The Effect of Motherhood on Wages and Wage Growth: Evidence for Australia

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ABSTRACT

Labour market theory provides numerous reasons why mothers may earn lower hourly wages than non-mothers; however the empirical evidence for Australia is limited. This paper examines the effect of motherhood on Australian women's wages and wage growth using a series of panel data models which account for unobserved factors affecting both wage levels and wage growth. Using data from the Household, Income and Labour Dynamics in Australia (HILDA) survey, an unexplained motherhood wage penalty of around five percent for one child, and nine percent for two or more children is found. Further analysis suggests that the wage penalty emerges over time through reduced wage growth, rather than through an immediate wage decline after birth. This reduction in wage growth is consistent with flatter wage profiles of part-time workers, discrimination and a reduction in mothers' work effort.

KEY WORDS

Motherhood Wage Penalty, Wage Growth, Fixed Effects, HILDA

JEL Classification: J31, J13, C33

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I. INTRODUCTION

A large body of international literature has found an unexplained wage differential between mothers and non-mothers (e.g. Anderson, Binder and Krause, 2002; Buligescu *et al.*, 2009; Drolet, 2002; Waldfogel, 1995); however the presence of a 'motherhood wage penalty' in Australia is less clear. No study to date has examined the effect of motherhood on Australian women's wages taking account of unobserved factors, and the effect of motherhood on wage growth has not been assessed.

Understanding the effect of children on women's wages and wage growth however is important to current Australian policy. The policy options for counteracting the fiscal effects of an ageing population centre on increasing birth rates whilst maintaining high levels of female labour force participation (LFP) (Australian Treasury Department, 2007). However to encourage both outcomes, it is important to determine how the presence of children affects mothers' wages, which in turn affects LFP.

The effect of motherhood on wages is also important to the study of gender wage equality. The direct and indirect effects of children are often cited as a cause of the gender wage gap, and thus measuring the motherhood wage differential will shed light on this hypothesis (Waldfogel, 1998a).

Finally, the opportunity costs born by mothers are of social importance; since good parenting provides positive externalities to the community, it has been argued that mothers disproportionately share the costs of childbearing (Budig and England, 2001). This is exacerbated when the costs of children go beyond the *direct* costs of food, clothing, health, education and shelter and include *indirect* opportunity costs of wages foregone.

Motivated by the importance of the issue to Australian policy and the lack of prior research, this paper examines whether mothers, on average, earn lower hourly wages than

non-mothers. Fixed effects estimates robust to time invariant unobserved factors are obtained using an unbalanced panel from the first seven waves of the Household Income and Labour Dynamics in Australia (HILDA) survey. The fixed effects results are compared to OLS and Heckman-corrected cross-sectional models to gauge the extent of heterogeneity and selection bias. Due to the absence of a suitable instrument, the analysis does not account for reverse causality.

Whether the motherhood wage differential arises immediately after birth, or develops over time through wage growth is also investigated. The first-difference and fixed effects models of Loughran and Zissimopoulos (2009), which account for the effect of unobserved heterogeneity on both the wage level and wage growth, are applied to the Australia data. While insightful, the methodology is sensitive to outlying wage growth observations, and is likely to be more useful as additional waves of HILDA are available.

The paper is structured as follows. Section II reviews the empirical literature and discusses the theoretical reasons for a motherhood wage penalty. Section III presents the empirical approach adopted in this paper and Section IV describes the HILDA data and sample. Finally, Section V presents the empirical results and Section VI concludes.

II. EXISTING EVIDENCE AND THEORETICAL BACKGROUND

A large body of international literature has studied whether mothers earn lower wages than non-mothers. A significant wage penalty has been found in the United States[2], Britain (Waldfogel, 1995; 1998b), Canada (Drolet, 2002) and Germany (Buligescu *et al.*, 2009).[3] While other studies in Denmark (Gupta and Smith, 2002) and Sweden (Albrecht *et al.*, 1999) have found motherhood or maternal leave to have no direct effect on wages.

[2] Such as: Anderson, Binder and Krause (2002; 2003), Baum (2002), Budig and England (2001), Loughran and Zissimopoulos (2009), Lundberg and Rose (2000), Taniguchi (1999) and Waldfogel (1997; 1998b).

[3] Most studies which found a motherhood wage penalty control for marital status in their analysis (for example, Anderson, Binder and Krause, 2002; 2003; Baum, 2002; Budig and England, 2001) which demonstrates that motherhood has a negative effect on wages, independent of the effects of marriage.

Although the effects of children on wages may work indirectly through characteristics such as experience, tenure, education and job choices, most studies focus on estimating the direct effect of children. To that end, the 'residual' motherhood penalty is typically estimated with human capital, job characteristics and time invariant unobserved heterogeneity held constant. In studies which have found a residual penalty, estimates range from two percent (Baum, 2002; Loughran and Zissimopoulos, 2009) to nine percent (Waldfogel, 1995; 1998b) for one child and a further two (Anderson, Binder and Krause, 2002; 2003) to nine percent (Budig and England, 2001) for additional children.

In contrast to the large international literature, the effect of motherhood on wages or wage growth has received little attention in Australia. In fact, only two Australian studies (Krepp, 2007; Whitehouse, 2002) have sought to examine whether mothers earn lower hourly wages than non-mothers, and no Australian study to date has examined the effect of motherhood on wage growth. Using cross-sectional data from the Australian Workplace Industrial Relations Survey in 1995, Whitehouse (2002) found no significant effect of dependant children on Australian women's wages. Similarly, Krepp (2007) found no residual wage penalty using a Heckman-corrected cross-sectional model to account for selection into employment. Although these Australian studies have found no direct effect of motherhood on wages, their results are potentially biased by unobserved heterogeneity and the omission of key controls.[4]

Economic theory provides a number of non-mutually exclusive reasons why a raw wage differential between mothers and non-mothers may exist. Fore mostly, the greater frequency

[4] In Whitehouse's model, the coefficient of motherhood may be biased upward by the omission of experience if mothers in the sample are older than non-mothers, as the two categorical age variables included may not successfully control for the effect of aging on experience. Similarly, Krepp's models do not control for part-time employment status; if mothers are more likely to work part-time jobs, and part-time work attracts a pay premium (Booth and Wood, 2008), the motherhood coefficient may be biased towards zero. Although Krepp accounts for selection into employment, her estimates may be biased by other unobserved factors correlated with both motherhood and wages (Anderson, Binder and Krause, 2002; 2003; Korenman and Neumark, 1992).

and duration of work interruptions among mothers may reduce wages through foregone experience, depreciation of skills and loss of tenure.[5] The anticipation of work interruptions may also slow wage growth if it induces lower investment in human capital (Ben-Porath, 1967).[6]

The propensity of mothers to seek employment offering flexibility, part-time hours, maternity leave entitlements or limited travel time may also result in lower wages as a compensating differential (Rosen, 1986). Part-time work explains a large portion of the motherhood wage penalty in the United States (Waldfogel, 1997) and Britain (Joshi, Paci and Waldfogel, 1999), however Australian studies of part-time wages (Booth and Wood, 2008; Rodgers, 2004) suggest that part-time work may not directly cause (or increase) a motherhood wage penalty. Nevertheless, working part-time may still affect Australian mothers' wages in the long run through lower human capital accumulation (due to less time spent working) and fewer opportunities for promotion (Abhayaratna *et al.*, 2008).

The effort required to raise children may also reduce mothers wages following Becker's (1985) 'worker effort' hypothesis (Budig and England, 2001). However even between equally productive mothers and non-mothers a wage differential may arise through statistical discrimination if employers assume childcare and housework responsibilities make mothers less productive (Hyclak, Johnes and Thornton, 2005, p.384). It is also possible that employers with a prejudice against mothers will pay a wage below productivity by an amount sufficient to compensate for their taste for discrimination (Becker, 1957).

Even in the absence of any direct or indirect effect of children on wages, a motherhood wage differential may be observed in OLS models if there are unobserved factors, such as work motivation, which are negatively correlated with the desire for children, and positively

[5] See Anderson, Binder and Krause (2002; 2003), Baum (2002), Budig and England (2001), Hill (1979), Joshi, Paci and Waldfogel (1999), Lundberg and Rose (2000), and Waldfogel (1995; 1997).
[6] This effect is accentuated for mothers who expect to work part-time hours following the birth of a child.

correlated with wages. On the other hand, the effect of motherhood on wages will be underestimated if those women most likely to experience a motherhood wage penalty are also the least likely to be employed. To account for these sources of bias, international studies have typically used panel data to estimate fixed effects models (e.g. Anderson, Binder and Krause, 2002; 2003; Budig and England, 2001; Lundberg and Rose, 2000).

A few of studies have also addressed reverse causality between motherhood and wages with instrumental variables methods. This paper does not account for reverse causality as potential instruments are either not available in Australia or not possible given the sample size.[7] The direction of possible reverse causality bias is not entirely clear. The motherhood penalty may be overstated if those women with lower wages, and hence a lower opportunity cost of leaving the workforce, are more likely to become mothers (Lundberg and Rose, 2000, p.692). Alternatively, an increase in the wage rate may have a positive income effect on having a child (Ariza and Ugidos, 2007).

III. EMPIRICAL APPROACH

Women's wages are assumed to be determined according to the human capital model:

$$\begin{aligned}\ln W_{it} = {} & \eta + \beta_1 Child1_{it} + \beta_2 Child2_{it} \\ & + \gamma_1 HC_{it} + \gamma_2 JC_{it} + \gamma_3 MS_{it} + \gamma_4 Year_t + \phi_i + u_{it}\end{aligned} \qquad \text{(Equation 1)}$$

where $\ln W_{it}$ is the natural logarithm of the hourly wage (in 2007 dollars) of woman i ($\forall i = 1,2,...,N$) in year t ($\forall t = 1,2,...,T$); $Child1_{it}$ and $Child2_{it}$ are dummy variables equal to one if the woman has one or more children (and has a valid wage rate), and two or

[7] Instruments used in the motherhood penalty literature include father's and mother's education, whether the woman lived with her parents in adolescence (Amuedo-Dorantes and Kimmel, 2005; Neumark and Korenman, 1994), the parent's educational goals for the woman, whether the woman's mother worked at age 14, the number of siblings (Neumark and Korenman, 1994; Simonsen and Skipper, 2006), the woman's past attitudes and her mother's family building history (Joshi, Paci and Waldfogel, 1999). Instruments used in studies of motherhood and other labour market outcomes include state and county indicators of the cost of fertility and fertility control and laws on pregnancy termination (Klepinger, Lundberg and Plotnick, 1999), miscarriage (Hotz, Williams McElroy and Sanders, 2005), sex-mix of the first two children (Angrist and Evans, 1998) and twin births (Jacobsen, Wishart Pearce and Rosenbloom, 1999).

more children respectively; HC_{it} is a vector of human capital variables, namely, work experience, experience squared, education and tenure with the current employer; JC_{it} is a vector of job characteristics, namely, part-time and casual employment status, industry, occupation, sector, firm size and union membership; MS_{it} is a vector of dummy variables representing marital status, namely, partnered and separated; $Year_t$ is a vector of year dummies; ϕ_i is an individual specific intercept; and u_{it} is a random error term.

To remove the individual specific intercepts ϕ_i, and hence control for time invariant unobserved characteristics, the variables in Equation 1 are demeaned, obtaining fixed effects estimates of the motherhood wage differential. A significantly negative (positive) β_1 indicates that there is a residual motherhood wage penalty (premium). Since $Child1_{it}$ and $Child2_{it}$ are equal to one if the woman has one or more children and two or more children respectively, the coefficient β_2 gives the incremental effect of a second child.[8]

To understand whether the wage differential arises immediately after birth or develops over time through wage growth, the methodology of Loughran and Zissimopoulos (2009, pp.331-333) is employed.

Modifying Equation 1 we obtain:

$$\ln W_{it} = \eta + b_1 Child1_{it} + b_2 Child2_{it} + b_3 YChild1_{it} + b_4 YChild2_{it} + \gamma_1 HC_{it} + \gamma_2 JC_{it} + \gamma_3 MS_{it} + \gamma_4 Year_t + \gamma_5 Gap_{it} + \alpha_i Exp_{it} + \vartheta Exp_{it}^2 + \phi_i + u_{it} \quad \text{(Equation 2)}$$

where HC_{it} represents education and tenure, with experience (Exp_{it}) and the quadratic in experience (Exp_{it}^2) included separately. In addition to $Child1_{it}$ and $Child2_{it}$, two

[8] To test for selection bias a Heckman selection model (Cameron and Trivedi, 2009, p.542-543) is estimated with the pooled sample using maximum likelihood estimation (see Table A.1, Appendix B for results). Non-labour income is used as an exclusion restriction following other studies (such as Amuedo-Dorantes and Kimmel, 2005; Baum, 2002; Booth and Wood, 2008; Joshi, Paci and Waldfogel, 1999; Korenman and Neumark, 1992; Krepp, 2007). Since self-employed women are excluded from the sample, the selection correction accounts for selection into being an employee rather than employment in general.

variables $YChild1_{it}$ and $YChild2_{it}$ are included which count the number of years since returning to the workforce after giving birth to the first and second child respectively (equal to one in the first year of return to work after birth).[9] Moreover, Gap_{it}, which measures the number of years not in the labour force around the first and second births, is included to capture the effect of human capital depreciation.[10]

In this specification, motherhood is allowed to affect both wage levels and wage growth. The immediate effect on the wage level in the first year of work after giving birth is given by $b_1 + b_3 + \gamma_5 \times \overline{Gap}^{1st}$ for the first child and the incremental effect of a second child is given by $b_2 + b_4 + \gamma_5 \times \overline{Gap}^{2nd}$. The effect of the birth on subsequent annual wage growth is given by b_3 for a first child and b_4 gives the incremental effect of additional children.

As well as allowing the wage equation to have separate intercepts (ϕ_i) the above model also allows different slopes in experience (α_i) for each individual, enabling individual specific unobserved factors to affect both wage levels and wage growth.

By taking first-differences of each variable and assuming that experience increases by one every year, we obtain:[11]

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[9] Instead of constructing first-differences of *YChild1* and *YChild2* and dividing by the number of years between interviews, this paper follows Loughran and Zissimopoulos (2009) in using the conceptually equivalent *Child1* and *Child2* variables instead. *Child1* and *Child2* are the more reliable measure as the information required to construct *YChild1* and *YChild2* is not available in the general release HILDA data.

[10] For women who gave birth and had an employment break, Gap_{it} is set equal to the number of waves not working, and remains at this value in the years thereafter. The coefficient γ_5 is constrained to be the same for first and second children.

[11] In the panel used by Loughran and Zissimopolous, individuals are not observed every year so experience does not necessarily increase by one between observations. To account for this, Loughran and Zissimopoulos re-introduce the square of experience in Equations 3 and 4 and divide the change in the log wage, experience and experience squared by the time elapsed between the respondent's interviews. Instead of diverging from the specifications, the sample and experience measure used in this paper to estimate Equations 3 and 4 will be constructed in such a way to ensure that experience increases by one between wage observations. In doing so, it is not necessary to include any additional variables in Equations 3 or 4, or to divide any variables by the time between interviews.

$$\Delta \ln W_{it} = b_1 \Delta Child1_{it} + b_2 \Delta Child2_{it} + b_3 Child1_{it} + b_4 Child2_{it} + \gamma_1 \Delta HC_{it} + \gamma_2 \Delta JC_{it} + \gamma_3 \Delta MS_{it} + \gamma_4 \Delta Year_t + \gamma_5 \Delta Gap_{it} + \alpha_i + \delta Exp_{it} + \Delta u_{it} \quad \text{(Equation 3)}$$

where $\delta = 2\vartheta$. The time invariant ϕ_i has been removed, however the effect of unobserved heterogeneity on wage growth, α_i, remains. This allows for the possibility that wages have different growth rates over time for different individuals. If unobserved productivity traits such as career motivation are positively correlated with wage growth and also induce women to delay or forego childbearing, coefficients b_{1-4} will be negatively biased. Similarly, if there are unobserved factors which increase wage growth and induce women to become mothers b_{1-4} will be positively biased. Demeaning Equation 3 eliminates α_i, obtaining a first-difference with fixed effects model:

$$\begin{aligned} \Delta \ln W_{it} - \overline{\Delta \ln W_i} = {} & b_1 \left(\Delta Child1_{it} - \overline{\Delta Child1_i}\right) + b_2 \left(\Delta Child2_{it} - \overline{\Delta Child2_i}\right) \\ & + b_3 \left(Child1_{it} - \overline{Child1_i}\right) + b_4 \left(Child2_{it} - \overline{Child2_i}\right) \\ & + \gamma_1 \left(\Delta HC_{it} - \overline{\Delta HC_i}\right) + \gamma_2 \left(\Delta JC_{it} - \overline{\Delta JC_i}\right) + \gamma_3 \left(\Delta MS_{it} - \overline{\Delta MS_i}\right) \\ & + \gamma_4 \left(\Delta Year_t - \overline{\Delta Year_t}\right) + \gamma_5 \left(\Delta Gap_{it} - \Delta Gap_i\right) + \delta \left(Exp_{it} - \overline{Exp_i}\right) + \left(\Delta u_{it} - \overline{\Delta u_i}\right) \end{aligned} \quad \text{(Equation 4)}$$

Estimation results will be presented for Equation 1 (as a pooled cross-section and with fixed effects), Equation 3 (first-difference) and Equation 4 (first-difference with fixed effects).

IV. DATA

The wage equations are estimated using unit-record data from the first seven waves (2001-2007) of the Household, Income and Labour Dynamics in Australia (HILDA) survey.[12] Over the seven waves of HILDA, a total of 9,792 women were surveyed resulting in 47,727 woman-year observations.[13]

[12] Table A1 defines the variables used.
[13] For more information on the HILDA survey see Wooden and Watson (2007).

TABLE 1

Sample Construction: Remaining Woman-Year Observations

Sample A:	
Women	47 727
Aged between 21 and 52	26 849
Employed	19 529
Employees (not self-employed)	17 131
Not studying full time	16 550
Not missing wage data	16 412
Not an outlying wage	16 272
Not inconsistent child data	16 195
No deceased children	15 953
Not missing human capital data	15 478
Not missing job characteristic data	14 975
Not missing marital status	14 972
Sample B:	
Part of a valid block encompassing 3 or more wages	11 683
Dropping the first observation from each block in making first-differences	9 365
Ratio of consecutive wages no more than 1.5	7 989

To estimate the effect of motherhood on wages (Equation 1) the sample is restricted to women between the ages of 21 and 52.[14] Since each woman-year observation must have a valid wage rate, 7,320 observations in which a woman was unemployed or out of the labour force were dropped. Other observations were excluded if the woman was self-employed, in full-time education, or had missing or in-consistent data.[15] Furthermore, outlying wage

[14] Women aged 21 years or less were excluded as wage rates of young workers are generally determined by junior pay rate scales and as such, do not reflect individual worker productivity. A further 2,549 women older than the usual childbearing age-range were also dropped. Inspection of the HILDA data shows that pregnancy rates fall greatly beyond the age of 45. To allow a woman aged close to 45 to have a child in the first of HILDA and be included in the sample in the waves that follow, only women aged 52 years or older were excluded.

[15] The self-employed were excluded as their wages are not determined in the same way as employees. Full-time students were excluded as their decisions about occupations and wage contracts are likely to differ from individual's no longer in full-time education. Observations were excluded if the total number of children the woman currently has exceeded the total number of children ever given birth to or adopted. This should not occur as foster and step children are not counted as children currently have in HILDA. Women with deceased children were also dropped as they may have wage effects stemming from childbearing and rearing in the past and therefore differ to women who have never had children. Observations with missing data on salary or hours worked, human capital, job characteristics or marital status were excluded.

observations in the top or bottom 0.5 percent of the remaining sample were excluded.[16] After applying all restrictions, a sample of 4,255 women (2,596 with one or more children, 1,998 with two or more children) making 14,972 woman-year observations was obtained (Sample A). Descriptive statistics for Sample A are provided in Table 2.

To estimate Equations 3 and 4, the change in each variable between the years a woman is working must be constructed. To ensure that experience changes by (around) one year between consecutive wage observations (as required to obtain Equation 3) first-differences are not taken over non-responding years. Instead, 'blocks' of consecutive years are identified where a woman was working and had a valid wage observation *or* was not employed.[17] To be included in the sample, each woman must have a valid block of responding years encompassing at least three wage observations to allow first-differences to be constructed, and the first-difference with fixed effects model to be estimated.[18] Excluding outlying wage growth observations where the ratio of consecutive wages exceeded a factor of 1.5, a final sample of 2,247 women making 7,989 woman-year observations remained (1,460 with one or more children, 1,137 with two or more children). In this sample, a total of 132 first births and 96 second births were observed (Sample B).[19]

[16] Testing revealed the results are generally insensitive to the wage cut-off chosen, and changing the wage cut-off has little effect on the conclusions drawn.

[17] This method should ensure that for the women in the sample, experience does not increase in the years no wage is observed.

[18] To make full use of the data, additional second blocks were identified. 82 women have 2 valid blocks (Waves 1-3 and Waves 5-7). First-differences are only taken within each block, that is, *not* across waves 5 and 3.

[19] That is, any wage which increased by more than 50 percent or decreased by more than one third was excluded. This corresponds to a change in the natural log of the hourly wage of $\pm$ 0.405. As discussed in Section VI, the results are sensitive to outlying wage growth observations.

TABLE 2
Descriptive Statistics for Sample A

	Mother	Non-Mother			Mother	Non-Mother	
Hourly wage	22.22	22.36		*Industry Continued*			
Log-hourly wage	3.03	3.04		Construction	0.04	0.04	
Age (years)	40.62	30.29	***	Retail/Hospitality	0.20	0.19	
Experience (years)	18.20	11.08	***	Transport	0.02	0.02	
Tenure (years)	6.03	4.29	***	Culture	0.03	0.06	***
Education				Finance/Science	0.11	0.21	***
Post-Graduate	0.10	0.13	***	Education/Health	0.49	0.37	***
Bachelor Degree	0.17	0.30	***	Other (Omitted)	0.03	0.03	
Diploma	0.10	0.13	***	*Sector*			
Certificate	0.17	0.12	***	Private Sector	0.56	0.62	***
Year 12	0.16	0.19	***	Public Sector	0.33	0.28	***
Year 11 (Omitted)	0.30	0.12	***	Other (Omitted)	0.11	0.10	
Occupation				*Firm Size*			
Manager	0.07	0.08		Small	0.24	0.22	**
Professional	0.26	0.36	***	Medium (Omitted)	0.13	0.14	
Trade	0.04	0.05	**	Large	0.62	0.64	
Community	0.16	0.09	***	*Other Job Characteristics*			
Clerical	0.27	0.27		Part-time Worker	0.54	0.18	***
Sales	0.10	0.09		Casual Worker	0.27	0.17	***
Machinery	0.02	0.01	*	Union member	0.30	0.27	***
Labourer (Omitted)	0.09	0.05	***	*Marital Status*			
Industry				Partnered	0.80	0.49	***
Primary	0.01	0.00	**	Separated	0.15	0.03	***
Utilities/Mining	0.00	0.01	***	Never Married	0.04	0.48	***
Manufacturing	0.06	0.07		(Omitted)			

Source: HILDA, Waves 1-7

Notes: *,**,** means mothers and non-mothers are statistically different at the 5%, 1% and 0.1% levels of significance. Means are weighted by cross-sectional probability weights

V. EMPIRICAL RESULTS

The pooled cross-sectional model reveals no significant raw wage differential between mothers and non-mothers (Table 3).[20] However, as mothers in the sample are older, and consequently have more years of experience than non-mothers, a significant eight percent penalty arises when controlling for experience. The penalty becomes small (around two percent) and insignificant when controlling for education and tenure. There continues to be no significant difference between mothers' and non-mothers' wages until controls are

[20] All models presented are un-weighted. There are no appropriate probability weights available for an unbalanced panel (using fixed effects and first difference estimation). Applying cross-sectional responding person weights to the pooled cross-sectional model has little effect on the estimates (results available on request).

included for marital status. In the final model, there remains a significant residual wage penalty of 2.7 percent for one child, and no incremental penalty for additional children.

A Heckman-corrected wage model (Table A.1, Appendix B) shows significant evidence of selection bias, with the Heckman-corrected motherhood penalty estimate for one child larger (by around 2.6 percentage points) than the pooled OLS results. This suggests that mothers most likely to suffer a wage penalty are less likely to be employed, and therefore failure to account for selection into employment will understate the true motherhood wage penalty.

The fixed effects estimates show no significant motherhood penalty controlling for human capital variables. However when part-time and casual status are added, a significant five percent penalty for one child, and four percent penalty for two or more children (significant at the ten percent level) appears, reflecting the large premium to part-time employment for Australian women (Table A.1, Appendix B).[21] This contrasts results for Britain and the United States which found part-time work to be a source of the motherhood penalty (Joshi, Paci and Waldfogel, 1999, Waldfogel, 1997).

Including other job characteristics and marital status has an immaterial effect on the motherhood coefficient. With all controls included, the fixed effects results show mothers with one child receive a five percent penalty while mothers of two or more children earn around nine percent less than non-mothers on average, even after controlling for observable and time-invariant unobservable differences.[22] These penalties are similar to the unweighted Heckman-corrected pooled estimates providing some evidence that selection into employment may be accounted for by fixed effects.

[21] A part-time wage premium is in line with the findings of Booth and Wood (2008)

[22] Fixed effects models were estimated allowing for interaction between motherhood and professional occupation, partnered and part-time status (results not shown). None of the interaction terms however were significant suggesting that the motherhood penalty is not statistically different across marital, part-time work and professional occupation status.

TABLE 3

Pooled Cross-Section OLS

N = 14915 (4242)	*No controls*	*Experience Only*	*+Education, tenure*	*+Part-time, Casual Status*	*+Industry, Occupation*	*+Sector, Firm Size, Union Status*	*+Marital Status (All Controls)*
Child1	-0.007	-0.075***	-0.022	-0.022	-0.013	-0.014	-0.027*
	(0.016)	(0.016)	(0.014)	(0.015)	(0.013)	(0.013)	(0.013)
Child2	-0.006	-0.026	-0.009	-0.009	-0.020	-0.018	-0.023
	(0.016)	(0.016)	(0.014)	(0.014)	(0.012)	(0.012)	(0.012)
R^2	0.009	0.054	0.231	0.235	0.300	0.311	0.313
F	17.721***	45.854***	114.438***	106.573***	87.553***	82.867***	82.338***
Fixed Effects							
N = 14915 (4242)							
Child1	0.013	0.010	0.010	-0.051*	-0.049*	-0.049*	-0.049*
	(0.020)	(0.020)	(0.020)	(0.021)	(0.020)	(0.020)	(0.020)
Child2	-0.041	-0.033	-0.032	-0.042	-0.041	-0.040	-0.039
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
R^2	0.042	0.048	0.048	0.065	0.073	0.076	0.076
F	46.600***	42.155***	27.352***	32.588***	19.783***	17.957***	17.166***

Source: HILDA, Waves 1-7

Notes: Robust clustered standard errors are used; standard errors are in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependant variable is the natural log of the hourly wage in constant 2007 dollars. All regressions correspond to Equation 1. *Child1* is the estimated effect of motherhood on log wages of the first child;*Child2* gives the incremental effect of a second child. Regressions are not weighted. Full results for final model reported in Table A.1, Appendix B.

This implies that mothers do not differ from non-mothers on unobservable productivity traits, other than those which affect selection into employment.

The residual wage penalty is consistent with a 'tired mother' effect whereby mothers have less energy to devote to work. Alternatively, motherhood may have no causal effect on productivity, yet a wage penalty arises through 'taste' discrimination or an (inaccurate) perception by employers that mothers are less productive.

The penalty estimates are similar to some observed for the United States (Lundberg and Rose, 2000; Waldfogel, 1997; Waldfogel, 1998b) however are larger than estimates for Denmark (Gupta and Smith, 2002) and other American results (Anderson, Binder and Krause, 2002; 2003; Budig and England, 2001), and smaller than results for Britain (Waldfogel, 1995; 1998b).[23]

To determine whether the wage differential arises immediately after the birth of a child, or reflects the effect of motherhood on wage growth, Equations 3 and 4 have been estimated. The first-difference results reveal that having a first or second child has no immediate effect on the wage level (Table 4). Across all sets of control variables, the average effect of having a child in the first year of return to work is close to zero and not statistically significant. Contrary to prior expectations of a negative effect, the coefficient of *Gap* is not statistically different from zero.

In contrast, the coefficient of *YChild1* shows that having a first child significantly reduces wage growth. After the birth of a first child, annual wage growth is reduced by one percentage point ($p<0.05$). The coefficient of *YChild2* shows an offsetting positive effect of a second child on wage growth, however is not significant at conventional

[23] This result stands in contrast to prior Australian studies which found no significant residual motherhood wage penalty (Krepp, 2007; Whitehouse, 2002). The difference does not appear to be due to unobserved heterogeneity as a significant motherhood wage penalty was also found in the pooled cross-sectional model. As such, the contrasting results are likely to be due to differences in the way mothers are defined, sample composition, the time periods covered and the controls included in the models.

levels. Altogether, the first-difference model suggests that the wage differential between mothers and non-mothers has come about through a reduction in wage growth, rather than an immediate fall in the wage level after birth. Loughran and Zissimopoulos (2009) found the opposite result for the United States finding motherhood reduces wages by two percent in the year of birth, and has no significant effect on subsequent wage growth

The first difference with fixed effects model was estimated to account for the effect of unobserved heterogeneity on wage growth (Table 5). The immediate effects of motherhood on the wage level remain generally the same. In contrast, allowing for individual slopes in experience has a large impact on the effect of motherhood on wage growth. The point estimates show having a first child reduces wages by 3.5 percent per year and having a second child *increases* annual wage growth by around 4.5 percentage points. However, the standard errors are much larger in Equation 4 rendering the effect of a first child insignificant, and the effect of a second child only significant at the ten percent level.

The dissimilarity of the Equation 3 and 4 point estimates may be due to the effect of unobserved heterogeneity on wage growth, which is only controlled for in the latter model. A comparison of the coefficients suggests that those women with wage-growth enhancing unobserved traits are more likely to have a first child, but less likely to have a second. However, since these effects are only marginally significant at best, there may be no systematic effect on wage growth when unobserved factors are taken into account.

Further analysis reveals that while the first-difference model (Equation 3) is relatively insensitive to the inclusion of large wage-growth observations, the first-difference with fixed effects model (Equation 4) shows very large and opposing impacts

TABLE 4

First Difference

N = 7989 (2247)	*No controls*	*Experience Only*	*+Gap*	*+Education, tenure*	*+Part-time, Casual Status*	*+Industry, Occupation*	*+Sector, Firm Size, Union Status*	*+Marital Status (All Controls)*
Child1 (b_1)	0.036*	0.034	0.018	0.018	-0.004	-0.005	-0.005	-0.005
	(0.018)	(0.018)	(0.019)	(0.019)	(0.018)	(0.018)	(0.018)	(0.018)
Child2 (b_2)	-0.019	-0.021	-0.034	-0.033	-0.034	-0.033	-0.033	-0.033
	(0.019)	(0.019)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Gap (γ_5)	-	-	0.038	0.039	0.031	0.033	0.033	0.033
			(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Effect of Motherhood on Wage Growth								
YChild1 (b_3)	-0.014**	-0.012*	-0.012*	-0.012*	-0.010*	-0.010	-0.010	-0.010*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
YChild2 (b_4)	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Immediate Effect of Motherhood:								
First Child: $b_1 + b_3 + \gamma_5 \times \overline{Gap}^{1st}$	0.0218	0.022	0.030	0.031	0.005	0.006	0.007	0.006
	(0.017)	(0.018)	(0.019)	(0.019)	(0.018)	(0.018)	(0.018)	(0.020)
Second Child: $b_2 + b_4 + \gamma_5 \times \overline{Gap}^{2nd}$	-0.013	-0.015	0.030	-0.004	-0.008	-0.007	-0.006	-0.007
	(0.019)	(0.019)	(0.019)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
R^2	0.003	0.003	0.003	0.005	0.018	0.024	0.024	0.024
F	2.212*	2.261**	2.260**	2.142**	5.984***	4.322***	3.823***	3.743***

Source: HILDA, Waves 1-7

Notes: Robust clustered standard errors are used; standard errors are in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependant variable, the natural log of the hourly wage, and all regressors, are in first-difference form as specified in Equation 3. Full results for final model are reported in Table A.1, Appendix B. $b_1 + b_3 + \gamma_5 \times \overline{Gap}^{1st}$ gives the estimated average effect of motherhood on log wages in the year of returning to work after the birth of the first child where $\overline{Gap}^{1st}$ is equal to 0.63; b_3 gives the estimated effect of a first child on subsequent annual wage growth. $b_2 + b_4 + \gamma_5 \times \overline{Gap}^{2nd}$ and b_4 give the incremental effect of a second child on wage levels and wage growth where $\overline{Gap}^{2nd}$ is equal to 0.59. In regressions where *Gap* is not controlled for, the immediate effects for a first and second child are $b_1 + b_3$ and $b_2 + b_4$ respectively.

TABLE 5

First Difference with Fixed Effects

N = 7989 (2247)	*No controls*	*Experience Only*	*+Gap*	*+Education , tenure*	*+Part-time, Casual Status*	*+Industry, Occupation*	*+Sector, Firm Size, Union Status*	*+Marital Status (All Controls)*
Child1 (b_1)	0.055*	0.054*	0.039	0.039	0.018	0.019	0.019	0.020
	(0.026)	(0.026)	(0.028)	(0.028)	(0.026)	(0.026)	(0.026)	(0.026)
Child2 (b_2)	-0.033	-0.033	-0.045	-0.044	-0.045	-0.045	-0.045	-0.045
	(0.026)	(0.026)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Gap (γ_5)	-	-	0.039	0.039	0.032	0.034	0.033	0.034
			(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Effect of Motherhood on Wage Growth								
YChild1 (b_3)	-0.037	-0.036	-0.034	-0.035	-0.032	-0.034	-0.033	-0.035
	(0.022)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
YChild2 (b_4)	0.048	0.049	0.048	0.047	0.048	0.045	0.045	0.045
	(0.026)	(0.027)	(0.026)	(0.027)	(0.026)	(0.027)	(0.027)	(0.027)
Immediate Effect of Motherhood								
First Child: $b_1 + b_3 + \gamma_5 \times \overline{Gap}^{1st}$	0.018	0.018	0.030	0.029	0.007	0.006	0.007	0.006
	(0.015)	(0.023)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Second Child: $b_2 + b_4 + \gamma_5 \times \overline{Gap}^{2nd}$	0.015	0.015	0.026	0.026	0.022	0.020	0.020	0.020
	(0.027)	(0.027)	(0.028)	(0.028)	(0.028)	(0.028)	(0.030)	(0.028)
R^2	0.003	0.003	0.003	0.004	0.017	0.023	0.023	0.023
F	1.569	1.442	1.408	1.244	4.445***	3.269***	2.919***	2.853***

Source: HILDA, Waves 1-7

Notes: Robust clustered standard errors are used; standard errors are in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependant variable, the natural log of the hourly wage, and all regressors, are in first-difference form as specified in Equation 4. Full results for final model are reported in Table A.1, Appendix B. $b_1 + b_3 + \gamma_5 \times \overline{Gap}^{1st}$ gives the estimated average effect of motherhood on log wages in the year of returning to work after the birth of the first child where $\overline{Gap}^{1st}$ is equal to 0.63; b_3 gives the estimated effect of a first child on subsequent annual wage growth. $b_2 + b_4 + \gamma_5 \times \overline{Gap}^{2nd}$ and b_4 give the incremental effect of a second child on wage levels and wage growth where $\overline{Gap}^{2nd}$ is equal to 0.59. In regressions where *Gap* is not controlled for, the immediate effects for a first and second child are $b_1 + b_3$ and $b_2 + b_4$ respectively.

of a first and second child on wage growth, which are inconsistent with the motherhood penalties presented in Table 2 (Table A.2, Appendix B). In estimating the latter model for the United States with the National Longitudinal Survey (NLS) data sets, Loughran and Zissimopoulos (2009) reported no such sensitivity. It appears that the first-difference with fixed effects specification is too demanding for seven waves of HILDA data used and requires a longer panel to obtain precise results.

The sample sizes reported in Table A.2 show that a large portion of women have large year-to-year wage changes. The source of these large changes is unclear, however given the sensitivity of the results, they are presumably not explained by the variables included in the model.

VI. Summary and Conclusions

Holding observable and unobservable differences constant, fixed effects estimates reveal mothers with one child earn around five percent less than non-mothers on average, with a further four percent penalty for a second child. This residual wage penalty may be due to actual productivity differences if responsibility for children leaves mothers with less energy to exert at work. Alternatively, mothers may be paid less than non-mothers because employers perceive mothers to be less productive or have a 'taste' for discriminating against them.

Contrary to studies overseas, part-time employment was not found to be a source of the motherhood wage penalty. Similarly, the propensity of mothers to work in certain occupations, industries and sectors explains little of the gap.

The first-difference results (Equation 3) show a first or second child has no immediate effect on wages in the first year of returning to work, but a first child reduces subsequent annual wage growth by one percentage point. Sensitivity tests showed these

results are relatively robust to large wage changes. The first difference with fixed-effects (Equation 4) results however proved much more sensitive to outliers.

Overall, the wage growth analysis suggests that the motherhood penalty emerges through reduced wage growth, rather than an immediate wage decline after birth. This is consistent with Australian maternity leave legislation which entitles most women to return to their prior position with their pre-birth employer and thus wages may be unaffected in the short-term. However subsequent wage growth may be reduced if the presence of children reduces mothers' actual or perceived productivity, or if employers have a taste for discrimination. Moreover, a reduction in wage growth is also consistent with flatter wage profiles for part-time workers.

As such, policies which make combining work and motherhood easier are likely to improve Australian mothers' wages and wage growth relative to non-mothers'. Greater access to childcare services, particularly in the workplace, may improve women's ability, and employer's perception of their ability, to balance family and work. Moreover, practices which improve career advancement of part-time workers are likely to increase mothers' wage growth.

Future research may estimate the motherhood penalty using instrumental variables techniques; as more waves of data become available in HILDA, instruments used overseas such as sibling sex-mix may be feasible. A longer panel may also render the first-difference with fixed effects specification more robust. Given the sensitivity of the wage growth results and the large proportion of women with large year-to-year wage changes, further investigation into the source of outlying wage trajectories is warranted.

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APPENDIX A

Description of Variables

Hourly Wage. Usual weekly gross wages and salary in the main job divided by the hours per week usually worked in the main job. Nominal wages are converted to 2007 dollars.

Child Variables. A mother is defined as a woman with one or more natural or adopted, resident or non-resident living children of any age. Children who have since died, foster children and step children are not counted when constructing the $Child1$ and $Child2$.

Experience (Equations 1 and 2). Equations 1 and 2 use the HILDA variable for work experience which measures time (expressed in years) spent in paid work in all jobs, part-time or full-time, since finishing full-time education for the first time.

Experience (Equations 3 and 4). In the way the sample is constructed, actual experience increases by approximately one year between wage observations. However due to differences in the interview dates, and incomplete work years, most changes in experience are slightly more or less than one. Since the econometric specification requires that experience increases by exactly one each year, experience has been constructed which equals actual experience in the first year, and increases by one each working year thereafter. The constructed and HILDA experience variables are strongly correlated ($\rho = 0.99$).

Education. The highest education level achieved:

Post Grad = Doctorate, Masters, Graduated Diploma or Graduate Certificate
Bachelor = Bachelor Degree
Diploma = Diploma or Advanced Diploma
Certificate = Certificate I, II, III, IV or undefined certificate level
Yr 12 = Year 12
Yr 11 = Year 11 or below

Tenure. Time (expressed in years) spent working with the current employer.

Part-time. Part-time employees are those working fewer than 35 hours per week.

Casual. Casual workers are those receiving no paid holiday or pay sick leave.

Industry: The Australian and New Zealand Standard Industrial Classification (ANZSIC) classification is used:

Primary = Agriculture, Forestry and Fishing
Util/Mining = Electricity, Gas, Water, Waste Services and Mining
Manufacture = Manufacturing
Construction = Construction and Wholesale Trade
Ret/Hosp = Retail Trade, Accommodation, Food Services and Administration
Transport = Transport, Postal and Warehousing
Culture = Information, Media, Telecommunications, Arts and Recreation
Fin/Science = Financial, Insurance, Rental, Hiring, Real Estate, Professional, Scientific and Technical Services
Educ/Health = Public Administration and Safety, Education and Training, Health Care and Social Assistance
Other = Other Services

Occupation: The Australia and New Zealand Standard Classification of Occupations (ANZSCO) is used:

Managers = Managers
Professionals = Professionals
Trade = Technicians and Trade Workers

Community = Community and Personal Services Work
Clerical = Clerical and Administrative Workers
Sales = Sales Workers
Machinery = Machinery Operators and Drivers
Labourers = Labourers

Sector. Sector is defined as:
Private = Private for Profit Organisation
Public = Government Enterprise or Organisation
Other = Private not-for-profit Organisation, Other Commercial, Other Non-Commercial

Firm Size. The number of people employed by the respondent's employer at locations throughout Australia is used as the measure of firm size. If respondent's indicated that their firm only operated from their workplace, the number of employees at their place of work was used:
Small = < 20 employees
Medium = 20-99 employees, including those who responded "don't know but more than 20" to the question of number of employees at place of work, and those who responded "don't know but less than 100" to the question of number of employees in locations around Australia.
Large = >100 employees

Union Status. Union members

Marital Status. Marital status categories are:
Partnered = Married and De facto
Separated = Divorced, Separated or Widowed
Never = Never Married and not De-facto

Non-Labour Income. A woman's financial year wages and salary was subtracted from the household financial year income (excluding windfall gains), and the result divided by the number of adult equivalents in the household.

APPENDIX B
Estimation Results

TABLE A.1

	Pooled OLS	Pooled Heckman	Fixed Effects	First-Difference	First-Difference with Fixed Effects
Child1	-0.027*	-0.053***	-0.049*	-0.005	0.020
YChild1				-0.010*	-0.035
Child2	-0.023	-0.027*	-0.039	-0.033	-0.045
YChild2				0.006	0.045
Exp	0.019***	0.023***	0.068***		
Exp²/100	-0.042***	-0.048***	-0.043***	-0.040*	-0.074
Gap				0.033	0.034
Post Grad	0.231***	0.250***	0.096	0.105*	0.068
Bachelor	0.174***	0.196***	0.050	0.087*	0.055
Diploma	0.083***	0.096***	0.035	0.033	0.036
Certificate	0.023	0.035**	0.019	0.010	0.022
Year 12	0.028*	0.040**	0.046	0.052	0.051
Tenure	0.005***	0.005***	-0.000	0.001	0.001
Part-time	0.057***	0.056***	0.107***	0.048***	0.044***
Casual	-0.003	-0.005	0.032**	0.034***	0.035***
Primary	-0.028	-0.027	0.048	-0.010	-0.017
Util/Mining	0.194***	0.196***	0.127**	0.029	0.019
Manufacturing	0.056*	0.057*	0.014	0.001	-0.015
Construction	0.041	0.042	0.037	0.011	0.003
Ret/Hosp	-0.055*	-0.053*	-0.010	0.020	0.016
Transport	0.052	0.052	0.000	0.030	0.034
Culture	0.067*	0.067*	0.038	0.010	0.011
Fin/Science	0.083***	0.083**	0.026	0.020	0.014
Educ/Health	0.031	0.032	0.052*	0.042*	0.033
Manager	0.286***	0.285***	0.059*	0.011	0.011
Professional	0.284***	0.285***	0.069**	0.011	0.009
Trade	0.073***	0.074***	0.025	0.000	-0.003
Community	0.063***	0.063***	0.008	0.011	0.013
Clerical	0.135***	0.135***	0.025	-0.011	-0.009
Sales	0.080***	0.081***	-0.014	-0.028	-0.031
Machinery	0.034	0.035	0.028	0.005	0.010
Private	0.064***	0.064***	-0.013	-0.009	-0.005
Public	0.077***	0.077***	0.009	-0.001	-0.005
Small	-0.029*	-0.029*	-0.021	-0.004	(0.011)
Large	0.044***	0.044***	0.023*	-0.001	-0.000
Union	0.010	0.011	-0.004	0.001	-0.003
Partnered	0.055***	0.050***	0.028*	-0.007	0.005
Separated	0.032*	0.030	0.044*	0.004	-0.016
Constant	2.417***	2.348***	2.063***	0.070***	0.077
R^2	0.313		0.076	0.024	0.024
F	82.338***		17.166***	3.743***	3.743***
N (Censored)	14972	14972	14972	7989	7989
N (Uncensored)		8347			
Log L		-17104.7***			
λ		0.080			
ρ		0.248			
Wald χ^2		16.84***			

Notes: Robust clustered standard errors are used; standard errors are in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Year dummies are included in all models. *Log L* is the log pseudolikelihood. λ is the estimated inverse Mill's ratio. ρ is the estimated correlation between the wage and employment equation error terms. χ^2 is the chi squared value from a Wald test of independence of the wage and selection equations ($H_0 : \rho = 0$).

TABLE A.2

	Wage Growth Cut-off *Observations with wage growth in excess of this were dropped*			
	0.182	0.405	0.693	0.916
First-Difference (Equation 3)				
Effect of Motherhood on Wage Growth				
YChild1 (b_3)	-0.001	-0.010*	-0.010	-0.008
	(0.004)	(0.005)	(0.006)	(0.007)
YChild2 (b_4)	-0.000	0.006	0.008	0.002
	(0.004)	(0.005)	(0.006)	(0.006)
Immediate Effect of Motherhood				
First Child: $b_1 + b_3 + \gamma_5 \times \overline{Gap}^{1st}$	-0.014	0.006	-0.022	-0.027
	(0.013)	(0.020)	(0.025)	(0.027)
Second Child: $b_2 + b_4 + \gamma_5 \times \overline{Gap}^{2nd}$	-0.018	-0.007	0.027	0.026
	(0.013)	(0.020)	(0.029)	(0.033)
First-Difference with Fixed effects (Equation 4)				
Effect of Motherhood on Wage Growth				
YChild1 (b_3)	-0.030	-0.035	-0.085*	-0.080*
	(0.019)	(0.023)	(0.033)	(0.035)
YChild2 (b_4)	0.030	0.045	0.079*	0.099**
	(0.021)	(0.027)	(0.035)	(0.037)
Immediate Effect of Motherhood				
First Child: $b_1 + b_3 + \gamma_5 \times \overline{Gap}^{1st}$	-0.009	0.006	-0.059	-0.055
	(0.018)	(0.025)	(0.033)	(0.036)
Second Child: $b_2 + b_4 + \gamma_5 \times \overline{Gap}^{2nd}$	0.012	0.020	0.065	0.094
	(0.019)	(0.028)	(0.014)	(0.048)
N (Total Observations)	5553	7989	8948	9159
N (First Births)	76	132	162	167
N (Second Births)	66	96	119	126

Source: HILDA, Waves 1-7. *Notes:* Robust clustered standard errors are used; standard errors in parentheses, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$. The dependant variable, the natural log of the hourly wage, and all regressors, are in first-difference form as specified in Equations 3 and 4. All regressions include full controls and are unweighted.