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Marriage and Education in Australia: Decomposing the Enrolment and Human Capital Effects

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The data used in this study are from the first wave of the Household, Income and Labour Dynamics in Australia (HILDA) survey. HILDA is a confidentialised file and is managed by the Melbourne Institute of Applied Economic and Social Research. The findings and views reported in the paper are from the author, and should not be attributed to the Melbourne Institute. A data appendix with additional results, and copies of the computer programs used to generate the results presented in the paper, are available from the author upon request.

ABSTRACT

Using the first two waves of the Household, Income and Labour Dynamics in Australia (HILDA) survey, this paper explores the relationship between educational attainment and age at first marriage. Theory suggests that there are two effects driving the relationship, namely the Enrolment effect and the Human Capital effect. Using a Proportional Hazards model we analyse the effect of an individual's education level on the timing of first marriage. Controlling for other institutional factors, cohort effect and social/ family background we find that the higher an individual's education level, the older they are when they first marry. We find that the effect of education is much stronger for females than for males.

Keywords: marriage, education, proportional hazard
JEL Classification: I2, J1

"Accordingly, we conclude that the appropriate age for marriage is about the eighteenth year for girls and the thirty seventh plus or minus for men".
- Aristotle: Politics

1. Introduction

Marriage is considered to be one of the most important events that will take place in an individual's life. Not only does it publicly affirm an individual's commitment to their partner but it also signals the formation of a new single household unit separate from the parental unit, and in most cases it also marks the beginning of the family formation process.

Marital behaviour is a potentially important economic variable. Marital behaviour, how it's changed and what factors influence this change can have further implications for other economic phenomenon. For example, the intensity of partnership rates along with the duration and timing of those partnerships can have important effects on other economic variables such as the rate of population growth, labour supply (especially female labour supply), demand for housing, consumption expenditure wage rates and in recent years fertility rates. Moreover, we know from the vast life satisfaction literature that married people are significantly happier than those individuals who are not. Therefore any change in marital patterns may potential impact on overall life satisfaction and lead to a decrease in welfare.

In Australia over the past three decades there has been a distinct change in marital patterns. No longer are households consisting of married couples in the majority. Cohabitation has become the norm, and of those that choose to marry, they are choosing to marry much later in life compared to older generations. According to the Australian Bureau of Statistics (2005) the number of people that are in de facto relationships has risen from 744,100 in 2001 to 951,500 in 2005, while the median age at marriage between 1991 and 2001 has increased from 21 to 29 and 25 to 32 for females and males respectively (ABS, 2002)[1].

[1] When looking at the marriage intentions of cohabitating females and males in Australia, Qu (2003) noted that out of the total population that was eligible to marry, the proportion that did so in 2000 was three percent, down from six percent in 1976. Furthermore, the proportion of 25-29 year olds that never married rose from 26 percent in 1976 to 67 percent in 2000 for males and 13 percent to 53 percent for females. The author suggests that this later trend partly reflects that people are choosing to marry later in life.

This social change in partnering has not happened in isolation however. In Australia, as in other developed economies, there has been an expansion of educational attainment. There has been increased participation by both genders in secondary schooling and the percentage of people who have attained a bachelors degree has risen from 9 percent in 1991 to 17 percent in 2002 while at the same time the percentage of the population holding a non-school vocational qualification stands at around 35 percent. The increasing number of females pursuing higher education drives a large part of the increase in qualification attainment. Birrell and Rapson (1998) point out that by 1996 there were more degree qualified women then men in their twenties. Therefore an important set of question needs to be asked as to the extent of the effect of one on the other. Does increased educational attainment increase the age an individual marries?

Economists, sociologists and demographers alike have long acknowledged the connection between education and marriage. There has been a number of empirical works that have investigated the effects of education on the age at marriage. Most find a direct correlation between an individual's level of education and the age at which they marry (Keely 1977; Marini 1978; Blossfeld and Jaenichen 1992; Brien and Lillard 1994). However the nature of the association between educational attainment and the timing of marriage, to date, has primarily been estimated using parametric techniques only. In addition, the association between education and age at first marriage in Australia has not been fully investigated to date. This paper addresses these issues by primarily looking at the effect of educational attainment on the timing of first marriage in Australia. This question employs a semi parametric duration model, namely a proportional hazard model pioneered by Cox (1975), to analyse data from the Household, Income and Labour Dynamic in Australia (HILDA) survey. This survey was first conducted in 2001 and there has been a subsequent wave every year since. The sample provides an Australia-wide representation of family and partnering dynamics.

The chapter is organised as follows: Section 2 introduces a theoretical background for the analysis followed by a discussion of the previous work. A brief description of the data and the variables of choice are presented in Section 3, while Section 4 outlines the estimation methodology. Sections 5 and 6 report the results of the analysis and robustness checks respectively. Section 7 concludes.

2. Conceptual and Empirical Issues

Family economists and sociologists alike have forwarded many different views as to how the extent of an individual's education affects their entrance into marriage or cohabitation.

Economic analysis, more specifically Beckerian theory, suggests that there are gains to marriage due to specialisation in the production of household goods (which is found to depend negatively on the ratio of the wife's to husbands wage rates) and individuals will choose to marry if and when the utility in the married state exceeds the utility gained when single (Becker 1973,1977, 1991). More specifically, given differences in the marginal products of marketplace capital and household capital between the two individuals to a partnership, due to different "experiences" (be it biological, sexual or environmental), welfare improvements can be gained through the division of labour within the household unit. Individuals to a union will "specialise" in either the marketplace or household sector (Brien and Lillard 1994).

Although Becker (1991) suggests that a traditional division of labour partly stems from a biological commitment on part of the female, reinforced by environmental differences, the theory in relation to specialization is in no way gender biased. The theory does not predict that a woman should specialise in the household sector nor should a male specialise in the market sector exclusively. In fact, the theory implies that if a non-traditional division of labour can make the biggest welfare gains for the union then that is what should take place.

Additionally, specialisation gains in the marriage partnership can have a polarising effect. Even if there is an infinitesimally small difference in the marginal products of market and household capital between the individuals to the union, those individuals that specialise will gain human capital that is specific to the household or market sectors. For example, assuming a traditional division of labour, a female will invest in human capital that makes household production more efficient since women spend more of their time doing this. On the other hand, males will invest in human capital that makes market activities more productive since they spend more of their time working in the marketplace. Therefore they will both gain more skills that will make them more productive in those specific environments. Since the theme of this paper is on the effect of education on first marriage the focus will be limited to those qualifications an individual obtains within the educational sector.

Therefore, economic theories of marriage imply a strong correlation between male and female returns in the labour market and their return in the marriage market, measured in terms of utility or welfare gains from marriage. Gains from marriage and therefore marital status decisions will thus depend on (potential) market and household wage rates (Van Der Klaauw 1996). Becker shows that gains from marriage are decreasing in the female wage rate and increasing in (potential) husband's earnings and education.

This implies that education can have an effect on the gains to a marriage and martial decisions. Not only is increased educational attainment likely to open up economic alternatives to getting married (Gangadharan and Maitra 2003), education accumulation increases labour market opportunities and therefore the market returns to education. The returns to education investment include increased efficiency in the marketplace and the household alike. Since the returns to education can affect the productivity of market and household production, the specialisation hypothesis suggests that there is an influence on the decision to marry by the level of education obtained. The former (marketplace productivity) affects the opportunity cost of marriage while increased household production increases the return to marriage. Education is expected to delay marriage since the potential increased welfare gains will not eventuate until the process of accumulating education is complete.[2]

[2] As an aside, sociologists have argued that education affects the timing of marriage, but that education has an additional intensity effect, and especially for women, education leads to greater independence. That is, the higher an individual's education level, the more likely it is that they will be economically independent. This is referred to in the literature as the independence hypothesis (Becker et al 1977, Bruderl and Diekmann 1997, Oppenhiemer 1997, Chan and Halpin 2002). This independence hypothesis not only delays marriage but will also lower the rate of marriage (Oppenhiemer 1997). In addition, sociologist have often argued that an increase in education levels for both men and women will make them more attractive to the opposite sex. This is known as the attractiveness hypothesis. Thus, the attractiveness hypothesis should increase the rate at which an individual enters marriage (Anderberg 2004, Bruderl and Diekmann 1997). There has been increased evidence in support of the attractiveness hypothesis. Blossfeld (1995) argues that highly educated women show higher rates of marriage. Therefore, the decline in marriage rates over the past decade cannot be put down to the increase in levels of female education.

Accordingly, there are two transmission channels through which education affects specialisation and therefore the decision to marry or partner. These are the Human Capital Effect and the Enrolment Effect (Bruderl and Diekmann 1997).[3]

If we assume a traditional division of labour the human capital effect predicts two different outcomes for the separate genders. In the study of female labour supply there is a growing awareness that both marital status and fertility decisions are strongly interrelated with female labour supply decisions. Female labour force participation decisions have also been found to depend strongly on the marital status of women (Van Der Klaauw 1996). A female might opt for a labour market career and consciously postpone marriage.[4] On the other hand, more work experience generally implies higher wages, which in turn might affect gains from a potential marriage. Further, women are likely to reduce their labour force participation after marriage (due to family formation, assuming of course a traditional division of labour in the household) and hence the opportunity cost of marriage would be higher for more educated women (assuming of course a higher education level translates into a higher wage rate).

As a result, women with low wage rates and women with high expected husbands' earnings are predicted to be more likely to marry soon after leaving school. Partnering earlier could negatively impact on long run earning, especially for those individuals for whom the return to mobility and career development is high; hence, high wage women are more likely to postpone marriage until after several years of market work. Therefore, we would expect females to have a negative human capital effect, that is, a significant delaying effect on partnership induced by higher educational attainment.[5]

For males, increased tenure at educational institutions should increase the tendency to marry since they now have more to gain from a traditional division of labour within the household unit, *ceterius paribas*. Furthermore, there could be second tier effects increasing the gains from trade for males. Korenman and Neumark (1991), Breusch and

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[3] The authors refer to the enrolment effect as the institutional effect.

[4] However, as Goldin and Katz (2002) point out, the advent of the pill has enabled more women to pursue career investment by giving women more certainty regarding the opportunity cost of pregnancy.

[5] Increased education could imply that for women the utility of being single might exceed the utility of being married (Gangadharan and Maitra, 2003).

Gray (2004) and Birch and Miller (2006) have all found that married men extract a form of " marriage wage premium" compared to those males that remain single. That is, wage levels increase after marriage, although this premium has been declining (Gray 1997). If we assume perfect foresight in the marriage market then potential partners would recognise this extra increase in welfare gains when searching for a partner.

Up until now we have assumed a traditional division of labour within a household. However, in recent times the pattern of Australian households has changed. Female workplace participation has increased. Over the last ten years female workplace participation rates, as reported by the Australian Bureau of Statistics (2005), have increased from 52 percent to just over 57 percent. In addition, the marketplace is increasingly providing products, (for example, childcare and frozen dinners) which act as close substitutes to those goods that would have been produced through the household. This, in addition to the division of labour within a partnership becoming less and less traditional (Baxter 2001, Ferree 1991), decreases the opportunity cost of marriage for highly educated women.[6] However, it has the opposite effect for males, as they can no longer gain from a traditional division of labour. Since the gains from marriage can no longer be realised at high education levels, this would imply that those individual's with a low education should marry earlier. Nevertheless, this implication fails to take into account that those individual's who specialise in the marketplace need to earn enough to support both individuals in the union and therefore afford the gains in specialisation. If we assume that education is more likely to translate into higher wages, we would expect those individuals with a low education to marry later since both individuals would need to work and therefore, the gains from trade in a marriage cannot be realised at low education levels.

The timing of marriage maybe influenced by not only the benefits of marriage but also by the cost of search for a suitable mate and the opportunity cost of being married. The pool of available partners and the cost of search for a suitable partner may affect the waiting time to marriage. The lack of available partners makes it more difficult to find a mate and therefore lengthens search and duration of singlehood. This would imply that

[6] In addition, an increase in the age at marriage for women is also likely to reduce the age differential between the husbands and the wife. This is likely to increase the bargaining power of the female and reduce the power imbalance.

factors such as the ratio of men to women might play an important role in partnership formation.

One of the characteristics of a student is that they are more likely to be liquidity constrained and therefore lack the financial resources to finance a longer search (or even a search period at all) to find a better partner. In addition, partnership formation can truncate knowledge accumulation, which can lead to less favourable labour market outcomes or lower (potential) wage rates. Since there is a tendency towards positive assortative mating in traits to a partnership (Mare 1991), the decision to truncate formal educational attainment and partner could result in partnering with an individual with less education (and therefore lower earnings potential) and consequently lower joint wealth. Hence, there is a greater opportunity cost of partnering and we would expect educational enrolment to inhibit exit from singlehood. The enrolment effect therefore contends that people will show a tendency to delay marriage while attaining educational qualifications. This is the case for both genders.

To complement the above economic reasoning for delay of marriage induced by educational enrolment, sociologists have put forward the following additional arguments. People will tend to marry less simply because individuals are spending more time in educational institutions. Thornton et al (1995) suggest: “Marriage is… an adult status incompatible with the role of a student”. They put forward the following arguments: -

1. Students indicate that at that particular point in time they are not economically independent.
2. Education requires time that cannot be allocated to the dating/relationship[7]

To summarise, for females we would expect that the higher the level of education, the higher the marriage age since both the institution and human capital effects work in the same direction in the case of females (i.e. reinforce each other). That is both effects work together is cause a delay in the marriage age. In the case of men, the increase in age at marriage should be less pronounced since the positive human capital effects

[7] So to does investment in a market career

works against the enrolment effect. In addition, we would expect that the human capital effect across cohorts would become more similar between females. Finally, we would expect that those individuals with a low education to get married later since the gains from trade within a union cannot be afforded and therefore disappear.

Much of the empirical work done in this area employs duration analysis to investigate the effects of education on the timing of marriage, with a handful of works extending the analysis to include effects on first birth.

One of the first to recognise a pattern in the age at first marriage was Keeley (1979). Using the 1960 US Census, the author uses a two-stage estimation framework to model the patterns of age at first marriage and its explanatory variables. First, the author estimates a log logistic function of the percentage ever married at a specific age for each of the 50 states of the US. Three parameters, the age co-efficient, the percent ever married and an incept term then become dependant variables in the second stage regression. These are regressed against a number of independent variables, which include education.

The author finds that variables that lead to greater marital income relative to single income lead to earlier entry into marriage. Increases in variables that change the gains from trade in marriage leads to a greater variance in the age at first marriage.

Brien and Lillard (1994) investigate how educational attainment has impacted on the timing of marriage and first childbirth for women in Malaysia. Malaysia provides a good point of comparison to empirical works conducted on data from developed countries. Malaysia has three ethnic “classes”, which represent three different socio-economic classes. The authors investigate their question of interest by using the 1988 Malaysian Family Life Survey within a duration framework.

The authors highlight the potential endogeneity of age at first marriage, age at first conception and educational attainment and try to account for it by employing a “simultaneous equations for hazards” model. There are two processes to the estimation. The first stage of the estimation is to examine the highest level of education attained by a woman via a sequential probit model. The results are then used in the second stage of the estimation. The second stage involves estimating two parametric log-logistic hazard models for age at first marriage and age at first conception are estimated simultaneously.

Since our question of interest is only in the timing of marriage we will only discuss the relevant results. The authors find that the level of schooling has a negative effect on the hazard rate of women. They also find that enrolment also has a significant delaying effect on marriage, with leaving school likely to increase the risk of marriage. In addition, the authors control for ethnicity with results indicating that compared to ethnic Malays, Chinese and Indian women are more likely to marry later.

Gangadharan and Maitra (2003) use the same methodology as Brien and Lillard (1994) to investigate the same question in Pakistan using the Pakistan Integrated Household Survey of 1991. Their results are similar, in that they find a significant delaying effect of education on age at first marriage and age to first conception.

The method employed in the two above-mentioned papers is not appropriate for our current problem since the authors use the sequential probit model to estimate the conditional probability of an individual moving between the different levels of primary and secondary school education. Given that educational attainment in Australia is compulsory till the age of 16, with marriage not being legal until 18 (since the Marriage Act, 1961 anyway), we believe that modelling primary and secondary education is not necessary since everyone is assumed to have completed at least a secondary education.

In addition to the economic work that has been conducted in this area, sociologists have also done much work with the work covering a large number of countries, both developed and developing. The findings are generally in line with results from the economics sphere.

Blossfeld and Jaenichen (1992), within an exponential duration framework, investigate the effect of education on the timing of marriage in the Federal Republic of Germany for females using the first 4 waves of the German Socio-economic Panel (GSOEP). Their model assumes the hazard rate is exponential in nature. Their results indicate that increasing educational attainment for females can explain part of the rise in the delaying of marriage, with highly educated females most likely to delay marriage and their first child. In addition, the authors find some evidence on a non-linear effect of education on the timing of marriage with upper secondary school educated individuals partnering earlier than those with a lower secondary school qualification. University graduates marry later than both. However their result is not significant when enrolment in education is taken into account. Further, the definition of the education level variable assumes the same marginal effects on the delay of marriage across the different education levels.

Thornton *et al* (1995) use a panel study that is drawn from the Detroit metropolitan area only and investigate the effect of school enrolment on marriage within a (parametric) log logistic hazard model framework. Their findings indicate that school enrolment has a significant delaying effect. School enrolment decreased the risk of marriage by 60 percent and 25 percent for females and males respectively.

Additionally, there have been a number of works that also investigate this question across a range of different countries. Given their number, they will not be discussed individually. However, the common them they all present is that increased educational attainment is likely to increase the age of first marriage with the effects much larger for females than it is for males.

Our empirical work to follow is in line with the existing literature in that we employ a duration framework to the question of interest. In addition though, the work makes two critical departures from the literature. Much of the existing literature employs duration models with pre determined parametric hazard rates. That is, the shape of the hazard function is assumed to take the shape of a given mathematical function, before anything has been estimated. For example in the empirical work cited previously, two works assume a log-logistic function and one an exponential function. It is therefore assumed that the hazard rate takes a form that is equivalent to a natural logarithmic function. We take the analysis one step further and introduce two models where the hazard rates are described as semi parametric. In other words, the hazard rate is estimate separately and there are no underlying assumptions about the shape of the hazard rate.

The first of our models employs the Cox Proportional Hazard. The Cox PH model assumes no formulaic structure on the hazard rate, but the hazard rate is a function of the covariates. Further, we advance the estimation by introducing a Cox PH model with time varying education covariates. Much of the literature investigating education and age at first marriage employs models that assume education qualifications do not vary with time. In Australia it is compulsory for all individuals to be educated at least to the age of 16, with a vast majority of those continuing on to further secondary and tertiary education. In addition, the legal age of marriage is 18 years with the mean age at first marriage is 29 and 32 for females and males respectively. Therefore the assumption that education does not vary with time after an individual first becomes at risk of marriage does not seem reasonable, we allow education to vary conditional on the highest level of education an individual has attained.

The second of our models is the discrete time piecewise constant model. The piecewise constant hazard model is considered another form of semi parametric estimation. However, unlike the Cox PH model, the piecewise constant assumes that the hazard rate is constant within a specific time interval, but the hazard rate is allowed to differ between time intervals. Once again, we allow education to vary with time in this model.

Not only does much of the literature use restrictive parametric assumptions in the analysis, inevitably unobserved differences between individuals in traits, preferences and attitudes etc are not taken into account. This is referred to as unobserved heterogeneity and is generally interpreted as a problem of omitted variables, which may bias estimates. We account for this in our analysis by introducing a final semi parametric model, a piecewise constant model which accounts for unobserved heterogeneity and is discussed in depth in Section 4.

3. Data and Descriptive Analysis

3.1. Data

The analysis reported uses a pooled cross section consisting of the first two waves of the Household, Income and Labour Dynamics in Australia survey (HILDA). The HILDA survey is a longitudinal survey co-managed by the Department of Family and

Community Services and the Melbourne Institute of Applied Economic and Social Research.

The HILDA survey has several main advantages for addressing the research questions mentioned. First, individuals are asked to specify the year in which their current or first marriage commenced. Secondly, the highest level to date of an individual's education is also reported. Finally, the survey contains a broad number of questions relating to retrospective family details, background and attitudinal variables.

The initial size of the sample for Wave 1 of HILDA, as reported by the Melbourne Institute, comprised 12,252 households. From this sample 13,969 individuals responded. At the time of the survey, August 2001, the individuals' ages ranged from 0 to 90 years, however, only those individuals who were 15 years and over took further part in the survey.

In Wave 2, an extra 1048 observations were added to the analysis due to new entrants being taken up. After accounting for questioning and reporting irregularities, the final sample size for the analysis consisted of 14,456 observations. Due to the methodology for constructing one of the variables of interest (presented in Section 5 of the paper), namely the enrolment variable, the number of observations used in the analysis is 103,503.[8]

Table 1 presents the means of the variables used in the analysis, with a brief description of each. Of the sample, 51.4 percent of the sample is female and 48.6 percent male. 36 percent of the sample has a lifetime high education level of Year 11 or below, with a smaller percentage of males having an education level below Year 11 than the female sub-sample. Males have a higher percentage that holds a non-school certificate qualification. This reflects the fact that more men hold a trade certificate than females.

[8] The large number of observations is created through a technique called "Episode splitting". Episode splitting entails creating one observation for each individual at each period of time that same individual is at risk of failure (or marriage in this case). For example, if an individual is single for 5 years and then marries, there will be 5 separate observations for that one individual representing each year that individual was at risk of exiting.

Table 1: Means and Description of Variables

Variable	Mean (Female)	Mean (Male)	Mean (Pooled)	Description
No.Obs	7433	7023	14456	
yr11	0.4044	0.3221	0.3644	Highest education attained: Yr11 or below
yr12	0.1943	0.1411	0.1684	Highest education attained: Yr12
cert	0.1610	0.2947	0.2260	Highest education attained: Certificate
dip	0.0718	0.0753	0.0735	Highest education attained: Diploma
bach	0.1203	0.1079	0.1143	Highest education attained: Bachelors Degree
graddip	0.0375	0.0345	0.0360	Highest education attained: Grad.Cert/Grad Dip
mastphd	0.0106	0.0243	0.0173	Highest education attained: Masters/PhD
cohort1910	0.0066	0.0044	0.0055	Indicates born between 1910-14
cohort1915	0.0118	0.0088	0.0104	Indicates born between 1915-19
cohort1920	0.0272	0.0205	0.0239	Indicates born between 1920-24
cohort1925	0.0386	0.0372	0.0379	Indicates born between 1925-29
cohort1930	0.0405	0.0396	0.0401	Indicates born between 1930-34
cohort1935	0.0452	0.0488	0.0470	Indicates born between 1935-39
cohort1940	0.0558	0.0618	0.0587	Indicates born between 1940-44
cohort1945	0.0726	0.0767	0.0746	Indicates born between 1945-49
cohort1950	0.0800	0.0813	0.0807	Indicates born between 1950-54
cohort1955	0.0993	0.1004	0.0998	Indicates born between 1955-59
cohort1960	0.1098	0.1052	0.1076	Indicates born between 1960-64
cohort1965	0.0993	0.0947	0.0971	Indicates born between 1965-69
cohort1970	0.0927	0.0918	0.0923	Indicates born between 1970-74
cohort1975	0.0809	0.0810	0.0809	Indicates born between 1975-79
cohort1980	0.0515	0.0541	0.0528	Indicates born between 1980-83
immigrante	0.1008	0.1119	0.1062	indicates whether an imigrant from english speakir country
immigrantne	0.1470	0.1400	0.1436	Indicates whether an immigrant from a non englisl speaking country
immibck~deng	0.1955	0.2028	0.1990	Indicates whether had at least one parent from an E speaking immigrant background
immibck~neng	0.1998	0.1919	0.1960	Indicates whether had at least one parent from a no English speaking immigrant background
liveparents	0.8488	0.8519	0.8503	Was living with two parents at age 14
divorce	0.0870	0.0843	0.0857	Parents were divorced at age 14
no_siblings	2.8417	2.6812	2.7637	Number of siblings an individual had
eldest	0.2888	0.2858	0.2874	Dummy variable. 1= Was eldest sibling
manager	0.1699	0.1704	0.1702	Father employed as a manager
professional	0.1066	0.1094	0.1079	Father employed as a professional
ass_profess	0.1044	0.1001	0.1023	Father employed as a associate professional
trade	0.1933	0.1922	0.1928	Father employed in a trade
adv_clerical	0.0070	0.0065	0.0068	Father employed as an advanced clerical role
int_clerical	0.0601	0.0523	0.0563	Father employed as an intermediate clerical role
int_prod	0.1137	0.1086	0.1112	Father employed as an intermediate production
ele_clerical	0.0293	0.0278	0.0286	Father employed as an elementary clerical role
labourers	0.0858	0.0881	0.0870	Father employed as a labourer
motherjob	0.4253	0.4027	0.4143	Mother was working when individual was 14
aboriginal	0.0222	0.0154	0.0189	Dummy variable. 1= Aboriginal/Torres Strait Islan

Notes:1. Father job classifications provided by the Australia Bureau of Statistics: Australian Standard Classification of Occupations, ABS Catalogue No.1220 (1997)

Source:Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

However, in contrast, the number of females with a Bachelors degree is greater than that of men with 12 percent and 10 percent respectively. In total, more females (17 percent) then males (13 percent) have University level qualifications. 51 percent of the sample was born between the years of 1955 and 1974, with 38 percent of the overall sample being from an immigrant background.[9]

3.2. Variables

The independent variables chosen include a range that measure educational attainment, enrolment over time, cohort effects, family and social background. The variables were formulated as follows:

Time Varying Education variables: In the survey, individuals were asked directly what level of education they had achieved. However, this variable is measured as at the time of the survey and not at the time of first marriage, which is what this paper is concerned with. Therefore in order to model the general level of an individuals education at the time of marriage, we use the number of years required to obtain a qualification as specified by the Australian Bureau of Statistics' (ABS) Australian Standard Classification of Education (ASCED).[10] Primary school qualifications = 7 years of formal education; Junior High School = 11 years; Senior High School = 13 years; Vocational/ Non Vocational post school = 15 years; university degree =16 years; and post-graduate education 18-21 years.

To model the education level of an individual at first marriage we take the age at marriage and update the level of education as predicted by the ASCED guidelines, subject to the highest level of education an individual has achieved in their lifetime[11]. For example, an individual who reports age at first marriage of 21 years but in addition also reports the highest level of education achieved as a Masters Degree, their level of education at marriage will be a Bachelors Degree. Similarly, an individual who reports

[9] For the purposes of this analysis, "Immigrant background" has been defined as coming for a family that has at least one parent who was not born in Australia.

[10] We have imposed the ABS standard to all cohorts. The ABS classification is valid for relatively recent cohorts. For earlier cohorts, secondary schooling might have been completed earlier. The cohort effects will capture some of this. However, we believe that the imposition of the rule will not detract all that much from the analysis.

[11] In construction of the education at marriage variable the paper assumes that all individuals commenced formal education at the age of 5.

age at first marriage of 21 years but reports only a Year 10 qualification, their level of education at marriage will be Year 10.

Finally, once an individual's education proxy level is determined, then at every time period the individual is at risk of marriage, an indicator is assigned to the highest qualification level the individual has in that particular time interval. In doing so, this allows an individual's education level to vary with time and also allows us to capture the variation in an individual's educational attainment throughout the risk period unit marriage (failure) or the observation is censored.

Enrolment (*enrol*): As indicated previously a key driver for people marrying later in life is that they are just spending more time in educational institutions. Therefore, the enrolment variable should capture this effect. In order to include this variable in our model, we generate a time varying dummy variable, which indicates at each specific period in time after an individual becomes at risk of marriage (i.e. after age 18) whether or not that individual was enrolled in an educational institution (See Figure 1).[12]
Cohort effect (*cohortxxxx*): The analysis of age at marriage within the sample takes place over a time period of 90 years. The oldest individual observations in the sample are 90 years of age with the youngest being 15 year of age. Therefore, to control for cohort effects generated by historical events, social norms and other attitudes we use a set of dummy variables indicating the birth cohort of an individual. Each cohort variable represents a 5-year period starting from 1910 through to 1980. The base cohort for comparison is 1910 – 1914.[13]

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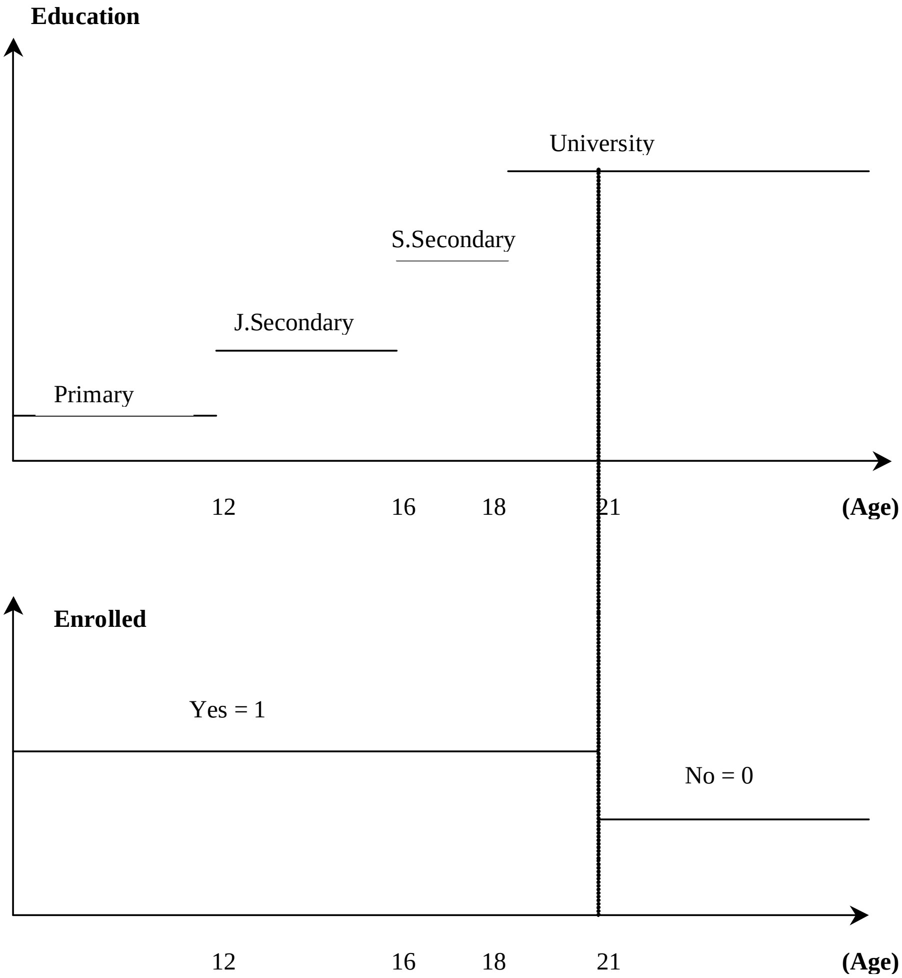
[12] Under Commonwealth Government legislation, the Marriage Act (1961), an individual can only legally marry at the age of 18. In some circumstances an individual may marry at the age of 16, conditional on agreement from both parents of the marrying individuals and the courts. Before this date, marriage was governed by common law. There were 108 observations that were married before 1961 that were also below the age of 18. Additionally, there were 192 that were married after 1961 and below 18 years of age. These 300 observations were excluded from the analysis.

[13] The last cohort of 1984-onwards was not used in the analysis since all the observations were still enrolled in school.

Figure 1: Educational enrolment over an individual's lifetime



Social indicators and Family background: As part of the HILDA survey, individuals were asked about a number of family background indicators. A selection of these was used as explanatory variables in the analysis. These included such variables as the number of siblings an individual had; whether the individual grew up with two parents or was from a divorced home; if the mother/father was working etc. The majority of these were measured when the surveyed individual was 14 years of age. These variables were included to capture social and family background effects and along with the cohort dummies are used primarily to control for unobserved heterogeneity among the individual observations.

4. Estimation Methodology

The estimation methodology in this chapter explores the relationship between education and the age an individual is first married. Accordingly, the dependent variable of interest is age at first marriage as determined by completed years of duration.

The age at first marriage can be interpreted as the duration (T) of moving from a "single-hood" state into that of marriage. Through out this time interval an individual can either marry (fail) or remain single at the time of the survey. An individual who remains single at the end of the survey is described as being "right censored". That is, we know that the period of duration is at least till the time of the survey from the first time the individual became at risk of marriage, but we do not actually observe the individual failing. Censoring requires special treatment in estimating duration times; consequently normal regression procedures such as OLS are not appropriate. Due to the censoring problem, several econometric techniques are used to investigate the above-mentioned relationship.

First, a continuous time event history model is employed to analyse an individual's entry into marriage. The model chosen for this first part of the analysis is a Cox proportional hazard model. The model is described as a semi-parametric model, in that it does not limit the shape of the baseline hazard function, as it is unspecified. The values of the quantitative covariates for individual i, as well as the coding for dummy variables and qualitative variables included in the model, are collected in a q-dimensional vector x_i, with some of the covariates are time varying. We are interested in the influence the covariates have on the duration of an individual. The effects would be collected in a parameter vector β, where β represents the covariate parameters $(\beta_1, \ldots, \beta_n)^T$. T is the duration time from which the individual first became at risk of failing. In the following analysis an individual first becomes at risk of marriage (failing) at age 18.

The hazard rate of the Cox proportional hazard model is specified as:

$$\lambda(t \mid x) = \lambda_0(t)\exp(x'\beta) \qquad (1)$$

Where λ_0 is defined as the "baseline" hazard, which normally requires estimation. No particular shape is assumed for the baseline hazard and it is therefore unknown. The hazard rate is the key concept in survival analysis. It represents the rate of transition into a particular state. In the following analysis the hazard function will measure the transition from being single into being married. The contributions of the covariates to the hazard function are multiplicative, where x_1 captures all time constant covariates and $x_2(t)$ represents all time varying covariates

$$\lambda(t \mid x) = \lambda_0(t)\exp(\beta_1 x_1 + \beta_2 x_2(t)) \qquad (2)$$

where t denotes years.

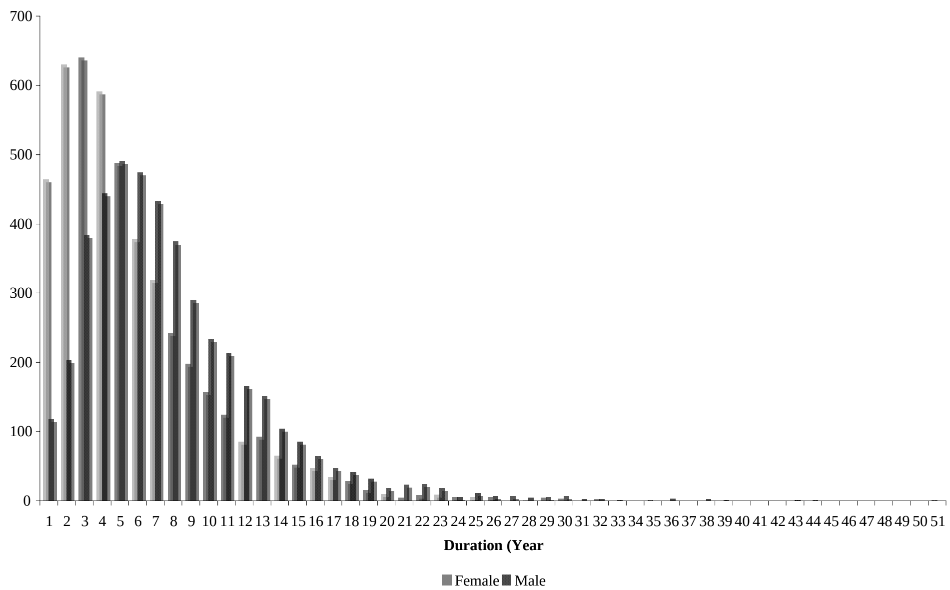
Equation 2 represents the main continuous time specification that is to be estimated in the analysis. Accounting for educational (time varying educational indicators; enrolment dummies), demographic (birth cohort; immigrant background; family background) and attitudinal variables, the equation for estimation will be:

$$\begin{aligned}\lambda(t \mid x) = \lambda_0(t)\exp(&\beta_1 EDUCATIONINDICATORS(t)_i \\ &+\beta_2 ENROL(t)_i + x_i'\beta)\end{aligned} \qquad (3)$$

where $(x_i'\beta)$ represents all other time invariant covariates used in the regression.
The model is estimated and presented in a stepwise regression format. By applying this method to the previously used set of explanatory variables, the new sets of variables are systematically tested to determine whether or not they should be included in the Cox model.

One of the major concerns in relation to the continuous time estimation specification is the number of ties in the survival analysis. Ties are described as where more than one individual fails from the analysis in the same time interval (See Appendix B). Figure 2 presents the frequency distribution of the ties involved in the sample. Due to the large number of ties, especially at earlier ages, the final two specifications of the model are also estimated in a discrete time format. Not only will this treat the large number of ties in a more robust manner, but also confidence in the results should increase if both specifications of the model yield similar results.

Figure 2: Frequency of Failed Durations by



The discrete time model is estimated using a Piecewise Constant format where the time duration is separated into several distinct time intervals[14]. The discrete hazard rate takes the form:

$$h(t, X_i) = 1 - \exp\{-\exp(\beta_0 + \beta' X_i + \gamma' D_j)\} \qquad (4)$$

where: $i = (1,...,N)$, $j = (1,...,K)$

β_0 is an intercept

$\beta' X_i$ represents the impact of time varying and time invariant covariates of choice

$\gamma' D_j$ is a vector of binary dummy variables corresponding to each specific time interval

Given equation 4, the first specification of the discrete time equation to be estimated is as follows:

$$h(t, X) = 1 - \exp\{-\exp(\beta_0 + \beta_1 EDUCINDICATORS(t)_i + \beta 2 ENROL(t)_i + \beta' X + \gamma' D_i)\} \qquad (5)$$

[14] The intervals chosen are: *female* [1-26] [28-30] [32] [35] [51]; *male* [1-33] [36] [38-39] [43-44]. These intervals have been chosen to ensure identifiably of the estimation and exclude all intervals in which no failures took place.

The final specification of the discrete time model is estimated with unobserved heterogeneity. The method used to estimate the individual level unobserved heterogeneity is that suggested by Heckman and Singer (1984) where the distribution of the unobserved heterogeneity is estimated non-parametrically using a multinomial form. In ignoring unobserved heterogeneity the estimates obtained from a non-unobserved heterogeneity model with positive (negative) co-efficients will underestimate (overestimate) the true estimate. In including unobserved heterogeneity equation 4 becomes:

$$h(t,X) = 1 - \exp\{-\exp(m_z + \beta_0 + \beta' X_i + \gamma' D_j + u)\} \quad (6)$$

where: $z = (1,2)$

m_z is the discrete "mass point", with m_1 normalised to 1

u is the error term which is characterised non-parametrically and has an arbitrary distribution

The most common interpretation of the error term is that it measures the impact of omitted variables from the model. The final model specification to be estimated is:

$$\begin{aligned} h(t,X) = 1 - \exp\{-\exp(m_z + \beta_0 + \beta_1 EDUCINDICATOR(t)_i \\ + \beta_2 ENROL(t)_i + \beta' X_i + \gamma' D_j + u)\} \end{aligned} \quad (7)$$

5. Results

5.1. Preliminary Analysis

As mentioned above, the question of interest is how does education effect the age an individual marries. However it is important to begin by asking how educational expansion over the past several decades has affected the level of education attained. Table 2 and Table 3 present the disaggregation of educational attainment by cohort and by sex. Careful inspection of Tables 2 and 3 suggests that there is a monotonic increasing pattern in the level of education achieved across successive birth cohorts. This is the case for both females and males.

Table 2: Educational attainment by selected cohort (Female)

Educational Attainment	Birth Cohort														
	1910 -1914	1915 - 1919	1920 - 1924	1925-1929	1930 - 1934	1935 - 1939	1940 - 1944	1945 - 1949	1950 - 1954	1955 - 1959	1960 - 1964	1965 - 1969	1970 - 1974	1975 - 1979	1980 - 1983
Year 11 or below	36	68	151	189	191	176	220	246	216	216	239	177	151	97	64
	73%	45%	44%	34%	33%	26%	26%	23%	18%	15%	15%	13%	11%	8%	8%
Year 12	2	4	8	21	17	16	10	36	52	75	82	103	82	116	181
	4%	3%	2%	4%	3%	2%	1%	3%	4%	5%	5%	7%	6%	10%	24%
Certificate	6	12	24	45	45	69	87	115	159	180	216	174	180	147	93
	12%	8%	7%	8%	8%	10%	10%	11%	13%	12%	14%	12%	13%	13%	12%
Adv Diploma/ Diploma	3	2	10	17	19	34	38	50	37	75	84	90	76	55	25
	6%	1%	3%	3%	3%	5%	4%	5%	3%	5%	5%	6%	6%	5%	3%
Bachelor	2	3	9	10	21	28	32	51	70	118	105	126	140	164	18
	4%	2%	3%	2%	4%	4%	4%	5%	6%	8%	7%	9%	10%	14%	2%
Grad Cert/ Grad Dip	0	0	0	4	6	7	21	32	42	55	60	49	44	16	1
	0%	0%	0%	1%	1%	1%	2%	3%	4%	4%	4%	3%	3%	1%	0%
Post Grad (Masters, Doctorate)	0	0	0	1	2	6	7	10	19	19	30	19	16	6	1
	0%	0%	0%	0%	0%	1%	1%	1%	2%	1%	2%	1%	1%	1%	0%
Total (N):	49	89	202	287	301	336	415	540	595	738	816	738	689	61	383
Total (%):	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

Table 3: Educational attainment by selected cohort (Male)

Educational Attainment	Birth Cohort														
	1910 -1914	1915 - 1919	1920 - 1924	1925-1929	1930 - 1934	1935 - 1939	1940 - 1944	1945 - 1949	1950 - 1954	1955 - 1959	1960 - 1964	1965 - 1969	1970 - 1974	1975 - 1979	1980 - 198
Year 11 or below	19	34	65	130	114	128	158	157	135	155	175	160	111	97	76
	61%	55%	45%	50%	41%	37%	36%	29%	24%	22%	24%	24%	17%	17%	20%
Year 12	2	5	10	12	9	14	26	44	41	45	48	67	76	114	191
	6%	8%	7%	5%	3%	4%	6%	8%	7%	6%	6%	10%	12%	20%	50%
Certificate	7	16	40	74	102	111	145	168	209	265	279	234	252	200	92
	23%	26%	28%	28%	37%	32%	33%	31%	37%	38%	38%	35%	39%	35%	24%
Adv Diploma/ Diploma	3	6	11	21	29	42	40	54	51	68	71	61	49	46	5
	10%	10%	8%	8%	10%	12%	9%	10%	9%	10%	10%	9%	8%	8%	1%
Bachelor	0	1	11	14	11	21	32	61	71	96	89	97	117	99	14
	0%	2%	8%	5%	4%	6%	7%	11%	12%	14%	12%	15%	18%	17%	4%
Grad Cert/ Grad Dip	0	0	5	7	5	15	14	29	37	40	37	26	18	11	2
	0%	0%	3%	3%	2%	4%	3%	5%	6%	6%	5%	4%	3%	2%	1%
Post Grad (Masters, Doctorate)	0	0	2	3	8	12	19	26	27	36	40	20	22	2	0
	0%	0%	1%	1%	3%	3%	4%	5%	5%	5%	5%	3%	3%	0%	0%
Total (N):	31	62	144	261	278	343	434	539	571	705	739	665	645	569	380
Total (%):	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

Table 2 presents the number of females who have attained a specific level of education segmented by selected birth cohort. Compared to the base cohort of 1910 the changes in education level achieved are quite marked. The percentage of individuals that have only a Year 11 or below qualification has dropped from 73 percent in the earliest cohort to 8 percent in the most recent. In addition the percentage of people who have achieved at least a tertiary qualification has increased from 4 percent in the latest cohort to 14 percent in Cohort 1975.[15]

The pattern is similar for males. The results are presented in Table 3. 61 percent of males in the base cohort had a qualification that was no higher than a Year 11 or below qualification whereas for the younger cohorts only 17 percent of the individuals have achieved only a top education level as high as Year 11. Conversely we observe an opposite trend with higher education levels for males. In the birth cohort 1915 the percentage of individuals that have achieved a qualification as high as a tertiary qualification is only 1 percent of the cohort. By cohort 1975 this percentage has increased to 17 percent.

Now we consider the changes in entry into marriage across successive cohorts in Australia. Tables 4 and 5 present the percentage of individuals remaining single at specific ages. The results are measured for successive birth cohorts and are calculated from the Kaplan Meier survival estimates for each cohort. The Kaplan Meier estimate is a simple way of measuring how many individuals "survive" (or remain single in our question of interest) for at least a given period of time. Computationally, it involves calculating the number of people who failed (married) in the sample at a given point in time as a proportion of those individuals who were still in the sample, or at risk of exiting the sample.[16]

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[15] Educational attainment in Cohort 1980 is initially low since it contains individuals who would not as of yet completed tertiary education. However, they still need to be included in the preliminary analysis since the cohort is 18 and over and considered part of the entire risk set.

[16] Formally, the Kaplan Meier estimate of the survivor function is calculated as: $\hat{S}(t_j) = \prod_{j|t_j<t} (1 - \frac{d_j}{n_j})$. Therefore the Kaplan Meier estimate is the proportion of individuals who enter a state and survive to at least time t_j and is one minus the proportion of those individuals who transitioned (failed) out of that state, d_j, divided by those who were at risk of failing, n_j.

Inspection of Table 4 highlights an interesting pattern. The percentage of women who remain single decreases systematically for each cohort until Cohort 1950. From this point the proportion of people remaining single increases. The largest movement has been for women aged 23, however a similar pattern can be seen throughout each specific age group. In the 1910 cohort only 53 percent of 23 year olds are still single. This rate had fallen steeply to 31 percent for the 1945 cohort. Since this time the rate has been steadily increasing. More markedly, the percentage of those people who are still single in the older age brackets is rising.

Table 4: Changes in entry into marriage at specific ages by birth cohort (Female)

Birth cohort	Proportions of Unmarried individuals at age					
	18	23	28	33	38	43
1910 - 1914	98%	53%	26%	14%	5%	5%
1915 - 1919	96%	46%	16%	5%	2%	2%
1920 - 1924	90%	40%	14%	8%	3%	3%
1925 - 1929	93%	39%	15%	9%	6%	4%
1930 - 1934	87%	30%	9%	5%	4%	4%
1935 - 1939	89%	32%	10%	6%	2%	2%
1940 - 1944	88%	33%	11%	7%	5%	4%
1945 - 1949	90%	31%	13%	8%	7%	6%
1950 - 1954	85%	39%	20%	13%	9%	8%
1955 - 1959	90%	49%	27%	19%	14%	13%
1960 - 1964	93%	56%	29%	19%	15%	12%
1965 - 1969	95%	64%	39%	22%	-	-
1970 - 1974	97%	75%	48%	-	-	-
1975 - 1979	98%	79%	-	-	-	-
1980 - 1983	99%	68%	-	-	-	-

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

A similar pattern for men can also be seen. The results are presented in Table 5. From the earliest cohort to birth cohort 1945 the percentage of men remaining single has decreased. Yet again, the largest movement has been with in the age bracket of 23 year olds and a similar pattern exists across all the specific age groups. In the birth cohort 1910 the percentage of males remain single was 76 percent. By the 1945 cohort this percentage had fallen to 52 percent. However, since this time the percentage of men remaining single has steadily increased.

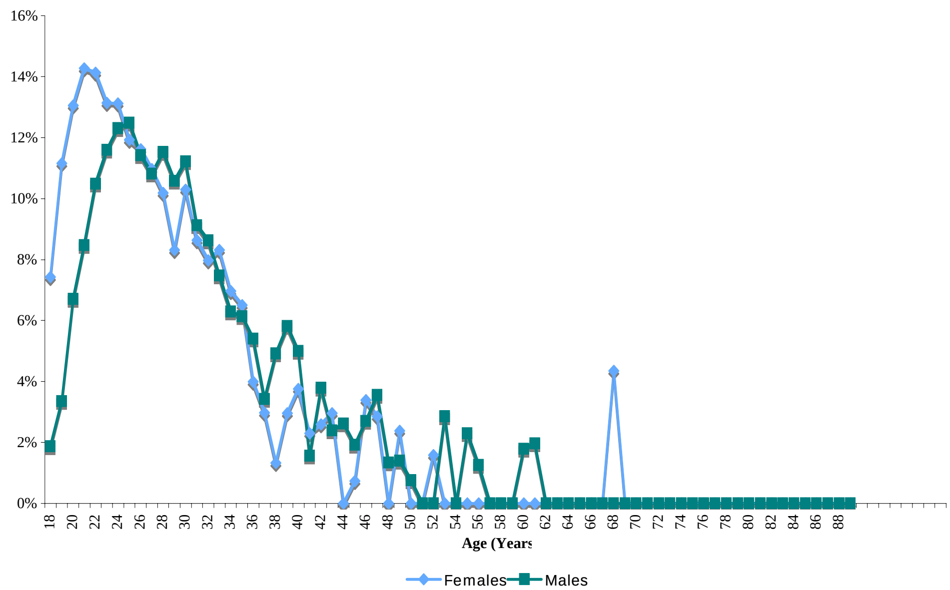
Table 5: Changes in entry into marriage at specific ages by birth cohort (Male)

Birth cohort	Proportions of Unmarried individuals at age					
	18	23	28	33	38	43
1910 - 1914	93%	76%	38%	24%	14%	14%
1915 - 1919	98%	73%	31%	11%	8%	6%
1920 - 1924	99%	68%	29%	13%	8%	6%
1925 - 1929	99%	68%	29%	13%	8%	2%
1930 - 1934	97%	61%	23%	10%	8%	6%
1935 - 1939	97%	62%	25%	13%	9%	6%
1940 - 1944	97%	64%	22%	12%	10%	8%
1945 - 1949	97%	52%	22%	13%	10%	8%
1950 - 1954	96%	59%	28%	16%	12%	10%
1955 - 1959	98%	71%	40%	24%	17%	15%
1960 - 1964	99%	79%	46%	29%	23%	15%
1965 - 1969	98%	81%	51%	32%	-	-
1970 - 1974	99%	87%	58%	-	-	-
1975 - 1979	99%	90%	51%	-	-	-
1980 - 1983	99%	93%	-	-	-	-

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

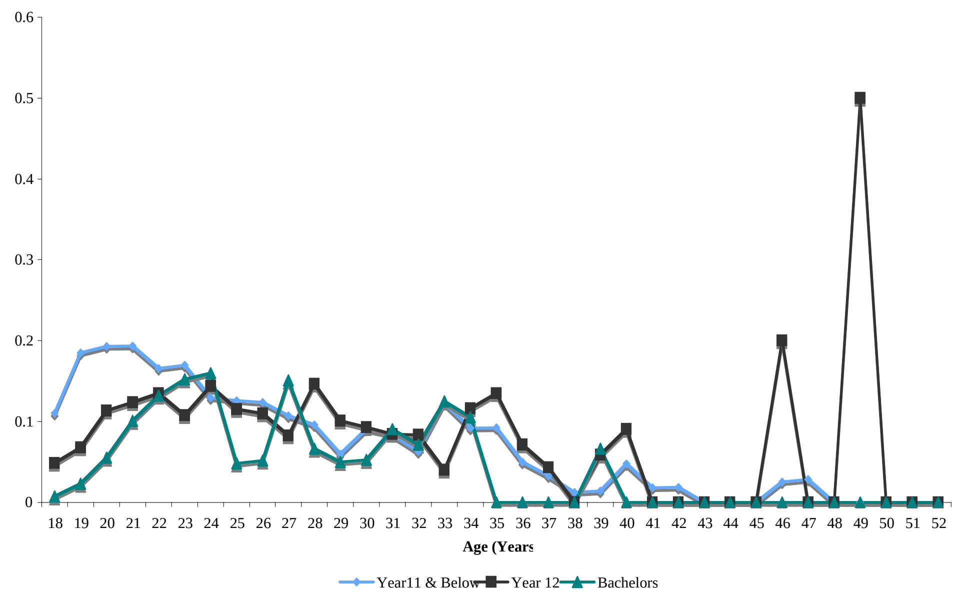
Figure 3 presents the raw hazard function for both males and females. The hazard function (also referred to as the hazard rate) is described as the rate at which individuals transition out of a state. In our example it would be the rate as which individuals transition out of singlehood and into marriage. We interpret the figure in the following way, the higher is the hazard rate, the faster individuals are exiting the singles market, therefore the lower the survivor function, or in other words, the earlier individuals marry. We can see from the graph that females have a higher hazard rate and therefore exit the singles market earlier than males.

Figure 3: Hazard Function by



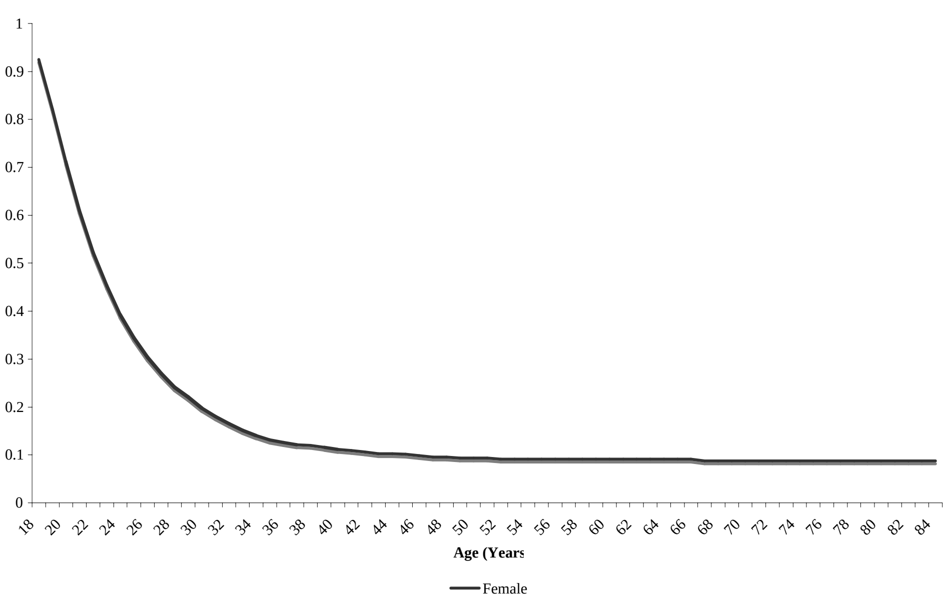
In Figure 4 we further analyse the association between timing of marriage and education level. Figure 4 presents the raw hazard functions for females at certain education levels as calculated by the proxy education variable. Inspection of the graph suggests that there is some evidence to confirm that the higher the education level of females the longer an individual remains single. The way we interpret the figure is as follows. The lower a given hazard rate is, the higher the given survival rate. In other words, the lower the hazard rate, the greater the probability that an individual remains single. For instance those females that have a bachelor's degree have a lower hazard rate than those with Year 12 qualifications Therefore those individuals with a bachelor's degree remain single longer. In addition, those with Year 12 qualifications have the highest hazard function and are therefore more likely to marry earlier, even compared to those females with a Year 11 and below education. This not only seems to provide anecdotal confirmation of the hypothesis that those with low education marry later, but in addition that there is a non-linear effect of education on the timing of marriage.

Figure 4: Hazard Function by Education Level (Fe



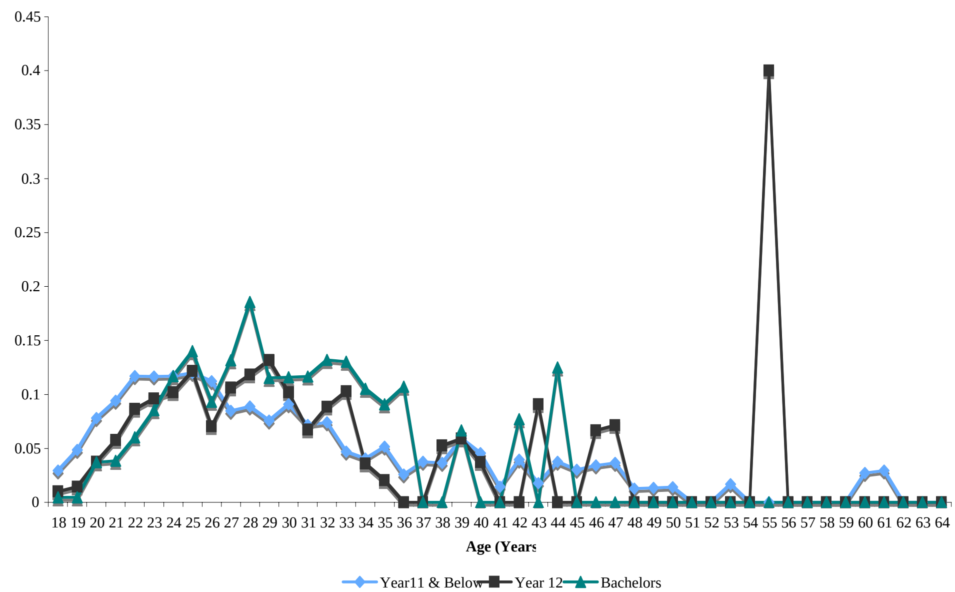
At later years, there are large spikes in the hazard function. This is due to individuals marrying relative to a very small “singles” pool. While this pattern in educational effect on marriage timing may exist, the survivor function for females, presented in Figure 5, shows that most women are married by the age of 28.[17]

Figure 5: Female Survivor Funct



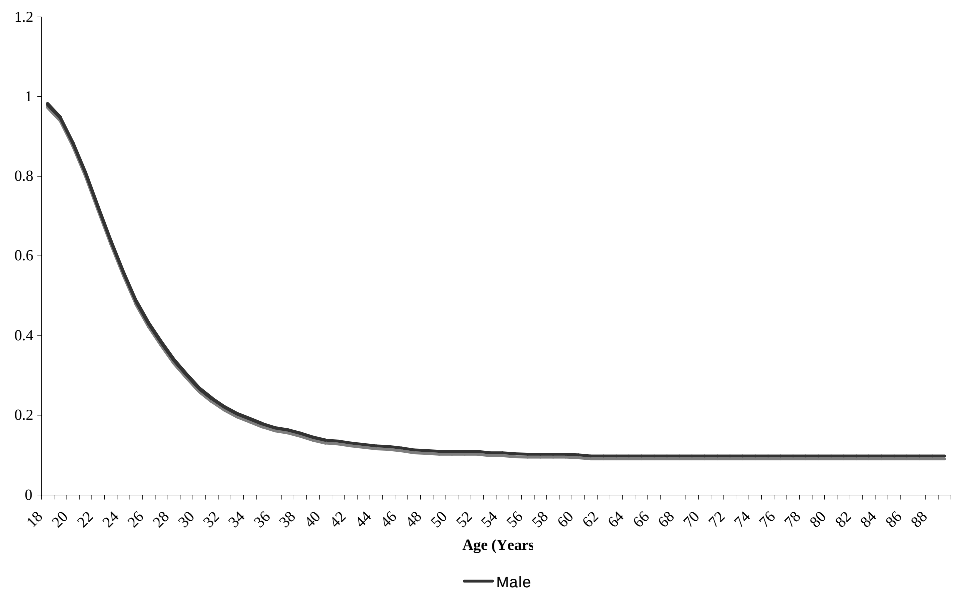
For males the raw hazard functions for various levels of educational attainment at marriage are presented in Figure 6. Inspection of the figure shows a somewhat different pattern to that of females. The hazard functions indicate that those with a Bachelor's degree have a higher hazard rate than those with a Year 12 or Year 11 qualification. Comparing the two lowest educations levels, those with a Year 11 & below qualification have the lowest hazard function. This result is consistent with the hazard rate found for women with a low education level and provides more evidence to suggest that those with a low education do in fact marry later. The survivor function presented in the Figure 7 shows that most men are married by the age of 32.

Figure 6: Hazard Function by Education Level (M



[17] Like the Kaplan Meier estimate, the survivor function measures the probability of being single beyond a specified age.

Figure 7: Male Survivor Funct



5.2. Effects of Education on Age at First Marriage

The detailed analysis below starts by asking how the level of education at marriage affects the time of marriage. A continuous time and a discrete time proportional hazards model are used in the estimation (See Section 3). The results obtained from fitting the Cox model (both with and without time varying variables) are presented in Table 6 and Table 7 respectively, with piecewise constant baseline hazard results (with and without unobserved heterogeneity) presented in Table 8. These differing semi parametric models are presented to show the robustness of our hypotheses to different assumptions about the shape of the baseline hazard function. All model specifications are separated by sex. Standard errors are in parenthesis with significance of the statistic highlighted by an asteric.

The results presented are coefficients. The interpretation of the co-efficients is as follows: a negative co-efficient reduces the hazard rate and therefore increases the survival function. A negative co-efficient is therefore attributed to a longer duration of "singlehood". Conversely the opposite is the same; a positive co-efficient translates into a decreased survival function and therefore an individual marries earlier. In addition, we can further interpret the effect of the coefficient by examining the percentage change in the underlying hazard rate, given a one-unit increase in the coefficient.[18] If the value of coefficient β_i is increased by one unit, then the underlying hazard rate changes by the following equation:

$$\zeta_\Delta = (\exp(\beta_i) - 1) \times 100 \qquad (8)$$

For example, the coefficient on the Year 12 dummy variable has a positive sign. (See Table 6, Specification 1). Compared to the lowest educated (ie Year 11 and below) the tendency to get married for those individuals who are educated to a Year 12 level is

$$\begin{aligned} \zeta_{Yr12} &= (\exp(0.184) - 1 \times 100 \\ &= 20.2\% \end{aligned} \qquad (9)$$

The preferred specification of the model is the Piecewise Constant (with unobserved heterogeneity) estimation (Specifications 10 and 12). Firstly, since the estimation of the baseline hazard is semi parametric, the form of the baseline hazard is flexible and is not as restrictive as parametric forms of the model such as Weibull and Gamma models. Secondly, significance tests show that the estimated value of the unobserved heterogeneity is significant at the 1 percent level and finally, the robustness checks (See Section 6) conducted on the continuous time specification of the model reveal that the proportionality assumption is violated by several variables and more importantly at the global level as well.[19]

5.2.1. Time invariant educational indicators

Now turning attention to Table 6. Specification 1 of the model shows the effect of the education variables only on the hazard rate when modelled by the Cox proportional hazard model in continuous time. The education variable indicators are the only explanatory variables. At this stage of the analysis the education indicators are static (i.e. do not vary with time).[20] This specification will act as our base model for comparison. Standard errors are presented in parenthesis. All co-efficients are significant at the 1 percent level for females. As predicted by economic theory the sign

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[18] These are sometimes referred to as α effects and take the value of 1 when the variable has no effect upon the underlying hazard rate ($\beta_i = 0$). If the variable exhibits diminishing $\beta_i < 0$ or and increasing $\beta_i > 0$ influence then the effect on the hazard rate will be smaller than or greater than 1.

[19] One of the methods of correcting for this is to stratify the model by the variables that are violating the proportional hazard assumption. This is not an optimal choice for this paper since stratifying does not allow for comparisons across co-efficients. Stratifying results are however presented in the appendix.

[20] This point will be addressed in the following sub-section.

Table 6: Specifications [1] to [4]: Timing of Marriage fitting Cox PH Model without ti

	Specification 1		Specification 2		Specification 3		Specification 4	
	Female	Male	Female	Male	Female	Male	Female	Male
Yr12	0.184***	0.207***	0.276***	0.213***	0.516***	0.422***	0.502***	0.479***
	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.06)
Certificate	-0.426***	0.012	-0.209***	0.108***	-0.059	0.234***	-0.075	0.248***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Dip/Adv.Diploma	-0.547***	0.084	-0.275***	0.192***	-0.153**	0.261***	-0.181***	0.301***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Bachelors	-0.629***	-0.078	-0.261***	0.088	-0.078	0.274***	-0.101*	0.323***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
Grad.Cert/Dip	-0.819***	-0.017	-0.408***	0.218***	-0.332***	0.285***	-0.354***	0.323***
	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Masters/PhD	-1.221***	-0.331***	-0.688***	0.024	-0.575***	0.124	-0.599***	0.200**
	(0.15)	(0.09)	(0.16)	(0.10)	(0.16)	(0.10)	(0.16)	(0.10)
enrol (t)			-0.833***	-0.703***	-0.793***	-0.752***	-0.785***	-0.756**
			(0.06)	(0.07)	(0.06)	(0.07)	(0.06)	(0.07)
cohort1915					0.172	0.229	0.212	0.213
					(0.19)	(0.23)	(0.19)	(0.23)
cohort1920					0.274	0.212	0.294*	0.156
					(0.17)	(0.21)	(0.17)	(0.21)
cohort1925					0.257	0.273	0.262	0.220
					(0.16)	(0.20)	(0.17)	(0.20)
cohort1930					0.489***	0.368*	0.493***	0.326
					(0.16)	(0.20)	(0.17)	(0.20)
cohort1935					0.504***	0.309	0.535***	0.278
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1940					0.501***	0.322	0.522***	0.263
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1945					0.449***	0.371*	0.483***	0.324
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1950					0.316**	0.225	0.343**	0.149
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1955					0.073	-0.041	0.110	-0.124
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1960					-0.029	-0.218	0.014	-0.282
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1965					-0.215	-0.358*	-0.141	-0.411**
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1970					-0.503***	-0.608***	-0.418**	-0.640**
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1975					-0.823***	-1.114***	-0.704***	-1.101**
					(0.17)	(0.22)	(0.17)	(0.22)
cohort1980					-1.675***	-1.559***	-1.484***	-1.508**
					(0.29)	(0.40)	(0.29)	(0.41)
Immigrant Variables	NO	NO	NO	NO	NO	NO	YES	YE
Family Background	NO	NO	NO	NO	NO	NO	YES	YE
No. Observations	44080	57515	44080	57515	44080	57515	44080	5751
$\chi 2$	537.1	42.1	760.14	151.38	1440.11	753.85	1542.87	867.
log Likelihood	-37438.645	-35831.37	-37347.128	-35776.733	-37007.143	-35475.498	-36955.759	-35418.

*Notes: 1. Standrd Errors are presented in parentheses. 2. *** singnificant at 1% level, ** significant at 5% le cohort effects is Birth cohort 1910 4. Base category for education variables is Yr11 & below*

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

of the co-efficients for females is negative except for those individuals with a Year 12 education. Compared to those with a Year 11 & below education, individuals with Year 12 education marry earlier. Females with higher education levels will marry later. Conversely for males, only those with a Year 12 education and a Masters/PhD qualification have a “singlehood” duration that is significantly different from those with a Year 11 & below qualification. Those that have a Year 12 education marry earlier while those with a Masters/PhD marry later.

We augment Specification 1 by introducing the time varying variable “enrol” into the analysis. The introduction of the enrolment variable provides a way of interpreting the enrolment effect of education on marriage. As can be seen from the results presented in Specification 2 of Table 6, the enrolment variable has a significant effect on the time to marriage. For both females and males alike the co-efficient for enrolment is negative which suggests that enrolment in an educational institution delays marriages. In addition for males, the inclusion of the enrolment variable increases the effect of the education variables. No longer is the delaying effect of marriage for those males with a Masters/PhD significant. This suggests that the majority of the delaying effect for males is in fact driven by the enrolment effect, with further evidence of this is provided by the education level variables. All the co-efficients on the education variables for males are positive with a majority of them significantly decreasing the age at which a male enters first marriage.

Social, family background and attitudinal variables are next introduced into the model. The extended models are presented as Specification 3 and Specification 4 in Table 6. In these specifications of the model the main variables of interest (education level dummies; enrolment) are negative (with the except of Year 12) and significant for females. The results also indicate a non-linear effect of education on the timing of marriage for females only. Those with a high education have a lower hazard function and therefore marry later compared to those with a Year 11 & below qualification. Year 12 educated females marry earlier. Furthermore, turning our focus to Specification 4, the results indicate that, for each level of educational qualification achieved at entry into marriage, those individuals with a Year 12 education increase their risk of marriage (exit) by 65 percent. However, compared to those individuals with Year 11 and below, those females that have an education that is higher than a Year 12 qualification, their risk of exit is reduced. Those with a Certificate; Dip/Advance Dip; Bachelors; Grad Cert/Diploma; and Masters/PhD all decrease their risk of marriage by 7.2 percent; 16.5 percent; 9.6 percent; 29.8 percent and 45 percent respectively thereby providing some evidence of a non linear effect of education on the risk of marriage.

For males, we see that all education levels compared to our base category of Year 11 and below are positive and significant. For males, after including all control variables of choice it can be seen from the results that at all levels of education males will significantly marry earlier compare to those with a Year 11 & below qualification once enrolment is controlled for. Therefore compared to those with a year 11 and below education, those males with a Year 12; Certificate; Dip/Advance Dip; Bachelors; Grad Cert/Diploma; and Masters/PhD all increase their risk of marriage by 61.4 percent; 28.1 percent; 35 percent; 38.1 percent; 38.1 percent and 22.1 percent respectively.

Again we can see that the enrolment effect as captured by the enrolment variable is negative and indicates that for both genders being enrolled in education significantly increases the age at first marriage. Enrolment in an educational institution has a negative a significant impact on the time into marriage for both males and females. As stated previously, we are interpreting this effect as the “enrolment effect” of education on marriage. For both female and males alike the risk of marriage from being enrolled in education is quite similar and is decreased by 54.4 percent and 53 percent respectively.

In summary, when modelling the duration of singlehood using a continuous time proportional hazard model with time invariant educational indicators and time varying enrolment variable, we find some evidence to support our main hypotheses. First, we find evidence to suggest that there is significant delaying effect of educational attainment and enrolment on marriage for females. Furthermore we also find evidence that the enrolment effect as captured by the “enrol” variable re-enforces the human capital effect. Second, males with a higher education significantly marry earlier with enrolment in education significantly delaying marriage, thereby providing evidence that the enrolment effect and human capital effects work against each other in the case of men. Finally, we find evidence of a non-linear effect of education on the risk of marriage for females only.

5.2.2. *Time varying educational indicators*

A limitation with the analysis so far is that it assumes that the level of education that an individual attains at marriage is not timing varying. That is, the level of education at marriage at the end of an individuals duration, as measured by whether or the individual had failed or was censored, is used to predict the conditional probability over the entire length of duration. This does not seem reasonable. Given than an individual in the analysis first falls at risk of marriage at age 18, when the only formal education completed up until that point is Year 12, and the survivor functions indicate that the vast majority of people marry later than this age, it is reasonable to assume that education attainment is still continuing throughout the duration period. To account for the limitation in the analysis, the education variables are interacted with time to capture the fact that educational attainment does indeed vary with time.

In calculating the effect of the time varying covariates on the underlying hazard rate there is one major assumption underpinning it. The time dependant covariates may change their values continuously over the entire duration. In general, however, educational attainment does not change continuously over time. It is much more likely to be characterised by a step function (see Figure 1) and therefore influence the rate with a given episode. To account for this we introduce the time vary education variables as discrete time dependant covariates by "episode splitting" the data at each of the failure times, thereby allowing us to specify at for time period what education level an individual has. Results of this current method are presented in Table 7.

Similar to Specifications 1 through to 4, Specifications 5 to 8 introduce the continuous time Cox Proportional hazard model with time varying education dummies in a stepwise format with Specification 5 providing a base model for comparison. Specification 5 introduces the time varying education level dummies only. The results indicate that compared to our base category that females with an education equal and above a Year 12 level decrease their risk of exit from singlehood to marriage. Excluding the Year 12 coefficient, the results are in the same direction as those presented in Specification 1, although their magnitude is much less. Results for males indicate that they are more likely to marry earlier, compared to year 11 and below educated individuals. The results (and more specifically, the standard errors) also indicating that

Table 7: Specifications [5] to [8]: Timing of Marriage fitting Cox PH Model with time va

	Specification 5		Specification 6		Specification 7		Specification 8	
	Female	Male	Female	Male	Female	Male	Female	Male
Yr12 (t)	-0.264***	-0.035	0.103**	0.071	0.325***	0.264***	0.320***	0.323***
	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.05)	(0.06)
Certificate (t)	-0.284***	0.071**	-0.056	0.166***	0.090**	0.295***	0.083*	0.311***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Dip/Adv.Diploma (t)	-0.286***	0.193***	-0.036	0.288***	0.085	0.359***	0.074	0.405***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Bachelors (t)	-0.471***	-0.061	-0.096*	0.123**	0.079	0.304***	0.079	0.362***
	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Grad.Cert/Dip (t)	-0.313***	0.300***	0.021	0.473***	0.102	0.549***	0.109	0.597***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Masters/PhD (t)	-0.631***	0.032	-0.145	0.333***	-0.036	0.449***	-0.037	0.532***
	(0.15)	(0.09)	(0.16)	(0.09)	(0.16)	(0.09)	(0.16)	(0.10)
enrol (t)			-1.113***	-0.763***	-1.100***	-0.831***	-1.088***	-0.833**
			(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)
cohort1915					0.157	0.219	0.200	0.196
					(0.19)	(0.23)	(0.19)	(0.23)
cohort1920					0.260	0.196	0.281*	0.137
					(0.17)	(0.21)	(0.17)	(0.21)
cohort1925					0.233	0.253	0.234	0.196
					(0.16)	(0.20)	(0.17)	(0.20)
cohort1930					0.459***	0.330	0.463***	0.283
					(0.16)	(0.20)	(0.17)	(0.20)
cohort1935					0.474***	0.281	0.505***	0.245
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1940					0.442***	0.295	0.458***	0.233
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1945					0.414***	0.344*	0.447***	0.290
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1950					0.291*	0.183	0.309*	0.102
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1955					0.032	-0.086	0.058	-0.173
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1960					-0.064	-0.254	-0.030	-0.322
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1965					-0.241	-0.382*	-0.175	-0.437**
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1970					-0.532***	-0.626***	-0.454***	-0.660**
					(0.16)	(0.20)	(0.16)	(0.20)
cohort1975					-0.825***	-1.117***	-0.709***	-1.108**
					(0.17)	(0.22)	(0.17)	(0.22)
cohort1980					-1.580***	-1.519***	-1.395***	-1.467**
					(0.29)	(0.40)	(0.29)	(0.41)
Immigrant Variables	NO	NO	NO	NO	NO	NO	YES	YE
Family Background	NO	NO	NO	NO	NO	NO	YES	YE
No. Observations	44080	57515	44080	57515	44080	57515	44080	5751
χ2	124.19	32.27	611.31	181.52	1259.93	770.2	1362.28	884.
log Likelihood	-37665.1	-35836.289	-37421.539	-35761.66	-37097.23	-35467.319	-37046.054	-3541.

*Notes: 1. Standrd Errors are presented in parentheses. 2. *** singnificant at 1% level, ** significant at 5% leve*
cohort effects is Birth cohort 1910 4. Base category for education variables is Yr11 & below
Source: Hous cohort effects is Birth cohort 1910 4. Base category for education variables is Yr11 & below

those with a Year 12 and Bachelors degree are no more likely to marry earlier or later than Year 11 educated individuals.

Next we introduce Specification 6, which now included the time varying variable "enrol" into the estimation. The results, compared to our base model have changed quite markedly. It is important to pause here for a moment to highlight the fact we need to interpret our results with extreme caution since school enrolment and educational accumulation are closely related. Thornton *et al* (1994) point out that those individuals that are enrolled in an educational facility are more likely, on average, to accumulate educational qualifications. As a result, the time varying educational dummy variables could capture some of the effect of educational enrolment since they go hand in hand. For a further discussion, see Section 6.

For females only those with a bachelors degree have a significant decrease in their risk of exit. Interestingly though, those with a Year 12 education are now more likely to marry significantly earlier thereby providing some evidence of a non-linear human capital effect at tertiary educational attainment levels. Once again for males we see at every education level that they are likely to marry earlier once being enrolled in an educational facility is taken into account. The time vary enrolment variable for both males and females indicates that they are more likely to marry later if enrolled in an educational institution.

Finally, we introduce into the estimation cohort effect, Immigrant and family background variables, which are presented in Specification 7 and Specification 8 in Table 7. However, the following commentary will concentrate on Specification 8 only. Results of our full, time varying specification reveal a different story from the results presented in Specification 4. Firstly for males, the results indicate a very similar story to that told by our previous specifications. That for every level of educational attainment above a Year11 education, individuals marry earlier. If a male were to hold a Year 12; Certificate; Dip/Adv Diploma; Bachelors; Grad.Cert/Diploma or Masters/PhD, their risk of exiting singlehood state would increase by 38.1 percent; 36.5 percent; 50 percent; 43.6 percent; 81 percent and 70.2 percent respectively. The enrolment variable indicates, however, that a there is significant delaying effect associated with educational enrolment, with the co-efficient indicating that a males risk of exit is decreased by 56.5

percent. Therefore, similar to our previous time invariant model, we find some evidence that for males the human capital effect and enrolment effects work against each other.

The story being told for females is quite different though. The results show that there is a significant delaying effect induced by educational enrolment, with the magnitude of the co-efficient decreasing the exit to marriage by 66.3 percent. Once this is controlled for, that educational attainment (excluding Year 12 and Certificate level) has no significant delaying effect different from holding a Year 11 qualification. This result is in complete contrast to our previous fully specified model.

To summarise, Once again we find evidence to suggest that, compared to year 11 or below educated males, highly educated males marry earlier with a significant delaying of marriage associated with enrolment. This provides more evidence of our hypothesis that the enrolment and human capital effects work against each other for males. However, for females we find evidence of a negative human capital effect associated with enrolment only, thereby providing no evidence of the enrolment and human capital effects reinforcing each other. In fact for those females that have a Year 12 or Certificate education, similar to males, the two effects work against each other.

These results are presented with two important caveats in mind though. First, as stated earlier, we believe that some of our educational attainment information may also be captured by our enrolment variable. Although simple correlation measures suggest that the relationship is weak, it is much more likely that those who are enrolled are acquiring more formal qualifications. Second, we have not taken into account unobserved heterogeneity. Ignoring unobserved heterogeneity is likely to under (over) estimate a positive (negative) co-efficient (See Lancaster 1990). Although, following, we account for individual unobserved heterogeneity within the sample by estimating our problem using a piecewise constant econometric framework, these two caveats imply that the magnitude, interpretation and robustness of our results need to be viewed with some scepticism.

5.2.3. Discrete Piecewise Constant models with and without unobserved heterogeneity.

We further investigate the timing of marriage subject to education in a discrete time framework that allows us to take into account individual level unobserved heterogeneity. Results are presented in Table 8, where only the full model is specified.[21] Specification 9 presents the results of the piecewise constant model without unobserved heterogeneity accounted for with Specification 10 presenting the results with unobserved heterogeneity.

The first main implication presented in the results is the stark differences of educational attainment on the exit rates from being single to being married between females and males. Firstly for males, when controlling for education level and enrolment the magnitude of the results does not differ much whether or not unobserved heterogeneity is account for. Results indicate that education levels above Yr11 & below are associated with higher exit rates from singlehood to first marriage. In addition there is a significant delaying effect of exit into marriage induced by enrolment. This result is consistent with the theory presented in Section 2 and our previous results estimated under the continuous time Cox PH model. To recapitulate, the theory for males predicted a delaying effect in the marriage decision associated with the enrolment effect, which in turn would be offset by the human capital effect. That is, the delaying decision for males would be less pronounced since each effect worked against each other. The results presented for males show that the enrolment effect (enrolment) significantly delays entry into first marriage at the 1 percent level whereas the human capital effect (as captured by the education variables) works in the opposite direction, that is, it significantly increases exit into first marriage.[22]

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[21] For completeness, estimation results from a discrete time model, which excludes the "enrol" variable, are presented in the Appendix.

[22] All co-efficients attributed to education levels are significant at the 1 percent level. The base category for comparison is those individuals with an education level of Yr11 & below.

Table 8: Specifications [9] to [10]: Timing of Marriage fitting PieceWise Constant Model w time varying education and enrolment

	Specification 9 (w/o Unobserved Hetro.)		Specification 10 (with Unobserved Hetro.)	
	Female	Male	Female	Male
Yr12 (t)	0.350***	0.338***	0.472***	0.443***
	(0.05)	(0.06)	(0.06)	(0.07)
Certificate (t)	0.089*	0.328***	-0.016	0.34***
	(0.05)	(0.04)	(0.06)	(0.05)
Dip/Adv.Diploma (t)	0.076	0.427***	-0.006	0.468***
	(0.06)	(0.06)	(0.08)	(0.08)
Bachelors (t)	0.078	0.378***	-0.080	0.321***
	(0.06)	(0.06)	(0.08)	(0.08)
Grad.Cert/Dip (t)	0.112	0.631***	0.026	0.740***
	(0.08)	(0.08)	(0.11)	(0.11)
Masters/PhD (t)	-0.046	0.555***	-0.392	0.436***
	(0.16)	(0.10)	(0.20)	(0.13)
enrol (t)	-1.165***	-0.858***	-1.175***	-0.891***
	(0.05)	(0.06)	(0.06)	(0.07)
cohort1915	0.215	0.210	0.232	0.368
	(0.19)	(0.23)	(0.25)	(0.30)
cohort1920	0.293*	0.147	0.503**	0.284
	(0.17)	(0.21)	(0.23)	(0.28)
cohort1925	0.252	0.212	0.459**	0.337
	(0.16)	(0.20)	(0.22)	(0.26)
cohort1930	0.501***	0.308	0.786***	0.547**
	(0.16)	(0.20)	(0.22)	(0.26)
cohort1935	0.544***	0.266	0.811***	0.565**
	(0.16)	(0.20)	(0.22)	(0.26)
cohort1940	0.505***	0.256	0.795***	0.525***
	(0.16)	(0.20)	(0.22)	(0.26)
cohort1945	0.483***	0.315	0.808***	0.694***
	(0.16)	(0.20)	(0.22)	(0.26)
cohort1950	0.326**	0.109	0.710***	0.432*
	(0.16)	(0.20)	(0.22)	(0.26)
cohort1955	0.058	-0.179	0.315	-0.037
	(0.16)	(0.20)	(0.22)	(0.26)
cohort1960	-0.040	-0.336*	0.123	-0.265
	(0.16)	(0.20)	(0.21)	(0.25)
cohort1965	-0.194	-0.457**	-0.183	-0.438*
	(0.16)	(0.20)	(0.21)	(0.25)
cohort1970	-0.487***	-0.688***	-0.498**	-0.685***
	(0.16)	(0.20)	(0.21)	(0.26)
cohort1975	-0.759***	-1.143***	-0.709***	-1.039***
	(0.17)	(0.22)	(0.22)	(0.27)
cohort1980	-1.464***	-1.491***	-1.305***	-1.308***
	(0.29)	(0.41)	(0.32)	(0.44)
Unobserved Hetro.		Prob		
Immigrant Variables	YES	YES	YES	YES
Family Background	YES	YES	YES	YES
No. Observations	44366	57492	44366	57492
log Likelihood	-13962.47	-14621.43	-13939.144	-14593.35

*Notes: 1. Standrd Errors are presented in parentheses. 2. *** singnificant at 1% level, ** significant at 5% level, * 10% level. 3. Base category for cohort effects is Birth cohort 1910 4. Base category for education variables i*
Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

Now turning our attention to females, when controlling for enrolment and education only the results indicate that for those individuals with a Year 12 and Certificate level qualification, they are more like to exit into marriage earlier, compared to the reference group (Year 11 and below). The results also indicate a significant delaying effect of marriage induced by enrolment. We therefore find not evidence of our main hypothesis. That is, for females the human capital effect and enrolment effect reinforce each other.

However, once individual level unobserved heterogeneity is taken into account, results still indicate that for those individuals with a Year 12 education are more likely to exit singlehood earlier compared to those with a Year 11 & below education. Although the standard errors indicate that the results are not significant, educational attainment above this level is attributed to a delaying in female entry into marriage.[23] Once again the results provide some evidence to support the theory presented in the earlier sections. Unlike males, the theory suggested that the delaying effect of education on marriage would be more pronounced since the enrolment effect, as measured by the enrolment variable would work in the same direction as the human capital effect. The results of the preferred model indicated that there is a significant delaying in exit rates of females into first marriage attributed to enrolment. The co-efficient is significant at the 1 percent level.

To summarise, our preferred specification of the model for both males and females accounts for unobserved heterogeneity. Once again for males we find evidence to support our main hypothesis that the enrolment effects and the human capital effects work against each other. For females, we find weak evidence to support the hypothesis that the two effects reinforce each other with some evidence of a non-linear effect of education on entry into marriage.

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[23] Although the co-efficients attributed to Certificate, Diploma, Bachelors Degree and Grad.Certificate/Grad.Dip are not statistically significant; the co-efficients are negative and have the expected sign.

6. Robustness Checks

6.1. Residual Analysis

The proportional hazard assumption was tested using the Schoenfeld residuals for the continuous time specification (Specification 8) of the model. In particular the tests indicate that the proportionality assumption is violated by several individual variables, which include a number of the educational level dummies and the cohort indicators for both the female and male versions of the model. In addition the null hypothesis of proportional hazards is rejected at the 1 percent level for the global model as a whole.

A common method to correct for this is to stratify the sample by those covariates that violate the proportionality assumption. We do not undertake this in this analysis since it does not allow us to make comparison across covariates and different models.
A plot of the Cox-Snell residuals suggests that the data is not a good fit for the continuous time model. See Appendix B for a full description. Accordingly our preferred specification of the model is the piecewise constant model. Since the results indicate that unobserved heterogeneity is a problem, we conclude that our preferred model accounts for unobserved heterogeneity.

6.2. Co-linearity in Time Varying Education and Enrolment

In the previous section, we presented a caveat regarding our results estimated using the time varying education and enrolment dummies. We suspect that some of the enrolment information is captured by the time varying education dummy variables. To highlight this point and investigate it's possible effect on our estimation, Table 9 presents results of the correlations between the time varying education dummies and the enrolment dummy. The co-efficients indicate that the correlation between the variables is weak. However, it is also important to investigate how robust the results are, given this caveat. For both the continuous time Proportional Hazard model and the discrete time piecewise constant model, we find that the results are robust to the change on specification for males but differ for females to our full specifications (Specification 8 and 10 respectively) when the enrolment variable is excluded from the analysis. Results and further discussion are presented in Appendix E.

Table 9: Correlation of Time varying Education dummies

Pooled	
	enrol
enrol	1.0000
yr11t	-0.2375
yr12t	0.3761
certt	-0.0298
dipt	-0.0618
bacht	-0.0107
graddipt	-0.0454
mastphdt	0.0153

Female	
	enrol
enrol	1.0000
yr11t	-0.2692
yr12t	0.4323
certt	-0.0396
dipt	-0.0673
bacht	-0.0242
graddipt	-0.0642
mastphdt	0.0013

Male	
	enrol
enrol	1.0000
yr11t	-0.2126
yr12t	0.3281
certt	-0.0218
dipt	-0.0578
bacht	0.0003
graddipt	-0.0277
mastphdt	0.0251

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

6.3. Comparisons with the earlier literature

Much of the literature in this field uses parametric estimation to investigate the timing of marriage subject to education. To our knowledge, there has been little work done in this field in an Australian context and therefore there is no work for a direct comparison. However, the same question has been investigated in other countries, both developed and developing.

In general, our findings are in line with results found by other authors. Most authors find a significant delaying effect of marriage (and child birth) induced by higher education. Keeley (1979), Brien and Lillard (1994) and Gangadharan and Matira (2003) all find a significant delaying effect of education on the timing of first marriage. Our results are no different in that we find a significant delaying effect on age at first marriage indivuced by higher education. However, the magnitude of our results are not directly comparable, especially with the work done my Lillard & Brien and Gangadharan & Matria since their work is primarily focused on primary and junior secondary educational effect in developing countries.

Of the authors who investigate the effect of enrolment on marriage, they all find that enrolment also significantly delays marriage. Blossfeld and Jaenichen (1992) and Thornton *et al* (1995) find a significant delaying effect of enrolment for females and males. Our results confirm the same for both females and males alike, with the effect much stronger for females. For an extended discussion on the comparison of existing empirical research and further estimations using the common parametric models popular in the empirical literature, please see Appendix F.

7. Conclusions

This paper investigates the relationship between education, enrolment and the length of time to takes for an individual to enter into their first marriage upon turning 18 years of age. Much of the existing literature suggests that the higher is ones education the older they will be when they get married. Moreover, the theory in this area suggests that there are two effects driving this delay in marriage, namely the human capital effect and the enrolment effect. The theory predicts two different effects for the different genders. For females the two effects reinforce each other, where for males, the two effects work in the opposite directions. Additionally, the theory in the field assumes that one individual to a partnership can financially support the partnership, but this may not be the case for low educated individuals. Therefore, we would expect to see some sort of non-linear effect of education on the timing of marriage.

These questions were investigated by employing for the first time in an Australian context, a semi parametric duration approach. Our results indicate that the human capital effect of obtaining formal educational qualifications for females is associated with a lower exit rates from singlehood into marriage. The results also indicate that the higher the education level obtained, the stronger the effect. However, we find that the opposite is true for males. Each education level for males is associated with a higher exit rate into marriage. In addition, we find some weak evidence to suggest that there is a non-linear relationship between education and time to marriage for females only.

It was also found that the enrolment effect, as measured by being enrolled in an educational facility in each specific time period, was associated with lower exit rates into marriage. This was the case for both genders with the strength of the effect being much more significant for females than for males.

Finally, our results are robust to several changes in specification, especially for males. We account for unobserved heterogeneity amongst individuals and show that our duration dependence may be a result of unobserved heterogeneity. This suggests that either unobserved characteristics are potentially important or that there is some selection occurring.

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Appendix A – A Search Theoretical Framework

The following economic model is designed to explain the theory of the marriage market and is based on a one sided search model by Ermisch (2003).

A Market for Partners

The marriage market consists of two separate individuals, female, f, and male, m, who partner from a population of other suitable females and males. Each individual has certain attributes that make him or her desirable to their future partner. We can summarize the relative desirability of each potential partner in an "Attractiveness" function, B_i, where B_i is a weighted sum of the value of each characteristic. The weighting of the attributes of any potential partner are governed by their own preferences.

Each individual brings these characteristics into the marriage. These traits range from quantitative in nature such as years of education, level of parent's education and pre-marital wealth through to qualitative factors, which include charisma, attractiveness and sexual attitudes. This paper will only focus on those quantitative factors, wealth and human capital.

Optimal Search Strategy: The model

Firstly, the search for a partner is categorised by a two-stage process. An individual decides whether or not to enter the marriage market and upon doing so, proceed via a sequential search pattern for a suitable partner. Each individual has a utility function that captures wealth and human capital. Marital offers from potential partners happen at rate α and is determined via a Poisson process. In each time period, Δ, an individual encounters n potential partners. Therefore the probability of meeting n potential partners is defined by a Poisson density function and is given by the following equation:

$$A(n,\Delta) = (\alpha\Delta)^n \exp\frac{(-\alpha\Delta)}{n!} \qquad \text{(A1)}$$

As a simplifying assumption, we assume that a person can only receive one offer per time period. Upon meeting a potential partner, an individual can either make an offer and stop the search process or try a new potential partner in the next period, Δ'.
We assume that each individual can fully observe any potential partners B, therefore their own utility if the match occurs, which we denote U. The probability of an individual i receiving an offer less than U is denoted by $F_i(U)$, which has a uniform distribution. That is, all offers between the maximum and minimum offer are just a likely. In addition we assume that the action of marriage is a risk-less undertaking. That is, once married, the union lasts indefinitely. Therefore divorce is not taken into account. Although this assumption is highly stylised, and grossly unrealistic, it is consistent with the structure of the data for wave one of the HILDA survey and is enforced primarily for computational ease.[24]

We can now derive an individuals discounted lifetime utility if an individual decides to take an offer and marry.

$$V_{iM} = \frac{U}{r} \qquad \text{(A2)}$$

Where V_{iM} is the discounted utility from marrying, U is the utility from accepting an offer and r is the discount rate.

The utility for individual i being single is the utility of being single, u_i, the probability of receiving an offer, α_i, which will only be accepted if and only if the utility from being married, V_{iM}, is greater than that derived from remaining single, V_i. Therefore:

$$V_i = \frac{u_i + (1-\alpha_i)V_i + \alpha_i E \max\{V_i, V_{iM}\}}{1+r} \qquad \text{(A3)}$$

where E is an expectations operator. If we simplify and rearrange, and substituting in A2 and $rV_i = R_i$ we get

$$R_i = u_i + \alpha_i \frac{[E \max\{R_i, U\} - R_i]}{r} \qquad \text{(A4)}$$

[24] Ermisch shows that the divorce not only creates a utility loss, but also in addition decreases the value of a marriage as its (divorce) risk increases. See Ermisch (2003): 137 - 140

R is described as the "reservation wage" or "reservation offer" and states that if the utility of an offer, x, is greater than the reservation wage, then the individual should accept the offer. All other offers less than x will be rejected. Ermisch (2003) shows that the equation (A4) can be written as:

$$R_i = u_i + \frac{\alpha_i}{r}\int_{R_i}^{\infty}(x - R_i)dF_i(x) \qquad \text{(A5)}$$

with the integral representing the gains from a marriage offer. Hence, in the absence of costs, it is easy to see that the reservation wage is increasing in the utility of being single, the arrival rate of marriage offers and is decreasing in the discount rate.

The probability of partnering or the "hazard rate" of partnering is then defined as

$$\lambda_i = \alpha_i(1 - F_i(R_i)) \qquad \text{(A6)}$$

The probability of an individual exiting singlehood is decreasing in the reservation wage. Therefore the duration of being single increases as the discount rate falls, utility of being single increases. However, an increase in the rate of marital offers has two opposing effects. Increasing the number of offers received in a specific time period decreases the duration of remaining single with this effect slightly offset by an increase in the reservation wage.

Effects of Education

Education can influence the hazard rate through three different channels; the arrival rate of offers, the utility of being single and the gains to the marriage offer. First, while attaining formal education qualifications, students, being liquidity constrained, cannot fund a search period and therefore have a lower offer arrival rate thereby decreasing the hazard rate of marriage, although this effect would be partial offset by a reduction in the reservation wage an individual would be willing to accept.

Second, it is a commonly held notion that a higher education level is correlated with the level of one's wage/income. Higher incomes imply increased utility through higher economic independence and consumption level. Reservation wages are therefore increased, which increases the duration of remaining single.

Finally, education level, influence the gains from marriage. If the decision to partner is taken on a cost/benefit analysis, the gains to marriage would be equal to the opportunity cost of marriage. In a single sided search model, increases in education levels increases the opportunity cost of the marriage for individual i, ceterius paribas and hence decreases the hazard rate of marriage and increases the time of remaining single. This is especially true from a female perspective.

Appendix B – Cox Partial Likelihood Estimator

Following on from equation two, the likelihood function for the Cox proportional hazard model is given by:

$$L(\beta, \lambda_0; t, x) = \prod_{i=1}^{n} [\lambda_0(t_i) \exp(x_i'\beta)]^{\delta_i} \exp[-\int_0^{t_i} \lambda_0(u) \exp(x_i'\beta) du] \qquad \text{(B1)}$$

where i denotes the individual

Equation B1 above contains the unknown baseline hazard function and the co-efficient vector β, which also needs to be estimated. Since the equation contains two unknowns, it cannot be used to estimate β. Cox (1972,1975) suggests a partial likelihood estimator as a method of estimating β without having to estimate the baseline hazard.

The likelihood function (equation B1 above) is factorised by the following equation known as the partial likelihood.

$$PL(\beta) = \prod_{i=1}^{n} \left\{ \frac{\exp(x_i'\beta)}{\sum_{j \in R(t)} \exp(x_j'\beta)} \right\}^{\delta_i} \qquad \text{(B2)}$$

Where R(t) denotes the risk set at time t. The risk set is defined as the set of individuals whose duration just before time t has not yet ended and is not yet censored. Note that only the event times contribute their own factor to the partial likelihood. However, all censored and uncensored observations are captured in the denominator, where the sum of the risk set includes all observations who are still at risk of failing immediately before time t. Thus, as can be seen from equation B2, the factorising sweeps out the baseline hazard function so the proportional effect of x on the conditional probability of ending a spell does not depend on the duration. Cox proposed that the partial likelihood function be treated as a usual likelihood function and to maximise it with respect to β. Let β^* be the maximum partial likelihood estimator with respect to β, obtained by maximising the partial log-likelihood function. From equation B2 it follows that:

$$l(\beta) = \sum_{i=1}^{n} \delta_i (x_i ' \beta) - \sum_{i=1}^{n} \delta_i \ln \left\{ \sum_{j \in R(t)} \exp(x_j ' \beta) \right\}$$

$$where: l(\beta) = \ln PL(\beta) \qquad \text{(B3)}$$

However, equation B3 is conditional on the assumption that there are no ties, that is, when more that one event occurs simultaneously. For example, in the case of this paper if more than one observation marries at any time interval there is said to be a tie. In the event that ties appear, and they generally do, the likelihood function can be defined in several different ways. One of the most popular ways of treating ties was proposed by Breslow (1974).

All specifications of the continuous time model are estimated using the Breslow method for ties in durations. However, this may not be appropriate. When there are few ties the Breslow treatment of ties is a good approximation to the partial likelihood. As shown by Figure 2, the frequency of ties for both males and females is quite high, especially at young ages, therefore the Breslow method may not be appropriate. This could be an indication of interval censoring. Interval censoring occurs when the transition process takes place in continuous time but the data are not provided in that form. Given that the data reports only the year of first marriage, but marriage could have taken place at anytime throughout this interval, we believe that interval censoring could be a problem.

Appendix C - Effects of Family Background and social variables[25]

This section presents outlines results that are peripheral to the main interest of this paper. Included in the analysis are dummy variables to capture the historical background of the individual and were primarily included to account for some of the unobserved heterogeneity between individuals. Cohort effects have been presented in the tables included in the main body of this paper. Effects of the all the other peripheral control variables are listed below in Appendix C – Table 1.[26]

Comparing the cohort effect for both male and female in the preferred specification, on inspection of the results an interesting pattern emerges for both females and males[27]. The cohort effects present a non-monotonic "U" shaped effect on the exit rate into marriage. From the 1945 cohort the effect on the timing for marriage starts out positively but decreases to be negative by the 1960 cohort. The effect continues to become more negative with the younger cohorts. The patterns in cohort effects presented are similar to results found by other authors (Blossfeld and Jaenichen 1992).

Also included are sets of family background variables. Compared to those individual whose father was unemployed, the profession of an individual's father has a significant impact on the exit rate into marriage for females and males alike. The results indicate that for all occupations levels there is an increase in the rate of exiting into marriage.

[25] As part of the preliminary analysis, the variable of religiosity was included. The results are not presented since the question of "How important is religion in your life' was only asked for wave one of the survey. In including it into the analysis, the estimation discards all 1048 wave 2 observations that were included, before episode splitting. More importantly the variable is highly endogenous in relation to marriage and to a lesser extent family formation. It seems reasonable to assume that religious individuals would marry earlier but as Axinn et al (1992) point out those individuals that marry also become more active in religious participation. Thus, there maybe reverse causation. Nonetheless, when the model was estimated with religiosity as an explanatory variable, the co-efficient on religiosity was positive and statistically significant both females and males. Those individuals for whom religion is more important in their life are more likely to marry earlier. The more religious is an individual as measured by the survey question, the greater the risk of marriage; it increases by 2 percent for both males and females alike. Finally, the estimates of the other variables remain robust to this change in specification. Measures of Immigrant background were also included in the final specification of the model. None of the co-efficients were significant and are therefore not presented in the results.

[26] Comments on the other controlling variables are in relation to the final preferred specification of the piecewise constant model with unobserved heterogeneity and time varying enrolment.

[27] The reference cohort for the analysis is the birth cohort 1910.

The majority of the co-efficients are significant at the 1 percent level[28]. It is hypothesised that these dummy variables are capturing a wealth effect.
Whether or not an individual's mother had a job (as measured when the subject was 14) has a significant effect on the hazard rate for males only. The co-efficients for males is positive. This is interpreted as having a shorter duration of being single if your mother had a job at age 14. Again this could be capturing a wealth effect that allows males to finance a greater, or more intense search period.

Being an immigrant or from an immigrant background, only has a significant effect on an individual's risk of marriage for males only. For those individual who immigrated from a non-English speaking background, there risk of marriage is reduced. Immigrants are more likely to be single males, and with English as a second language they find it hard to assimilate with the broader community. Similarly, for those from an English-speaking immigrant background, their risk of marriage is also reduced.

Finally, being of Aboriginal or Torres Strait Islander heritage is associated with marrying later. The co-efficients are statistically significant at the 1 percent level for both male and female in the preferred model. For both females and males the risk of marriage is reduced by 51 percent and 35 percent respectively. Economic theory suggests that, if both individuals in the household are forced to work, the gains from trade disappear. Therefore there is no incentive to marry. The result presented seems intuitive since indigenous individuals are more likely to be associated with a more disadvantaged background.

[28] Occupation categories are determined as per the Australian Classification Standard of Occupations as outlined by the ABS. The reference category for both males and females is those individuals whose father was unemployed at age 14. All co-efficients are significant at the 1 percent level except for professional (female): significant at 5 percent, Advanced clerical (female): significant at 10 percent, Advanced Clerical (male): not significant.

Appendix C - Table 1: Specification [10]: Results of other controlling variables

	Specification 10 (with Unobserved Hetro.) Female	Male
immigrante	-0.010	0.035
	(0.08)	(0.08)
immigrantne	-0.034	-0.194**
	(0.09)	(0.09)
immibck~deng	0.030	-0.141**
	(0.06)	(0.07)
immibck~neng	-0.012	-0.042
	(0.08)	(0.08)
liveparents	0.184***	0.102
	(0.06)	(0.06)
divorce	-0.216***	-0.081
	(0.07)	(0.07)
no_siblings	0.016*	0.020**
	(0.01)	(0.01)
eldest	0.045	0.042
	(0.04)	(0.04)
manager	0.461***	0.629***
	(0.10)	(0.10)
professional	0.182*	0.336***
	(0.11)	(0.11)
ass_profess	0.493***	0.587***
	(0.11)	(0.11)
trade	0.491***	0.738***
	(0.10)	(0.10)
adv_clerical	0.258	0.349
	(0.23)	(0.23)
int_clerical	0.438***	0.452***
	(0.12)	(0.12)
int_prod	0.544***	0.706***
	(0.11)	(0.11)
ele_clerical	0.431***	0.753***
	(0.14)	(0.15)
labourers	0.551***	0.681***
	(0.11)	(0.12)
motherjob	0.026	0.110***
	(0.04)	(0.04)
aboriginal	-0.649***	-0.414**
	(0.17)	(0.19)

Notes: 1. Standrd Errors are presented in parentheses.
*2. *** singnificant at 1% level, ** significant at 5% level, * significant at 10% level. 3. Base category for Father occupation is unemployed*

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

Appendix D – Robustness Checks: Residual Analysis

In this section, we present our diagnostic tests from the analysis of residuals. As was previously stated in the Robustness Checks in Section 6, the proportional hazards assumption for the full model of the time varying (Specification 8) Cox estimations are analysed.

So what do we mean by "proportional hazard"? One of the major assumptions underpinning the Cox model is that the unknown hazard rate is a multiplicative function of the independent variables and the baseline hazard. This is referred to as the proportionality assumption. In practical terms this means that if there are two observations with different values for a specific covariate, their hazard rate will only differ multiplicatively by the value of the covariate and therefore, be constant over time. In other words, the hazard rate is "flexed" up or down by the ratio of the value of the covariates.

However, in most cases this may not be a plausible assumption. For instance, many empirical works control for age. Since we are looking for age at first marriage, it is likely that age is more important in predicting risk of failure than the time period after becoming at risk of failure. In this case the impact of the covariate is clearly dependant on time.

The most common method of testing the proportional hazards assumption is by using the Schoenfeld residuals. Schoenfeld (1982) proposed a set of residuals for use with the Cox PH model to test the fit of the model. The Schoenfeld residuals are defined as the covariate value for the individual that failed minus its expected value. Unlike a normal linear regression equation, which reveals a single residual for the individual observation only, the Schoenfeld residual yields a residual for each covariate for each individual that failed.[29]

Formally the Schoenfeld residual can be expressed as the follow:

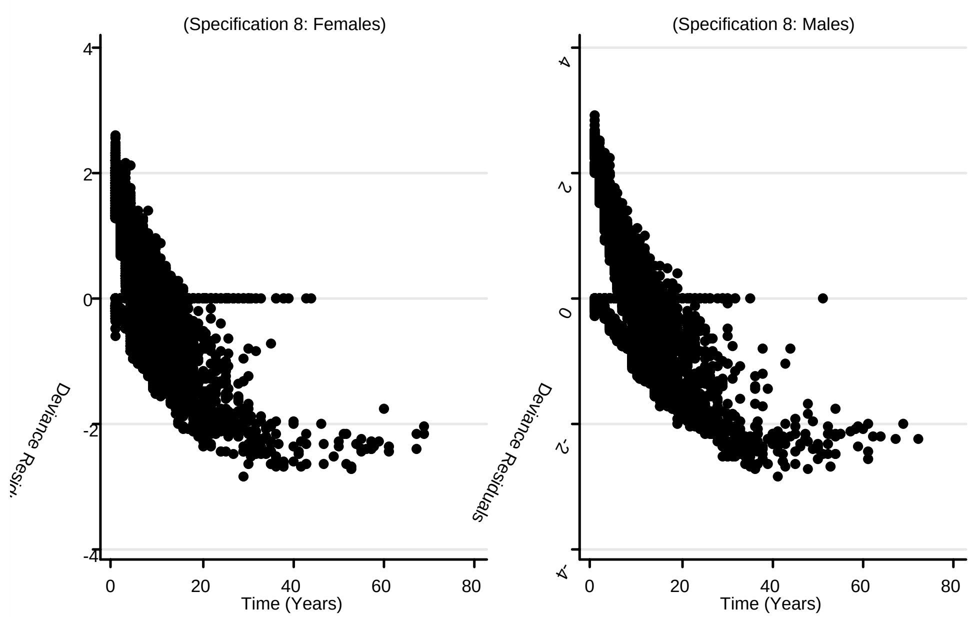
[29] The Schoenfeld residual is not calculated on those individuals that are censored.

$$Sch\,\mathrm{Re}\,sidual = x_{ik} - \sum_{i=1}^{j \in R(t_i)} x_{kj} p_j \qquad \text{(D1)}$$

where x_{ik} is the value for individual i of covariate k and $\sum_{i=1}^{j \in R(t_i)} x_{kj} p_j$ is the weighted average of the covariate, weighted by the probability of failure p_j for each individual, in the risk set $R(t)$. Since it can be shown that the Schoenfeld residuals are independent of time, a plot against time of the Schoenfeld residuals that shows some non-random pattern is evidence that the proportionality assumption is violated.

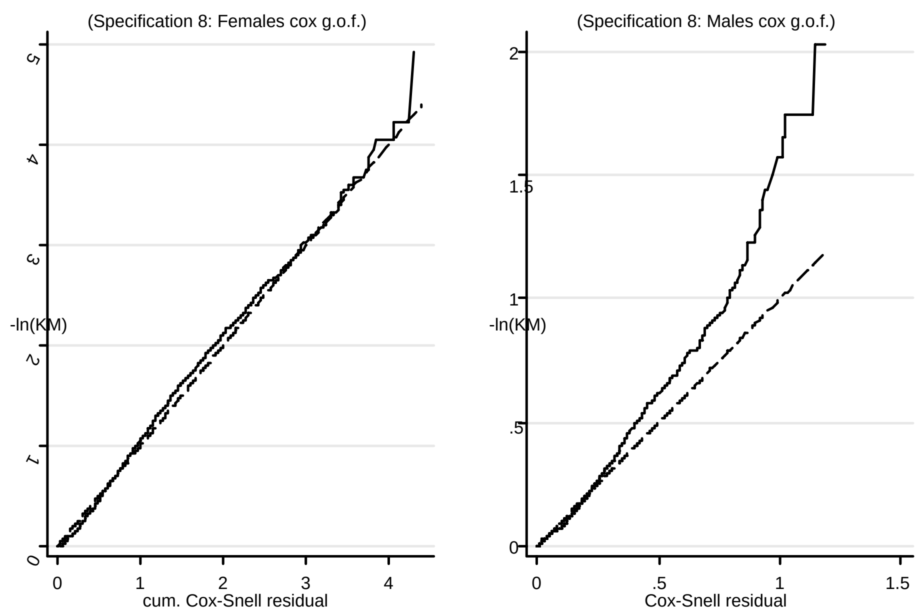
Figure 1 of Appendix D (below) presents the plot of these residuals against time. As stated previously, if there is a non-random pattern to the plot of the residuals against time, then when can conclude that the proportionality assumption is violated. Inspection of the figure reveals that the plot of the residuals, for both the female and male models of Specification 8, has an asymptotic decreasing trend against time.

Appendix D - Figure 1: Plot of Deviance Residuals



Further to our residual analysis we plot the Cox-Snell residuals. The Cox-Snell residuals are useful if determining the effectiveness of the overall model fit. Appendix D – Figure 2 presents the plots of the generalised Cox-Snell residuals.

Appendix D - Figure 2: Plot of Cox-Snell Residuals



Appendix D – Figure 2 plots the Cox-Snell residuals against the integrated hazard. If the data fits the model well, one would expect the plot to be close to the 45-degree line. From the figure we can see that the data seems to fit the model well for females. In contrast, for males, the data only fits well at very short durations.

In addition to the graphical plot of the residuals, and as a final test of the proportionality assumption, we also conduct a test of the slope of a linear regression through the Schoenfeld residuals (Grambsch and Therneau 1994). Since the Schoenfeld residuals can be calculated on each of the individual covariates and globally on the entire model, this allows us to test the individual covariates and global model against the null hypothesis of a zero slope. A zero slope indicates that the hazard function is constant over time. If we can reject the null hypothesis, then we conclude that the proportionality assumption of the model is violated. The results are presented below.

Appendix D – Table 1 below, presents the results of the regression of residuals. Rho represents the co-efficient of the regression, which is approximately χ^2 distributed. Column 2 represents the critical value with the final column presented the p value scores. The null hypothesis is that the co-efficient slope equals zero and hence the function is constant over time. The results indicate that on several variables that we can reject the null hypothesis. Therefore for those variables we violate the proportionally assumption. In addition, the results also indicate that for both the male and female specifications that the proportionality assumption is violated.

The most common method of accounting for non-proportionality is to stratify the estimation by those covariates that violate this assumption. Stratification involves dividing the sample up into smaller sub-samples, with the sub-samples defined by the covariates that violate the proportionality assumption. It is equivalent to running a separate Cox PH model on the sub-sample under the constraint that the co-efficients are equal. For example, covariate cohort 1930 in the female model violates the proportionality assumption. If we were to stratify by this variable, it would be the equivalent of running the Cox PH model on those individuals in cohort 1930 only.

There are several drawbacks with this though. First, one or more of the sub-samples maybe too small for effective statistical inference, leading to problems in the reliability of tests. Second, since it is implied that the co-efficients are equal, we cannot make inferences across the different covariates we stratify by. Hence we cannot determine the relative effect of the education variables (both level dummies and enrolment).

Since we find that the Deviance and Cox-Snell residual plots infer that the data is not a good fit to the assumptions of the Cox PH model, with our finding reinforced by the formal test of the proportionality assumption of the Schoenfeld residuals, we conclude that our preferred specification of the model is the piecewise constant estimation. Table 9 indicates that unobserved heterogeneity is significant; therefore our preferred model is Specification 10, which accounts for unobserved heterogeneity.

Appendix D - Table 1: Test of Proportional Hazards Assumption

Specification 8 (Female)

	rho	Chi Square	df	P>Chi Sq
yr12t	-0.068	22.81	1	0.0000
certt	0.003	0.04	1	0.8449
dipt	-0.039	7.11	1	0.0076
bacht	-0.023	2.51	1	0.1131
graddipt	-0.055	14.09	1	0.0002
mastphdt	-0.032	4.75	1	0.0293
enrol	0.048	11.39	1	0.0007
cohort1915	-0.002	0.02	1	0.8961
cohort1920	-0.016	1.19	1	0.2760
cohort1925	-0.024	2.61	1	0.1060
cohort1930	-0.030	4.26	1	0.0391
cohort1935	-0.021	2.08	1	0.1492
cohort1940	-0.034	5.38	1	0.0204
cohort1945	-0.046	10.16	1	0.0014
cohort1950	-0.051	12.47	1	0.0004
cohort1955	-0.041	8.13	1	0.0043
cohort1960	-0.030	4.26	1	0.0391
cohort1965	-0.016	1.18	1	0.2766
cohort1970	-0.013	0.80	1	0.3710
cohort1975	-0.013	0.80	1	0.3708
cohort1980	-0.010	0.45	1	0.5020
Global		196.43	40	0
Specification 8 (Male)				
yr12t	-0.054	13.57	1	0.0002
certt	-0.007	0.25	1	0.6178
dipt	-0.011	0.56	1	0.4533
bacht	0.005	0.11	1	0.7351
graddipt	-0.031	4.29	1	0.0384
mastphdt	-0.009	0.37	1	0.5450
enrol	0.029	4.09	1	0.0432
cohort1915	-0.014	0.89	1	0.3443
cohort1920	-0.024	2.58	1	0.1084
cohort1925	-0.019	1.64	1	0.2009
cohort1930	-0.037	6.18	1	0.0129
cohort1935	-0.036	5.88	1	0.0153
cohort1940	-0.042	7.86	1	0.0051
cohort1945	-0.049	10.65	1	0.0011
cohort1950	-0.049	10.70	1	0.0011
cohort1955	-0.040	7.06	1	0.0079
cohort1960	-0.031	4.36	1	0.0368
cohort1965	-0.027	3.35	1	0.0672
cohort1970	-0.023	2.28	1	0.1308
cohort1975	-0.023	2.40	1	0.1212
cohort1980	-0.015	0.99	1	0.3189
Global		186.17	40	0

Notes: 1. Test of Porportional Hazards assumption. Test is Approx Chi Squared distributed.

2. Column 2 respresents the ChiSq critical value, Column 4 is the P Value

3. Null Hypothesis: Slope of the regression co-efficent =0

Appendix E – Results of Further Estimations

The following section introduces results from estimations where the time varying enrolment variable was excluded from the econometric model. These results are presented to investigate the impact of the variable since we believe it is correlated with the time varying education dummies.

Appendix E - Table 1: Timing of Marriage fitting Cox PH Model education with time varying only

	Specification 11		Specification 12	
	Female	Male	Female	Male
Yr12 (t)	-0.054	0.131**	-0.040	0.191***
	(0.04)	(0.05)	(0.04)	(0.06)
Certificate (t)	-0.127***	0.188***	-0.125***	0.205***
	(0.04)	(0.04)	(0.04)	(0.04)
Dip/Adv.Diploma (t)	-0.160***	0.254***	-0.152**	0.301***
	(0.06)	(0.06)	(0.06)	(0.06)
Bachelors (t)	-0.289***	0.097*	-0.263***	0.157***
	(0.05)	(0.05)	(0.06)	(0.06)
Grad.Cert/Dip (t)	-0.228***	0.356***	-0.191**	0.406***
	(0.08)	(0.08)	(0.08)	(0.08)
Masters/PhD (t)	-0.519***	0.107	-0.485***	0.194**
	(0.15)	(0.09)	(0.16)	(0.09)
cohort1915	0.181	0.228	0.235	0.198
	(0.19)	(0.23)	(0.19)	(0.23)
cohort1920	0.282*	0.205	0.306*	0.140
	(0.17)	(0.21)	(0.17)	(0.21)
cohort1925	0.264	0.259	0.265	0.197
	(0.16)	(0.20)	(0.17)	(0.20)
cohort1930	0.479***	0.332	0.484***	0.278
	(0.16)	(0.20)	(0.17)	(0.20)
cohort1935	0.468***	0.272	0.502***	0.231
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1940	0.434***	0.287	0.452***	0.221
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1945	0.411***	0.339*	0.451***	0.280
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1950	0.270*	0.181	0.284*	0.095
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1955	0.022	-0.085	0.045	-0.175
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1960	-0.083	-0.258	-0.052	-0.330*
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1965	-0.251	-0.373*	-0.184	-0.432**
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1970	-0.551***	-0.615***	-0.470***	-0.653***
	(0.16)	(0.20)	(0.16)	(0.20)
cohort1975	-0.833***	-1.079***	-0.711***	-1.075***
	(0.17)	(0.22)	(0.17)	(0.22)
cohort1980	-1.542***	-1.346***	-1.360***	-1.297***
	(0.29)	(0.40)	(0.29)	(0.41)
Immigrant Variables	NO	NO	YES	YES
Family Background	NO	NO	YES	YES
No. Observations	44080	57515	44080	57515
χ2	791.84	593.89	907.36	707.45
log Likelihood	-37331.276	-35555.477	-37273.518	-35498.695

Source: *Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2*
Notes: *1. Standrd Errors are presented in parentheses. 2. *** singnificant at 1% level, ** significant at 5% level, * significant at 1% level. 3. Base category for cohort effects is Birth cohort 1910 4. Base category for education variables is Yr11 & below*

Appendix E - Table 2: Timing of Marriage fitting PieceWise Constant Model wit time varying education only

	Specification 13 (w/o Unobserved Hetro.) Female	Male	Specification 14 (with Unobserved Hetro.) Female	Male
Yr12 (t)	-0.047	0.199***	-0.046	0.221***
	(0.04)	(0.06)	(0.05)	(0.07)
Certificate (t)	-0.137***	0.219***	-0.303***	0.186***
	(0.04)	(0.04)	(0.06)	(0.05)
Dip/Adv.Diploma (t)	-0.168***	0.320***	-0.303***	0.320***
	(0.06)	(0.06)	(0.08)	(0.08)
Bachelors (t)	0.290***	0.164***	-0.531***	0.032
	(0.06)	(0.06)	(0.08)	(0.08)
Grad.Cert/Dip (t)	-0.205***	0.433***	-0.309***	0.481***
	(0.08)	(0.08)	(0.11)	(0.11)
Masters/PhD (t)	-0.522***	0.202**	-0.949***	0.018
	(0.16)	(0.09)	(0.21)	(0.12)
cohort1915	0.248	0.211	0.225	0.384
	(0.19)	(0.23)	(0.28)	(0.31)
cohort1920	0.312*	0.150	0.605***	0.296
	(0.17)	(0.21)	(0.26)	(0.28)
cohort1925	0.277*	0.213	0.569**	0.352
	(0.16)	(0.20)	(0.25)	(0.27)
cohort1930	0.513***	0.300	0.873***	0.553**
	(0.16)	(0.20)	(0.25)	(0.27)
cohort1935	0.529***	0.249	0.843***	0.561**
	(0.16)	(0.20)	(0.25)	(0.27)
cohort1940	0.482***	0.240	0.819***	0.511**
	(0.16)	(0.20)	(0.25)	(0.26)
cohort1945	0.471***	0.302	0.836***	0.691***
	(0.16)	(0.20)	(0.25)	(0.27)
cohort1950	0.287*	0.100	0.735**	0.439
	(0.16)	(0.20)	(0.25)	(0.27)
cohort1955	0.032	-0.184	0.369	-0.028
	(0.16)	(0.20)	(0.25)	(0.26)
cohort1960	-0.072	-0.346*	0.125	-0.270
	(0.16)	(0.20)	(0.24)	(0.26)
cohort1965	-0.211	-0.453**	-0.220	-0.425
	(0.16)	(0.20)	(0.25)	(0.26)
cohort1970	-0.512***	-0.686***	-0.557***	-0.636***
	(0.16)	(0.20)	(0.25)	(0.26)
cohort1975	-0.762***	-1.109***	-0.687***	-0.972***
	(0.17)	(0.22)	(0.25)	(0.28)
cohort1980	-1.413***	-1.313***	-1.166***	-1.081**
	(0.29)	(0.41)	(0.34)	(0.44)
Immigrant Variables	YES	YES	YES	YES
Family Background	YES	YES	YES	YES
No. Observations	44366	57492	44366	5749
log Likelihood	-14221.98	-14715.33	-14167.889	-14688.5

*Notes: 1. Standrd Errors are presented in parentheses. 2. *** singnificant at 1% level, ** significant a 10% level. 3. Base category for cohort effects is Birth cohort 1910 4. Base category for educatio*

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

The results for males seem to be quite robust to the change in specification. Although the magnitude of the co-efficients is larger, we find that the co-efficients for all the education variables are positive and significant, which is in line with the theory presented in Section 2 and our results from Section 5. This is the case for both the continuous time Cox PH model and the discrete time piecewise constant model.

Conversely, we find that the result for females changes quite significantly. Once the enrolment variable is in excluded, at all education levels, compared to Year 11 and below, females marry later. In addition, we find no evidence of non-linearity in the effect of educational attainment of the duration to marriage. This is the case for both the Cox PH and piecewise constant model.

Appendix F – Estimations from parametric methods and models

As stated previously, much of the existing literature investigating the effects of education on the age at marriage employ parametric methods to model the question of interest. This appendix follows on from the main analysis in the text and presents results and figures estimated by the three most popular parametric duration models, namely the exponential model, the Gompertz model and the Weibull model. This section also shows that the impact of the variables are somewhat different to estimated under our preferred discrete time piecewise constant model. In particular we find strong delaying effects of education on the duration of singlehood for females, with the opposite true for males. In addition the enrolment effect significantly delays entry into marriage for both genders.

The Parametric Baseline Hazard

The estimations that we did not include in the main text of the chapter are estimations with a parametric baseline hazard. More specifically, the estimations presented here use are the exponential and Gompertz model. In addition we also present a model that includes a Weibull baseline hazard accounting for heterogeneity with a gamma distribution. For a formal development on the three parametric models mentioned, please see Lancaster (1990) and Blossfeld *et al* (1989). The estimation is presented as further evidence of the robustness of the results. The co-efficients in the following tables are hazard ratios. Although not directly comparable to you preferred piecewise constant model, since coefficients were presented, the effect of each variable on the probability of exit is much simpler to calculate. It is simply the hazard ratio minus 1. For example, a hazard ratio of 1.30 is interpreted as increasing duration by 30 percent. Conversely, a hazard ratio of 0.5 decreases duration by 50 percent.

The results are presented in Appendix F – Table 1. The results are very similar to those presented in the main text. However, the results differ in their sign, magnitude and significance. The key results from Appendix F – Table 1 are that for females we see a significant delaying of entry into marriage induced by higher education. In addition, this effect is reinforced by the enrolment effect. Moreover, there is evidence to suggest that there is a non-linear relationship of education on singlehood duration. This is the case for both parametric models presented. For males, once enrolment is accounted for, we find that at each education level, males marry earlier compared to their Year 11 and below counterparts. Therefore, we find evidence of the human capital effect and enrolment effect acting in the opposite direction for males.

In terms of magnitude of the coefficients, we find that the exponential model has almost all the variables being larger than those of the Gompertz model for females. In particular we see that the impact of having a Bachelors degree drops from 22.2 percent to 1.04 percent, 46.7 percent to 26 percent for those with a Graduate Certificate/Diploma. For males, however, we find the size and significance of the coefficients across the two models remarkably stable.

These results suggest that the coefficients are mostly of the same sign but are however more significant that those found in the main text. However, the discrete time piecewise constant model is still our preferred specification because it assumes a much more flexible form for the baseline hazard.

Comparison with the existing literature

Blossfeld and Jaenichen (1992) investigate the effect of education on females' entry into marriage in Germany. In using an exponential model, they find that the enrolment effect is likely to delay marriage by up to 73 percent. Our results are much less. The results from our exponential model indicate that enrolment is likely to delay entry into marriage by 47 percent. In addition, each level of education is likely to delay marriage by 7.25 percent. Our results are in contrast to this. Given the nature of our education dummies, it provides us with a more flexible insight into how each level of education affect the risk of marriage. Our exponential model results indicate that compared to those individuals with a year 11 and below education, those that hold a Certificate, Advance Diploma, Bachelors, Graduate Certificate/Diploma and Master PhD are likely to delay marriage by 11.3 percent, 25.9 percent, 22.2 percent, 46.7 percent and 61.7 percent respectively. In addition we find evidence of a non-linear effect of education with those possessing a Year 12 qualification likely to marry earlier by 62.5 percent.

Appendix F - Table 1: Timing of Marriage fitting Parametric models

	Exponential		Gompertz	
	Female	Male	Female	Male
Yr12	1.625***	1.725***	1.712***	1.720***
	(0.07)	(0.10)	(0.08)	(0.10)
Certificate	0.887***	1.517***	1.019	1.568***
	(0.04)	(0.06)	(0.05)	(0.06)
Dip/Adv.Diploma	0.741***	1.663***	0.907	1.690***
	(0.04)	(0.10)	(0.05)	(0.10)
Bachelors	0.778***	1.729***	0.986	1.818***
	(0.04)	(0.10)	(0.05)	(0.10)
Grad.Cert/Dip	0.533***	1.811***	0.740***	1.926***
	(0.04)	(0.15)	(0.06)	(0.16)
Masters/PhD	0.383***	1.567***	0.572***	1.782***
	(0.06)	(0.15)	(0.09)	(0.17)
enrol (t)	0.529***	0.305***	0.376***	0.243***
	(0.02)	(0.02)	(0.02)	(0.01)
cohort1915	1.380*	1.511*	1.258	1.314
	(0.26)	(0.35)	(0.24)	(0.31)
cohort1920	1.536**	1.36	1.359*	1.218
	(0.26)	(0.29)	(0.23)	(0.26)
cohort1925	1.364*	1.582**	1.276	1.332
	(0.23)	(0.32)	(0.21)	(0.27)
cohort1930	1.789***	1.649**	1.607***	1.419*
	(0.30)	(0.34)	(0.27)	(0.29)
cohort1935	2.114***	1.618**	1.741***	1.385
	(0.35)	(0.33)	(0.29)	(0.28)
cohort1940	1.957***	1.573**	1.671***	1.349
	(0.32)	(0.31)	(0.27)	(0.27)
cohort1945	1.798***	1.694***	1.580***	1.430*
	(0.29)	(0.34)	(0.25)	(0.28)
cohort1950	1.563***	1.449*	1.390**	1.22
	(0.25)	(0.29)	(0.22)	(0.24)
cohort1955	1.285	1.148	1.119	0.956
	(0.21)	(0.23)	(0.18)	(0.19)
cohort1960	1.241	1.039	1.051	0.851
	(0.20)	(0.21)	(0.17)	(0.17)
cohort1965	1.139	0.976	0.928	0.775
	(0.18)	(0.20)	(0.15)	(0.16)
cohort1970	0.91	0.803	0.714**	0.616**
	(0.15)	(0.16)	(0.12)	(0.13)
cohort1975	0.718*	0.473***	0.536***	0.349***
	(0.12)	(0.10)	(0.09)	(0.08)
cohort1980	0.285***	0.217***	0.214***	0.156***
	(0.08)	(0.09)	(0.06)	(0.06)
Immigrant Variables	YES	YES	YES	YES
Family Background	YES	YES	YES	YES
No. Observations	44080	57515	44080	57515
c2	1388.18	1263.34	1602.76	1443.16
log Likelihood	-7660.4766	-6964.337	-7487.0316	-6874.4205

Source: Household, Income and Labour Dynamics in Australia Survey, Waves1 & 2

*Notes: 1. Standrd Errors are presented in parentheses. 2. *** significant at 1% level, ** significant at 5% level, * significant at 1% level. 3. Base category for cohort effects is Birth cohort 1910 4. Base category for education variables is Yr11 & below*