used by Bagger et al (2011) uses occupational data with the wage bill to augment the production function. Although they did not find a large decrease in productivity dispersion, across industries dispersion did reduce.

In this paper we will use this work as a basis the explore New Zealand's productivity dispersion, incorporating the most promising measures of the wage bill, in the production function. We will examine whether the large distribution seen in New Zealand industries can be explained (at least in part) by augmenting with labour quality. We outline in the next sections the method and data used in the analysis.

3. Measuring Productivity

In our analysis we report results using both Cobb-Douglas and Translog production functions. Both of these functional forms allows us to estimate multi-factor productivity (MFP), using the standard labour measure of number of workers and augmented using the quality input measure, proxied by the wage bill. The method has utilised the method in Fox and Smeets (2011).

Cobb Douglas production function

(1) $$\ln va = \alpha + \beta_l \ln l + \beta_k \ln k + \varepsilon$$

where va is value added, i is the number of workers, k is capital stock, and β_l and β_k are the estimated coefficients on labour (number of workers) and capital respectively. The residual ε is measured as the MFP or productivity measure. The residual captures technical or productivity change that is not explained by either labour or capital. Although the notation has been left out for simplicity this production functions and all that follow, are calculated for each one-digit industry for firm i, at time t. We assume for simplicity, perfect competition.

We also calculate the Translog form of the production function to allow for comparison and robustness checking. The Translog incorporates flexible functional form allowing for differences in substitutability of inputs, providing a second order approximation.

Translog production function

(2) $$\ln va = \alpha + \beta_{l1} \ln l + \beta_{k1} \ln k + \beta_{l2} (\ln l)^2 + \beta_{k2} (\ln k)^2 + \beta_{lk} (\ln l)(\ln k) + \varepsilon$$

Next we augment the production function by incorporating the wage bill. Above we identified that the wage bill is likely to capture unobservable worker characteristics and captures labour quality by assuming the wage [price] reflects quality, and be correlated with worker ability. We have the advantage that wage bill for the firm is easily measured through the Linked Employer Employee Database (LEED) in Statistics New Zealand prototype Longitudinal Business Database (LBD). We augment the Cobb-Douglas and the Translog production function below by replacing the number of workers, l with measure of the wage bill, w.

Cobb Douglas production function augmented using the wage bill

(3) $$\ln va = \alpha + \beta_w \ln w + \beta_k \ln k + \varepsilon$$

Translog production function augmented using the wage bill

(4) $$\ln va = \alpha + \beta_{w1} \ln w + \beta_{k1} \ln k + \beta_{w2} (\ln w)^2 + \beta_{k2} (\ln k)^2 + \beta_{wk} (\ln w)(\ln k) + \varepsilon$$

Where the wage bill is;

(5) $$w = \sum_{i=1}^{l} w_i$$

The wage bill is calculated as the sum of a firms total monthly wages and salaries, capturing part time employees, in year *i*, for including employees and working proprietors.

We include a series of controls into the production function for the quality of labour including the proportion of female workers, tenure and employee growth. Including the proportion of female and male employees controls for any difference in productivity in the firm. Worker tenure in firms is used as a control for firm specific skills or labour quality acquired in the firm. Employment growth is included to count for correlation between productivity and employment growth (Baldwin 1995). The possibility of matching or sorting between workers and firms within the market, where more able workers are employed by more productive firms, can bias results (Lentz and Mortensen 2009). We include this as a control as a correlation between productivity and employment growth may lead to overestimation of productivity dispersion.

In estimating a production function we must account for two biases, simultaneity where firms may observe a productivity shock before they choose combination of inputs creating correlation of inputs and productivity, or selection bias, where the due to selection in the market the distribution is skewed left as low productivity firms leave the market and are therefore not observable increasing the level of the industry. This is corrected for by using the Levinsohn and Petrin (2003) and extension of Olley and Pakes (1996) where a firms decision to invest is used to control for any selection or simultaneity as the decision to invest is correlated to productivity but may not lead to higher production. Levinsohn and Petrin (2003) use intermediate consumption as the control, instead of investment as it can be lumpy over time. We use Levinsohn and Petrin (2003) model to estimate our production function as a robustness check.

4. Data

The data used in this paper comes from the Statistics New Zealand's prototype Longitudinal Business Database (LBD). The LBD is built around the Longitudinal Business Frame (LBF), which matches different data sources. This includes financial accounts (IR10), Goods and Services Returns (GST) provided by the Inland Revenue Department (IRD) and survey data such as the Annual Enterprise Survey (AES). The prototype LBD is described in full detail in Fabling, Sanderson and Stevens (2008) and Fabling (2009).

The data is derived from Annual Enterprise Survey (AES) providing financial data, such as gross output and sales and the Linked Employer Employee Database (LEED) providing labour market variables. For this analysis firm level data is used from 2000 – 2009. Productivity is measured using AES value added (where gross output minus intermediate consumption) and labour is from rolling mean employment and working proprietors from LEED. All values are calculated at 2009 constant prices. We do not weight the MFP calculations.[1] Production function estimates are presented at the 1 digit ANZSIC (Australia New Zealand Standardized Industrial Classification), dropping industries M – Government Administration and Defence, Q97 – Private and Household Employing Staff and R – Not Elsewhere Classified.

5. Results

In this section, we present the labour productivity dispersion results. Labour productivity distributions are widely cited and comparable with international studies allowing us to establish the extent of productivity dispersion within New Zealand industries. We then summarise the production function results and the calculated dispersion of productivity and compare if including a measure of input quality reduces the dispersion within industries.

5.1. Dispersion levels

Table 1 shows the labour productivity distributions presented by 1-digit ANZSIC. The 90/10 ratios describe the difference between labour productivity of firms in the 90th percentile and firms in the 10th percentile. Also presented are 90/50 and 50/10

[1] We treat the wage bill as a weighted measure of employment, a measure of labour quality.

ratios, these allow us to observe differences in each half of the distribution to determine the extent of any skew in the distribution towards one end or the other.

From Table 1 we can see there is considerable variation of productivity within industries. The 'Finance and Insurance' industry has the greatest productivity distribution of 28.25, with 'Agriculture, Forestry and Fishing' with the lowest differential at 3.30. Services industries appear to have greater productivity dispersion than those in either manufacturing or agriculture. Although the 90/50 and 50/10 distributions do not vary a great deal, there is larger variation in the bottom half of the distribution (50/10 column) than is seen in the upper half of the distribution, indicating a wider spread of poorer performers. We see this in 'Electricity', 'Communication Services', 'Transport and Storage' and 'Education' industries. Whereas 'Mining', 'Health and Community Services' and 'Cultural and Recreational Services' have a large dispersion in the top half of the distribution.

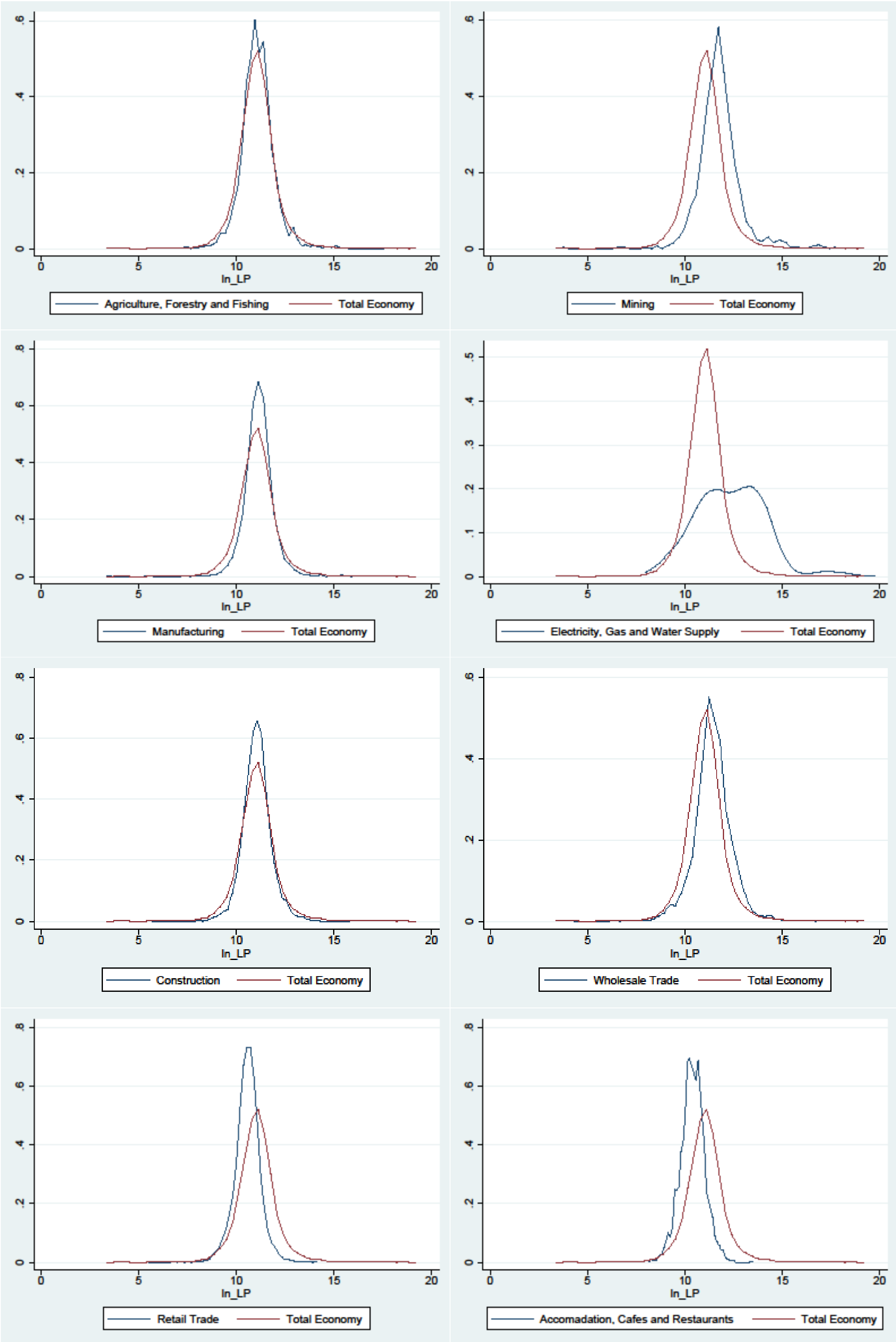
Table 1 Labour Productivity Distribution, 2000-2009

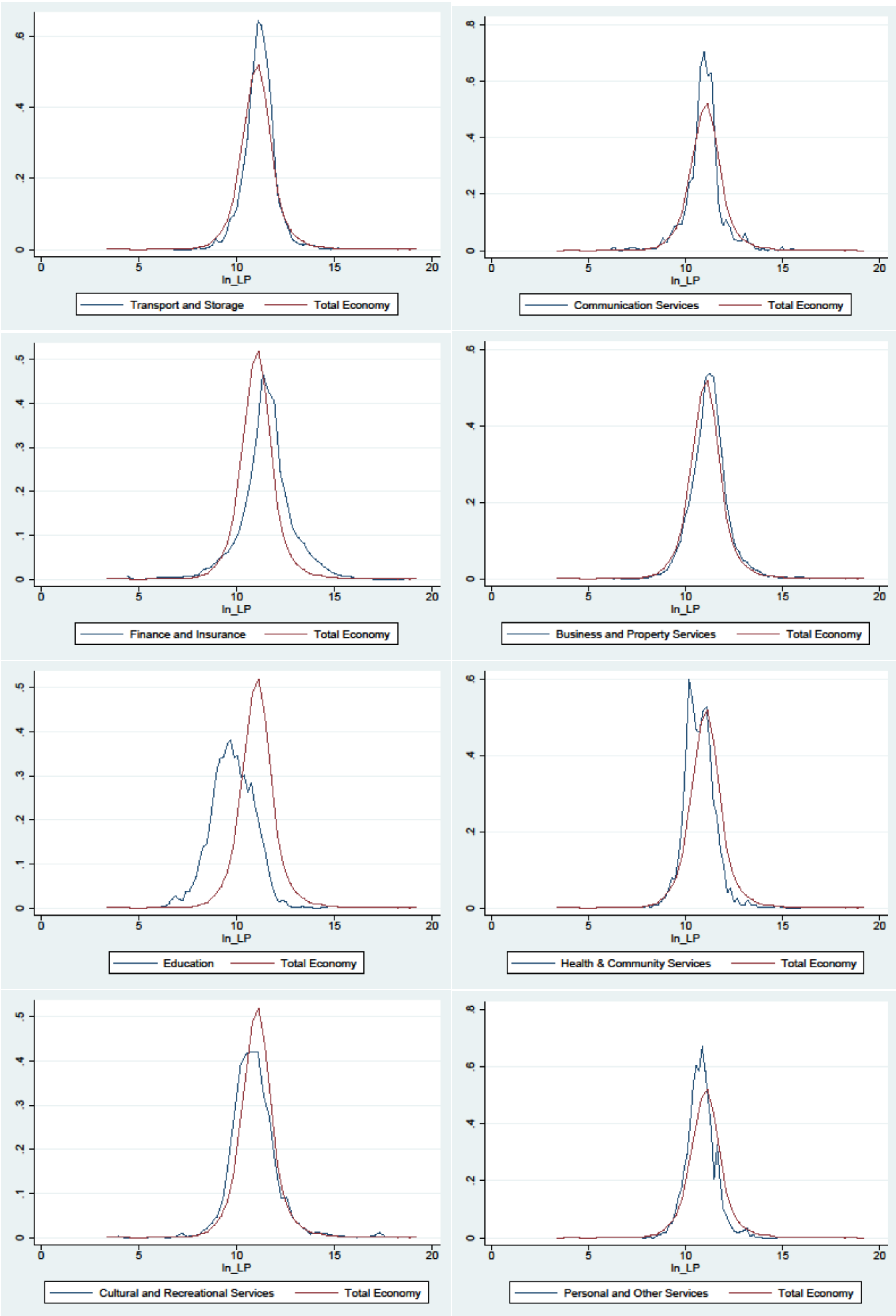
ANZSIC 1-digit	P90/10	P50/10	P90/50	SD (P90/10)	SD (P50/10)	SD (P90/50)
Agriculture, Forestry and Fishing	3.30	1.82	1.81	1.09	0.74	1.02
Mining	10.06	2.96	3.40	1.18	0.73	1.10
Manufacturing	3.95	2.04	1.94	0.53	0.36	0.45
Electricity	27.42	6.80	4.03	1.14	1.21	1.42
Construction	5.32	2.20	2.42	0.40	0.26	0.43
Wholesale Trade	8.47	2.95	2.87	0.53	0.34	0.60
Retail Trade	4.51	2.19	2.05	0.45	0.33	0.43
Accommodation, Cafes and Restaurants	4.06	2.09	1.95	0.24	0.23	0.27
Transport and Storage	4.62	2.37	1.95	0.52	0.39	0.43
Communication Services	6.35	3.16	2.01	1.08	0.45	0.62
Finance and Insurance	28.15	5.74	4.91	1.22	0.37	0.56
Business and Property Services	14.18	3.15	4.51	0.58	0.54	1.13
Education	16.38	5.25	3.12	0.42	0.37	0.46
Health & Community Services	7.22	2.40	3.01	0.63	0.44	0.78
Cultural and Recreational Services	18.57	3.59	5.18	0.81	0.53	1.43
Personal and Other Services	4.45	2.14	2.08	0.48	0.28	0.54
Economy Aggregate	7.45	2.58	2.89	0.71	0.59	1.08

Note: Labour productivity is calculated as ln(VA)/ln(RME). ANZSIC 1-digit industries presented, omitting M – Government Administration and Defence, Q97 – Private and Household Employing Staff and R – Not Elsewhere Classified.

Figure 1 presents a series of kernel distributions showing the labour productivity distribution of each 1-digit industry compared with the total economy labour productivity distribution. We can see there is considerable variation both between and within industries. Between industries variation can be observed by comparing the differences in distributions to the total economy benchmark. ‘Manufacturing’ and ‘Agriculture, Forestry and Fishing’ distribution profile compares closely to the economy average. However, industries such as ‘Retail Trade’ and ‘Accommodation, Cafes and Restaurants’ both have distributions that sit to the left of the total economy. In contrast, ‘Wholesale Trade’, ‘Transport and Storage’ and ‘Finance and Insurance’ have distributions to the right of the total economy, indicating higher median labour productivity.

Figure 1 Kernel Densities Labour Productivity, 1-digit ANZSIC





Note: Figure 1 top and bottom 1% for each industry were removed to ensure confidentiality. ANZSIC 1-digit industries presented, omitting M – Government Administration and Defence, Q97 – Private and Household Employing Staff and R – Not Elsewhere Classified.

Given this the large distribution of labour productivity, the most widely used measure, now we look to Multi-Factor Productivity (MFP). The two different functional forms we utilise enable us to account for the effects of both capital and labour inputs, augmenting the function with the measure of labour input quality, using the wage bill. We then compare the difference in variance from incorporating the input quality.

5.2. Production Function estimates

In this section we present the results of the production function to provide context for the discussion of productivity dispersion. Table 2 reports the results of the Cobb-Douglas production function, estimated for the 16 1-digit ANZSIC industries. For each industry we presents results using both the standard measure, number of workers and the augmented production function using the wage bill. For conciseness we only will present the Cobb-Douglas results, and include the Translog in the Appendix, as the results are broadly consistent across the models.

Each column in Table 2 show the same model specification including both number of workers and the wage bill, across industries we will discuss the results (two panels) across rows comparing the coefficients by industries. The results are what we expect to see with positive and significant coefficients for both the capital and labour measures. It is important to note that this papers does not come to any conclusions or inference on the results of the production function estimates as we are testing for sensible robust results that are able to be used to calculate the effect of measurement or input quality on productivity dispersion, and whether better specification of inputs provides better specification of productivity measures.

The coefficients on labour (number of workers) in row 1, are between 0.50 and 0.74 across the 16 industries and the coefficient on capital is 0.30 and 0.52. All coefficients are positive and significant. The coefficients on the labour quality measure (wage bill) are generally lower than for those on the number of workers, ranging between 0.44 and 0.64. The R-squared across the different specifications do not change the explanatory power of the model to a great degree. In skill intensive services industries such as ‘Accommodation, Cafes and Restaurants’ and ‘Retail Trade’ have greater coefficients than less skill intensive industries.

Generally we see consistent results across industries the models (Cobb-Douglas and Translog). There is very little difference in the R-squared between the Cobb-Douglas and Translog function.

A study by Mason and Osborne (2007) highlight the importance of labour quality in New Zealand. They compare New Zealand's labour and multi-factor productivity with the UK and compare the relative levels of labour quality and capital intensity. They find as we do considerable variation across industries, but in general New Zealand has lower capital intensity in most industries than the UK. Although we have a skilled workforce that goes some way to offsetting the low capital intensity, we are still behind in terms of productivity. It is important to remember in these measures do not incorporate any correlation between labour and capital i.e. skills required to fully utilise capital (Mason and Osborne 2007). Despite the possible difficulties interpreting the production function we want to understand the relationship between these factors of production and if they drive productivity dispersion.

Table 2 Production Function (Cobb-Douglas)

OLS	Industry															
	Agriculture, Forestry and Fishing		Mining		Manufacturing		Electricity		Construction		Wholesale Trade		Retail Trade		Accommodation, Cafes and Restaurants	
Dependent Variable Log Value-added	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill
lnLN	0.6321***		0.6900***		0.6931***		0.5693***		0.7397***		0.5994***		0.6606***		0.7296***	
	[0.0185]		[0.0420]		[0.0097]		[0.0693]		[0.0120]		[0.0134]		[0.0113]		[0.0204]	
lnLW		0.5165***		0.4924***		0.5898***		0.4837***		0.5048***		0.5914***		0.5559***		0.5916***
	[0.0185]	[0.0165]		[0.0348]		[0.0091]		[0.0623]		[0.0098]		[0.0111]		[0.0098]		[0.0161]
lnK	0.3260***	0.2793***	0.4463***	0.4550***	0.3540***	0.3268***	0.5279***	0.4790***	0.3451***	0.3650***	0.4180***	0.3075***	0.3398***	0.3365***	0.3057***	0.3176***
	[0.0149]	[0.0151]	[0.0283]	[0.0303]	[0.0071]	[0.0075]	[0.0431]	[0.0467]	[0.0096]	[0.0100]	[0.0106]	[0.0102]	[0.0098]	[0.0095]	[0.0162]	[0.0149]
Constant	8.1002***	3.6617***	6.9844***	2.1335***	7.8772***	2.3826***	6.1877***	2.1024***	8.0222***	3.1681***	7.7920***	2.8618***	7.8199***	2.6027***	7.5998***	2.0694***
	[0.1419]	[0.1323]	[0.2692]	[0.2112]	[0.0585]	[0.0541]	[0.4469]	[0.2941]	[0.0794]	[0.0592]	[0.0896]	[0.0696]	[0.0795]	[0.0516]	[0.1412]	[0.0975]
4-Digit Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1350	1350	1893	1893	17427	17427	309	309	8826	8826	10956	10956	12894	12894	3411	3411
R-squared	0.75	0.74	0.82	0.82	0.89	0.89	0.89	0.9	0.82	0.81	0.77	0.79	0.85	0.86	0.86	0.86

OLS	Transport and Storage		Communication Services		Finance and Insurance		Business and Property Services		Education		Health & Community Services		Cultural and Recreational Services		Personal and Other Services	
Dependent Variable Log Value-added	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill
lnLN	0.7433***		0.5560***		0.6607***		0.5002***		0.5579***		0.6648***		0.4319***		0.4817***	
	[0.0124]		[0.0454]		[0.0137]		[0.0159]		[0.0291]		[0.0162]		[0.0166]		[0.0186]	
lnLW		0.6262***		0.6198***		0.6441***		0.4493***		0.6419***		0.6253***		0.4424***		0.6332***
		[0.0109]		[0.0578]		[0.0162]		[0.0127]		[0.0257]		[0.0141]		[0.0200]		[0.0228]
lnK	0.3266***	0.3055***	0.4803***	0.3626***	0.2697***	0.2381***	0.4635***	0.4045***	0.2524***	0.2889***	0.1653***	0.2169***	0.4076***	0.4811***	0.3979***	0.4118***
	[0.0102]	[0.0103]	[0.0363]	[0.0513]	[0.0113]	[0.0121]	[0.0125]	[0.0121]	[0.0239]	[0.0206]	[0.0112]	[0.0117]	[0.0162]	[0.0162]	[0.0170]	[0.0179]
Constant	7.9793***	2.0740***	6.5445***	1.3626***	8.3696***	2.2540***	6.7211***	3.0520***	2.6241***	7.6812***	3.1593***	9.3964***	3.2052***	6.6162***	2.7644***	7.0485***
	[0.0970]	[0.0797]	[0.2942]	[0.2173]	[0.0987]	[0.1326]	[0.1107]	[0.0900]	[0.2303]	[0.1760]	[0.1419]	[0.1033]	[0.1273]	[0.1468]	[0.1140]	[0.1532]
4-Digit Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5190	5190	834	834	5532	5532	14490	14490	2658	2658	3927	3927	3099	3099	2091	2091
R-squared	0.85	0.87	0.92	0.93	0.61	0.62	0.76	0.78	0.51	0.51	0.74	0.7	0.74	0.71	0.86	0.86

5.3. Input quality explaining productivity dispersion

In this section we use the 90/10 distributions to examine whether including the input quality of labour using the wage bill reduces the dispersion in productivity. The dispersion is calculated using percentile differences between production function residuals (productivity). Table 3 provides dispersion estimates using Cobb-Douglas production function. Again we present only Cobb-Douglas results with the Translog results reported in the Appendix. Column 1-3 report results using number of workers, and columns 4-6 outline the results of the augmented production function by the wage bill. The final columns represent the differences between these two specifications.

The 90/10 ratio vary considerably within industries in the period of our analysis. The results show that all 1-digit industries saw a reduction in dispersion except 'Agriculture, Forestry and Fishing', 'Mining' and Personal and Other Services'. These were only small increases of between 1 – 4 percent. The industries that experienced a decrease in productivity dispersion from including a measure of input quality varied depending on the industry. There was also considerable variation in the decrease in the top and bottom of the distribution. The industries with the largest dispersion are 'Electricity', 'Wholesale Trade', 'Finance and Insurance' experienced the greatest reduction in dispersion. The 90/50 and 50/10 distributions do not vary hugely, there is larger variation in the bottom half of the distribution (50/10 column) than the upper half of the distribution, indicating a greater spread of poorer performer.

High elasticities for services possibly reflect the heterogeneity of production technology in the services sector. It is worth noting that as MFP takes into account capital as well a labour, the measures of dispersion derived from MFP will be less than those of labour productivity. Fox and Smeets (2011) find any measure of wage bill does a better job at reducing dispersion than including human capital measures or firm growth. If we compare these results with those in Table 1 the results are lower across all industries.

Table 3 Multi Factor Productivity Distribution (Cobb-Douglas) using Number of Workers and Wage Bill

ANZSIC 1-digit	Cobb-Douglas RME			Cobb-Douglas Wage			Change		
Percentile differences	90/10	50/10	90/50	90/10	50/10	90/50	90/10	50/10	90/50
Agriculture, Forestry and Fishing	8.79	3.08	2.85	9.09	3.11	2.92	3%	1%	2%
Mining	6.50	2.21	2.95	6.59	2.29	2.87	1%	4%	-3%
Manufacturing	3.55	1.86	1.91	3.29	1.81	1.82	-8%	-3%	-5%
Electricity	13.24	3.10	4.27	10.34	2.98	3.47	-22%	-4%	-19%
Construction	4.89	2.11	2.32	4.68	2.07	2.26	-4%	-2%	-3%
Wholesale Trade	7.23	2.60	2.78	5.44	2.25	2.42	-25%	-14%	-13%
Retail Trade	3.97	2.04	1.95	3.59	1.94	1.85	-10%	-5%	-5%
Accommodation, Cafes and Restaurants	3.65	1.90	1.92	3.59	1.87	1.92	-1%	-2%	0%
Transport and Storage	4.45	2.27	1.96	3.88	2.05	1.89	-13%	-9%	-3%
Communication Services	4.79	2.27	2.12	3.77	1.92	1.96	-21%	-15%	-7%
Finance and Insurance	24.95	5.30	4.71	18.26	5.03	3.63	-27%	-5%	-23%
Business and Property Services	8.89	2.73	3.25	8.39	2.71	3.09	-6%	-1%	-5%
Education	14.32	4.94	2.90	12.57	4.79	2.62	-12%	-3%	-10%
Health & Community Services	4.58	2.20	2.08	4.20	2.06	2.04	-8%	-6%	-2%
Cultural and Recreational Services	9.50	3.19	2.98	8.63	2.79	3.10	-9%	-13%	4%
Personal and Other Services	3.82	1.95	1.96	3.98	1.97	2.03	4%	1%	3%
Total	6.64	2.55	2.60	5.96	2.44	2.44	-10%	-4%	-6%

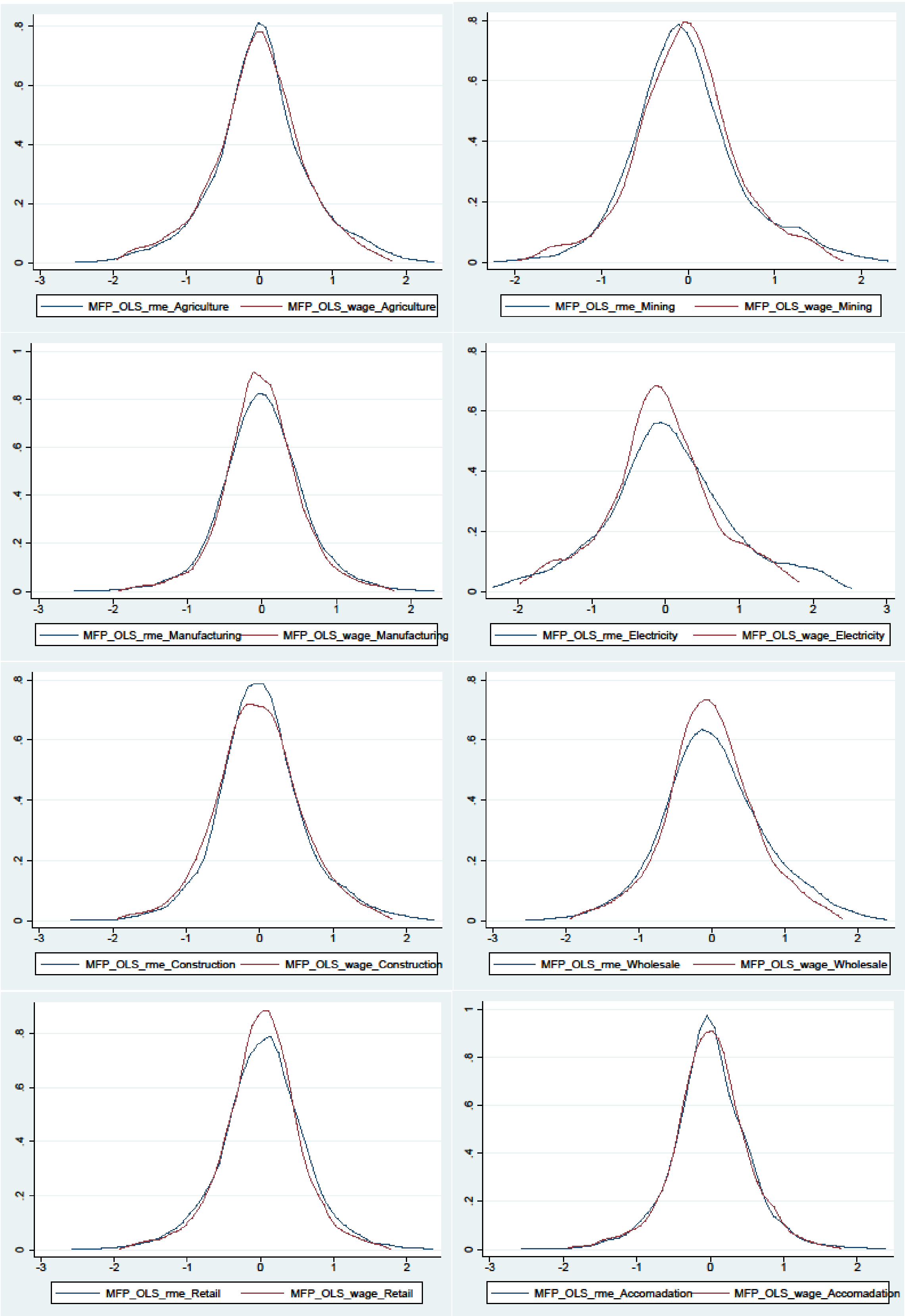
Note: Labour productivity is calculated as ln(VA)/ln(RME). ANZSIC 1-digit industries presented, omitting M – Government Administration and Defence, Q97 – Private and Household Employing Staff and R – Not Elsewhere Classified.

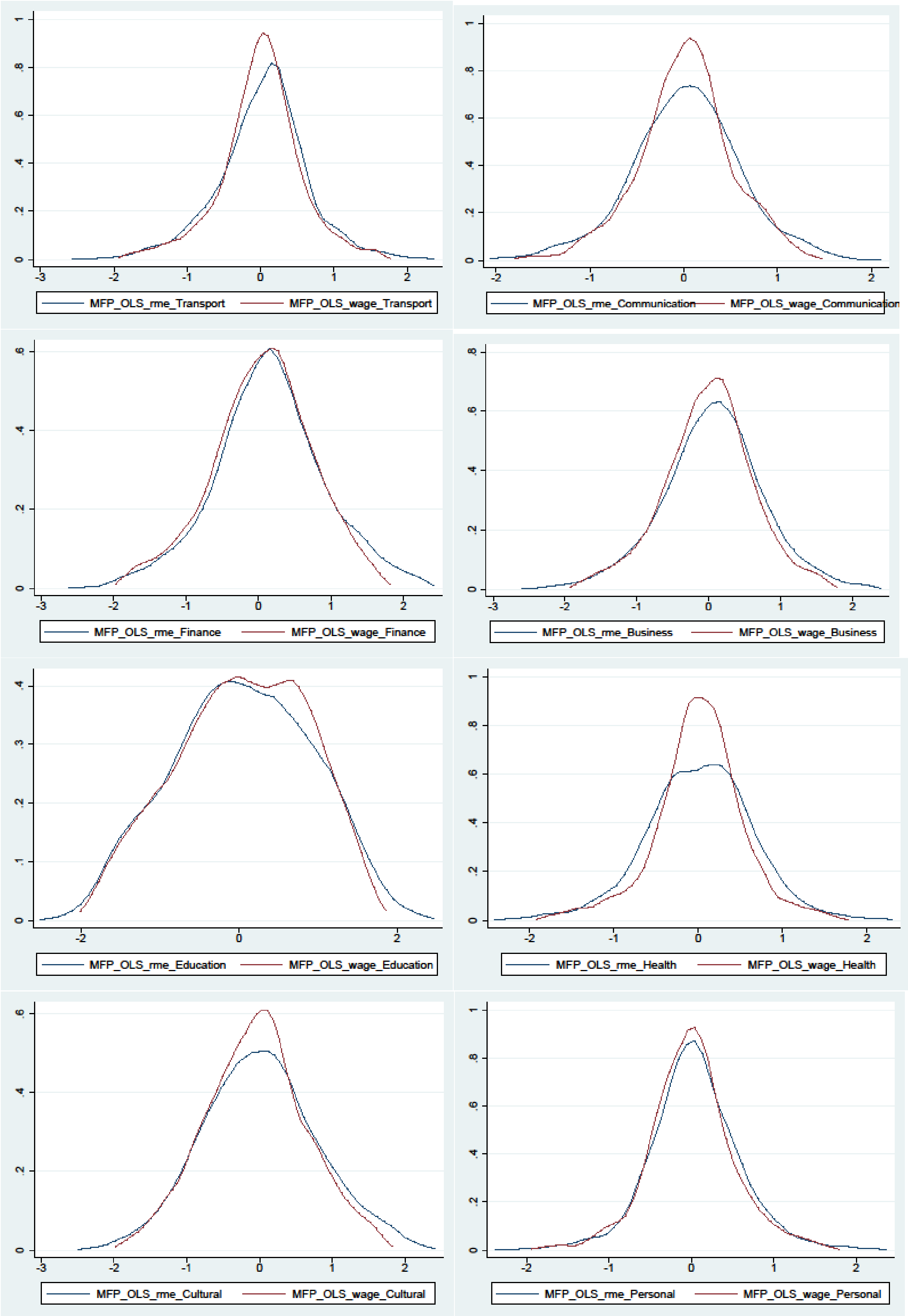
Looking at the last three columns of Table 3 that outlines the change in productivity dispersion from including the wage bill. We find that including a quality input measure of labour does reduces the observed productivity dispersion. The magnitude of reduction changes significantly across and within the industries. The industries with the largest dispersion are ‘Electricity’, ‘Wholesale Trade’, ‘Finance and Insurance’ experienced the greatest reduction in dispersion.

The industries with the largest dispersion using the standard model specification, experienced the greatest reduction using input quality adjusted model, these were mostly services industries. These services firms indicate that the quality of labour if mismeasured can affect the calculations, especially when the firm is skill intensive. The wage bill, even as the crude measure of quality, appears to reflect quality where workers are paid their marginal value.

Figure 2 presents a series of kernel densities of MFP by 1 digit ANZSIC which includes estimates for both the number of employees and the wage bill. These, like the 90/10 ratios vary considerably by industry, by the effect the augmented by the wage bill measures. In some cases they track closely, where other differ greatly with the inclusion of the wage bill. 'Agriculture', 'Mining', 'Manufacturing', 'Accommodation, Cafes and Restaurants' and Finance and Insurance', do not change with the wage bill. The largest difference in distributions is in the 'Electricity", Wholesale Trade', 'Communication Services' and 'Health and Community Services'. In these industries there does not appear to be large difference in the variation of the distribution, but with reduced mean. One interesting characteristic is that while the lower half of the distribution appears to track closely for the two model specifications, there is considerable differences in the upper half of the distribution, for example 'Wholesale trade, 'Communications Services', 'Business Services', 'Finance and Insurance', 'Education' and 'Cultural and Recreational Services'. Incorporation of the wage bill appear to affect the poor performers over the lower performers. This is perhaps due to top performing firms (possibly large firms) where the wage bill is highly correlated to productivity. Accounting for the wage bill appears to change the top half distribution to a greater extent than the bottom half of the distribution.

Figure 2 Kernel Densities Multi-Factor Productivity: Comparing number of workers and wage bill, 1-digit ANZSIC




MFP_OLS_rme_Transport
MFP_OLS_wage_Transport
MFP_OLS_rme_Communication
MFP_OLS_wage_Communication
MFP_OLS_rme_Finance
MFP_OLS_wage_Finance
MFP_OLS_rme_Business
MFP_OLS_wage_Business
MFP_OLS_rme_Education
MFP_OLS_wage_Education
MFP_OLS_rme_Health
MFP_OLS_wage_Health
MFP_OLS_rme_Cultural
MFP_OLS_wage_Cultural
MFP_OLS_rme_Personal
MFP_OLS_wage_Personal

6. Conclusion

This paper looks at the effect accounting for labour input quality has on explaining productivity dispersion. We estimate production functions for separate industries using both volume measures of labour input measured by number of workers and quality adjusted measured by wage bill. We compare the variations in the across the results to determine whether mismeasurement of inputs increases productivity dispersion within industries. This paper is an application of recent work by Fox and Smeets (2011) where analysis is undertaken on Danish industries.

First we look at the productivity distribution within New Zealand industries. We find firms in the 90th percentile and 10th vary considerably in the period of our analysis. Services industries appear to have greater productivity dispersion than those in either manufacturing or agriculture. Although the 90/50 and 50/10 distributions do not vary hugely, there is larger variation in the bottom half of the distribution (50/10 column) than the upper half of the distribution, indicating a greater spread of poorer performers.

We find that including a quality input measure of labour does reduces the observed productivity dispersion. The reduction in dispersion varies within and across industries. 'Electricity', 'Wholesale Trade', 'Finance and Insurance' initially had largest productivity dispersion and experienced the greatest reduction in dispersion. The industries with the largest dispersion using the standard model specification, experienced the greatest reduction using input quality adjusted model, these were mostly services industries. These services firms indicate that labour inputs if mismeasured can affect productivity, especially when the firms is skill intensive. The wage bill, even as a crude measure of quality, appears to reflect workers marginal value. These results imply that care should be taken when interpreting standard measures of productivity, as the within industry dispersion may (at least in part) be driven by failing to account for input quality..

Despite the reduced dispersion there remains a large productivity dispersion still unexplained by input quality. Table 3 results indicate the although that incorporating labour inputs into the model other firm characteristics such as management practices, business strategy, new technology or competition drive firm heterogeneity and productivity differences requiring ongoing work in this area.

Future work in this area will look at incorporation of occupational measures from the BOS for labour input quality as in Bagger et al (2011). This would provide a robustness check for the Fox and Smeets (2011) results. Greater understanding of productivity dispersion will look to understand how it manifests itself across other dimension such as firm's size, foreign ownership and by regions.

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Appendix A1. Data Appendix

The source of our data is the prototype Longitudinal Business Database (LBD). The full LBD is described in more detail in Fabling, Grimes, Sanderson and Stevens (2008) and Fabling (2009).

A1.1 Data

Annual Enterprise Survey (AES)

The Annual Enterprise Survey (AES) is Statistics New Zealand's primary data source for the production of National Accounts, providing the benchmark for estimating value added. The survey covers all large firms, with a stratified sample for smaller firms and has industry specific questions in order to accurately measure aggregated GDP.

Linked Employer-Employee Data (LEED)

Linked Employer-Employee Data (LEED) is constructed by Statistics New Zealand from IRD Pay-As-You-Earn (PAYE) returns for employees. LEED variables are aggregated to the firm's level for confidentiality reasons. It is generally assumed by researchers that missing employment data implies zero employees on the grounds that personal income tax non-compliance is negligible in the population of firms that comply with mandatory GST. Variables available include counts of employers (on an annual firm level basis) and employees (on a monthly plant level basis). Summary characteristics are available by gender, and age-band breakdowns, tenure distributions of employees and summary measures of wage distribution within the firm.

Employees

Employment is measured using an average of twelve monthly PAYE employee counts in the year. These monthly employee counts are taken as at 15^{th} of the month. This figure excludes working proprietors and is known as Rolling Mean Employment (RME).

Working proprietors

The working proprietor count is the number of self-employed persons who were paid taxable income during the tax year (at any time). In LEED, a working proprietor is assumed to be a person who (i) operates his or her own economic enterprise or engages independently in a profession or trade, and (ii) receives income from self-employment from which tax is deducted.

From tax data, there are five ways that people can earn self-employment income from a firm:

- As a sole trader working for themselves (using the IR3 individual income tax form [this is used for individuals who earn income that is not taxed at source]);
- Paid withholding payments either by a firm they own, or as an independent contractor (identified through the IR348 employer monthly schedule);
- Paid a PAYE tax-deducted salary by a firm they own (IR348);
- Paid a partnership income by a partnership they own (IR20 annual partnership tax form [this reports the distribution of income earned by partnerships to their partners] or the IR7 partnership income tax return);
- Paid a shareholder salary by a company they own (IR4S annual company tax return [this reports the distribution of income from companies to shareholders for work performed (known as shareholder-salaries)]).

Note that it is impossible to determine whether the self-employment income involves labour input. For example, shareholder salaries can be paid to owner-shareholders who were not actively involved in running the business. Thus there is no way of telling what labour input was supplied, although the income figures do provide some relevant information (a very small payment is unlikely to reflect a full-year, full-time labour input).

Appendix A2. Additional Tables

Appendix A1. MFP Productivity Dispersions –Cobb Douglas including Standard Errors

2-digit ANZSIC	Cobb-Douglas RME						Cobb-Douglas Wage					
	90/10	50/10	90/50	sd (90/10)	sd (50/10)	sd (90/50)	90/10	50/10	90/50	sd (90/10)	sd (50/10)	sd (90/50)
Agriculture, Forestry and Fishing	8.79	3.08	2.85	1.86	2.37	3.16	9.09	3.11	2.92	2.16	2.20	2.50
Mining	6.50	2.21	2.95	10.38	3.25	0.41	6.59	2.29	2.87	3.41	3.41	1.99
Manufacturing	3.55	1.86	1.91	1.69	0.41	0.53	3.29	1.81	1.82	2.76	0.46	0.61
Electricity	13.24	3.10	4.27	2.73	1.40	2.22	10.34	2.98	3.47	2.47	1.71	1.82
Construction	4.89	2.11	2.32	1.40	0.41	0.27	4.68	2.07	2.26	1.43	0.42	0.27
Wholesale Trade	7.23	2.60	2.78	2.83	1.10	0.58	5.44	2.25	2.42	2.63	0.98	0.37
Retail Trade	3.97	2.04	1.95	1.15	0.33	0.28	3.59	1.94	1.85	1.25	0.48	0.27
Accommodation, Cafes and Restaurants	3.65	1.90	1.92	0.20	0.09	0.02	3.59	1.87	1.92	0.16	0.11	0.03
Transport and Storage	4.45	2.27	1.96	2.51	0.45	0.79	3.88	2.05	1.89	2.35	0.60	0.56
Communication Services	4.79	2.27	2.12	1.66	0.41	0.37	3.77	1.92	1.96	1.43	0.55	0.22
Finance and Insurance	24.95	5.30	4.71	3.84	2.42	3.78	18.26	5.03	3.63	3.66	2.30	4.60
Business and Property Services	8.89	2.73	3.25	6.84	2.10	0.60	8.39	2.71	3.09	6.75	1.34	0.81
Education	14.32	4.94	2.90	5.62	0.79	1.35	12.57	4.79	2.62	5.68	0.89	1.28
Health & Community Services	4.58	2.20	2.08	2.91	0.62	0.58	4.20	2.06	2.04	2.45	0.72	0.50
Cultural and Recreational Services	9.50	3.19	2.98	4.34	0.89	0.79	8.63	2.79	3.10	3.77	1.01	0.69
Personal and Other Services	3.82	1.95	1.96	2.83	0.39	1.25	3.98	1.97	2.03	2.95	0.44	2.54
Total	6.64	2.55	2.60	1.73	1.76	1.87	5.96	2.44	2.44	2.10	1.53	2.39

Appendix A2. MFP Productivity Dispersions –Translog with Standard Errors

2-digit ANZSIC	Translog RME						Translog Wage					
	90/10	50/10	90/50	sd (90/10)	sd (50/10)	sd (90/50)	90/10	50/10	90/50	sd (90/10)	sd (50/10)	sd (90/50)
Agriculture, Forestry and Fishing	7.39	2.89	2.56	2.04	1.56	3.12	8.22	3.34	2.46	6.11	2.76	2.65
Mining	5.74	2.39	2.40	10.03	1.73	0.87	5.38	2.33	2.31	3.90	2.98	1.66
Manufacturing	3.40	1.86	1.82	1.54	0.29	0.52	3.14	1.80	1.74	2.17	0.29	0.62
Electricity	9.66	3.09	3.13	2.09	0.56	1.53	6.89	2.94	2.34	5.25	0.43	1.41
Construction	4.68	2.13	2.20	1.35	0.38	0.28	4.15	2.04	2.03	1.23	0.34	0.28
Wholesale Trade	6.96	2.66	2.62	2.82	0.94	0.58	5.16	2.26	2.29	1.97	0.72	0.38
Retail Trade	3.83	2.03	1.88	1.19	0.32	0.31	3.40	1.92	1.77	0.94	0.28	0.29
Accommodation, Cafes and Restaurants	3.50	1.91	1.84	0.15	0.06	0.03	3.09	1.82	1.70	0.24	0.12	0.02
Transport and Storage	4.09	2.19	1.87	2.03	0.40	0.70	3.53	2.00	1.77	1.36	0.32	0.52
Communication Services	4.56	2.30	1.98	1.48	0.30	0.53	3.41	1.91	1.79	0.66	0.25	0.13
Finance and Insurance	22.65	5.04	4.49	3.42	2.23	3.34	16.87	4.88	3.46	5.50	1.42	4.43
Business and Property Services	7.74	2.67	2.90	4.10	1.31	0.57	6.59	2.48	2.66	5.79	1.72	0.64
Education	13.17	4.62	2.85	4.09	0.38	1.06	10.94	4.60	2.38	3.13	0.22	1.04
Health & Community Services	4.51	2.19	2.05	2.93	0.76	0.52	3.87	2.03	1.91	2.88	1.03	0.49
Cultural and Recreational Services	8.46	3.25	2.60	3.99	0.67	1.34	7.12	2.75	2.59	3.01	0.93	0.47
Personal and Other Services	3.47	1.93	1.80	2.70	0.25	1.21	3.36	1.88	1.79	5.92	0.22	1.06
Total	6.11	2.52	2.42	1.47	1.36	1.71	5.26	2.38	2.21	2.10	1.37	2.85

Appendix A3. Production Function (Translog)

Translog	Industry: Agriculture, Forestry and Fishing		Mining		Manufacturing		Electricity		Construction		Wholesale Trade		Retail Trade		Accommodation, Cafes and Restaurants	
Dependent Variable - Log Value-added	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill
lnLN	1.6877***		2.3638***		1.8680***		2.3671***		2.0985***		2.1041***		1.8410***		1.8140***	
	[0.0904]		[0.1834]		[0.0858]		[0.1768]		[0.0807]		[0.1085]		[0.1086]		[0.1090]	
lnLW		-0.2107**		-0.0228		-0.0391		0.258		-0.3611***		0.1485**		-0.1119*		-0.1239
		[0.0913]		[0.1348]		[0.0477]		[0.1809]		[0.0472]		[0.0584]		[0.0578]		[0.0772]
lnK	-0.6509***	0.3608***	-0.8723***	0.6235***	-0.4753***	0.5222***	-0.5969***	0.6733***	-0.4808***	0.6314***	-0.6096***	0.6816***	-0.4871***	0.5462***	-0.5483***	0.6974***
	[0.0837]	[0.0878]	[0.1110]	[0.1257]	[0.0619]	[0.0403]	[0.1330]	[0.1294]	[0.0584]	[0.0493]	[0.0798]	[0.0590]	[0.0747]	[0.0546]	[0.1048]	[0.0769]
lnK2	0.0555***	0.0460***	0.0682***	0.0518***	0.0529***	0.0394***	0.0540***	0.0490***	0.0561***	0.0365***	0.0655***	0.0621***	0.0569***	0.0438***	0.0519***	0.0390***
	[0.0045]	[0.0045]	[0.0058]	[0.0071]	[0.0038]	[0.0042]	[0.0054]	[0.0043]	[0.0036]	[0.0040]	[0.0050]	[0.0051]	[0.0048]	[0.0050]	[0.0055]	[0.0053]
lnLN2	0.0724***		0.1129***		0.0757***		0.1102***		0.1032***		0.0656***		0.0700***		0.0797***	
	[0.0078]		[0.0201]		[0.0077]		[0.0192]		[0.0076]		[0.0093]		[0.0101]		[0.0074]	
kln	-0.1205***		-0.1727***		-0.1377***		-0.1615***		-0.1682***		-0.1642***		-0.1432***		-0.1291***	
	[0.0097]		[0.0193]		[0.0105]		[0.0151]		[0.0101]		[0.0134]		[0.0140]		[0.0118]	
ln LW2		0.0742***		0.0772***		0.0639***		0.0770***		0.0756***		0.0765***		0.0702***		0.0802***
		[0.0055]		[0.0084]		[0.0047]		[0.0104]		[0.0038]		[0.0052]		[0.0059]		[0.0050]
klw		-0.0912***		-0.1140***		-0.0868***		-0.1215***		-0.0887***		-0.1356***		-0.0958***		-0.1056***
		[0.0091]		[0.0154]		[0.0090]		[0.0090]		[0.0076]		[0.0105]		[0.0108]		[0.0096]
Constant	12.2112***	7.0317***	13.1763***	3.9541***	10.9275***	5.1594***	11.6077***	1.4976	10.8666***	6.8442***	11.5234***	3.3601***	10.5858***	5.4210***	10.9643***	3.9831***
	[0.4150]	[0.6261]	[0.5483]	[1.0281]	[0.2574]	[0.2898]	[0.8127]	[1.0367]	[0.2429]	[0.3063]	[0.3296]	[0.3842]	[0.2953]	[0.3078]	[0.5215]	[0.5244]
4-Digit Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1350	1350	1893	1893	17427	17427	309	309	8826	8826	10956	10956	12894	12894	3411	3411
R Squared	0.79	0.78	0.86	0.85	0.9	0.9	0.92	0.94	0.83	0.84	0.78		0.85	0.87	0.87	0.89

Translog	Industry															
	Transport and Storage		**Communication Services**		**Finance and Insurance**		**Business and Property Services**		**Education**		**Health & Community Services**		**Cultural and Recreational Services**		**Personal and Other Services**	
Dependent Variable - Log Value-added	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill	Number of Workers	Wage Bill
lnLN	1.8128***		1.0667***		1.4501***		1.0624***		-1.0172***		-0.4935***		-0.1469*		-0.1004	
	[0.1017]		[0.2676]		[0.0866]		[0.0286]		[0.1395]		[0.1231]		[0.0846]		[0.0953]	
lnLW		0.0408		0.1235		-0.0824		-0.1893***		1.2144***		0.9163***		1.4638***		1.9604***
		[0.0589]		[0.1338]		[0.0728]		[0.0339]		[0.1471]		[0.0619]		[0.0757]		[0.1264]
lnK	-0.2771***	0.7087***	0.1241	0.7040***	-0.2141***	0.3398***	-0.2430***	0.4117***	0.3787***		0.6123***		0.2095***		0.5332***	
	[0.0910]	[0.0599]	[0.2419]	[0.0970]	[0.0595]	[0.0656]	[0.0277]	[0.0291]	[0.1400]		[0.0835]		[0.0809]		[0.0839]	
lnK2	0.0397***	0.0321***	0.0212	0.0505***	0.0299***	0.0280***	0.0312***	0.0306***		-0.9097***		-0.2196***		-0.8285***		-0.6186***
	[0.0049]	[0.0051]	[0.0134]	[0.0055]	[0.0031]	[0.0030]	[0.0014]	[0.0014]		[0.1280]		[0.0656]		[0.0702]		[0.1035]
lnLN2	0.0677***		0.0209		0.0506***		0.0178***		0.1110***	0.0852***	0.0753***	0.0497***	0.0768***	0.0728***	0.0808***	0.0775***
	[0.0072]		[0.0190]		[0.0090]		[0.0028]		[0.0072]	[0.0136]	[0.0063]	[0.0068]	[0.0053]	[0.0080]	[0.0066]	[0.0108]
kln	-0.1201***		-0.0511*		-0.0789***		-0.0451***									
	[0.0110]		[0.0308]		[0.0100]		[0.0030]									
ln LW2		0.0640***		0.0755***		0.0504***		0.0586***	0.0535***	0.0714***	0.0216***	0.0284***	0.0641***	0.0679***	0.0562***	0.0610***
		[0.0044]		[0.0065]		[0.0049]		[0.0018]	[0.0082]	[0.0075]	[0.0035]	[0.0035]	[0.0047]	[0.0035]	[0.0041]	[0.0059]
klw		-0.0891***		-0.1208***		-0.0542***		-0.0643***	-0.1034***	-0.0967***	-0.0709***	-0.0555***	-0.1069***	-0.1149***	-0.1173***	-0.1480***
									[0.0150]	[0.0174]	[0.0084]	[0.0082]	[0.0087]	[0.0077]	[0.0096]	[0.0149]
		[0.0090]		[0.0087]		[0.0071]		[0.0027]								
Constant	9.9721***	3.1851***	7.8855***	2.3678***	10.9006***	6.9269***	11.0257***	7.1313***	11.1053***	12.8006***	8.0043***	11.1768***	7.3400***	12.7843***	5.1258***	11.2254***
	[0.4295]	[0.3634]	[1.1178]	[0.6314]	[0.2921]	[0.4252]	[0.1395]	[0.2406]	[1.1004]	[0.5759]	[0.7755]	[0.3504]	[0.5767]	[0.3544]	[0.5838]	[0.4657]
4-Digit Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5190	5190	834	834	5532	5532	14490	14490	2658	2658	3927	3927	3099	3099	2091	2091
R Squared	0.87	0.88	0.92	0.94	0.65	0.69	0.78	0.81	0.56	0.54	0.76	0.71	0.78	0.75	0.89	0.88

Appendix A4. Multi Factor Productivity Dispersion (Translog) using Number of Workers and Wage Bill

ANZSIC 1-digit	Translog RME			Translog Wage			Change		
Percentile differences	**90/10**	**50/10**	**90/50**	**90/10**	**50/10**	**90/50**	**90/10**	**50/10**	**90/50**
Agriculture, Forestry and Fishing	7.39	2.89	2.56	8.22	3.34	2.46	11%	16%	-4%
Mining	5.74	2.39	2.40	5.38	2.33	2.31	-6%	-3%	-4%
Manufacturing	3.40	1.86	1.82	3.14	1.80	1.74	-8%	-4%	-4%
Electricity	9.66	3.09	3.13	6.89	2.94	2.34	-29%	-5%	-25%
Construction	4.68	2.13	2.20	4.15	2.04	2.03	-11%	-4%	-8%
Wholesale Trade	6.96	2.66	2.62	5.16	2.26	2.29	-26%	-15%	-13%
Retail Trade	3.83	2.03	1.88	3.40	1.92	1.77	-11%	-6%	-6%
Accommodation, Cafes and Restaurants	3.50	1.91	1.84	3.09	1.82	1.70	-12%	-5%	-8%
Transport and Storage	4.09	2.19	1.87	3.53	2.00	1.77	-14%	-9%	-5%
Communication Services	4.56	2.30	1.98	3.41	1.91	1.79	-25%	-17%	-10%
Finance and Insurance	22.65	5.04	4.49	16.87	4.88	3.46	-25%	-3%	-23%
Business and Property Services	7.74	2.67	2.90	6.59	2.48	2.66	-15%	-7%	-8%
Education	13.17	4.62	2.85	10.94	4.60	2.38	-17%	0%	-17%
Health & Community Services	4.51	2.19	2.05	3.87	2.03	1.91	-14%	-7%	-7%
Cultural and Recreational Services	8.46	3.25	2.60	7.12	2.75	2.59	-16%	-15%	-1%
Personal and Other Services	3.47	1.93	1.80	3.36	1.88	1.79	-3%	-3%	-1%
Total	6.11	2.52	2.42	5.26	2.38	2.21	-14%	-6%	-9%