The Australian gender wage gap: how much can be explained with fixed effects?

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The Australian gender wage gap was measured using a fixed effects model and a panel dataset from 12 waves of the Household Income and Labour Dynamics in Australia Survey. The fixed effects method accounts for time-invariant unobserved individual heterogeneity. A comparison of the fixed effects and ordinary least squares estimates of the gender wage gap shows that the Australian gender wage gap has previously been overestimated by 62 per cent.

1.1 Introduction

The gender wage gap is generally measured by estimating productivity related labour market characteristics with a slope and/or intercept gender dummy variable. The coefficient estimate on the gender dummy variable is unexplained by labour market characteristics and is said to be the gender wage gap.

There are many explanations for the existence of a gender wage gap in the labour market. The explanations can become complex as they involve a range of individual specific and job and workplace specific compensating differentials. Usually, individual characteristics are related to productivity and may include education, experience, and tenure. While compensative differentials[1], which are difficult to measure, include choices such as occupations based on job security.

Discrimination in the labour market occurs when individuals with identical labour market characteristics receive different wages based on non-productivity related characteristics. Discrimination may exist because of employers' willingness to compensate profit for taste discrimination such as gender. Alternatively, potential employees may face statistical discrimination, which involves the judgement of individuals based on statistical averages. For example, this may involve not employing women around the childbearing age with the

[1] Compensating differential is the additional amount of income that a given worker must be offered in order to motivate them to accept a given job relative to other jobs that the worker could perform.

assumption that they will take maternity leave in the near future (Altonji & Blank 1999; England 1992; Phelps 1972).

Wage differentials may also arise from occupational crowding. This involves the attraction of women to particular occupations leading to an increase in supply for those occupations and therefore a decline in the wages offered for the jobs (Bergmann 1974).

The mean and distributional gender wage gap in Australia has been measured and decomposed into two components. The first component is attributed to differences in labour market characteristics and the second component is attributable to differences in returns to labour market characteristics. Some studies have found that gender wage differentials can be explained by differences in labour market characteristics such as experience, tenure, and education. Australian studies that decompose the gender wage gap have found that a proportion of the gap remains unexplained (Kidd 1993; Baron & Cobb-Clark 2010; Kee 2006).

As the unexplained component is generally regarded as discrimination in the labour market, the existence of a gender wage gap as a result of unequal opportunities due to discrimination highlights an economic failure in the utilisation of productive employees. However, the unequal gender earnings could be the result of individual choices rather than discrimination. The unexplained component of the decomposition is also driven by individual heterogeneity that is not captured by the model. As such, it is important to measure the gender wage gap while controlling for unobserved individual heterogeneity.

International studies have measured the gender wage gap and have accounted for unobserved individual heterogeneity by using panel data and fixed effects (FE) models. The finding is a decline in the gender wage gap compared to the ordinary least squares (OLS) estimation, particularly of the unexplained component of the decomposition (Polachek & Kim 1994).

In this paper, the Australian gender wage gap will be estimated using panel data and fixed effects methods to account for time-invariant unobserved individual heterogeneity in an Australian context. This is the first time that the gender wage gap has been measured in an

Australian context by taking into account individual fixed effects[2]. However, this method has been applied by prior Australian studies to measure the gender wage gap while accounting for firm-specific fixed effects (see Meng 2004; Meng & Meurs 2004).

The earnings of men and women and the gender wage gap will be estimated while accounting for both the observed labour market characteristics and the time-invariant unobserved individual heterogeneity. The estimation will be undertaken using an unbalanced panel dataset compiled from Wave 1 (2001) to Wave 12 (2012) of the Household, Income and Labour Dynamics (HILDA) Survey. The gender wage gap will be measured using OLS and FE models and the results will be compared. The comparison will show the impact of accounting for unobserved individual heterogeneity on the estimate of the gender wage gap.

The OLS and FE gender wage gap estimates will be decomposed into the explained (endowment), unexplained (coefficient), and interaction components using an Oaxaca-Blinder type decomposition method (Oaxaca 1973; Blinder 1973; Biewen 2012). The decomposition will show whether the estimation of the gender wage gap using the FE model leads to a reduction in the unexplained component of the decomposition, an increase in the explained component, and/or a change in the simultaneous interaction between the two components.

The rest of this paper is organised as follows. Section 1.2 provides an overview of relevant empirical literature. An outline of the estimation methods used to measure and decompose the gender wage gap are provided in Section 1.3. The data used and details of the variables are provided in Section 1.4. The empirical results are presented and explained in Section 1.5. Finally, a discussion and conclusion are provided in Section 1.6 and Section 1.7, respectively.

1.2 **Empirical literature**

Despite the different data sources and estimation methods used to measure the gender wage gap, Australian empirical studies have found evidence of a persistent average gender wage gap (Haig 1982; Jones 1983; Chapman & Mulvey 1986; Langford 1995; Chang & Miller 1996; Preston 2001; Wooden 1999). This gap has been analysed in further detail through the investigation of the differential between part-time and full-time workers (Preston 2003),

[2] Watson (2010) used mixed-effects models and restricted maximum likelihood estimation. The author used an unbalanced panel data from the HILDA survey to estimate the unexplained wage gap between men and women in full-time, private sector managerial occupations.

gender occupational segregation (Miller 1994; Wooden 1999), and the contribution of firm-specific effects on the gender wage gap (Meng 2004).

Prior Australian studies have estimated the mean gender wage gap while accounting for observed labour market characteristics of individuals. These estimates range between 7.1 per cent and 15 per cent (Chapman & Mulvey 1986; Wooden 1999; Preston 2001; Chang & Miller 1996; Eastough & Miller 2004; Miller 2005). This is limited as the method does not account for unobserved individual heterogeneity which can influence earnings and the gender wage gap.

In a survey of literature on the determinants of human capital and the gender wage gap, Kunze (2000) stressed the importance of accounting for unobserved individual heterogeneity. The author demonstrated the econometric implications of failing to account for these controls. In their report, Beblo et al. (2003) highlighted unobserved individual heterogeneity as a methodological issue related to the analysis of gender gaps in employment, earnings, and career progression. The authors suggested methods to overcome this measurement issue including the use of individual fixed effects.

A small number of Australian studies have accounted for firm-specific fixed effects while estimating the gender wage gap (Meng 2004; Meng & Meurs 2004). Using the 1995 Australian Workplace Industrial Relations Survey, Meng (2004) measured and decomposed the mean gender wage gap while accounting for firm-specific fixed effects. The author found that at the sample mean, firm-specific wage policies reduced the gender wage gap. Further, firms with smaller gender wage gaps had stronger market competition, could easily identify individual labour productivity, and did not have enterprise wage bargaining (Meng 2004).

Using employer-employee linked data from the 1995 Australian Workplace Industrial Relations Survey and the 1992 French Labour Cost and Wage Structure Survey, Meng and Meurs (2004) measured the Australian and French gender wage gap while accounting for firm-specific fixed effects. The authors found that in Australia, firm-specific wage policies had a greater impact on the narrowing of the gender wage gap compared to France. This was attributed to Australia’s more decentralised wage bargaining system which operates under a stronger union presence compared to France.

Australian studies that have accounted for unobserved individual heterogeneity using fixed effects or other methods are relevant to the labour market literature. However, the studies are not directly related to the measure of the gender wage gap.

For example, McAllister (1990) used multiple methods including fixed effects to measure the impact of housework on the earnings of men and women in Australia. Similarly, Baxter and Hewitt (2013) measured the impact of housework on women's earnings in Australia while accounting for unobserved individual heterogeneity. While Booth and Wood (2008) accounted for unobserved individual heterogeneity in measuring the wage gap between full-time and part-time Australian employees and found that part-time men and women earn an hourly pay premium compared to their full-time equivalents.

International studies have used the same methods as Australian studies to estimate the gender wage gap. However, international studies have measured the gender wage gap using panel data and fixed effects models to account for the unobserved individual heterogeneity.

Polachek and Kim (1994) measured, decomposed, and compared the gender wage gap using results from OLS and FE models. The authors used USA data from the Panel Study of Income Dynamics and found that the gender wage gap declined after accounting for time-invariant unobserved individual heterogeneity. Further, the authors found that, compared to the estimates of the OLS model, the FE estimates presented a reduction of the unexplained component of the decomposition.

Barnard (2008) measured the gender wage gap in the United Kingdom between 1998 and 2006 using panel data and FE models to account for the unobserved individual heterogeneity. The author controlled for regional, industrial, sectoral, and other effects. The gender wage gap decomposition showed that most of the gap could not be explained by gender differences in labour market characteristics.

Mumford and Smith (2004) used the 1998 British Workplace Employee Relations Survey to measure the gender wage gap in the workplace and within-occupations after accounting for unobserved individual heterogeneity. The authors found that the earnings gap differs across sectors of the labour market and found evidence of a substantial within-occupation gender wage gap.

Mumford and Smith (2007) used FE models to measure the gender wage gap in British full-time and part-time jobs. After accounting for individual and workplace fixed effects, the authors found that female workplace segregation impacts the gender wage gap in part-time jobs, but not full-time jobs. Further, the authors found that part-time employees work in more "female" jobs and earn less than their full-time counterparts.

Using German Socio-Economic Panel data between 2001 and 2008, Busch and Holst (2011) analysed the impact of labour market gender segregation on gender earnings. After controlling for time-constant unobserved individual heterogeneity, the FE results showed that working in more "female" jobs rather than more "male" jobs only impacted women's earnings negatively. An Oaxaca-Blinder decomposition of the gender earnings gap showed that 35 per cent of the gap remained unexplained. This reflected possible time-varying discrimination policy and practices in the labour market.

1.3 Methodology

In this paper, a FE model is used to estimate a gender wage gap that accounts for observed and unobserved individual heterogeneity. The estimation considers within-person unobserved heterogeneity. As such, variables that vary between individuals such as ability or personal traits are excluded from the model.

1.3.1 Panel estimation

1.3.1.1 Ordinary least squares

The estimation of the returns to men's and women's labour market characteristics will begin with a simple log wage equation that only incorporates the observed labour market characteristics of individuals. This is undertaken using an ordinary least squares (OLS) model as specified by Equation 1.

Equation 1 $$In\, W_{it} = \beta_0 + \beta_1 x_{it} + \varepsilon_{it}$$

where W is the real hourly wage for individual i; β_0 is an intercept term; β_1 is a vector of coefficients for the individual's characteristics; x_{it} are observed labour market characteristics of the individual; t refers to time; and ε_{it} is the 'usual' error term.

1.3.1.2 Fixed effects

The fixed effects estimating equation incorporates the impact of observed and unobserved individual heterogeneity on the log of real hourly wage, which is given by:

Equation 2 $\quad In\, W_{it} = \beta_0 + \beta_1 x_{it} + c_i + \varepsilon_{it}$

where W is the real hourly wage for individual i; β_0 is an intercept term; $\beta_1$is a vector of coefficients for the individual's characteristics; x_{it} are observed labour market characteristics of the individual; c_i are the individual unobserved effects or heterogeneity; t refers to time; and $\varepsilon_{\mathrm{it}}$ is a random variable error term.

The estimation of Equation 2 using cross-sectional data will produce biased estimates of β_1. This is because individuals make labour market decisions, have different productivity and motivation, and face discrimination, which are unobserved. Suppose that c_i denotes female discrimination which has a positive impact on the gender wage gap and negative impact on hourly earnings of women. Then the coefficient estimate on the gender dummy variable using a cross-sectional regression will be negatively biased as a result of omission of the unobserved c. Once unobserved heterogeneity is control for, it is expected that the gender wage gap would decline. Failure to control for unobserved characteristics results in omitted variable bias to the coefficient estimate β_1.

As such, panel data techniques (fixed effects models) are utilised in this analysis to control for unobserved heterogeneity through the estimation of Equation 2. The results from the fixed effects estimation are compared to results from OLS estimation of Equation 1 using pooled person-year observations. The standard errors of the estimations are robust to heteroskedasticity and are clustered by respondents' cross-wave identifier.

Equation 2 is estimated for men and women separately and will show the returns to male and female labour market characteristics while accounting for the unobserved individual heterogeneity. More importantly, the estimation of Equation 2 segregated by gender will allow for a more robust estimation of the gender wage gap.

A critical limitation of fixed effects models is that this method does not produce estimates for variables that do not change over time for an individual such as sex, race, and place of birth.

As these characteristics are not included in the estimating equations, this limitation is not of concern for this study.

1.3.1.3 Gender wage gap

The gender wage gap is computed using Equation 3 and the coefficient estimates for men and women from the estimations of Equation 1 and Equation 2.

Equation 3

$$Gender\ wage\ gap = \left(Exp\left(\sum_{i=1}^{n} (\hat{\beta}_i^m * \bar{X}^m) \right) \middle/ Exp\left(\sum_{i=1}^{n} (\hat{\beta}_i^f * \bar{X}^f) \right) \right) - 1 * 100$$

where Exp represents the exponential, $\bar{X}_t^M$ and $\bar{X}_t^F$ denote the mean labour market characteristics of individual i, and $\hat{\beta}_i^m$ and $\hat{\beta}_i^f$ are the male and female estimated coefficients of individual i, respectively (as denoted by the male (m) and female (f) superscripts).

1.3.2 **Counterfactual wage decomposition**

An Oaxaca-Blinder (Oaxaca 1973; Blinder 1973) type wage decomposition is used to decompose the gender wage gap into three components; the explained, unexplained, and interaction component. This decomposition follows Biewen (2012) and shows whether the gender wage gap is due to differences in labour market characteristics, to returns that men and women receive for their labour market characteristics, or to the simultaneous interaction between endowments and coefficients. The results from the FE and OLS estimation will be decomposed using this method. The decomposition is written as:

Equation 4

$$\overline{In(W^m)} - \overline{In(W^f)} = \sum_{i=1}^{n} \hat{\beta}_i^m (\bar{X}^m - \bar{X}^f) + \sum_{i=1}^{n} \bar{X}^f (\hat{\beta}_i^m - \hat{\beta}_i^f) + \sum_{i=1}^{n} (\hat{\beta}_i^m - \hat{\beta}_i^f) * (\bar{X}^m - \bar{X}^f)$$

where $\overline{In\ W}_t^m$ and $\overline{In\ W}_t^f$ are the male and female average log hourly wages, respectively. $\bar{X}_t^m$ and $\bar{X}_t^f$ denote the mean labour market characteristics of individual i, and $\hat{\beta}_i^m$ and $\hat{\beta}_i^f$ are the male and female estimated coefficients of individual i, respectively (as denoted by the male (m) and female (f) superscripts).

In Equation 4, the first term on the right-hand side of the equation represents the part of the gender wage gap that is due to the difference in observed labour market differences between men and women such as experience, tenure, and education. This is usually referred to as the explained components as it can be explained by the observed labour market characteristics.

The second term in Equation 4 represents the part of the gender wage gap that is due to the differences in returns to labour market characteristics. This is usually referred to as the unexplained component as it cannot be explained by differences in labour market characteristics or other variables used in the estimation.

The third term in Equation 4 is the interaction component and presents the proportion of the gender wage gap that is due to the simultaneous change in endowments and coefficients of men and women (Biewen 2012). This term also reflects the notion that relatively higher returns (coefficients) to labour market characteristics (endowments) lead to greater investment in labour market characteristics.

1.4 **Data**

Waves 1 to Wave 12 of the Household, Income and Labour Dynamics in Australian (HILDA) Survey are compiled to form an unbalanced panel dataset and used in this analysis. The HILDA Survey is a nationally random panel survey of households which began in 2001[3]. The HILDA Survey is appropriate for the estimation undertaken in this analysis due to the extensive range of wage determinant variables available for the same individuals over a period of time.

The Survey contains panel responses on a wide range of information including data on the respondents' earnings, education, labour market status, occupation, industry and sector of employment, labour market experience, hours of work, and attitude towards work and gender roles as well as extensive information on children. Information on the respondents' family background, fertility and relationship histories, health and attitude on certain aspects of life is also collected.

The dataset used in this analysis is an unbalanced panel, compiled using Wave 1 to Wave 12 of the HILDA survey. The dataset contains employees aged between 18 and 65 years

[3] For details on the survey including attributional issues, visit http://www.melbourneinstitute.com/hilda.

working at a full-time, part-time, and casual basis in the Australian labour force and excludes the self-employed. The dataset used in this analysis comprises of 81,807 observations.

1.4.1 The Variables

The dependent variable is a measure of real hourly wages in 2012 dollars. The hourly wage is calculated using the respondents' weekly gross wage or salary and hours usually worked in the main job per week. As the Survey collects nominal earnings, the hourly wages are adjusted for inflation and productivity changes over time using the Average Weekly Ordinary Time Earnings (AWOTE) from the Australian Bureau of Statistics[4].

This study adopts the human capital model as the theoretical basis for the earnings function. It is assumed that at an individual employee level, an increase in accumulated human capital such as education, experience, and tenure leads to an increase in earnings; although, this effect is not expected to be linear.

The variables and a definition of the variables used in this analysis are presented in Table 1. The labour market continuity variables used in this analysis are experience (the years spent in paid work), experience squared, tenure (years spent with current employer), and tenure squared. Educational dummy variables are generated using the respondent's highest level of education.

In addition, a further three categories of variables are included in the estimations (Table 1); demographic, parenthood, and job characteristic variables. The dummy variable for geographical location indicates whether or not the individual resides in a major Australian city. The children dummy variable is an indication of actual or expected parenthood. The job characteristics variables are part-time work status, and the occupation, industry and sector of employment.

The panel dataset used in this study comprises of 81,807 observations and contains almost the same proportion of women (40,970) and men (40,837). The descriptive statistics of the variables for the total sample, and for men and women separately are presented in Table 2.

[4] The AWOTE series is obtained from the ABS cat. no. 6302.0 Table 3.

Over 62 per cent of the total sample reported their highest levels of education attained as certificate (22.2 per cent), year 11 or less (21.9 per cent), and year 12 (18 per cent). Most women reported their highest level of education as year 11 or less (23 per cent), university degree (19 per cent), and year 12 (18.9 per cent). Most men in the sample reported their highest level of education as a certificate I or II level (28 per cent), year 11 or less (20 per cent), and year 12 (18 per cent).

Overall, a greater proportion of women have university degrees, graduate diplomas, and advance diplomas as their highest level of education. This indicates that compared to men, more women are undertaking education at higher levels, which require greater years of investment. However, there are also more women than men that reported the lower educational levels such as year 12 and year 11 (or less) as their highest level of education. A greater proportion of men compared to women reported their highest attained educational level as certificate (28 per cent men, 16 per cent women) and post graduate (5 per cent men, 4 per cent women).

As expected, there is a noticeable difference between the labour market continuity and status of men and women. Most men in the sample have greater years of experience and tenure. Labour market experience for the average man in the sample is 19 years while the average woman has 17 years of labour market experience. Similarly, the average man has spent 9 years with his current employer (tenure) while the average woman has spent 8 years with her current employer.

These results are expected as women are more likely than men to have career interruptions due to the birth of a child. Following the arrival of children, some women return to the labour market at a part-time basis. This is evident in the sample as a greater proportion of women (45 per cent) work at a part-time basis compared to men (12 per cent).

A work interruption due to the arrival of a child suggests that women forgo human capital that could have otherwise been accumulated on the job. This leads to slower human capital accumulation and the deterioration of existing skills (Anderson et al. 2003; Budig & England 2001; Hill 1979; Joshi et al. 1999; Lundberg & Rose 2000; and Waldfogel 1995, 1997). Women employed in part-time jobs also accumulate human capital at a slower rate than if they were in full-time employment, and therefore accumulate less human capital than men (Anderson et al. 2002; Baum 2002).

Prior studies show that working in the Australian public sector provides women with greater flexibility, job security, more intensive anti-discriminatory enforcement, faster occupational integration, and a smaller gender pay gap (Baron & Cobb-Clark 2010; Gregory & Borland 1999; Kee 2006; Pfeifer 2011). Although a smaller proportion of the sampled individuals reported to be employed in the Australian public sector (28 per cent) than the private sector, a greater proportion of women (33 per cent) work in the Australian public sector compared to men (23 per cent).

Men and women in the sample have similar average characteristics in regards to residential location and parenthood status. Most individuals in the sample (66 per cent) reside in a major Australian city. Regarding parenthood status, a large proportion of women (85 per cent) and men (83 per cent) in the sample have or intend to have children.

Table 1 Variables and definitions

Name	Definition
real hourly wage	
sex	= 1 for male; = 0 for female
Labour market continuity	
tenure	Tenure with current employer (in years)
$tenure^2$	Tenure squared
experience	Years in paid work
$experience^2$	Experience squared
Education variables	
post graduate	= 1 if respondent's highest level of education is postgraduate; = 0 otherwise
university	= 1 if respondent's highest level of education is graduate diploma; = 0 otherwise
graduate diploma	= 1 if respondent's highest level of education is bachelor or honours; = 0 otherwise
advance diploma or diploma	= 1 if respondent's highest level of education is a diploma or advanced diploma; = 0 otherwise
certificate	= 1 if respondent's highest level of education is certificate I or II; = 0 otherwise
year 12	= 1 if respondent's highest level of education is year 12; = 0 otherwise
year 11 or less	= 1 if respondent's highest level of education is year 11 or below; = 0 otherwise
Residential location	
city	= 1 if respondent resides in major cities of Australia; = 0 otherwise

Parenthood	
children	= 1 if has residential child(ren) or intend to have child(ren); 0 = otherwise
Labour force status	
part time	= 1 if respondent is working part time; = 0 otherwise
private sector	= 1 if respondent works in the private sector; = 0 otherwise

Table 2 Variables and descriptions (2001 to 2012 panel)

Name	Total sample	Women	Men
	n = 81,807	**n = 40,970**	**n = 40,837**
real hourly wage	$ 31.40	$ 29.29	$ 33.53
sex	50%	-	-
Labour market continuity			
tenure	9	8	9
tenure^2	-	-	-
experience	18	17	19
experience^2	-	-	-
Education variables			
post graduate	5%	4%	5%
university	17%	19%	15%
graduate diploma	7%	8%	5%
advance diploma or diploma	9%	10%	9%
certificate	22%	16%	28%
year 12	18%	19%	18%
year 11 or less	22%	23%	20%
Residential location			
city	66%	66%	66%
Parenthood			
children	84%	85%	83%
Labour force status			
part time	28%	45%	12%
private sector	72%	67%	77%

1.5 **Results**

In this analysis, the Australian gender wage gap was estimated using different methods and the results are reported in this section. The estimation of the gender wage gap begins with the most simple; unconditional raw wage gaps in the sample. Next, gender specific earnings are estimated using Equation 1 and Equation 2 and the gender wage gap is computed using

Equation 3. Finally, the estimated gender wage gap is decomposed using Equation 4 to determine whether the gender wage gap is attributable to differences in endowments (explained), coefficients (unexplained), or an interaction of the two components.

1.5.1 **Raw gender wage gap**

Observation of the real hourly wages of men and women in the sample reveals a gender wage gap of 14 per cent (Table 3). The average woman in the sample earns $29.29 per hour while the average man earns $33.53 per hour. The observation of earnings at the sample mean without accounting for the labour market characteristics of individuals is limited. However, these results are consistent with prior Australian studies that have found a positive raw wage gap at the mean (Preston 2001; Wooden 1999).

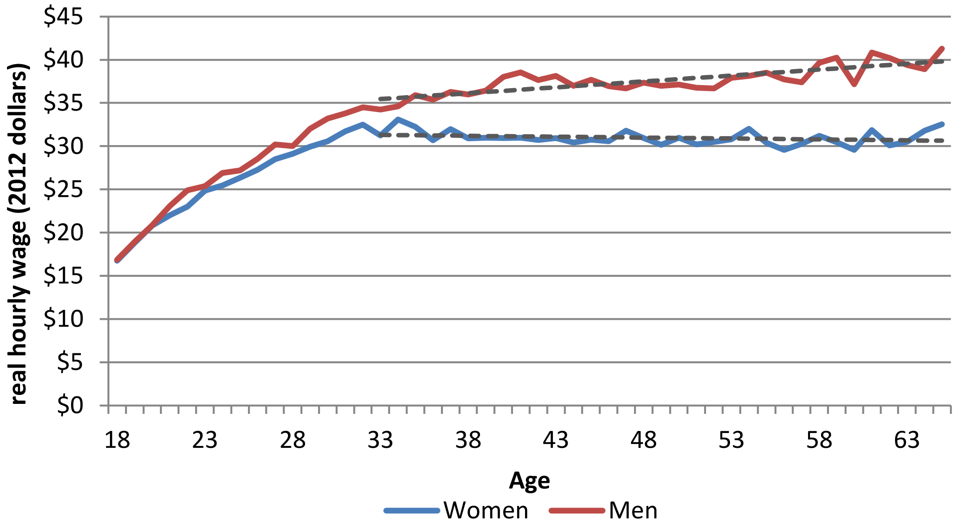
Table 3 Raw gender wage gap

	2001 to 2012 panel n = 81,807	
	Women	Men
Real hourly wage	$ 29.29	$ 33.53
Gender wage gap	14%	

The average earnings by age of the pooled sample show that men and women earn similarly and have steep wage growth rates between 18 years of age (labour market entry) and 32 years of age (Figure 1). However, between the ages of 32 and 65 years, women's earnings do not increase while men's earnings follow a slow increasing trend.

The difference in wage growth rates between men and women after the age of 32 years could be reflecting the impact of motherhood on women's earnings and wage growth. As specified by Livermore, Rodgers and Siminski (2011), the motherhood wage penalty is a result of reduced wage growth rather than an immediate wage decline following the birth of a child. Further, the authors found that the reduced wage growth is consistent with both discrimination and a decline in mothers' work effort.

Figure 1 Average real hourly wages by age and gender



1.5.2 **Gender segregated estimates**

The estimation of Equation 1 and Equation 2 was undertaken separately by gender using the panel dataset. The estimates of the returns to labour market characteristics are presented in Table 2. The coefficient estimates from the OLS and FE models for men and women show that as experience increases, the real hourly wages increase at a decreasing rate.

The FE coefficient estimates on the experience variable are larger compared to the OLS experience coefficient estimates. For women, the FE coefficient estimates show that an additional year of work experience leads to a 4.5 per cent increase in average hourly wages. While the OLS coefficient estimates show that an additional year of work experience leads to a 2.3 per cent increase in women's average hourly wages.

Similarly for men, the FE coefficient estimates show that an additional year of work experience leads to a 4.7 per cent increase in average hourly wages. While the OLS coefficient estimates show that an additional year of work experience leads to a 3 per cent increase in average hourly wages.

The OLS coefficient estimates on the experience variable are consistent with the results of early Australian studies. Prior studies reported a 2 per cent to 3 per cent increase in average earnings due to an additional year of experience (Chang & Miller 1996; Chapman & Mulvey 1986; Wooden 1999).

The comparison of the OLS and FE experience coefficient estimates indicates that the inclusion of unobserved individual heterogeneity (FE model) in the estimation leads to an increase in the estimate of men's and women's returns to labour market experience. As such, the OLS estimation in this analysis and in prior studies is likely to underestimate the returns to labour market experience, especially for women.

The OLS and FE coefficient estimates present similar results on the returns to tenure. These estimates show that the earnings of men and women increase at a decreasing rate with an additional year of tenure.

The OLS and FE coefficient estimates present evidence of significant differences in the returns to education between men and women. Higher levels of education have a greater impact on women's earnings compared to the earnings of men. Whereas men receive higher returns for lower levels of education such as diploma or advance diploma and certificate.

The inclusion of unobserved individual heterogeneity in the estimation (FE model) leads to a reduction in the returns to education at all levels for both men and women. Estimation using FE models reduces the impact of education on earnings as the models may be accounting for unobserved training and informal education that positively impact earnings but have not been included in the standard OLS model.

The OLS and FE coefficient estimates show that residing in a major Australian city (herein referred to as city) has a significantly greater impact on the earnings of women compared to men. Both men's and women's average hourly wage are higher if they reside in a city compared to the counterfactual. For women, the impact of residing in a city is positive and significant (OLS and FE models).

The combination of the time allocation theory (Becker 1965) and the spatial mobility theory (Madden & White 1980) assist in explaining this impact. Assuming that most occupations are undertaken in a city, if women reside in a city, they will allocate a smaller proportion of their time to commuting. As such, women are likely to allocate a greater proportion of time to paid work, which in turn, will lead to higher earnings.

The coefficient estimates from the FE model show that the impact of the location of residence is not significant for men. This may be that in response to an increase in time dedicated to commuting, men are more likely than women to reduce time allocated to family and leisure, rather than work.

The coefficient estimates from the OLS and FE models show different impacts on the average hourly earnings of men and women from working at a part-time basis compared to working full-time. For men, the OLS estimates show that working part-time leads to a significant reduction in men's earnings. However, with the incorporation of unobserved individual heterogeneity, men working part-time earn significantly higher average hourly wages compared to their full-time counterparts.

For women, the OLS estimates show that their average hourly wages are not expected to significantly increase by working at a part-time basis. However, the incorporation of unobserved individual heterogeneity (FE model) shows that women's earnings are expected to increase by 11 per cent if they work at a part-time basis compared to full-time. These results are in line with the FE estimates of Booth and Wood (2008) which showed that Australian individuals working at a part-time basis have higher average hourly returns compared to their full-time counterparts.

Working in the Australian private sector compared to the Australian public sector has a significantly greater negative impact on the hourly wages of women than men. For women, the negative impact of working in the private sector declines with the estimation of the FE model, however, this effect remains relatively constant for men. The reduced hourly wages from working in the private sector compared to the public sector could be the result of the public sector wage setting method, which is politically based rather than set through the market environment (Gregory & Borland 1999). Further, the Australian public sector has higher levels of occupational integration and stronger enforcement of anti-discrimination legislation (Baron & Cobb-Clark 2010).

Finally, having children or expecting to have children is positively associated with the hourly wages of both men and women. For men, the positive impact of having or intending to have children on earnings is reduced with the estimation of the FE model while the effect remains constant for women.

The positive impact of having or intending to have children on the hourly wages of men can be explained by the fatherhood wage premium (Glauber 2008; Hodges & Budig 2010;

Koslowski 2011). This implies that men with children have higher earnings than their childless counterparts. However, the positive impact of children on the hourly wages of women is surprising given the results of prior studies that have estimated a motherhood wage penalty in the Australian labour market (Livermore, Rodgers & Siminski 2011; Harkness & Waldfogel 2003; Hosking 2010).

A comparison of the coefficient estimates from the OLS and FE models shows that both models present similar results in sign and magnitude for most of the independent variables. However, the FE models present higher estimates on the returns to the labour market experience of men and women. Further, the FE coefficient estimates on the returns to all levels of education are lower compared to the OLS coefficient estimates. The largest disparities between the FE and OLS coefficient estimates are the returns to part-time employment. Further, the impact of having or intending to have children is shown to differ for men depending on whether the unobserved individual heterogeneity (FE model) are included or excluded (OLS model) from the estimation.

Table 4 Pooled OLS and Fixed effects model – returns to labour market characteristics

log real hourly wage	**Women n = 35,120**				**Men n = 35,002**			
	OLS		**Fixed effects**[5]		**OLS**		**Fixed effects**	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
experience	0.023	19.42	0.045	7.24	0.030	20.91	0.047	6.35
$experience^2$	0.000	-14.70	-0.001	-12.50	0.000	-14.91	-0.001	-17.95
tenure	0.008	6.97	0.001	1.55	0.011	8.04	0.002	2.69
$tenure^2$	0.000	-2.98	0.000	-0.98	0.000	-5.18	0.000	-1.95
post graduate	0.466	22.61	0.263	6.63	0.531	19.92	0.101	2.03
university	0.376	21.60	0.227	5.86	0.473	19.44	0.068	1.45
graduate diploma	0.343	26.33	0.178	5.53	0.427	22.69	0.045	1.07
advance diploma or diploma	0.181	11.67	0.094	3.09	0.252	12.88	0.062	1.66
certificate	0.069	6.01	0.053	2.45	0.148	11.32	0.086	3.46
year 12	0.092	7.50	0.016	0.56	0.131	8.23	-0.123	-3.33
year 11 or less				omitted				
city	0.068	8.75	0.056	4.22	0.085	8.59	0.015	0.99

[5] Individual and time fixed. All of the coefficient estimates presented in this paper are corrected for clustering and are therefore robust. Diagnostics undertaken showed that fixed effects were preferred over random effects models. For comparison, preliminary estimates included random effects but the results have not been reported.

children	0.026	2.20	0.026	2.62	0.090	6.93	0.018	1.93
part time	0.001	0.13	0.107	15.63	-0.067	-4.98	0.133	10.05
private sector	-0.107	-13.03	-0.060	-6.28	-0.037	-3.49	-0.042	-3.38
waves								
3	-0.017	-1.92	-0.051	-3.70	-0.013	-1.57	-0.015	-0.97
4	-0.013	-1.35	-0.057	-3.13	0.004	0.45	-0.008	-0.40
5	-0.016	-1.58	-0.074	-3.19	-0.005	-0.55	-0.015	-0.55
6	-0.008	-0.85	-0.070	-2.49	-0.009	-0.99	-0.015	-0.43
7	-0.007	-0.71	-0.072	-2.17	0.009	0.93	0.003	0.08
8	0.008	0.82	-0.069	-1.82	0.021	2.14	0.018	0.38
9	0.000	0.05	-0.082	-1.91	0.022	2.34	0.012	0.22
10	0.001	0.13	-0.097	-1.98	0.013	1.28	0.000	0.00
11	-0.007	-0.70	-0.115	-2.13	0.017	1.79	0.003	0.05
12	-0.024	-2.53	-0.130	-2.26	0.015	1.61	0.006	0.08
constant	2.859	138.99	2.655	35.42	2.713	119.15	2.814	27.48
sigma_u			0.406				0.445	
sigma_e			0.290				0.263	
rho			0.662				0.741	

robust standard errors adjusted for clusters in the wave ids

1.5.3 OLS and FE gender wage gap

The OLS and FE gender wage gap estimates as specified by Equation 3 were constructed using the gender specific coefficient estimates obtained through the estimation of Equation 1 and Equation 2 and the mean characteristics of men and women in the sample.

Table 5 shows real hourly wages by gender and the gender wage gap using estimates from a specification which consists of a constant, a wave dummies, labour market continuity variables, labour market status dummies, education dummies, a residential location dummy, and a parenthood dummy.

The OLS results show that after accounting for the observed labour market characteristics, women earn an average of $26.50 per hour while men earn $29.30 per hour. This equates to a gender wage gap of 11 per cent (Table 5). The FE results show that after accounting for the observed and unobserved individual heterogeneity, women earn $28.41 per hour while men earn $29.54 per hour. This equates to a gender wage gap of 4 per cent.

The difference between the gender wage gap results using OLS and FE coefficient estimates shows that unobserved individual heterogeneity explains 62 per cent of the gender wage gap.

The comparison shows that estimation of the gender wage gap using OLS methods leads to an overestimation of the gap by approximately 7 percentage points.

When unobserved heterogeneity are taken into consideration, the estimate of women's average hourly earnings is 7 per cent higher; the OLS average estimate of $26.50 compared to the FE estimate of $28.41 per hour. The OLS model also leads to an underestimation of men's average hourly wages. However, the effect is to a much smaller extent of 1 per cent; OLS average estimate of $29.30 per hour compared to the FE estimate of $29.54 per hour.

These results are consistent with Polachek and Kim (1994) who developed individual-specific slope models to account for unobserved individual heterogeneity in estimating the gender wage gap. The authors compared the gender wage gap findings from the FE model with the traditional OLS model and found that unobserved individual heterogeneity accounted for around 50 per cent of the gender wage gap.

Table 5 Gender wage gaps – OLS and FE

Model	Gender	Real hourly wages	Gender wage gap
OLS	Women	$ 26.50	11%
	Men	$ 29.30	
FE	Women	$ 28.41	4%
	Men	$ 29.54	

Note: The real hourly wages and gender wage gaps were calculated using estimates with robust standard errors.

1.5.4 Gender wage gap decomposition

This section presents the gender wage gap decomposition results that were estimated using the OLS and FE models' coefficient estimates as specified by Equation 4. The counterfactual decomposition follows Biewen's (2012) extension of the Blinder (1973) and Oaxaca (1973) method. The decomposition presents the proportion of the gender wage gap attributable to differences in labour market characteristics/endowment (explained), returns/coefficients to labour market characteristics (unexplained), and the simultaneous interaction of the two components. The gender wage gap decomposition results are presented in Table 6.

The OLS gender wage gap decomposition presents an explained component of -3 per cent, unexplained component of 9 per cent, and an interaction component of 4 per cent (Table 6). These results imply that, if women obtained men's labour market characteristics and continued to be paid like women, their average hourly wage would decline by 3 per cent; from \$26.50 to \$25.80 per hour. However, if women retained their labour market characteristics and were paid like men, their average hourly wages would increase by 9 per cent to \$29 per hour. Further, if women eventually obtained the same labour market characteristics as men and were rewarded like men for those labour market characteristics, their average hourly wage would increase by 4 per cent; from \$26.50 to 27.54 per hour.

The decomposition results of the FE gender wage gap present an explained component of -2 per cent, an unexplained component of 6 per cent, and an interaction component of -0.2 per cent (Table 6). These results imply that, if women obtained men's labour market characteristics and continued to be paid like women, their earnings would decline by 2 per cent; from \$28.40 to \$27.90 per hour. However, if women retained their labour market characteristics and were paid like men, their average earnings would increase by 6 per cent to \$30.10 per hour. Further, if women eventually obtained men's labour market characteristics and were rewarded like men for those characteristics, their average hourly wage would decline by 0.2 per cent to \$28.34 per hour.

The negative sign on the explained component of the decompositions implies that men have less productive skills than women and that they are over-rewarded for these characteristics. The positive sign on the unexplained component of the decompositions implies that gender earnings differences are due to factors not captured by the model. While the interactive impact of endowments and coefficients on the gender wage gap is small and negative.

A comparison of the OLS and FE gender wage gap decomposition results shows that after accounting for unobserved individual heterogeneity (with the FE model), the explained component of the decomposition increases from -3 per cent to -2 per cent. By contrast, the unexplained component of the decomposition declines from 9 per cent to 6 per cent. The change in the interaction component of the decomposition shows that after accounting for the time-invariant unobserved individual heterogeneity, the simultaneous impact of coefficients and endowments reduces from 4 per cent to -0.2 per cent.

This comparison shows that the inclusion of unobserved individual heterogeneity in the estimation leads to a simultaneous increase of the explained component of the decomposition and a decline in the unexplained component. The results show that by accounting for the unobserved heterogeneity of individuals, the gender wage gap becomes increasingly explained by differences in labour market characteristics. This implies that unobserved individual heterogeneity assist in explaining the gender wage gap. This finding could be a reflection of women's unobserved productive characteristics relative to men's. For example, due to family responsibilities, women may be less motivated than men to undertake employment that provides higher pay and greater responsibilities. The results also show that the inclusion of individual unobserved heterogeneity reduces the unexplained component of the decomposition and allows for a more accurate measure of gender based discrimination.

These decomposition results are in line with prior studies that have decomposed the FE gender wage gap. For example, Barnard (2008) estimated the gender wage gap using FE models and UK panel data (1998 to 2006). Barnard's (2008) decomposition results showed that a large proportion of the gap (67 per cent) could not be explained by characteristic differences between men and women.

Mumford and Smith (2004) estimated the British gender wage gap while accounting for individual employee characteristics, and workplace and occupational characteristics. The authors decomposed the FE gender wage gap and found that the gap was almost equally attributable to differences in characteristics between men and women (50.7 per cent) and to the unexplained component (49.3 per cent) of the decomposition.

Mumford and Smith (2007) measured the gender wage gap of part-time employees using a FE model and found a 20 log percentage point gender wage gap. The authors noted that if women working part-time retained their labour market characteristics and were paid like men working part-time (unexplained component) their earnings would increase by an average of 34.2 log percentage points. By contrast, if these women obtained the labour market characteristics of men but continued to be paid like women, their earnings would decline by an average of 14.1 log percentage points. The authors concluded that men working part-time had less productive skills compared to women working part-time and that men were over-rewarded for their labour market characteristics.

In contrast to these findings, Busch and Holst (2011) measured the gender wage gap of full-time managers in Germany. The author used panel data and FE methods and found a gender wage gap of 37.1 per cent. The author decomposed the gender wage gap and found that most of the gap (65 per cent) was attributable to differences in characteristics between full-time male and female managers in Germany.

Table 6 Counterfactual decomposition – OLS and FE gender wage gaps

	Men Real hourly wages	Women Real hourly wages	Gender wage gap	Explained	Unexplained	Interaction
OLS	$ 29.30	$ 26.50	**11%**	-3% $25.79	9% $29.00	4% $27.54
FE	$ 29.54	$ 28.41	**4%**	-2% $27.91	6% $30.10	-0.2% $28.34

1.6 **Discussion**

The estimation of the gender wage gap in this paper extends the work of prior Australian research by accounting for time-invariant unobserved individual heterogeneity. Using panel data and FE models, the Australian gender wage gap estimate reduced by 62 per cent compared to traditional OLS estimation. The major limitation from the exclusion of unobserved individual heterogeneity from the estimation is the overestimation of the gender wage gap. This is influenced by an underestimation of the impact of experience on the real hourly wages of women.

Previous studies that reported the gender wage gap at the sample mean accounted for the observed labour characteristics of individuals (Chapman & Mulvey 1986; Wooden 1999; Preston 2001; Chang & Miller 1996; Eastough & Miller 2004; Miller 2005). These studies reported a gender wage gap ranging from 7.1 per cent to 15 per cent. The OLS gender wage gap of 11 per cent[6] reported in this analysis is consistent with prior studies.

The inclusion of unobserved individual heterogeneity in the estimation shows that the gender wage gap estimate declines to 4 per cent. This reduction implies that unobserved individual heterogeneity accounts for 62 per cent of the gender wage gap. The reduction also implies that traditional estimates of the gender wage gap overestimate the Australian gender wage gap by approximately 7 percentage points.

The difference between the OLS and FE gender wage gap estimates is driven by differences in the returns for an additional year of experience. The OLS coefficient estimate on the

[6] According to specification [1], which contains a constant, labour market continuity variables, education dummies, parenthood dummy, residential location dummy, labour market status dummies and wave dummies.

experience variable shows that an additional year of work experience for women and men leads to a 2.3 per cent and 3 per cent increase in average hourly wages, respectively.

These findings are in line with prior studies, which report an increase in wages ranging from 2 per cent to 3 per cent for an additional year of work experience (Chapman & Mulvey 1986; Chang & Miller 1996; Wooden 1999). However, the FE models' experience coefficient estimates show that an additional year of experience leads to a 4.5 per cent and 4.7 per cent increase in the average hourly wages of women and men, respectively.

In turn, the underestimation of the impact of experience leads to an underestimation of average real hourly wages, particularly for women. Using OLS models leads to an underestimation of women's average real hourly wages by approximately 7 per cent. While the OLS model leads to an underestimation of men's average hourly wages by 1 per cent.

These results indicate that prior studies overestimated the gender wage gap. The overestimation occurred due to the exclusion of unobserved individual heterogeneity from the estimation of earnings by gender. This exclusion also resulted in an underestimation of the impact of work experience on the earnings of men and women. The findings in this chapter emphasise that individual fixed effects contribute to the explanation of the Australian gender wage gap and need to be incorporated in its estimation.

1.7 Conclusion

This paper measured the Australian gender wage gap using pooled data from Wave 1 (2001) to Wave 12 (2012) of the HILDA Survey. The FE models were implemented to account for observed labour market characteristics and time-invariant unobserved individual heterogeneity.

The returns to labour market characteristics for men and women from the estimation of the FE model were compared with the traditional OLS model. The comparison presented similar results on the returns to labour market characteristics from the estimation of OLS and FE models for men and women separately. A disparity between the estimates of the FE and OLS models was most evident on the returns to experience, part-time employment, and on men's returns for having or intending to have children.

The gender wage gap estimates from the OLS model and FE model were 11 per cent and 4 per cent, respectively. These results show that unobserved individual heterogeneity explains 62 per cent of the earnings differentials between men and women. The results highlight that the OLS method leads to an overestimation of the gender by approximately 7 percentage points. This is influenced by the underestimation of women's real hourly wages as a result of an underestimation of the impact of experience on their earnings.

The estimated OLS and FE gender wage gap results were decomposed into the explained, unexplained, and interaction components. The decompositions showed that the gender wage gap is attributable to the unexplained component of the decomposition rather than to characteristic differences between men and women.

A comparison of the gender wage gap decomposition estimates using OLS and FE models showed that after accounting for unobserved individual heterogeneity, the explained component of the decomposition increased by 1 percentage point while the unexplained and interaction components declined by 3 and 4.2 percentage points, respectively. These findings imply that unobserved individual heterogeneity contributes to the reduction of the unexplained component of the gender wage gap by 33 per cent and to an increase of the explained component of the decomposition by 33 per cent.

Given the availability of Australian panel data, FE models should be used to account for unobserved individual heterogeneity when estimating the gender wage gap. In particular, the implementation of FE models to estimate the gender wage differentials over the earnings distribution is a major gap in the Australian and international literature. Future research in this area will assist in explaining wage differentials along the earnings distribution while accounting for unobserved individual heterogeneity.

1.8 **References**

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