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The impact of measurement error on wage decompositions: evidence from the British Household Panel Survey and the Household, Income and Labour Dynamics in Australia Survey

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Non-Technical Summary

Analyses of all survey data are to some extent impacted by measurement error. Research in many social science disciplines often recognises that measurement error could influence results, yet established methods of error correction are rarely applied. One method of error correction is to use information about survey measure reliability to rescale model parameters. A survey measure's reliability is an indicator of how accurately it reflects some underlying social construct. Reliability assessments rarely investigate whether reliability is stable over time or the extent to which change in reliability affects findings in substantive models. Indeed in some types of analysis, measurement error is expressly confounded with the main conclusions of the research. For example, analyses of the gender gap in wages ordinarily interprets the portion of the gap unexplained by worker characteristics to be discrimination, however doing so conflates discrimination with omitted variables and measurement error present in variables included in the model. To our knowledge, established measurement error correction techniques have never been incorporated into these approaches. Focusing on the gender wage gap, we address two questions. First, to what extent does the reliability of measures of employment experience vary over time, across genders and across measurement protocols? Secondly, does correcting for measurement error in employment experience influence substantive conclusions about the amount of gender wage inequality? Analysing the first five waves of British Household Panel Survey and the Household, Income and Labour Dynamics in Australia Survey data, we find that reliability is generally stable across the range of measures examined. We observed improved reliability in measures reliant on respondent interpretation and understanding of "job" and "occupation", and the reporting of durations for each of these

Our analysis of measurement error effects on substantive models of gender wage inequality showed a consistent and often sizeable attenuation effect for all significant predictors of wages that could be corrected for measurement error. Even though reliability was largely stable, the measurement error effects on models decreased over time somewhat. The net effect of measurement error, for which we could correct, on the comparison of men's and women's wages was, however, small.

We encourage others to undertake similar exercises with other well-known substantive models in order to develop an evidence base about the effects of measurement error on substantive models. We further encourage survey managers to publish reliability information about the measures that they collect.

The impact of measurement error on wage decompositions: Evidence from the British Household Panel Survey and the Household, Income and Labour Dynamics in Australia Survey

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Abstract
Test-retest reliability assessments rarely investigate whether reliability itself is stable or whether change in reliability affects findings from substantive models. Research across the social sciences often recognises that measurement error could influence results, yet it rarely applies established error correction methods. Focusing on gender wage inequality, we address two questions. First, to what extent does reliability vary over time, across genders and across measurement protocols? Second, does correcting for measurement error influence substantive conclusions about gender wage inequality? Comparing British and Australian panel data, we find little temporal variability in reliability; however measurement error effects are variable and sometimes substantial.

Keywords
British Household Panel Survey (BHPS); Household, Income and Labour Dynamics in Australia (HILDA) Survey; Measurement Error; Quasi-Simplex Models; Gender wage discrimination; Decomposition methods; Panel data

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While measurement error can be studied in various ways, little is known about longitudinal patterns of reliability for most types of survey measures. Reliability assessments using test-retest methods rarely investigate whether reliability itself is stable or the extent to which change in reliability affects findings in substantive models. Research in the social sciences often recognises that measurement error could influence results, yet established methods of error correction are rarely applied. Indeed in some types of analysis, measurement error is expressly confounded with the main conclusions of the research. For example, Jones and Kelly (1984) demonstrate how discrimination assessments can conflate discrimination with omitted variables and random measurement error present in variables included in the models. Wage discrimination monitoring exercises routinely add new variables to core human capital arguments about wage setting, or shift the nature of analyses to demonstrate how disparities remain in certain segments of the labour market or sections of the income distribution (Cobb-Clark and Tan 2011; Joshi, Dex, and McCran 1996; Kee 2006; Marini and Fan 1997; Miller 2005). To our knowledge, established measurement error correction techniques have never been incorporated into these approaches, although some effort has been made to examine the extent to which estimates are bounded within certain ranges (Bollinger 2001; Bollinger 2003). Focusing on gender wage inequality, we address two problems in the wage discrimination literature. First, we examine the reliability of employment experience measures and explore the extent to which measurement reliability varies over time, across genders and across measurement protocols. Secondly, we examine whether correcting for measurement error in employment experience influences substantive conclusions about the amount of gender wage inequality. We analyse panel data from Britain and Australia. Both nations adopted wage equality legislation in the 1970s. Both have household panel studies of comparable designs affording direct comparisons. However, measurement protocols differ between the studies thus providing an instructive comparison in how measurement can influence substantive conclusions about discrimination.

1. Measuring Wage Discrimination

Since the introduction of equal pay legislation in both Britain and Australia in the early 1970s, gender pay differentials narrowed quickly then slowed in recent years. In Britain, gender wage inequality nearly halved through the 1990s (Harkness 1996; Miller 1987; Wright and Ermisch 1991) and wage parity became more common among lower income groups (Blackaby, Clark, Leslie, and Murphy 1997; Harkness 1996; Manning and Robinson 2004). However, significant regional and sector variation remains (Mumford and Smith 2007). In Australia by the mid-1990s, discrimination in women's wages was nearly one-quarter the size of the early 1970s (Borland 1999; Jones 1983), with greater pay parity among lower income groups (Kee 2006). Gender differences in work experience, occupational distribution, sector and personality characteristics also account for pay differences (Barón and Cobb-Clark 2010; Cobb-Clark and Tan 2011; Rummery 1992; Watson 2010; Wooden 1999).

The main method for identifying discrimination is a counterfactual approach reliant on respondent characteristics and coefficients from comparable wage equations for groups being compared (Blinder 1973; Iams and Thornton 1975; Oaxaca 1973; Winsborough and Dickinson 1971). That is,

$$y^h = a^h + \sum b^h X^h \quad \textbf{(1)}$$

$$y^l = a^l + \sum b^l X^l \quad \textbf{(2)}$$

where y^h is the wage for a high earning group and y^l is the wage for a low earning group. The items b^h and b^l are the estimated coefficients corresponding to respondent characteristics X^h and X^l. The predicted wage differential is decomposed by subtracting the wage equations for one group off the other:

$$(y^h - y^l) = (a^h + \sum b^h X^h) - (a^l + \sum b^l X^l) \quad \textbf{(3)}$$

To examine low earner disadvantage, Equation 3 could be re-arranged and expanded:

$$(y^h - y^l) = (a^h - a^l) + \sum X^l (b^h - b^l) + \sum b^l (X^h - X^l) + \sum (b^h - b^l)(X^h - X^l) \quad \textbf{(4)}$$

As Jones and Kelly (1984) explain, the four right hand side components of Equation 4 are interpreted as follows. The item $\sum X^l (b^h - b^l)$ represents the portion of the gap that is due to differences in coefficients, or rather the differential valuation of the lower wage group relative to the higher wage group. It captures how much more the low wage group would earn if their attributes were valued at the rate of the high wage group. Many interpret this as a direct measure of wage discrimination, and we follow this practice here. The term $\sum b^l (X^h - X^l)$ represents differences in characteristics across groups as wages may vary due to the way marketable attributes differ between groups. The item $(a^h - a^l)$ is the portion of the gap due to differences in group membership while the term $\sum (b^h - b^l)(X^h - X^l)$ represents the portion of the gap due to the interaction between differences in characteristics and differences in coefficients. While various model elaborations have occurred over the past four decades, all are largely similar in approach but differ in comparison methods (Cotton 1988; Neumark 1988; Oaxaca and Ransom 1994; Reimers 1983). "Discrimination" is always measured as the portion of the gap not explained by differences in characteristics between groups, typically including the intercepts and interaction terms from the wage equations.

Wage equation residuals hold information about omitted variables – such as indicators of alternative mechanisms -- and also measurement error of variables included in the model (Jones and

Kelley 1984). For example, economists have hotly debated the best measure of work experience as women routinely have gaps in their work histories as a consequence of having children (See e.g., Miller 1987; Wright and Ermisch 1991; Zabalza and Arrufat 1985). Such labour market discontinuity has a 'scaring' effect and the impact on women's wages tends to be harsher than on men's (e.g., Joshi, Dex, and McCran 1996; Rummery 1992). Full labour market histories require longitudinal data which was less prevalent during the early years of wage equality analysis. Now, nearly all examinations of the gender wage gap in Britain and Australia use longitudinal data with labour force histories (See e.g., Barón and Cobb-Clark 2010; Cobb-Clark and Tan 2011; Olsen and Walby 2004; Watson 2010). Moreover, panel data methods are useful for estimating effects distinct from unmeasured fixed effects, thereby reducing -- though not eliminating -- some omitted variable problems.

2. The Problem of Measurement Error in Wage Decomposition Research

The second aspect of the wage decomposition residual is that it contains information about measurement error among the variables that *are* included in the model. Measurement error can significantly impact substantive conclusions. For example, Bielby et al. (1977a; 1977b) found that measurement error for blacks is greater than for whites in models of status attainment in the 1970s United States. Ignoring error underestimates the effects of educational attainment on occupational status outcomes of blacks by about 15 percent. Kreuter et al. (2010) examined error in student reports of parental educational achievement and its impact on family background effects on student achievement. Error in reporting family background is correlated with student cognitive ability, consequently family background effects are underestimated unevenly across students depending on their ability.

Classical measurement theory assumes that observed variables are measured with error. For any measured construct x, $x = \tau + \varepsilon$, where τ is the true value of the measured construct and ε is random error associated with the attempted measurement. Equation 1 and Equation 2 concerning wages assume a linear model of the form:

$$y = \alpha + \beta\tau + u \qquad \textbf{(5)}$$

where y is the measure of wages and u is a normally distributed error term with mean 0. The variable τ, some covariate of interest such as "work experience", is however measured with error. This means that the regression line ordinarily estimated is:

$$y = a + bx + e \qquad \textbf{(6)}$$

where, as before, $x = \tau + \varepsilon$.

To correct for measurement error in a linear model, covariates can be rescaled using information about the observed measure's variance and its reliability (Bohrnstedt 1983; Fuller 1987;

Lord and Novick 1968; Munck 1991). A measure's reliability, ρ_x, is defined as the ratio of true score variance to observed variance:

$$\rho_x = \frac{Var(\tau)}{Var(x)}. \quad \textbf{(7)}$$

The coefficient b in Equation 6 can be obtained by:

$$b = \frac{Cov(x, y)}{Var(x)} \quad \textbf{(8)}$$

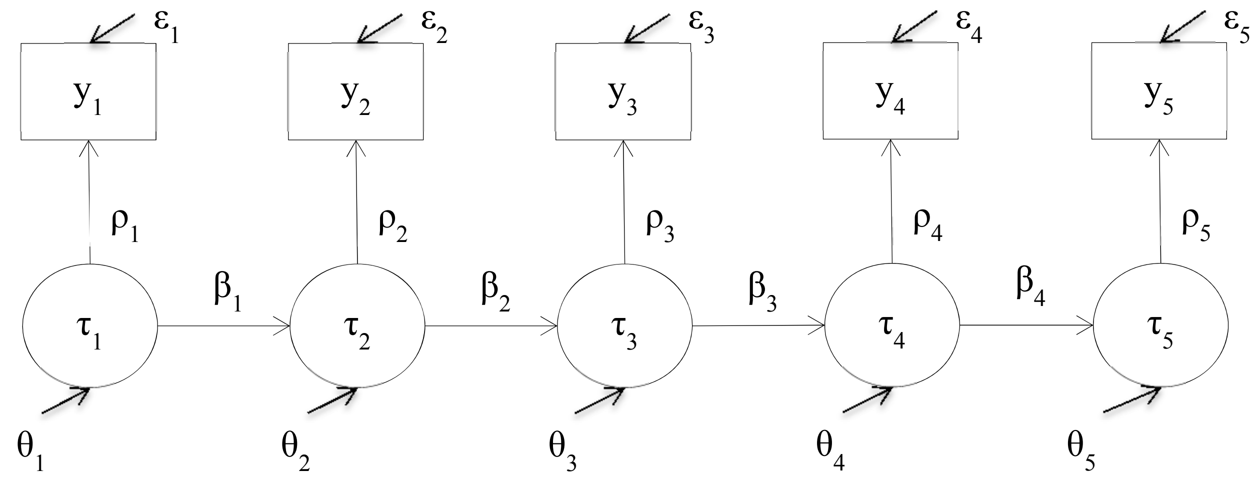
(Hanushek and Jackson 1977). Nevertheless, one would ideally like to obtain β:

$$\beta = \frac{Cov(\tau, y)}{Var(\tau)} \quad \textbf{(9)}$$

Re-writing Equation 7 as $Var(\tau) = Var(x)\rho_x$, we can see that in the bivariate case, the coefficient b is clearly attenuated version of β, that is $\beta = b/\rho_x$ (Bohrnstedt 1983; DeShon 1998; Lord and Novick 1968). The effects of measurement error in the multivariate case are less clear-cut though attenuated effects are also often observed (Cohen, Cohen, Teresi, Marchi, and Velez 1990; Kreuter, Eckman, Maaz, and Watermann 2010). There are similar approaches for non-linear and discrete outcome models (Frost and Thompson 2000; Hausman 2001), yet here we concern ourselves with the simple linear case.

A measure's reliability can be obtained in various ways. Quasi-Simplex Models (QSM) were developed in the early 1970s to assess change in observed true scores free from measurement error, and a measures reliability can be extracted from such models (Alwin 2007). This approach posits a latent variable structure and identification that relies on at least three measurement occasions to obtain estimates (Heise 1969; Wiley and Wiley 1970). With more than three waves of data, this model is identified with most inherent assumptions warranted apart from serially correlated errors (Cernat, Lugtig, Uhrig, and Watson 2014; Palmquist and Green 1992). Figure 1 depicts a path diagram of this model over five waves of data.

Figure 1 Path diagram of the quasi-simplex model (QSM) using four waves of data



The measurement model relates observed variables to latent variables. This set of equations parallels classical measurement theory but is time specific:

$$\begin{aligned} x_1 &= \tau_1 + \varepsilon_1 \\ x_2 &= \tau_2 + \varepsilon_2 \\ x_3 &= \tau_3 + \varepsilon_3 \\ x_4 &= \tau_4 + \varepsilon_4 \\ x_5 &= \tau_5 + \varepsilon_5 \end{aligned} \qquad \textbf{(9)}$$

The structural model relates latent variables to one another. This is the way to account for change in the underlying variable of interest:

$$\begin{aligned} \tau_1 &= \theta_1 \\ \tau_2 &= \beta_1\tau_1 + \theta_2 \\ \tau_3 &= \beta_2\tau_2 + \theta_3 \\ \tau_4 &= \beta_3\tau_3 + \theta_4 \\ \tau_5 &= \beta_4\tau_4 + \theta_5 \end{aligned} \qquad \textbf{(10)}$$

Thetas (i.e., $\theta_1, \theta_2, \theta_3, \theta_4$ and θ_5) represents the disturbances in the set of structural equations. Reliabilities can be obtained from the system:

$$\begin{aligned} \rho_1 &= Var(\theta_1)/Var(x_1) \\ \rho_2 &= [\beta_1^2\, Var(\theta_1) + Var(\theta_2)\,]/Var(x_2) \\ \rho_3 &= [\beta_2^2[\beta_1^2 Var(\theta_1) + Var(\theta_2)] + Var(\theta_3)]/Var(x_3) \\ \rho_4 &= [\beta_3^2[\beta_2^2[\beta_1^2 Var(\theta_1) + Var(\theta_2)] + Var(\theta_3)] + Var(\theta_4)]/Var(x_4) \\ \rho_5 &= [\beta_4^2[\beta_3^2[\beta_2^2[\beta_1^2 Var(\theta_1) + Var(\theta_2)] + Var(\theta_3)] + Var(\theta_4)] + Var(\theta_5)]/Var(x_5) \end{aligned} \qquad \textbf{(11)}$$

Alwin (2007) has shown that facts are generally more reliable than attitudes, values or beliefs, that self-reports are more reliable than proxy reports, that open-ended questions are more reliable than closed/forced choice questions, and that reliability varies with indicators of cognitive ability.

Of concern for panel analysis is the extent to which measures change because of survey participation. Various panel conditioning mechanisms might influence reliability estimates (Warren and Halpern-Manners 2012; Waterton and Lievesley 1989). Random measurement error could be reduced as a consequence of repeated questioning about attitudes, beliefs, or opinions (Bridge, Reeder, Kanouse, Kinder, Nagy, and Judd 1977; Sturgis, Allum, and Brunton-Smith 2009). Repeated factual questioning could also improve knowledge thereby reducing random reporting error (Wilson and Howell 2005; Yalch 1976). Improved respondent trust in the survey itself and practice at answering questions could both also reduce random error and improve accuracy (Johnson, Hoch, and Johnson 1991; Uhrig 2013; Wagstaff, Kulis, and Elek 2009). Random error may appear to remain stable or possibly increase if participation means respondents learn to manipulate questionnaire routing to reduce burden (Cantor 1989; Fendrich and Vaughn 1994; Kreuter, McCulloch, Presser, and Tourangeau 2011; Thornberry 1989).

This paper makes two contributions. We first examine whether reliability itself is stable. While QSM have been fruitfully employed in analyses of opinion stability and change controlling for measurement error (Alwin and Krosnick 1991; Angrist 1971; Putz 2002; Thornton 1985), to our knowledge no one has considered how reliability might change a consequence of panel conditioning. Do measures become more or less reliable over time? Secondly, we use reliabilities obtained from QSM to assess the effects of error in employment experience measurements on substantive analyses of gender wage equality. Can measurement error correction impact conclusions about the amount of gender wage discrimination remaining in labour markets in Australia and Britain? Our approach is inductive largely because no established theory would predict how reliability might change in panel surveys.

3. Data, Measures and Reliability Analysis

We analyse panel data from the UK and Australia. The British Household Panel Survey (BHPS) is a nationally representative household survey that began in 1991 with a Wave 1 response rate of 73.9 percent (Lynn, Buck, Burton, Laurie, and Uhrig 2006). The study has continued annually to (re)interview the same individuals living in participating households about a diverse set of topics including income, labour market status and job characteristics (if employed) amongst other life-course information. The Household, Income and Labour Dynamics in Australia (HILDA) Survey parallels the BHPS in design. The HILDA Survey is nationally representative sample with a Wave 1 response rate was 65.7 (Summerfield, Freidin, Hahn, Ittak, Li, MacAlalad, Watson, Wilkins, and Wooden 2012). As with the BHPS, HILDA Survey respondents are (re)interviewed annually about a diverse range of topics.

Our analyses use a restricted sample. First, we analyse a balanced panel across the first five waves of both studies. Even though the first five waves of BHPS and the HILDA Survey do not overlap in time, the first five waves of each parallel one another with respect to respondent experience. Second, a balanced panel implies that we study only original sample members who provided a full interview for each wave they were eligible over the first five waves. Third, sample members were considered eligible for a wave if they were aged 25 to 65 at that wave. Thus, we *did* incorporate respondents who were otherwise ineligible for inclusion at a prior wave but subsequently became eligible given these restrictions, e.g., turning 25 at Wave 3, or shifting from being a full-time student to being employed at Wave 4. Finally, consistent with prior studies of wages, we eliminate cases at the top or bottom one percent of the wage distribution in any wave (e.g., see Nandi and Nicoletti 2009).

Our methods of assessing reliability limit the range of survey items that can be assessed. Items must (a) be “continuous variables”, (b) be measured across at least five waves, and (c) be relevant for assessing the gender pay gap. Given these limitations, we focus on hours and wages, as well as measures of employment experience: employment tenure and occupation score. Although there are various arguments about the nature and causes of gender wage inequality, we rely on arguments concerning human capital (Becker 1975; Kilbourne, Farkas, Beron, Weir, and England 1994; Polavieja 2012). Human capital theory argues that pay reflects the skills and experience that a person brings to employment (Becker 1975). This includes education, but also skills acquired while working in specific jobs (Polavieja 2012; Wright and Ermisch 1991). In both the BHPS and the HILDA Survey, respondents were required to report information on employment tenure and occupation at each wave. Despite similarities in overall survey design, aspects of measurement protocols differed across the BHPS and the HILDA Survey. Some of these differences may lead to different observed patterns of reliabilities for the studies.

Hours and Wages. Hours of work measures differed between the BHPS and the HILDA Survey. BHPS respondents were reported on usual paid and unpaid hours in separate questions whereas HILDA Survey respondents were asked to report paid and unpaid hours together. These are cognitively different tasks which suggest that we may observe differences in reliabilities between surveys. Questions on pay are broadly similar between the surveys with the only notable difference being their placement. The BHPS pay questions are asked along with other employment details whereas HILDA Survey pay questions appear in a section covering all income, not just employment income.

Employment, Job and Occupation Tenure. Measures of employment tenure also varied across the BHPS and the HILDA Survey. BHPS respondents were asked to report the exact day, month and year they started their current job whereas HILDA Survey respondents provided the duration of working with their current employer and working in their current occupation. These measures differ in type; BHPS respondents are asked about exact dates whereas HILDA Survey respondents provided durations. Moreover, occupation tenure rather than job tenure adds a layer of cognitive complexity to the question; respondents must correctly identify the boundaries around their occupation to ascertain when their current occupation started.

Both surveys publish measures of time within the past year in employment. The HILDA Survey uses a calendar questioning technique (See e.g., Belli 1998) to gather this information. Respondents are asked to report on their employment status for specific periods of time referencing the calendar without gaps in time. BHPS, however, uses a question-list to collect the same information, querying the current status and whether this has been continuous since a specific reference date. If not continuous, then a series of questions probes backwards in time to collect employment status transitions and their dates.

Occupation Score. In both surveys, respondents report their current occupational title and describe the work that they perform using broadly similar measurement protocols. These descriptions are coded to standard occupational codes (Australian Bureau of Statistics 2006; Office of Population Censuses and Surveys 1990) and then converted to continuous occupational scores (McMillan, Beavis, and Jones 2009; Prandy 1990).

To estimate wages, we also incorporate a number of control variables. These include age, education qualifications, a derived variable about lifetime months in employment, an indicator of part-time status (BHPS only), the proportion male in the occupation (from national labour force survey data), and whether the employment is permanent (versus temporary), involves supervisory duties, is unioned, is in the private sector. We also control for workplace size, industry, and region. Table 1 and Table 2 show descriptive statistics for each measure examined across the five waves for BHPS men and women respectively, while Table 3 and Table 4 contain HILDA Survey descriptive statistics.

Table 1 BHPS men's descriptive statistics of variables used in the analysis, shown are means, standard deviations, or percentages as appropriate.

	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD
Hourly Wage	6.72	*4.15*	6.77	*4.70*	6.78	*4.47*	6.81	*5.07*	6.91	*4.62*
Log Hourly Wage	1.74	*0.58*	1.74	*0.57*	1.74	*0.59*	1.73	*0.61*	1.76	*0.58*
Work Hours	42.03	*12.11*	41.34	*11.07*	40.84	*12.11*	41.06	*11.80*	41.45	*11.53*
Job Tenure (years)	5.36	*6.72*	5.08	*6.44*	4.93	*6.32*	4.86	*6.13*	4.79	*6.16*
Occupation Score	32.35	*18.77*	32.85	*18.70*	33.59	*19.53*	34.46	*19.22*	34.95	*19.71*
Age	36.65	*12.71*	36.73	*12.33*	36.35	*12.34*	36.05	*12.26*	36.50	*12.23*
Education										
Degree+	11.34%		12.39%		13.95%		14.65%		16.08%	
Other higher quals	21.50%		23.28%		23.98%		24.49%		26.08%	
A-levels, or equivalent	14.83%		14.42%		15.31%		15.50%		15.13%	
Other qualifications	32.47%		31.36%		31.18%		30.90%		29.02%	
No qualifications	19.64%		18.15%		15.11%		13.76%		12.94%	
Total lifetime months in employment	207.18	*154.73*	225.18	*150.42*	219.64	*148.22*	230.45	*143.56*	238.73	*141.80*
Part-Time	6.44%		6.49%		8.31%		8.00%		7.42%	
%-male in occupation	73.19%		71.59%		70.76%		69.70%		70.03%	
Permanent Employee	92.72%		93.66%		92.13%		90.46%		91.04%	
Supervisory Duties	40.49%		40.06%		40.88%		40.97%		40.41%	
Unioned	40.95%		39.98%		36.70%		32.98%		33.07%	
Private Sector	78.40%		77.29%		77.38%		79.19%		78.65%	
Workplace size										
1-9 employees	15.05%		14.83%		13.62%		13.46%		12.39%	
10-49 employees	26.64%		27.49%		26.52%		27.57%		29.08%	
50+ employees	58.31%		57.68%		59.86%		58.97%		58.52%	

continued...

Table 1 continued...	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD
Industry										
Agriculture, Forestry & Fishing	1.60%		1.40%		1.71%		1.69%		1.59%	
Energy & Water Supplies	4.06%		3.78%		3.32%		2.83%		2.94%	
Extraction, mining, etc.,...	4.38%		4.31%		4.38%		4.72%		5.08%	
Metal Goods, Engineering & Vehicles	16.55%		16.21%		14.71%		14.16%		14.78%	
Other Manufacturing	13.00%		12.20%		12.39%		11.67%		12.34%	
Construction	5.97%		4.65%		4.38%		4.97%		4.33%	
Distribution, Hotels & Catering	15.64%		17.09%		17.38%		18.28%		17.07%	
Transport & Communication	8.48%		8.66%		8.41%		8.40%		7.77%	
Banking, Finance, Insurance, etc.,...	10.26%		11.08%		11.34%		12.27%		12.74%	
Other Services	20.06%		20.62%		21.96%		21.01%		21.35%	
Region										
London	9.57%		9.54%		10.38%		9.54%		9.36%	
Rest of the Southeast	19.32%		19.07%		18.79%		19.72%		20.81%	
Southwest	9.21%		9.24%		9.92%		9.94%		9.16%	
Anglia & Midlands	20.95%		20.96%		21.11%		21.41%		21.45%	
Northwest	10.25%		10.50%		10.38%		10.28%		10.10%	
Rest of the North	16.96%		17.04%		15.87%		16.19%		16.48%	
Wales	4.85%		5.28%		5.09%		4.97%		4.53%	
Scotland	8.89%		8.37%		8.46%		7.95%		8.11%	
Sample size	2,205		2,066		1,985		2,013		2,009	

Table 2 BHPS women's descriptive statistics of variables used in the analysis, shown are means, standard deviations, or percentages as appropriate.

	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD
Hourly Wage	4.90	*3.07*	5.12	*5.50*	5.10	*4.02*	5.07	*3.35*	5.18	*3.57*
Log Hourly Wage	1.44	*0.54*	1.46	*0.55*	1.46	*0.56*	1.47	*0.55*	1.49	*0.55*
Work Hours	29.48	*12.44*	29.13	*12.61*	29.61	*13.15*	29.77	*12.85*	29.81	*12.86*
Job Tenure	4.12	*5.24*	4.00	*4.83*	4.15	*4.97*	4.30	*5.14*	4.31	*5.35*
Occupation Score	36.42	*17.10*	36.54	*17.11*	37.38	*17.90*	37.50	*17.72*	37.97	*17.95*
Age	37.03	*12.16*	36.95	*12.34*	37.10	*12.28*	37.07	*12.22*	36.88	*12.15*
Education										
Degree+	8.59%		9.37%		11.06%		11.11%		11.79%	
Other higher qualifications	17.83%		19.28%		19.98%		21.68%		21.63%	
A-levels, or equivalent	10.00%		10.76%		11.46%		11.77%		12.89%	
Other qualifications	41.04%		39.64%		38.83%		37.32%		37.61%	
No qualifications	22.50%		20.58%		18.40%		17.81%		15.71%	
Total lifetime months in employment	170.75	*122.46*	184.94	*121.30*	185.91	*121.49*	195.50	*117.22*	201.08	*113.96*
Part-Time	39.98%		40.85%		40.24%		39.85%		40.16%	
%-male in occupation	26.85%		25.90%		26.69%		27.38%		27.89%	
Permanent Employee	90.07%		90.58%		89.58%		89.38%		89.39%	
Supervisory Duties	29.67%		27.86%		28.92%		28.58%		29.08%	
Unioned	32.58%		31.39%		30.65%		29.28%		28.94%	
Private Sector	66.87%		66.30%		66.52%		67.13%		67.67%	
Workplace size										
1-9 employees	24.24%		23.23%		20.84%		20.74%		20.89%	
10-49 employees	31.77%		33.09%		32.76%		33.50%		34.32%	
50+ employees	44.00%		43.68%		46.40%		45.76%		44.79%	

continued...

Table 2 continued...	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD	Mean/Pct	SD
Industry										
Agriculture, Forestry & Fishing	0.75%		0.72%		0.54%		0.80%		0.68%	
Energy & Water Supplies	0.75%		0.81%		0.45%		0.58%		0.46%	
Extraction, mining, etc.,...	1.95%		1.57%		1.86%		1.42%		1.37%	
Metal Goods, Engineering & Vehicles	5.15%		4.13%		3.85%		3.86%		3.92%	
Other Manufacturing	8.08%		7.31%		7.11%		7.33%		6.88%	
Construction	0.67%		0.94%		0.91%		0.76%		0.64%	
Distribution, Hotels & Catering	21.84%		23.23%		23.06%		26.21%		26.23%	
Transport & Communication	2.75%		2.83%		3.17%		3.07%		3.10%	
Banking, Finance, Insurance, etc.,...	12.12%		12.65%		12.51%		12.31%		13.07%	
Other Services	45.94%		45.83%		46.53%		43.67%		43.67%	
Region										
London	10.30%		10.85%		10.10%		10.48%		10.29%	
Rest of the Southeast	19.33%		19.42%		20.84%		20.39%		21.22%	
Southwest	7.75%		8.39%		8.38%		8.57%		8.93%	
Anglia & Midlands	20.78%		19.55%		19.94%		20.21%		20.13%	
Northwest	10.83%		10.67%		10.65%		10.04%		9.70%	
Rest of the North	15.76%		15.96%		15.63%		15.42%		15.21%	
Wales	4.71%		4.93%		4.40%		4.80%		4.51%	
Scotland	10.52%		10.22%		10.06%		10.08%		10.02%	
Sample size	2,271		2,230		2,207		2,251		2,196	

Table 3 HILDA men's descriptive statistics of variables used in the analysis, shown are means, standard deviations, or percentages as appropriate.

	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD
Hourly Wage	21.48	*9.49*	21.55	*9.32*	21.92	*9.53*	22.28	*9.53*	22.67	*9.55*
Log Hourly Wage	2.97	*0.45*	2.98	*0.44*	3.00	*0.43*	3.02	*0.43*	3.03	*0.43*
Work Hours	43.40	*11.40*	43.28	*11.46*	43.21	*11.15*	43.04	*10.96*	43.03	*11.05*
Job Tenure	8.16	*8.73*	7.82	*8.42*	7.92	*8.53*	8.26	*8.70*	8.31	*8.61*
Occupation Tenure	10.72	*9.62*	10.42	*9.61*	10.57	*9.63*	10.96	*9.94*	10.71	*10.08*
Occupation Score	49.86	*24.77*	49.87	*24.51*	49.56	*24.65*	50.45	*24.49*	50.41	*24.20*
Age	40.69	*9.70*	41.04	*9.68*	41.62	*9.61*	41.86	*9.73*	42.18	*9.90*
Foreign Born	23.09%		22.77%		22.89%		21.56%		21.93%	
Education										
Degree+	26.91%		27.13%		27.37%		27.72%		27.86%	
Vocational qualifications	38.93%		39.57%		39.42%		40.29%		41.16%	
Year 12	11.18%		10.59%		10.63%		10.27%		10.45%	
Year 11 or below	22.99%		22.71%		22.58%		21.72%		20.53%	
Lifetime years in employment	22.52	*10.55*	22.69	*10.53*	23.16	*10.46*	23.31	*10.56*	23.54	*10.68*
%-male in occupation	64.52%		65.22%		64.83%		65.15%		65.19%	
Permanent employee	80.08%		77.87%		80.21%		82.66%		81.24%	
Supervisory duties	58.90%		56.86%		55.89%		59.44%		58.16%	
Unioned	37.71%		35.74%		35.74%		35.58%		35.14%	
Private Sector	81.14%		82.39%		81.05%		80.58%		80.20%	
Firm size										
1-19 employees	18.27%		18.62%		18.21%		17.71%		16.63%	
20-99 employees	17.37%		16.06%		16.47%		16.96%		17.31%	
100+ employees	64.35%		65.32%		65.32%		65.33%		66.06%	

Continued…

Table 3 continued…	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD
Industry										
Manufacturing, wholesale, transport	35.06%		36.49%		36.37%		34.51%		34.67%	
Primary, utilities, construction	16.42%		14.68%		14.89%		15.46%		14.81%	
Retail	5.46%		5.85%		6.21%		6.42%		6.39%	
Govt, health, education	19.12%		19.31%		19.37%		19.58%		19.33%	
Other services	23.94%		23.67%		23.16%		24.02%		24.79%	
High growth states (Queensland & Western Australia)	30.46%		30.96%		30.89%		29.64%		30.51%	
Major capital city	60.06%		58.99%		59.37%		59.02%		58.73%	
Sample size	1,888		1,880		1,900		1,869		1,924	

Table 4 HILDA women's descriptive statistics of variables used in the analysis, shown are means, standard deviations, or percentages as appropriate.

	Wave 1		Wave 2		Wave 3		Wave4		Wave 5	
	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD
Hourly Wage	18.54	7.33	18.65	7.26	18.99	7.58	19.05	7.57	19.47	8.05
Log Hourly Wage	2.85	0.40	2.85	0.39	2.87	0.39	2.87	0.40	2.89	0.42
Work Hours	31.59	13.31	31.79	13.65	31.69	13.25	31.77	13.08	31.93	13.43
Job Tenure	6.61	6.95	6.48	6.93	6.62	6.95	6.77	7.18	6.95	7.33
Occupation Tenure	9.62	8.84	9.43	8.82	9.31	9.05	9.27	9.03	9.42	9.34
Occupation Score	55.15	23.63	55.18	23.10	54.63	23.16	54.88	23.01	55.09	22.93
Age	40.96	9.40	41.27	9.31	42.00	9.38	42.10	9.45	42.50	9.56
Foreign Born	22.10%		21.62%		21.61%		20.78%		20.37%	
Education										
Degree+	32.47%		33.02%		33.53%		33.21%		34.13%	
Vocational qualifications	21.56%		22.76%		23.88%		24.39%		25.14%	
Year 12	14.52%		14.74%		14.02%		14.45%		14.12%	
Year 11 or below	31.45%		29.48%		28.57%		27.95%		26.61%	
Lifetime years in employment	19.11	9.05	19.31	9.01	19.97	9.18	20.12	9.38	20.44	9.48
%-male in occupation	38.97%		38.45%		38.82%		38.99%		39.03%	
Permanent employee	66.94%		66.81%		68.63%		70.24%		70.65%	
Supervisory duties	43.76%		46.18%		45.23%		45.32%		44.29%	
Unioned	34.73%		33.79%		33.68%		33.16%		32.76%	
Private Sector	68.55%		71.62%		69.69%		69.93%		69.43%	
Firm size										
1-19 employees	22.10%		23.42%		19.66%		20.72%		19.50%	
20-99 employees	14.41%		13.10%		14.60%		13.66%		13.76%	
100+ employees	63.49%		63.48%		65.74%		65.62%		66.73%	

Continued…

Table 4 continued…	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD	Mean / Pct	SD
Industry										
Manufacturing, wholesale, transport	35.06%		36.49%		36.37%		34.51%		34.67%	
Primary, utilities, construction	16.42%		14.68%		14.89%		15.46%		14.81%	
Retail	5.46%		5.85%		6.21%		6.42%		6.39%	
Govt, health, education	19.12%		19.31%		19.37%		19.58%		19.33%	
Other services	23.94%		23.67%		23.16%		24.02%		24.79%	
High growth states (Queensland & Western Australia)	30.46%		30.96%		30.89%		29.64%		30.51%	
Major capital city	60.06%		58.99%		59.37%		59.02%		58.73%	
Sample size	1,888		1,880		1,900		1,869		1,924	

4. The Longitudinal Stability of Reliability Estimates

How stable is measurement reliability and do men and women differ in their patterns of reliability in longitudinal data? Are measures of reliability comparable across surveys? We explore whether panel conditioning affects the reporting of work hours and wages, and the measurement of employment tenure and occupation itself. We estimate a set of baseline QSM and check whether errors may be serially correlated. We also estimate QSM where the data are grouped by sex to assess whether doing so accommodates likely differences between men and women in reporting information about their employment. Then to assess whether reliabilities are stable over time, we examine the reliabilities obtained from the best fitting model for each variable as determined by sample size adjusted Bayesian Information Criteria (BIC) values.

Table 5 contains model fit statistics where BHPS results are in the upper panel and HILDA data results are in the lower panel. For the models that could be fitted to the BHPS data, the BIC values suggest that we should examine the longitudinal properties of reliability estimates from the baseline QSM grouped by sex for log wages, log hourly wages, the proportion of the year employed, and current job tenure. A QSM with serially correlated errors grouped by sex is appropriate for work hours and occupation score.

Table 5 Sample size adjusted Bayesian Information Criteria (BIC) under different model assumptions for continuous variables relevant for estimating wages, BHPS and HILDA Waves 1 to 5.

BHPS	Work hours	Log Wage	Log hourly wage	% of Ref Yr Employed	Current Job Tenure (yrs)	Occupation Score
Baseline QSM	95,387	13,349	7,079	109,866	77,364	102,141
QSM with serially correlated errors	95,361	13,359	7,077	109,862	77,322	102,120
Baseline QSM grouped by sex	93,719	***11,383***	***6,662***	***109,045***	***76,740***	102,122
QSM with serially correlated errors grouped by sex	***93,713***	11,407	---	---	---	***102,110***

HILDA	Work hours	Log Wage	Log hourly wage	% of Ref Yr Employed	Current Job Tenure (yrs)	Current Occupation Tenure (Yrs)	Occupation Score
Baseline QSM	145,916	24,151	11,669	***167,765***	117,234	***133,406***	162,229
QSM with serially correlated errors	145,942	24,148	11,685	167,779	117,263	133,424	162,258
Baseline QSM grouped by sex	***144,693***	***22,757***	***11,414***	---	***117,039***	133,430	***162,218***
QSM with serially correlated errors grouped by sex	144,738	22,782	11,451	---	117,083	133,463	162,273

Notes: Numbers if ***bold-italics*** indicate the lowest BIC value. Models that could not be estimated are indicated with "-----"

Across 5 of the 7 variables examined using HILDA data, BIC values indicate that the baseline QSM grouped by sex is the most appropriate model (work hours, log wages, log hourly wage, job tenure and occupation score). For the proportion of the year employed and occupation tenure, BIC values suggest the baseline QSM *not* grouped by sex is the most appropriate model. Taken together, these results are somewhat striking in that for both BHPS and HILDA, the assumptions of the baseline QSM would seem to be appropriate in most cases.

The longitudinal reliability of employment hours, wages and calculated log-hourly wages. Figure 1 shows reliability of stated employment hours for BHPS and HILDA both, whereas Figure 2 shows reliability for hourly wages and Figure 3 shows reliability of computed log hourly wages. The figures show that among all three measures, reliabilities are reasonably high – routinely in excess of 0.8 – though this is not surprising given that these are factual measures (see e.g., Alwin 2007). Some exceptions to this finding of high reliability are worth noting. BHPS men's reports of hours worked show reliabilities lower than 0.80 (about 0.77 on average). Also, women's log hourly wages in the HILDA Survey are closer to 0.70 across the five waves. The detail of Figure 1 suggests that women in both studies are more reliable at reporting their work hours than men. HILDA Survey men seem to be somewhat more reliable than BHPS men at reporting hours. Recall that BHPS respondents report on paid and unpaid work hours separately whereas HILDA respondents report on all work hours in a combined question. Some of these reliability differences between surveys could result from differences in measurement protocols, though the differences are minor. Figure 3, concerning log-wages, shows BHPS women reporting wages with higher reliability than men, with some improvement in BHPS men's reliability over the first five waves. Figure 3 shows that once log-hourly wage are computed, BHPS men and women have roughly the same reliability though it increases somewhat over the first five waves of data collection for men. Reliabilities for log hourly wage measures for HILDA men are higher than HILDA women, though these reliabilities seem to converge at later waves.

Figure 1 Reliabilities for hours worked from the baseline QSM grouped by sex, BHPS and HILDA Waves 1 to 5.

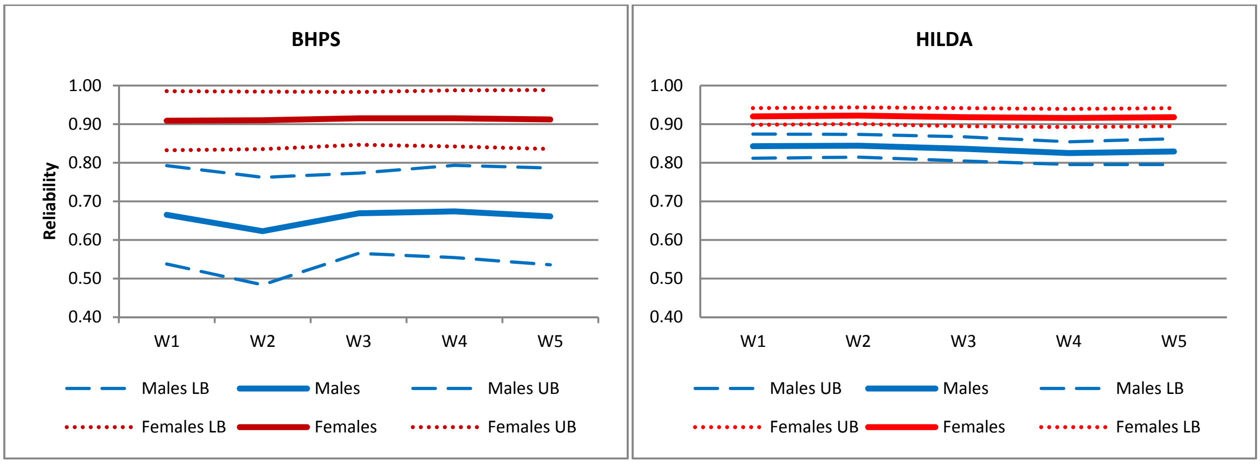


Figure 2 Reliabilities for log wages from the baseline QSM grouped by sex, BHPS and HILDA Waves 1 to 5.

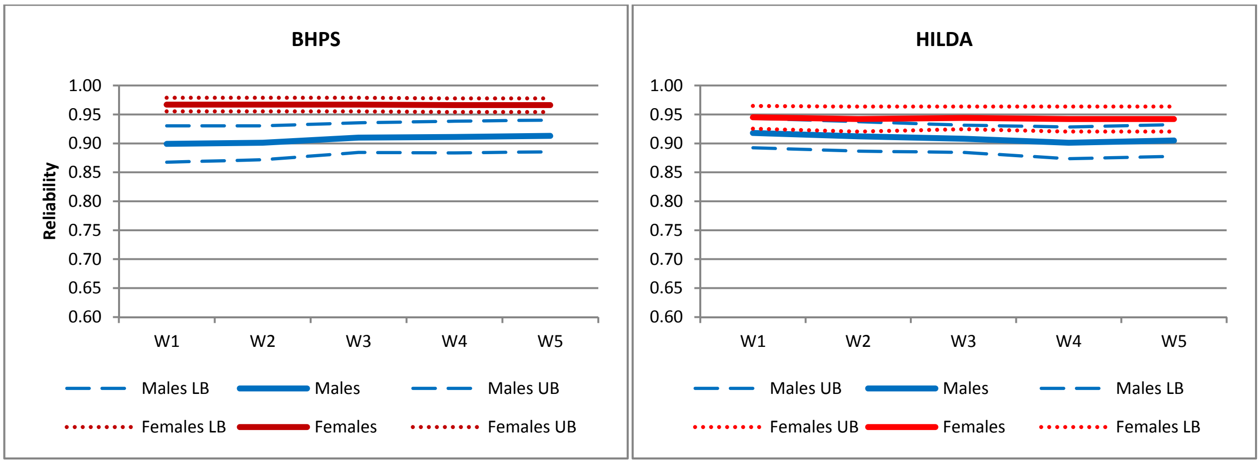
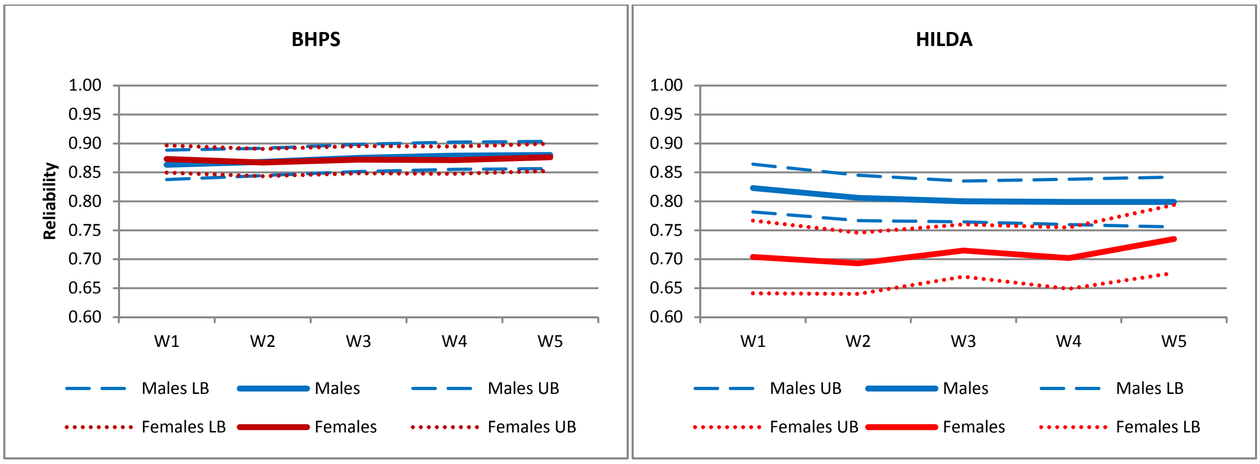


Figure 3 Reliabilities for log hourly wages from the baseline QSM grouped by sex, BHPS and HILDA Waves 1 to 5.



The longitudinal reliability of job and occupational tenure. Figure 4 shows reliabilities for measures of job tenure in BHPS and HILDA. Since the approaches to measuring this concept differ markedly between the surveys, it is not surprising to observe different reliability patterns across them. BHPS respondents are somewhat less reliable in reporting the job start dates whereas HILDA respondents are uniformly and more highly reliable at reporting current job duration. Moreover, the

BHPS data suggests a slight increase in job start date reliability. HILDA men and women are practically identical, with a slight increase in job tenure reliability over time. Note that reliabilities for both BHPS and HILDA are high overall – above 0.80 in both instances – with the duration measure used in HILDA obtaining reliabilities in excess of 0.90. Figure 5 shows the reliability of occupation tenure measured in the HILDA Survey. Not surprisingly, reliabilities here are somewhat lower than for job tenure as occupation is perhaps a more complex concept than job. Occupation reliabilities increase slightly across the five waves as one might expect if the concept of occupation, and how it might be distinct from job, becomes clearer to respondents.

Figure 4 Reliabilities for job tenure from the baseline QSM grouped by sex, BHPS and HILDA Waves 1 to 5.

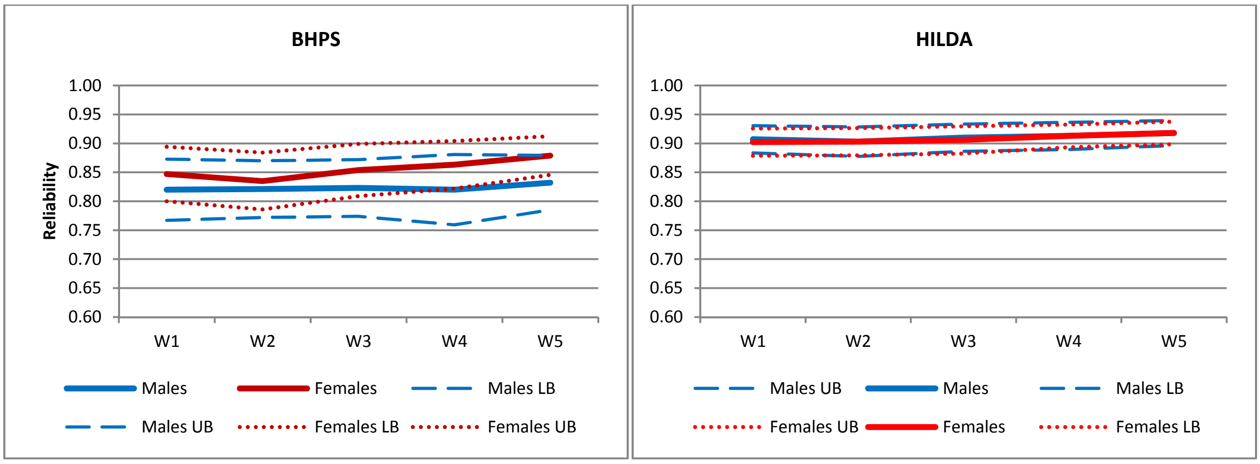
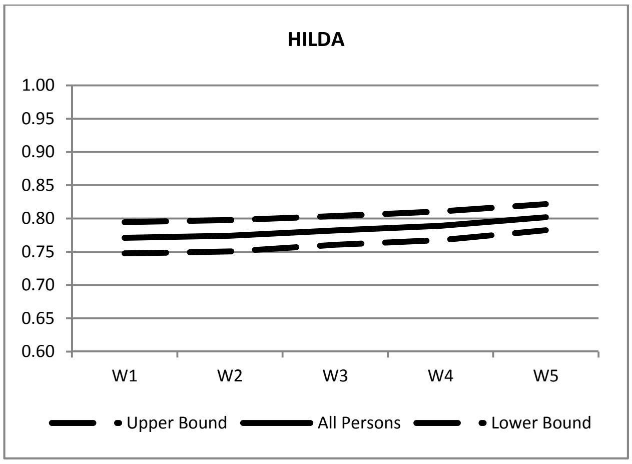


Figure 5 Reliabilities for occupation tenure from the baseline QSM, HILDA (only) Waves 1 to 5.



Yearly Employment Status and Occupational Score. Figure 6 and Figure 7 show reliabilities for the proportion of the year employed and occupational score respectively. The first is included because respondents may be observed in employment at consecutive waves when, in fact, they may have had a spell of non-employment between interviews. This is an important control for continuous employment through which human capital accumulation occurs. The reliability of this measure is very close to 1.0 for BHPS men, while it is much lower for BHPS women, perhaps because women are more likely to have work interruptions than men. Given that the reliability is very close to 1.0 for BHPS men, maximum likelihood estimation yields somewhat erratic confidence intervals. HILDA Survey results suggest the overall reliability is very high. As with BHPS, confidence intervals are somewhat erratic using maximum likelihood estimation and reliability scores close to 1.0.

Figure 6 Reliabilities for proportion of the year in employment from the baseline QSM grouped by sex in BHPS and not grouped by sex in HILDA, Waves 1 to 5.

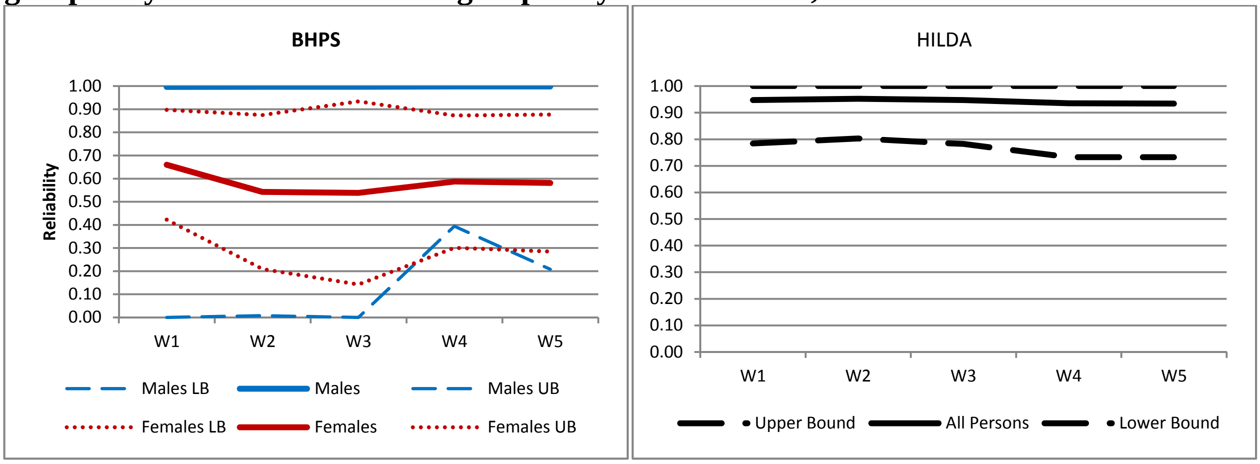


Figure 7 Reliabilities for occupational score from the baseline QSM grouped by sex, BHPS and HILDA Waves 1 to 5.

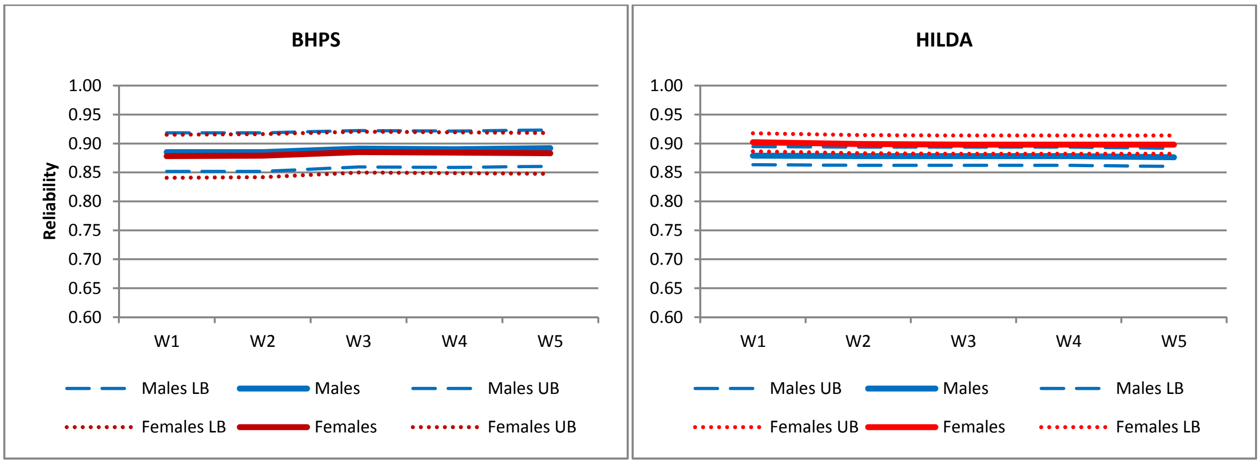


Figure 7 shows occupational score reliabilities. Occupational scores are a translation of coded job titles and occupational descriptions. If we assume constant noise in coding across waves, variation in the reliability associated with respondents should be observable in occupational scores. Moreover, the reliability of occupation related measures such as the proportion male of a person's occupation would be influenced by the occupation coding process. We see similar reliabilities for men and women and also across the two surveys.

Table 6 Calculated reliabilities from simplex models for various variables, shown are wave on wave differences and average differences between beginning and end of the investigation period.

BHPS	**Group**	**Mean reliability**	**W2-W1**	**W3-W2**	**W4-W3**	**W5-W4**	**W5/W4 vs W2/W1**
Hours worked	Males	0.66	-0.04	0.05	0.005	-0.01	0.02
	Females	0.91	0.001	0.005	0.000	-0.003	0.004
Log wages	Males	0.91	0.001	**0.01**	0.001	0.002	**0.01**
	Females	0.97	0.001	0.01	0.001	0.002	0.01
Log hourly wage	Males	0.87	0.006	0.006	**0.004**	***0.001***	***0.01***
	Females	0.87	0.006	0.006	0.00	0.00	0.01
% of Ref Yr in E'ment	Males	0.997	0.001	0.000	0.001	0.000	0.001
	Females	0.58	0.001	0.000	0.001	0.000	0.001
Job Tenure	Males	0.82	0.001	0.002	-0.00	0.012	0.01
	Females	0.86	**0.001**	0.002	-0.00	*0.012*	***0.01***
Occupational Score	Males	0.89	0.000	*0.006*	-0.001	0.002	***0.01***
	Females	0.88	0.000	*0.006*	-0.001	0.002	*0.01*
HILDA							
Hours worked	Males	0.835	0.000	-0.008	-0.010	0.004	**-0.016**
	Females	0.919	0.002	*-0.004*	-0.002	0.002	*-0.004*
Log wages	Males	0.909	-0.006	-0.005	-0.007	0.004	***-0.013***
	Females	0.943	-0.003	0.002	-0.002	0.000	-0.002
Log hourly wage	Males	0.805	-0.017	-0.006	-0.001	0.000	*-0.015*
	Females	0.710	-0.011	0.022	-0.014	*0.034*	0.020
Employment tenure	Males	0.910	-0.005	***0.007***	0.003	*0.004*	***0.010***
	Females	0.908	0.000	0.004	***0.007***	**0.005**	***0.013***
Occupation tenure	Males	0.800	0.003	0.004	*0.011*	**0.010**	***0.022***
	Females	0.762	0.004	0.012	0.000	**0.018**	***0.023***
Occupation score	Males	0.878	-0.001	0.001	-0.001	-0.002	-0.002
	Females	0.899	**-0.003**	-0.001	0.000	0.000	-0.002
% of Ref Yr Employed	All	0.943	0.005	-0.005	-0.012	-0.001	-0.015

Notes: *Italics* means $p < 0.10$, **Bold** means $p < 0.05$, ***Bold-Italics*** means $p < 0.01$.

Table 6 reports results from an examination of change in reliabilities over the five waves in greater detail. Shown are the mean reliabilities for men and women in HILDA and BHPS along with the wave on wave differences in reliability estimates and whether the differences in these estimates are significant across waves. The final column shows the difference between the Wave 1/Wave 2 average and the Wave 4/Wave 5 average. This final measure indicates an overall increasing or decreasing trend in reliabilities over time. The BHPS data show a slight increase in some reliabilities: men's log wages, men's log hourly wages, women's job tenure and both men's and women's occupation scores. These trends are very modest, however, as improvements in reliability are all 0.01 or less. HILDA results show decreasing reliabilities for men's and women's hours worked, men's log wages and men's log hourly wages, but increasing reliabilities in men's and women's employment tenure and occupation tenure. As with the BHPS, shifts in HILDA reliabilities are modest and only improvements in occupation tenure reliabilities are greater than 0.02.

6. The Effects of Measurement Error on Models of Gender Wage Inequality

What is the effect of measurement error on assessments of the gender wage gap? Table 7 and Table 8 contain selected wage equation estimates for BHPS and HILDA respectively, though full models are included in the Appendix. Table 7 shows the unadjusted and adjusted effects of job tenure and occupation score on men's and women's wages using the BHPS data. We find no effect of job tenure in these models however occupation score is statistically significant across both men and women and all five waves of data. A comparison of the occupation score variance rescaled coefficient to the uncorrected coefficient suggests a consistent attenuation effect for both men and women across all five waves. For men, the attenuation ranges from 3.5 percent in Wave 4 to a maximum of 12.9 percent in Wave 1. For women, the attenuation is consistently higher with a low of 7.9 percent in Wave 3 and 14.1 percent in Wave 1. Though these findings are not monotonic, it should be noted that one could discern a downward trend in the attenuation for both men and women with the highest attenuation in Wave 1. The attenuation in Wave 5 for men (5.4 percent), for example, is less than half the size as at Wave 1 (12.9 percent).

Table 7 Unadjusted and Adjusted coefficients from wage equations for men and women, BHPS data.

	Men					Women				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
Unadjusted										
Job Tenure	0.093	-0.001	-0.041	0.061	0.273	-0.023	-0.177	0.196	-0.191	-0.051
	(0.152)	(0.164)	(0.171)	(0.179)	(0.175)	(0.184)	(0.212)	(0.208)	(0.193)	(0.194)
Occupation Score	0.923***	1.073***	1.092***	1.093***	1.029***	0.929***	1.069***	1.021***	1.05***	0.991***
	(0.067)	(0.071)	(0.07)	(0.077)	(0.075)	(0.065)	(0.067)	(0.069)	(0.065)	(0.072)
Adjusted										
Job Tenure	0.113	-0.04	-0.032	0.068	0.325	-0.028	-0.155	0.268	-0.184	-0.012
	(0.184)	(0.195)	(0.204)	(0.21)	(0.202)	(0.218)	(0.249)	(0.237)	(0.222)	(0.215)
Occupation Score	1.042***	1.144***	1.174***	1.131***	1.085***	1.06***	1.193***	1.102***	1.164***	1.088***
	(0.076)	(0.077)	(0.074)	(0.083)	(0.082)	(0.074)	(0.074)	(0.076)	(0.073)	(0.08)
Pct change in estimates										
Job Tenure	21.5%	3900.0%	-22.0%	11.5%	19.0%	21.7%	-12.4%	36.7%	-3.7%	-76.5%
Occupation Score	**12.9%**	**6.6%**	**7.5%**	**3.5%**	**5.4%**	**14.1%**	**11.6%**	**7.9%**	**10.9%**	**9.8%**

Notes: *** $p < 0.001$. Percent change in estimates in **bold** reflect significance in the models. Standard errors in parentheses. Models also control for age, education, lifetime months in employment, part-time, proportion male in occupation, employment contract term, supervisory duties, unionisation, sector, workplace size, industry and region.

Table 8 Unadjusted and Adjusted coefficients from wage equations for men and women, HILDA Survey data.

	Men					Women				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
Unadjusted										
Job Tenure	0.126	0.096	0.052	-0.023	0.029	0.087	-0.170	0.126	0.100	0.091
	(0.147)	(0.154)	(0.151)	(0.128)	(0.119)	(0.155)	(0.162)	(0.17)	(0.146)	(0.146)
Occupation Tenure	0.360***	0.227*	0.095	0.289**	0.131	0.270**	0.316**	0.311**	0.266**	0.184
	(0.113)	(0.119)	(0.129)	(0.104)	(0.089)	(0.118)	(0.111)	(0.105)	(0.102)	(0.119)
Occupation Score	0.600***	0.569***	0.568***	0.501***	0.583***	0.613***	0.627***	0.638***	0.530***	0.673***
	(0.047)	(0.054)	(0.046)	(0.049)	(0.051)	(0.05)	(0.058)	(0.059)	(0.056)	(0.062)
Adjusted										
Job Tenure	0.141	0.105	0.058	-0.017	0.037	0.100	-0.188	0.139	0.104	0.101
	(0.162)	(0.171)	(0.165)	(0.141)	(0.13)	(0.172)	(0.180)	(0.188)	(0.162)	(0.159)
Occupation Tenure	0.464***	0.292*	0.121	0.365**	0.163	0.347**	0.409**	0.397**	0.334**	0.225
	(0.146)	(0.153)	(0.165)	(0.133)	(0.112)	(0.152)	(0.144)	(0.134)	(0.131)	(0.148)
Occupation Score	0.683***	0.651***	0.648***	0.570***	0.670***	0.679***	0.698***	0.710***	0.595***	0.751***
	(0.053)	(0.061)	(0.053)	(0.056)	(0.058)	(0.055)	(0.064)	(0.065)	(0.062)	(0.069)
Pct change in estimates										
Job Tenure	11.9%	9.4%	11.5%	-26.1%	27.6%	14.9%	10.6%	10.3%	4.0%	11.0%
Occupation Tenure	**28.9%**	**28.6%**	27.4%	**26.3%**	**24.4%**	**28.5%**	**29.4%**	**27.7%**	**25.6%**	22.3%
Occupation Score	**13.8%**	**14.4%**	**14.1%**	**13.8%**	**14.9%**	**10.8%**	**11.3%**	**11.3%**	**12.3%**	**11.6%**

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$. Percent change in estimates in **bold** reflect significance in the models. Standard errors in parentheses. Models also control for age, foreign born, education, lifetime years in employment, proportion male in occupation, employment contract term, supervisory duties, unionisation, sector, firm size, industry, high-growth Australian state and major capital city.

HILDA Survey results are shown in Table 8. As with the BHPS, job tenure has no effect on wages. However, occupation score predicts wages for both men and women, and occupation tenure is frequently a significant predictor of wages. Attenuation in both occupation tenure and score is substantial. For occupation tenure, the attenuation effect ranges from 28.9 percent in Wave 1 to 24.4 percent in Wave 5 for men, and 28.5 percent in Wave 1 to 25.6 percent in Wave 4 for women. Thus, this attenuation effect would seem to drop somewhat over time. Attenuation in occupation score coefficients similarly ranges from 13.8 percent (Wave 4) to 14.9 percent (Wave 5) for men, and 10.8 percent (Wave 1) to 12.3 percent (Wave 4) for women though we find no discernable pattern in the attenuation effect over time.

The portion of the wage gap that is unexplained by differences in characteristics or remunerative attributes of men and women represents a measure discrimination existing in the labour market. Men and women's wages would be approximately equal if there was no discrimination; a greater unexplained portion suggests greater discrimination. However, the unexplained portion also includes the total amount of measurement error in the variables included in the wage equation (Jones and Kelley 1984). Table 9 shows the effects of variance adjustment on the wage decomposition for BHPS (upper panel) and HILDA (lower panel). We find greater wage parity between Australian men and women than British men and women. The unexplained portion of the wage decomposition in the HILDA data is on average about 13-14 percentage points lower than in the BHPS data. Part of this difference may be due to a 10 year gap in the British and Australian surveys; an analysis of comparable British data overlapping the dates of the Australian data might result in similar human capital and labour market position for men and women in Britain (Pérez 2010).

Table 9 Wage decomposition results, shown is the proportion of the gender wage gap unexplained by attributes using models unadjusted and reliability adjusted models.

BHPS	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Unadjusted	44.0%	51.1%	34.1%	22.2%	39.9%
Adjusted	45.4%	50.8%	37.9%	25.4%	40.8%
Diff	1.3%	-0.2%	3.8%	3.2%	0.9%
HILDA					
Unadjusted	7.5%	29.5%	30.2%	29.7%	19.3%
Adjusted	9.5%	31.8%	32.9%	31.0%	22.0%
Diff	2.0%	2.3%	2.7%	1.3%	2.8%

BHPS results suggest that job tenure and occupation score adjustments increase the unexplained portion of the wage decomposition between 0.9 percent (Wave 5) and 3.8 percent (Wave 3) – or about 1.8 percentage points on average. The adjustment has the opposite effect at Wave 2, though the magnitude is very small (-0.2 percent). For HILDA, the results suggest greater measurement error effects on the decomposition – most likely because more variables could be corrected. Here the adjustment increases the unexplained portion of the wage gap between 1.3 percent in Wave 4 to 2.8 percent in Wave 5, though the effect is generally larger than 2 percent across the remaining waves for about a 2.2 percentage point on average.

7. Conclusions

We explored whether reliabilities are longitudinally stable over the first five waves of both the BHPS and the HILDA Survey. Although the reliability measures we investigated where quite high overall, the HILDA data seem to show somewhat greater change in reliability than the BHPS. Improved accuracy in reporting would tend to move true and observed variances into equality, thereby improving reliability over the life of these surveys. We do not generally find improved reliability over time, however, apart from in areas where respondent comprehension and understanding might play a role. That is, significant HILDA Survey reliability improvements were in measures reliant on respondent interpretation and understanding of "job" and "occupation". Like opinion crystallisation, respondents can make up their mind about these meanings and continue to use them at subsequent waves. We do not seem to find any other effects over time, for example improved motivation to report accurate wage amounts or dates.

Our analysis of measurement error effects on wage decomposition showed a consistent and often sizeable attenuation effect for all significant predictors of wages that could be corrected in both data sets. In the BHPS, the attenuation effect of occupation score halved for men and dropped 4 percentage points for women. In the HILDA Survey, occupation tenure attenuation similarly dropped in magnitude though we found no discernable pattern in attenuation change over time for occupation score. It should be noted that we found a slight improvement, though not statistically significant, in the reliability of occupation score measures in the BHPS and a significant improvement in occupation tenure reliabilities in the HILDA Survey data. This would be consistent with the theoretical understanding of measurement error, that improvement in reliability reduces attenuation effects in substantive models. The findings for BHPS men are perhaps the most striking where a significant improvement over time in reliability translated directly into a striking drop in the attenuation effect in occupation score. Note that attenuation is *not* always expected in multivariate models (Bohrnstedt 1983), nevertheless it is frequently found in them.

Examining the effects of measurement error on the wage decomposition, we find a small attenuation effect though we could only correct a small number of relevant variables. We found an approximate measurement error effect of less than 2 percent in the BHPS and just slightly more than 2 percent in the HILDA Survey data. We were limited to correcting only continuous variables measured at each wave as only these types of variables lend themselves to QSM from which reliabilities could be obtained. Variance rescaling can be done with any variable regardless of type so long as reliability could be obtained for the variable. Though our results are modest they suggest a lower edge of total measurement error effects on the wage decomposition.

We have examined a limited set of variables relevant to a particular substantive question about gender wage discrimination. This examination of measurement error's impact on wage decompositions using panel data highlights the need for related further scholarship in at least three areas. First, survey methodologists, survey statisticians and substantive researchers should collaboratively study the effects of measurement error on other well-known substantive analyses using a wider range of variables. This would include elaborating generally tractable methods of accommodating measurement error in categorical variables, though admittedly progress has been made in this area in recent years (Alwin 2007; Laenen, Alonso, Molenberghs, and Vangeneugden 2007; Vermunt 2010). Systematically examining a range of substantive models would help develop theoretical lines to inform researchers about when they might expect measurement error effects on substantive conclusions. This is particularly important in areas where policy development relies on empirical findings which may not be accurate. Next, and relatedly, substantive research should habitually engage in a robustness check for the impact of measurement error on substantive conclusions wherever possible. Our findings suggest that measurement error effects are variable and a mounting body of evidence about measurement error effects on substantive conclusions is necessary to develop methodological theory related to how the types of measurement protocols substantively matter. Finally, survey managers and others responsible for general use social surveys should consider, if not actually, provide reliability information about the variables they release with their data. Doing so would alert substantive researchers to areas were measurement error may impact findings thereby facilitating robustness checks and the development of systematic evidence of measurement error impacts.

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Appendix

Table 10 BHPS men's wages regressed on personal and employment characteristics, job tenure and occupation score are adjusted for measurement error, standard errors shown in parentheses.

	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Job Tenure	0.093	-0.001	-0.041	0.061	0.273	0.124	-0.044	-0.035	0.072	0.350
	(0.152)	(0.164)	(0.171)	(0.179)	(0.175)	(0.200)	(0.212)	(0.222)	(0.225)	(0.218)
Occupation Score	***0.923***	***1.073***	***1.092***	***1.093***	***1.029***	***1.040***	***1.142***	***1.175***	***1.129***	***1.084***
	(0.067)	(0.071)	(0.070)	(0.077)	(0.075)	(0.076)	(0.077)	(0.074)	(0.083)	(0.082)
Age	***0.900***	0.275	0.322	0.295	0.214	***0.892***	0.325	**0.513**	*0.406*	0.318
	(0.149)	(0.287)	(0.228)	(0.254)	(0.244)	(0.148)	(0.279)	(0.204)	(0.229)	(0.228)
Degree+	***0.228***	***0.238***	***0.255***	***0.202***	***0.189***	***0.229***	***0.262***	***0.270***	***0.241***	***0.226***
	(0.036)	(0.039)	(0.038)	(0.039)	(0.039)	(0.036)	(0.037)	(0.036)	(0.038)	(0.038)
Other higher qualification	***0.133***	***0.105***	***0.147***	***0.106***	**0.064**	***0.133***	***0.109***	***0.142***	***0.118***	**0.069**
	(0.026)	(0.027)	(0.027)	(0.029)	(0.029)	(0.026)	(0.026)	(0.026)	(0.028)	(0.028)
A-levels, or equivalent	***0.083***	***0.077***	**0.076**	***0.082***	0.037	***0.083***	***0.087***	**0.070**	**0.079**	0.039
	(0.028)	(0.030)	(0.031)	(0.033)	(0.034)	(0.028)	(0.029)	(0.030)	(0.032)	(0.033)
Other qualifications	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
No qualifications	*-0.051*	***-0.094***	**-0.071**	***-0.099***	***-0.123***	*-0.051*	***-0.094***	***-0.085***	***-0.107***	***-0.133***
	(0.027)	(0.029)	(0.032)	(0.035)	(0.035)	(0.027)	(0.028)	(0.031)	(0.034)	(0.035)
Total lifetime months in employment	0.000	**0.050**	*0.036*	0.030	0.028	0.000	**0.048**	0.023	0.021	0.020
	(0.012)	(0.023)	(0.018)	(0.020)	(0.020)	(0.012)	(0.023)	(0.016)	(0.018)	(0.018)

continued...

Table 10 continued	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Part-Time	0.007	0.080	-0.086	***-0.145***	*-0.091*	0.007	0.070	*-0.090*	**-0.131**	*-0.100*
	(0.048)	(0.052)	(0.052)	(0.056)	(0.054)	(0.048)	(0.051)	(0.050)	(0.054)	(0.053)
%-male in occupation	***0.023***	***0.020***	***0.022***	***0.024***	***0.017***	***0.023***	***0.019***	***0.022***	***0.024***	***0.016***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Permanent Employee	***0.219***	***0.206***	0.078	***0.132***	***0.163***	***0.219***	***0.215***	0.065	***0.139***	***0.160***
	(0.041)	(0.048)	(0.050)	(0.048)	(0.049)	(0.041)	(0.046)	(0.047)	(0.046)	(0.049)
Supervisory Duties	***0.204***	***0.177***	***0.164***	***0.177***	***0.172***	***0.205***	***0.186***	***0.162***	***0.185***	***0.180***
	(0.020)	(0.021)	(0.022)	(0.024)	(0.024)	(0.020)	(0.020)	(0.021)	(0.023)	(0.023)
Unioned	***0.090***	***0.084***	***0.109***	***0.124***	***0.076***	***0.091***	***0.082***	***0.106***	***0.114***	***0.079***
	(0.022)	(0.023)	(0.024)	(0.025)	(0.026)	(0.022)	(0.022)	(0.023)	(0.024)	(0.025)
Private Sector	-0.029	-0.015	-0.028	-0.028	-0.013	-0.028	-0.029	-0.019	-0.036	-0.015
	(0.033)	(0.034)	(0.036)	(0.038)	(0.039)	(0.032)	(0.033)	(0.035)	(0.036)	(0.038)
1-9 employees	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10-49 employees	***0.202***	***0.131***	***0.159***	***0.132***	***0.114***	***0.202***	***0.129***	***0.167***	***0.134***	***0.112***
	(0.030)	(0.031)	(0.034)	(0.036)	(0.036)	(0.030)	(0.030)	(0.033)	(0.035)	(0.035)
50+ Employees	***0.279***	***0.248***	***0.243***	***0.229***	***0.231***	***0.279***	***0.252***	***0.253***	***0.243***	***0.225***
	(0.029)	(0.030)	(0.032)	(0.035)	(0.035)	(0.029)	(0.029)	(0.031)	(0.033)	(0.034)
Agriculture, Forestry & Fishing	-0.186	-0.027	0.050	**-0.206**	**-0.197**	**-0.187**	-0.040	0.026	**-0.198**	**-0.199**
	(0.078)	(0.088)	(0.083)	(0.085)	(0.090)	(0.078)	(0.086)	(0.080)	(0.084)	(0.089)

continued...

Table 10 continued	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Energy & Water Supplies	***0.305***	***0.165***	***0.287***	**0.156**	**0.164**	***0.303***	***0.173***	***0.273***	**0.162**	**0.155**
	(0.052)	(0.056)	(0.060)	(0.066)	(0.069)	(0.052)	(0.055)	(0.058)	(0.064)	(0.068)
Extraction, mining, etc.,...	***0.194***	0.048	***0.176***	***0.182***	0.099	***0.193***	0.056	***0.169***	**0.189**	*0.100*
	(0.054)	(0.055)	(0.058)	(0.058)	(0.061)	(0.053)	(0.053)	(0.056)	(0.056)	(0.059)
Metal Goods, Engineering & Vehicles	***0.108***	*0.079*	*0.081*	0.060	0.053	***0.108***	*0.074*	0.061	0.069	0.055
	(0.040)	(0.041)	(0.044)	(0.046)	(0.048)	(0.040)	(0.040)	(0.042)	(0.044)	(0.046)
Other Manufacturing	***0.115***	0.043	*0.087*	0.042	0.022	***0.115***	0.046	*0.076*	0.039	0.018
	(0.042)	(0.043)	(0.046)	(0.049)	(0.049)	(0.042)	(0.042)	(0.044)	(0.047)	(0.048)
Construction	0.028	-0.019	0.058	0.015	0.043	0.027	-0.013	0.055	0.008	0.045
	(0.049)	(0.052)	(0.060)	(0.061)	(0.060)	(0.049)	(0.051)	(0.057)	(0.058)	(0.058)
Distribution, Hotels & Catering	-0.042	*-0.077*	-0.033	*-0.081*	*-0.086*	-0.043	**-0.085**	-0.057	*-0.085*	*-0.085*
	(0.041)	(0.042)	(0.044)	(0.046)	(0.048)	(0.041)	(0.040)	(0.042)	(0.044)	(0.046)
Transport & Communication	0.025	-0.001	-0.041	-0.047	-0.058	0.024	-0.006	-0.043	-0.041	-0.061
	(0.041)	(0.041)	(0.043)	(0.046)	(0.047)	(0.041)	(0.040)	(0.041)	(0.044)	(0.045)
Banking, Finance, Insurance, etc.,...	***0.240***	***0.109***	***0.192***	***0.193***	***0.207***	***0.238***	***0.117***	***0.194***	***0.199***	***0.198***
	(0.041)	(0.041)	(0.044)	(0.045)	(0.047)	(0.041)	(0.040)	(0.042)	(0.043)	(0.045)
Other Services	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

continued...

Table 10 continued	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
London	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rest of the Southeast	***-0.076***	-0.054	***-0.112***	***-0.112***	-0.038	**-0.077**	*-0.059*	***-0.103***	***-0.131***	-0.039
	(0.035)	(0.037)	(0.038)	(0.041)	(0.041)	(0.035)	(0.035)	(0.036)	(0.039)	(0.040)
Southwest	***-0.219***	***-0.141***	***-0.185***	***-0.151***	*-0.086*	***-0.219***	***-0.152***	***-0.188***	***-0.165***	**-0.097**
	(0.041)	(0.043)	(0.044)	(0.047)	(0.048)	(0.041)	(0.041)	(0.042)	(0.045)	(0.047)
Anglia & Midlands	***-0.251***	***-0.183***	***-0.217***	***-0.238***	***-0.172***	***-0.251***	***-0.195***	***-0.217***	***-0.248***	***-0.180***
	(0.035)	(0.037)	(0.038)	(0.041)	(0.040)	(0.035)	(0.035)	(0.036)	(0.039)	(0.039)
Northwest	***-0.218***	***-0.166***	***-0.229***	***-0.133***	-0.075	***-0.218***	***-0.191***	***-0.244***	***-0.155***	**-0.093**
	(0.040)	(0.042)	(0.043)	(0.046)	(0.047)	(0.040)	(0.040)	(0.041)	(0.044)	(0.045)
Rest of the North	***-0.208***	***-0.221***	***-0.163***	***-0.171***	***-0.151***	***-0.208***	***-0.231***	***-0.166***	***-0.184***	***-0.156***
	(0.036)	(0.038)	(0.040)	(0.043)	(0.043)	(0.036)	(0.037)	(0.038)	(0.041)	(0.042)
Wales	***-0.311***	***-0.225***	***-0.248***	***-0.164***	***-0.173***	***-0.311***	***-0.244***	***-0.252***	***-0.192***	***-0.185***
	(0.049)	(0.050)	(0.052)	(0.057)	(0.059)	(0.049)	(0.049)	(0.050)	(0.056)	(0.058)
Scotland	***-0.207***	***-0.162***	***-0.159***	***-0.140***	***-0.158***	***-0.207***	***-0.170***	***-0.161***	***-0.155***	***-0.166***
	(0.041)	(0.044)	(0.045)	(0.049)	(0.049)	(0.041)	(0.042)	(0.043)	(0.047)	(0.048)
Constant	***0.474***	***0.652***	***0.739***	***0.754***	***0.825***	***0.781***	***0.997***	***1.079***	***1.110***	***1.191***
	(0.075)	(0.096)	(0.093)	(0.096)	(0.096)	(0.073)	(0.091)	(0.084)	(0.089)	(0.091)

Note: Numbers shown in *italics* $p < 0.10$, **bold** $p < 0.05$, and ***bold-italics*** $p < 0.01$.

Table 11 BHPS women's wages regressed on personal and employment characteristics, job tenure and occupation score are adjusted for measurement error, standard errors shown in parentheses.

	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Job Tenure	-0.023	-0.177	0.196	-0.191	-0.051	-0.0314	-0.165	0.286	-0.197	-0.013
	(0.184)	(0.212)	(0.208)	(0.193)	(0.194)	(0.241)	(0.264)	(0.252)	(0.237)	(0.229)
Occupation Score	***0.929***	***1.069***	***1.021***	***1.050***	***0.991***	***1.079***	***1.214***	***1.126***	***1.186***	***1.109***
	(0.065)	(0.067)	(0.069)	(0.065)	(0.072)	(0.076)	(0.075)	(0.077)	(0.074)	(0.082)
Age	0.204	-0.141	0.081	-0.007	-0.238	*0.215*	-0.131	0.129	0.085	-0.174
	(0.129)	(0.165)	(0.154)	(0.158)	(0.165)	(0.129)	(0.160)	(0.143)	(0.151)	(0.157)
Degree+	***0.221***	***0.296***	***0.285***	***0.245***	***0.279***	***0.224***	***0.323***	***0.325***	***0.264***	***0.286***
	(0.036)	(0.037)	(0.038)	(0.035)	(0.039)	(0.036)	(0.035)	(0.036)	(0.034)	(0.037)
Other higher qualification	***0.187***	***0.165***	***0.162***	***0.109***	***0.131***	***0.190***	***0.182***	***0.169***	***0.113***	***0.135***
	(0.026)	(0.026)	(0.027)	(0.024)	(0.026)	(0.026)	(0.025)	(0.026)	(0.024)	(0.026)
A-levels, or equivalent	0.024	*0.059*	0.019	0.022	0.049	0.027	**0.073**	0.033	0.040	0.051
	(0.030)	(0.032)	(0.033)	(0.031)	(0.034)	(0.030)	(0.031)	(0.031)	(0.030)	(0.033)
Other qualifications	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
No qualifications	***-0.103***	***-0.078***	**-0.059**	*-0.051*	***-0.084***	***-0.101***	***-0.075***	***-0.080***	***-0.071***	***-0.104***
	(0.024)	(0.026)	(0.028)	(0.027)	(0.030)	(0.024)	(0.025)	(0.027)	(0.026)	(0.029)
Total lifetime months in employment	**0.025**	***0.061***	0.015	*0.029*	**0.039**	**0.025**	***0.061***	0.014	*0.023*	**0.037**
	(0.012)	(0.016)	(0.015)	(0.015)	(0.016)	(0.012)	(0.016)	(0.013)	(0.014)	(0.015)

continued...

Table 11 continued	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Part-Time	***0.080***	***0.090***	*0.042*	0.015	*0.041*	***0.079***	***0.102***	**0.047**	0.017	**0.046**
	(0.020)	(0.021)	(0.022)	(0.020)	(0.022)	(0.020)	(0.020)	(0.021)	(0.020)	(0.022)
%-male in occupation	***0.027***	***0.031***	***0.022***	***0.024***	***0.023***	***0.026***	***0.033***	***0.024***	***0.025***	***0.025***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Permanent Employee	**0.075**	0.048	**0.081**	0.009	**0.087**	***0.074***	0.056	***0.093***	0.026	**0.091**
	(0.031)	(0.035)	(0.036)	(0.036)	(0.038)	(0.031)	(0.034)	(0.035)	(0.035)	(0.037)
Supervisory Duties	***0.151***	***0.121***	***0.088***	***0.121***	***0.138***	***0.149***	***0.122***	***0.093***	***0.122***	***0.141***
	(0.020)	(0.021)	(0.022)	(0.021)	(0.023)	(0.020)	(0.021)	(0.021)	(0.020)	(0.022)
Unioned	***0.098***	***0.140***	***0.118***	***0.119***	***0.091***	***0.100***	***0.140***	***0.104***	***0.116***	***0.095***
	(0.021)	(0.022)	(0.023)	(0.022)	(0.024)	(0.021)	(0.021)	(0.022)	(0.021)	(0.023)
Private Sector	***-0.165***	***-0.160***	***-0.147***	***-0.091***	***-0.088***	***-0.161***	***-0.170***	***-0.161***	***-0.101***	***-0.102***
	(0.028)	(0.029)	(0.030)	(0.028)	(0.031)	(0.028)	(0.028)	(0.029)	(0.027)	(0.030)
1-9 employees	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10-49 employees	***0.169***	***0.134***	***0.112***	***0.155***	***0.188***	***0.169***	***0.145***	***0.113***	***0.153***	***0.196***
	(0.023)	(0.025)	(0.027)	(0.025)	(0.027)	(0.023)	(0.024)	(0.026)	(0.025)	(0.026)
50+ Employees	***0.232***	***0.199***	***0.162***	***0.216***	***0.283***	***0.234***	***0.207***	***0.163***	***0.220***	***0.288***
	(0.023)	(0.025)	(0.027)	(0.026)	(0.028)	(0.023)	(0.024)	(0.026)	(0.025)	(0.027)

continued...

Table 11 continued	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Agriculture, Forestry & Fishing	-0.104	0.090	-0.104	-0.009	0.015	-0.102	0.090	-0.105	-0.014	0.009
	(0.099)	(0.107)	(0.123)	(0.103)	(0.110)	(0.099)	(0.107)	(0.123)	(0.104)	(0.110)
Energy & Water Supplies	***0.377***	***0.305***	***0.388***	**0.235**	*0.235*	***0.377***	***0.283***	***0.408***	0.176	**0.252**
	(0.097)	(0.097)	(0.130)	(0.119)	(0.122)	(0.097)	(0.095)	(0.129)	(0.111)	(0.122)
Extraction, mining, etc.,...	***0.235***	**0.184**	***0.187***	0.020	*0.167*	***0.236***	**0.177**	***0.208***	0.036	0.129
	(0.065)	(0.076)	(0.070)	(0.076)	(0.087)	(0.065)	(0.072)	(0.068)	(0.075)	(0.084)
Metal Goods, Engineering & Vehicles	***0.215***	**0.120**	***0.189***	**0.103**	0.072	***0.215***	**0.120**	***0.197***	**0.111**	0.069
	(0.044)	(0.048)	(0.053)	(0.050)	(0.053)	(0.044)	(0.047)	(0.051)	(0.049)	(0.052)
Other Manufacturing	***0.110***	***0.130***	**0.093**	0.004	0.035	***0.110***	***0.119***	**0.100**	-0.001	0.027
	(0.038)	(0.042)	(0.045)	(0.042)	(0.047)	(0.038)	(0.040)	(0.042)	(0.041)	(0.045)
Construction	0.051	0.115	0.148	0.099	0.066	0.054	0.141	0.146	0.111	0.070
	(0.098)	(0.093)	(0.108)	(0.103)	(0.115)	(0.098)	(0.089)	(0.105)	(0.100)	(0.111)
Distribution, Hotels & Catering	-0.001	0.005	*-0.059*	***-0.086***	***-0.094***	-0.001	0.012	*-0.055*	***-0.076***	***-0.091***
	(0.029)	(0.030)	(0.032)	(0.030)	(0.033)	(0.029)	(0.029)	(0.031)	(0.029)	(0.032)
Transport & Communication	**0.111**	**0.122**	0.078	-0.042	**0.135**	**0.113**	***0.159***	*0.096*	-0.018	**0.134**
	(0.052)	(0.055)	(0.058)	(0.056)	(0.059)	(0.053)	(0.052)	(0.054)	(0.054)	(0.056)
Banking, Finance, Insurance, etc.,...	***0.203***	***0.215***	***0.135***	***0.121***	***0.116***	***0.204***	***0.221***	***0.152***	***0.129***	***0.120***
	(0.033)	(0.034)	(0.036)	(0.033)	(0.036)	(0.033)	(0.032)	(0.034)	(0.033)	(0.035)
Other Services	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

continued...

Table 11 continued	Unadjusted					Adjusted				
	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
London	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rest of the Southeast	***-0.114***	*-0.066*	***-0.128***	***-0.143***	***-0.103***	***-0.115***	**-0.079**	***-0.127***	***-0.147***	***-0.106***
	(0.032)	(0.034)	(0.036)	(0.033)	(0.037)	(0.032)	(0.032)	(0.034)	(0.033)	(0.036)
Southwest	***-0.232***	***-0.189***	***-0.186***	***-0.235***	***-0.211***	***-0.232***	***-0.203***	***-0.176***	***-0.237***	***-0.214***
	(0.040)	(0.041)	(0.044)	(0.041)	(0.045)	(0.040)	(0.040)	(0.042)	(0.040)	(0.044)
Anglia & Midlands	***-0.271***	***-0.218***	***-0.226***	***-0.219***	***-0.203***	***-0.272***	***-0.228***	***-0.219***	***-0.221***	***-0.194***
	(0.031)	(0.034)	(0.036)	(0.034)	(0.038)	(0.031)	(0.032)	(0.034)	(0.033)	(0.036)
Northwest	***-0.191***	***-0.196***	***-0.223***	***-0.200***	***-0.182***	***-0.192***	***-0.211***	***-0.221***	***-0.198***	***-0.173***
	(0.036)	(0.038)	(0.041)	(0.039)	(0.043)	(0.036)	(0.036)	(0.039)	(0.038)	(0.042)
Rest of the North	***-0.270***	***-0.229***	***-0.256***	***-0.269***	***-0.204***	***-0.270***	***-0.240***	***-0.240***	***-0.268***	***-0.205***
	(0.033)	(0.035)	(0.037)	(0.035)	(0.039)	(0.033)	(0.033)	(0.035)	(0.034)	(0.038)
Wales	***-0.237***	***-0.271***	***-0.253***	***-0.256***	-0.079	***-0.238***	***-0.285***	***-0.257***	***-0.267***	*-0.097*
	(0.046)	(0.047)	(0.055)	(0.050)	(0.055)	(0.046)	(0.046)	(0.052)	(0.048)	(0.053)
Scotland	***-0.152***	***-0.154***	***-0.122***	***-0.145***	**-0.110**	***-0.157***	***-0.169***	***-0.125***	***-0.157***	***-0.127***
	(0.036)	(0.040)	(0.042)	(0.038)	(0.043)	(0.036)	(0.037)	(0.039)	(0.038)	(0.041)
Constant	***0.804***	***0.825***	***0.906***	***0.972***	***0.905***	***1.145***	***1.196***	***1.263***	***1.322***	***1.253***
	(0.064)	(0.071)	(0.074)	(0.074)	(0.080)	(0.060)	(0.065)	(0.067)	(0.068)	(0.073)

Note: Numbers shown in *italics* p < 0.10, **bold** p < 0.05, and ***bold-italics*** p < 0.01.

Table 12 HILDA Survey men's wages regressed on personal and employment characteristics, job tenure and occupation score are adjusted for measurement error, standard errors shown in parentheses.

	Unadjusted					Adjusted				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
Job Tenure	0.126	0.096	0.052	-0.023	0.029	0.141	0.105	0.058	-0.017	0.037
	(0.147)	(0.154)	(0.151)	(0.128)	(0.119)	(0.162)	(0.171)	(0.165)	(0.141)	(0.13)
Occupation Tenure	***0.36***	*0.227*	0.095	***0.289***	0.131	***0.464***	*0.292*	0.121	***0.365***	0.163
	(0.113)	(0.119)	(0.129)	(0.104)	(0.089)	(0.146)	(0.153)	(0.165)	(0.133)	(0.112)
Occupation Score	***0.6***	***0.569***	***0.568***	***0.501***	***0.583***	***0.683***	***0.651***	***0.648***	***0.57***	***0.67***
	(0.047)	(0.054)	(0.046)	(0.049)	(0.051)	(0.053)	(0.061)	(0.053)	(0.056)	(0.058)
Age	2.131	1.481	-0.03	1.324	0.65	2.137	1.503	-0.03	1.32	0.627
	(1.861)	(1.588)	(1.525)	(1.516)	(1.368)	(1.86)	(1.589)	(1.525)	(1.515)	(1.366)
Age (squared)	-4.181	-2.66	-1.336	-2.795	-2.135	-4.19	-2.681	-1.336	-2.781	-2.09
	(2.444)	(1.96)	(1.871)	(1.898)	(1.612)	(2.443)	(1.961)	(1.871)	(1.897)	(1.61)
Foreign Born	**0.055**	-0.003	0.031	**0.054**	0.019	**0.055**	-0.003	0.031	**0.053**	0.019
	(0.019)	(0.019)	(0.018)	(0.02)	(0.024)	(0.019)	(0.019)	(0.018)	(0.02)	(0.024)
Degree+	***0.218***	***0.223***	***0.193***	***0.215***	***0.212***	***0.218***	***0.222***	***0.193***	***0.214***	***0.208***
	(0.033)	(0.034)	(0.037)	(0.034)	(0.033)	(0.033)	(0.034)	(0.037)	(0.034)	(0.033)
Vocational qualifications	**0.059**	***0.104***	***0.086***	***0.089***	***0.068***	**0.058**	***0.104***	***0.086***	***0.089***	***0.068***
	(0.023)	(0.023)	(0.021)	(0.022)	(0.023)	(0.023)	(0.023)	(0.021)	(0.022)	(0.023)
Year 12	**0.078**	**0.086**	***0.093***	***0.119***	***0.088***	**0.077**	**0.088**	***0.093***	***0.119***	***0.088***
	(0.031)	(0.034)	(0.031)	(0.033)	(0.031)	(0.031)	(0.034)	(0.031)	(0.033)	(0.031)
Year 11 or below	----	----	----	----	----	----	----	----	----	----
Lifetime years in emp'ment	*1.296*	1.132	***1.786***	**1.499**	***2.126***	*1.302*	1.132	***1.786***	**1.485**	***2.115***
	(0.777)	(0.74)	(0.681)	(0.698)	(0.642)	(0.777)	(0.741)	(0.681)	(0.696)	(0.642)
Lifetime years in emp'ment (squared)	0.211	-0.291	-0.849	-0.72	-1.654	0.204	-0.292	-0.849	-0.715	-1.668
	(1.844)	(1.577)	(1.414)	(1.505)	(1.267)	(1.843)	(1.578)	(1.414)	(1.501)	(1.266)

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Table 12 continued	Unadjusted					Adjusted				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
%-male in occupation	***1.962***	***1.509***	***1.546***	***1.976***	***2.214***	***1.971***	***1.515***	***1.545***	***1.965***	***2.242***
	(0.386)	(0.437)	(0.392)	(0.405)	(0.373)	(0.386)	(0.437)	(0.392)	(0.404)	(0.374)
Permanent employee	-0.012	-0.022	*-0.04*	0.009	**-0.051**	-0.011	-0.022	*-0.04*	0.008	**-0.048**
	(0.023)	(0.024)	(0.022)	(0.027)	(0.023)	(0.023)	(0.024)	(0.022)	(0.026)	(0.024)
Supervisory duties	***0.085***	***0.06***	***0.06***	***0.062***	***0.08***	***0.084***	***0.06***	***0.06***	***0.061***	***0.079***
	(0.019)	(0.019)	(0.018)	(0.019)	(0.017)	(0.019)	(0.019)	(0.018)	(0.019)	(0.017)
Unioned	***0.075***	***0.074***	***0.072***	***0.068***	***0.074***	***0.075***	***0.074***	***0.072***	***0.069***	***0.071***
	(0.02)	(0.021)	(0.019)	(0.02)	(0.017)	(0.02)	(0.021)	(0.019)	(0.02)	(0.017)
Private Sector	**0.075**	**0.061**	***0.064***	0.044	***0.095***	**0.075**	**0.061**	***0.064***	*0.046*	***0.092***
	(0.029)	(0.027)	(0.024)	(0.027)	(0.022)	(0.029)	(0.027)	(0.024)	(0.027)	(0.023)
1-19 employees	---	---	---	---	---	---	---	---	---	---
20-99 employees	**0.077**	***0.105***	***0.093***	***0.103***	**0.07**	**0.078**	***0.105***	***0.093***	***0.104***	**0.07**
	(0.032)	(0.029)	(0.032)	(0.03)	(0.028)	(0.032)	(0.029)	(0.032)	(0.03)	(0.028)
100+ employees	***0.207***	***0.21***	***0.212***	***0.224***	***0.218***	***0.207***	***0.211***	***0.212***	***0.223***	***0.218***
	(0.028)	(0.025)	(0.026)	(0.027)	(0.025)	(0.028)	(0.025)	(0.026)	(0.027)	(0.025)
Manufacturing, wholesale, transport	---	---	---	---	---	---	---	---	---	---
Primary, utilities, construction	***0.096***	***0.128***	***0.133***	***0.137***	***0.129***	***0.098***	***0.128***	***0.133***	***0.137***	***0.129***
	(0.026)	(0.028)	(0.03)	(0.028)	(0.025)	(0.026)	(0.028)	(0.03)	(0.028)	(0.025)
Retail	-0.04	***-0.134***	***-0.096***	-0.019	***-0.141***	-0.04	***-0.135***	***-0.096***	-0.019	***-0.141***
	(0.039)	(0.035)	(0.031)	(0.033)	(0.037)	(0.039)	(0.035)	(0.031)	(0.033)	(0.037)
Govt, health, education	***0.092***	**0.062**	***0.115***	***0.086***	***0.083***	***0.092***	**0.06**	***0.115***	***0.085***	**0.08**
	(0.032)	(0.027)	(0.026)	(0.028)	(0.026)	(0.032)	(0.027)	(0.026)	(0.028)	(0.026)
Other services	-0.012	-0.008	-0.001	0.023	-0.031	-0.012	-0.009	-0.001	0.023	-0.031
	(0.032)	(0.032)	(0.028)	(0.03)	(0.026)	(0.032)	(0.032)	(0.028)	(0.029)	(0.026)

continued…

Table 12 continued	Unadjusted					Adjusted				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
High growth states (Queensland & Western Australia)	**-0.044**	-0.023	-0.028	-0.023	-0.017	**-0.044**	-0.023	-0.028	-0.022	-0.017
	(0.021)	(0.02)	(0.019)	(0.018)	(0.017)	(0.021)	(0.02)	(0.019)	(0.018)	(0.017)
Major capital city	**0.048**	***0.072***	***0.055***	***0.066***	***0.057***	**0.047**	***0.071***	***0.055***	***0.065***	***0.058***
	(0.021)	(0.019)	(0.018)	(0.018)	(0.017)	(0.021)	(0.019)	(0.018)	(0.018)	(0.017)
Constant	***1.634***	***1.778***	***2.104***	***1.804***	***1.906***	***1.981***	***2.088***	***2.4***	***2.089***	***2.221***
	(0.296)	(0.253)	(0.247)	(0.25)	(0.23)	(0.296)	(0.257)	(0.249)	(0.253)	(0.232)

Note: Numbers shown in *italics* $p < 0.10$, **bold** $p < 0.05$, and ***bold-italics*** $p < 0.01$.

Table 13 HILDA Survey women's wages regressed on personal and employment characteristics, job tenure and occupation score are adjusted for measurement error, standard errors shown in parentheses.

	Unadjusted					Adjusted				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
Job Tenure	0.087	-0.17	0.126	0.1	0.091	0.1	-0.188	0.139	0.104	0.101
	(0.155)	(0.162)	(0.17)	(0.146)	(0.146)	(0.172)	(0.18)	(0.188)	(0.162)	(0.159)
Occupation Tenure	**0.27**	***0.316***	***0.311***	***0.266***	0.184	**0.347**	***0.409***	***0.397***	**0.334**	0.225
	(0.118)	(0.111)	(0.105)	(0.102)	(0.119)	(0.152)	(0.144)	(0.134)	(0.131)	(0.148)
Occupation Score	***0.613***	***0.627***	***0.638***	***0.53***	***0.673***	***0.679***	***0.698***	***0.71***	***0.595***	***0.751***
	(0.05)	(0.058)	(0.059)	(0.056)	(0.062)	(0.055)	(0.064)	(0.065)	(0.062)	(0.069)
Age	0.144	0.176	-0.225	-0.149	-1.529	0.16	0.176	-0.222	-0.227	-1.554
	(0.833)	(0.934)	(0.913)	(0.963)	(1.01)	(0.832)	(0.934)	(0.913)	(0.965)	(1.008)
Age (squared)	-0.531	0.017	0.038	-0.095	1.22	-0.55	0.017	0.035	-0.035	1.224
	(0.989)	(1.088)	(1.088)	(1.1)	(1.111)	(0.989)	(1.088)	(1.088)	(1.1)	(1.109)
Foreign Born	**0.039**	**0.044**	***0.059***	*0.037*	0.023	**0.039**	**0.044**	***0.059***	*0.039*	0.023
	(0.019)	(0.019)	(0.018)	(0.02)	(0.024)	(0.019)	(0.019)	(0.018)	(0.02)	(0.024)
Degree+	***0.097***	***0.11***	***0.122***	***0.147***	***0.086***	***0.098***	***0.11***	***0.122***	***0.148***	***0.084***
	(0.024)	(0.028)	(0.028)	(0.028)	(0.031)	(0.024)	(0.028)	(0.028)	(0.028)	(0.031)
Vocational qualifications	-0.01	0.007	0.021	*0.042*	-0.001	-0.009	0.007	0.021	**0.043**	-0.002
	(0.022)	(0.022)	(0.024)	(0.021)	(0.022)	(0.022)	(0.022)	(0.024)	(0.021)	(0.022)
Year 12	0.033	0.025	0.033	*0.049*	0.018	0.033	0.025	0.033	*0.051*	0.016
	(0.025)	(0.027)	(0.025)	(0.026)	(0.024)	(0.025)	(0.027)	(0.025)	(0.026)	(0.024)
Year 11 or below	----	----	----	----	----	----	----	----	----	----
Lifetime years in emp'ment	0.699	**1.011**	*0.935*	**1.365**	***2.095***	0.695	**1.011**	*0.941*	**1.405**	***2.129***
	(0.441)	(0.487)	(0.488)	(0.624)	(0.567)	(0.442)	(0.487)	(0.488)	(0.626)	(0.562)
Lifetime years in emp'ment (squared)	-1.287	**-2.346**	*-1.882*	**-2.663**	***-3.751***	-1.279	**-2.346**	*-1.892*	**-2.684**	***-3.78***
	(0.962)	(1.049)	(1.085)	(1.308)	(1.127)	(0.962)	(1.049)	(1.084)	(1.308)	(1.123)

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Table 13 continued	Unadjusted					Adjusted				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
%-male in occupation	-0.404	-0.026	0.205	0.513	0.119	-0.409	-0.026	0.198	0.468	0.124
	(0.421)	(0.42)	(0.383)	(0.42)	(0.445)	(0.421)	(0.42)	(0.382)	(0.423)	(0.445)
Permanent employee	0.02	0.014	-0.004	0.001	-0.01	0.019	0.014	-0.004	0	-0.01
	(0.02)	(0.019)	(0.018)	(0.019)	(0.02)	(0.02)	(0.019)	(0.018)	(0.02)	(0.02)
Supervisory duties	0.007	**0.034**	0.026	***0.047***	**0.042**	0.007	**0.034**	0.026	***0.047***	**0.042**
	(0.015)	(0.017)	(0.016)	(0.016)	(0.017)	(0.015)	(0.017)	(0.016)	(0.017)	(0.017)
Unioned	0.027	0.007	0.029	*0.032*	*0.031*	0.027	0.007	0.03	*0.032*	*0.031*
	(0.019)	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)	(0.018)	(0.019)	(0.019)	(0.019)
Private Sector	-0.01	-0.011	-0.002	-0.025	-0.016	-0.01	-0.011	-0.002	-0.024	-0.016
	(0.021)	(0.019)	(0.021)	(0.02)	(0.02)	(0.021)	(0.019)	(0.021)	(0.02)	(0.02)
1-19 employees	—-	—-	—-	—-	—-	—-	—-	—-	—-	—-
20-99 employees	0.015	0.021	0.001	-0.008	-0.004	0.017	0.021	0.002	-0.013	-0.003
	(0.025)	(0.03)	(0.022)	(0.028)	(0.03)	(0.025)	(0.03)	(0.022)	(0.028)	(0.029)
100+ employees	***0.081***	***0.077***	***0.054***	***0.065***	**0.059**	***0.081***	***0.077***	***0.055***	***0.065***	**0.06**
	(0.023)	(0.022)	(0.02)	(0.022)	(0.024)	(0.023)	(0.022)	(0.02)	(0.022)	(0.024)
Manufacturing, wholesale, transport	—-	—-	—-	—-	—-	—-	—-	—-	—-	—-
Primary, utilities, construction	0.023	0.061	-0.047	0.025	**0.119**	0.023	0.061	-0.047	0.03	**0.119**
	(0.043)	(0.061)	(0.048)	(0.044)	(0.052)	(0.043)	(0.061)	(0.048)	(0.044)	(0.052)
Retail	-0.017	***-0.081***	-0.042	*-0.063*	***-0.086***	-0.017	***-0.081***	-0.042	*-0.059*	***-0.086***
	(0.031)	(0.031)	(0.028)	(0.033)	(0.033)	(0.031)	(0.031)	(0.028)	(0.033)	(0.033)
Govt, health, education	**0.066**	***0.081***	0.034	**0.064**	0.019	**0.066**	***0.081***	0.034	**0.068**	0.018
	(0.028)	(0.029)	(0.029)	(0.03)	(0.033)	(0.028)	(0.029)	(0.029)	(0.03)	(0.033)
Other services	0.009	-0.006	-0.031	-0.025	-0.026	0.009	-0.006	-0.031	-0.021	-0.026
	(0.025)	(0.026)	(0.023)	(0.026)	(0.025)	(0.025)	(0.026)	(0.023)	(0.026)	(0.025)

continued…

Table 13 continued	Unadjusted					Adjusted				
	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
High growth states (Queensland & Western Australia)	***-0.054***	***-0.05***	**-0.04**	**-0.037**	*-0.031*	***-0.055***	***-0.05***	**-0.04**	**-0.036**	*-0.031*
	(0.018)	(0.016)	(0.016)	(0.018)	(0.017)	(0.018)	(0.016)	(0.016)	(0.018)	(0.017)
Major capital city	***0.065***	0.023	*0.029*	***0.056***	***0.054***	***0.064***	0.023	*0.029*	***0.054***	***0.054***
	(0.016)	(0.016)	(0.017)	(0.018)	(0.02)	(0.016)	(0.016)	(0.017)	(0.018)	(0.02)
Constant	***2.297***	***2.199***	***2.363***	***2.325***	***2.577***	***2.665***	***2.564***	***2.747***	***2.66***	***2.976***
	(0.151)	(0.167)	(0.166)	(0.171)	(0.187)	(0.152)	(0.169)	(0.165)	(0.165)	(0.18)

Note: Numbers shown in *italics* $p < 0.10$, **bold** $p < 0.05$, and ***bold-italics*** $p < 0.01$.