AUSTRALIAN JOURNAL OF LABOUR ECONOMICS
VOLUME 21 • NUMBER 2 • 2018

Labour Market Implications of Promoting Women's Participation in STEM in Australia

A. M. Dockery (Bankwest Curtin Economics Centre, Curtin University)
Sherry Bawa (School of Economics and Finance, Curtin University)

Abstract

It is commonly argued that maintaining and enhancing Australia's standard of living will require increasing the proportion of the population attaining university level qualifications in science, technology, engineering and mathematics (STEM). Accordingly, governments and universities have been proactive in encouraging women, who represent only around 30 per cent of Australians with STEM qualifications, to enter STEM courses. However, recent analyses of data from the Australian Graduate Survey found that female STEM graduates had relatively poor wage and job-match outcomes upon entering the labour market. This paper presents evidence on career outcomes for women with STEM degrees in Australia from Australian Bureau of Statistics Census data and panel data from the Household, Income and Labour Dynamics in Australia Survey (HILDA). The results provide further evidence that policies to promote female participation in STEM need to be accompanied by measures to address career barriers they face in the labour market. Women who gain STEM qualifications have lower labour market participation rates, higher unemployment rates, are relatively dissatisfied with their employment opportunities and with the extent to which their skills are utilised in their jobs compared to women with other tertiary qualifications. They also face a larger wage gap relative to men with equivalent qualifications.

Corresponding author: Associate Professor Mike Dockery, Principal Research Fellow, Bankwest Curtin Economics Centre, m.dockery@curtin.edu.au.

1. Introduction

It is commonly argued that maintaining and enhancing Australia's standard of living will require increasing the proportion of the population attaining university level qualifications (Dawkins, 1988; Bradley et al. 2008), with qualifications in science, technology, engineering and mathematics (STEM) seen as being of particular strategic importance for promoting competitiveness and productivity (Australian Industry Group, 2013; Office of the Chief Scientist, 2013). The 2008 *Review of Australian Higher Education* (the Bradley Review) identified the need to increase participation in higher education among a number of under-represented groups in order to sufficiently raise overall participation rates in higher education. Following recommendations from that Review, the government adopted targets to increase enrolment shares for a number of 'equity groups', including students from low socio-economic status backgrounds, Aboriginal and Torres Strait Islander Australians and people from rural and isolated regions. One of those equity groups for which participation is now monitored with a view to addressing their stark under-representation, is women studying in STEM courses. Women make up only around 30 per cent of Australians with STEM qualifications.

However, a recent analyses of data from the Australian Graduate Survey linked to university administrative records found that women who had graduated from STEM related courses earned markedly lower wages upon entry to the labour market compared to both female graduates from other fields and compared to male STEM graduates; and were much less likely than their male STEM graduates to report being in a job for which their STEM qualification was a pre-requisite (Li *et al*. 2017). These findings present a quandary for equity policy in higher education. On the one hand, it is seen as important to increase female participation in STEM courses to address occupational segregation by gender and to enhance Australia's STEM workforce. On the other hand, those same policies may be confining women to inferior labour market outcomes and limiting their career prospects. To inform policy in this area, there is a need for richer information on the labour market experiences of women who graduate from university with STEM qualifications.

This paper presents evidence on labour market and career outcomes for women with STEM degrees in Australia using two sources of data: Australian Bureau of Statistics Census data and the Household, Income and Labour Dynamics in Australia Survey (HILDA). The Census data provide near universal coverage of the Australian population, and is ideal for simple comparisons of those with and without STEM qualifications. HILDA has more limited sample sizes, but provides a longitudinal dimension and much richer data in terms of individual characteristics and outcomes. Census data are used to compare the employment status of university qualified women with STEM qualifications to other university qualified women, and to male university qualified graduates with and without STEM qualifications; and how these differentials have changed over time. Longitudinal data from the HILDA survey are now available for 16 years, spanning 2001 to 2016, and data on field of highest qualification was collected in expanded education modules contained in the Wave 12 and Wave 16 surveys, allowing us to identify people holding STEM qualifications in

2012 and 2016. We derive a panel dataset consisting of observations for which STEM status is known, comprised of intervals around 2012 and 2016 in which there is no change in the person's highest level of qualification or new qualifications completed at the degree or post-graduate level. This allows more detailed tests of the effect of gaining STEM qualifications on women's labour market outcomes.

2. Background

A range of interest groups have argued the need for Australia to increase the proportion of the workforce with qualifications in science, technology, engineering and mathematics (Australian Industry Group, 2013; Office of the Chief Scientist, 2013; PwC, 2015). A survey by the Australian Industry Group (2013) found that 75 per cent of the fastest growing occupations require STEM skills and knowledge and that industry experiences difficulty recruiting employees with STEM skills. The Office of the Chief Scientist (2012), argued that governments of other countries are focusing on increasing the supply of STEM graduates in response to the world's increasing dependence on knowledge and innovation. Compared to other OECD countries, it is observed that Australia is lagging behind on a number of key STEM indicators such as the number of enrolments of Year 12 students in mathematics and science and businesses struggling to find STEM qualified employees (Office of the Chief Scientist, 2012; PwC, 2015). Based on their own modelling, PwC claim that increasing Australia's STEM workforce to match that of other leading STEM countries would generate an additional $57 billion in GDP over 20 years.

According to a report by the Office of the Chief Scientist (2016), there were 2.3 million people with STEM qualifications in Australia, with men making up 84 per cent of that total. Healy, Mavromaras and Zhu (2011) define the STEM qualified population as those with a Bachelor Degree or higher qualification in the fields of Natural and Physical Sciences (NPS), Information Technology (IT) or Engineering and Related Technologies (ERT). By this definition they find that, in 2011, men represented 72 per cent of the STEM-qualified population and overall the STEM-qualified population corresponds to 20 per cent of the tertiary qualified Australian population. The percentage of the Australian population in STEM increases to 28 per cent if Agriculture, Environment and Related Studies is included in the above definition of STEM (Office of the Chief Scientist, 2016).

There is a stark under-representation of women in STEM fields of study and in the STEM workforce. If one accepts arguments of the imperative to expand STEM skills in the Australian labour market overall, it clearly follows that there is a concomitant need to increase female representation in STEM courses of study. Accordingly, encouraging female participation in STEM has been a government priority in recent years. One such investment was $54 million allocated in the 2012 Federal Budget to support Science, Mathematics and Engineering in response to the Office of the Chief Scientist report. Another $3.9 million was allocated for projects that encourage more women in STEM related studies in 2016 from a proposed total of $8 million for women in STEM under the National Innovation and Science Agenda.

Assessing a range of labour market indicators Healy *et al.* (2016) find mixed evidence of the presence of skills shortages in STEM, with the signs of shortages most acute in engineering. Norton (2016) argues that Australia actually has many more science graduates than the labour market can absorb in related jobs and that science graduates remain less likely than other STEM graduates to use their qualifications at work. The study finds that for science coursework graduates, 55 per cent reported a well-matched job in 2014, only slightly above the overall undergraduate rate. In 2015, just over half of science graduates worked in the same field as their degree, another 13 per cent of science graduates regarded their degree as relevant to their work, even though it is not directly in a science field (Norton 2016).

While it has been generally regarded as good policy to 'foster women in STEM', there has been only limited evidence on the labour market outcomes and experiences of women graduates in STEM - evidence that is needed to critically assess the efficacy of such policies. Encouraging women to enter STEM courses will only provide social benefits if those women subsequently become more productive than they would have otherwise been. Presumably, this would be reflected in higher rates of employment and earnings than women gaining qualifications in other fields of study. However, there are reasons to be concerned that this is not the case.

Women entering the STEM workforce face substantial challenges in their career paths ahead. Once in the workplace, pay, progression and job-security issues are barriers to women reaching the higher levels of STEM professions (Prinsley, Beavis and Clifford-Hordacre 2016). STEM qualifications appear to serve as a hedge against unemployment for men, but the reverse is true for women (Office of the Chief Scientist 2016). The *Women in the STEM professions survey report 2015* reveals that strategies to attract, retain and promote professional women may be hampered by cultural barriers, inflexible working practices, systemic bias in advancement strategies and inequities in remuneration (Professionals Australia 2015). The study notes that while women have made considerable inroads into STEM fields over the past three decades in particular, workplace practices have been slow to catch up. Hence there is a need to look at both sides of the coin, encouraging women to enter STEM education and occupations and also facilitating the male dominated STEM-based workplaces to be more equitable to women and more family friendly in order to fully engage women in STEM.

Daly, Lewis, Corliss and Heaslip (2015) provide estimates of the private rate of return to a degree in Australia across different disciplines based largely on 2006 census data on earnings and labour force status. Though the estimates are sensitive to assumptions used, they show a high rate of return for women from completing a university degree of 12 per cent, with similarly high rates for degrees in the fields of science (11 per cent), mathematics and statistics (12 per cent), IT (15 per cent) and engineering (14 per cent). More recently, Li *et al.* (2017) analysed linked data from university records and the Australian Graduate Survey from four Australian universities for graduates who completed bachelor's degrees between 2010 and 2014. They found that men and women who graduated from STEM courses had similar outcomes in terms of employment propensities, but overall they actually had inferior employment rates to non-STEM graduates. Alarmingly, female graduates from STEM courses were markedly less likely than their male counterparts to have secured jobs for which their STEM qualifications were important, and earned around 16 per cent lower salaries than women graduates from non-STEM courses.

Based on the 2011 ABS Census, the Office of the Chief Scientist (2016) noted that across all age groups, the unemployment rate for men with STEM qualifications was lower than for those with non-STEM qualifications, while the opposite was true for women. The unemployment rate among women with STEM-qualifications at the university level was 5.2 per cent compared to 3.5 per cent for men; and 6.3 per cent for STEM-qualified women with VET level qualifications, compared to 3.3 per cent for males (Office of the Chief Scientist 2016).

Prinsley *et al.* (2016) find that the gender pay gap in Professional, Scientific and Technical Services in Australia in 2016 was 23.5 per cent as against the national gender pay gap of 16.2 per cent. When comparing the percentage of STEM graduates in the highest income bracket, across all STEM fields as a total, 20 per cent of graduates reported an annual personal income in the highest bracket, but 32 per cent of men earn above $104,000 compared with just 12 per cent of women. Fewer women STEM graduates earn in the top bracket regardless of age, or whether their highest degree is a bachelor or PhD. The disparity is not accounted for by the percentage of women with children, or by the higher proportion of women who work part-time.

An element of the pay gap results from women tending to work in lower-paid professions, resulting in lower average wages for women. Nevertheless, the evidence suggests that as men move into traditionally female-dominated professions, men's salaries and status levels rise above that of women's. Prinsley *et al.* (2016) argue that women face significant attrition as they progress through their scientific careers. There are strong systemic deterrents to women in scientific research, including a lack of career prospects, job insecurity from short-term contracts, and the impact of leave and part-time work on their careers.

2.1 Women and the challenges of a male dominated STEM workforce

The Women in the STEM Professions Survey Report (Professionals Australia 2015) reports on issues relating to attracting, developing and retaining women in the STEM workforce. Based on a survey of their women members in 2015, the Professionals Australia report states that the three greatest barriers to women's career advancement are balancing work/life responsibilities, workplace culture and the lack of access to senior roles for women. Men appeared to receive significantly higher remuneration packages during the middle stages of their career than their female counterparts and women appeared to be disadvantaged at all levels. Women are more likely to be employed part-time than men across the STEM professions, with women with children less likely to be employed full-time than those without, which in turn has adverse impacts on promotion opportunities and career advancement. Unconscious bias on the part of employers appears to play a role in sidelining women who could otherwise be undertaking further training and professional development activities that would underpin career advancement.

Gendered access to part-time work arrangements was identified in the report as a significant issue, with women who work part-time concentrated in less senior roles and their skills underutilised. Many respondents commented that part-time or flexible work arrangements were only available in lower-paid, less senior roles. A lack of role models and lack of access to senior roles for women were reported by respondents as detrimentally impacting their career advancement. According to the study, 37.9 per cent of respondents (who are all female) said they felt like they had to "become one of the boys" if they wanted to "fit into" their workplace; 55.5 per cent agreed or strongly agreed that in their occupation, women have to prove themselves, where men are assumed to be capable. The study finds that 51.6 per cent of respondents reported having been directly discriminated against during the course of their employment (78.8 per cent of these on the basis of gender); 25.8 per cent of respondents reported that they had been subject to sexual harassment and 42.1 per cent to bullying in the course of their employment (Professionals Australia 2015).

According to the study as long as flexibility and work/life balance provisions operate to entrench systemic bias, and while workplace culture continues to affect employees' ability to access these core working conditions, the types of cultural problems highlighted by respondents to the survey will continue to undermine the attraction and retention of women in STEM professions (Professionals Australia 2015).

International evidence on the causes and consequences of gender bias in STEM is mixed. Ceci, Ginther, Kahn and Williams' (2014) synthesis of the literature dismisses hypotheses of biological differences between the genders in terms of abilities in mathematical or spatial reasoning. Rather, gender differences in attitudes about careers and abilities, forming from early childhood, reduce the likelihood of women entering mathematics intensive fields. Ceci *et al.* (2014) note that women are well represented in science fields such as psychology and the life sciences, but underrepresented in maths-intensive fields, suggesting relative female preferences for fields involving 'living things', and relative male preferences for fields involving symbol manipulation influence occupational outcomes.

Numerous studies highlight the potential problems women face in male dominated STEM occupations. In the US, for example, Williams *et al.* (2014) find that 34.5 per cent of women working in science had reported sexual harassment. Scientists conducting fieldwork were at even greater risk, with two-thirds (64 per cent) of researchers surveyed internationally experiencing sexual harassment, mostly at the hands of a senior researcher. Women were 3.5 times more likely than men to report being subject to sexual harassment. Ceci *et al.* suggest that arguments that discrimination and lack of career opportunities in STEM is a major cause of female under-representation must be tempered by the observation that women's career outcomes appear to be relatively better in those science fields in which they are in shortest supply (2014: 125), although this conclusion is based primarily on US evidence relating to academic careers in the sciences. They also acknowledge a potential role of the effects of child-bearing and preferences for part-time work in limiting career prospects for women in male dominated fields.

3. Broad trends: Evidence from the Census

This section provides an update on some of those previous studies by presenting recently released data from the 2016 ABS Census. Comparisons are made to 2006 Census data to give an indication of longer term trends in the STEM workforce. The Census records individuals' highest level of non-school qualification and the field of study of that qualification based on the 2001 Australian Standard Classification of Education (see ABS 2001 and Table 3 below). Following Healy *et al*. (2011) and others, we define the STEM qualified population as those with a Bachelor Degree or higher qualification in the fields of Natural and Physical Sciences (NPS), Information Technology (IT) or Engineering and Related Technologies (ERT). Table 1 shows the number of STEM qualified persons by gender in 2006 and 2016. Overall the number of graduates with STEM as their field of highest qualification increased from 497,000 persons in 2006 to 844,500 in 2016. This represents an increase of 69.8 per cent over the 10 years, marginally greater than the 68.1 per cent increase in the number of graduates in other fields. Consequently the proportion of tertiary qualified persons with STEM qualifications rose from 20.0 per cent in 2006 to 20.2 per cent in 2016.

Women are well represented among people with NPS qualifications, but comprise just 26.2 per cent and 16.1 per cent of people with IT and engineering and related qualifications, respectively. The share of women in each of these fields increased between 2006 and 2016, but only marginally in the case of IT. On a proportionate basis, growth was highest for women in ERT, increasing 134 per cent and leading to the female share in ERT expanding from 12.3 per cent in 2006 to 16.1 per cent in the latest Census.

The labour force status of men and women conditional upon STEM status is shown in Table 2. Women with STEM qualifications had a marginally lower labour force participation rate than other tertiary qualified women in both 2006 and 2016. In contrast STEM qualified men had almost the same participation rate as men with non-STEM qualifications in 2006, but by 2016 a gap of 3.3 percentage points had emerged in favour of STEM qualified men. While the IT qualified workforce has relatively high participation rates for women, it also displays the greatest gender gap in participation rates. That gap grew from 9.9 percentage points in 2006 to 13.1 percentage points in 2016.

In terms of unemployment rates, STEM qualifications are associated with more favourable outcomes for men relative to non-STEM qualified men, but the reverse is true for women. As noted, this was also the case with participation rates. Between 2006 and 2016 the unemployment rate increased more for persons with non-STEM degrees than for STEM qualified persons. However, a gap in unemployment rates persisted in the two censuses in which women with STEM qualifications have a higher unemployment rate than men with STEM qualifications. This applied in each of the three sub-fields of study, but is most pronounced for those with IT qualifications. Furthermore, those gender gaps widened in all three fields to be quite substantial in 2016: the female unemployment rate in IT was 2.3 percentage points above the male rate of 3.9 per cent; and for those with qualifications in an engineering and related field, the female unemployment was 2.9 percentage points above the male rate of 3.2 per cent.

Table 1: The Australian STEM population by gender: 2006 and 2016, ABS Census.

	2006				*2016*			
	Male	*Female*	*Total*	*% Female*	*Male*	*Female*	*Total*	*% Female*
Natural & physical sciences	104,034	84,866	188,900	44.9%	146,587	138,283	284,870	48.5%
Information technology	88,055	29,123	117,178	24.9%	161,741	57,365	219,106	26.2%
Engineering & related Tech.	167,674	23,498	191,172	12.3%	285,577	54,954	340,531	16.1%
STEM	359,763	137,487	497,250	27.6%	593,905	250,602	844,507	29.7%
Other fields[a]	786,979	1,198,060	1,985,039	60.4%	1,255,673	2,081,218	3,336,891	62.4%
All graduates	1,146,742	1,335,547	2,482,289	53.8%	1,849,578	2,331,820	4,181,398	55.8%
STEM share all graduates	31.4%	10.3%	20.0%		32.1%	10.7%	20.2%	

Notes: a. includes field of study inadequately described and not stated.

These differences in the incidence of unemployment are even more significant in light of women already having lower participation rates and the fact that within the non-STEM labour force women have lower unemployment rates than men.

Table 2: Labour force Status – STEM and non-STEM qualified persons, 2006 and 2016 Census

	NPS	*IT*	*ERT*	*STEM*	*non-STEM*
2006 Census					
Participation rate					
Men	82.6%	93.4%	86.1%	86.9%	87.0%
Women	77.9%	83.6%	79.7%	79.4%	80.3%
Unemployment rate					
Men	3.04%	4.18%	2.63%	3.15%	2.66%
Women	3.38%	4.80%	4.91%	3.96%	2.53%
2016 Census					
Participation rate					
Men	80.2%	93.4%	85.8%	86.2%	82.9%
Women	76.4%	80.3%	78.5%	77.7%	78.6%
Unemployment rate					
Men	3.63%	3.92%	3.16%	3.49%	4.70%
Women	4.28%	6.22%	6.02%	5.06%	4.13%

4. STEM and women's labour market outcomes: evidence from HILDA

4.1 The data

HILDA is a panel survey of individuals from a representative sample of private households (see Watson and Wooden 2010). Within selected households all occupants aged 15 and over are surveyed annually. Around 13,000 individuals from over 7,000 households have responded in each year, with year-on-year attrition rates averaging below 10 per cent. In 2011 an additional top-up sample of 2,153 households encompassing 4,009 responding individuals was recruited to the survey sample (HILDA Survey Annual Report 2012). The HILDA survey collects extensive information about economic outcomes; labour market experience and history; family and household formation; subjective well-being and other attitudinal data.[1]

In addition to core data items collected annually, the HILDA questionnaires have included a series of 'major modules' on wealth, retirement, fertility, health and education that are repeated roughly every four years on a rotating basis. The education module, first included in 2012 and repeated in 2016, collects more detailed information from individuals with post-school qualifications, including the field of study and the institution from which those qualifications were gained (see Wilkins 2015).

1 See http://melbourneinstitute.unimelb.edu.au/hilda for further details on the HILDA survey.

For the purposes of this study we restrict the sample to persons who held a bachelor degree or higher qualification. In the first wave of HILDA, and for each new person who enters the survey, respondents are asked their highest level of qualification attained. In each survey in subsequent years they are asked about any courses they have successfully completed and the associated level of qualification obtained. As noted, more detailed information on qualifications obtained was collected in Waves 12 and 16. From this information a derived variable is generated for every year indicating the respondents' highest education level achieved.

Hence it is straightforward to identify, in each year, persons with a bachelor degree or higher qualification. For this study we also need to establish whether an individuals' highest qualification is in a STEM field. Field of highest post-school qualification is collected only in Wave 12 (2012) and Wave 16 (2016). Table 3, based on the Wave 16 data, shows population estimates for the number of persons and gender breakdown by the field of study categories available in HILDA. Within this classification, and consistent with studies cited above, we define STEM fields as including natural and physical sciences, information technology and engineering and related technologies. The HILDA estimates indicate that women make up more than half of the overall population with university and higher qualifications (54.3 per cent). Slightly more men have qualifications in the natural and physical sciences, but it is information technology and engineering and related qualifications that are most male dominated (with 32.0 per cent and just 14.4 per cent female representation respectively). These population estimates derived from the HILDA data and survey weights closely align with Census estimates.

Table 3: Persons with bachelor degree or higher: field of study by gender, 2016

Field of study	*Persons*	*Male (%)*	*Female (%)*
Natural and physical sciences	264,540	53.5	46.5
Information technology	260,011	68.0	32.0
Engineering and related technologies	401,248	85.6	14.4
Architecture and building	100,820	71.0	29.0
Agriculture, environment and related studies	105,459	62.9	37.1
Medicine	157,939	53.6	46.4
Nursing	350,809	8.7	91.3
Other health-related	317,485	28.6	71.4
Education	765,976	28.6	71.4
Management and commerce	1,029,647	55.7	44.3
Law	173,621	56.2	43.8
Society and culture	630,985	31.1	68.9
Creative arts	186,242	41.1	58.9
Food, hospitality and personal services	43,738	51.1	48.9
Other	70,400	38.7	61.3
Total	4,858,920	45.7	54.3

Notes: frequencies calculated using HILDA person weights.

The construction of the panel dataset is best described by way of an example. Persons with a bachelor degree or higher are classified into one of three levels of qualification: bachelor or honours; graduate diploma or graduate certificate; or post-graduate (masters or doctorate). Consider a respondent observed in Wave 12 to have a graduate diploma/certificate in a STEM field. If in Wave 11 their highest level of qualification is also graduate diploma/certificate *and* in Wave 12 they do not report having completed any course with a qualification at that level or above in the past year, then we can assume that the highest qualification held in Wave 11 is the same one as that reported in Wave 12. If they also report the same level of qualification in Wave 10 *and* in Wave 11 do not report having completed a course at the graduate diploma/ certificate level or above in the past year, then we can infer that the same STEM qualification was held in Wave 10. Hence it is possible to work backwards from Wave 12 to identify the period in which the same qualification is held. Where there is any change in the level of qualification or an equivalent qualification is completed in the following year, that and all prior observations are dropped for that individual, since the field of that qualification is indeterminable. In this way, we can identify an interval leading up to 2012 during which the individual held the same highest qualification and whether it is in a STEM or non-STEM field.

STEM status is also known for Wave 2016. For Waves 13 to 15 it is possible to follow the same approach working forwards from Wave 12 or backwards from Wave 16 to define intervals with the individual's qualification unchanged. It is useful to draw on both checkpoints since some people leave the survey in Waves 14 and 15, meaning only the Wave 12 reference qualification can be used; while others enter the survey or gain university qualifications after Wave 12, so that the Wave 16 reference qualification must be used. This process yielded a panel with a total of 41,237 pooled observations on 4,993 individuals for which field of study is determined. Slightly fewer observations are available for much of the analysis conducted below due to missing observations on other variables included in the modelling, particularly given our focus on employed persons. Table 4 shows the (unweighted) number of persons in the sample in each wave by STEM status and gender. The sample numbers are much lower in the early waves due to the longer time between the survey and the reference point (2012) at which STEM status can be observed. In total there are 2,037 observations on 265 women with STEM qualifications and 5,348 observations on 634 men with their highest qualification in a STEM field.

Table 4: Graduates with field of study of highest qualifications determined, HILDA sample by Wave (unweighted)

	Observations (persons)			*Female share (%)*		
Wave	*STEM*	*Non-STEM*	*Total*	*STEM*	*Non-STEM*	*Total*
1 (2001)	218	952	1170	22.5	62.1	54.7
2 (2002)	233	1022	1255	24.0	61.8	54.8
3 (2003)	258	1104	1362	25.2	61.8	54.8
4 (2004)	284	1202	1486	24.3	61.9	54.7
5 (2005)	307	1331	1638	24.4	62.0	54.9
6 (2006)	319	1370	1689	25.4	62.4	55.4
7 (2007)	355	1550	1905	25.6	62.6	55.7
8 (2008)	379	1673	2052	26.4	61.9	55.4
9 (2009)	417	1829	2246	26.6	61.5	55.0
10 (2010)	444	2000	2444	27.7	62.3	56.0
11 (2011)	660	2899	3559	28.8	62.5	56.2
12 (2012)	715	3275	3990	28.7	62.5	56.4
13 (2013)	685	3238	3923	28.8	62.2	56.3
14 (2014)	669	3313	3982	28.8	62.4	56.8
15 (2015)	698	3438	4136	29.2	62.7	57.1
16 (2016)	744	3656	4400	30.6	63.0	57.5
Pooled	7385	33852	41237	27.6	62.3	56.1

4.2 Some descriptive statistics

To assess the benefits women derive from gaining STEM qualifications, relative to university qualifications in other fields, we use the HILDA data to look at labour force status and a range of subjective assessments relating to individuals' satisfaction with various aspects of their jobs. Table 5 presents averages for selected data from the HILDA data pooled from Waves 1 to 16. Of those observations on university qualified people for whom field of study could be determined, people with STEM qualifications had marginally lower participation rates and a smaller percentage of those employed worked on a part-time basis. This holds from both males and females. However, the unemployment rate for women with STEM qualifications was significantly higher than for other university qualified women, consistent with Census data presented above. This did not apply for men, for whom the unemployment rate was the same for both groups

In terms of hourly wages, the average for STEM qualified women was slightly lower than that for other women, but the difference is not statistically significant. As expected, given the overall gender pay gap in Australia, women with STEM qualifications earned significantly less than males with STEM qualifications. For men, however, STEM qualifications are associated with higher hourly earnings compared to men with qualifications in non-STEM fields. Thus the gender wage gap is observed to be larger among workers with STEM qualifications. Wages of women with STEM qualifications were 79.1 per cent of those of their male counterparts, but among those with non-STEM qualifications women's hourly wages are 86.3 per cent of male wages.

Table 5: Labour market outcomes: means for graduates with and without STEM qualifications, by gender, HILDA 2001-2016.

	Females			*Males*		
	STEM	*non-STEM*	*All*	*STEM*	*Non-STEM*	*All*
Labour force status:						
Participation rate	76.8%#†	79.5%	79.2%	83.2%	85.7%	84.9%
% of workers part-time	36.7%#†	39.8%	39.5%	11.1%	14.3%	13.4%
Unemployment rate	3.0%#	1.9%	2.0%	2.5%	2.5%	2.5%
Real hourly wages (in $2016)	$39.08†	$39.70	$39.65	$49.42	$46.00	$47.00
Satisfaction with [0-10]						
Employment opportunities[a]	6.93#†	7.50	7.45	7.39	7.52	7.52
Total pay[b]	7.20	7.15	7.16	7.27	7.20	7.20
Job security[b]	7.50#†	7.96	7.92	7.72	7.90	7.90
The work itself (what you do)[b]	7.47#†	7.70	7.68	7.61	7.66	7.66
The hours you work[b]	7.37#†	7.21	7.22	7.19	7.17	7.17
Work/non-work flexibility[b]	7.83#†	7.35	7.39	7.70	7.53	7.53
Overall job satisfaction[b]	7.51#	7.63	7.62	7.57	7.60	7.60
I use many of my skills & abilities[b] [1-7]	5.38#†	5.74	5.71	5.58	5.62	5.61

Note: a. assessed by all persons; b. assessed by employed persons only. # indicates the figure is significantly different to that for females with non-STEM qualifications at the 5% level by the standard t-test; † indicates the figure is significantly different to that for males with STEM qualifications.

In terms of subjective assessments, we report results for satisfaction assessed on an 11-point scale ranging from 0 (totally dissatisfied) to 10 (totally satisfied) and whether workers feel their skills and abilities are well utilised in their work on a 7-point scale (1=strongly disagree, 7= strongly agree). STEM qualified women are substantially less satisfied with their employment opportunities compared to other university qualified women. Among those who are in employment, they are also significantly less satisfied with their job security, and the nature of the work they do, and feel their skills and abilities are less well utilised. However, STEM qualified women are more satisfied with the hours they work and the flexibility their job provides to balance work and non-work commitments. All this contributes to STEM qualified women reporting lower overall job satisfaction than those with non-STEM qualifications. For men those same differences between STEM qualified and other workers apply in terms of their relative direction, but the gaps are far smaller in each case.

4.3 The pay-off to STEM qualifications: Multivariate analyses

To more rigorously control for differences in the characteristics of STEM and non-STEM qualified men and women, a series of multivariate models are estimated. Binary logit models are estimated for the probability of participating in the labour force, and for the probability of being unemployed, conditional upon participating. Wages are modelled using a standard Mincerean wages equation with the log of real hourly wages as the dependent variable. Ordered probit models are estimated for each of the satisfaction ratings reported in Table 5. Conditional upon the explanatory variables, these models estimate the probability of the individual reporting a higher rather than lower satisfaction rating of the job attribute (or stronger agreement in the case of use of skills and abilities). In each case the models are random-effect panel models, taking into account the fact that we have repeat observations on individuals.

The models for labour force participation are estimated separately by gender because of the well-known differential effects of family circumstances on men's and women's participation. In all other models we include dummy variables indicating whether the respondent is female and whether they have STEM qualifications, plus a *Female*STEM* interaction term. Under this specification, the coefficient on STEM approximates the independent effect of holding a STEM related qualification on the outcome for men, and the coefficient on the *Female*STEM* interaction term captures any additional effect of holding STEM qualifications for women. All models are estimated as random effects panel models which account for unobservable individual effects. Fixed effects models, which control more rigorously for unobservable individual effects, are not used in this instance because of the very limited variation in the key variable of interest at the individual level, namely the field of study of highest qualification.[2]

We include controls for basic demographic characteristics, including age[3], marital status, presence of dependent children, the presence of a long-term health condition and migrant/English language background. Controlling for age is particularly important, because the push for more women to enter 'non-traditional' STEM fields is likely to mean that the female STEM workforce is made up of a disproportionate number or younger and more recent graduates. Indeed, in our pooled sample, the mean age of women with STEM qualifications is 41.9 years compared to 43.8 years for other university qualified women. The age difference between STEM and non-STEM qualified males is more marginal, at 45.8 years compared to 46.2 years. By definition all individuals included in the sample report having a university degree. We include additional dummy variables capturing highest level of qualification (graduate certificate/diploma or masters/doctorate).

2 Estimation of the effect of STEM in the fixed effects models would be based only on those individuals for whom there is a change in the value of STEM, and thus a change in the field of their highest qualification.

3 Models for participation are restricted to persons aged 69 years and under. Models for unemployment relate only those participating in the labour market, who range in age from 18 to 89 years. With the exception of satisfaction with employment opportunities, all other 'satisfaction' variables are defined only for employed graduates, for whom ages range from 18 to 89 years.

An extremely rich set of potential covariates is available in HILDA relating to individuals' labour market history, characteristics of their job and of their workplaces. We opt for a reduced form approach because we are primarily interested in net outcomes for women who gained STEM qualifications. For example, it is possible to include previous time out of the workforce as an independent variable in the model of employment and wages; and to include wages, hours of work or contract status as independent variables in the various models of satisfaction. However, each of these covariates may themselves be influenced by STEM status. The addition of such covariates would be useful for exploring the source of differences in outcomes for women with and without STEM qualifications, but our concern here is to establish whether or not such differences exist in the first place. We leave more detailed decompositions of those differences - if identified - to future research. For models estimated on the sample of employed persons we add controls for sector (private, government business enterprise, public and not-for-profit), workplace size and the respondent's geographical location (major city, inner regional or outer regional).

Full regression results are included in the tables in the appendix, and here we summarise the results by presenting coefficients relating to gender and holding of STEM qualifications (see Table 6). As noted, the models of labour force participation are estimated separately for males and females. We also restrict the sample to persons aged 69 and under for these models. For both genders, holding STEM related qualifications is associated with a lower probability of participation in the labour force relative to persons holding non-STEM qualifications (see Appendix Table A1). For females the coefficient (β) is -0.367 and significant at the 10 per cent level (p=0.08). The estimated negative effect is larger for males and significant at the 5 per cent level (β=-0.468, p=0.05), however a formal test indicates that we cannot reject the null hypothesis that the true effect for women is equivalent to that for men (chi-square=0.63).

Results from the model for the probability of being unemployed, conditional upon participation in the labour market, indicate that women university graduates are significantly less likely than male graduates to be unemployed. Estimated odds ratios suggest women are around 25 per cent less likely to be in unemployment (p=0.07), presumably reflecting women being more likely to leave the labour force when out of work. Holding STEM qualifications has no significant effect on the chance of being unemployed for men. The result for the female*STEM interaction term implies a substantial 46 per cent increase in the probability of being unemployed associated with holding a STEM qualification for women, but we cannot reject the hypothesis of no effect (p=0.30).

Table 6: Summary of coefficients for female and STEM variables, panel models, HILDA Waves 1-16.

Sample	*Males and females*						*Females only*	
Independent. var	*Female*		*STEM*		*Female*STEM*		*STEM*	
Model/Dep var.	β	P>z	β	P>z	β	P>z	β	P>z
Binary logit								
Participation[a]	n.a.		n.a.		n.a.		-0.37*	0.08
Unemployment	-0.28*	0.07	-0.03	0.87	0.38	0.30	0.33	0.28
OLS								
Real hourly wages	-0.11***	0.00	0.09***	0.00	-0.09**	0.02	0.00	1.00
Ordered probit (Satisfaction with …)								
Emp. opportunities	0.00	0.90	-0.04	0.48	-0.18*	0.06	-0.21***	0.00
Total pay	0.02	0.59	0.08*	0.10	0.09	0.32	0.18**	0.02
Job security	0.00	0.98	-0.05	0.39	-0.04	0.69	-0.10	0.23
The work itself	0.06*	0.07	0.03	0.60	-0.10	0.22	-0.09	0.19
Hours worked	0.05	0.17	0.09**	0.04	0.18**	0.04	0.24***	0.00
Flexibility	-0.02	0.62	0.12**	0.01	0.15	0.11	0.24***	0.00
Job overall	0.06	0.10	0.05	0.28	0.00	0.96	0.03	0.70
(disagree/agree…)								
Uses skills/abilities	0.16***	0.00	0.06	0.28	-0.34***	0.00	-0.27***	0.00

Note: ***, * *and * indicate the estimated coefficient is significantly different from zero at the 1, 5 and 10 per cent levels, respectively; a. sample restricted to persons aged 69 and under.

In the wages equation the dependent variable is the log of real hourly wages[4], so the coefficients approximate the percentage change in wages associated with a one unit change in the independent variable. In this sample of university qualified workers, women are observed to earn around 11 per cent lower hourly wages than men (β=-0.11, p=0.00). Having your highest qualification in a STEM related field is associated with 9 per cent higher earnings, but this is exactly offset by a 9 per cent wage penalty if those STEM qualifications are held by a women. Hence, after controlling for basic demographics and job characteristics, women with a STEM qualification face a gender wage gap of around 20 per cent. Restricting the sample to women only, there is no difference in hourly earnings between STEM qualified women and other female graduates: the STEM 'penalty' is a penalty relative to men with those qualifications, rather than relative to other women.

To further explore sources of differences in wages earned by STEM-qualified women relative to other female graduates and relative to STEM-qualified men, Blinder-Oaxaca decompositions were conducted. Consider a linear regression of the log of wages (Y) of the form: $Y_\rho = \beta_\rho X'_\rho + \varepsilon_\rho$ for two different groups (ρ=group A or group B), where *X'* is a vector of observed characteristics with associated vector of estimated coefficients β and ε a standard error term. The difference in mean (log) wages between

4 Hourly wages are calculated as weekly earnings in main job divided by hours usually worked per week, and indexed by the consumer price index to be expressed in 2016 dollars.

group A and group B can be decomposed into components associated with differences in observed characteristics (differences in the *X'*s) and differences in the returns to those characteristics (differences in the β's).[5] The wage equations above revealed no statistically significant difference between the hourly earnings of female graduates with STEM qualifications and female graduates with non-STEM qualifications. The Blinder-Oaxaca decomposition of differences in hourly earnings for women with STEM and non-STEM qualifications confirms that differences attributable both to characteristics and to estimated coefficients are insignificantly different from zero. Within the STEM qualified workforce, the decomposition analysis shows a 20 per cent wage penalty for women. The wage gap attributable to differences in observable characteristics, at 3.8 percentage points, is not significantly different to zero. In contrast, differences in coefficients account for 15.4 percentage points of that wage gap (p=0.00). Given the sample numbers the estimated contributions for individual variables are imprecise, but the results suggest that both differences in age profiles by gender and the return to age are important. For males with STEM qualifications, wages increase by an estimated 5.7 per cent per year, compared to just 4.1 per cent for women, suggesting lower returns to experience and more limited career progression for women.[6] More career interruptions and greater time spent in part-time work for women may also contribute to this result.

Surprisingly, given the estimated gender wage gap within the STEM workforce, there is evidence from the model of workers' satisfaction with their pay that women with STEM qualifications are more satisfied with their pay than other female workers. Results from the models including the interaction term suggest this arises from a combination of higher pay satisfaction for STEM qualified workers overall, and higher satisfaction again for women with STEM qualifications.

Several other results stand out in the 'satisfaction' models. Each year respondents to the HILDA Person Questionnaire are asked their satisfaction with a range of aspects of their lives, of which one is 'Your employment opportunities'. STEM-qualified women are less satisfied with their employment opportunities than both STEM-qualified males and women with qualifications in other fields. The effect is only marginally significant in the model estimated across males and females (p=0.06), but highly significant and of some magnitude in the model estimated for females only.

The observations above that STEM qualified women are markedly less likely to feel their skills and abilities are well utilised in their jobs persists in the multivariate models. Typically women tend to agree more strongly than men with the statement 'I

---

5 To be complete, there is a further component associated with the interaction between the differences in X's and differences in the β's. The decompositions are conducted using STATA's 'oaxaca' command with standard errors clustered at the individual level to account for the panel dimension of the data. Details can be found in Jann (2008). In the two decompositions reported here we use the coefficients for females with non-STEM qualifications, and for males with STEM qualifications, as the base or 'non-discriminatory' coefficients, as those are the majority groups in the relevant comparisons.

6 These estimates are direct effects of age (in years) and do not take into account the second order (age-squared) effects. The total effect is contingent upon the point in the age distribution at which it is evaluated. The decomposition shows a very large contribution from the lower return to years of age for women, but the effect is not significantly different to zero (p=0.36).

use many of my skills and abilities in my current job'. However, the opposite applies for women with STEM qualifications. No such evidence of skill under-utilisation is evident for male workers with STEM qualifications.

Generally workers with STEM qualifications are more satisfied with their hours and flexibility to balance work and non-work commitments, and this reflects both a general association that applies to men and women, plus added satisfaction for STEM qualified women.

Given Li *et al.*'s (2017) findings of inferior outcomes for recent graduates from STEM courses, we re-estimated the models with the sample restricted to persons aged 40 and under. This reduced sample included just under half (48 per cent) of the observations on employed persons, and the lower sample size will reduce the power of the models for making statistical inferences, including with respect to the minority of women with STEM qualifications. As can be seen in Table 7, the results are very similar for the younger cohort as for the overall sample. The lower labour force participation for women with STEM degrees is less pronounced and becomes insignificant (β=-0.29; p=0.21), though this may reflect the smaller sample size. However, the wage penalty associated with the female*STEM interaction term is more pronounced for the younger cohort (β=-0.15; p=0.00). With a STEM wage premium estimated at 10 per cent (p=0.00), the implied gender wage gap widens to 25 per cent among younger STEM qualified workers. The result pertaining to perceptions of skill utilisation holds for the younger cohort.

Table 7: Summary of coefficients for female and STEM variables, persons aged 40 and under

Sample	*Males and females*						*Females only*	
Independent. var	*Female*		*STEM*		*Female*STEM*		*STEM*	
Model/Dep var.	β	P>z	β	P>z	β	P>z	β	P>z
Binary logit								
Participation[a]	n.a.		n.a.		n.a.		-0.29	0.21
Unemployment	-0.18	0.31	-0.22	0.38	0.44	0.29	0.21	0.54
OLS								
Real hourly wages	-0.07***	0.00	0.10***	0.00	-0.15***	0.00	-0.04	0.24
Ordered probit (Satisfaction with …)								
Emp. opportunities	-0.01	0.82	-0.07	0.30	-0.15	0.18	-0.20**	0.02
Total pay	-0.03	0.43	0.03	0.58	0.16	0.12	0.20**	0.01
Job security	0.02	0.69	-0.09	0.17	0.08	0.45	-0.02	0.83
The work itself	0.04	0.32	0.03	0.59	-0.10	0.29	-0.08	0.27
Hours worked	0.56	0.57	1.70*	0.09	1.36	0.17	0.21**	0.01
Flexibility	-0.06	0.23	0.11*	0.10	0.18*	0.09	0.26***	0.00
Job overall	0.03	0.53	0.04	0.43	0.02	0.80	0.05	0.48
(disagree/agree…)								
Uses skills/abilities	0.12**	0.03	0.04	0.56	-0.29**	0.01	-0.23***	0.01

Note: ***, * *and * indicate the estimated coefficient is significantly different from zero at the 1, 5 and 10 per cent levels, respectively; a. sample restricted to persons aged 69 and under.

Finally, we further differentiated qualifications between the three STEM fields of natural and physical sciences, information technology and engineering and related technologies. We stress that the numbers of observations available for estimating the effects of holding each qualification specifically for women are low, particularly for those models applicable only to employed persons. In total there are observations for 105 employed women with qualifications in NPS; 39 in IT; and 45 in ERT, although we have repeated observations on those individuals. With this caveat in mind, the results, as reported in Table 8, suggest:

- the lower participation of females with STEM qualifications applies primarily to those with qualifications in the natural and physical sciences (β=-0.59; p=0.02);
- the higher incidence of unemployment is driven by higher unemployment for women with information technology qualifications (interaction term β=1.53; p=0.01). The associated odds ratio implies females with IT related qualifications are around 4 times more likely than a male with IT qualifications to be unemployed;
- females' reduced satisfaction with their employment opportunities applies across the three fields, with the estimates for the interaction term largest for IT (β=-0.37; p=0.02);
- Women with engineering related qualifications earn 20 per cent higher hourly wages than women with non-STEM qualifications, and it is these women that mainly drive the result noted above of relatively high pay satisfaction among STEM qualified women;
- The perceptions of under-utilisation of skills and abilities is refined to women with qualifications in the natural and physical science and in IT; it does not apply to women in engineering fields.

Table 8: Summary of coefficients for individual STEM fields of study

	*Males & Females: female*field Interaction term*						*Females only: STEM field of study*					
	Nat & Phys science		*IT*		*Engineer & related*		*Nat & Phys science*		*IT*		*Engineer & related*	
Model/Dep var.	β	P>z	β	P>z	β	P>z	β	P>z	β	P>z	β	P>z
Binary logit												
Participation[a]							-0.59**	0.02	-0.37	0.38	0.30	0.53
Unemployment	-0.22	0.67	1.53**	0.01	-0.35	0.68	0.17	0.67	1.05**	0.04	-0.50	0.52
OLS												
Real hourly wages	-0.07	0.22	-0.06	0.40	0.07	0.21	-0.08**	0.05	0.06	0.31	0.20***	0.00
Ordered probit (Satisfaction with …)												
Emp. opportunities	-0.10	0.49	-0.37**	0.02	-0.14	0.39	-0.19*	0.06	-0.32**	0.01	-0.16	0.25
Total pay	0.13	0.33	0.07	0.62	0.20	0.19	0.12	0.21	0.21*	0.10	0.33**	0.01
Job security	-0.13	0.40	-0.09	0.59	0.18	0.21	-0.14	0.24	-0.12	0.37	0.05	0.67
The work itself	-0.17	0.17	0.00	0.98	-0.06	0.65	-0.14	0.12	0.01	0.92	-0.05	0.68
Hours worked	0.19	0.13	0.23	0.12	0.10	0.47	0.23**	0.01	0.38***	0.00	0.13	0.30
Flexibility	0.12	0.39	-0.01	0.97	0.37***	0.01	0.18*	0.06	0.33***	0.00	0.31**	0.01
Job overall	0.01	0.92	-0.09	0.56	0.05	0.73	0.02	0.80	0.03	0.81	0.04	0.76
(disagree/agree…)												
Uses skills/abilities	-0.42***	0.00	-0.42**	0.02	-0.04	0.80	-0.35***	0.00	-0.26*	0.08	-0.03	0.83

Note: ***, * *and * indicate the estimated coefficient is significantly different from zero at the 1, 5 and 10 per cent levels, respectively; a. sample restricted to persons aged 69 and under.

5. Conclusion

Data from both the 2016 ABS Census of Population and Housing and from the HILDA survey provide little support for the received wisdom that STEM skills are in shortage relative to other skills gained at the tertiary level. In recent times unemployment rates have been higher among tertiary qualified persons whose highest qualification is in a STEM field. There is, however, some evidence of a positive wage premium for males only. More importantly, for the research question at hand, we find that women who gain STEM qualifications fare relatively poorly in the labour market in a number of respects. For women with STEM qualifications, labour force participation rates are lower and unemployment rates higher than for women qualified in other fields. While wages appear to be on par for women with STEM and non-STEM qualifications, women with STEM qualifications face higher wage inequality in the form of lower relative wages when compared to their male counterparts holding those same qualifications. The gender wage gap among STEM qualified workers appears to be more pronounced for younger women.

In addition to gender wage inequality, women who gain a university degree in a STEM related field are markedly less satisfied with their employment opportunities and, once employed, feel their skills and abilities are less well utilised. This is in comparison both to other women, and to men with STEM qualifications. The field of information technology, in particular, seems to be one in which women face substantial barriers, although this conclusion is based on a relatively small number of observations.

Overall, for women who enter university, the evidence suggests there is little labour market benefit to be gained from entering a STEM related field as opposed to other fields, and doing so presents a number of challenges. There is clearly a degree of disconnect between the evidence on labour market outcomes and the narrative of the need for more women to enter such fields and, to our knowledge, those advocating greater participation of women in STEM have not clearly articulated any market failure to support the argument that current levels of participation are sub-optimal. There has been a modest increase in the female representation in STEM fields in the past 10 years. If women are to be encouraged to enter such courses in what is seen to be in the best interests of the country and economy overall - by increasing Australia's capacity in strategic occupations and being the pioneers who tackle occupational gender segregation - but this comes at the cost of sacrificing their own labour market opportunity, then it seems reasonable that such policies should be backed by compensatory incentives for those women. This may be in the form of scholarships to meet the cost of studying in those courses, or tax breaks through the Higher Education Contribution Scheme and associated Higher Education Loans Program (HECS-HELP).

Positive action to change attitudes and behaviours at the workplace is also needed. It is difficult to conceive of reasons for why women in such fields do relatively worse in terms of employment opportunity, earnings and the matching of their skills to their jobs, other than the fact that they enter male dominated working environments that adversely affect their job opportunities, promotion prospects and earnings growth. We note, however, that engineering and related technologies is the most male dominated field, but not necessarily the worst in terms of gender outcomes, in fact offering high wages for women. This is an encouraging sign that more pronounced gender segregation need not necessarily translate into poorer outcomes for women. Further research focussing on women's experiences in engineering and related careers, and accompanying workplace policies and practices, may be of benefit in identifying ways to address discrimination in other strongly gender-segregated sectors.

A limitation of the research is that it has been necessary to define STEM status on the basis of the field of a person's highest qualification, as recorded in HILDA or the Census. Hence persons who gained their first university degree in STEM, but who go on to gain qualifications in other fields, such as management, would not be included in our definition of the 'STEM workforce'. Healy *et al.* (2011) also note the example of those who gain an undergraduate degree in mathematics or science and become teachers. Typically their highest qualification is a graduate diploma or masters in education, and thus they would also be excluded from the definition of STEM. One might argue that it is returns by field of study of an individual's first degree that are of most relevance. As the number of HILDA waves increases, sample sizes will eventually become sufficient to support a similar analysis based on the field of study of individuals' first observed degree. Certainly research based on larger samples at the level of individual fields of study would be highly valuable for drawing policy implications. This could most readily be achieved via access to Australian Taxation Office's data, which in principle can readily match graduate data to employment and earnings outcomes through their administration of HECS-HELP scheme. This could provide confidentialised records on employment status and earnings for the high proportion of graduates that leave university with a HECS debt, matched to university data on field of study, level of qualification, institution and other aspects of their tertiary education. Unfortunately the ATO has been reluctant to date to provide such data to researchers, despite its obvious relevance to issues surrounding the economics of higher education in Australia.

References

Australian Bureau of Statistics (ABS)(2001), *Australian Standard Classification of Education, 2001*, Catalogue Number 1272.0, ABS, Canberra.

Australian Industry Group (2013), Lifting our Science, Technology, Engineering and Maths (STEM) Skills, Australian Industry Group.

Bradley, D., Noonan, P., Nugent, H. and Scales, B. (2008), *Review of Higher Education: Final Report* (The Bradley Review), Department of Education, Employment and Workplace Relations. Canberra: AGPS.

Ceci, S.J., Ginther, D.K., Kahn, S. and Williams, W.M. (2014), 'Women in academic science: A changing landscape', *Psychological Science in the Public Interest*, 15(3), 75-141.

Daly, A., Lewis P.E.T., Corliss, M. and Heaslip, T. (2015), 'The Private Rate of Return to a University Degree in Australia', *Australian Journal of Education*, 59(1) 97-112.

Dawkins, J. (1988), Higher Education: A Policy Statement. Department of Employment, Education and Training, Canberra: Australian Government Publishing Service.

Healy, J., Mavromaras, K. and Zhu, R. (2011), *Consultant report: Securing Australia's future STEM: Country Comparisons, The STEM Labour Market in Australia*, Australian Council of Learned Academies.

Jann, B. (2008), 'The Blinder-Oaxaca decomposition for linear regression models', *The Stata Journal*, 8(4), 433-479.

Li, I., Dockery, A.M., Jununkar, P.N., Mahuteau, S. (2017), 'Equity in higher education and graduate labour market outcomes', *Journal of Higher Education Policy and Management*, 39(6), 625-641.

Norton, A. (2016), Mapping Australian Higher Education, Report prepared by Grattan Institute, 2016-11, August. https://grattan.edu.au/wp-content/uploads/2016/08/875-Mapping-Australian-Higher-Education-2016.pdf

Office of the Chief Scientist (2016), 'Australia's STEM Workforce: Science, technology, Engineering and Mathematics Report', Commonwealth of Australia, March.

Office of the Chief Scientist (2013), 'Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach: A Position Paper', Commonwealth of Australia, July.

Office of the Chief Scientist (2012), 'Mathematics, Engineering & Science in the National Interest', Australian Government, May, http://www.chiefscientist.gov.au/wp-content/uploads/Office-of-the-Chief-Scientist-MES-Report-8-May-20121.pdf

Prinsley, R., Beavis, A.S. and Clifford-Hordacre, N. (2016), Busting Myths about Women in STEM, Occasional Paper Series, Office of the Chief Scientist, Issue 13, November.

Professionals Australia (2015), 'The Slower Track, Women in the STEM professions survey report' Professionals Australia, Melbourne. http://www.professionalsaustralia.org.au/professional-women/wp-content/uploads/sites/48/2014/03/2015-Women-in-the-STEM-Professions-Survey-Report.pdf

PwC (2015), *A smart move: future proofing Australia's workforce by growing skills in science, technology engineering and maths*, PwC, April.

Watson, N, and Wooden, M. (2010), 'The HILDA survey: progress and future developments', *Australian Economic Review*, 43, 326–36.

Wilkins, R. (2015), *The Household, Income and Labour Dynamics in Australia Survey: Selected findings from Waves 1 to 12*, Melbourne Institute of Applied Economic and Social Research, University of Melbourne.

Williams, J.C., Phillips, K.W., Hall, E.V. (2014), *Double jeopardy: gender bias against women of color in science.* University of California Hastings College of the Law, San Francisco, California, USA.

Appendix Table A1: Regression results, binary logit models for probability of participating in the labour market and probability of being unemployed (given participation), HILDA Waves 1-16

	Labour force participation[a]				*Unemployment*	
	Females		*Males*		*(males & females)*	
	β	*P*>|*z*|	β	*P*>|*z*|	β	*P*>|*z*|
Constant	-4.33 ***	0.00	-5.77 ***	0.00	-4.24 ***	0.00
Age	0.53 ***	0.00	0.68 ***	0.00	-0.08 **	0.02
Age-squared/100	-0.73 ***	0.00	-0.90 ***	0.00	0.10 **	0.01
Family status:						
Married, no dep. children	—		—		—	
Married, kids aged 0-4	-3.54 ***	0.00	-0.27	0.34	-0.05	0.80
Married, kids aged 5-14	-0.84 ***	0.00	0.61 *	0.06	-0.50 **	0.02
Married, kids aged 15-24	0.29	0.22	1.00 ***	0.00	-0.56 **	0.02
Single, no dep. children	0.25	0.12	-0.33	0.16	0.81 ***	0.00
Single, kids aged 0-4	-2.59 ***	0.00	-1.40	0.40	1.04 *	0.06
Single, kids aged 5-14	-0.66 **	0.04	-1.32	0.41	0.40	0.26
Single, kids aged 15-24	0.45	0.26	0.59	0.52	0.12	0.81
Has long-term health condition	-0.61 ***	0.00	-0.68 ***	0.00	0.69 ***	0.00
Born in Australia	—		—		—	
Born overseas:						
English speaking background	-0.22	0.32	0.09	0.79	0.50 **	0.02
Non-English sp background	-1.27 ***	0.00	-0.54 **	0.05	1.43 ***	0.00
Highest level of qualification:						
Bachelor/honours degree	—		—		—	
Graduate cert/diploma	0.44 ***	0.01	0.00	0.99	-0.33 *	0.08
Masters or doctorate	0.96 ***	0.00	0.24	0.37	0.06	0.73
STEM (field of study)	-0.37 *	0.08	-0.47 **	0.05	-0.03	0.87
Female					-0.28 *	0.07
Female * STEM					0.38	0.30
Observations	21993		16790		33654	
Individuals	2800		2081		4646	
Obs/individual						
Minimum	1		1		1	
Average	7.9		8.1		7.2	
Maximum	16		16		16	
Wald chi-square	826.7 ***	0.00	415.66 ***	0.00	180.7 ***	0.00

Note: ***, * *and * indicate the estimated coefficient is significantly different from zero at the 1, 5 and 10 per cent levels, respectively; a. sample restricted to persons aged 69 and under.

Appendix Table A2: Regression results – wage equation, HILDA Waves 1-16 (dependent variable = log of real hourly wages in 2016 dollars)

	β		P>|z|
Constant	2.273	***	0.00
Age	0.056	***	0.00
Age-squared/100	-0.050	***	0.00
Married	0.049	***	0.00
Has long-term health condition	-0.010		0.28
Born in Australia	—		
Born overseas:			
English speaking background	-0.006		0.80
Non-English speaking background	-0.132	***	0.00
Highest level of qualification:			
Bachelor/honours degree	—		
Graduate cert/diploma	-0.005		0.75
Masters or doctorate	0.073	***	0.00
Sector of employment:			
Private, for profit	—		
Private, not for profit	-0.026	*	0.05
Government business enterprise	0.055	***	0.00
Public sector	0.031	***	0.01
Other	-0.080	***	0.01
Workplace size:			
Small (1-19 workers)	-0.130	***	0.00
Medium (20-99 workers)	-0.060	***	0.00
Large (100+ workers)	—		
Region of residence:			
Major city	—		
Inner regional centre	-0.079	***	0.00
Outer regional or remote	-0.053	***	0.01
Employed part-time	0.117	***	0.00
Female	-0.112	***	0.00
STEM (field of study)	0.088	***	0.00
Female * STEM	-0.089	**	0.02
Observations	29860		
Individuals	4448		
Obs/individual: Minimum	1		
Average	6.7		
Maximum	16		
Wald chi2	1986.8	***	0.00
R-sq: within	0.08		
Between	0.16		
Overall	0.12		

Note: ***, * *and * indicate the estimated coefficient is significantly different from zero at the 1, 5 and 10 per cent levels, respectively.

Appendix Table A3: Regression results, panel ordered probit models for employment opportunity/job satisfaction ratings, HILDA Waves 1-16.

			Satisfaction with … [0=totally dissatisfied to 10=totally satisfied]												*Use skills and abilities [1-7]*	
	Emp. opport.		*Pay*		*Job security*		*The work itself*		*Hours of work*		*Flexibility*		*Job overall*			
Independent var	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*
Age	-0.06	0.00	-0.01	0.16	-0.05	0.00	-0.02	0.00	-0.07	0.00	-0.05	0.00	-0.05	0.00	0.02	0.02
Age-squared/100	0.06	0.00	0.03	0.00	0.05	0.00	0.04	0.00	0.09	0.00	0.07	0.00	0.07	0.00	-0.01	0.20
Married	0.12	0.00	0.08	0.00	0.18	0.00	0.08	0.01	0.12	0.00	0.11	0.00	0.13	0.00	0.10	0.00
Has long-term health condition	-0.12	0.00	-0.10	0.00	-0.08	0.00	-0.03	0.28	0.03	0.18	0.04	0.14	-0.04	0.11	0.02	0.53
Born in Australia	—		—		—		—		—		—		—		—	
Born overseas:																
English sp. background	-0.04	0.50	-0.05	0.38	-0.03	0.64	-0.05	0.35	-0.03	0.61	-0.02	0.73	-0.05	0.38	-0.11	0.07
Non-ESB	-0.56	0.00	-0.22	0.00	-0.29	0.00	-0.15	0.00	-0.02	0.70	-0.13	0.00	-0.19	0.00	-0.20	0.00
Highest level of qual,:																
Bachelor/honours	—		—		—		—		—		—		—		—	
Graduate cert/dip	0.12	0.01	-0.02	0.68	0.07	0.13	0.06	0.10	0.00	0.98	-0.10	0.01	-0.01	0.87	0.12	0.01
Masters/doctorate	0.09	0.03	0.04	0.28	-0.10	0.02	0.09	0.02	-0.06	0.14	-0.05	0.22	-0.03	0.50	0.14	0.00
Sector of employment:																
Private, for profit			—		—		—		—		—		—		—	
Private, not for profit			0.08	0.05	0.19	0.00	0.19	0.00	0.19	0.00	0.00	0.98	0.19	0.00	0.21	0.00
Government business			0.16	0.00	0.19	0.00	0.00	0.99	0.19	0.00	-0.01	0.85	0.11	0.01	0.16	0.00
Public sector			0.18	0.00	0.21	0.00	0.03	0.43	0.19	0.00	-0.06	0.09	0.13	0.00	0.27	0.00
Other			-0.04	0.64	0.21	0.02	0.32	0.00	0.06	0.48	0.04	0.64	0.11	0.22	0.09	0.41
Workplace size:																
Small (1-19 workers)			-0.20	0.00	-0.03	0.23	0.18	0.00	0.16	0.00	0.37	0.00	0.15	0.00	-0.06	0.07

Continued / ….

Appendix Table 3 (Cont'd)

	Satisfaction with ... [0=totally dissatisfied to 10=totally satisfied]														Use skills and abilities [1-7]	
	Emp. opport.		*Pay*		*Job security*		*The work itself*		*Hours of work*		*Flexibility*		*Job overall*			
Independent var	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*	β	*P>z*
Medium (20-99 wrkrs)			-0.11	0.00	-0.03	0.18	0.02	0.42	0.05	0.04	0.03	0.25	0.00	0.99	-0.06	0.03
Large (100+ workers)			—		—		—		—		—		—		—	
Region of residence:																
Major city	—		—		—		—		—		—		—		—	
Inner regional	-0.01	0.84	0.04	0.33	0.03	0.48	0.09	0.03	0.07	0.08	0.02	0.66	0.10	0.01	0.09	0.06
Outer regional/remote	0.02	0.80	0.09	0.15	0.21	0.00	0.15	0.01	0.02	0.75	-0.07	0.27	0.11	0.05	0.16	0.02
Female	0.00	0.90	0.02	0.59	0.00	0.98	0.06	0.07	0.05	0.17	-0.02	0.62	0.06	0.10	0.16	0.00
STEM (field of study)	-0.04	0.48	0.08	0.10	-0.05	0.39	0.03	0.60	0.09	0.04	0.12	0.01	0.05	0.28	0.06	0.28
Female * STEM	-0.18	0.06	0.09	0.32	-0.04	0.69	-0.10	0.22	0.18	0.04	0.15	0.11	0.00	0.96	-0.34	0.00
Observations	36806		32656		32642		32671		32670		32664		32669		29360	
Individuals	4869		4568		4567		4569		4569		4569		4569		4388	
Obs/individual																
Minimum	1		1		1		1		1		1		1		1	
Average	7.6		7.1		7.1		7.2		7.2		7.1		7.2		6.7	
Maximum	16		16		16		16		16		16		16		16	
Wald chi2	271.5	0.00	331.0	0.00	216.1	0.00	275.5	0.00	267.0	0.00	387.3	0.00	327.4	0.00	274.4	0.00

Note: Cut points from ordered probit models omitted. a. Sample for the model for employment opportunities includes all responding persons, while the remaining models apply to employed persons only; b. scale ranges from 1=strongly disagree to 7=strongly agree.