Labour productivity, real wages, and workforce age structure

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Abstract

This paper examines the role of workforce age structure on real wages, labour productivity, and the productivity-real wage gap in New Zealand across the period 2001–2007. Using an industry-level approach, no significant differences between labour productivity and workforce age structure are found. This result holds under a range of sensitivity tests: however, real wages for younger workers are significantly lower. The productivity-real wage gap does not generally hold for older workers, but the data provides some evidence that younger workers are paid less than their productivity would warrant. This, in turn, suggests that seniority wage schemes are not typically present in New Zealand, and that focus should be given to how wages are set for younger workers.

Introduction

New Zealand's population and workforce are ageing. Declining levels of fertility and increasing life expectancy suggest that the proportion of those aged 65 and over to the whole population will increase from 13 percent in 2011 to 25 percent in 2061 (Statistics New Zealand, 2011). While the potential effects of New Zealand's ageing population on labour force participation and government finances have been well explored (Bell et al., 2010; Boston & Davey, 2006), little is known about the relationship between productivity and ageing. A number of international studies (Skirbekk, 2003; Werding, 2008) suggest that population ageing might negatively impact on labour productivity. Because productivity is often seen as a key long-term indicator of living standards, a decline in productivity due to population ageing ultimately places pressure on the competitiveness of the economy (Walewski, 2008). The age-productivity differentials, and gaps with wages, could also impact on the projected fiscal costs of population ageing, given the links between ageing, productivity, wages, and New Zealand Superannuation (Bell et al, 2010).

Productivity is generally seen to be one of the main policy responses to meet the fiscal challenges of ageing (OECD, 2006). This is particularly true in New Zealand where labour force participation rates are already relatively high (Ministry of Social Development, 2011), and it is difficult to influence fertility and migration. If the relationship between ageing and productivity could be more clearly established, then greater insight into the impact productivity might have on other economic variables (and the potential efficacy of increasing productivity to meet the economic challenges of population and workforce ageing) might be obtained.

Moreover, by exploring the relationship between real wages and ageing (and the productivity-real wage gap), the economic incentives to help older workers remain in the labour market, the functioning of the labour market, and intergenerational equity might be better understood. If older workers are paid at a rate greater than their productivity (which may be the case if seniority wage schemes exist), then this analysis can also assess whether an older workforce can be afforded by employers.

The relationship between workforce ageing, real wages, and productivity can be assessed at any level of aggregation. Most studies have concentrated on firm- or individual-level relationships, relatively few have focused on the economy level, and only one has considered the intermediate industry level of the economy (Mahlberg, Freund, & Prskawetz, 2012). It is not necessarily the case that a decline in productivity with age at the firm- or individual-level holds at a higher level of aggregation: the distribution of economic factors is crucial when comparing across the aggregation hierarchy. To derive a complete picture of the age-wage-productivity relationship, and to understand its various policy implications, analysis is needed at various levels of aggregation.

The industry-level approach, outlined in Mahlberg et al. (2012), is used in this paper to address the relative lack of evidence at this level of aggregation. This approach accounts for fixed industry effects that are otherwise omitted from macroeconomic models. It also makes use of Statistics NZ's new 'levels of labour hours paid' series which is appropriate for productivity analysis. By identifying some of the factors that may have contributed to the productivity-real wage gap (such as workforce age structure, firm size, and capital deepening), and accounting for heterogeneity across industries, this paper further explores the finding that the gap between real wages and productivity growth has widened in a number of industries (Rosenberg, 2010).

This paper begins with an informal overview of the economic theory of ageing, wages, and productivity and summarises the empirical research in this area. A formal model is then presented which decomposes labour input into age groups and relates these groupings to labour productivity and real wages. The econometric estimates of the model are then presented. It is concluded that, relative to middle-aged workers, neither younger nor older workers are significantly more or less productive. This finding is robust across specifications. However, a significant productivity-real wage gap is found for younger workers, but not for older workers. This suggests that seniority wage schemes are not present in New Zealand, and that focus should be given to how wages are set for younger workers.

Background

Population and workforce ageing

New Zealand, like many other countries, is undergoing a permanent and unprecedented shift to an ageing population. The decline in fertility rates and increased life expectancy suggest that the population of New Zealand will grow from just over 4 million in 2006 to nearly 5.5 million in 2051. Not only will the population be one third larger than its current size, it will also be older: the median age of 36 in 2006 will shift to over 45 by 2051.[1]

This demographic shift has already meant that the average age of New Zealand's workforce has risen. In 1991, the median age of the labour force was 36; by 2006 it was 40. The median age will continue to rise until 2016, after which it will stabilise at the age of 42-43 (Statistics NZ, 2010). Figure 1 shows that the proportion of older workers in the labour force (defined as those between 45 and 64) increased from 25 percent in 1991 to 38 percent in 2011. The gradual increase in the median age of the workforce reflects both the general ageing of the population and the increased labour force participation rates among older workers.

Theory

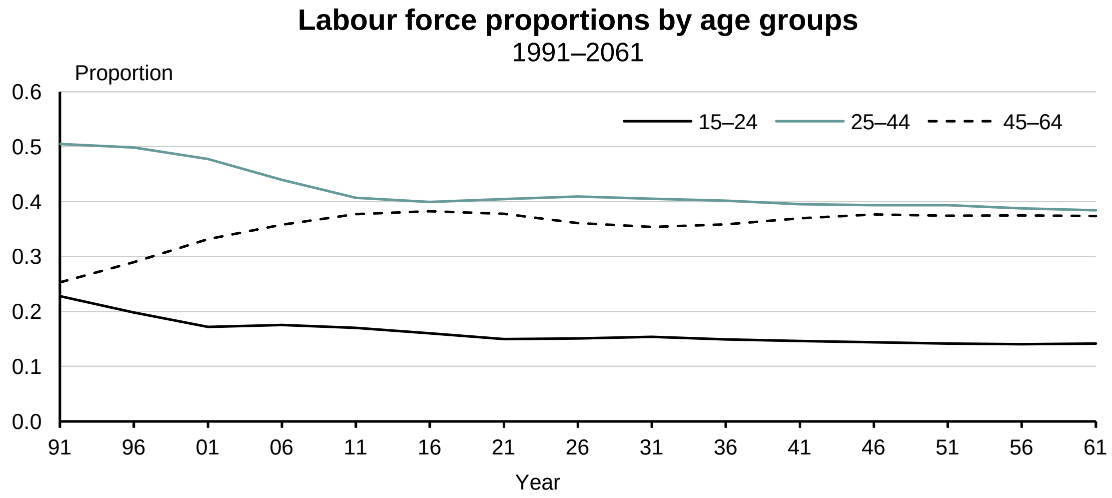
An increase in the proportion of older workers may benefit productivity simply because an older work force is more experienced (Becker, 1962). The possibility for diminishing returns, however, needs to be considered as cognitive abilities decline with age (Skirbekk, 2003). The link between age and wages was primarily established in Lazear's (1979) model, where compensation for worker effort is delayed, thus leading to wages increasing with age.

While cognitive abilities may decline with age, there are a number of reasons why productivity might increase with age, or why a decline in cognitive ability on productivity may be offset by other characteristics of the worker. Davey (2007) summarises the attitudes towards older workers in New Zealand. Older workers are, in general, likely to be more experienced, have more institutional knowledge, and be seen to be more reliable, loyal, and committed. However, older workers are also perceived to have problems with technology and adaptability, be less flexible and more resistant to change, more expensive to employ, and lacking ambition, innovation, and creativity. The decline in health as the worker ages means that they become less physically able and have less energy for the job. While this may lead to a decline in productivity,

[1] Based on Statistics NZ's mid-range (Series 5) projections. The mid range projections of the labour force assume medium labour force participation rates, medium migration, medium life expectancy and medium fertility.

empirical studies show that health and wages are also strongly correlated. This implies that the wage mechanism works to reflect any productivity decline experienced from a decline in health.

Figure 1



Source: Statistics New Zealand

If markets are competitive, then workers should be paid their marginal revenue products of labour. Observed changes in the productivity-age profile should therefore be reflected in the wage-age profile. A number of factors, such as imperfect competition, may, however, drive a wedge between real wages and productivity across age groups. Ioannides and Pissarides (1985) show that if the labour market is characterised by monopsony power (where one employer is able to set market wage rates for all age groups), then the marginal productivity for a younger worker is greater than the wage rate, while it is equal to the wage rate for older workers. In the model, younger workers can stay with the firm to be promoted at a later date. The difference between productivity and real wages only exists for younger workers because the participation decision depends on discounted lifetime earnings, whereas older workers base their decision on outside options.

An alternative explanation for productivity-real wage gaps by age could be that lower levels of experience mean that there is a degree of risk associated with younger workers. Risk averse employers may therefore be less willing to offer higher wages. It is debatable, however, whether these effects hold at the industry level: they may not hold, for example, if employers observe market wage rates and can offer higher wage rates to attract higher quality workers.[2] The age productivity-real wage effect may thus be lessened if tenure or educational status can be accounted for.

Imperfect information, team structure, and bargaining may also provide insight into the gap. Where workers are segmented into teams, imperfect information regarding the productivity of younger workers may result as their productivity may not be completely observed. If bargaining power also increases with age, which is a fair assumption given the higher occupation status and experience of older workers, then this too could result in a discrepancy between wages and productivity.

Analysing the relationships between wages, productivity, and age can be conducted at a microeconomic or macroeconomic level. The microeconomic approach relates productivity to an individual's age or the average age of workers in a firm, and thus examines the effect of human capital on productivity. The macroeconomic and industry approaches assess the role of workforce age composition and structure.

[2] This assumes that there are market imperfections as firms set wages, and that workers can effectively signal their quality.

Assessing the age-productivity-real wage relationship at the industry level is important for a number of reasons.[3] First, the age distribution across firms does not necessarily concur with the distribution within its industry (reflecting an aggregation effect). This may be due to different age distributions between small and large firm sizes. For example, if the age distribution is more dispersed among large firms compared to small firms, then the average age across firms (using a micro approach) may be the same, but the industry distribution will be influenced by the tails in the large firm's distribution.

Second, the industry level approach overcomes the problematic assumption of perfectly inelastic labour supply at the firm level. If the labour supply curve facing a firm, in a perfectly competitive market, is perfectly elastic then a reduction in the firm wage rate leads to all workers leaving the firm. In this case, firms are price (wage) takers and lack the ability to vary wages to adjust workforce age structure. At the industry level, labour supply is elastic. A supply shock (such as demographic change) may therefore impact on firms differently to an industry depending on the distribution of wages within an industry.

However, there are two drawbacks to the industry level approach. First, the production function may differ across levels of aggregation. This means that the Cobb-Douglas production function, used to assess the role of ageing on labour productivity and real wages, may not be appropriate at all levels of economic activity. It is theoretically plausible that the aggregate production function may be of the Cobb-Douglas form, while for industries or firms within the economy it may be of linear form (Houthakker, 1955). The Cobb-Douglas model assumes that capital and labour are perfectly substitutable. Tipper (2011) shows that this is a reasonable assumption at an aggregated level in New Zealand, but is problematic at the industry level where the average elasticity of substitution is around 0.4, implying that a constant elasticity of substitution model is more appropriate.

The second drawback is that the level of aggregation may lead to different implications about the direction of causal effects. At the individual level, age is completely exogenous (ie labour productivity cannot influence a person's biological age). At the industry level, however, high wage workers, who are typically older, may be employed in high labour productivity industries in order to sustain productivity. At the economy level, high productivity growth may lead to more employment opportunities, and those opportunities may be taken by those where the pool of available labour is greatest. This implies that productivity may determine workforce age structure, but in a different way than for a typical industry. Econometrically, however, reverse causation can be difficult to account for meaning that the estimated age-productivity-wage relationships may be biased.

Policy context

The changing age composition of the labour market, and ageing in general, poses a number of challenges for labour market policy. Age related labour market policy tends to focus on participation rather than productivity (OECD 2006, Ministry of Social Development 2011), with productivity seen more as a general policy instrument to meet the fiscal challenges of ageing and to compensate for the increasing dependency ratio. However, if there are differences in productivity and wages across age groups, then there may be trade-offs between productivity and participation policies: increasing labour market participation for a given age group may not lead to optimal productivity gains if the average labour productivity for that group is lower than that of others. However, the (pecuniary and non-pecuniary) flow on effects of unemployment and productivity losses by age need to be factored into any analysis of such trade-offs.

The industry level approach can inform policy about how the labour market is functioning at that level. However, its findings should be contextualised with firm level and aggregate level studies to provide a cohesive understanding of productivity and real wages by age. For example, while microeconomic studies often show a declining age-productivity relationship in a given industry, it

[3] Mahlberg et al. (2012) discuss the advantages of the industry approach in greater detail, highlighting the lack of statistical noise at firm level and the need to account for across-firm spill-over effects.

needs to be ascertained whether those relationships are significant at the industry level once the data has been aggregated and inter-firm spill-overs (for firms within an industry) have been accounted for.

Empirical evidence

International studies

Skirbekk's (2003) summary of the productivity-age relationship at the individual level, concludes that "the evidence suggests that productivity tends to follow an inverted U-shaped profile, where significant decreases take place from around 50 years of age". Declines in cognitive abilities are seen as the key reason for these declines. Although older workers have more experience, they learn at a slower pace, have reductions in their memory and reasoning abilities, and are likely to have difficulties in adjusting to new ways of working. Declines in productivity with age are observed even after accounting for a range of other factors that may affect the age-productivity relationship (Skirbekk, 2003).[4]

A number of empirical studies suggest that productivity is declining with age, although the point at which the age effect occurs is contentious. Tang and MacLeod (2006) found that older workers were, on average, less productive than younger workers, and that labour force ageing had a modest negative direct impact on productivity growth (of 0.13 per cent per year) in Canada between 1981 and 2001. Van Ours (2009) used firm level data for Dutch manufacturing firms across the period 2000–2005 to examine the relationship between age, wage, and productivity. The results suggested that the productivity of older workers decreased with age, although the decline was limited, and there was no evidence of a productivity-wage gap at higher ages.

Borsch-Supan and Weiss (2011) studied the relation between workers' age and their productivity in work teams, using data on errors which occurred in the production process of a large car manufacturer. Productivity declines were not found for those aged under 60. Aubert and Crépon (2007) found productivity increased with age until age 40 to 45, but remained stable after this age. The findings of this study, of French firms during the late 1990s, were stable across the manufacturing, trade, and service sectors. Aubert and Crépon also rejected the hypothesis that the lower employability of older workers was due to a significant wage-productivity gap, at least before age 55.

Many studies have assessed the relationship between ageing and productivity using samples of manufacturing firms (Ilmakunnas et al., 1999; Hageland and Klette, 1999; Hellerstein et al. 1999), although the findings are also present for non-manufacturing industries (Crépon et al., 2002; Haltiwanger et al., 2002). Gobel and Zwick (2011) argue that age-related productivity may differ across industries due to differences in skills, physical demands of workers, or management techniques. However, no empirical differences in age-related productivity between manufacturing and service sector workers in Germany could be established. Cataldi, Kampelmann, and Rycx (2011) show that while productivity declines with age in Belgium, it is similar across firms with different levels of information and communication technology intensity. In addition, Cataldi et al. find that younger workers are paid less than their marginal productivity would dictate, while the converse is found for older workers, thus supporting Lazear's (1979) model of deferred compensation.

Empirical studies of the relationship between workforce ageing, productivity, and wages have also been conducted at the industry level, although this approach is much less common. Mahlberg et al. (2012) analyse the link between the age structure of the labour force and average labour productivity and wages in Austria using industry level data covering the period 2002–2007. They find a positive correlation between the share of older employees and productivity, but no significant relationship between the share of younger employees and productivity. In exploring

[4] In addition, output as well as productivity may decline with age. Andersson et al. (2002) found a decline in firm's value added for those aged 50 or over and with lower education levels. Hageland and Klette (1999), also using value added, found the decline to occur from age 30 after accounting for a range of firm-specific factors.

the effect of workforce age structure on wages, they find that the estimated age-wage pattern does not hint at an over-payment of older employees. Gronqvist (2009) examined the effect of an older labour force on labour productivity in Finland between 1995–2005 using industry level data. While the historical effects of workforce ageing on productivity are found to be negative, the effect from demographic change is forecasted to be positive from 2010, at around 0.2–0.7 percentage points per year between 2010 and 2020.

New Zealand studies

There is a lack of evidence on the direct relationship between ageing and productivity in New Zealand. The quality-adjusted labour productivity series produced by Statistics NZ provides some indication of the correlation between age and productivity. The model uses the estimated effect of experience (derived from age) on wages to account for skill in the labour market, and then incorporates this effect into the estimates of labour input. The effect of ageing on labour productivity is therefore indirect rather than direct. The quality-adjusted labour input series has grown at a faster rate than the headline series since 1998 (1.3 percent versus 0.9 percent per annum) reflecting increased skills in the workforce (Statistics NZ, 2012b). Labour productivity has correspondingly declined during this period. The quality adjusted series, however, is based on a microeconomic framework and micro data. As discussed earlier, this effect may differ when a macroeconomic approach is adopted. In addition, the effect of age on productivity in the quality-adjusted series impacts on nominal rather than real wages.

Gardiner, Bell and Rodway (2012) analyse the relationship between productivity and ageing at the macroeconomic level in order to assess the sensitivity of fiscal projections. Ordinary least squares regressions show an inverted-U shape relationship between real wages and ageing. However, in relating ageing and wages to productivity, their analysis still relies on the assumption that wage growth is approximately equal to productivity growth for all age groups. After accounting for the relationship between real wages and ageing and changing demographics, labour productivity is projected to be similar to baseline assumption growth of 1.5 percent. This suggests that New Zealand’s fiscal projections are robust to productivity-age differentials.

Analysis of the productivity-real wage gap shows that real wages have grown slower than labour productivity since 1996 (Rosenberg, 2010). However, neither the age structure of industries or heterogeneity of industries is accounted for in Rosenberg’s analysis. If the effect of workforce ageing on productivity is fixed across industries, then an alternative approach to the observed productivity-real wage gap that accounts for this may provide further insight into the drivers of the gap.

Model

Assessing the relationship between workforce age structure and labour productivity begins with a production function relating value added to the factors of production (capital and labour) with a Hicks-neutral technical progress parameter (the Solow residual). The production function is assumed to be of the Cobb-Douglas form. This approach has been the most frequently used in the productivity literature (Miller, 2008), and has important properties (such as constant returns to scale and constant factor shares) and assumptions that facilitate productivity analysis. The production function takes the form:

$$V_i = A_i(t)L_i^{\alpha}K_i^{\beta} \tag{1}$$

where V_i = industry chain-volume value added;

$A_i(t)$ = a parameter that captures disembodied technical shifts over time – ie outward shifts of the production function allowing output to increase with a given level of inputs (or multifactor productivity).

L_i= industry labour inputs;

K_i= industry capital inputs; and

α, β= industry factor weights.

Accounting for the age of workers requires manipulation of the labour input term. Assuming that there is perfect substitutability (or homogeneity) between workers of different ages, the labour input series for industry i can be expressed as a weighted additive sum:

$$L_i = \sum_{k=0}^{m} \gamma_{ik} L_{ik} \quad (2)$$

The γ_{ik}weights represent a productivity parameter for each age group k. To show the effect of workforce structure on productivity and wages, Equation 2 can be rearranged to define industry labour input as:

$$\ln L_i = \ln \gamma_{i0} + \ln \gamma_i + \ln(1 + \sum_{k=1}^{m} \gamma_{ik} \frac{L_{ik}}{L_i}) \quad (3)$$

Combining this with Equation 1, assuming that $\gamma_{ik} = \gamma_k$, and imposing constant returns to scale $(\alpha + \beta = 1)$, the relationship between workforce age structure and labour productivity is:

$$\ln \frac{V_i}{L_i} = \alpha \ln \frac{K_i}{L_i} + (1 - \alpha) \sum_{k=1}^{m} \gamma_k \frac{L_{ik}}{L_i} + \ln A_i(t) \quad (4)$$

Equation 4 shows that labour productivity is a function of the capital-to-labour ratio, workforce age structure, and multifactor productivity. The age group decomposition included in Equation 4 enables more of the multifactor productivity residual to be explained. By analogy, the relationship between real wages in a given industry and workforce age structure is:

$$\ln \frac{w_i}{L_i} = \alpha \ln \frac{K_i}{L_i} + (1 - \alpha) \sum_{k=1}^{m} \gamma_k \frac{L_{ik}}{L_i} + \ln A_i(t) \quad (5)$$

Data

Empirical implementation of Equations 4 and 5 requires data on value added, labour input, real wages, capital input, and the age of workers by industry.[5] Labour productivity is defined as value added (in constant 1995/96 prices) for an industry over hours paid. Value added data is sourced directly from National Accounts. Hours paid for each industry is sourced from the labour volume series, used in the compilation of productivity statistics. This is a composite series using data from the Linked-Employee-Employer Dataset (LEED), Household Labour Force Survey, Quarterly Employment Survey, and the Business Demography Database. Real (gross) wages were derived as total labour income divided by labour hours paid, deflated by the producers price index (PPI) for inputs.[6] Although alternative price deflators, such as the consumers price

[5] Further details on the data sources and construction of the series can be found in *Productivity statistics: Sources and methods,* Statistics New Zealand (2011b).

[6] Industry-specific PPIs were used where available. Where industry-specific PPIs could not be applied, the PPI for the industry-aggregate were used. The PPI for agriculture, forestry, and fishing was applied to forestry; the PPI

index, could have been used, the model is constructed from the perspective of the producer and therefore the PPI is considered to be appropriate.

Three age groups, 15–24, 30–44, and 45 and over, were used to show workforce age structure. These groupings are consistent with those used in Statistics NZ's (2010) labour force projections. Broad groupings are advantageous in order to reduce the number of regressors in the model. However, it is worth noting that the definition of an older worker can be contentious and may change over time. McGregor (2007), for example, notes that the definition of older workers ranges from 40 and over to 55 and over. To check whether the results were sensitive to these age groups, models were also analysed using 15–29, 30–49, and 50 years and over age groupings. This last set of age groups is consistent with those used by Mahlberg et al. (2012).

Additional control variables accounted for in the model included the capital-to-labour ratio, gender, the worker turnover rate, tenure, and proportions of large and medium sized firms (relative to small firms). These variables reflect both employer and employee characteristics, and are included in the model to capture any further influences on labour productivity and real wages that may otherwise be attributed to age structure (ie to mitigate omitted variable bias).[7] The capital-to-labour ratio for a given industry was defined as the ratio of the productive capital stock to hours paid and is specified in levels.[8] The worker turnover rate and firm size variables may reflect distortions from the assumption of a perfectly competitive labour market which may affect labour productivity or real wages. The age groups, gender proportions, and firm size variables are constructed from person level counts.[9] This means that these variables do not fully account for hours paid, or even full-time and part-time differences. The tenure variable is based on the number of jobs. Although related to age, tenure may have a distinct relationship with productivity and real wages. For example, although older workers may be receive higher wages, the starting rate for an older worker who has moved jobs may still be less than another worker of equivalent age who has longer tenure if the firm considers that there will be lags before the productivity gains are realised.

The period of analysis covers the years 2001 to 2007. The year 2001 is taken as the starting point because the data for workforce age structure (LEED) and all control variables are only available from this year. Data until 2007 is used as this is the last year for which constant price value-added and productive capital stock data at industry-level is available. This period reflects some of the largest structural changes in the age composition of the workforce, as shown previously in Figure 1.

The industries included in the analysis are those covered by the measured sector. From 2001, the measured sector covers the following Australia New Zealand Standard Industrial Classification 1996 (ANZSIC96) industries: agriculture, forestry, and fishing; mining; manufacturing; electricity, gas, and water supply; construction; wholesale trade; retail trade; accommodation, cafes, and restaurants; transport and storage; communication services; finance and insurance; property and business services; cultural and recreational services; and personal and other community services. This meant 24 industries were included in the model; 13 of these are at the one-digit level; nine were the manufacturing sub-industries; and property services and business services were separated. The government administration and defence, health, and community services, and education industries were excluded from this analysis as the outputs for these industries are largely based on inputs to production. In 2007, the measured sector covered 80 percent of the economy in terms of current price gross domestic product (GDP).

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for aggregate manufacturing was applied to the following manufacturing industries: food, beverage, and tobacco products; wood and paper products; petroleum, chemical, plastic, and rubber products; metal products; machinery and equipment; and furniture and other.

[7] Mahlberg et al. (2012) control for education, occupation, and proportion of full-time and part time workers. These variables were not accounted for in this analysis as they were not available at the required level.

[8] This definition of the capital-to-labour ratio differs from that used in productivity statistics as land and inventories which are not included in the perpetual inventory method (used to derive the flow of capital services), are not accounted for in this analysis.

[9] Small firms were defined as those with less than 19 employees, medium size firms as those with 20-99 employees, and large firms as those with over 100 employees. Changing the definitions of firm size had little material impact on the fixed effects estimates.

Methods

As the available data contain cross sectional and time series elements, Equations 4 and 5 can be generalised as:

$$y_{it} = x'_{it}B_i + a'z + u_{it} \tag{6}$$

This formulation accounts for the cross section (industry) and time series nature of the data. The x'_{it} term is the set of time varying explanatory variables (the age groups and the additional control variables), B is the set of parameters to be estimated, $a'z$ represents the heterogeneity to be accounted for, and u_{it} is an independent and identically distributed error term. The decision between estimators depends on the assumption regarding the sources of heterogeneity. If it is assumed that the industry effect is correlated with the explanatory variables, then the fixed effects model is appropriate. This approach recognises that there is heterogeneity across industries which should be accounted for. In this case, Equation 6 can be written as:

$$y_{it} = x'_{it}B_i + a_i + u_{it} \tag{7}$$

where a_i is the time invariant industry specific effect to be estimated. A priori, the assumption that $\mathrm{cov}(x, a) \neq 0$ is valid if different industries are composed of different age structures, and changes in age structure are more pronounced in certain industries.

The panel data approach with fixed effects is preferred to account fully for the cross sectional and time series nature of the data, and to reflect the heterogeneity of industries. The baseline model includes all 24 industries, all control variables, and spans the period 2001–2007. A range of sensitivity tests were employed, such as: dropping all control variables; changing age group structure; dropping selected industries; and accounting for non-linearity in the age group-productivity and wage relationship.

When the same explanatory variables are used in both the productivity-age and real wage-age regressions, a comparison of the effects of age on these two variables can be made and it can be tested whether older and younger workers are overpaid (Mahlberg et al., 2012). Similar comparisons can also be made for control variables. Appropriate control variables can reflect departures from perfect competition in labour markets. Manning (2003), for example, shows that monopsony power is a fundamental feature of labour markets due to search frictions while Kaufman (2007) shows that the perfect competition assumption is problematic from an institutional economics perspective.

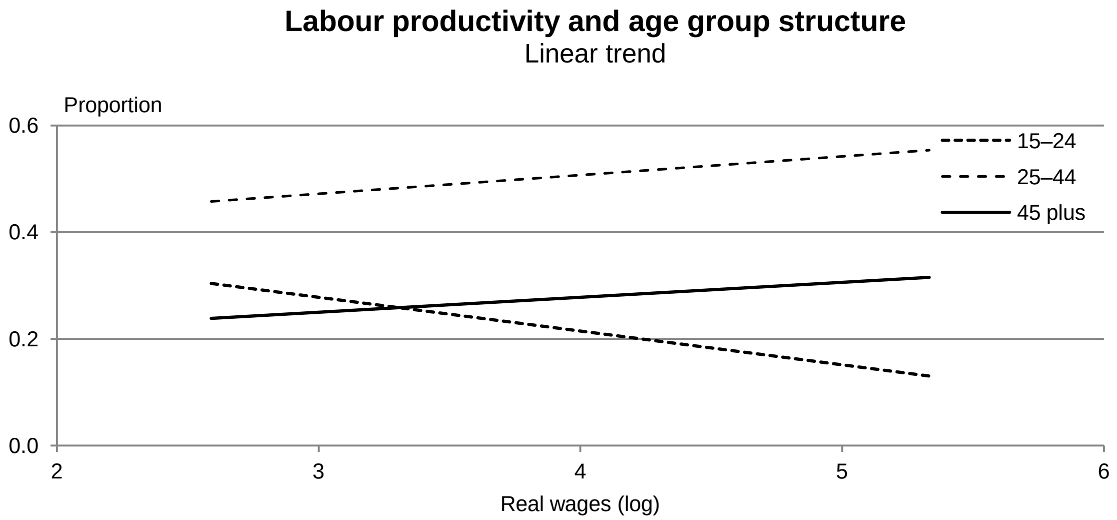
Results

Descriptive statistics

Figure 2 shows that labour productivity is decreasing in the proportion of younger workers, increasing slightly in the proportion of middle-aged workers, and increasing with the proportion of older workers. A similar pattern is present for real wages and age groups (see Figure 3).

Industry-specific effects can be observed in the relationship between age groupings and labour productivity, while there is less of a pattern in the wage-age groupings. There also seems to be greater dispersion among the older age groups.

Figure 2



Source: Author's calculations using Statistics New Zealand data

Figure 3

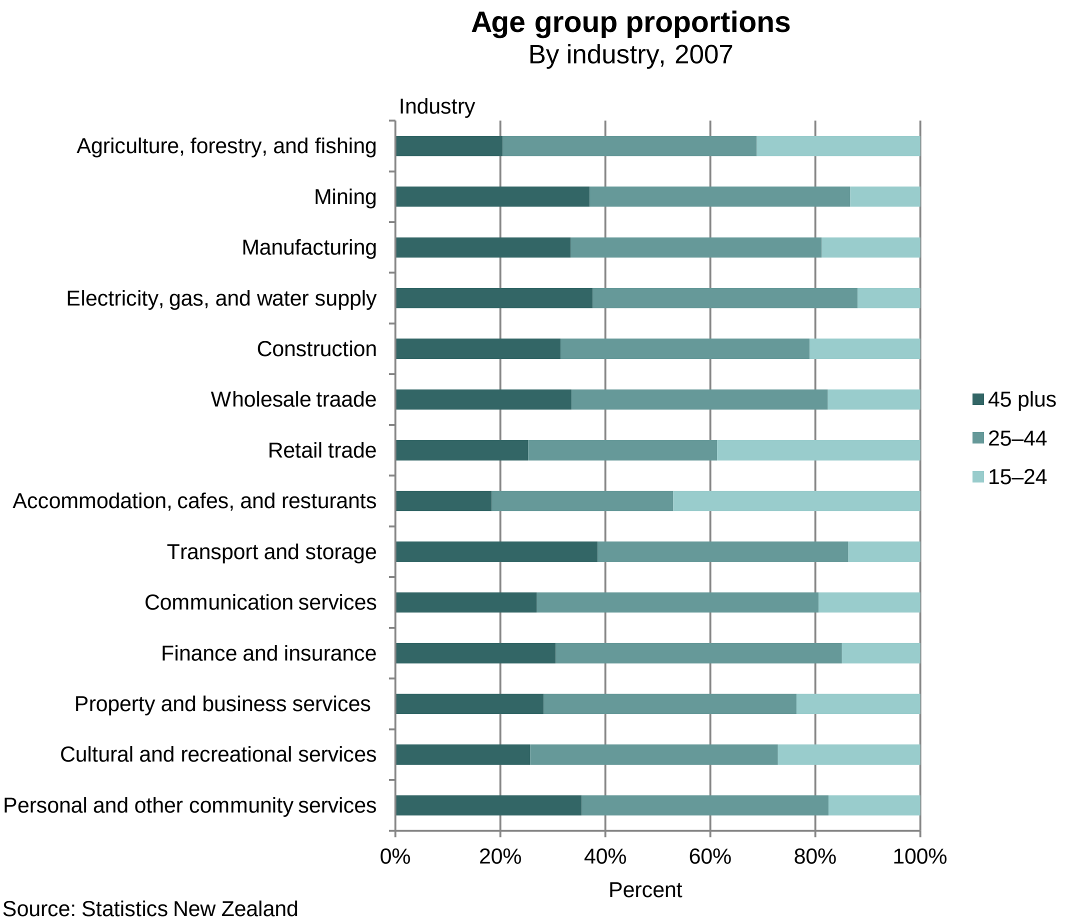
Source: Author's calculations using Statistics New Zealand data

Table 1 presents the main descriptive statistics of the data. Labour productivity is, on average, greater than that of real wages, but also has greater variability. Statistics NZ (2012a) show that labour productivity ranges from around $200 per hour paid in communication services to $13 per hour paid in accommodation, cafes, and restaurants. A productivity-real wage gap appears to be present. The majority of workers are aged between 25 and 44, followed by those aged 45 and over. The ranges indicate that the proportion of those aged 25–44 is relatively similar across industries, but a number of industries employ either a greater share of younger or older workers. Just over one third of the workers are male. This low share could be the result of 'sample selection' by only including measured sector industries or by not accounting for full and part time splits. Total employment from the Household Labour Force Survey, for example, suggests that the workforce is more evenly split by gender.

Table 1

Descriptive statistics (pooled sample)		
Variable	Mean	Standard deviation
Log labour productivity	3.65	0.70
Log real wage	2.93	0.29
Log capital-to-labour ratio	4.31	1.17
Aged 15–24	0.22	0.09
Aged 25–44	0.50	0.05
Aged 45 plus	0.28	0.06
Male proportion	0.35	0.16
Small firm size proportion	0.36	0.18
Medium firm size proportion	0.23	0.08
Large firm size proportion	0.41	0.19
Worker turnover rate	16.21	5.67
Source: Author's calculations using Statistics NZ data		

Figure 4



Source: Statistics New Zealand

Figure 4 presents a snapshot of the workforce age structure profile by industry in 2007. Variations across industries are observable. For example, the accommodation, cafes, and restaurants industry has the largest proportion of younger workers, while mining has the lowest. The greatest proportion of older workers is in transport and storage, followed by personal and other community services, and mining.

Across the period 2001–2007, the proportion of older workers increased most in transport and storage, followed by construction and then wholesale trade. The greatest decline in the proportion of younger workers was in agriculture, forestry and fishing. For middle-aged workers, the greatest decline was in construction. In general, most industries aged. Mining, construction, accommodation, cafes, and restaurants were the only industries in which the proportion of younger workers increased relative to older workers. Apart from agriculture, forestry, and fishing, no industry saw an increase in the proportion of middle-aged workers.

Econometric results

The estimates from the fixed effects panel data model (Table 3) show labour productivity to be increasing in the proportion of older workers relative to the proportion of middle-aged workers, and decreasing with the proportion of younger workers relative to the proportion of middle-aged workers. This effect, however, is not significant for either age group. Only the log of the capital-labour ratio and proportion of large firm variables are significant in the labour productivity regression.

Table 2

Panel data estimates using fixed effects						
	Productivity		Real wages		Productivity-real wage gap	
Variable	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
Intercept	1.12**	2.35	0.54	0.87	0.58	0.88
Log cap-to-labour ratio	0.57**	8.32	0.42**	4.72	0.15	1.58
Aged 15-24	-0.79	-1.55	-2.18**	-3.28	1.39*	1.95
Aged 45 plus	0.26	0.80	0.95**	2.24	-0.69	-1.52
Proportion of male workers	0.91	1.22	0.66	0.68	0.25	0.24
Medium firm size	0.58	1.09	1.93**	2.80	-1.36*	-1.84
Large firm size	-1.30**	-3.50	1.34**	2.77	-2.64**	-5.11
Worker turnover rate	-0.01	-1.52	-0.02**	-2.34	0.01	1.09
F-test for joint significance test of age parameters	1.48		7.68**		2.98*	
F-test for no fixed effects	185.27**		21.64**		51.96**	
R^2	0.995		0.951		0.981	
Observations	175		175		175	

Symbols: ** significant at the 95 percent confidence level * significant at the 90 percent confidence level.

Table 2 also shows that there is a significant relationship between age groups and real wages. The signs of the coefficients concur with those under the productivity model: however, the magnitude is much greater. Both firm size proportion variables were significant in this model, along with the capital-to-labour ratio and the worker turnover rate. In both the age-productivity and age-wage model, the proportion of male workers variable was insignificant.

The productivity-real wage gap is defined as the logarithm of labour productivity less the logarithm of real wages. A positive coefficient means that the data suggests there is an underpayment of wages relative to labour productivity. A negative coefficient, on the other hand, implies that there is over payment. The final two columns of Table 2 present the estimates for the productivity-real wage gap. The positive sign of the coefficient for younger workers indicates that they are paid less than their productivity would warrant. This is the only variable which shows significant evidence of under payment. Older workers, while paid more, are not being overpaid relative to their productivity. A test for the joint significance of the proportion of younger and older workers suggested that there was no relationship between workforce age structure and labour productivity. However, workforce ageing is significantly related to real wages (at the 95 percent confidence level) and the productivity-real wage gap (at the 90 percent confidence level).

Large and medium firms, on the other hand, are, significantly, paying more to their employees than their productivity dictates. This finding concurs with a number of studies that have shown wages to be increasing with firm size, potentially due to monopsony power (Green, Machin, and Manning, 1996).This analysis shows that the employer size-wage effect holds even after accounting for productivity, which may also reflect labour market imperfections. An alternative possibility is that large firms are able to exploit economies of scale (or scope), and thus use resources more efficiently to allow capital deepening to be the main driver of labour productivity.

The F-test was used to show whether the fixed effects model was appropriate. The null hypothesis that the fixed effects parameters were equal to zero was rejected in all models, highlighting the heterogeneity of industries and the suitability of the fixed effects model.

Results of the sensitivity tests, using fixed effects, are presented in Table 3.[10] In general, the age-productivity profiles were robust to model specification under the fixed effects approach. Dropping all control variables, changing the definition of younger, middle-aged, and older workers, dropping accommodation, cafes, and restaurants, or finance and insurance, and accounting for non-linearity did not affect the finding of the main fixed effects model. Accounting for tenure did not mitigate the effect of ageing on productivity, real wages, or the gap. The tenure variables were insignificant in the productivity model, but significant in the productivity-real wage gap model.

However, younger workers were found to have significantly lower real wages than middle-aged workers in all sensitivity specifications. In only two sensitivity tests were older workers' wage rates found to be statistically similar to those of middle-aged workers. In other words, the data suggests that older workers' wage rates are significantly higher than those for middle-aged workers. In four of the six sensitivity tests, the coefficient for younger workers was found to be significant. This suggests underpayment of younger workers. Evidence for overpayment of older workers was found in just two sensitivity tests.

[10] Random effects models were also examined as an alternative estimation method. Some significant effects were found when using random effects. Under this estimation method, a significant negative relationship between younger workers and productivity was found in all specifications except when the definition of age groups was changed. Hausman test results, however, indicated that the random effects model was not appropriate. Given the results of the F-test, discussed earlier, the fixed effects model was preferred. The feasible generalised least squares (FGLS) method was also used on a pooled sample to account for any potential autocorrelation and heteroscedascity. However, there were no observable differences between the results of the fixed effects and FGLS models. Autocorrelation appeared to be present when the data were pooled, but heteroscedasticity was not. It has not been tested whether these specification issues are present at the panel level.

Table 3

Sensitivity analysis – Age group coefficients for fixed effects model

		Productivity		Real wages		Productivity-real wage gap	
Model	Age group variable	Estimate	T-stat	Estimate	T-stat	Estimate	T-stat
Change age group definition	15–29	-0.26	-0.51	-3.34**	-5.29	3.08**	4.58
	50 plus	0.27	0.56	-0.90	-1.49	1.18	1.83
Drop all control variables	15–24	-0.74	-1.36	-2.19**	-3.42	1.45**	1.99
	45 plus	0.50	1.43	1.42**	3.45	-0.92**	-1.96
Non-linearity in age group effect	15–24 (log)	-0.15	-1.17	-0.35**	-2.16	0.20	1.17
	45 plus (log)	0.12	1.30	0.40**	3.32	-0.28**	-2.16
Account for tenure	15–24	-0.82	-1.44	-2.96**	-4.09	2.14**	2.79
	45 plus	0.30	0.70	-0.03	-0.06	0.34	0.57
Exclude accommodation, cafes, and restaurants	15–24	-0.46	-0.79	-2.45**	-3.25	1.99**	2.49
	45 plus	0.20	0.6	1.00**	2.30	-0.8	-1.73
Exclude finance and insurance	15–24	-0.74	-1.46	-2.1**	-3.21	1.37	1.89
	45 plus	0.04	0.12	0.67**	1.57	-0.63	-1.34

Symbols: ** significant at the 95 percent confidence level * significant at the 90 percent confidence level.

Conclusion

This paper has explored the relationship between workforce age structure, real wages, and productivity in New Zealand between 2001 and 2007. The data suggests that productivity is decreasing in the proportion of younger workers, and slightly increasing in the proportion of older workers, but the effect is not significant. In general, the data suggests that seniority wage schemes are not typical at the industry level, and also that workforce ageing does not necessarily imply any additional labour costs beyond productivity growth. This finding may also have implications for whether seniority wage schemes should be used as a policy lever.

Under the baseline model, significant differences in wage rates across age groups are observed, and younger workers appear to be paid less than their productivity would warrant. This finding concurs with the result from Ioannides' and Pissarides' (1985) model which showed only younger workers are paid less than their marginal products. While this suggests monopsony power may be present, this paper does not directly test the firm level approach of Ioannides and Pissarides so any such inference is merely suggestive. Lazear's (1979) deferred compensation model is not supported in this analysis.

This analysis has assumed that workforce age structure is exogenous. The possibility for reverse causation, however, does exist when data are analysed at the industry-level. This may exist on both the labour demand and labour supply side. For example, high labour productivity industries may choose a workforce that has a mix of ages, while a low labour productivity industry may consist of a greater proportion of younger workers as they are relatively cheaper to employ. Alternatively, higher wages may incentivise labour force participation for older workers. The potential for endogeneiety has not been examined in this analysis, given that the number of observations may be too small to generate reliable estimates using alternative econometric models that can account for this problem in panel data. This is an important limitation if any policy implications are to be drawn from these findings.

Broad age groups have been used in this paper to highlight the relationship between workforce age structure, real wages, and labour productivity. Further work could break down the younger and older age groups into five-year bands. This would capture some of the heterogeneity that may exist at the tails of the age distribution.

References

Andersson, B, Holmlund, B, and Lindh, T (2002). *Labor productivity, age and education in Swedish mining and manufacturing 1985–96.* Unpublished Paper, Uppsala, Sweden.

Aubert, P and Crépon, B (2007). *Are older workers less productive? Firm-level evidence on age-productivity and age-wage profiles.* Mimeo.

Bell, M, Blick, G, Parkyn, O, Rodway, P, and Vowles, P (2010). *Challenges and choices: modelling New Zealand's long-term fiscal position.* New Zealand Treasury Working Paper 10/01. Available from www.treasury.govt.nz**.**

Börsch-Supan, A, and Weiss, M (2011). *Productivity and age: evidence from work teams at the assembly line.* Mannheim Research institute for the economics of ageing 148.

Boston, J, and Davey, JA (eds) (2006). *Implications of population ageing: Opportunities and risks.* Institute of Policy Studies, School of Government, Victoria University of Wellington, Wellington, New Zealand.

Cataldi, A, Kampelmann, S, and Rycx, F (2011). Productivity-wage gaps among age groups: Does the ICT environment matter? *De Economist*, 159(2), 193–221.

Crépon, B, Deniau, N, and Perez-Duarte, S (2002). *Wages, productivity and worker characteristics: A French perspective*. Mimeo, INSEE*.*

Gardiner, P, Bell, M, and Rodway, P (2012). *Long-term fiscal projections under alternative labour force scenarios*. Paper presented at Population Ageing and Labour Market International Research Workshop, University of Waikato.

Gobel, C, and Zwick, T (2011). *Age and productivity – sector differences?* Centre for European Economic Research Discussion Paper No.11-058.

Green, F, Machin, S, and Manning, A (1996). *The employer size-wage effect: Can dynamic monopsony provide an explanation?* Oxford Economic Papers, 46, 433-455.

Gronqvist, C (2009). *The effect of labour force ageing on productivity in Finland*. Bank of Finland Monetary Policy and Research working paper.

Hellerstein, JK, Neumark, D, and Troske, KN (1999). Wages, productivity and worker characteristics: Evidence from plant level production function and wage equations. *Journal of Labor Economics*, 17, pp.409-446.

Houthakker, HS (1955). The Pareto distribution and the Cobb-Douglas production function in activity analysis. *The Review of Economic Studies* 23(1), pp.27–31.

Hægeland, T, and Klette, TJ (1999). Do higher wages reflect higher productivity? Education, gender and experience premiums in a matched plant-worker data set. In Haltiwanger, JL, Spletzer, JR, Theeuwes, J and Troske, KN *The Creation and Analysis of Employer-Employee Matched Data*, Elsevier Science, Holland.

Haltivanger, JC, Lane, JI and Spletzer, JR (1999). Productivity differences across employers: The roles of employer size, age and human capital. *American Economic Review, Papers and Proceedings*, 89(2), pp.94–98.

Ioannides, Y, and Pissarides, C (1985). Monopsony and the lifetime relation between wages and productivity. *Journal of Labor Economics*, 3(1), pp.91–100.

Ilmakunnas, P, Maliranta, M, and Vainiomäki, J (1999). *The role of employer and employee characteristics for plant productivity.* Helsinki School of Economics and Business Administration Working Paper 223.

Kaufman, B (2007). The impossibility of a perfectly competitive labour market. *Cambridge Journal of Economics*, 31(5), pp. 775–787.

Lazear, E (1979). Why is there mandatory retirement? *Journal of Political Economy*, 87, 1261–1284.

Mahlberg, B, Freund, I, and Prskawetz, A (2012). Ageing, productivity and wages in Austria: Sector level evidence. *Empirica Journal of European Economics.*

Manning, A (2003)*. Monopsony in motion.* Princeton University Press, Princeton.

Miller, E (2008). *An assessment of CES and Cobb-Douglas production functions.* Congressional Budget Office Working Paper, 2008-05. Washington: Congressional Budget Office.

Ministry of Social Development (2011). *Business of ageing*. Wellington, New Zealand.

Organisation for Economic Co-operation and Development (2006). *Live longer work longer*. OECD, Paris.

Rosenberg, B (2010). *Real wages and productivity in New Zealand.* Paper presented at the Labour, Employment, and Work Conference, Wellington, New Zealand.

Skirbekk, V (2003). *Age and individual productivity: A literature survey*. MPIDR Working Paper 2003-028.

Statistics New Zealand (2010*). National labour force projections: 2006(base)–2061 update*. Wellington, New Zealand.

Statistics New Zealand (2011). *National population projections: 2009-base to 2061.* Retrieved 1 March 2012 from http://www.stats.govt.nz/

Statistics New Zealand (2012a). *Labour hours paid for productivity statistics*. Wellington, New Zealand.

Statistics New Zealand (2012b). *Productivity Statistics: 1978–2011*. Wellington, New Zealand.

Tang, J, and MacLeod, C (2006). Labour force ageing and productivity performance in Canada. *Canadian Journal of Economics*, 39(2), pp.582-603.

Tipper, A (2011, June). *One for all? The capital-labour substitution elasticity in New Zealand.* Paper prepared for the 52nd New Zealand Association of Economists conference, Wellington, New Zealand.

Van Ours, JC (2009). Will you still need me when I'm 64? *De Economist*, 157(4), pp.441–460.

Walewski, M (2008). *Differences in the productivity levels of older workers in the EU – a cross-country analysis of the age-wage relationship*. ENEPRI Research Report No. 49.