University of Wollongong
Economics Working Paper Series 2010

http://www.uow.edu.au/commerce/econ/wpapers.html

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WP 10-12

November 2010

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October 2010

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Key Words: Motherhood Wage Penalty, Wage Growth, Fixed Effects

JEL Classification: J31, J13, C33

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Abstract

Labour market theory provides several reasons why mothers are likely to earn lower hourly wages than non-mothers. However, the size of any motherhood penalty is an empirical matter and the 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 control for other relevant factors, both observed and unobserved. Using data from the Household, Income and Labour Dynamics in Australia (HILDA) survey, an unexplained motherhood wage penalty of around four per cent for one child, and eight per cent 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 the birth of a child. This reduction in wage growth is consistent with discrimination but also with a reduction in mothers' work effort.

I. Introduction

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[1], Britain (Waldfogel, 1995; 1998a), Canada (Drolet, 2002) and Germany

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[1] 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; 1998a).

(Buligescu *et al.*, 2009).[2] However, 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, so the evidence is mixed.

Although the effects of children on wages may work indirectly by affecting the mother's work experience, job tenure, education and job choices, most studies focus on estimating the direct effect of children. To that end, a motherhood penalty is typically estimated with the characteristics of the woman and her job, and sometimes time-invariant unobserved heterogeneity, held constant. In studies which have found such a penalty, estimates range from two per cent (Baum, 2002; Loughran and Zissimopoulos, 2009) to nine per cent (Waldfogel, 1995; 1998a) for one child and a further two (Anderson, Binder and Krause, 2002; 2003) to nine per cent (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 wage penalty using a Heckman-corrected cross-sectional model to account for selection into employment. Although these Australian studies have found no direct

[2] 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). This indicates that motherhood has a negative effect on wages, independent of the effects of marriage.

effect of motherhood on wages, their results are potentially biased by unobserved heterogeneity and the omission of key controls.[3]

Understanding the effect of children on women's wages and wage growth is important to current Australian policy. The policy options for counteracting the fiscal effects of an ageing population include increasing birth rates whilst maintaining high levels of female labour force participation (LFP) (Australian Treasury Department, 2007). However the success of such a policy depends upon the extent to which the presence of children affects mothers' wages, which in turn affect 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, so measuring the motherhood wage differential will shed light on this hypothesis (Waldfogel, 1998b).

Finally, the opportunity costs born by mothers are of social importance. If good parenting provides positive externalities to the community, it can be argued that 'good' mothers disproportionately incur the costs of childbearing (Budig and England, 2001), which include not only the *explicit* costs of food, clothing, health, education and shelter but also the implicit costs of wages foregone.

Given the importance of the issue to policy and the paucity of prior Australian research, this paper contributes to the literature by examining whether Australian mothers, on average, earn lower hourly wages than non-mothers. Fixed-effects estimates of the motherhood penalty, which are robust to time-invariant unobserved

[3] In Whitehouse's model, the coefficient of motherhood may be biased towards zero 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).

factors, are obtained using an unbalanced panel from the first eight waves of the Household Income and Labour Dynamics in Australia (HILDA) survey.[4] The fixed-effects results are compared with OLS and Heckman-corrected estimates, calculated with pooled cross-sectional data, to gauge the extent of heterogeneity and selection bias.

Whether the motherhood wage differential arises immediately after birth, or develops over time through wage growth is also investigated. The first-difference and first-difference with 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 estimated using the Australian data. The results consistently show that the wage penalty is a result of slower wage growth.

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

II. Theoretical Background

Economic theory provides a number of non-mutually exclusive reasons why a raw wage penalty between mothers and non-mothers may exist. The main reason is the greater frequency and duration of work interruptions among mothers, which may reduce

[4] The HILDA Project was initiated and is funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and is managed by the Melbourne Institute of Applied Economic and Social Research (MIAESR). The findings and views reported in this paper, however, are those of the authors and should not be attributed to either FaHCSIA or the MIAESR.

wages through foregone work 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 if they accumulate less work experience and have fewer opportunities for promotion (Abhayaratna *et al.*, 2008).

The effort required to raise children may also reduce mothers' wages according to Becker's (1985) 'worker effort' hypothesis (Budig and England, 2001). Furthermore, even if mothers and non-mothers are equally productive, a wage penalty may arise through statistical discrimination if employers *believe* 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 penalty may be observed in OLS models if there are unobserved factors, such as work motivation, which are negatively correlated with the desire for

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[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.

children, and positively 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 some of 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 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 the Australian data 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, higher wage rates may have an income effect that increases the probability of having a child (Ariza and Ugidos, 2007).

III. Empirical Approach

Initially, women's wages are assumed to be determined according to the human capital model:

[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 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).

$$\ln W_{it} = \eta + \beta_1 Child1_{it} + \beta_2 Child2_{it} + \gamma_1 HC_{it} + \gamma_2 JC_{it} + \gamma_3 MS_{it} + \gamma_4 Year_t + \varphi_i + u_{it} \quad [1]$$

where $\ln W_{it}$ is the natural logarithm of the hourly wage (in 2008 dollars) of woman i (i=1,2,…,N) in year t (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 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 time-demeaned, facilitating fixed-effects estimates of the motherhood wage differential. A significantly negative (positive) estimate of β_1 indicates that there is a 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.

To understand whether the wage differential arises immediately after birth or develops over time through wage growth, a methodology similar to that of Loughran and Zissimopoulos (2009, pp.331-333) is employed. Modifying Equation 1 we obtain:

$$\begin{aligned}\ln W_{it} = {} & \eta + \beta_1 Child1_{it} + \beta_2 Child2_{it} + \beta_3 YChild1_{it} + \beta_4 YChild2_{it} \\ & + \gamma_1 HC_{it} + \gamma_2 JC_{it} + \gamma_3 MS_{it} + \gamma_4 Year_t + \gamma_5 Gap_{it} \\ & + \alpha_i Exp_{it} + \vartheta Exp_{it}^2 + \varphi_i + u_{it}\end{aligned} \quad [2]$$

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 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).[8] 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.[9]

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 $\beta_1 + \beta_3 + \gamma_5 \times \overline{Gap}^{1st}$ for the first child and the incremental effect of a second child is given by $\beta_2 + \beta_4 + \gamma_5 \times \overline{Gap}^{2nd}$. The effect of the birth on subsequent annual wage growth is given by β_3 for a first child and β_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:[10]

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[8] 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.

[9] 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 $\gamma_5$is constrained to be the same for first and second children.

[10] 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

$$
\begin{aligned}
\Delta \ln W_{it} = & \beta_1 \Delta Child1_{it} + \beta_2 \Delta Child2_{it} + \beta_3 Child1_{it} + \beta_4 Child2_{it} \\
& + \gamma_1 \Delta HC_{it} + \gamma_2 \Delta JC_{it} + \gamma_3 \Delta MS_{it} + \gamma_4 \Delta Year_t + \gamma_5 \Delta Gap_{it} \\
& + \alpha_i + \delta Exp_{it} + \Delta u_{it}
\end{aligned} \quad [3]
$$

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 β_1 to β_4, will be negatively biased. Similarly, if there are unobserved factors which increase wage growth and induce women to become mothers β_1 to β_4 will be positively biased.

Time-demeaning Equation 3 eliminates α_i, obtaining a first-difference with fixed-effects model:

$$
\begin{aligned}
\Delta \ln W_{it} - \overline{\Delta \ln W_{it}} = & \beta_1 (\Delta Child1_{it} - \overline{\Delta Child1_{it}}) + \beta_2 (\Delta Child2_{it} - \overline{\Delta Child2_{it}}) \\
& + \beta_3 (Child1_{it} - \overline{Child1_{it}}) + \beta_4 (Child2_{it} - \overline{Child2_{it}}) \\
& + \gamma_1 (\Delta HC_{it} - \overline{\Delta HC_{it}}) + \gamma_2 (\Delta JC_{it} - \overline{\Delta JC_{it}}) + \gamma_3 (\Delta MS_{it} - \overline{\Delta MS_{it}}) \\
& + \gamma_4 (\Delta Year_t - \overline{\Delta Year_t}) + \gamma_5 (\Delta Gap_{it} - \overline{\Delta Gap_{it}}) \\
& + \delta (Exp_{it} - \overline{Exp_{it}}) + (\Delta u_{it} - \overline{\Delta u_{it}})
\end{aligned} \quad [4]
$$

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 eight waves (2001-2008) of the Household, Income and Labour Dynamics in Australia

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estimate Equations 3 and 4 is 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.

(HILDA) survey.[11] Over the eight waves of HILDA, a total of 10,121 responding women were surveyed resulting in 54,490 woman-year observations.[12]

To estimate the effect of motherhood on wages (Equation 1), the sample is restricted to women between the ages of 21 and 52 (see Table 1).[13] Since each woman-year observation must have a valid wage rate, 8,146 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 inconsistent data.[14] Furthermore, outlying wage observations in the top or bottom 0.5 per cent of the remaining sample were excluded.[15] After applying all restrictions, a sample of 4,476 women (2,731 with one or more children in at least one wave, 2,103 with two or more children) making 17,012 woman-year observations was obtained (Sample A). Descriptive statistics for Sample A are provided in Table 2.

[Table 1 about here.]

[Table 2 about here.]

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 (approximately) one year between consecutive wage observations (as required to obtain

[11] Definitions of the variables used appear in Livermore (2009) and are available on request.

[12] For more information on the HILDA survey see Wooden and Watson (2007).

[13] 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. 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 wave of HILDA and be included in the sample in the waves that follow, only women aged 52 years or older were excluded.

[14] 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 woman currently has a total number of children in excess of the total number she ever gave 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. Therefore, they may differ from women who have never had children. Observations with missing data on salary or hours worked, human capital, job characteristics or marital status were excluded.

[15] 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.

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.[16] 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.[17] Excluding outlying wage growth observations where the ratio of consecutive wages exceeded a factor of 1.5, a final sample of 2,420 women making 9,397 woman-year observations remained (1,576 with one or more children in at least one wave, 1,225 with two or more children). In this sample, a total of 161 first births and 114 second births were observed (Sample B).[18]

V. Empirical Results[19]

In the absence of controls, Child1 and Child2 in Equation 1 are not statistically significant) (Table 3).[20] However, as mothers in the sample are older, and consequently have more years of experience than non-mothers, a significant eight per cent penalty arises when controlling for experience. The penalty becomes small (around two per cent) and insignificant when controlling for education and tenure. There continues to be no significant difference between mothers' and non-mothers' wages until controls are

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

[17] 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.

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

[19] Full results for all the models are reported in Appendix A, Table A.1.

[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 wage penalty of 3.0 per cent for one child, and a slightly smaller incremental penalty for an additional child, which is also significant.

[Table 3 about here.]

A Heckman-corrected wage model (Appendix A, Table A.1) shows significant evidence of selection bias, with the Heckman-corrected motherhood penalty estimate for one child larger (by around 2.8 percentage points) than the pooled OLS results.[21] This suggests that mothers who are 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 of Equation 1 in Table 3 show no significant motherhood penalty after controlling for human capital variables. However when part-time and casual status are added, a significant 4.5 per cent penalty for one child, and 3.9 per cent penalty for two or more children (significant at the ten per cent level) appears, reflecting the large premium to part-time employment for Australian women.[22] This contrasts with 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 little effect on the motherhood coefficient. With all controls included, the fixed-effects results show mothers with one child receive a 4.4 per cent penalty while mothers of two or more children earn around 8.1 per cent less than non-mothers on average, even after

[21] A Heckman selection model (Cameron and Trivedi, 2009, p.542-543) was estimated with the pooled sample using maximum likelihood estimation. Non-labour income was 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.
[22] A part-time wage premium is in line with the findings of Booth and Wood (2008).

controlling for observable and time-invariant unobservable differences (Appendix A, Table A.1).[23] These penalties are similar to the Heckman-corrected pooled estimates providing some evidence that selection into employment may be accounted for by fixed effects.

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

The wage penalty is consistent with Becker's (1985) 'worker effort' hypothesis 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, 1998a) but 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; 1998a).[24]

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 (FD) 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

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[23] Additional fixed-effects models were estimated allowing for interaction between motherhood and professional occupation, partnered and part-time status. The results are not included in this paper because none of the interaction terms were significant, suggesting that the motherhood penalty is not statistically different across marital, part-time work and professional occupation status.

[24] This result stands in contrast to prior Australian studies which found no significant 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.

not statistically significant. Contrary to prior expectations of a negative effect, the coefficient of *Gap* is not statistically different from zero.

[Table 4 about here.]

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 1.2 percentage points (p=0.012). The coefficient of *YChild2* shows an offsetting positive effect of a second child on wage growth that borders on statistical significance (p=0.054). 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; they found motherhood reduces wages by two per cent in the year of birth, and has no significant effect on subsequent wage growth.

The first-difference with fixed-effects (FD-FE) 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 are nonsignificant, small and very similar to those estimated in the FD models. However, allowing for individual slopes in experience increases the estimated effect of motherhood on wage growth. The point estimates imply that having a first child reduces wage growth by 3.1 per cent per year. In both the FD and FD-FE results, the effect of motherhood on wage growth is largely confined to mothers of only one child. The effect of having 2 or more children (compared to childlessness) on wage growth is the sum of the coefficients of Ychild1 and Ychild2. In all models considered, this sum is close to zero.

[Table 5 about here.]

The larger effect of motherhood on wage growth in the FD-FE model 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, the discrepancy may just reflect the lower precision in the FD-FE models. In any case, the FD-FE results strongly suggest that the (significant) FD estimates are not simply a result of a bias due to high skill women opting out of motherhood. If anything, the magnitude of the wage growth effects are underestimated in the FD models.

The magnitude (and significance) of the estimates is somewhat sensitive to the criteria for excluding outlying wage observations (see Table A.2). However, the key results are not qualitatively sensitive to the exclusion criteria, nor to the choice of model (FD vs FD-FE).

VI. Summary and Conclusions

Holding observable and unobservable differences constant, fixed-effects estimates reveal mothers with one child earn around four per cent less than non-mothers on average, with a further four per cent 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. Policies which help mothers balance work and family, such as greater access to childcare services, are likely to improve Australian mothers’ wages relative to that of non-mothers.

The first-difference results (Equation 3) show that 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 wage growth by over one percentage point per annum. The first-difference with fixed-effects results (Equation 4), whilst less precise, demonstrate that the effect of a first child on wage growth is not simply the result of bias due to high skill women opting out of motherhood, and imply that the effect of a first child on wage growth may be considerably larger (around 3 percentage points per annum).

These results are 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.

Furthermore, the significant effects on wage growth are confined to mothers of only one child. The most plausible explanation for this surprising result is that having *only* one child is acting as a proxy for the presence of young infants. In our models, the effect of one child on wage growth is identified by wage changes amongst mothers with one child only. This child is usually young, since most mothers have a second child fairly soon after the first. In contrast, the incremental effect of a second child is identified by all women with two or more children and a small fraction of these children are infants. This explanation is consistent with the simpler models which find the incremental effect on wages of a second child to roughly equal the effect of a first child. More research is warranted to investigate this further as additional waves of HILDA data become available.

Future research might also focus on estimating the motherhood penalty using instrumental variables techniques; as more waves of HILDA data become available, instruments such as sibling sex-mix may be feasible. A longer panel may also yield greater precision to the estimates, particularly for the first-difference with fixed-effects specification.

APPENDIX A

Estimation Results

TABLE A.1

	Pooled OLS	Pooled Heckman	Fixed Effects	First Difference	First Difference with Fixed Effects
Child1	-0.030*	-0.058***	-0.044*	-0.001	0.020
YChild1				-0.012*	-0.031
Child2	-0.025*	-0.027*	-0.037	-0.023	-0.032
YChild2				0.009	0.040
Exp	0.020***	0.023***	0.066***		
Exp^2/100	-0.043***	-0.049***	-0.045***	-0.000*	-0.010
Gap				0.022	0.017
Post Grad	0.223***	0.246***	0.083	0.077	0.028
Bachelor	0.176***	0.199***	0.053	0.066	0.021
Diploma	0.084***	0.099***	0.017	0.046	0.033
Certificate	0.021	0.034**	0.014	0.019	0.026
Year 12	0.030*	0.043***	0.018	0.053	0.056
Tenure	0.005***	0.005***	-0.001	0.001	0.001
Part-time	0.054***	0.055***	0.103***	0.048***	0.045***
Casual	0.007	0.002	0.039***	0.035***	0.040***
Primary	-0.015	-0.022	0.055	-0.004	-0.006
Util/Mining	0.200***	0.201***	0.135**	0.030	0.015
Manufacturing	0.061*	0.061*	0.025	0.004	-0.010
Construction	0.048	0.049	0.035	0.003	-0.007
Ret/Hosp	-0.046*	-0.049*	-0.009	0.014	0.010
Transport	0.062	0.065	0.010	0.026	0.030
Culture	0.076**	0.076**	0.048	0.016	0.015
Fin/Science	0.093***	0.090***	0.043	0.024	0.014
Educ/Health	0.041	0.041	0.058*	0.045**	0.040*
Manager	0.291***	0.291***	0.079***	0.018	0.016
Professional	0.289***	0.287***	0.096***	0.017	0.016
Trade	0.082***	0.084***	0.029	0.010	0.013
Community	0.075***	0.073***	0.026	0.024	0.025
Clerical	0.143***	0.143***	0.046*	-0.003	-0.005
Sales	0.084***	0.086***	0.010	-0.015	-0.021
Machinery	0.050	0.043	0.068	0.024	0.022
Private	0.064***	0.068***	-0.010	-0.004	-0.001
Public	0.080***	0.082***	0.014	-0.006	-0.008
Small	-0.033**	-0.033**	-0.026*	-0.006	-0.003
Large	0.045***	0.047***	0.027**	-0.002	-0.002
Union	0.011	0.013	0.008	-0.003	0.001
Partnered	0.056***	0.051***	0.042**	-0.000	-0.005
Separated	0.041**	0.037*	0.047*	0.002	-0.009
Constant	2.443***	2.368***	2.119***	0.054***	0.219*
R^2	0.319		0.089	0.024	0.025
F	89.27***		20.95***	4.15***	3.47***
N (Uncensored)	17,012	17,036	17,012	9,397	9,397
N (Censored)		9,224			
Log L		-19274***			
λ		0.080			
ρ		0.249			
Wald χ^2		28.12***			

Source: HILDA, Waves 1-8.

Notes: Robust clustered standard errors are used; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. 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 (β_3)	-0.000	-0.012*	-0.009	-0.006
	(0.003)	(0.005)	(0.006)	(0.006)
YChild2 (β_4)	-0.002	0.009	0.008	-0.001
	(0.003)	(0.004)	(0.005)	(0.006)
First Difference with Fixed effects (Equation 4)				
Effect of Motherhood on Wage Growth				
YChild1 (β_3)	-0.018	-0.031	-0.063**	-0.048
	(0.015)	(0.019)	(0.024)	(0.026)
YChild2 (β_4)	0.017	0.040	0.058*	0.056
	(0.017)	(0.022)	(0.027)	(0.032)
N (Total Observations)	6,544	9,397	10,479	10,728
N (First Births)	95	161	192	197
N (Second Births)	79	114	139	148

Source: HILDA, Waves 1-8.

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.

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TABLE 1

Sample Construction: Remaining Woman-Year Observations

Sample A:	
Women	54 490
Aged between 21 and 52	30 444
Employed	22 298
Employees (not self-employed)	19 605
Not studying full time	18 934
Not missing wage data	18 777
Not an outlying wage	18 591
Not inconsistent child data	18 511
No deceased children	18 238
Not missing human capital data	17 585
Not missing job characteristic data	17 015
Not missing marital status	17 012
Sample B:	
Part of a valid block encompassing 3 or more wages	13 454
Dropping the first observation from each block in making first differences	10 922
Ratio of consecutive wages no more than 1.5	9 397

Source: HILDA, Waves 1-8.

TABLE 2

Descriptive Statistics for Sample A

	Mother	Non-Mother			Mother	Non-Mother	
Hourly wage	23.35	23.54		*Industry Continued*			
Log-hourly wage	3.08	3.09	*	Construction	0.04	0.04	
Age (years)	40.68	30.29	***	Retail/Hospitality	0.19	0.19	
Experience (years)	18.23	11.04	***	Transport	0.02	0.02	
Tenure (years)	6.11	4.35	***	Culture	0.03	0.06	***
Education				Finance/Science	0.11	0.20	***
Post-Graduate	0.10	0.14	***	Education/Health	0.49	0.37	***
Bachelor Degree	0.17	0.30	***	Other (Omitted)	0.02	0.03	
Diploma	0.10	0.13	***	*Sector*			
Certificate	0.17	0.12	***	Private Sector	0.56	0.62	***
Year 12	0.15	0.19	***	Public Sector	0.33	0.28	***
Year 11 (Omitted)	0.29	0.12	***	Other (Omitted)	0.11	0.10	*
Occupation				*Firm Size*			
Manager	0.07	0.08	*	Small	0.24	0.21	***
Professional	0.26	0.36	***	Medium (Omitted)	0.13	0.15	*
Trade	0.04	0.05	***	Large	0.63	0.64	
Community	0.16	0.10	***	*Other Job Characteristics*			
Clerical	0.27	0.27		Part-time Worker	0.53	0.18	***
Sales	0.10	0.09		Casual Worker	0.26	0.17	***
Machinery	0.02	0.01	***	Union member	0.30	0.26	***
Labourer (Omitted)	0.09	0.05	***	*Marital Status*			
Industry				Partnered	0.80	0.48	***
Primary	0.01	0.01	***	Separated	0.15	0.03	***
Utilities/Mining	0.01	0.01	***	Never Married (Omitted)	0.04	0.49	***
Manufacturing	0.07	0.07					

Source: HILDA, Waves 1-8.

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

TABLE 3

Pooled Cross-Section OLS

N = 17012 (4476)	*No controls*	*Experience Only*	*+Education, tenure*	*+Part-time, Casual Status*	*+Industry, Occupation*	*+Sector, Firm Size, Union Status*	*+Marital Status (All Controls)*
Child1	-0.010	-0.077***	-0.024	-0.024	-0.017	-0.015	-0.030*
	(0.015)	(0.015)	(0.013)	(0.013)	(0.012)	(0.012)	(0.012)
Child2	-0.004	-0.026	-0.011	-0.011	-0.019	-0.021	-0.025*
	(0.015)	(0.015)	(0.013)	(0.012)	(0.011)	(0.011)	(0.011)
R^2	0.012	0.057	0.235	0.238	0.316	0.305	0.319
F	20.25***	49.41***	119.77***	110.87***	90.44***	93.76***	89.27***

Fixed Effects

N = 17012 (4476)	*No controls*	*Experience Only*	*+Education, tenure*	*+Part-time, Casual Status*	*+Industry, Occupation*	*+Sector, Firm Size, Union Status*	*+Marital Status (All Controls)*
Child1	0.021	0.014	0.014	-0.045*	-0.044*	-0.044*	-0.044*
	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Child2	-0.037	-0.029	-0.028	-0.039	-0.039	-0.039	-0.037
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
R^2	0.049	0.056	0.056	0.073	0.083	0.087	0.087
F	50.14***	47.29***	31.62***	36.91***	23.76***	21.79***	20.95***

Source: HILDA, Waves 1-8.

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 2008 dollars. All regressions correspond to Equation 1. Regressions are not weighted. Full results for final model reported in Table A.1, Appendix A.

TABLE 4
First Difference

N = 9397 (2420)	*No controls*	*Experience Only*	*+Gap*	*+Education, tenure*	*+Part-time, Casual Status*	*+Industry, Occupation*	*+Sector, Firm Size, Union Status*	*+Marital Status (All Controls)*
Child1 (β_1)	0.039*	0.036*	0.024	0.024	-0.000	-0.001	-0.001	-0.001
	(0.016)	(0.016)	(0.017)	(0.018)	(0.017)	(0.016)	(0.016)	(0.016)
Child2 (β_2)	-0.008	-0.010	-0.022	-0.021	-0.024	-0.023	-0.023	-0.023
	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)	(0.018)	(0.019)	(0.019)
Gap (γ_5)			0.030	0.031	0.023	0.022	0.022	0.022
			(0.021)	(0.021)	(0.021)	(0.020)	(0.021)	(0.021)
Effect of Motherhood on Wage Growth								
YChild1 (β_3)	-0.015**	-0.013**	-0.013**	-0.013**	-0.012*	-0.012*	-0.012*	-0.012*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
YChild2 (β_4)	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009
	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Immediate Effect of Motherhood:								
First Child: $\beta_1 + \beta_3 + \gamma_5 \times \overline{\text{Gap}}^{1st}$	0.023	0.023	0.029	0.030	0.002	0.001	0.002	0.002
	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Second Child: $\beta_2 + \beta_4 + \gamma_5 \times \overline{\text{Gap}}^{2nd}$	-0.000	-0.002	0.004	0.005	-0.002	-0.002	-0.001	-0.002
	(0.018)	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
R^2	0.003	0.003	0.003	0.004	0.018	0.024	0.024	0.024
F	2.28**	2.33**	2.33**	2.04**	6.48***	4.84***	4.33***	4.15***

Source: HILDA, Waves 1-8
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 A.

TABLE 5

First Difference with Fixed Effects

N = 9397 (2420)	*No controls*	*Experience Only*	*+Gap*	*+Education , tenure*	*+Part-time, Casual Status*	*+Industry, Occupation*	*+Sector, Firm Size, Union Status*	*+Marital Status (All Controls)*
Child1 (β_1)	0.046*	0.051*	0.040	0.040	0.018	0.019	0.019	0.020
	(0.023)	(0.023)	(0.025)	(0.025)	(0.024)	(0.023)	(0.023)	(0.023)
Child2 (β_2)	-0.026	-0.023	-0.032	-0.032	-0.033	-0.032	-0.032	-0.032
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Gap (γ_5)			0.026	0.026	0.018	0.017	0.017	0.017
			(0.025)	(0.025)	(0.025)	(0.024)	(0.024)	(0.024)
Effect of Motherhood on Wage Growth								
YChild1 (β_3)	-0.025	-0.031	-0.030	-0.031	-0.029	-0.030	-0.030	-0.031
	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
YChild2 (β_4)	0.048*	0.044	0.043	0.043	0.042	0.040	0.040	0.040
	(0.022)	(0.023)	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)	(0.022)
Immediate Effect of Motherhood								
First Child $\beta_1 + \beta_3 + \gamma_5 \times \overline{\mathrm{Gap}}^{\mathrm{1st}}$	0.021	0.019	0.026	0.026	0.000	-0.000	-0.000	-0.000
	(0.019)	(0.019)	(0.021)	(0.021)	(0.021)	(0.020)	(0.020)	(0.020)
Second Child $\beta_2 + \beta_4 + \gamma_5 \times \overline{\mathrm{Gap}}^{\mathrm{2nd}}$	0.023	0.020	0.026	0.026	0.020	0.018	0.018	0.018
	(0.025)	(0.025)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
R^2	0.002	0.003	0.003	0.004	0.018	0.025	0.025	0.025
F	1.34	1.37	1.41	1.27	5.07***	3.99***	3.61***	3.47***

Source: HILDA, Waves 1-8

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 A.