An Econometric Evaluation of Women's Labour Supply in WA

A Report Prepared for the Western Australia Department of Consumer and Employment Protection

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23 July 2008

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[1] Thanks to staff at the National Institute of Labour Studies (NILS) for their valuable assistance.

Executive Summary

Following a comprehensive review of the recent theoretical and applied econometric literature, we use sophisticated panel (longitudinal) data econometric models to examine factors affecting female labour force participation and hours of labour supply for Western Australia (WA) and Australia.

Labour supply behaviour of females differs to that of males, and the behaviour of single females differs to that of females with partners. Notwithstanding the changes in forms of employment over the last decade, female labour force participation and hours work are significantly lower than for males. Moreover, a greater proportion of single females work full-time hours compared to females with partners, and single females generally work more hours per week compared to females with partners. Child-rearing is generally undertaken by females, and childcare responsibilities continue throughout much of the female's working age life thus partially explaining lower average rates of labour market activity of females.

This Report examines which factors explain labour force participation and of hours of work of single and partnered females, with or without dependants, of age 18-64 years (excluding full-time students and self-employed females) using the six annual (2001-2006) waves of the Household, Income and Labour Dynamics in Australia (HILDA) survey data.

In the HILDA data, the WA sample is small in comparison with the preferred sample size used in empirical research directed at labour market issues. Therefore, notwithstanding the aim of this Report is to provide distinct analysis for WA, models for Australia are likely to be a superior guide to underlying drivers of labour market behaviour and to provide indicators of directions for further research, and implications for policy directions.

In this Report, econometric models issues such as "sample selection bias" (female supply hours of work are not a random selection from the population), unobserved individual characteristics (unobserved heterogeneity), and dynamics of behaviour are controlled so that econometric model estimates are unbiased and reliable, leading to dependable conclusions.

When models are estimated, a number of issues are dealt with at a more refined level than necessarily included in previous studies—and issues not always included in previous analysis are examined. For example, the influence on hours of work supplied of maternity leave, union membership, and immigrant's length of residence in Australia are examined.

While the econometric results in this Report are robust, several areas where further research is warranted are identified. For example, the analysis of female hours of work is estimated based on the "unitary" labour supply model: although, the more recent literature suggests a "collective" model of household labour supply is more appropriate for couple-households (with or without children), currently available econometric software precludes the use of this more advanced approach.

Female Labour Force Participation

Models for female labour force participation require adjustment for labour market dynamics, but no underlying trend in participation was found for the six-year period of the HILDA data.

A number of factors are confirmed as influences on female participation including, years of work experience, education, non-labour income, health, non-residential children, and marital status.

Generally, children below five years of age reduce couple females' participation, but children over five years of age increase participation. Single Australian females do not appear to be influenced by children below the age of five years, but increase participation for children between 15 and 24 years. WA single females' results differ (e.g. children below age five reduce participation, but older children have no impact). This is an area where further investigation would be useful (e.g. interaction effects such as access to childcare).

The immigrant's period of residence was strongly influential in the Australian, but not the WA, models of participation (the WA result is probably due to a small sample exacerbated by immigrants making up a small proportion of the sample). Thus, government-provided access to English language tuition, job search skills, and information about the operation of the Australian labour market may increase the participation of immigrant females to that of otherwise similar non-immigrants. This method of measuring the impact of being an immigrant is an innovation and is an area where further research may be valuable.

Interestingly, there appears to be little if any impact of partner's attributes on participation: partner's education plays no role; partner's non-resident children play no role; and although partner's wage is statistically significant for WA couple females, the impact is quite small. Nonetheless, marital status always matters for couple females hence suggesting an inter-dependence of female and partner's decisions and hence supporting use of the "collective" labour supply models when the limitations imposed by currently available theory and software can be overcome (see further comments below).

Conventional wisdom is that single and couple females have different patterns of labour force participation. It is clear from the models for Australia and WA that there are surprising similarities, but there remain distinct differences for single and couple females (e.g. non-labour income has a larger impact for single females than couple females).

In summary, although there are, for both Australia and WA, a number of similarities in the model estimates for single females and couple females, there are important differences. Failure to model singles and couples separately is an aggregation problem leading to potentially incorrect inference and misguided policy analysis and recommendations.

Policy implications arising from the analysis of female labour force participation tend to follow the literature—there are limits to potential intervention, and most policy can at best be directed to longer-term issues. For example, education generally increases the probability of labour force participation, but education (and associated vocational skills development) is not subject to short-run manipulation. Similarly, very young children in a household reduces the participation rate of females, but whether there is a long-term advantage to pursue methods to increase the participation of this group is a complex question, as is the issue of what influences the decision to have a child and its relationship to labour market participation.

Examination of the model results does not suggest any particularly striking differences in drivers of labour force participation between Australia and WA females for single or partnered females.

Supply of Hours of Paid Work

Econometric models examine the impact of selected determinants on females' supply of hours of paid work per week for the sub-sample of females who are employed.

As with labour force participation, dynamics must be accounted for in models, but there is no evidence of a consistent underlying trend in hours supplied (except for an irregular reduction in hours worked for single females in WA across the waves of data). Similarly, examination of hours supplied confirms the appropriateness of modelling single and partnered females separately.

Not all partner's attributes include in the models are significant influences on female hours of work, but they are not irrelevant—and in conjunction with the participation equation (and the employment equation used to ensure hours supplied equations do not suffer from selection bias) suggest a tendency for inter-dependence of female and partner's labour market decisions. This supports further research using "collective" labour supply models to obtain more efficient and robust estimates, and to observe intra-household welfare allocations (when, in particular, software to estimate appropriate models is available).

Some factors influence females' probability of labour force participation, but do not have a further impact on hours supplied, e.g. non-labour income has no impact, and education has a much reduced impact.

Mental health appears to have no impact on the number of hours supplied. This result is at odds with common understanding of the influence of stress in the workplace. The influence of physical health also requires further research: while results are consistent for three of the four models (and influence participation as expected), they are counter intuitive: good health implies reduces hours of labour supplied. The impact of mental and physical health requires further investigation.

The influence of children at home on hours supplied depends, as expected, on the age of the children. For example, for Australian couple females, an own-child at home reduce the number of hours worked, but the impact of children for single females is about half that of couple females for children to age 14—with no impact of children age 15 to 24. Results appear to differ for the WA models—this is a case where the Australian results probably are more reliable to sample size issues (combined with the distribution of children across the samples). The presence of non-residential own or partner's children have little impact on hours supplied, being significant in only the Australia couple females model.

The direction of the impact of age on hours supplied is generally consistent across specifications, but the size of the impact varies with model specification (e.g. a one year increase in age increase hours supplied by two per cent for Australia single and couple females, and by six per cent for WA single females, but for WA couples there is a perverse 6 per cent reduction). The Australian results should be considered more reliable. Diminishing returns to age are generally observed, but the impact is very small. An implication from age results is that industry's apparent preference for younger workers is counter-productive. It is often due to discrimination, as employers simply assume older workers are less productive. Hours worked by females may be increased by demand side policy that influence industry's reported negative attitude to older workers.

The impact of being an immigrant differs in models for Australia and WA (the Australian result is probably more reliable). Where significant, in contrast with the impact on participation, as the length of residence increases the number of hours supplied decreases. The reason for this outcome is unknown and warrants further investigation.

Wage rates matters only in the Australian couple model—and the direction of the influence is consistent with the "backward bending" labour supply curve associated with higher level wage earners. The lack of influence for single females suggests a lack of access to other sources of income curtails their ability to reduce hours, but neither do they increase hours when wage increases suggesting they are "time poor". The issue of the impact of wage on hours supplied may be complex and requires further investigation.

All models demonstrate that the availability of paid or unpaid maternity leave is an important influence on hours supplied by both single and couple females. In addition, partner's paternity leave is influential for Australian couple females, but the result is counter-intuitive: the availability of leave reduces hours supplied. As maternity leave is an area that could be influenced by government intervention the importance of the availability of such leave requires further investigation. Thus, for example, as well as more detailed specification of leave entitlements in econometric specifications, the interaction between industry sector and leave could be considered—are there industries where greater attention should be directed?

There are other influences on hours supplied, although there is little if any scope to influence them, directly or indirectly, and hence no avenue for policy intervention. Nonetheless, their absence in previous models is a model misspecification—leading to unreliable econometric results. Factors considered are trade union membership (generally, a positive influence on hours worked); industry sector, and in the Australian models state of residence.

In summary, as with the participation models, there are, generally (but not necessarily across the four models or sub-samples) a number of similarities for single and couple females behaviour with respect to hours of work supplied (e.g. control for dynamics and "state dependency", trend, non-residential "own" children, health, age, maternity leave, and impact of being an immigrant). On the other hand, there are important differences for single and couple females (e.g. the impact of children, education, non-labour income, wage, employed in the public or private, state of residence, and industry).

Conclusion

This Report is based on estimating labour force participation and supply of hours of paid work equations for single and couple females in Western Australia and Australia. The Report provides justification for the econometric models chosen and discusses the limitations of the models and the ensuing results. Throughout, references are made to a number of issues that should be considered for future research to extend the scope of this work.

To the extent possible, given current theoretical and applied limitations, models reported are based on recent advances in both theoretical and practical applications of panel (longitudinal) data econometric models. Notwithstanding constraints, the models are an advance on previous methods, and so provide econometric model results that are more reliable: biases due to model misspecification (including missing variables), unobserved heterogeneity, selection bias, and dynamics and "state dependency", have been addressed.

A number of innovations in this Report (beyond the use of advanced modelling techniques) provide added perspective on the hours supplied decision of females. For example, the availability of maternity leave has an impact in all hours of supply equations, and the period of residence of immigrants is also influential (via a more detailed method of including immigrants' in models not previous considered).

Overall, the model results clearly indicate that female data must be disaggregated to single and couple females sub-samples. Although the explanatory power of several important explanatory variables is not different across single and couple female models, a sufficient number differ importantly—aggregation of single and couple females results in "aggregation bias" and unreliable econometric estimates.

The Report provides interesting insights to females' behaviour, and suggests some areas where government policy intervention may contribute to increased hours supplied—for example, maternity leave and access to labour market skills for immigrants. Advances in theory and econometric practice are likely to provide appropriate, "collective" model which may lead to further insights into female labour market interactions and hence may suggest avenues for government intervention to increase hours of work.

On the other hand, the probability of labour force participation seems to suggest few areas where state government intervention could successfully influence participation. This area could be considered for further investigation.

Suggestions for further Research

The most important field for future research is to utilise recent theoretical extension of labour supply modelling, and move beyond the "unitary" approach to the "collective" approach. In the collective approach, labour market decisions of couples are made according to the power relationship, and not on the assumption that there is an entity, the household, that makes the "unitary" decision. Nonetheless, although theoretically advanced, impediments to constructing complex "collective" models exist, including the appropriate treatment of children, and designation of the internal balance of power which influences the decision making process. While such models are currently beyond "off the shelf" econometric packages, academic work continues, and testable specifications, and econometric package add-ons—are expected to become available.

Samples for smaller population state such as WA limit the application of advance models. Differential results for Australian females and WA females are probably due to small samples for WA and not necessarily differential behaviour, thus models for Australia may be satisfactorily informative. This constraint cannot be overcome without a large investment in state specific data collections—which, even if conducted, will require several years of data collection before there are sufficient data and time-period or waves of survey data to construct the necessarily complex models for female labour market interactions.

Finally, models for females have been examined. An important question for further research is consideration of the reaction of male partners to female's changes in participation and hours supplied—if female increased participation or hours worked is at the expense of a reduction in male participation or hours the overall problem of shortages of supply are not addressed: which sector should be targeted?

The Work Undertaken

This National Institute of Labour Studies (NILS) "Report" for the Western Australian Department of Consumer and Employment Protection (DOCEP) presents the results of econometric modelling of female labour force participation and the supply of hours (contingent on being employed) for females in Western Australia (WA) and for Australia.

We use sophisticated panel (longitudinal) data econometric models which are based on an extensive review of the recent theoretical and applied econometric literature addressing labour supply for single and partnered individuals.[2] Applied econometric models of labour force participation and hours of labour supply in this Report:

a) investigate the set of factors which influence women's decisions, the relative importance of explanatory factors, and implied semi-elasticities (i.e. the percent change in the dependent variable for a one unit change in an explanatory variable);

b) control for unobserved individual level attributes or characteristics (i.e. unobserved heterogeneity);

c) incorporate dynamics to control for the influence of previous period values and "state dependency"[3] on the current value of the dependent variable;

d) adopt a two-stage selection model to account for potential bias in econometric estimates due to "selection bias" in models of hours of labour supply (i.e. labour supply is contingent on a labour force participant female being employed); and

e) analyses separate models for single females and for females with male partners.

Following the report of the results of econometric modelling, we canvas the implications of the econometric model results for influencing the labour supply of women.

Background

Labour Supply Shortages—WA and Australia

The present shortage of labour in WA is an amplified version of that being experienced throughout Australia. Labour shortages, which present a serious problem from the point of view of employers, are a consequence of the surge in the demand for skilled workers from the above average annual rate of economic growth: for example, between 1992 and 2006, real per capita Gross State Product (GSP) rose by 78 per cent in WA—and Gross Domestic Product (GDP) in Australian rose by 52 per cent (ABS 2006a). Skill or labour shortages also reflect underlying demographic changes in WA and nationally. Moreover, the Productivity Commission projects a rapid decline in labour force growth in Australia (annual labour force growth is projected to fall from the current levels of around 1.6 per cent per annum to less

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[2] See Chiappori (1988); Chiappori (1992); Nijman and Verbeek (1992); Fortin and Lacroix (1997); Aronsson *et al.* (1999); Vella and Verbeek (1999); Ligon (2002); Donnie (2003); Bloemen (2004); Chiappori and Donni (2005); Breunig *et al.* (2005); Creedy and Kalb (2005); Vermeulen (2005); Vermeulen (2006); Blundell *et al.* (2007); Couprie (2007); and van Klaveren (2008).

[3] Specifically, when correlation between observations over time (e.g. waves of panel data) is due to a mechanism influenced by the individual's state prior to the observed data.

than 0.6 per cent over the next 20 years). The diminution in Australian labour force growth is a result of an ageing population and the resulting fall in labour force participation: retirement rather than contraction in the number of young entrants to the labour force is the main explanation for the projected fall in Australia's labour force growth rate.

Employment Issues

The increased labour market participation of women during the last 20 years (e.g. from 61 per cent in 1988 to 65 per cent in 2007—concurrent with a fall in male participation from 78 per cent to 72 per cent), particularly those married and with children, has been one of the most significant economic and social changes of recent times. Moreover, recent growth in employment has been particularly strong in casual employment (e.g. between 1992 and 2005, nationally, there as a 19 per cent increase in casual employment for men and a 16 per cent increase for women, while part-time permanent employment for women grew by 20 per cent compared to 4 per cent for men (ABS 2006b)). A new trend has also developed—the full-time casual, but this trend has affected men more than women (e.g. between 1992 and 2005 an increase of 9 per cent for men and 5 per cent for women (ABS 2006c)).

Focus of Attention in this Report

While the gender wage gap is a useful summary of one aspect of women's labour supply, it is not the wage gap that should be, or is, the focus of attention in this Report. Moreover, a great deal is known about the gender wage gap—for example, Todd and Eveline (2004, p.24) note "There is a substantial body of research to explain the gender wage gap both in Australia and internationally". Todd and Eveline's comprehensive review, and nine-point list of factors contributing to the gender wage gap, support the view that the gender gap is not the issue that is of direct concern.

Moreover, a recent study using the HILDA data for Australia concludes that the gender wage gap for low-paid workers is fully explained by gender differences in productivity-related characteristics. The gender wage gap for high-wage women cannot, however, be attributed to productivity-related differences—the wage gap for private sector workers is about 40 per cent productivity-related, the gap in the public sector is unexplained (Barón and Cobb-Clark 2008).[4]

In addition, the conclusion from the materials presented in the NILS Submission to DOCEP (October 2007) was that the issue is not what has caused the increase in the WA gender wage gap, because the increase has been a feature of relative pay for over 10 years and there are several understandable reasons for the increases that are beyond policy control (e.g. occupational structure). More important for policy development is to understand what factors contribute to a change in labour supply (participation rates and hours supplied) of women. Thus, the substantive issue is women's labour supply—wage (and hence the wage gap) plays some part, but it is not the whole answer to increasing labour force participation and hours supplied by women in WA (the impact of wage is an empirical question addressed below).

[4] Barón and Cobb-Clark (2008) suggest this result is consistent with the presence of a "glass ceiling" rather than a "sticky floor" and different wage setting mechanisms in the public and private sectors. Due to small sample for WA, separate public-private models are not considered, but a dummy variable is included in the labour supply equation to control for sector.

Finally, policy aimed at reducing the gender wage gap may not directly alter women's labour supply—e.g. the gender wage gap could be closed by a reduction in male wages, but this would not directly change female supply.[5] Labour shortage analysis requires assessment of the determinants of female labour supply (i.e. hours worked, employment and participation)—with wage examined for its relevance as a contributing factor.

Factors Influencing Women's Labour Supply

When considering the determinants of labour market outcomes it is possible to take advantage of the extensive, detailed, theoretical and empirical literature and thus assemble a list of variables to be included as explanatory variables in labour market models (Winkelmann 2006). This Report follows the second course and uses the abundant literature to identify measures that influence the probability of being a labour market participant, of being employed, and the hours supplied (see Lester (2008) for a detailed review of the literature of factors influencing labour market outcomes[6]).

In addition to variables derived from the literature review, there remain unobserved (and generally unmeasurable) individual attributes that influence labour market outcomes, including psychological and behavioural traits, motivation, self-direction, and ambition, (Groves 2005; Isacsson 2007). General unobserved characteristics, which bias econometric estimates based on cross-sectional (or pooled panel data[7]) data, are not usually available (and are not available in the data used in this Report—or any other potential data set), but econometric models—discussed below—can be constructed to deal with individual unobserved heterogeneity (Lester 2007).

Labour supply behaviour of females with partners differs from single females. Child-rearing activity is clearly undertaken more by females than males, and this continues throughout much of the female's working age life. Moreover, beyond the age when it can be assumed children have left the family home, female labour supply remains less than males (e.g. after the first child, at age 48, hour of work per annum by women is about 35 per cent that of men's hours[8]). Female labour supply, as a household decision, favours male labour force participation due to comparative advantage (e.g. women who have exited the labour market to bear children will, on average, have less labour market experience than a similar aged male and will therefore attract a lower per hour wage rate). In addition, one view is that Australian families are "time poor" and this is particularly so for working mothers. If this is so, at some point in the wage distribution, a further increase in wage may not necessarily increase labour supply: it may allow women to reduce hours worked—i.e. a "backward bending" labour supply curve, usually associated with higher wage brackets, may operate for mothers with partners.

In addition, a greater proportion of single females work "full-time" hours compared to partnered females, and single females work an average of 36 hours per week compared to 26

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[5] In a "collective" model where bargaining took place in the household this may alter female labour supply—see below.
[6] Lester (2008, Ch.4) examines immigrants' labour market success, but, except for immigrant specific issues (e.g. country of education), the review is equally informative for labour market outcomes for all individuals.
[7] That is, treating waves of the panel data as if they were collected at the same time, or as a single cross-section.
[8] Apps (2007)—Original data: ABS Survey of Income and Housing 2003-04.

hours for couple females. Sole parent females may also have a different pattern of hours supplied, but small sample size for WA precludes treating them as a separate group.[9]

While a female's age is expected to influence labour supply—child rearing or caring generally occurs in a specific age period—due to limits on sample size, particularly for WA, it is not possible to estimate econometric models for individual age groups, it is only possible to control for age in the hours of supply equation by including age as an explanatory variable.[10]

The empirical questions therefore are, using models of female participation and hours worked (contingent on being employed), which explanatory variables (measured attributes, characteristics, or demographic factors) are shown to have a statistically significant estimated coefficient (e.g. wage rate is expected to have a positive coefficient and therefore is associated with increased hours). In models used in this Report, estimated coefficients can be interpreted as semi-elasticities (i.e. if an explanatory or independent variable x increases by 1 unit, what is the percent increase or decrease in the dependent variable such as hours supplied?).

Econometric modelling of the participation decision, and for those in the labour force their labour supply (i.e. hours of work), is undertaken based on the Household, Income and Labour Dynamics in Australia (HILDA) survey data.

The HILDA Data

The Household, Income and Labour Dynamics in Australia (HILDA) survey (funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs) is designed and managed by the Melbourne Institute of Applied Economic and Social Research at the University of Melbourne. The impetus for the survey was to trace the income, labour market, and family dynamics of the Australian population, over an extended period. The first survey was conducted in 2001, with subsequent surveys conducted annually: six waves of data are currently available.

The initial sample selection of the HILDA survey went to great lengths to ensure that the sample was random, that attrition of respondents from year to year was minimised, and that the survey had an indefinite life. The reference population was all Australian residents who lived in private households as their primary place of residence. The sample was selected using a stratified approach by state and by metropolitan and non-metropolitan regions. Data were collected through personal interviews and through self-completion questionnaires.

In the first wave, 7683 households were selected. This resulted in a sample of 15127 persons, age 15 years or older, eligible for interview: 13969 individuals were successfully interviewed. Subsequent interviews for later waves were conducted one year apart.

The HILDA wave-on-wave (Australia wide) attrition rates have fallen at each wave, and falls compare well with international standards: 13.2 per cent (Wave 2), 9.6 per cent (Wave 3), 5.6 per cent 8.4 per cent (Wave 4) 5.6 per cent (Wave 5), and 5.2 per cent (Wave 6). The sample

[9] Pooled WA data for females with greater than zero hours worked.

[10] Age and labour market experience are highly correlated and hence only one of the two measures can be included in the labour force participation equation: labour market experience is chosen in this Report.

increases whenever a new household is formed when a current sample member exits a multi-person household.

For this Report, single females are defined as females that either lived alone with or without dependent children, that lived with another family member but were not a dependent child themselves, or were unrelated to all other household members (as in a share house). Couple females are defined as those who are married or in a *de facto* relationship to a male partner, with or without dependent children.

The specific criteria for females selected for analysis in this Report are as follow:

- Single or partnered females with or without dependants of age 18-64 years.[11] For females in a relationship, their partner also had to be within the age range of 18-64 years.
- Self-employed females are excluded as the distribution of their wages differs to that for wage and salary earners (i.e., the relationship between earned income and labour supply differs). Moreover, data collected from self-employed individuals is less reliability than that from wage and salary earners—in addition to the know problems associated with self-reported income data.
- Full-time female students under the age of 24 are excluded (classified as a dependent child).

There are 21688 usable observations from waves 1 to 6 of the HILDA for Australia and 2172 for Western Australia which result in 1351 and 14655 usable observations for females for WA and Australia respectively. From this sample, 1351 (WA) and 14655 (Australia) females are labour force participants, and 748 (WA) and 8635 (Australia) females supply hours of labour (see Table 1 below).

Table 1: HILDA Observations (Combined Waves 1 to 6)

	WA	Australia	WA as % of Australia
Participation and Employment			
Single Females	516	5852	8.8
Couple Females	835	8803	9.5
Hours Worked			
Single Females	320	3512	9.1
Couple Females	428	5123	8.4

Notes: (1) Sample HILDA pooled data Wave 1 to 6 (unweighted). (2) Sample is unbalanced (individuals need not be present for all waves)—there are an average of approximately 2.5 observations for each individual (with a range of 1 to 6 waves of observations).

Sample Size and Statistical Significance

From Table 1 above it is apparent that there are important differences in sample size: the sample sizes for WA are small in comparison with the sample size for Australia—for example, in the sample used to estimate labour force participation for single females, there are 516 observations (216 individuals) in WA, compared to 5852 observations (2340 individuals) for Australia. In addition, the WA sample is small in comparison with the usual

[11] It is common in labour market studies to restrict analysis to this age group (although the sample can be restricted to those under, say, 55 if it is thought that the behaviour of those nearing retirement will differ from the younger individuals).

sample size encountered, and preferred, in empirical research directed at labour market issues. Thus, for example, most Australian studies focus on the national population.

Rules-of-thumb have been suggested for determining the minimum sample size for multiple regression analyses (Tabachnick and Fidell 1996). Simple rules such as a ratio of 5 to 1 for observations and explanatory variables (e.g. Hair Jr *et al.* 1992) are generally considered too simplistic; Green (1991) provides some support for the general rule that $N \geq 50 + 8K$ is sufficient (where N represents the minimum sample size and K the number of explanatory variables in the regression model), while Montenegro (2001) provides support for the simple rule $N = 10K$. More complex sample size determination methods do not appear to provide sufficient advance: there is a tendency to trade simplicity for absolute accuracy when determining minimum sample size (Green 1991). It is clear that for models for WA for labour market outcome, the sample size boarders on being "too small"—estimated coefficients and their standard errors will show little or no bias (Maas and Hox 2004), but statistical tests (e.g. the *t*-statistic for individual coefficients) which rely on sample size for precision will be unreliable. Thus, interpreting the statistical significance—and hence implications for individual behaviour—must be done with care for econometric models based on small samples (and to a lesser extent, very large samples).

To reduce the potential for large sample results leading to statistical significance when only small differences are "detected", the usual 5% level (p-value ≤ 0.05) of statistical significance is maintained as the necessary (maximum) level for models based on the sample for Australia; to reduce the potential that for small sample models for WA the probability of "correctly" finding statistical significance is reduced, in the model results considered below, statistical significance at the 10% level (p-value ≤ 0.10) is treated as acceptable (Leamer 1978; Kennedy 1998).[12]

Given the issues regarding small and large samples, and that the aim of this Report is to provide distinct analysis for WA, it must be recognised that, to the extent Australia and WA are similar, models for Australia are likely to be a superior guide as to underlying drives of labour market behaviour and to provide implications for policy directions. Throughout this Report, generally, both the Australia and WA results are discussed as they provide insights into participation and hours worked—and they suggest further avenues for research. Nonetheless, unless the WA government funds a larger sample survey for WA, the problems of sample size are going to remain in all further work relating specifically to WA; that is, statistical significance (indicating an explanatory variable is relevant) will be harder to discover and model results will remain less reliable than studies based on the complete HILDA data set.

In the next section, issues relating to appropriate model building for panel data based on restricted samples are considered.

[12] Statistical significance is a function of sample size. The (two-sided *t*-statistic) test for the significance of individual coefficients is $Ho{:}\beta = 0$ vs. the alternative $Ha{:}\beta \neq 0$, where the test statistic is calculated as Coefficient/Standard Error = β/SE (and the standard error is calculated as Standard Deviation/√Sample Size=$SD/\sqrt{N}$ hence the *t*-statistic is calculated as $\beta/(SD/\sqrt{N})$ so as the sample size gets smaller the *t*-statistic is less likely to be statistically significant. Thus, for very large samples, small differences may be 'detected' as significant, but for very small samples the probability of finding statistical significance is reduced.

Econometric Issues for Model Building

The panel data econometric models in this Report deal with two issues pertaining to females in WA: the supply of hours (the *Hours* equation, contingent on the probability of being employed) and the decision to participate in the labour force. For convenience in discussing the rational for the econometric models, the *Hours* equation (including the influence of the probability of being *Employed* equation) is considered first—the probability of being a labour force participant (the *Participation*) equation can then be presented simply as a parallel to the employment equation (i.e. both are limited dependent variable specifications). Before outlining the specific models used in this Report it is necessary to deal with two complexities for econometric modelling:

a) Sample selection bias—present when the sub-sample being analysed (e.g. those who supply hours of work) is a non-random selection from a larger sample (e.g. all employed female labour force participants in the specified age group).

b) Panel versus cross-sectional econometric modelling—the benefits and drawbacks of using sophisticated (and more complex) panel data models versus the more common and less sophisticated cross-sectional models.

Sample Selection Bias

Sample selection bias occurs naturally in labour supply modelling as hours worked (or wage rates) and the probability of being employed (or of being a labour force participant) are inter-related.[13] Potential bias arises from the exclusion of non-working females from the sample when estimating the hours of work equation). As the hours worked of non-working females are zero, the distribution of hours is truncated. Thus, the sample of those who do supply hours overstates the desire to supply hours of work beyond that of the population of all females of the selected age range). In the econometric model that do not account for this "selection bias" the error term will not necessarily be a mean-zero random variable in the resulting sub-sample of women who supply hours of work (it generally tends to be positive) even though it is a mean-zero random variable in the population of all females. Consequently, econometric model-based estimates of coefficients may be biased and inconsistent (i.e. amongst other things, the size and statistical significance of individual model estimates or coefficients may lead to false conclusions and poor policy prescription or advice).

Since Heckman (1978, 1979), it has been commonplace in econometric analysis to correct for sample selection bias when estimating labour supply models through a two-step procedure. In the first step, a "reduced form" secondary equation is specified: for example, when modelling wage outcomes, a probability of *Participation* in the labour force equation is fitted for the complete random sample. Outcomes from the *Participation* equation are then used to construct a selection bias "correction term" that is incorporated into the second step "structural" or primary wage equation and by accounting for the non-randomness of the sample for wage earners (a non-random sub-sample of all surveyed individuals) controls for selection bias. If the model is to explain hours of labour supply (an *Hours* equation) sample selection is due to the sample of those supplying hours of work being a non-random sub-set of all individuals.

[13] More specifically, the dependent variable hours, to be explained by regression analysis, is non-randomly selected because the probability of being employed influences the number of hours worked.

Despite the achievements of the Heckman two-step procedure in overcoming sample selection bias, its application in empirical studies has been limited to cross-sectional data (or pooled panel data) analysis (see below). It is only recently that well developed two-step panel data procedures, similar to the Heckman two-step cross-sectional procedure, have been developed (based on innovative work by Ridder (1990); Nijman and Verbeek (1992); and Vella and Verbeek (1999). The advanced two-step estimation procedure developed by Vella and Verbeek (1999) is adopted in this Report to estimate labour supply models (see below).

Cross-Sectional versus Panel Data Econometric Analysis

As is well documented, the consequence of using cross-sectional (or pooled panel data) is that individuals' unobserved time-constant characteristics (or unobserved heterogeneity[14]) are not considered; unobserved heterogeneity, if present, results in inefficient econometric model estimates (with high standard errors leading to lack of statistical significance of estimated parameters). Moreover, treating panel or longitudinal data as if it were a cross-section ignores the information contained in the progress or change in measured variables, and importantly ignores that in panel data across-time correlations are common; autocorrelation results in inefficient parameter estimates, standard errors of the estimates are biased invalidating hypothesis tests such as *t*-statistics, and the R^2 (coefficient of determination[15]) is no longer reliable (Greene 2003). Moreover, the scarcity of Australian longitudinal survey data incorporating "economic", has until recently contributed to the restriction to analysis at the cross-sectional data level. The HILDA survey data has provided much needed longitudinal data for Australia. Nonetheless, as discussed in detail above, the availability of HILDA data may not have solved the problem for analysis at the Australian state level as sample size for smaller population states remains small.

Panel data models treat the unobserved heterogeneity as a random variable: alternative assumptions are that the heterogeneity is not correlated with the (exogenous) explanatory variables (the random effects model, REM) or that there is correlation (the fixed effects model, FEM).[16] There are benefits and drawbacks of both approaches to panel data modelling—subject to much discussion in the econometric literature (see e.g. Lester, 2007 for a review). Despite the advances in panel data analysis, there are few estimators for panel models with limited dependent variables and sample selection, but the Vella and Verbeek (1999) two-step procedure deals with these mattes. Moreover, the method allows the inclusion in the econometric model specification of explanatory variables that may be correlated with the unobserved heterogeneity, and of time-invariant (or slow-changing) explanatory variables that are not usual in FEM models.[17]

Having dealt with issues common to panel data analysis and sample selection an overview of the current state of knowledge regarding labour market supply by individuals and couples follows.

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[14] Note that the unobserved heterogeneity is not itself of interest in the analysis: interest is in controlling for the potential bias caused by ignoring its influence.

[15] A measure of model goodness-of-fit bounded between zero and one, where $R^2 = 1$ represents a perfect fit.

[16] Notwithstanding the confusion that may be created by the nonclamature REM and FEM, in both cases the individual unobserved heterogeneity is assumed to be a random variable. In the FEM model, heterogeneity is treated as an (estimateable) individual specific dummy variable (generally resulting in the incidental parameter problem) but in the REM, individual unobserved heterogeneity is assumed to have an empirical distribution.

[17] Since the FEM model is based on first-differences (e.g. x_{it}-x_{it-1}) time-invariant explanatory variables are "differenced" out of the models.

Unitary and Collective Models of Labour Supply

In the analysis presented in this Report, household labour supply is estimated based on the "unitary" labour supply model. Although, as outlined below, the more recent literature suggests a "collective" model of household labour supply is more appropriate for households with two (or more) adults, currently available econometric software precludes the use of the more advanced estimators.

It is commonplace in microeconomic analysis to treat household labour supply behaviour as the utility maximisation behaviour of an individual (i.e. the household is treated as if it were an individual)—referred to in the literature as the "unitary" labour supply approach. In recent years, however, the unitary approach has been criticised at the theoretical level because it assumes that the household is characterised by a single preference or utility function. In the common unitary model, a couple in a household are treated as if they are a single unit—or, as if one individual made all the decisions concerning the labour supply provision of all household members to maximise joint utility. Hence, the unitary model approach does not allow individual household members' preferences to be considered, or the intra-household distribution of welfare to be identified. In Addition, the unitary model implies that household members aggregate, or pool, their incomes so that labour supply and consumption decisions are determined only by the total exogenous income (which may include welfare payments and investment income), rather than the distribution of income across household members.

Modelling labour supply of households that includes two or more income earners (such as couple households), by application of the unitary model has come under much scrutiny both theoretically and empirically recently, and in general, the theoretical restrictions that the unitary model approach imposes are not necessarily supported by the empirical literature for households that contain more than one individual. The result of the recent evaluation of the unitary model has been the development of the "collective" approach, which considers the household members individual, but interrelated, labour supply behaviour rather than the household as if it were a single unit (Chiappori 1988; 1992).

The collective approach explicitly determines household labour supply and consumption decisions by means of the individual household members' preferences or utility functions—which allow the inclusion of the partner's welfare to be taken. In the Chiappori (1988; 1992) approach, when the preferences of one or more individuals in a couple household include concern for their own welfare and the welfare of their partner,[18] then a bargaining process dictates labour supply. Thus, in the collective model of labour supply for partner households, the interaction between household members' labour supply decisions is explicitly recognised through a sharing rule based on the division of household income between the partners. The welfare function defined in the collective model can be interpreted as a method which defines an inter-household bargaining process. Labour supply is a two-stage process, first non-labour income—a function of wage rates—is divided between individual household members, and in the second-stage individuals decide about their labour supply conditional on their share on non-labour income.[19]

[18] And, their consumption is private—e.g. individuals do not share the consumption of goods such as clothes.

[19] A useful explanation of the assumption underpinning the bargaining process between the individuals in a household is explained by application of economic Game theory which show how the economically efficient (Nash equilibrium) can be obtained (Ligon 2002; Chiappori and Donni 2005).

An extensive review of the econometric literature, however, indicates that the application of the two-step panel model has limitations. Thus, a comprehensive model of female labour supply (hours of work) would include both single and partnered individuals, with or without children, who do or do not participate in the labour force, which includes individual utility functions for partnered households and the rules or process for joint decisions about the supply of labour hours by each household member. At the current stage of development, however, this comprehensive, inclusive, panel data model is not available. The application of the collective approach to couple households that contain children (who, in the collective model, must be treated as a public good) are still in their infancy, as are models which include non-participants—with many models restricted to households without children where the couple are both employed (Donni 2003; Bloemen 2004; Blundell *et al.* 2007; Couprie 2007; Van Klaveren 2008).

Although variations on the collective model can be written in equation form, no theoretical microeconometric solution has yet been devised, and hence software to estimate the model has not been written (i.e. accessible econometrics packages do not include an appropriate econometric estimator for the collective models). Currently, restrictive estimators devised that provide accessible econometric models for simplified models only. The Vella and Verbeek (1999) model, which can be applied to single and couple females separately represents the current level of sophistication available for applied econometric panel data models of labour supply, but its theoretical base is the unitary model. Consequently, the unitary approach has been adopted in this Report for analysis of couple households with and without children. Future research should be considered to overcome this simplification, and potential mis-specification when applying the unitary model to couples.

Simultaneity and the Two-Step Selection Bias Models

The collective model outlined above does not require a simultaneous equation model of female and male behaviour for couple households because the interaction is accommodated through the bargaining process—hours of labour supply are an inter-related decision of household members. In the unitary model of labour supply, one approach is to consider a simultaneous equation model for individual female and male supply in which partner's wage and hours of work (or wage per hour) appear in the hours supplied equation. The drawback of this approach (abstracting from the preference for a collective model) is that wage and hours on the right-side of equations are endogenous (they are simultaneously determined). Consequently, an instrumental variables (IV) model is required. As with all IV models, it is not clear which instruments are appropriate, and there is the persistent difficulty of finding instruments that correlate with the endogenous variable but are suitable exogenous. Further, the current specification of the two-step selection bias model does not accommodate a simultaneous equation model of female and male behaviour for couple households. The approach adopted in this Report is to include a number of male partner characteristics which attempts to capture the "flavour" of joint decision-making to some extent, while avoiding practical and econometric problems such as the IV approach.

The following section describes the process of applying theoretical labour supply models to observed data. Models are presented in a simplified form (for a more technically detailed expose see Vella and Verbeek 1999).

The Two-step Econometric Model of Hours of Work Supplied

Having discussed the underlying theoretical implications of estimating a labour supply model, the specification of the econometric models are considered. In this Report, the estimation of the labour supply model follows closely the two-step panel data procedure developed by Vella & Verbeek (1999) to overcome selection bias and endogeneity in the labour supply equation.

In the Vella and Verbeek (1999) model approach, the estimates of a "structural" primary hours worked equation [1], are obtained via a "reduced form" secondary equation [2] which determines the selection rule—the probability of being employed. Equation [3] determines when the probability of being employed is positive. Equation [4] determines (based on selection equation [3]) when labour hours supply is greater than zero—Equations [3] and [4] are referred to as the censoring and selection rules.

Two-Step Panel Data Model

Primary "Structural" Hours Supplied Equation:

$$Hours_{it}^{*} = f_1\left(X_{it}, Employed_{it}; \beta_1\right) + \mu_i + \eta_{it} \qquad [1]$$

Secondary "Reduced Form" Employment Equation:

$$Employed_{it}^{*} = f_2\left(X_{it}, Employed_{i,t-1}; \beta_2\right) + \alpha_i + v_{it} \qquad [2]$$

Censoring and Selection Rules

Probability of Being Employed Equation:

$$Employed_{it} = f_3\left(Employed_{it}^{*}; \beta_3\right) \qquad [3]$$

Hours Supplied Equation:

$$Hours_{it} = Hours_{it}^{*} \quad \text{if } f_4\left(Employed_{i1}, \ldots, Employed_{iT}\right) = 1$$

$$Hours_{it} = 0 \quad \text{if } f_4\left(Employed_{i1}, \ldots, Employed_{iT}\right) = 0 \qquad [4]$$

where i are individuals (survey participants, $i = 1,\ldots, N$), t is time (or survey waves, $t = 1,\ldots, T$), and f represents functions characterised by the unknown parameters (vector) $\boldsymbol{\beta}$. The $\boldsymbol{x}$ are the vector of observed individual characteristics or explanatory variables (e.g. education level, children in the household, marital status, partner's attributes, etc.), and covariates or control variables which while influential are not the subject of interest in this Report. Random, time-invariant, individual heterogeneity are represented by μ_i and α_i and random, time-variant, individual specific, independent, effects as η_{it} and υ_{it}. Note that $\boldsymbol{x}$ need not contain identical explanatory variables across functions. Starred variables are latent (unobserved) endogenous variables (i.e. preferred hours supplied, *Hours**, and the probability of a labour force participant being employed, *Employed**)—with observed counterparts (actual hours supplied, *Hours*; and whether or not employed, *Employed*). The terms μ_i and α_i represent the panel-model (random) time-invariant unobserved individual effects (heterogeneity), and η_{it} and ν_{it} represent the random individual-specific time-variant effects—that are assumed independent across individuals.

To specify the "correction" terms estimated in Equation [1] to be incorporated into Equation [2], allow the error component of the secondary equations (e.g. the reduced form probability of employment) to be denoted by $u_{it} = \alpha_i + \nu_{it}$ (i.e., a combination of individual time-invariant unobserved heterogeneity and an individual time-varying component). The time-invariant "correction" is approximated by the mean of the time-varying component, $\overline{u}_i$ (i.e. the average of the u_{it}[20]), and the time-varying correction is u_{it}. Thus, in the *Hours* equation, the panel-model unobserved heterogeneity (μ_i) and time-variant heterogeneity (η_{it}) are approximated by $\overline{u}_i$ and u_{it} respectively; as $\overline{u}_i$ and u_{it} are treated as "data" in the *Hours* equation, their parameters (coefficients) can be estimated and if non-significant suggest no endogeneity.

The model of Equations [1] to [4] demonstrates that the determination of *Employed* (the probability of employment) is a function (f_3) of the unknown parameter vector β_3, and the function f_4 indicates that *Hours* (actual worked) is only observed for positive values of *Employed*. Thus, sample selection bias in the primary *Hours* equation is controlled for by including the selection and censoring rule from the *Employed* equation ($Employment_{it}$)—the primary *Hours* equation should not be estimated without first considering what determined its sub-sample, the reduced form *Employed* equation, or parameter estimates are potentially biased and inconsistent leading to incorrect attribution of causes of hours supplied.

Thus, the two-step model depicted above describes how to control or account for selection bias, and the inclusion of individual effects controls for heterogeneity in the panel data econometric models.

For estimation, further assumptions are made: as usual, errors are normally distributed and explanatory variables are exogenous; autocorrelation in the secondary reduced form *Employed* probit equation errors is inadmissible, but heteroscedasticity and/or autocorrelation in the primary *Hours* equation errors can be accommodated.

As shown in the reduced form Equation [2], the model features a potential role for dynamics (e.g. $Employment_{i,t-1}$): in addition, "state dependence" is controlled by inclusion of information on the dependent variable in the period preceding the first available data period ($Employment_{i,t=0}$).[21] The inclusion of $Employment_{t=0}$ may be endogenous due to recall problems or respondents' perceptions when concurrently reporting their current and previous behaviour at $t = 1$. The example provided by Vella and Verbeek (1999) found that while endogeneity existed, it did not affect the results in any significant way, nonetheless, they suggest potential endogeneity (due to dynamics and/or state dependency) can be controlled by including a polynomial of predicted values of the dependent variable from the *Employed* equation including in the *Hours* equation.

For the purposes of this Report, the lagged dependent variable for the zero period was constructed using information provided by respondents in the first time period above their experience in the previous year,[22] which controls for "state dependency" (and has the benefit of preserving observations—particularly important for the relatively small samples for WA). Potential endogeneity was controlled by the *Employed* polynomial (in addition to the selection bias and heterogeneity correction terms in the *Hours* equation).

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[20] More generally, $\overline{u}_i = W_i^{-1}\Sigma_{t=1}^{W} u_{it}$ where W_i represents the number of waves for individual *i*.

[21] In model estimation, a single variable includes both $Employment_{i,t-1}$ and $Employment_{i,t=0}$.

[22] When new households form, period "zero" (the previous year) may be between waves 1 and 5.

Empirical Equations for the Two-step Model of Hours Worked

Based on the theoretical model outlined above, the empirical equations can be specified. First, *Employed* is estimated as a limited dependent variable (probit) panel data model (see Appendix I for the probit model specification). Second, *Hours* is estimated as a panel data model of a continuous dependent variable, corrected for selection bias (i.e. only employed labour force participants supply hours worked) by inclusion of panel data "correction" terms (the $\overline{u}_i$ and u_{it} "data"):

$$Employed_{it}^{*} = \beta_1 x_{1,it} + \ldots + \beta_k x_{k,it} + \beta_E Employment_{i,t-1} + \alpha_i + \nu_{it} \quad [5]$$

$$Hours_{it} = \beta_1 x_{1,it} + \ldots + \beta_k x_{k,it} + f_P\left(Employment_{it};\beta_P\right) + \overline{u}_i + u_{it} \quad [6]$$

Where the quadratic function (f_P) to control for endogeneity is defined as:

$$f_P\left(Employed_{it};\beta_P\right) = \beta_{P1} Employment_{it} + \beta_{P2} Employment_{it}^2 + \beta_{P3} Employment_{it}^3 + \beta_{P4} Employment_{it}^4 \quad [7]$$

where *Hours* represents the log of hours worked in paid employment per week, $\boldsymbol{x}$ represent observed independent or explanatory variables (e.g. work experience, education, health, and marital status). f_P denotes a polynomial (of pre-specified length) with unknown coefficients ($\boldsymbol{\beta}_P$) controlling for endogeneity due to dynamics, and β_E controls for "state dependence". Note that the *Employed* equation is required in contrast to a *Participation* equation because the selection bias is due to selection into employment not selection into participation—hours supplied are not independent of selection into employment—a female who is not employed does not independently select her hours of work.

The Participation Equation

The participation equation, modelled as a panel data limited dependent variable probit model has the following specification:

$$Participation_{it}^{*} = \beta_1 x_{1,it} + \ldots + \beta_k x_{k,it} + \beta_P Participation_{i,t-1} + \alpha_i + \nu_{it} \quad [8]$$

Where:

$$Participation_{it} = 0 \quad \text{if } f_P(Participation_{it}^{*},\ldots,Participation_{iT}^{*}) = 0$$

$$Participation_{it} = Participation_{it}^{*} \quad \text{if } f_P(Participation_{it}^{*},\ldots,Participation_{iT}^{*}) = 1 \quad [9]$$

where *Participation** represent the (unobserved) endogenous probability of being a labour force participant—with observed counterpart *Participation*. As previously, $\boldsymbol{x}$ represent observed independent or explanatory variables, $Participation_{i,t-1}$ controls for "state dependency", βs are parameters to be estimated, α_i represent the unobserved individual unobserved random effects (heterogeneity), and ν_{it} are the usual regression error terms.

As it is hours supplied and participation that are the primary concern of this Report, estimates relating to these two functions are summarised and discussed below (since the employment equation is included to control for selection bias the results are not discussed)—full econometric output from models for the probability of participating in the labour market, the probability of being employment, and hours of labour supply is provided in Appendix II.

Summary Statistics

Table 2 provides a legend of variable names and description of those included in models for WA and Australia, and Table 3, which follows, has summary statistics for these variables.

Table 2: Legend: Explanatory Variables Used in Econometric Models

Variable Name	Description	Variables Required
lnhoursf	Log of weekly hours worked in paid employment	Continuous
lbfst & lbfst_lag	Employed (full-time or part-time) and unemployed or not in the labour force (and the one-period lag)	Binary state
exp	Total employment experience in years	Continuous
exp-sq	Total employment experience in years squared	Continuous
jbsearch	Total time out of employment in years	Continuous
jbsearch_sq	Total time out of employment in years squared	Continuous
ed1	Highest level of education is Bachelor/Graduate Diploma/Postgraduate degree	Dummy
ed2	Highest level of education is Advanced Diploma/Diploma	Dummy
ed3	Highest level of education is Certificate III/IV	Dummy
ed4	Highest level of education is Certificate I/II or Year 12	Dummy
ed5 (base)	Highest level of education is Year 11 & below, or undetermined	Dummy
ped1	Partner's highest level of education is Bachelor/Graduate Diploma/Postgraduate degree	Dummy
ped2	Partner's highest level of education is Advanced Diploma/Diploma	Dummy
ped3	Partner's highest level of education is Certificate III/IV	Dummy
ped4	Partner's highest level of education is Certificate I/II or Year 12	Dummy
ped5 (base)	Partner's highest level of education is Year 11 & below	Dummy
C4_1	One resident child under 5 years, and no others	Dummy
C4_2	2 or more resident children under 5 years, and no others	Dummy
C514_1	One resident child between 5-14 years, and no other	Dummy
C514_2	2 or more resident children age 5-14 years, and no others	Dummy
C4	Any resident children between 0-4 years, and no others	Dummy
C514	Any resident children between 5-15 years, and no others	Dummy
C1524	Any resident children between 15-24 years, and no others	Dummy
nonresch	Any non-resident children	Dummy
pnonresch	Partner has any non-resident children	Dummy
wage	Real hourly wage of female (AUD)[*]	Continuous
wage_sq	Real hourly wage of female squared (AUD)[*]	Continuous
pwage	Real hourly wage of male partner (AUD)[*]	Continuous
nonlbinc	Real non-labour income[^]	Continuous
rural	Household located in a rural area[#]	Dummy
age	Age of females (between 18 and 64 years)	Continuous
age_sq	Age of females squared	Continuous
page	Age of male partner (between 18-64 years)	Continuous

Variable Name	Description	Variables Required
page_sq	Age of male partner squared	Continuous
gh	Physical Health (from the SF-36)	Index [0:100]
mh	Mental Health (from the SF-36)	Index [0:100]
immi	Index of immigration[$]	Ratio [0:1]
mtleave	Paid maternity leave	Dummy
umtleave	Unpaid maternity leave	Dummy
pptleave	Paternity leave of male partner (paid or unpaid)	Dummy
union	Trade union membership[%]	Dummy
sector	Employed in the private sector	Dummy
unemprt	Unemployment rate (%) [@]	Continuous
married	Legally married	Dummy
ind01	Agriculture, Forestry and Fishing Industry[†]	Dummy
ind02	Mining Industry [†]	Dummy
ind03	Manufacturing Industry [†]	Dummy
ind04	Electricity, Gas and Water Supply Industry [†]	Dummy
ind05	Construction Industry [†]	Dummy
ind06	Wholesale Trade Industry [†]	Dummy
ind07	Retail Trade Industry [†]	Dummy
ind08	Accommodation, Cafes and Restaurants Industry [†]	Dummy
ind09	Transport and Storage Industry [†]	Dummy
ind10	Communication Services Industry [†]	Dummy
ind11	Finance and Insurance Industry [†]	Dummy
ind12	Property and Business Services Industry [†]	Dummy
ind13	Government Administration and Defence Industry [†]	Dummy
ind14	Education Industry [†]	Dummy
ind15	Health and Community Services Industry [†]	Dummy
ind16	Cultural and Recreational Services Industry [†]	Dummy
Other (Base)	Personal and Other Services Industry [†]	Dummy
NSW	New South Wales	Dummy
VIC	Victoria	Dummy
QLD	Queensland	Dummy
SA	South Australia	Dummy
WA	Western Australia	Dummy
TAS	Tasmania	Dummy
NT	Northern Territory	Dummy
ACT (base)	Australian Capital Territory	Dummy

Note: (1) Dummy variables are coded so that presence is set to one and absence to zero. (2) Index [0:100] is an index measured as a continuous variable with range 0 to 100. (3) [*] The hourly wage rate is inflated to the value in the year 2006 by the RBA annual inflation rate over the period (2001-2006). (4) [^] Non-labour income is inflated to the value in the year 2006 by the RBA annual inflation rate over the period (2001-2006). (5) [#] Rural location of a household is defined by the ABS Australian Standard Geographical Classification (2001), Cat. No. 1216.0, based on population counts of Census Collection Districts (CD). (6) [$] *immi* is the proportion of years spent in Australia—the ratio, equals one for individuals born in Australia. (7) [%] Trade Union membership as defined by the ABS. (8) [@] The unemployment rate is derived from Data Cube LM8–Labour Force Status by Sex, State, Age, Marital Status (ABS Labour Force, Australia, Detailed – Electronic Delivery, Mar 2008, Cat. No. 6291.0.55.001). (9) [†] Industry classifications are defined by the ABS Australian and N. Z. Standard Industrial Classification (ANZSIC) 1-digit code, first edition (1994), Cat. No. 1293.0.

Table 3: Summary Statistics for WA and Australia

	Western Australia Couple Females				Australia Couple Females				Western Australia Single Females				Australia Single Females			
	Participation		**Hours Supplied**		**Participation**		**Hours Supplied**		**Participation**		**Hours Supplied**		**Participation**		**Hours Supplied**	
	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*
lnhoursf	-	-	3.279	*0.623*	-	-	3.341	*0.562*	-	-	3.480	*0.532*	-	-	3.446	*0.550*
lbfst & lbfst_lag	0.525	*0.500*	-	-	0.609	*0.488*	-	-	0.672	*0.470*	-	-	0.662	*0.473*	-	-
exp	16.00	*10.18*	-	-	16.45	*9.86*	-	-	15.95	*12.07*	-	-	15.43	*11.85*	-	-
exp-sq	359.5	*408.5*	-	-	367.9	*386.8*	-	-	399.9	*479.7*	-	-	378.6	*456.2*	-	-
jbsearch	0.33	*0.91*	-	-	0.44	*1.51*	-	-	0.51	*1.45*	-	-	0.76	*2.14*	-	-
jbsearch_sq	0.93	*5.95*	-	-	2.46	*26.02*	-	-	2.35	*13.06*	-	-	5.14	*32.07*	-	-
ed1	0.212	*0.409*	0.315	*0.465*	0.268	*0.443*	0.363	*0.481*	0.246	*0.431*	0.313	*0.464*	0.242	*0.429*	0.336	*0.472*
ed2	0.113	*0.316*	0.121	*0.327*	0.094	*0.292*	0.105	*0.306*	0.140	*0.347*	0.153	*0.361*	0.092	*0.289*	0.114	*0.318*
ed3	0.141	*0.348*	0.131	*0.338*	0.116	*0.320*	0.119	*0.324*	0.076	*0.265*	0.063	*0.242*	0.134	*0.341*	0.143	*0.350*
ed4	0.169	*0.375*	0.175	*0.381*	0.178	*0.382*	0.171	*0.376*	0.165	*0.371*	0.166	*0.372*	0.189	*0.391*	0.195	*0.396*
ed5 (base)	0.366	*0.482*	0.257	*0.437*	0.344	*0.475*	0.243	*0.429*	0.374	*0.484*	0.306	*0.462*	0.343	*0.475*	0.213	*0.409*
ped1	0.229	*0.420*	0.311	*0.463*	0.268	*0.443*	0.320	*0.467*	-	-	-	-	-	-	-	-
ped2	0.076	*0.265*	0.084	*0.278*	0.101	*0.301*	0.110	*0.313*	-	-	-	-	-	-	-	-
ped3	0.345	*0.476*	0.325	*0.469*	0.294	*0.456*	0.277	*0.448*	-	-	-	-	-	-	-	-
ped4	0.116	*0.320*	0.124	*0.330*	0.109	*0.312*	0.112	*0.315*	-	-	-	-	-	-	-	-
ped5 (base)	0.234	*0.424*	0.157	*0.364*	0.229	*0.420*	0.181	*0.385*	-	-	-	-	-	-	-	-
C4_1	-	-	-	-	0.177	*0.382*	0.153	*0.360*	-	-	-	-	0.082	*0.275*	0.042	*0.201*
C4_2	-	-	-	-	0.083	*0.277*	0.051	*0.219*	-	-	-	-	0.018	*0.133*	0.005	*0.069*
C514_1	-	-	-	-	0.169	*0.375*	0.180	*0.384*	-	-	-	-	0.130	*0.337*	0.115	*0.319*
C514_2	-	-	-	-	0.205	*0.403*	0.209	*0.406*	-	-	-	-	0.089	*0.284*	0.067	*0.249*
C4	0.261	*0.440*	0.173	*0.379*	-	-	-	-	0.093	*0.291*	0.038	*0.190*	-	-	-	-
C514	0.312	*0.464*	0.306	*0.461*	-	-	-	-	0.231	*0.422*	0.188	*0.391*	-	-	-	-
C1524	0.195	*0.396*	0.248	*0.432*	0.211	*0.408*	0.244	*0.430*	0.141	*0.349*	0.122	*0.328*	0.148	*0.355*	0.146	*0.354*

	Western Australia Couple Females				Australia Couple Females				Western Australia Single Females				Australia Single Females			
	Participation		**Hours Supplied**		**Participation**		**Hours Supplied**		**Participation**		**Hours Supplied**		**Participation**		**Hours Supplied**	
	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*
nonresch	0.325	*0.469*	0.287	*0.453*	0.301	*0.459*	0.227	*0.419*	0.281	*0.450*	0.222	*0.416*	0.325	*0.468*	0.242	*0.428*
pnonresch	0.395	*0.697*	0.318	*0.466*	0.343	*0.475*	0.285	*0.452*	-	-	-	-	-	-	-	-
wage	-	-	22.73	*10.68*	-	-	23.27	*10.62*	-	-	21.42	*10.05*	-	-	21.25	*9.34*
wage_sq	-	-	630.5	*802.2*	-	-	654.4	*772.9*	-	-	559.6	*715.1*	-	-	538.9	*623.6*
pwage	22.15	*16.96*	24.55	*14.19*	21.59	*16.33*	24.38	*14.63*	-	-	-	-	-	-	-	-
nonlbinc	127.1	*251.3*	67.7	*153.3*	114.9	*236.4*	68.2	*219.8*	186.4	*276.9*	88.1	*161.1*	196.4	*24278*	109.7	*21148*
rural	0.141	*0.348*	0.133	*0.340*	0.159	*0.366*	0.145	*0.352*	0.078	*0.268*	0.066	*0.248*	0.092	*0.289*	0.074	*0.262*
age	-	-	39.56	*10.16*	-	-	39.88	*9.58*	-	-	37.69	*12.81*	-	-	37.77	*12.62*
age_sq	-	-	1667.9	*836.7*	-	-	1682.0	*776.6*	-	-	1584.5	*1007.4*	-	-	1586.1	*979.0*
page	-	-	41.78	*10.54*	-	-	42.13	*9.98*	-	-	-	-	-	-	-	-
page_sq	-	-	1856.5	*899.6*	-	-	1874.8	*852.1*	-	-	-	-	-	-	-	-
gh	73.93	*20.49*	78.36	*16.65*	71.39	*21.00*	74.96	*18.12*	69.60	*21.18*	77.07	*16.14*	66.76	*22.76*	72.21	*19.21*
mh	75.44	*16.36*	77.72	*14.20*	74.16	*16.69*	75.99	*14.86*	70.69	*19.59*	74.69	*16.96*	69.12	*19.37*	72.69	*16.86*
immi	0.75	*0.36*	0.74	*0.37*	0.83	*0.32*	0.84	*0.32*	0.82	*0.33*	0.83	*0.33*	0.87	*0.29*	0.88	*0.28*
mtleave	-	-	0.374	*0.484*	-	-	0.483	*0.500*	-	-	0.509	*0.501*	-	-	0.499	*0.500*
umtleave	-	-	0.708	*0.455*	-	-	0.740	*0.439*	-	-	0.675	*0.469*	-	-	0.705	*0.456*
pptleave	-	-	0.631	*0.483*	-	-	0.654	*0.476*	-	-	-	-	-	-	-	-
union	-	-	0.248	*0.432*	-	-	0.330	*0.470*	-	-	0.306	*0.462*	-	-	0.322	*0.467*
sector	-	-	0.636	*0.482*	-	-	0.612	*0.487*	-	-	0.609	*0.489*	-	-	0.645	*0.479*
unemprt	3.34	*1.48*	-	-	3.43	*1.79*	-	-	6.98	*2.87*	-	-	7.83	*3.00*	-	-
married	0.837	*0.370*	0.811	*0.392*	0.824	*0.381*	0.815	*0.388*	-	-	-	-	-	-	-	-
ind01	-	-	0.019	*0.136*	-	-	0.010	*0.100*	-	-	0.009	*0.097*	-	-	0.008	*0.089*
ind02	-	-	0.005	*0.068*	-	-	0.001	*0.037*	-	-	0.006	*0.079*	-	-	0.004	*0.065*
ind03	-	-	0.030	*0.172*	-	-	0.050	*0.218*	-	-	0.016	*0.124*	-	-	0.063	*0.244*

	Western Australia Couple Females				Australia Couple Females				Western Australia Single Females				Australia Single Females			
	Participation		**Hours Supplied**		**Participation**		**Hours Supplied**		**Participation**		**Hours Supplied**		**Participation**		**Hours Supplied**	
	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*	Mean	*Std Dev*
ind04	-	-	0.019	*0.136*	-	-	0.003	*0.054*	-	-	0.006	*0.079*	-	-	0.003	*0.056*
ind05	-	-	0.009	*0.096*	-	-	0.014	*0.119*	-	-	0.003	*0.056*	-	-	0.011	*0.102*
ind06	-	-	0.014	*0.118*	-	-	0.026	*0.158*	-	-	0.016	*0.124*	-	-	0.022	*0.146*
ind07	-	-	0.124	*0.330*	-	-	0.097	*0.296*	-	-	0.125	*0.331*	-	-	0.119	*0.324*
ind08	-	-	0.040	*0.196*	-	-	0.037	*0.189*	-	-	0.066	*0.248*	-	-	0.063	*0.242*
ind09	-	-	0.016	*0.127*	-	-	0.021	*0.145*	-	-	0.013	*0.111*	-	-	0.016	*0.124*
ind10	-	-	0.009	*0.096*	-	-	0.020	*0.142*	-	-	0.025	*0.156*	-	-	0.019	*0.136*
ind11	-	-	0.054	*0.226*	-	-	0.052	*0.222*	-	-	0.044	*0.205*	-	-	0.046	*0.210*
ind12	-	-	0.121	*0.327*	-	-	0.105	*0.307*	-	-	0.122	*0.328*	-	-	0.096	*0.295*
ind13	-	-	0.058	*0.235*	-	-	0.064	*0.244*	-	-	0.094	*0.292*	-	-	0.067	*0.250*
ind14	-	-	0.231	*0.422*	-	-	0.214	*0.410*	-	-	0.163	*0.369*	-	-	0.160	*0.367*
ind15	-	-	0.203	*0.403*	-	-	0.227	*0.419*	-	-	0.213	*0.410*	-	-	0.235	*0.424*
ind16	-	-	0.019	*0.136*	-	-	0.025	*0.157*	-	-	0.031	*0.174*	-	-	0.027	*0.162*
Other (Base)	-	-	0.028	*0.165*	-	-	0.032	*0.176*	-	-	0.050	*0.218*	-	-	0.041	*0.198*
NSW	-	-	-	-	0.290	*0.454*	0.301	*0.459*	-	-	-	-	0.295	*0.456*	0.286	*0.452*
VIC	-	-	-	-	0.240	*0.427*	0.250	*0.433*	-	-	-	-	0.238	*0.426*	0.253	*0.435*
QLD	-	-	-	-	0.213	*0.410*	0.202	*0.401*	-	-	-	-	0.218	*0.413*	0.212	*0.409*
SA	-	-	-	-	0.089	*0.285*	0.086	*0.281*	-	-	-	-	0.102	*0.302*	0.087	*0.282*
WA	-	-	-	-	0.097	*0.296*	0.084	*0.277*	-	-	-	-	0.086	*0.281*	0.090	*0.286*
TAS	-	-	-	-	0.034	*0.181*	0.031	*0.173*	-	-	-	-	0.036	*0.185*	0.040	*0.196*
NT	-	-	-	-	0.008	*0.088*	0.012	*0.108*	-	-	-	-	0.009	*0.092*	0.011	*0.102*
ACT (base)	-	-	-	-	0.029	*0.166*	0.035	*0.184*	-	-	-	-	0.017	*0.131*	0.022	*0.146*

Notes: (1) Means are for the pooled data (i.e. six waves 2001-2006). (2) *Std Dev* represents the standard deviation.

Although many of the independent explanatory variables (i.e. $\boldsymbol{x}$) included in the analysis for this Report are common in previous labour supply models (e.g. level of education, marital status, and wage) there are a number that have, generally, not been included in previous work, or they are defined to a greater level of detail in this Report:[23]

- In the hours supplied equation for couple households, separate dummy variables representing maternity leave are included; specifically:[24]
  - female's paid maternity leave
  - female's unpaid maternity leave
  - male partner's paternity leave
- A dummy variable is included to represent union membership.
- In contrast with many other studies, in this analysis the children are represented by sets of dummy variables (not a count), and therefore do not assume a linear relationship. Dummy variables cover:
  - children 0 to 4 years
  - children 5 to 14 years
  - children 15 to 24 years.

  For the Australian equations—but not the WA equations due to small sample size—dummy variables differentiating between one and two children:
  - one child 0 to 4
  - two children 0 to 4
  - one child 5 to 15
  - two children 5 to 15
  - any children 15-24
- A dummy variable for non-resident (own and partner's) children was included.
- In place of the usual dichotomous dummy variable (zero if not an immigrant, one if an immigrant) the variable included in this Report is a continuous ratio of the proportion of time the immigrant has lived in Australia (i.e. a value of zero represents a newly arrive immigrant, a value of one represents an Australian born individual).[25]
- Health variables are taken from the questions for the Short Form (36) Health Survey (SF-36).[26] They provide continuous measures (scales range between zero and 100). There is discussion in the literature regarding the appropriateness of including health as it may be endogenous The relationship between the hours supplied decision and health may be endogenous (i.e. the direction of causality is unclear—poor health may reduce hours, or an involuntary reduction in hours may cause distress or poor health), but there was little evidence of endogeneity in estimated models. Health index variables are included for:
  - mental health
  - physical health

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[23] Noting that with all studies based on survey data, a potential drawback to increasing the number of explanatory variables is the increase in prevalence of missing data and hence reduced the sample size.

[24] Note that maternity leave dummy variables (and health variables below) are taken from the HILDA self-completion survey and are responsible for a reduction in sample size—particularly important for WA.

[25] English language ability was also considered for inclusion in the models but small "cell" numbers (i.e. a very unbalanced distribution between 0 and 1 for the dummy variable) caused the software to exclude the variable.

[26] The SF-36 consists of two summary measures calculated from eight scale scores (physical functioning, role physical, bodily pain, general health perceptions, vitality, social functioning, role emotional, and mental health). The summary measures, or scales, are the physical component score and the mental component score (see http://www.sf-36.org for further details).

- In couple female specifications, other measures for the partner's attributes included are:
    - education
    - employment status
    - age
- Industry sector is represented by dummy variables.
- State dummy variables are included.
- A dummy for rural versus urban living is included.
- Non-labour income is included.
- A dummy for public-private sector employment is included.
- Total time out of employment (representing de-skilling and strength of attachment to the labour force) is included.
- Total years of labour force experience is included.
- A state specific (for age group, gender, and marital status) measure of the unemployment rate is included to capture macroeconomic conditions (Wachter 1974).

In a number of cases the inclusion of the variables noted above is important (e.g. the availability of maternity or paternity leave is generally statistically significant). In some cases, however, explanatory variables are not statistically significant, but in several cases their inclusion adds to the understanding of labour supply (by suggesting that manipulating that individual attribute will not influence hours of work supplied). For example, being a rural resident does not influence the probability of labour force participation suggesting that extra services in the rural sector to encourage participation are not warranted. On the other hand, not surprisingly, the unemployment rate was found to be non-significant, probably because, during the 6 years of the HILDA data, unemployment had been low by historical standards, and thus the model should maintain this variable in the face of future higher rates of unemployment.

Econometric Model Results

The section below presents and discusses the results of the labour supply model (results are, for ease of access, restricted to coefficients and an indicator of statistical significance—see Appendix II for complete econometric model output).

The results are reported for single and coupled females in Western Australia (WA) and Australia—as the results demonstrate, the labour market behaviour of single females is different to those who reside with a male partner.[27] Single females are more likely to be labour force participants and are more likely to be employed than partnered females (i.e. they are more likely to allocate their time to work due to their limited family responsibilities to a male partner/husband and to children) and their limited access to alternative sources of income (e.g. a partner's income). The behaviour of single females is similar to that of single males, whereas the behaviour of partnered females differs importantly to that of partnered males.

Participation Equation

The labour force participation model examines the impact of selected explanatory (independent), and control variables, on females' probability of labour force participation:

[27] Same sex couples are a very small proportion of the HILDA sample and are excluded from this Report on econometric grounds.

where participation is defined as those who are employed or unemployed (i.e. not employed, but actively seeking work), relative to the total relevant population of females (i.e. employed, unemployed, and not in the labour force).

The fitted parameter estimates, for single and couple females, are reported in Table 4 below for WA and Australia. As the results are estimates of a random effects limited dependent variable (probit) panel data regression model, interpreting the estimated coefficients is not straightforward due to the non-linear nature of the underlying (probit) distribution function. Consequently, the parameter estimates are reported as the conversion to the marginal effects,[28] calculated at the variables' sample means.[29] For the continuous variables, including index variables, the coefficients are interpreted as the effect on the probability of labour force participation for a small (marginal) change in an explanatory variable. For discrete (dummy) variables, the coefficients are interpreted as the effect on the probability of labour force participation for a change from one state to the other (i.e. between zero and one) for that dummy explanatory variable.[30]

Results—Participation Equations[31]

As a general point, as previous discussed, the small sample for WA (i.e. 516 observations for 216 individual single females, and 853 for 324 individual couple females). One important question then is whether the difference in statistical significance for coefficients for explanatory variables for WA or Australia are an artefact of sample size, or different behaviour. Controlling for sample size (as discussed above by using different cut-off values for test of statistical significance) lends some credence to differences; nonetheless, results for Australia are likely to be more reliable and hence informative. Thus, where results for WA mirror those for Australia (e.g. labour market experience is significant in all models) results can be treated with a high level of confidence, but where they differ, cognisance of the Australian results is important.

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[28] More completely, from the probit model, the values presented in Tables 4 are defined as $\partial Pr[Participation_{it} = 1|x_{it}]/\partial x_{it} = F'(x'_{it}\beta)\beta_j$ (i.e. the partial derivative of Participation with respect to an individual explanatory variable, *x*). This specification demonstrates that the marginal effect differs depending on the value of the explanatory variables. Note that the ratio of coefficients is equal to the ratio of the marginal effects (i.e. the ratio of marginal effects is equal to the relative effects of changes in repressors) (Cameron and Trivendi 2005).

[29] More specifically the marginal effect is the change in the conditional mean of the probability of labour force participation when the explanatory variable (continuous, index, and dummy) changes by one unit.

[30] Note that work-related variables are not included in the participation equation as they are missing (i.e. not relevant) for non-participants and the unemployed (they cannot be included by assigning zeros to the missing values as this causes a spurious statistical relationship between those characteristics and participation).

[31] Recall that in the econometric models the dependent variable is the log odds ratio, model results are converted to the marginal effect, i.e. the increase in the probability of participation for a one-unit change (which for a dummy variable is a change from 0 to 1—or from absence to presence of the attribute).

Table 4: Participation: Single and Couple Females—WA and Australia

	Couple Females				Single Females			
	Western Aust.		Australia		Western Aust.		Australia	
lbfst_lag	1.889	***	1.870	***	1.319	***	1.786	***
	(0.126)		*(0.042)*		*(0.247)*		*(0.058)*	
waveb	-0.024	-	-0.082	-	0.280	-	0.129	-
	(0.198)		*(0.061)*		*(0.291)*		*(0.080)*	
wavec	-0.271	-	-0.154	**	0.184	-	0.061	-
	(0.196)		*(0.061)*		*(0.285)*		*(0.079)*	
waved	0.080	-	-0.033	-	0.420	-	0.086	-
	(0.207)		*(0.063)*		*(0.302)*		*(0.081)*	
wavee	-0.053	-	0.105	*	0.152	-	0.156	-
	(0.202)		*(0.064)*		*(0.291)*		*(0.083)*	
wavef	0.179	-	0.031	-	0.416	-	0.273	***
	(0.222)		*(0.064)*		*(0.329)*		*(0.087)*	
exp	0.059	***	0.062	***	0.080	**	0.048	***
	(0.022)		*(0.008)*		*(0.035)*		*(0.008)*	
exp_sq	-0.001	-	-0.001	***	-0.002	**	-0.001	***
	(0.001)		*(0.000)*		*(0.001)*		*(0.000)*	
jbsearch	0.153	-	-0.014	-	-0.025	-	0.009	-
	(0.121)		*(0.021)*		*(0.141)*		*(0.023)*	
jbsearch_sq	-0.011	-	0.000	-	0.009	-	-0.001	-
	(0.019)		*(0.001)*		*(0.014)*		*(0.002)*	
ed1	0.564	***	0.502	***	0.479	-	0.523	***
	(0.191)		*(0.063)*		*(0.332)*		*(0.080)*	
ed2	0.366	-	0.204	***	0.600	*	0.409	***
	(0.205)		*(0.071)*		*(0.359)*		*(0.101)*	
ed3	0.237	-	0.276	***	0.382	-	0.321	***
	(0.190)		*(0.066)*		*(0.358)*		*(0.082)*	
ed4	0.432	**	0.183	***	0.196	-	0.202	***
	(0.175)		*(0.056)*		*(0.305)*		*(0.073)*	
ped1	0.297	-	0.002	-	-	-	-	-
	(0.205)		*(0.063)*					
ped2	0.247	-	0.051	-	-	-	-	-
	(0.255)		*(0.075)*					
ped3	0.114	-	0.043	-	-	-	-	-
	(0.166)		*(0.054)*					
ped4	-0.117	-	0.024	-	-	-	-	-
	(0.224)		*(0.071)*					
c4_1	-	-	-0.405	***	-	-	-0.070	-
			(0.056)				*(0.089)*	
c4_2	-	-	-0.612	***	-	-	-0.010	-
			(0.077)				*(0.185)*	
c514_1	-	-	0.228	***	-	-	0.213	***
			(0.056)				*(0.078)*	
c514_2	-	-	0.048	-	-	-	0.231	**
			(0.056)				*(0.095)*	
c4	-0.567	***	-	-	-0.669	*	-	-
	(0.148)				*(0.375)*			

	Couple Females				Single Females			
	Western Aust.		Australia		Western Aust.		Australia	
c514	0.194	-	-	-	0.081	-	-	-
	(0.148)				*(0.284)*			
c1524	0.370	**	0.260	***	-0.042	-	0.197	***
	(0.166)		*(0.053)*		*(0.309)*		*(0.075)*	
nonresch	-0.069	-	-0.443	***	-0.513	*	-0.324	***
	(0.225)		*(0.069)*		*(0.271)*		*(0.066)*	
pnonresch	-0.025	-	-0.002	-	-	-	-	-
	(0.152)		*(0.061)*					
nonlbinc	-0.001	***	-0.001	***	-0.003	***	-0.002	***
	(0.000)		*(0.000)*		*(0.001)*		*(0.000)*	
pwage	-0.008	**	0.002	-	-	-	-	-
	(0.004)		*(0.001)*					
rural	0.025	-	-0.075	-	-0.018	-	-0.171	**
	(0.165)		*(0.053)*		*(0.347)*		*(0.083)*	
gh	0.004	-	0.006	***	0.019	***	0.007	***
	(0.004)		*(0.001)*		*(0.006)*		*(0.001)*	
mh	0.002	-	0.000	-	0.005	-	0.003	**
	(0.004)		*(0.001)*		*(0.005)*		*(0.001)*	
immi	0.221	-	0.227	***	-0.008	-	0.317	***
	(0.167)		*(0.061)*		*(0.317)*		*(0.088)*	
unemprt	0.048	-	0.032	***	5.843	-	0.037	***
	(0.058)		*(0.012)*		*(4.558)*		*(0.011)*	
married	-0.361	**	-0.208	***	-	-	-	-
	(0.169)		*(0.055)*					
_cons (intercept)	-2.032	***	-1.744	***	-2.731	***	-1.743	***
	(0.519)		*(0.191)*		*(0.778)*		*(0.274)*	
Sample	853		8803		516		5852	
Individuals	324		3347		216		2340	
Rho Test		0.15		0.05		0.50		0.04
Wald Test		0.00		0.00		0.00		0.00
Log Likelihood	-304.71		-3069.84		-158.90		-1801.35	

Notes: (1) See Table 2 above for variable name legend. (2) For WA, C4_2 and c514_2 includes 1 or 2 children in that age range, for Australia separate dummy variables are included for 1 or 2 children. (3) *** represents *p*-value ≤ 1%, ** represents *p*-value ≤ 5% (> 1%), * represents *p*-value ≤ 10% (> 5%)—indicated for WA models only (see text above regarding sample size). (4) Data are marginal effects for probit model (see text). (5) *Wald test* is the *p*-value for the hypothesis test that coefficients are jointly non-significant. (6) *Rho test* is the *p*-value for the hypothesis test that panel level variance explains some of the total variance (e.g. $p > 0.10$ suggests panel estimator is not different to pooled (cross-sectional) model at the 10% level of significance); thus these is some evidence that for the WA models, the panel model is not different to a pooled model—but for consistency with models for Australia, the panel model for maintained for WA. (7) Sample is the number of observations (i.e. spread across 6 waves of the HILDA). (8) Control variables for state are excluded.

Furthermore, as shown in Table 4 above, the *Rho* test (for the statistical test of pooled (cross-sectional) models versus the panel data model (which controls for unobserved heterogeneity) suggests the panel model is appropriate for the Australian models for couple females (*p*-value 0.04) and single females (*p*-value 0.05), but the test for WA single females is probably not significant (*p*-value 0.15) suggesting the panel model is not more efficient—and for WA couple females provides no support for controlling for unobserved heterogeneity.

Nonetheless, it is more likely to be a sample size issue for WA than a reliable statistical test—multi-wave longitudinal data (e.g. the HILDA data) are notoriously subject to unobserved heterogeneity (Baltagi 2003; Greene 2003; Hsiao 2003). Consequently, the panel model is maintained for WA.

Dynamics and State Dependency (Lagged Labour Force Participation): As is common in most labour force participation econometric models for Australia (and similar OECD countries), current labour force participation is influenced strongly by previous labour force status—the lagged value of labour force participation (or status, *lbfst_lag*) is statistically significant at better than the 0.001% level (*p*-value 0.000). The inclusion of the lagged dependent variable indicates the presence of "state dependence" as the other parameters effects on participation partly operate through lagged participation. Omitting this variable from the model specification generally increases the apparent statistical significance of other explanatory variables and increases the size of the estimated coefficients, moreover econometric model results are biased and not reliable (this is a missing variable model misspecification).

Trend: There is little evidence of a trend in labour force participation over the six-year period when other factors are controlled (i.e. any actual trend is accounted for by other explanatory variables). Only two of 20 wave dummy (*wavea* to *wavef* in four models) variables are statistically significant, and where significant the periods do not coincide (i.e. *wavef* for Australian single females, and *wavec* for Australian couple females).

Labour Market Experience: In all specifications, the variables representing years of work experience (*exp*) and years of experience squared (*exp_sq*), intended to capture "backward bending" supply due to decreasing returns to years of work experience on participation, are statistically significant. These results are common in participation equations. In all cases the impact of experience is very much larger than the "backward bending" impact, but the backward bending impact does not occur until the latter part of working life—that is, 25 (24) years for WA (Australian) single females, and 30 (28) years for WA (Australian) couple females (i.e. minimal difference between WA and Australia).[32] For example, for WA single females, a backward bending effect on participation is observed (due to the positive effect of "years of work experience" ($\beta_{exp} = +0.0803$) and the negative effect of "years of experience squared" ($\beta_{exp\text{-}SQ} = -0.0016$), results in a 3% increase for each additional year experience (evaluated at the mean of *exp*). Thus, each additional year of experience increases the probability of participation at a decreasing rate up to 25 years, after which time the impact of the backward bending effect dominates and additional work experience reduces the probability of participation.

For the probit models for participation for females, the "backward bending" effect is probably immaterial and it is more useful to focus on the impact of *exp* with coefficients ranging from 0.05 to 0.08 (or 5% to 8%). When considering the 95% confidence interval for the point

[32] For explanatory variables with quadratic components in the probit model (e.g. years of labour market experience and experience-squared) the joint impact of the two components is calculated as β_{exp} + (2 * $\beta_{exp\text{-}sq}$ * mean-exp). The impact of $\beta_{exp\text{-}sq}$ (the cause of the "backward bending" portion of the participation function) occurs only after the stationary point on the non-linear participation function, e.g. for WA single females the mean of years of experience is 15.03 years, but the stationary point, or point at which "backward bending" occurs is at 25 years of experience thus for this group there is little impact (the stationary point is found at the solution to the first order derivative, at β_{exp} / (2*$\beta_{exp\text{-}sq}$).

estimates for the coefficient, there is no statistical difference of the impact of *exp* on single females, coupled female, in WA or Australia.

Seeking Employment: Although work experience, generally, increases the probability of participation there appears to be no impact of years spent looking for work (*jbsearch*, and the square of the period seeking employment, *jbsearch_sq*–intended to capture the increasing cost of unemployment on participation). In all the specifications, *jbsearch* and *jbsearch_sq* were not statistically significant. One possible explanation is the strong labour market, and economic growth during the period of the HILDA data (i.e. 2001-2006)—also reflected by the lack of statistical significance for *uemprt*.

Education: At least one education-level dummy variable is statistically significant in each model—for Australia all four dummies (i.e. levels) are significant; for WA couple females three levels are significant; for WA single females just one level. This is an example where it is more likely that the results for Australia (and WA couples) are a more reliable guide to statistical significance: (1) for Australia, statistical significance is at the 0.6% at least and generally at better than 0.1% (i.e. less than 1 in 1000 chances the result is due to chance); (2) the distribution of observations across five categories (represented by 4 dummies); but, (3) the differential effect for single females in WA may be evidence of the limited choice they have in their participation decision (i.e. there is no alternative source of income—but this effect does not appear for Australian single females); or (4) it may be due to a skill shortage in the growth-economy experience by WA over the period of the HILDA data (which was stronger in WA than Australia in general). This latter explanation is also supported by the lack of statistical significance of the unemployment rate variable for females in WA compared to its significance in the models for Australia.[33] Thus, for Australia for example, couple females who hold a university degree have an increased probability of participation of 50 per cent relative to those who had only completed year 11 and below. At the other end of the spectrum, Australian couple females who only completed year 12 have an 18 per cent greater probability of participation than year 11 completion (note however that the relationship between education and participation is not linear, the impact on participation does not increase in line with education level). In further work, the interaction of education and other explanatory variables could be considered for the Australian sample. In general, the model results show that for couple females, education and increasing levels of education dramatically increase participation despite the presence of a male partner (with or without children in the household).

Children at Home:[34] Children below the age of 5 years reduce the probability of participation of couple females. For example, for Australian couple females, one child reduces participation by about 41 per cent; for WA couple females, having any children reduces the probability of participation by about 57 per cent. Results for single females are mixed, the coefficient is significant for WA, but not Australia (in both cases, less than 10% of the single females have a child under 5 years). Further investigation of this result would be useful; the result for WA is intuitive—perhaps the model specification can be adjusted with interaction

[33] The unemployment rate is a control for economic activity. Note that by definition if the number of unemployed increases and the number of employed remains unchanged the participation rate increases.

[34] Due to small sample size, children dummy variables vary between WA and Australian models: for Australia there are 5 dummies which differentiate between 1 and 2 children in an age group but for WA the dummy variable represents any child in that age group.

terms for children and other variables when later waves of HILDA provide a larger sample for WA.

On the other hand, the presence of children over 5 years of age increases the probability of participation. Thus, for couple females in Australia, a single child aged 5 to 14 years increases the probability of participation by 23 per cent, a further child increases the probability of participation by another 5 per cent. For WA, any children below 5 years of age reduced participation by about 57 per cent (possibly reflecting access to social security payments—an avenue for further investigation). Children between 15 and 24 years of age increase the probability of participation by 26 per cent. The result for couple females is, possibly, the consequence of the male "breadwinner" effect which allows couple females to exit the labour force to have children and to care for their very young, returning to the labour force when children attend school or higher education.

Single Australian females do not appear to be influenced by children below the age of five years, but increase participation by about 20 per cent for any children between 15 and 24 years. WA single female's results differ—children below age 5 reduce the probability of their participation, but older children have no impact. This is an area where further investigation would also be useful (again, a larger sample would allow investigation of the interaction effects such as access to transport or childcare).

In summary however, taking the results generally, very young children reduce the probability of female participation in the labour force, but older children encourage participation—perhaps, for example, because of the cost of raising children, the desire to resume a profession, or for social contact.

<u>Non-residential Children</u>: Female's children, of any age, who do not reside with the female (*nonresch*) also appear to have a significant impact on participation: for Australia females their presence reduces the probability of participation by 32 (44) per cent for single (couple) females. For WA single females, the impact is a 51 per cent reduction, but for couple females there is no impact—it seems more likely that the Australia (and WA single) results are more indicative of the true impact.

<u>Non-labour Income</u>: As is commonly suggested, access to non-labour real income per week (*nonlbinc*) obtained from investment income; private and public transfer income; and private and foreign pension income reduces the probability of females participating in the labour force. This variable is statistically significant at better than the 0.01% level in all models. Although estimated coefficients are small (ranging between -0.0015 and -0.0025), when translated to the impact due to a $100 increase in non-labour income per week the impact is a 15 to 25 per cent reduction in the probability of participation. Interestingly, on average, the impact does not appear to be linked to being single or a couple female (e.g. the decrease in the probability of participation per $100 increase in non-labour income for WA single females is -25%, for Australian single females is -18%, for WA couple female is -15%, and for Australian couple females is -23%). Clearly, this is a control variable as there is no, general, desire to reduce non-labour income and hence no acceptable policy objective—but the impact is large and hence it is important to note.

Immigrants' Residential Period: Although the ratio of years of residence of immigrants (*immi*[35]) is not itself subject to policy intervention, factors relating to the impact of length of residence can be influenced. The literature suggests that the length of residence of immigrants may proxy a number of other attributes. Some attributes are measurable (e.g. English language ability), some not (e.g. entrepreneurial attitude), and some are subject to influence (e.g. English ability, knowledge of Australian institutions and knowledge of the labour market processes). Thus, immigrants' labour market status represents their adjustment to the Australian labour market (Chiswick *et al.* 2005) (see Lester (2008) for a review).

In models for Australian females, *immi* is strongly significant (i.e. at better than the 0.01% level), but it is not significant for WA models (small sample combined with immigrants making up a small proportion of the sample strongly suggests the Australian result are more reliable). For immigrant single females (Australian sample), an increase of 10 per cent in the proportion of their life spent as an Australian resident increases the probability of participation by 3 per cent, for couple females the increase is 2 percent.

Thus, while the years of residence of immigrants cannot be influenced, government-provided access to English language tuition, job search knowledge including information about the operation of the Australian labour market, and other social capital formation may increase the probability of participation of immigrant females to that of otherwise similar non-immigrants. This is an area where further research may be valuable.

Health: Two measures of health are included in the models, general physical health (*gh*) and mental health (*mh*) as indexes with a range [0:100]. *gh* is statistically significant in all models except for WA couple females. Estimated coefficients imply 2 per cent (WA single females), 0.7 per cent (Australian single females), and 0.6 per cent (Australian couple females) increase in the probability of participation for a one unit increase in the index. Although there is no statistical difference at the 5% level between the values, results for Australian females seem more realistic than the WA result given the lack of significance for WA couple females.

For Australia single females *mh* is statistically significant (indicating a small 0.3% increase in the probability of participation for a one-index point increase), but not for other females. This result warrants further investigation, the literature is clearly supportive of the negative relationship between poor mental health and reduced probability of labour force participation. Moreover, poor mental health is not uncommon: about 20 per cent of Australians present as showing signs of psychological distress (Butterworth *et al.* 2004).

Control variables

In the context of the *Participation* equation, control or covariate variables are included to control for known (or expected) influential characteristics or factors that if excluded bias econometric estimates, but there is no scope to influence them, and hence beyond policy control consideration (although in some case, their impact is interesting).

Females' Partner's Attributes: For couple females, inclusion of partner attributes such as education, wage or salary, and non-resident children are control variables (variables with a *p* prefix, e.g. *pwage*). Nonetheless, interestingly, there appears to be little if any impact of these three partner's attributes: partner's education plays no role; partner's non-resident

[35] *immi* is defined as years spent in Australia divided by age (i.e. the proportion of life spent in Australia where a non-immigrant has a ratio of one, and a newly arrived immigrant ratio is zero.

children play no role; and although partner's wage is statistically significant for WA couple females, an increase in the partner's wage of $1 per hour reduces the female's probability of participation by just 0.8 per cent.

Finally, the influence of being legally married (*married*) is statistically significant and has a strong negative affect on the probability of participation. For the Australian sample of couple females, the impact is a 21 per cent reduction and for WA a 36 per cent reduction.

The tendency for inter-dependence of female labour force participation and a male resident partner or spouse indicates that further research using "collective" labour supply models to obtain more efficient and robust estimates, and to observe intra-household welfare allocations, is appropriate—when the limitations imposed by currently available theory and software can be overcome.

Other Control Variables: Other control variables, included to ensure unbiased results, include state of residence (*NSW* to *NT*), rural or urban resident (*rural*), and economic activity (*unemprt*).

Single females versus couple females—A summary

It is useful, as a final step, for examination of the influence on the probability of female labour force participation, to summarise and compare the model estimates for single and couple females at a more general level. Of interest is whether, as is conventional wisdom, there is empirical evidence that single and couple females have different patterns of labour force participation. It is clear from the models for both Australia and WA that there are surprising similarities. As noted previously, it is likely that models for the Australian samples of single and couple females result in more reliable model estimates.

Similarities for Australian single and couple females are:

- The control for state dependency (*lbfst_lag*) is necessary to correctly model single and partnered females (the absence of this control cause the importance of explanatory variables to be overstated). This control has a similar impact for single and couple females (that is, the 95% confidence intervals for single females and couple females coincide indicating no statistical difference in the estimated coefficients at the 5% level of significance[36]).
- Trends (via *wave* dummies) have little influence (one, different period dummy is significant in each group).
- Years of labour market experience (*exp*) (and experience squared, *exp_sq*) impacts do not differ substantially (the 95% confidence intervals for single females and couple females coincide).
- The period of job search (*jbsearch* and *jbsearch_sq*) is not material.
- Education (*ed1* to *ed4*) matters, the impact of each level of education are comparable, and there is little difference between single and couple females (the 95% confidence intervals coincide).
- Non-labour (*nonlbinc*) income matters, but there is little difference in impact (the 95% confidence intervals coincide).

[36] The 95% confidence interval for the estimated coefficient, β, is constructed as $\beta \pm$ (standard error of β) * (z-value for 95%=1.96).

- The impact of non-residential "own" children (*nonresch*) is similar (the 95% confidence intervals coincide).
- There are no differences in the impact of general physical health (*gh*) (the 95% confidence intervals coincide)—except *gh* is not statistically significant for WA couple females.
- The impact of being an immigrant measured as the period of residence (*immi*) is not different for single and couple females for Australia (the 95% confidence intervals coincide), but is not significant for WA.

Differences for Australian single and couple females are:

- There are important differences in the impact of children—which is not itself a variable that can be manipulated to any great extent (particularly in the short-run), but indirectly the impact of children can be influenced by, for example, the provision of childcare:
    - One or more children under 5 years of age (*c4_1, c4_2)* reduce participation of couple females significantly, but do not appear to alter the behaviour of single females.
    - One child between the age of 5 and 14 years (*c514_1)* has a similar, positive, impact on the participation of both single and couple females (the 95% confidence intervals coincide).
    - Two children between the age of 5 and 14 years (*c514_2*) further influences single females, but not couple females.
    - Any children between 15 and 24 years (*c1524*) increases participation for both groups similarly (the 95% confidence intervals coincide).
- Access to non-labour income has a significantly larger impact for single females compared to couple females (e.g., a $100 increase reduces participation for single females by 18%, but by only 6% for couple females).
- For the Australia model, single females mental health (*mh*) is important but not for couple females; this result warrants further investigation.
- Several control variables differ in their impact: rural or urban resident (*rural*), and the state of residence dummies (e.g. SA is significant for single females but not for couples—the dummy for WA is significant but of similar magnitude for both groups).

Although there are potentially small sample issues for WA models (which could be the subject of further investigation with additional waves of the HILDA) the results tend to support those for WA (putting aside differences between models for Australia and for WA). There are, however, a number of points to be considered:

- It is possible that the impact of education matters differently for single females and couple females in WA.
    - Only *ed2* is statistically significant in both groups (a 37% increase in probability of participation for couples compared to a 60% increase for single females)—significant at the 10 per cent level in both cases.

- For singles other education levels (*ed1*, *ed3*, *ed4*) are not statistically significant, for couple females two other levels are significant.

Specific differences for WA single and couple females are:

- A young child (*c4*) reduces participation similarly for single and couple females, but children between 15 and 24 years (*c514*) increases participation for couple females but not single females (children between 5 and 14 years (*c1524)* do not impact for either group).

- Non-residential children (*nonresch*) reduce participation for single females but not couple females.

- Mental health (*mh*) increases participation for Australian single females but not couple females.

In summary, although there are, for both Australia and WA, a number of similarities in the model estimates for single females and couple females, there are sufficient differences to confirm that failure to model singles and couples separately is an aggregation problem which results in "aggregation bias" (Greene 2003)—leading to potentially incorrect inference and misguided policy analysis and recommendations (notwithstanding that, as the partner control variables are non-significant, there appears to be no direct impact of partners on couple females when appropriate explanatory and control variables are included).

Policy implications arising from the analysis of female labour force participation tend to follow the literature—there are limits to potential intervention, and most policy can at best be directed to longer-term issues. For example, education generally increases the probability of labour force participation but education (and associated vocational skills development) is not subject to short-run manipulation. Similarly, very young children in a household reduces the participation rate of females, but whether there is a long-term advantage to pursue methods to increase the participation of this group is a complex question, as is the issue of what influences the decision to have a child and its relationship to labour market participation.

Examination of the model results does not suggest any particularly striking differences in drivers of labour force participation between Australia and WA females for single or partnered females.

Finally, a number of factors that influence participation have not been considered in this Report due either to their being out of scope of this Report and/or a lack of suitable data. For example, participation is influenced by availability of apprenticeships, access to educational institutions and the range of courses they offer (Richardson and Teese 2006). In addition, longer-term demographic changes influence participation: for example, projections suggest that there will be little change in the number of young people entering the labour force, but the ageing of Australia's population means more people will retire from the labour force suggesting an increased need for relatively older workers (Tan and Richardson 2006). More generally, it is clear that there are significant limitations when trying to forecast labour supply and demand (and participation), particular at the regional level. Thus, the complexity and uncertainty generally result in complicated large scale, data intensive and costly modelling methods, such as computable general equilibrium models (Tan, Lester *et al*. 2008), which are beyond the scope of this Report.[37] In addition, the impact of issues such as the "discouraged worker" effect (Pissarides 1976) and "hidden unemployment" (which alter the real and reported participation rate) and underemployment (Wooden 1993) are also beyond the scope of this Report but may be avenues for further research.

Hours Supplied Equation

The results of the labour hours supplied (primary) equations (*Hours*, equation [1] above) are the outcome of the panel two-step estimation procedure. As discussed previously, the model examines the impact of selected determinants on females' supply of hours of paid work per week for the sub-sample of females who are employed. Primary equation estimates include a variable derived from the reduced form secondary equation—the probability of employment equation (*Employed*, equation [2] above[38]). The correction terms used in the hours supplied equation are derived from females' probability of employment rather than their probability of labour force participation because the participation decision indicates their willingness to work (or more specifically to enter the labour force), but unemployed participants do not supply hours worked or additional hours worked. Hence, the inclusion of the correction terms in the primary hours supplied equations need to account for the selection bias that occurs from estimating the sub-sample of those that report positive hours in paid employment, rather than those who intend supplying hours. The derived variables (or "correction terms") from the *Employed* equation, incorporated in the *Hours* equation, correct for the influence of sample selection, potential endogeneity. The role of dynamics and state dependency, are controlled for by the inclusion of a lagged dependent variable in the *Hours* (primary) and *Employed* (reduced form) equations, respectively.

The *Hours* supplied equations are estimated as (log-linear[39]) ordinary least squares (OLS) regression model. As described previously, the OLS based approach incorporates adjustments from the *Employed* limited dependent variable model designed to account for unobserved heterogeneity and selection bias and is therefore equivalent to a panel data estimator.[40] In log-linear models, the parameter estimates (the βs) measure a constant proportional or relative change in hours for a given absolute change in an explanatory variable (i.e. semi-elasticity).[41] Thus, for continuous explanatory variables, when the estimated coefficients are multiplied by 100 the values are interpreted as a percentage change in hours supplied per week, for an additional, or marginal, unit change in the explanatory variable. For discrete (dummy) explanatory variables, the coefficients are interpreted as a percentage change in hours worked for a change in the dummy variable from zero and one (a change in state).

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[37] The participation models in this Report do not address the issue of reservation wage impacts. There is no reason to expect a significant change in behaviour, and there were no unexpected changes in the wage distribution, during the period of this analysis (2001-2006) which suggests the complexity of computing implied (consistent) estimates of females and partners market wage (which requires a full maximum likelihood approach to correct for selection effects) would improve this analysis.

[38] See Appendix III for *Employed* model estimation output.

[39] That is, the depended variable is the logarithm of hours of work (applicable as hours worked is greater than zero), the independent or explanatory variables are in levels (or as observed)—such models are also referred to as semilog models.

[40] That is, the adjustments to the OLS model incorporate the processes included in panel data estimators.

[41] If estimated parameters are large, the impact of the estimated parameters coefficient should be recalculated using exponentials (i.e. percent change in hours = $100 * [\exp(\beta_i \Delta x_i) - 1]$) to avoid an approximation error for the log-linear functions.

The impact of the individual time-invariant random effect (to deal with individual unobserved heterogeneity), and the time varying effect (to deal with endogeneity and/or selection bias) correction terms (see equation [6] above) are only statistically significant for the Australian sample (see Table 5 below).[42] Since unobserved heterogeneity is a consistent feature of panel data (Baltagi 2003; Greene 2003; Hsiao 2003), the correction terms are retained—the econometric cost is minimal, the possible bias if the corrections are not applied (i.e. failure to use a panel model) is more important issue. Further, as with *Participation* models discussed previously, the small sample size for WA models may make results less reliable than the Australian models and so the fitted parameter estimates, for single and couple females, reported in Table 5 below, restricted statistical significance to ≤ 5% for the models for Australia, but to the ≤ 10% for WA. Nonetheless, as sample sizes are smaller for *Hours* equations than the *Participation* equations, results for Australia are more likely to be more reliable and hence informative—where results for WA mirror those for Australia they imply a high level of confidence, but where they differ, small samples for WA suggest results be given less credence.

Results—Hours Equations

Overall, the estimated specifications appear to be of reasonable fit and have coefficients with the expected signs and magnitudes. The R^2 values indicate reasonable goodness-of-fit in line with the results of other labour supply models from the literature.

As noted above, *Hours* equations are log-linear models and hence coefficient estimates are interpreted as semi-elasticity: that is, the percent change in hours worked for a one-unit change in the explanatory variable or a change from zero to one for a dummy variable (see, e.g., Gujarati 1988 for details).

The *Hours* supplied equations, in Table 5 below, reveal interesting comparisons between single and couple females, for WA and Australia. For clarity, control variables such as industry sector and State (for Australian models) are excluded from the Table, as are trend (*wave*) and "state dependency" (*employment*) controls (complete econometric model output is in Appendix II).

[42] The *p*-values range from 0.20 to 0.40 for WA.

Table 5: Hours Worked: Single and Couple Females—WA and Australia

	Couple Females				Single Females			
	Western Aust.		Australia		Western Aust.		Australia	
ed1	-0.139	-	0.065	**	0.028	-	0.006	-
	(0.110)		(0.030)		(0.037)		(0.091)	
ed2	-0.098	-	0.042	-	-0.052	-	0.019	-
	(0.141)		(0.028)		(0.034)		(0.086)	
ed3	-0.142	-	-0.027	-	0.001	-	0.185	-
	(0.099)		(0.027)		(0.031)		(0.139)	
ed4	-0.219	**	-0.008	-	-0.063	**	0.198	**
	(0.103)		(0.024)		(0.032)		(0.093)	
ped1	-0.290	**	0.010	-	-	-	-	-
	(0.117)		(0.022)					
ped2	-0.295	**	0.009	-	-	-	-	-
	(0.125)		(0.027)					
ped3	-0.076	-	0.003	-	-	-	-	-
	(0.091)		(0.020)					
ped4	-0.065	-	0.044	-	-	-	-	-
	(0.110)		(0.026)					
c4_1	-	-	-0.173	***	-0.113	*	-	-
			(0.030)		(0.058)			
c4_2	-	-	-0.262	***	0.035	-	-	-
			(0.049)		(0.175)			
c514_1	-	-	-0.197	***	-0.116	***	-	-
			(0.022)		(0.033)			
c514_2	-	-	-0.238	***	-0.164	***	-	-
			(0.021)		(0.047)			
c4	0.012	-	-	-	-	-	-0.007	-
	(0.141)						(0.187)	
c514	-0.388	***	-	-	-	-	-0.005	-
	(0.087)						(0.068)	
c1524	-0.013	-	-0.060	***	0.010	-	-0.009	-
	(0.076)		(0.020)		(0.025)		(0.060)	
nonresch	0.120	-	0.068	-	0.043	-	0.083	-
	(0.133)		(0.037)		(0.029)		(0.066)	
pnonresch	-0.088	-	0.054	**	-	-	-	-
	(0.116)		(0.022)					
wage	0.009	-	-0.008	***	-0.002	-	-0.006	-
	(0.008)		(0.002)		(0.004)		(0.008)	
wage_sq	0.000	***	0.000	-	0.000	*	0.000	-
	(0.000)		(0.000)		(0.000)		(0.000)	
pwage	0.001	-	-0.003	***	-	-	-	-
	(0.002)		(0.001)					
nonlbinc	0.000	-	0.000	-	0.000	**	-0.001	**
	(0.000)		(0.000)		(0.000)		(0.000)	
rural	-0.091	-	0.018	-	0.033	-	-0.044	-
	(0.102)		(0.020)		(0.036)		(0.115)	
age	-0.056	*	0.023	**	0.015	**	0.056	**
	(0.030)		(0.010)		(0.006)		(0.023)	

	Couple Females				Single Females			
	Western Aust.		Australia		Western Aust.		Australia	
age_sq	0.001	*	0.000	***	0.000	**	-0.001	**
	(0.000)		(0.000)		(0.000)		(0.000)	
page	0.062	**	-0.008	-	-	-	-	-
	(0.031)		(0.008)					
page_sq	-0.001	**	0.000	-	-	-	-	-
	(0.000)		(0.000)					
gh	-0.007	***	-0.001	**	-0.001	**	-0.001	-
	(0.002)		(0.000)		(0.001)		(0.003)	
mh	0.002	-	0.000	-	0.000	-	0.002	-
	(0.002)		(0.001)		(0.001)		(0.002)	
immi	-0.034	-	-0.111	***	-0.075	**	-0.016	-
	(0.075)		(0.024)		(0.035)		(0.081)	
mtleave	0.106	*	0.151	***	0.097	***	0.095	-
	(0.056)		(0.015)		(0.018)		(0.053)	
umtleave	0.195	**	0.166	***	0.136	***	0.188	***
	(0.079)		(0.019)		(0.022)		(0.060)	
pptleave	0.054	-	-0.037	**	-	-	-	-
	(0.068)		(0.016)					
union	0.189	***	0.117	***	0.035	-	-0.028	-
	(0.055)		(0.014)		(0.022)		(0.057)	
sector	-0.065	-	0.037	**	0.085	***	-0.023	-
	(0.083)		(0.018)		(0.018)		(0.054)	
married	0.158	*	0.035	*	-	-	-	-
	(0.096)		(0.019)					
errorf_it	0.407	-	0.338	***	-0.218	***	-0.112	-
	(0.448)		(0.111)		(0.067)		(0.121)	
errorf_i	0.099	-	0.142	***	0.172	***	0.050	-
	(0.077)		(0.022)		(0.031)		(0.059)	
_cons (intercept)	3.286	***	3.536	***	2.428	***	1.666	**
	(1.015)		(0.268)		(0.287)		(0.711)	
Observations	428		5123		320		3512	
R^2	0.4755		0.3371		0.5807		0.3351	

Notes: (1) See Table 2 above for variable name legend. (2) For WA, *C4_2* and *c514_2* includes 1 or 2 children in that age range, for Australia separate dummy variables are included for 1 or 2 children. (3) *** represents *p*-value ≤ 1%, ** represents *p*-value ≤ 5% (> 1%), * represents *p*-value ≤ 10% (> 5%)—indicated for WA models only (see text above regarding sample size). (4) ni represents not included (e.g. the model for single females does not include a partner's wage). (5) *F*-test is the *p*-value for the hypothesis test that coefficients are jointly non-significant. (6) *errorf_it* and *errorf_i* are the corrections for unobserved heterogeneity and sample selection bias from the *Employed* equations. (7) R^2 (the coefficient of determination) is a measure of goodness-of-fit (1 represents a perfect fit). (8) Sample is the number of individual observations (i.e. spread across 6 waves of the HILDA). (9) Control variables for state, industry sector, trend, and "state dependency" are excluded for clarity.

Dynamics and State Dependency (Lagged Employment): Exclusion of the lagged employment variable ($Employment_{i,t-1}$ in Equation [5] above) or the quadratic function of $Employment_i$, (Equations [6] and [7] above: results in Appendix III) in the *Employed* equation (from where correction terms for the second-step primary *Hours* equation are obtained) caused a noticeable increase in the magnitudes of many of the estimated coefficients. This confirms that failing to accounting for "state dependence" and/or dynamics is a model misspecification which biases estimated coefficients—notwithstanding that the terms are not statistically significant in the *Hours* equations—see Vella and Verbeek (1999).

Trend: As with the *Participation* equation previously discussed, the time (or wave) dummy variables (*wavea* to *wavef*) are generally non-significant (a different wave dummy is significant in three models), except for the WA single female specification. This result suggests that there has been no discernable time-trend in the hours worked for females (or controlling for a time-trend is not required)—except that there was a distinct pattern of a reduction in hours worked for single females in WA; the reason for this differential result is unclear.

Education: As discussed above, education (*ed1* to *ed4*) has an important influence on the probability of labour force participation, but it has little influence, and even less consistency of impact, on the hours of work of females. In each model only one education dummy variable is statistically significant: *-ed4* for Australian single females (6% decrease), for WA couple females (22% decrease), and for WA single females (20% increase), and *+ed1* for Australia couple females (7% increase). Thus, no strong pattern of impact of education emerges.

For WA couple females, the partner's education (*ped1* to *ped4*) level matters: two of four education dummies are statistically significant with negative coefficients (30% decrease)—the higher the education of the female's partner the less hours the WA couple female supplies (suggesting some households are considering comparative advantage—an issue that could be the subject of further investigation in a "collective" model when software and theory advance). Nonetheless, the only other result that is close to being significant is for Australia couple females with a much lower impact of a 4% decrease (*p*-value 0.086).

On balance it appears that own and partner's education are not strongly influential in influencing the hours supplied by females, and there appears little if any role for policy intervention.

Children at Home:[43] There is some consistency for results for single and couple females for Australia, but not for WA, when considering the impact of own-children living with the female (*c4_1*, *c4_2, c514_1*, *c514_2*, *c1524* or *c4*, *c514*, *c1524*). Thus, for Australian couple females, an own-child at home (i.e. from baby to age 24) reduce the number of hours worked: for example, by 26 per cent for one child below 5 years of age; 20% for a child between 15 and 24; 6% for a child between 15 and 24 years. For Australian single females the impact of the number of children is about half that of couple females (with no impact of older children age 15 to 24).

On the other hand, single females in WA do not lower hours worked if there are children at home, and WA couple females only reduce hours for children aged 5 to 14 years. This is a case where the Australian results probably should be considered more reliable, not only are samples small for WA (i.e. 428 observations for WA couple females, and 320 for single females), but the numbers of children for single females potentially result in uneven distribution across dummy variables which may also contribute to less reliable results.

[43] As noted previously, small samples for WA require fewer children dummy variables in models (3 dummies) than used in the models for Australia (5 dummies).

Cognisant of the qualification regarding small samples for WA models, results for the impact of children on hours supplied are similar to their influence on the probability of labour force participation (by sign of coefficient, magnitudes are about twice the size for participation when statistically significant). Thus, for Australian couple females, any own-children at home reduce the probability of participation and of hours supplied while for WA couple females there is a negative affect, but not for all classes of children; Australian single females are also influenced, but to a lesser degree than couple females; on the other hand, for WA single females, young children aged below 5 years reduces the probability of participation but appear to have no impact on hours supplied

Non-residential Children: The presence of non-residential own (*nonresch*) or partner's children (*pnonresch*) appear to have little impact on hours supplied: for Australia couple females, they increase hours by about 6 per cent, but are not significant in any other *Hours* equation.

Non-labour Income: Although strongly significant with respect to the probability of participation, non-labour income (*nonlbinc*) has only a small impact on the hours supplied of single females. For WA single females, hours are reduced by 7 per cent for each $100 of non-labour income, and for Australian single females, the reduction is just 2 per cent. Thus, a single Australian female working average hours reduces her hours supplied by about 50 minutes for an increase of $100 extra in non-labour income—and a WA single female reduces hours by about 2 hours per week. Thus, once non-labour income has influenced females' probability of labour force participation it has no consequential impact on female hours supplied.

Age

Except for WA couple females, the impact of age (*age*) is consistent across specifications. Thus, a one year increase in age increase hours supplied by 2 per cent for Australia single and couple females, and by 6 per cent for WA single females. For WA couples however there is a perverse 6 per cent reduction in hours for each year. Perhaps the Australian results should be considered more reliable.

The impact of age-squared (*age_sq*), to account for diminishing returns to age, is as expected (except for WA couple females): the coefficient is negative and very small (e.g. a maximum of 0.06% for WA single females suggesting a 6% decrease in weekly hours supplied for a 10 year increase in age—which is overwhelmed by the direct impact of age).

The clear implication from this result is that industry's apparent preference for younger workers is counter-productive. It is often due to discrimination, as employers simply assume older workers are less productive. Moreover, older workers who no longer have dependent children may be more mobile, but may be selective and able to set a higher reservation wage if they have sufficient assets (Goza and DeMaris 2003; Mazerolle and Singh 2004; Mitchell and Bill 2005; Lester 2008). This suggests participation and hours worked by females can be influenced by actions designed to influence industry's reported attitude to older workers.

Health: Mental health (*mh*) has no impact on the number of hours supplied—this may be acceptable if it is thought that those under mental stress self-select out of the labour force, but that explanation is not appropriate for the sample investigated for this Report. For example, as expected in a measure of the general population, the *mh* score for Australian couple females has a mean of 76 with a minimum of 4 and a maximum of 100 (in the 0 to 100 index). Not all those in stress are self-selected out of the labour force. One possible explanation is that those in mental stress take paid leave and hence do not record a reduction in hours, or maintaining work attachment is seen as part of the treatment for some mental health conditions. While likely to influence some under mental stress this does not appear to be the explanation covering all employed females under mental stress. This is an area that requires further investigation.

General physical health (*gh*) is statistically significant for Australian females and for WA couple females, but while results are consistent (the 95% confidence intervals coincide) they are counter intuitive: the estimated coefficients are negative indicating an increase in health reduces hours of labour supplied. Do health female workers increase their "consumption" of leisure? This result also requires further investigation.

Immigrants' Residential Period: As with the *Participation* equation, in models for Australian females, *immi* is significant, but it is not significant for WA models (perhaps a result of small sample and a small proportion of immigrants). In contrast with the *Participation* equation, however, as the length of residence increases the number of hours supplied decreases—with an apparent difference for single and couple females being removed when the 95% confidence interval for the point estimates is considered. The reason for this outcome is not known and warrants further investigation.

Wage: The average hours worked are relatively high, particularly for single females (i.e., 32.5 (31.4) for WA (Australian) single females, and 26.6 (28.2) for WA (Australian) couple females). Consequently, a wage increase may have a limited impact on hours supplied since, Australian families are "time poor" (Apps 2007)—and this is particular so for working mothers. In this case, an increase in wage rates will not necessarily increase hours supplied, and it may result in a reduction in hours worked—i.e. the "backward bending" labour supply curve associated with higher level wage earners. This appears to be the case for Australian couple females—the only group for which the wage rate (*wage*) is statistically significant (at better than the 0.01% level, with the next highest p-value = 0.285). The impact of wage squared (*wage_sq*), to capture the "backward bending" labour supply affect in the more usual way (i.e. not through *wage*) operates for Australian couple females, but not WA couple females.

For single females the lack of statistical significance suggests a lack of access to other sources of income curtails their ability to reduce hours, but in parallel with Australia couple females, suggest that they are also "time poor" and choose to maintain hours. Which of these views predominates could be the subject of further investigation.

It should also be recalled that in many cases, workers have little control over the number of hours they work—generally, workers have limited discretion on the number of hours worked (even casual employees respond to employers' requests to increase or decrease hours with perhaps little freedom to deny requests).

Moreover, most low-wage workers live in middle and upper income households (Richardson 1998; Harding and Richardson 1999) and hence may choose hours with respect to the household requirements and not based simply on a wage change.[44] As noted previously, when the "collective" model for joint household decisions has been made more accessible, it may

[44] For example, at $10 per hour 15 hours work provides $150 income and an increase to $15 per hour requires only 10 hours for $150—if $150 is sufficient a worker may reduce hours worked.

be able to provide more empirical insights into the impact of wage on hours supplied. Inclusion of a partner's wage in models for couple females shows a small impact for Australian couple females (a coefficient of -0.003 suggesting a 0.3% reduction in hours (or, at the mean, less than one hour per week) for a $10 per week increase in their partner's wage). There is no impact for the WA couple female model.

The issue of the impact of wage on hours supplied appears to be complex and requires further investigation to draw conclusions.

<u>Maternity and Paternity Leave</u>: It is clear from all models that the availability of paid (*mtleave*) or unpaid maternity leave (*umtleave*) is an important influence on hours supplied by females. In the Australian model, both forms of leave are statistically significant at better than the 0.01% level; for the WA model *umtleave* is significant at the 0.1% level or better. Thus, for example, for Australian couple females the presence of maternity leave increases the hours supplied by about 16 per cent. Although point estimates suggest that *umtleave* has a larger impact than *mtleave*, the 95 per cent confidence intervals coincide.

Maternity leave is also reasonably important for single females, increasing hours supplied by between 10 and 20 per cent (depending on whether for Australia or WA, or paid or unpaid leave).

Partner's paternity leave (*pptleave*) is statistically significant for Australian couple females, but the result is counter-intuitive: the availability of *pptleave* reducing hours supplied by about 4 per cent.

As discussed above, these explanatory variables have rarely been included in previous labour supply models, and thus the consistent statistical significance indicates its absence is a model misspecification (resulting in biased model estimates). Moreover, maternity leave may also be a proxy for other employment conditions (e.g. desirable working conditions).

As maternity leave is an area that could be influenced by government intervention the importance of the availability of such leave requires further investigation. Thus, for example, as well as more detailed specification of leave entitlements in econometric specifications, the interaction between industry sector and leave could be considered—are there industries where greater attention should be directed?

<u>Control variables</u>

<u>Females' partner's attributes:</u> As with the *Participation* equations, for couple females, inclusion of partner attributes such as education, wage or salary, age, and non-resident children are control variables. Although for WA couple females, partner's education and age (but not wage or non-residential children) have an influence on females hours supplied, for Australian couple females partner's wage and non-residential children (but not education or age) have an influence on hours. As these are control variables, the estimated coefficients are of limited interest, but the statistical significance of partner's wage in the Australian model makes more intuitive sense thus adding further to any disquiet regarding the veracity of the econometric model results for the small sample WA.

Being married (*married*) increases hours supplied, by about 3% for the Australian couple females but by 16% for WA

As with the *Participation* equations, results confirm the appropriateness of modelling single and partnered females separately. Moreover, the *Hours* equations show some influence of partners' attributes on hours supplied by females, supporting further research using "collective" labour supply models.

Other control variables: There are a number of control variables included in both single female and couple female *Hours* equations. Although there is little if any scope to influence them, directly or indirectly, and hence no avenue for policy intervention, some results are quite interesting. Moreover, where statistically significant, they suggest their absence in previous models is a model misspecification—leading to unreliable econometric results.

- Trade union membership (*union*) has a positive influence on hours worked, except for single females in the WA sample. For single and couple females, in the Australian specifications, *union* increased hours worked by 9 per cent and 12 per cent, respectively. For couple females, in the WA specification, *union* increased hours worked by 21 per cent.
- In the Australian single female specification, five of the seven State of residence variables (*NSW* to *TAS* but not *NT*) are statistically significant, but in the Australian couple female model only *TAS* was significant.
- Six (seven) of the 16 industry sector variables (*ind01* to *ind16*) were significant in the Australian couple (single) female model. In the WA models, four (six) dummies were significant in the couple (single) females models.

Control variables private versus public employment (*sector*) and rural or urban resident (*rural)* were not statistically significant.

Single females versus couple females—A summary

As with the *Participation* models, a useful final step considers whether, as is conventional wisdom, there is empirical evidence that single and couple females have different patterns of labour hours supplied. Moreover, as noted for the *Participation* models, it is likely that models for the Australian samples of single and couple females result in more reliable model estimates than the WA models.

Similarities for single and couple females are:

- The control for dynamics and "state dependency" (the lagged value and polynomial for *employment*) is similarly not significant for single and couple females.
- Trends (via *wave* dummies) have little influence (significance shows no pattern for the two groups).
- The impact of non-residential "own" children (*nonresch*) is very similar.
- There is no difference in the impact of general physical health (*gh*) (*gh* is not statistically significant for WA single females). Mental health (*mh*) has no impact on either group.
- The impact of being an immigrant measured as the period of residence (*immi*) is not different for single and couple females for Australia, but is not significant for WA.
- Age (*age*) impacts are very similar for Australian females and WA single females (but for WA couple females results are perverse).

- Maternity leave (*mtleave* and *umtleave*) impacts are similar.

Differences for single and couple females are:

- There are important differences in the impact of children—which, as noted previously, is not amenable to manipulation, but indirectly the impact of children can be influenced by, for example, the provision of childcare. The pattern of the impact of children changes depending on the age of the children and how many children there are. For example, for single Australian females any children age between 15 and 24 years have no influence on hours, but for couple Australian females they reduce hours by 6 per cent.
- Only one education dummy variable (*ed1* to *ed4*) matters in each specification, but the education level for Australian couple females is not the same at that for Australian single females (and WA).
- Non-labour income (*nonlbinc*) matters for single but not couple females.
- There is an inverse relationship between wage and hours supplied for Australian couple females, but not single Australian females (*wage* does not matter in the WA models, however).
- Two control variables matter differently: employed in the public or private sectors (*sector*) matters for Australian couple females but not single females (it is not significant for WA); State of residence dummy patterns differ between single and couple Australian females; there are some differences in the patterns for industry dummy variables (*ind01* to *ind16*).

Conclusion

This Report is based on estimating *Participation* and *Hours* equations for single and couple females in Western Australia and Australia. The Report provides justification for the econometric models chosen and discusses the limitations of the models and the ensuing results. Throughout, references are made to a number of issues that should be considered for future research by the Western Australia Department of Consumer and Employment Protection to extend the scope of this work.

To the extent possible, given current theoretical and applied limitations, this Report provides models based on recent advances in both theoretical and practical applications of panel (longitudinal) data econometric models. To the extent that the work is an advance on previous methods, it provides econometric model results that are more reliable: biases due to model misspecification (including missing variables), unobserved heterogeneity, selection bias, and dynamics and “state dependency”, have been addressed.

A number of innovations in this Report (beyond the use of advanced modelling techniques) provide added perspective on the hours supplied decision of females. For example, the availability of maternity leave has an impact in all hours equations, and the period of residence is also influential—a method of examining immigrants’ labour supplied not previous considered.

The results clearly indicate that female data must be disaggregated to single and couple females sub-samples. Although the explanatory power of several important explanatory variables is not different across single and couple female models, a sufficient number differ importantly—aggregation of single and couple females results in “aggregation bias” and unreliable econometric estimates.

The Report provides interesting insights to females’ behaviour, and suggests several areas where government policy intervention may contribute to increased hours supplied—for example, in the are of maternity leave and access to labour market skills for immigrants. As discussed in the text, advances in theory and econometric practice are likely to provide more sophisticated models (e.g. the “collective” model) which may lead to further avenues for government intervention.

On the other hand, the probability of labour force participation seems to suggest few areas where state government intervention could successfully influence participation. This is an area that could be considered for further investigation.

Suggestions for further Research

In addition to suggestions made at various points above when discussing econometric results for the *Participation* and *Hours* equations, there are a number of comments that can be made with reference to areas that could be considered for future research by the Western Australia Department of Consumer and Employment Protection to both extend the scope of the current models and improve on the current results.

The most important field for future research is to utilise the recent theoretical extension of labour supply modelling, and move beyond the commonly used “unitary” approach to the “collective” decision making modelling method.

As previously discussed, the use of the “collective” approach observes the decision making process at the individual level, rather than at the household level in the “unitary” approach. While, not surprisingly, the “collective” approach has been found not to improve econometric models for single persons, the model consistently, significantly, alters the econometric results for coupled persons. The additional benefit of the “collective” approach in modelling labour supply is that it takes into account (and in some cases provides methods to extract) the rules or bargaining that takes place within a household (specifically, the intra-household allocations of welfare between male and female partners—which addresses the issue of inequality of decision making power). A consequence of the very recent theoretical advances are, however, that a number of impediments to constructing complex “collective” models exist. For example, extensions of the “collective” approach to include children and non-labour market participants are still in their infancy and, thus far, do not appear to be fully specified. Moreover, to the extent that “collective” models have been theoretically solved and hence can be specified for econometric analysis, the estimation of the models require sophisticated computational and econometric techniques beyond those utilised in this Report, and beyond the more sophisticated “off the shelf” econometric packages. Nonetheless, advanced work is continually appearing in working papers and other sources, and testable specifications—and econometric package add-ons (e.g. STATA ado files)—are expected to become available.

Small sample issues, for smaller population Australian state (e.g. WA), may limit the application of advance models, however. As demonstrated throughout this Report, models for Australian females and WA females differ to the extent that some explanatory variables are statistically significant in the Australian models but not the WA models. Thus, if sample size does not allow specific small population states to be successfully modelled, it appear to be clear that models for Australia may be satisfactorily informative. Alternatively, models for aggregation of similar Australian states could be considered (e.g. for WA and Queensland combined if this produces satisfactory sample size). Moreover, further waves of the HILDA survey become available annually and this may help with sample size issues. Moreover, sufficiently large samples may allow further disaggregation: for example, participation and hours supplied could then be considered at age group level, or for part-time and full-time employees.

Finally, this Report has considered models for females, with control for some partner's attributes. An important question—an extension to this Report—to be considered to further inform the decision making or policy planning process relates to the reaction of male partners to female's changes in participation and hours supplied—if female participation or increased hours was at the expense of a reduction in male participation or hours which sector should be targeted?

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Appendix I—Limited Dependent Variable (Probit) Employment and Participation Equations

An individual's probability of being a labour market participant or of being employed is a function of their attributes (and control variables such as current labour market conditions). The probability of the *i*-th individual being a participant or being employed (P = 1) can be written as the nonlinear (logit or probit) function (see e.g. Winkelmann and Winkelmann 1998):

$$\text{Prob}[P_t = 1 \mid X = x] = \Phi[X'\beta] \quad (1)$$

where **Φ** is the cumulative distribution function of the standard normal distribution.

The estimated coefficients take the form:

$$\frac{\partial \Pr[y_i = 1 \mid X_i]}{\partial x_i} = \Phi(\beta' x_i)\beta \quad (2)$$

The probit model can be represented as the linear model:

$$\text{Prob(Participation)} = \beta_1 x_{1it} + \beta_2 x_{2it} + \cdots + \beta_k x_{ikt} + \varepsilon_{it} \quad (3)$$

In this representation, the left-hand-side of the specification is the probability of being a labour force participant or of being employed to the probably of not being a participant or employed) of being a participant or being employed—functions of the individual's attributes (**X**) (and a random error term).

Appendix II—Econometric Model Output

Western Australia – Couple Females – Participation Equation

Random-effects probit regression — Number of obs = 853
Group variable: id — Number of groups = 324

Random effects u_i ~ Gaussian — Obs per group: min = 1, avg = 2.6, max = 6

Wald chi2(31) = 376.68
Log likelihood = -304.71391 — Prob > chi2 = 0.0000

lbfst	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lbfst_lag	1.888969	.1264514	14.94	0.000	1.641129	2.136809
waveb	-.0244927	.1976482	-0.12	0.901	-.4118761	.3628907
wavec	-.2713048	.1958002	-1.39	0.166	-.6550662	.1124565
waved	.0797148	.2068265	0.39	0.700	-.3256577	.4850873
wavee	-.0530078	.2019956	-0.26	0.793	-.4489118	.3428963
wavef	.1786049	.2218373	0.81	0.421	-.2561883	.6133981
exp	.0592047	.0221195	2.68	0.007	.0158514	.1025581
exp_sq	-.0009952	.000534	-1.86	0.062	-.0020418	.0000513
jbsearch	.1530309	.1214896	1.26	0.208	-.0850843	.3911461
jbsearch_sq	-.010904	.0189692	-0.57	0.565	-.0480829	.026275
ed1	.564478	.1907038	2.96	0.003	.1907054	.9382506
ed2	.365798	.2052276	1.78	0.075	-.0364408	.7680367
ed3	.2372521	.1900422	1.25	0.212	-.1352238	.609728
ed4	.4323775	.1750432	2.47	0.014	.0892991	.7754558
ped1	.2972435	.2054416	1.45	0.148	-.1054145	.6999016
ped2	.2472517	.2550489	0.97	0.332	-.252635	.7471384
ped3	.1139761	.1655719	0.69	0.491	-.2105388	.438491
ped4	-.116562	.2240809	-0.52	0.603	-.5557525	.3226286
c4	-.5673306	.1483223	-3.82	0.000	-.858037	-.2766242
c514	.1935347	.1480871	1.31	0.191	-.0967106	.48378
c1524	.3695578	.1655905	2.23	0.026	.0450064	.6941092
nonresch	-.0687947	.2245844	-0.31	0.759	-.5089721	.3713826
pnonresch	-.025466	.1517954	-0.17	0.867	-.3229795	.2720475
nonlbinc	-.0014854	.0003263	-4.55	0.000	-.002125	-.0008458
pwage	-.0081943	.0041081	-1.99	0.046	-.016246	-.0001426
rural	.0249105	.1654589	0.15	0.880	-.2993829	.3492039
gh	.0042457	.0036769	1.15	0.248	-.0029609	.0114523
mh	.0019575	.0044457	0.44	0.660	-.006756	.010671
immi	.2210534	.1671789	1.32	0.186	-.1066112	.548718
unemprt	.0480011	.0584305	0.82	0.411	-.0665205	.1625228
married	-.3613635	.1692246	-2.14	0.033	-.6930376	-.0296894
_cons	-2.032026	.5188827	-3.92	0.000	-3.049017	-1.015034
/lnsig2u	-11.60964	24.29482			-59.22661	36.00733
sigma_u	.003013	.0366001			1.38e-13	6.59e+07
rho	9.08e-06	.0002205			1.90e-26	1

Likelihood-ratio test of rho=0: chibar2(01) = 8.8e-05 Prob >= chibar2 = 0.496

Western Australia – Single Female – Participation Equation

Random-effects probit regression — Number of obs = 516
Group variable: id — Number of groups = 216

Random effects u_i ~ Gaussian — Obs per group: min = 1, avg = 2.4, max = 6

Wald chi2(24) = 139.28
Log likelihood = -158.90223 — Prob > chi2 = 0.0000

lbfst	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lbfst_lag	1.319273	.2474575	5.33	0.000	.8342656	1.804281
waveb	.280093	.2908363	0.96	0.336	-.2899356	.8501217
wavec	.1835671	.2854228	0.64	0.520	-.3758513	.7429856
waved	.4203635	.301654	1.39	0.163	-.1708675	1.011594
wavee	.1517401	.2907529	0.52	0.602	-.4181252	.7216053
wavef	.4156328	.3294766	1.26	0.207	-.2301294	1.061395
exp	.0802234	.0346148	2.32	0.020	.0123796	.1480672
exp_sq	-.0016058	.0008042	-2.00	0.046	-.0031819	-.0000296
jbsearch	-.0246419	.1408757	-0.17	0.861	-.3007533	.2514694
jbsearch_sq	.0088995	.0144282	0.62	0.537	-.0193792	.0371783
ed1	.4785195	.3316429	1.44	0.149	-.1714887	1.128528
ed2	.5996414	.3593074	1.67	0.095	-.1045881	1.303871
ed3	.3824094	.3583839	1.07	0.286	-.3200101	1.084829
ed4	.19623	.3050597	0.64	0.520	-.4016759	.794136
c4	-.668899	.3752694	-1.78	0.075	-1.404414	.0666156
c514	.0806253	.2844835	0.28	0.777	-.4769522	.6382028
c1524	-.0420995	.3092135	-0.14	0.892	-.6481468	.5639478
nonresch	-.5133601	.2710665	-1.89	0.058	-1.044641	.0179204
nonlbinc	-.0025145	.0006518	-3.86	0.000	-.0037919	-.0012371
rural	-.0182826	.3474776	-0.05	0.958	-.6993263	.662761
gh	.0186257	.0056481	3.30	0.001	.0075555	.0296958
mh	.0049937	.0053842	0.93	0.354	-.0055591	.0155465
immi	-.0078915	.3170338	-0.02	0.980	-.6292663	.6134833
unemprt	5.842966	4.55841	1.28	0.200	-3.091354	14.77729
_cons	-2.731335	.7781298	-3.51	0.000	-4.256441	-1.206228
/lnsig2u	-1.44963	1.209015			-3.819255	.9199957
sigma_u	.4844142	.292832			.1481355	1.584071
rho	.1900585	.1861113			.0214729	.7150412

Likelihood-ratio test of rho=0: chibar2(01) = 1.12 Prob >= chibar2 = 0.145

Australia – Couple Females – Participation Equation

Random-effects probit regression		Number of obs =	8803
Group variable: id		Number of groups =	3347
Random effects u_i ~ Gaussian		Obs per group: min =	1
		avg =	2.6
		max =	6
		Wald chi2(40) =	3442.60
Log likelihood = -3069.8352		Prob > chi2 =	0.0000

lbfst	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lbfst_lag	1.869992	.0423345	44.17	0.000	1.787018	1.952966
waveb	-.0823891	.061301	-1.34	0.179	-.2025368	.0377586
wavec	-.1536241	.0611342	-2.51	0.012	-.2734448	-.0338033
waved	-.0329212	.0627959	-0.52	0.600	-.1559989	.0901565
wavee	.1052931	.0635739	1.66	0.098	-.0193095	.2298956
wavef	.0307223	.0641951	0.48	0.632	-.0950977	.1565423
exp	.0615833	.0077803	7.92	0.000	.0463343	.0768323
exp_sq	-.0010965	.0001848	-5.93	0.000	-.0014588	-.0007342
jbsearch	-.0136266	.0209698	-0.65	0.516	-.0547266	.0274734
jbsearch_sq	-.0003363	.0012685	-0.27	0.791	-.0028225	.00215
ed1	.5017467	.0625724	8.02	0.000	.3791071	.6243864
ed2	.203659	.0709022	2.87	0.004	.0646933	.3426247
ed3	.27568	.0659742	4.18	0.000	.1463728	.4049871
ed4	.1831747	.0562179	3.26	0.001	.0729896	.2933598
ped1	.0020445	.0633533	0.03	0.974	-.1221257	.1262146
ped2	.051031	.0750801	0.68	0.497	-.0961232	.1981852
ped3	.0429009	.0537511	0.80	0.425	-.0624493	.1482511
ped4	.0241549	.0711333	0.34	0.734	-.1152638	.1635736
c4_1	-.4051332	.0560396	-7.23	0.000	-.5149689	-.2952975
c4_2	-.6122876	.0766114	-7.99	0.000	-.7624431	-.462132
c514_1	.2278666	.0561384	4.06	0.000	.1178373	.3378958
c514_2	.0484271	.0556267	0.87	0.384	-.0605991	.1574533
c1524	.2602025	.052936	4.92	0.000	.1564499	.3639551
nonresch	-.443269	.0691135	-6.41	0.000	-.578729	-.3078091
pnonresch	-.0022632	.0613397	-0.04	0.971	-.1224868	.1179605
nonlbinc	-.0006387	.0000743	-8.59	0.000	-.0007844	-.000493
pwage	.0016379	.0013103	1.25	0.211	-.0009302	.0042061
rural	-.0750038	.053121	-1.41	0.158	-.179119	.0291114
gh	.0059394	.0011198	5.30	0.000	.0037445	.0081342
mh	-.0002866	.001341	-0.21	0.831	-.0029149	.0023416
immi	.2267124	.0605042	3.75	0.000	.1081264	.3452984
unemprt	.0321374	.0124273	2.59	0.010	.0077803	.0564944
married	-.2080465	.0551436	-3.77	0.000	-.316126	-.099967
NSW	-.1515344	.1241469	-1.22	0.222	-.3948578	.0917889
VIC	-.1729308	.1255415	-1.38	0.168	-.4189877	.073126
QLD	-.2236143	.1277358	-1.75	0.080	-.4739718	.0267432
SA	-.1890076	.1352631	-1.40	0.162	-.4541183	.0761031
WA	-.2802002	.1336723	-2.10	0.036	-.5421932	-.0182072
TAS	-.2902468	.161763	-1.79	0.073	-.6072964	.0268027
NT	1.060301	.3714352	2.85	0.004	.3323011	1.7883
_cons	-1.743564	.1905336	-9.15	0.000	-2.117003	-1.370125
/lnsig2u	-2.732025	.6134422			-3.93435	-1.529701
sigma_u	.2551222	.0782514			.1398514	.4654036
rho	.0611098	.0351965			.0191832	.1780375

Likelihood-ratio test of rho=0: chibar2(01) = 3.14 Prob >= chibar2 = 0.038

Australia – Single Females – Participation Equation

Random-effects probit regression		Number of obs =	5852
Group variable: id		Number of groups =	2340
Random effects u_i ~ Gaussian		Obs per group: min =	1
		avg =	2.5
		max =	6
		Wald chi2(33) =	2123.96
Log likelihood = -1801.3518		Prob > chi2 =	0.0000

lbfst	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lbfst_lag	1.786043	.0578713	30.86	0.000	1.672617	1.899469
waveb	.1292491	.0800611	1.61	0.106	-.0276677	.2861659
wavec	.0608847	.0791243	0.77	0.442	-.094196	.2159655
waved	.0862443	.0810249	1.06	0.287	-.0725617	.2450502
wavee	.1562432	.0825641	1.89	0.058	-.0055794	.3180659
wavef	.2725404	.0866038	3.15	0.002	.1028002	.4422806
exp	.0477221	.0080564	5.92	0.000	.0319319	.0635122
exp_sq	-.0009843	.0001976	-4.98	0.000	-.0013715	-.0005971
jbsearch	.0094369	.0230402	0.41	0.682	-.035721	.0545949
jbsearch_sq	-.0007925	.0015833	-0.50	0.617	-.0038958	.0023107
ed1	.5225034	.0804068	6.50	0.000	.3649089	.6800979
ed2	.4085108	.1005936	4.06	0.000	.2113509	.6056706
ed3	.3208383	.0815207	3.94	0.000	.1610606	.480616
ed4	.2016972	.0729698	2.76	0.006	.058679	.3447153
c4_1	-.0696618	.0888369	-0.78	0.433	-.2437789	.1044554
c4_2	-.0102683	.1853356	-0.06	0.956	-.3735193	.3529828
c514_1	.2130745	.0780743	2.73	0.006	.0600517	.3660974
c514_2	.2312888	.0954823	2.42	0.015	.044147	.4184306
c1524	.1965285	.0745728	2.64	0.008	.0503685	.3426885
nonresch	-.3237336	.066197	-4.89	0.000	-.4534773	-.1939898
nonlbinc	-.0018199	.0001546	-11.77	0.000	-.002123	-.0015168
rural	-.1710688	.0828454	-2.06	0.039	-.3334428	-.0086947
gh	.007299	.0013346	5.47	0.000	.0046832	.0099147
mh	.0030497	.0014763	2.07	0.039	.0001561	.0059432
immi	.3166234	.0876266	3.61	0.000	.1448785	.4883683
unemprt	.0365796	.0106746	3.43	0.001	.0156578	.0575014
NSW	-.3845344	.2229934	-1.72	0.085	-.8215935	.0525247
VIC	-.351391	.2239412	-1.57	0.117	-.7903077	.0875257
QLD	-.4975815	.2286735	-2.18	0.030	-.9457734	-.0493896
SA	-.4833114	.2329825	-2.07	0.038	-.9399488	-.026674
WA	-.4604903	.233698	-1.97	0.049	-.9185299	-.0024507
TAS	-.3223671	.2614006	-1.23	0.217	-.8347029	.1899687
NT	-.2559375	.3379353	-0.76	0.449	-.9182785	.4064036
_cons	-1.742915	.2740347	-6.36	0.000	-2.280014	-1.205817
/lnsig2u	-2.509889	.6793177			-3.841328	-1.178451
sigma_u	.2850916	.0968339			.1465097	.5547568
rho	.0751678	.0472245			.021014	.2353308

Likelihood-ratio test of rho=0: chibar2(01) = 2.68 Prob >= chibar2 = 0.051

Western Australia – Couple Females – Employment Equation

```
Random-effects probit regression                Number of obs      =       853
Group variable: id                              Number of groups   =       324

Random effects u_i ~ Gaussian                   Obs per group: min =         1
                                                               avg =       2.6
                                                               max =         6

                                                Wald chi2(31)      =    315.40
Log likelihood  = -311.93445                    Prob > chi2        =    0.0000
```

empt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
empt_lag	1.796858	.1462758	12.28	0.000	1.510162	2.083553
waveb	-.0775868	.2016608	-0.38	0.700	-.4728346	.3176611
wavec	-.3310651	.201619	-1.64	0.101	-.7262312	.0641009
waved	-.1397278	.2127951	-0.66	0.511	-.5567986	.277343
wavee	-.0534717	.2072886	-0.26	0.796	-.45975	.3528065
wavef	-.095655	.223661	-0.43	0.669	-.5340224	.3427124
exp	.0602149	.0249191	2.42	0.016	.0113744	.1090554
exp_sq	-.0010068	.0005886	-1.71	0.087	-.0021604	.0001468
jbsearch	.0955203	.1322254	0.72	0.470	-.1636368	.3546774
jbsearch_sq	-.0240791	.0214936	-1.12	0.263	-.0662059	.0180477
ed1	.7405273	.2319638	3.19	0.001	.2858866	1.195168
ed2	.4596564	.2351497	1.95	0.051	-.0012286	.9205413
ed3	.3358393	.214016	1.57	0.117	-.0836243	.7553029
ed4	.508207	.201064	2.53	0.011	.1141288	.9022852
ped1	.3554263	.2295564	1.55	0.122	-.0944959	.8053485
ped2	.3264152	.2837523	1.15	0.250	-.2297291	.8825595
ped3	.1567323	.1845075	0.85	0.396	-.2048958	.5183603
ped4	-.0371341	.2486962	-0.15	0.881	-.5245697	.4503015
c4	-.5696142	.1828606	-3.12	0.002	-.9280144	-.2112139
c514	.3322138	.1616249	2.06	0.040	.0154348	.6489927
c1524	.2597034	.1769703	1.47	0.142	-.0871521	.6065589
nonresch	.0237979	.2563074	0.09	0.926	-.4785553	.5261512
pnonresch	-.1106515	.2014534	-0.55	0.583	-.5054929	.2841898
nonlbinc	-.0016401	.0004046	-4.05	0.000	-.0024331	-.0008471
pwage	-.0071313	.0043754	-1.63	0.103	-.0157069	.0014444
rural	.0575548	.1799022	0.32	0.749	-.2950469	.4101566
gh	.0071014	.0040812	1.74	0.082	-.0008976	.0151004
mh	.0000778	.004716	0.02	0.987	-.0091653	.0093209
immi	.2511185	.1877821	1.34	0.181	-.1169276	.6191646
unemprt	-.0032773	.0595516	-0.06	0.956	-.1199962	.1134416
married	-.356755	.1849778	-1.93	0.054	-.7193049	.0057949
_cons	-1.991679	.5580732	-3.57	0.000	-3.085482	-.8978757
/lnsig2u	-2.018616	1.167803			-4.307469	.2702363
sigma_u	.3644711	.2128153			.11605	1.144672
rho	.1172621	.1208814			.0132886	.5671509

Likelihood-ratio test of rho=0: chibar2(01) = 0.99 Prob >= chibar2 = 0.159

Western Australia – Couple Females – Hours Supplied Equation

```
Linear regression                                      Number of obs =     428
                                                       F( 58,   369) =    7.57
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.4755
                                                       Root MSE      =  .48567
```

lnhoursf	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
employment	4.996392	5.075566	0.98	0.326	-4.98427	14.97705
employment~q	-23.18373	16.19881	-1.43	0.153	-55.03728	8.669825
employment~b	32.268	22.16559	1.46	0.146	-11.31873	75.85473
employment_4	-14.21239	10.68707	-1.33	0.184	-35.22759	6.80281
waveb	-.1034116	.0800737	-1.29	0.197	-.2608696	.0540464
wavec	.0479054	.0984573	0.49	0.627	-.1457024	.2415132
waved	.0465251	.0804561	0.58	0.563	-.1116848	.204735
wavee	-.1088765	.0882393	-1.23	0.218	-.2823915	.0646384
wavef	-.1499159	.0921896	-1.63	0.105	-.3311988	.031367
ed1	-.139333	.109835	-1.27	0.205	-.355314	.076648
ed2	-.0983696	.1408252	-0.70	0.485	-.3752903	.1785511
ed3	-.1420012	.0987013	-1.44	0.151	-.3360888	.0520864
ed4	-.2185752	.1032656	-2.12	0.035	-.421638	-.0155124
ped1	-.2900325	.1168838	-2.48	0.014	-.5198745	-.0601906
ped2	-.2954972	.1248615	-2.37	0.018	-.5410265	-.049968
ped3	-.0759695	.0905402	-0.84	0.402	-.254009	.10207
ped4	-.0653085	.1095274	-0.60	0.551	-.2806846	.1500676
c4	.0119054	.1412147	0.08	0.933	-.2657812	.289592
c514	-.3881204	.0868905	-4.47	0.000	-.558983	-.2172577
c1524	-.0132075	.0758312	-0.17	0.862	-.1623231	.1359081
nonresch	.1201428	.1330705	0.90	0.367	-.1415289	.3818145
pnonresch	-.0881897	.1161413	-0.76	0.448	-.3165716	.1401922
wage	.0088626	.0075034	1.18	0.238	-.0058922	.0236174
wage_sq	-.0002961	.0000827	-3.58	0.000	-.0004587	-.0001336
pwage	.0008907	.0024631	0.36	0.718	-.0039528	.0057342
nonlbinc	.0003424	.00032	1.07	0.285	-.0002869	.0009717
rural	-.0909203	.1019617	-0.89	0.373	-.2914191	.1095785
age	-.0563386	.0304489	-1.85	0.065	-.1162137	.0035366
age_sq	.0006369	.0003333	1.91	0.057	-.0000185	.0012922
page	.0623834	.0307031	2.03	0.043	.0020083	.1227584
page_sq	-.000818	.0003628	-2.25	0.025	-.0015314	-.0001045
gh	-.0070317	.0021247	-3.31	0.001	-.0112098	-.0028536
mh	.0023899	.002139	1.12	0.265	-.0018162	.0065961
immi	-.0339694	.0747784	-0.45	0.650	-.1810147	.1130759
mtleave	.1061169	.0562925	1.89	0.060	-.0045775	.2168113
umtleave	.1948577	.0786836	2.48	0.014	.0401332	.3495821
pptleave	.054087	.0683489	0.79	0.429	-.0803152	.1884893
union	.1891117	.0554086	3.41	0.001	.0801555	.2980679
sector	-.0646699	.083379	-0.78	0.438	-.2286276	.0992878
married	.1576939	.09554	1.65	0.100	-.0301773	.345565
ind01	.4529722	.2826703	1.60	0.110	-.1028745	1.008819
ind02	.4815668	.2357266	2.04	0.042	.0180308	.9451027
ind03	.181453	.232215	0.78	0.435	-.2751777	.6380837
ind04	.1990301	.2067753	0.96	0.336	-.2075756	.6056359
ind05	.2336252	.2445821	0.96	0.340	-.2473245	.7145748
ind06	.6140772	.2926005	2.10	0.037	.0387035	1.189451
ind07	.0415125	.1788812	0.23	0.817	-.3102418	.3932669
ind08	.432692	.1911912	2.26	0.024	.056731	.808653
ind09	.1956453	.2288902	0.85	0.393	-.2544476	.6457382
ind10	.3644636	.2352366	1.55	0.122	-.0981088	.8270361
ind11	.0197905	.1926945	0.10	0.918	-.3591265	.3987076
ind12	.3480074	.1725329	2.02	0.044	.0087363	.6872784
ind13	.0215611	.1966851	0.11	0.913	-.3652031	.4083252
ind14	-.1476213	.1953542	-0.76	0.450	-.5317685	.2365258
ind15	.0191874	.1773173	0.11	0.914	-.3294918	.3678667
ind16	.1058635	.2144166	0.49	0.622	-.3157682	.5274952
errorf_it	.4071761	.4482372	0.91	0.364	-.4742436	1.288596
errorf_i	.0986946	.0771091	1.28	0.201	-.0529337	.2503229
_cons	3.286062	1.014907	3.24	0.001	1.290335	5.281788

Western Australia – Single Females – Employment Equation

```
Random-effects probit regression                Number of obs      =       516
Group variable: id                              Number of groups   =       216

Random effects u_i ~ Gaussian                   Obs per group: min =         1
                                                               avg =       2.4
                                                               max =         6

                                                Wald chi2(24)      =    107.05
Log likelihood  = -133.82261                    Prob > chi2        =    0.0000
```

empt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
empt_lag	1.470092	.2402113	6.12	0.000	.9992869	1.940898
waveb	.0787974	.3255933	0.24	0.809	-.5593538	.7169487
wavec	.0768976	.3309334	0.23	0.816	-.5717199	.7255151
waved	.5008379	.3433453	1.46	0.145	-.1721066	1.173782
wavee	.4457254	.3325221	1.34	0.180	-.2060061	1.097457
wavef	.6865679	.3808925	1.80	0.071	-.0599677	1.433104
exp	.1310706	.0442801	2.96	0.003	.0442832	.217858
exp_sq	-.0022122	.0009604	-2.30	0.021	-.0040945	-.0003298
jbsearch	-.2671398	.2141815	-1.25	0.212	-.6869278	.1526482
jbsearch_sq	.0083244	.0424778	0.20	0.845	-.0749306	.0915795
ed1	.8065746	.3773107	2.14	0.033	.0670591	1.54609
ed2	.5077502	.3901879	1.30	0.193	-.257004	1.272504
ed3	.4303357	.4007515	1.07	0.283	-.3551227	1.215794
ed4	.547233	.3529808	1.55	0.121	-.1445967	1.239063
c4	-.1687365	.3842243	-0.44	0.661	-.9218023	.5843292
c514	.0796799	.3144943	0.25	0.800	-.5367175	.6960774
c1524	.0642252	.3758887	0.17	0.864	-.6725031	.8009535
nonresch	-.5060962	.3200907	-1.58	0.114	-1.133462	.1212699
nonlbinc	-.0033313	.0008627	-3.86	0.000	-.0050222	-.0016405
rural	-.0535288	.3905546	-0.14	0.891	-.8190018	.7119442
gh	.0217708	.0064133	3.39	0.001	.009201	.0343406
mh	.0010334	.0062746	0.16	0.869	-.0112645	.0133313
immi	.5068601	.3553016	1.43	0.154	-.1895183	1.203238
unemprt	12.73438	5.6188	2.27	0.023	1.721737	23.74703
_cons	-4.407155	1.020962	-4.32	0.000	-6.408205	-2.406106
/lnsig2u	-.9796591	.838771			-2.62362	.6643019
sigma_u	.6127308	.2569704			.2693321	1.393963
rho	.2729594	.1664563			.0676337	.6602261

Likelihood-ratio test of rho=0: chibar2(01) = 3.13 Prob >= chibar2 = 0.038

Western Australia – Single Females – Hours Supplied Equation

```
Linear regression                                      Number of obs =     320
                                                       F( 48,   271) =   14.04
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5807
                                                       Root MSE      =  .37378
```

lnhoursf	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
employment	-3.07768	3.595152	-0.86	0.393	-10.15566	4.000297
employment~q	16.74391	14.02424	1.19	0.234	-10.86641	44.35423
employment~b	-23.7639	20.84928	-1.14	0.255	-64.81106	17.28326
employment_4	11.27136	10.14397	1.11	0.267	-8.699636	31.24235
waveb	-.0976045	.0714411	-1.37	0.173	-.2382546	.0430457
wavec	-.1503118	.0676183	-2.22	0.027	-.2834358	-.0171877
waved	-.171309	.0825828	-2.07	0.039	-.3338944	-.0087235
wavee	-.1223035	.0753592	-1.62	0.106	-.2706674	.0260603
wavef	-.1887674	.0870436	-2.17	0.031	-.360135	-.0173998
ed1	.0063101	.0905893	0.07	0.945	-.1720381	.1846584
ed2	.0191026	.0860026	0.22	0.824	-.1502155	.1884208
ed3	.1848383	.138996	1.33	0.185	-.0888109	.4584876
ed4	.1981534	.0925205	2.14	0.033	.016003	.3803038
c4	-.0065975	.1873072	-0.04	0.972	-.3753597	.3621647
c514	-.005273	.0677433	-0.08	0.938	-.1386431	.1280971
c1524	-.0090519	.0602614	-0.15	0.881	-.1276918	.1095881
nonresch	.0832293	.0661444	1.26	0.209	-.0469929	.2134515
wage	-.0063141	.0082921	-0.76	0.447	-.0226392	.0100111
wage_sq	.0001103	.0000929	1.19	0.236	-.0000725	.0002931
nonlbinc	-.0007239	.0003365	-2.15	0.032	-.0013862	-.0000615
rural	-.0439256	.1153932	-0.38	0.704	-.2711066	.1832554
age	.0559876	.0232607	2.41	0.017	.010193	.1017821
age_sq	-.0006569	.0002874	-2.29	0.023	-.0012228	-.000091
gh	-.0012171	.0026816	-0.45	0.650	-.0064965	.0040623
mh	.0016251	.0015892	1.02	0.307	-.0015037	.0047539
immi	-.0157136	.0811085	-0.19	0.847	-.1753964	.1439693
mtleave	.0952971	.053363	1.79	0.075	-.0097616	.2003559
umtleave	.188494	.060394	3.12	0.002	.069593	.307395
sector	-.0278937	.0569738	-0.49	0.625	-.1400613	.0842738
union	-.0232666	.0543301	-0.43	0.669	-.1302294	.0836963
ind01	.5104637	.1329168	3.84	0.000	.248783	.7721445
ind02	-.1457443	.1046269	-1.39	0.165	-.3517292	.0602406
ind03	-.3694347	.1798559	-2.05	0.041	-.7235271	-.0153424
ind04	.1570075	.2787271	0.56	0.574	-.3917383	.7057532
ind05	-.326229	.1224985	-2.66	0.008	-.5673987	-.0850593
ind06	-.3425784	.2686447	-1.28	0.203	-.8714743	.1863175
ind07	-.2389291	.116386	-2.05	0.041	-.4680648	-.0097934
ind08	-.2838931	.157495	-1.80	0.073	-.5939623	.0261762
ind09	.0816355	.2070072	0.39	0.694	-.3259112	.4891822
ind10	-.0639527	.1487815	-0.43	0.668	-.3568672	.2289617
ind11	.2786118	.1473949	1.89	0.060	-.0115728	.5687964
ind12	.0575602	.0918447	0.63	0.531	-.1232597	.23838
ind13	-.0627728	.1012843	-0.62	0.536	-.2621769	.1366314
ind14	.0012606	.0797602	0.02	0.987	-.1557679	.158289
ind15	-.0287781	.0765978	-0.38	0.707	-.1795805	.1220242
ind16	-.2427271	.1248446	-1.94	0.053	-.4885157	.0030615
errorf_it	-.1116253	.1207209	-0.92	0.356	-.3492954	.1260448
errorf_i	.0495133	.0592121	0.84	0.404	-.0670609	.1660874
_cons	1.665822	.7110398	2.34	0.020	.2659581	3.065686

Australia – Couple Females – Employment Equation

Random-effects probit regression | Number of obs = 8803
Group variable: id | Number of groups = 3347

Random effects u_i ~ Gaussian | Obs per group: min = 1; avg = 2.6; max = 6

Wald chi2(40) = 3356.14
Log likelihood = -3000.1798 | Prob > chi2 = 0.0000

empt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
empt_lag	1.896986	.0429071	44.21	0.000	1.81289	1.981083
waveb	-.0875515	.0627754	-1.39	0.163	-.2105891	.0354861
wavec	-.1436176	.0624045	-2.30	0.021	-.2659283	-.021307
waved	.0015806	.0642376	0.02	0.980	-.1243227	.127484
wavee	.1095108	.0646093	1.69	0.090	-.0171212	.2361427
wavef	.0695816	.0652344	1.07	0.286	-.0582755	.1974387
exp	.0736808	.0083332	8.84	0.000	.0573479	.0900136
exp_sq	-.0012911	.0001961	-6.58	0.000	-.0016754	-.0009068
jbsearch	-.0735696	.0234889	-3.13	0.002	-.119607	-.0275322
jbsearch_sq	.0028271	.0014159	2.00	0.046	.0000519	.0056022
ed1	.5065826	.0646869	7.83	0.000	.3797985	.6333667
ed2	.2571839	.0736751	3.49	0.000	.1127834	.4015843
ed3	.2544308	.0678475	3.75	0.000	.1214521	.3874094
ed4	.2201013	.058988	3.73	0.000	.104487	.3357156
ped1	-.0048088	.0655433	-0.07	0.942	-.1332713	.1236536
ped2	.0226445	.0774907	0.29	0.770	-.1292345	.1745236
ped3	.0357864	.0561599	0.64	0.524	-.074285	.1458578
ped4	.0088149	.0737138	0.12	0.905	-.1356615	.1532913
c4_1	-.3988251	.0574613	-6.94	0.000	-.5114471	-.2862031
c4_2	-.6171006	.0800547	-7.71	0.000	-.7740049	-.4601962
c514_1	.2023598	.0578011	3.50	0.000	.0890717	.3156479
c514_2	.0297079	.0576774	0.52	0.607	-.0833378	.1427536
c1524	.2234299	.0542463	4.12	0.000	.1171091	.3297507
nonresch	-.4989043	.0730923	-6.83	0.000	-.6421625	-.3556461
pnonresch	.0180375	.063776	0.28	0.777	-.1069611	.1430361
nonlbinc	-.0006321	.0000758	-8.34	0.000	-.0007807	-.0004835
pwage	.0029843	.0013448	2.22	0.026	.0003485	.0056201
rural	-.0601867	.0550476	-1.09	0.274	-.1680781	.0477047
gh	.0054484	.0011597	4.70	0.000	.0031753	.0077214
mh	.0018825	.0013884	1.36	0.175	-.0008387	.0046038
immi	.2648978	.0631428	4.20	0.000	.1411401	.3886554
unemprt	.0254568	.0122768	2.07	0.038	.0013948	.0495189
married	-.197953	.0567667	-3.49	0.000	-.3092137	-.0866924
NSW	-.1426078	.1264912	-1.13	0.260	-.390526	.1053104
VIC	-.1775895	.1278073	-1.39	0.165	-.4280873	.0729083
QLD	-.2190189	.130081	-1.68	0.092	-.4739729	.0359352
SA	-.1748999	.1382901	-1.26	0.206	-.4459436	.0961437
WA	-.2623143	.1363963	-1.92	0.054	-.5296462	.0050176
TAS	-.1857484	.1663185	-1.12	0.264	-.5117267	.1402298
NT	.7202942	.315156	2.29	0.022	.1025999	1.337989
_cons	-2.108978	.1997765	-10.56	0.000	-2.500533	-1.717423
/lnsig2u	-2.339167	.4489906			-3.219173	-1.459162
sigma_u	.3104962	.0697049			.1999703	.482111
rho	.0879307	.0360085			.0384506	.1885956

Likelihood-ratio test of rho=0: chibar2(01) = 6.28 Prob >= chibar2 = 0.006

Australia – Couple Females – Hours Supplied Equation

```
Linear regression                                      Number of obs =    5123
                                                       F( 67,  5055) =   30.28
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.3371
                                                       Root MSE      =  .46095
```

lnhoursf	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
employment	.2598602	1.703976	0.15	0.879	-3.080671	3.600391
employment~q	-6.990993	6.328691	-1.10	0.269	-19.39797	5.415985
employment~b	12.34658	8.772435	1.41	0.159	-4.851197	29.54435
employment_4	-6.407502	4.156109	-1.54	0.123	-14.55528	1.740273
waveb	-.0431729	.0237343	-1.82	0.069	-.0897023	.0033566
wavec	-.0136906	.0241133	-0.57	0.570	-.0609632	.033582
waved	-.0317954	.0234183	-1.36	0.175	-.0777054	.0141146
wavee	-.0365803	.0221095	-1.65	0.098	-.0799245	.0067638
wavef	-.0406276	.0219212	-1.85	0.064	-.0836027	.0023475
ed1	.0651737	.0299755	2.17	0.030	.0064087	.1239387
ed2	.0416674	.0281977	1.48	0.140	-.0136123	.096947
ed3	-.0273954	.026706	-1.03	0.305	-.0797507	.02496
ed4	-.007775	.0235966	-0.33	0.742	-.0540345	.0384845
ped1	.0095119	.0220151	0.43	0.666	-.0336472	.052671
ped2	.0092871	.0265634	0.35	0.727	-.0427887	.0613628
ped3	.0033479	.0201394	0.17	0.868	-.0361341	.0428299
ped4	.0437953	.0255387	1.71	0.086	-.0062716	.0938622
c4_1	-.1728833	.0300172	-5.76	0.000	-.23173	-.1140366
c4_2	-.2621109	.049198	-5.33	0.000	-.3585602	-.1656616
c514_1	-.1973361	.022252	-8.87	0.000	-.2409597	-.1537125
c514_2	-.2381848	.0206428	-11.54	0.000	-.2786536	-.197716
c1524	-.0597881	.0195445	-3.06	0.002	-.0981039	-.0214723
nonresch	.0682981	.0365525	1.87	0.062	-.0033606	.1399567
pnonresch	.053901	.0221618	2.43	0.015	.0104542	.0973478
wage	-.0081091	.0024676	-3.29	0.001	-.0129467	-.0032715
wage_sq	-.0000446	.0000346	-1.29	0.198	-.0001124	.0000233
pwage	-.003174	.0005513	-5.76	0.000	-.0042548	-.0020932
nonlbinc	-.0000126	.0000494	-0.25	0.799	-.0001094	.0000843
rural	.0180784	.0195459	0.92	0.355	-.0202401	.0563968
age	.0231646	.0096113	2.41	0.016	.0043222	.042007
age_sq	-.0003531	.0001148	-3.08	0.002	-.0005782	-.0001281
page	-.0081097	.0084447	-0.96	0.337	-.024665	.0084456
page_sq	.0000757	.0000975	0.78	0.437	-.0001154	.0002669
gh	-.0009858	.0004847	-2.03	0.042	-.001936	-.0000357
mh	.000076	.0005186	0.15	0.883	-.0009407	.0010928
immi	-.1106822	.0244594	-4.53	0.000	-.1586332	-.0627313
mtleave	.1514476	.0151811	9.98	0.000	.1216861	.181209
umtleave	.1663381	.0187746	8.86	0.000	.1295319	.2031444
pptleave	-.0373315	.0157706	-2.37	0.018	-.0682487	-.0064143
union	.1167729	.0140391	8.32	0.000	.0892501	.1442957
sector	.0368436	.0184527	2.00	0.046	.0006682	.073019
married	.0349262	.0192802	1.81	0.070	-.0028715	.0727238
ind01	.0846336	.0982794	0.86	0.389	-.1080366	.2773038
ind02	.2802402	.0775192	3.62	0.000	.128269	.4322113
ind03	.23011	.054033	4.26	0.000	.1241819	.3360381
ind04	.3592996	.0873183	4.11	0.000	.1881178	.5304814
ind05	.1219273	.0728662	1.67	0.094	-.020922	.2647765
ind06	.2115959	.0568005	3.73	0.000	.1002423	.3229496
ind07	-.0443994	.0524582	-0.85	0.397	-.1472402	.0584415
ind08	.0032199	.0629425	0.05	0.959	-.1201747	.1266144
ind09	.1826153	.0590722	3.09	0.002	.0668081	.2984224
ind10	.0751131	.060225	1.25	0.212	-.0429541	.1931802
ind11	.056827	.0514601	1.10	0.270	-.0440572	.1577112
ind12	.1136215	.0512901	2.22	0.027	.0130706	.2141724
ind13	.0868473	.0504469	1.72	0.085	-.0120505	.1857452
ind14	-.039436	.0491201	-0.80	0.422	-.1357326	.0568607
ind15	-.054748	.0476787	-1.15	0.251	-.148219	.038723
ind16	-.058836	.0642761	-0.92	0.360	-.1848451	.0671731
NSW	.0297169	.0380979	0.78	0.435	-.0449716	.1044054
VIC	-.0359616	.0388823	-0.92	0.355	-.1121878	.0402645
QLD	.0569571	.0396209	1.44	0.151	-.0207169	.1346312
SA	-.0483519	.0429898	-1.12	0.261	-.1326305	.0359266
WA	.0019531	.0442382	0.04	0.965	-.084773	.0886791
TAS	-.1175109	.0534316	-2.20	0.028	-.2222601	-.0127618
NT	-.1393013	.0754468	-1.85	0.065	-.2872098	.0086072
errorf_it	.3381637	.1110013	3.05	0.002	.1205531	.5557743
errorf_i	.1418493	.0223036	6.36	0.000	.0981246	.185574
_cons	3.535782	.2679774	13.19	0.000	3.01043	4.061134

Australia – Single Females – Employment Equation

```
Random-effects probit regression                Number of obs      =      5852
Group variable: id                              Number of groups   =      2340

Random effects u_i ~ Gaussian                   Obs per group: min =         1
                                                               avg =       2.5
                                                               max =         6

                                                Wald chi2(33)      =   2015.92
Log likelihood  = -1747.7425                    Prob > chi2        =    0.0000
```

empt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
empt_lag	1.843472	.0571308	32.27	0.000	1.731498	1.955446
waveb	.0451527	.0812344	0.56	0.578	-.1140638	.2043691
wavec	.0381491	.0815633	0.47	0.640	-.121712	.1980102
waved	.0001308	.0833711	0.00	0.999	-.1632736	.1635352
wavee	.1854056	.0849211	2.18	0.029	.0189634	.3518478
wavef	.2031199	.0877852	2.31	0.021	.031064	.3751757
exp	.0663352	.0087465	7.58	0.000	.0491923	.0834781
exp_sq	-.0013365	.0002099	-6.37	0.000	-.0017478	-.0009252
jbsearch	-.0959633	.0267474	-3.59	0.000	-.1483872	-.0435393
jbsearch_sq	.0030436	.0019734	1.54	0.123	-.0008242	.0069115
ed1	.5702672	.0813191	7.01	0.000	.4108847	.7296497
ed2	.3515611	.0999866	3.52	0.000	.1555909	.5475312
ed3	.2859318	.0829716	3.45	0.001	.1233105	.4485531
ed4	.2765403	.0761205	3.63	0.000	.1273468	.4257338
c4_1	-.1090569	.0971766	-1.12	0.262	-.2995195	.0814057
c4_2	.0923588	.2033264	0.45	0.650	-.3061535	.4908712
c514_1	.1993695	.0827182	2.41	0.016	.0372449	.3614941
c514_2	.2364918	.1009409	2.34	0.019	.0386513	.4343324
c1524	.1827447	.0782606	2.34	0.020	.0293568	.3361326
nonresch	-.3718341	.0701199	-5.30	0.000	-.5092666	-.2344015
nonlbinc	-.0018879	.0001594	-11.84	0.000	-.0022004	-.0015755
rural	-.0781985	.0865091	-0.90	0.366	-.2477532	.0913562
gh	.0080186	.0013843	5.79	0.000	.0053054	.0107317
mh	.004717	.0015289	3.09	0.002	.0017204	.0077135
immi	.3572954	.0888979	4.02	0.000	.1830587	.5315321
unemprt	.0284753	.0106582	2.67	0.008	.0075856	.049365
NSW	-.2494307	.2052902	-1.22	0.224	-.6517922	.1529307
VIC	-.1936411	.2062992	-0.94	0.348	-.5979801	.2106978
QLD	-.3116779	.2112976	-1.48	0.140	-.7258136	.1024579
SA	-.3126459	.2171453	-1.44	0.150	-.7382429	.112951
WA	-.2773484	.2181831	-1.27	0.204	-.7049794	.1502825
TAS	-.1056271	.2463144	-0.43	0.668	-.5883946	.3771403
NT	.1645814	.3370713	0.49	0.625	-.4960662	.825229
_cons	-2.304537	.2699935	-8.54	0.000	-2.833715	-1.77536
/lnsig2u	-2.297551	.580051			-3.43443	-1.160672
sigma_u	.3170247	.0919452			.1795655	.5597102
rho	.091326	.0481358			.0312366	.2385452

Likelihood-ratio test of rho=0: chibar2(01) =   3.81 Prob >= chibar2 = 0.025

Australia – Single Females – Hours Supplied Equation

```
Linear regression                                      Number of obs =    3512
                                                       F( 57,  3454) =   23.12
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.3351
                                                       Root MSE      =  .45182
```

lnhoursf	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
employment	3.305004	2.160362	1.53	0.126	-.9307119	7.540721
employment~q	-4.707099	7.321782	-0.64	0.520	-19.06256	9.648361
employment~b	.833539	9.592059	0.09	0.931	-17.97314	19.64022
employment_4	1.963313	4.293772	0.46	0.648	-6.455275	10.3819
waveb	-.0556226	.0270272	-2.06	0.040	-.1086136	-.0026317
wavec	-.0476015	.0258327	-1.84	0.065	-.0982505	.0030475
waved	-.0301421	.0267736	-1.13	0.260	-.0826358	.0223515
wavee	-.0444319	.0260819	-1.70	0.089	-.0955694	.0067057
wavef	-.0194164	.0264671	-0.73	0.463	-.0713092	.0324764
ed1	.027511	.0365564	0.75	0.452	-.0441633	.0991853
ed2	-.0523674	.0342824	-1.53	0.127	-.1195833	.0148485
ed3	.0010171	.0308904	0.03	0.974	-.0595482	.0615825
ed4	-.0630704	.0319091	-1.98	0.048	-.1256329	-.0005078
c4_1	-.1126175	.0580014	-1.94	0.052	-.2263627	.0011278
c4_2	.0353461	.1747122	0.20	0.840	-.3072036	.3778958
c514_1	-.1158842	.0333909	-3.47	0.001	-.1813522	-.0504163
c514_2	-.1639725	.0467425	-3.51	0.000	-.2556182	-.0723268
c1524	.0102013	.0247184	0.41	0.680	-.0382629	.0586654
nonresch	.0434938	.0290099	1.50	0.134	-.0133844	.100372
wage	-.0021662	.0036003	-0.60	0.547	-.0092251	.0048927
wage_sq	-.0000961	.0000566	-1.70	0.090	-.0002071	.0000149
nonlbinc	-.0002774	.0001197	-2.32	0.021	-.0005121	-.0000427
rural	.0328767	.0357975	0.92	0.358	-.0373097	.1030631
age	.0152098	.0063232	2.41	0.016	.0028122	.0276075
age_sq	-.0001746	.0000790	-2.21	0.027	-.0003295	-.0000196
gh	-.0014497	.0006127	-2.37	0.018	-.002651	-.0002483
mh	-.0004526	.0005739	-0.79	0.430	-.0015777	.0006725
immi	-.0747145	.034805	-2.15	0.032	-.1429549	-.0064741
mtleave	.0970005	.0176459	5.50	0.000	.0624031	.131598
umtleave	.1359207	.0218274	6.23	0.000	.0931248	.1787166
sector	.0354485	.0220868	1.60	0.109	-.007856	.0787529
union	.0852868	.0181963	4.69	0.000	.0496102	.1209634
ind01	.1795569	.0933345	1.92	0.054	-.0034394	.3625532
ind02	.2447429	.1205011	2.03	0.042	.0084824	.4810035
ind03	.2045263	.0486854	4.20	0.000	.1090713	.2999814
ind04	.2516458	.084287	2.99	0.003	.0863885	.4169032
ind05	.1856858	.0527236	3.52	0.000	.0823132	.2890585
ind06	.1224178	.0681424	1.80	0.073	-.0111856	.2560213
ind07	-.1040776	.0490288	-2.12	0.034	-.200206	-.0079491
ind08	-.081315	.0573926	-1.42	0.157	-.1938418	.0312118
ind09	.1645957	.0612747	2.69	0.007	.0444574	.2847341
ind10	.0796174	.0569025	1.40	0.162	-.0319486	.1911833
ind11	.13944	.0503689	2.77	0.006	.0406841	.2381958
ind12	.0826743	.0508169	1.63	0.104	-.0169599	.1823085
ind13	.0827699	.0463799	1.78	0.074	-.0081649	.1737047
ind14	-.0175081	.0444999	-0.39	0.694	-.1047568	.0697407
ind15	.0299888	.0424638	0.71	0.480	-.0532679	.1132456
ind16	-.0602604	.0680051	-0.89	0.376	-.1935946	.0730738
NSW	-.1093215	.0508123	-2.15	0.032	-.2089466	-.0096964
VIC	-.1589486	.0510847	-3.11	0.002	-.2591078	-.0587894
QLD	-.1242567	.0513067	-2.42	0.015	-.2248512	-.0236622
SA	-.1758095	.0556458	-3.16	0.002	-.2849115	-.0667075
WA	-.0930313	.0538669	-1.73	0.084	-.1986455	.0125829
TAS	-.2505759	.0636564	-3.94	0.000	-.3753839	-.1257678
NT	-.0264812	.0761527	-0.35	0.728	-.1757901	.1228278
errorf_it	-.2175424	.0672578	-3.23	0.001	-.3494115	-.0856732
errorf_i	.1724388	.0307509	5.61	0.000	.112147	.2327306
_cons	2.427691	.2869088	8.46	0.000	1.865163	2.990219

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