

How much does parental education explain educational attainment of males and females in Australia?

Jennifer Baxter*

Negotiating the Life Course Discussion Paper Series

Discussion Paper DP-015

October 2002

Abstract

Parental education is one of the main determinants of educational attainment. In research it is often measured using the education level of one parent, usually the father's. This research investigates how well father's education explains the variation in educational attainment for males and females, and compares this to models using mother's education and those using both parents' education. The analysis uses data from 1997 Negotiating the Life Course Survey, looking at determinants of education at age 25. A multinomial logistic regression model was fitted to a dependent variable measuring level of education in three categories. The results showed that both parents' education is important, for males and females. However, the influence of mother's and father's education is different for males and females, supporting the need to include the education levels of both parents into models of educational attainment, and also to allow for different effects for males and females.

Introduction

How much is educational attainment influenced by parents' education? Previous studies have found socio-economic background to be one of the important determinants of educational attainment (for example Blau & Duncan (1967), Hauser & Featherman (1977) and Peck (2001)). Parental education is often used to represent socio-economic status. However, there is some diversity in how parental education is measured, and it is often not acknowledged that mother's and father's education may have different effects or act differently between males and females.

This study aims to analyse the different effects of mothers' and fathers' education on the educational attainment at age 25 of males and females aged between 25 and 54 in Australia in 1997. It uses the 1997 wave of the Negotiating the Life Course Survey. This dataset contains a large range of data items relating to work, education and family. It does not contain the complete range of information usually included in analyses of educational attainment, so this analysis does not attempt to find the best predictive model of educational attainment. The focus of this analysis is solely on the effect of mother's and father's education.

The importance of understanding the determinants of educational attainment is without dispute. It receives wide-ranging attention from the community at large generally interested in equitable access to and variations in outcomes of the education system. Sociologists have also been interested in this subject, in studying how society is organised and to what extent social groups are reproduced from one generation to the next (stratification research). Others are interested in polarisation of incomes – the concern that some groups are unable to break out of poverty partly as a result of their background and their educational opportunities. Given that educational attainment is a well-acknowledged indicator of likely outcomes in labour market opportunities, in lifetime earnings and in other facets of life, there is broad acceptance of the need to understand who within the population has a relatively low education and who has a relatively high education. For a summary of these issues and relevant references see Miller, Mulvey & Martin (2001).

Studies of the determinants of education levels of course are not new. Within Australia there have been a considerable number of studies focusing either on determinants of educational attainment or participation in education. A number of relevant papers have been published based on the analysis of the International Social Science Survey (Evans & Kelley, 2000; Evans, Kelley, Borgers, Dronkers, & Rollenberg, 1995; Evans, Kelley, & Wanner, 2001; Kelley, 2001). The Longitudinal Surveys of Australian Youth have also been analysed for this purpose (Le & Miller, 2002; Long, Carpenter, & Hayden, 1999; Marks & Fleming, 1999; Marks, Fleming, Long, & McMillan, 2000).

Parental education is just one of a number of important determinants of educational attainment that have been identified. Rowe (2000) in reviewing recent research notes that parental background and ability explain only around 9 to 15 per cent of the variation in student's achievement progress, compared to some 30 to 60 per cent explained by class/teacher membership (Rowe, 2000:30). Miller et al. found that shared environmental factors (including family characteristics) accounted for about 25 per cent of the variance in educational attainment (Miller et al., 2001:223)

Other important determinants, and some of the studies discussing their effects include:

- Intelligence or aptitude (Clifton, Williams, & Clancy, 1991; Marks & Fleming, 1999; Miller et al., 2001)
- Gender (ABS, 1998; Collins, Kenway, & McLeod, 2000; Gallagher, 2000; Kelley, 2001; Le & Miller, 2002; Rowe, 2000; Watts, 1997)
- School or class/teacher factors (Le & Miller, 2002; Rowe, 2000)
- Parental occupation and economic status (Evans & Kelley, 2000; Haveman, Wolfe, & Spaulding, 1991)
- Other background factors such as family size, ethnicity and marital conflict (Biblarz & Raftery, 1999; Clifton et al., 1991; Ensminger & Slusarcick, 1992; Evans et al., 1995; Evans et al., 2001; Haveman et al., 1991; Le & Miller, 2002).

Most studies of determinants of educational attainment model the number of years in education or the probability of participating in education at some level on various characteristics. Other studies make use of more complex techniques using sibling or twin studies, for example Miller et al. (2001). This analysis uses a multinomial logistic model to fit the probability of having a low education (less than secondary education), a medium education (complete secondary, vocational or diploma) or high education (degree or higher).

While many of the studies undertaken in Australia are more comprehensive than this one with respect to the number of data items they are able to include in their analyses, their use of parents' education is somewhat limited. This happens in two ways. Firstly, many models include just one measure of parental education. In most cases this is taken as the father's education and no consideration is given to the possible influence of mother's education. The second way these models are often limited is that they model male and female educational attainment/participation together, including a term in the model for sex. This does not allow the effect of parental education to differ for males and females.

There are a number of examples of studies that have allowed for the effects of both mother's and father's education. Following is a summary of a selection of these studies.

Ganzach (2000) analysed how educational aspirations and attainment is associated with mother's and father's education and cognitive ability. He finds both mother's education and father's education are important in explaining educational attainment. He finds no interaction between mothers' and fathers' education in explaining educational attainment, but does find that the effect of mother's education interacts with cognitive ability. He comments on the bias researchers introduce by using schooling of the more educated parent, ignoring the effect of the less educated parent (Ganzach, 2000 437).

Clifton et al. (1991) included both mother's and father's education along with a range of ethnicity variables to analyse ethnic differences in educational achievement. This analysis did not separately model achievement for males and females – gender was

included as another variable in the model. In this model, mother's education did not significantly improve the model. Similarly, Le and Miller (2002) included both mother's and father's education, but found mother's education was not significant.

Haveman, Wolfe and Spaulding (1991) modelled different indicators of educational attainment, including mother's and father's education levels. Both variables were found to be significant. Sewell & Shah (1968) found that educational attainment did vary with mother's and father's education levels, and that the strength of the relationship with these explanatory variables changed depending on the sex of the child.

The link between educational attainment and parental education is explained by a number of different theories. There are three main sets of theories. First the *economic theory* says that parents with higher educational attainment are likely to be of a higher socio-economic status and to have the economic means to be able to finance higher levels of education. Second, *sociological or psychological theory* says that parents with higher educational background are likely to have and to instil strong norms and values with regard to education, and to be role models in this regard. Third, *genetic or biological theory* says that inheritance of intellectual ability through genes will reinforce the relationship between parental education and educational attainment. (Haveman et al., 1991; Miller et al., 2001; Sieben, Huinink, & de Graaf, 2001)

To explain this relationship between parent's education and educational attainment in more depth, there are a number of models that can be applied. A recent paper by Korupp, Ganzeboom & Van der Lippe (2002) presents these models and a summary of these is given below (Korupp et al., 2002:19-21):

The 'conventional' model

A number of decades ago, it was the father who was seen to set the socio-economic status of the family, as the vast majority of mothers left the workforce to care for the family. In analyses requiring a measure of family socio-economic status, the characteristics of the

father/husband were assumed to represent those of the family. The mother/wife's characteristics were ignored.

The dominance or power model

This model assumes that the person with the highest socio-economic status best represents the socio-economic status of the family. In most cases this would still be the male, but in cases where the female has a higher level of education or occupation, her characteristics would be used. The *modified dominance model* used in the paper by Korupp et al. also includes the effect of the less dominant partner.

The joined model

This model assumes that the socio-economic status of a family is best represented by the average education or occupation of the mother and father.

The sex-role model

This model makes the distinction between the role model of girls being their mothers and the role model of boys being their fathers. 'Here the leading hypothesis is that compared with the father the mother's educational and occupational status is important only for the daughter and compared with the mother, the father's socioeconomic influence is important only for the educational attainment of the son' (Korupp et al., 2002:21).

The individual model

This model advocates that mothers' and fathers' socioeconomic backgrounds are both important, and each exerts its own influence on the educational attainment of their children. Under this model, the background variables of both parents should be included in models of educational attainment.

This study does not aim to determine directly which of these models best fits the data as did Korupp et al. (2002). It is mindful of these theories however, and they are considered in the discussion of the results. This study seeks to understand how parental education

may be related to educational attainment. Specifically, the questions this analysis seek to answer are:

- How much do mother's and father's educational attainment, separately and together, explain children's educational attainment?
- How much do these effects differ for males and females?

The report is organised as follows. Following on from this introduction and literature review the methodology of this study is explained, including a description of the analytical techniques used, and the data and variables used. The results are then presented – first the results of the bivariate analysis and then the results of the multivariate analysis. A summary and discussion of the results follows.

The Data

The Negotiating the Life Course data from 1997 was used for this analysis. This survey was a random sample of persons living in Australia aged between 18 and 54. Detailed information relevant to education, work and family issues were collected from a total of 2231 respondents – 984 males and 1247 females.

As the main variable of analysis in this study was education at age 25, persons aged less than 25 were excluded. Also excluded were persons who stated that they lived overseas for most of the time they were at secondary school. This was in order to focus the analysis on those persons who had a shared experience of going to secondary school in Australia. Those who went to secondary school outside Australia quite possibly experienced a very different education system, and also may have been subject to different values and options in relation to education. Inclusion of these respondents would have been possible if details about country of birth and year of arrival in Australia were included in the analysis but to keep the study simpler, it was easier to remove them. The final sample then, was 753 males and 962 females.

Variables in the Analysis

The following set of variables was selected based on previous research of determinants of educational attainment. I restricted the set of variables to analyse to a smaller list than could have been chosen to focus the analysis on the effect of parental education on educational attainment. Parental occupation is examined in an introductory way – further analysis of this variable was not possible within the scope of this study. Control variables of birth cohort and residence while at school (city/country) were also included.

Other variables were considered but were excluded on the grounds that they added further complexity to the model without adding a great deal in added explanation of the patterns. Country of birth of respondent, or country of birth of parents was considered, but in a highly aggregated form did not add significantly to the model. Information on parental

death or parental divorce was also matched from the 2000 wave of the Negotiating the Life Course Survey, and was included in early analyses. There were, however, problems with these data because of the non-respondents to the 2000 wave of the survey. I decided the results from this matched data were not reliable for this reason.

Many variables that have been associated with educational attainment were simply not available. In particular, ability, as measured by some form of aptitude test, and school type or school characteristics have been found to be important determinants of educational attainment in previous studies.

A description of each data item is given below. The distribution of sample in each category, by sex, is given in Table 1.

The Dependent Variable

Education at age 25

The way in which education details were collected in the survey permitted the derivation of the data item education level at age 25. The derivation was based on a series of questions which asked about whether or not post-school qualifications had been attained, and if so what was the type of qualification gained and when was it completed. Using this data, any qualification gained after the age of 25 was ignored, so that the variable more closely reflected the education level attained in and immediately after school-age.

Education at age 25 was grouped into three categories which are referred to throughout the analysis as low, medium and high. ‘Low’ includes anyone who had incomplete secondary, primary or no schooling. ‘Medium’ includes those who had completed secondary, a vocational qualification or an undergraduate or associate diploma. ‘High’ includes those with a bachelor degree or higher. Categories similar to these are often used in studies of educational attainment.

I decided to use education at age 25 to remove any effect of mature age study. Many Australians undertake study after leaving the school system, starting work and perhaps starting a family. I expect that the further away, in time, that this is from leaving home, the weaker the effect of parental factors including parental education and occupation will be and I therefore chose to focus the study on what education had been gained by the age 25. Tables 1.1 and 1.2 in Appendix 1 provide some further information on educational attainment as background to this data item. Table 1.1 shows for each age group, the percentage that had gained a qualification on or after age 25. These percentages are quite high for both males and females, especially in the older age groups. Overall, 27 per cent of males and 25 per cent of females in the survey had gained a qualification after the age of 25. Note however that this refers to any additional qualification, and the additional qualification may not move the person from one of the grouped categories to the next – in particular, many move within the ‘medium’ category – gaining vocational or diploma qualifications, or within the ‘high’ category – gaining post-graduate qualifications. Table 1.2 compares education at age 25 to education at survey date, grouped into the categories used in this analysis. About 90 per cent of males and females who had a low education at age 25 were still in this category at the survey date – about 10 per cent had moved to a higher category. Slightly more – 12 per cent of males and 13 per cent of females had moved from the medium at age 25 to the high category at survey date.

The distribution of this variable is given in Table 1. The largest education group was ‘medium’ (56 per cent of males and 50 per cent of females). A greater proportion of females were in the low education group (35 per cent) compared to males (29 per cent). Males and females had equal proportions in the high education group (15 per cent).

The Independent Variables

Birth Cohort

Given that there have been quite significant changes in school retention and in participation in higher education over the period these respondents would have gained their education (ABS, 1998; NCVER, 2002), a birth cohort variable was included in the model. This was simply a dichotomous variable indicating whether the respondent was born in or before 1960, or born after 1960. This was entered as a dummy variable to aid interpretation of the coefficients. Ideally, the sample would have been split into birth cohorts representing narrower ranges, but I kept to split to just two categories to minimise problems with small cell size in the analysis. In the analysis the reference group was those born before 1960.

Residence while at secondary school

Whether attended school in an urban or rural area has consistently been found to be an important predictor in analysing educational attainment (Kelley, 2001; Le & Miller, 2002; Marks & Fleming, 1999; Marks et al., 2000). This variable categorises respondents according to the question “in what city or town were you living during most of the years when you were in secondary school?”. Those who lived in one of the capital cities or in another major urban centre (Newcastle, Wollongong, Geelong or Tweed Heads/Gold Coast) were defined as ‘city’. The remainder, those who lived in a large country town or a smaller place in Australia were the ‘country’ category, which was the reference category in the multivariate analysis. As mentioned earlier, those whose response to this question was ‘in another country’ were removed from the analysis.

Mother’s education level

Mother’s education level was recoded from the question “what was the highest level of education your mother reached?”. The categories used in the analysis were *low* (includes those with no schooling, primary school only and incomplete secondary, no post-school); *medium* (those with completed secondary, trade certificate or diploma course) and *high* (university degree or post-graduate degree). Cases in which the respondent did not know,

or for some other reason did not provide a response were included in the *low* category. Separate analyses with these respondents removed altogether from the analysis did not produce significantly different results and so it was believed the placement of these persons in this category was satisfactory.

The majority of respondents had mothers with a low education – 70 per cent of males and 71 per cent of females. Less than 5 per cent had mothers with a high education.

Father's education level

This was derived as above using the question “what was the highest level of education your father reached?” The education levels of fathers were marginally higher than that of mothers. While there were still only fairly small numbers with a high education (less than 10 per cent for males and females) the proportion with low education was less than it was for mothers (59 per cent of males and 63 per cent of females).

Table 1: Distribution of variables used in the analysis ^(a)

Variable	Males		Females		Total	
	Number	%	Number	%	Number	%
Highest education at age 25 ^(b)						
Low	221	29.3	337	35.0	558	32.5
Medium	419	55.6	481	50.0	900	52.5
High	113	15.0	144	15.0	257	15.0
Birth cohort						
Born in or before 1960	448	59.5	550	57.2	998	58.2
Born after 1960	305	40.5	412	42.8	717	41.8
Residence while at secondary school						
City	467	62.0	604	62.8	1071	62.4
Country	286	38.0	358	37.2	644	37.6
Mother's education ^(b)						
Low	530	70.4	688	71.5	1218	71.0
Medium	191	25.4	237	24.6	428	25.0
High	32	4.2	37	3.8	69	4.0
Father's education ^(b)						
Low	445	59.1	603	62.7	1048	61.1
Medium	236	31.3	282	29.3	518	30.2
High	72	9.6	77	8.0	149	8.7
Mother's occupation						
No occupation (home duties)	351	46.6	442	45.9	793	46.2
Worked other than manager professional	279	37.1	389	40.4	668	39.0
Professional/Manager	123	16.3	131	13.6	254	14.8
Father's occupation						
No occupation (home duties)	55	7.3	70	7.3	125	7.3
Worked other than manager professional	377	50.1	498	51.8	875	51.0
Professional/Manager	321	42.6	394	41.0	715	41.7
Total Number	753		962		1715	

Source: NLC 1997.

*(a) Excludes persons aged less than 25 and persons who did not go to secondary school in Australia**(b) "Low" refers to no or incomplete secondary education; "Medium" refers to complete secondary education, diploma, vocational or undergraduate qualification; "High" refers to bachelor degree or higher.*

Mother's occupation

Occupation group of mother was derived from the questions “when you were growing up, how much of the time was your mother in paid employment” and the derived item *mother's occupation*, which was created from the question “what was her main occupation?”. Where the respondents mother's occupation was coded as manager, professional or associate professional, her occupation group was *manager/professional*. If she worked in some other occupation (not including housewife) she was coded as *working, other occupation*. All others who said their mother did not work, or when asked her main occupation stated it as housewife were included in the *no occupation* category. Those few respondents who did not provide an answer, or stated that they did not grow up with their mother were included in the latter category.

Just under half of all respondents' mothers did not work. The proportions were similar for males and females (47 and 46 per cent respectively). A slightly higher proportion of males' mothers were classified as professionals/managers (16 per cent compared to 14 per cent for females).

Father's occupation group

Father's occupation was derived from the questions “what was your father's main occupation when you were aged about 15” and the derived item *father's occupation* which was created from the responses to this question. The three categories *manager/professional*, *working other occupation* and *no occupation* were created in the same way as they were for mother's occupation group. The no occupation group includes retired and unemployed fathers as well as those that did not grow up with their father or did not know their occupation. As above, this did not appear to alter the results.

Less than 10 per cent of fathers were in the no occupation group. The proportions in the professional/manager category were similar for males and females (43 and 41 per cent respectively).

Methodology

The intention of this research was to investigate the relationship between various background factors, and the educational attainment at age 25, and to see how these relationships differed for males and females. First, bivariate analyses were conducted to establish the relationships between the dependent and independent variables. Simple cross-tabulations, with tests of significance, were used for this analysis.

To investigate the relationships found in the bivariate analyses more fully, multivariate techniques were used. This comprised of (1) a cross-tabulation of the main variables of interest, mother's and father's education, with education at age 25 and (2) multinomial logistic model of the relationship between education at age 25 and the other variables.

The cross-tabulation was done to investigate whether education at age 25 appeared to be a factor of mother's education, father's education or of both. This was purely a descriptive exercise.

The multinomial logistic model enabled a much more thorough examination of the variables, such that the effect of one variable could be seen in isolation from the others. A multinomial logistic model was chosen because of the categorical nature of the dependent variable. An ordered logistic model was also tested, as the different categories of the education variable are ordered, but the model did not satisfy the condition of proportional odds¹, and therefore a multinomial logistic model was the best option.

Models were fitted separately for males and females, to enable variables to affect the education of males and females in different ways without having to include many

¹ In an ordered logistic regression the same parameters are used to explain the relationship between each category of the dependent variable and the independent variables. Only the intercepts are different. This is possible only under conditions of proportion odds, or parallel line. Using a test of parallel lines in SPSS, I found this model violated the assumption and so could not be used. That is, the parameters on the independent variables are significantly different for each of the categories of the dependent variable and so cannot be combined into one model with different intercept terms (O'Connell, 2000; SPSS, 2002; Williams, 2002).

difficult to interpret interaction terms. A series of models were fitted, to see how well different combinations of mother's and father's education explained the variation in education at age 25. An additional model including mother's and father's occupation was also fitted for comparison, but is not analysed in depth in this paper. Interaction terms between the parental education terms and birth cohort (in case of changes over time) and location while at secondary school (in case of differences between city and country effects as found in other studies – reference) were tested but found not to be significant.

Because the coefficients in a multinomial logistic regression are difficult to interpret in themselves, predicted values were calculated and analysed based on the preferred model. These are described more fully in the Results Section, and the formulae used to calculate predicted values are given in Appendix 3.

Results

Bivariate Analysis

The cross-tabulation of education at age 25 by each independent variables is given in Table 2. Results are given separately for males and females.

The results are as was expected according to previously found patterns, but there were a few interesting differences by sex. Education was not significantly different by birth cohort for males. For females, the older birth cohort were less educated - they were more likely to be represented in the lower education group, and less so in the high education group.

Persons who lived in the city while at secondary school were more highly educated. The relationship was very strong for males while for females there was still a clear relationship but there was more similarity in education levels between the city and country groups.

Table 2: Education at age 25 by characteristics and sex

	Males			Females		
	Education at age 25			Education at age 25		
	Low	Medium	High	Low	Medium	High
	<i>per cent</i>			<i>per cent</i>		
Birth cohort						
Born in or before 1960	30.8	55.1	14.1	39.5	46.9	13.6
Born after 1960	27.2	56.4	16.4	29.1	54.1	16.7
<i>Pearson Chi-square significance : males 0.471; females 0.004</i>						
Residence while at secondary school						
City	22.9	59.3	17.8	32.1	51.8	16.1
Country	39.9	49.7	10.5	39.9	46.9	13.1
<i>Pearson Chi-square significance : males 0.000; females 0.043</i>						
Mother's education						
Low	34.2	54.2	11.7	41.4	46.2	12.4
Medium	19.9	59.2	20.9	19.8	61.6	18.6
High	6.3	59.4	34.4	13.5	45.9	40.5
<i>Pearson Chi-square significance : males 0.000; females 0.000</i>						
Father's education						
Low	38.4	51.7	9.9	41.6	47.3	11.1
Medium	19.1	63.1	17.8	25.9	55.7	18.4
High	6.9	55.6	37.5	16.9	50.6	32.5
<i>Pearson Chi-square significance : males 0.000; females 0.000</i>						
Mother's occupation						
Professional/Manager	22.8	58.5	18.7	19.8	55.0	25.2
Working, other occupation	26.5	59.5	14.0	37.8	49.6	12.6
No occupation	33.9	51.6	14.5	37.1	48.9	14.0
<i>Pearson Chi-square significance : males 0.078; females 0.000</i>						
Father's occupation						
Professional/Manager	23.7	54.8	21.5	22.6	56.3	21.1
Working, other occupation	33.4	56.0	10.6	43.2	46.8	10.0
No occupation	34.5	58.2	7.3	47.1	37.1	15.7
<i>Pearson Chi-square significance : males 0.000; females 0.000</i>						
Total	29.3	55.6	15.0	35.0	50.0	15.0

Source: NLC 1997

Mother's education had a strong relationship with education at age 25 for males and females. As expected, persons whose mother had a low education were more likely to have a low education themselves, and those whose mother had a high education were more likely to have a high education. Very similar results are evident for father's education, again for both males and females. These results do not tell us anything about whether mother's education and father's education are acting independently in this relationship, and how different combinations of mothers' and fathers' education might produce different results. This as looked at more closely in Table 3, which is discussed in the next section.

Respondents whose mother had a professional job were more likely to be highly educated. In the case of males, those whose mother had no occupation were more likely to have a low education than those with working mothers. This association did not exist for females, but those whose mother did not work or did not work in a professional/managerial job were equally likely to have a low education.

The effect of father's occupation also appeared to be strong, particularly in looking at the difference between those whose father was a professional/manager and fathers with other or no occupation. Those with a professional/managerial father were less likely to have a low education and more likely to have a high education.

Multivariate Analysis

Cross-Tabulation

Initially, the effect of mother's and father's education on education at age 25 was examined through a cross-tabulation of these variables. In Table 3 each cell represents the proportion within that combination of mother education - father education with the specified level of education. For example, look at the top left-most figure in the first panel, 40.8 per cent. This figure tells us that of those males whose mother and father both have low education, 40.8 per cent have low education themselves. In the next panel down, you can see that within this same combination of mother's and father's education, 49.9 per cent have a medium education, and from the next panel down, 9.4 per cent have

a high education. Adding the three corresponding cells from each panel together gives the total, 100 per cent.

Table 3: Education level by mother's and father's education by sex

	Males				Females			
	Father's Low	Medium	High	Total	Father's Low	Medium	High	Total
Mother's	Percentage with low education at age							
Low	40.8	20.6	7.7	34.2	45.0	32.1	28.6	41.4
Medium	29.2	17.2	7.4	19.9	24.1	18.6	12.5	19.8
High	0.0	16.7	5.3	6.3	25.0	12.5	5.9	13.5
<i>Total</i>	38.4	19.1	6.9	29.3	41.6	25.9	16.9	35.0
Mother's	Percentage with medium education at age							
Low	49.9	66.4	53.8	54.2	44.6	50.0	53.6	46.2
Medium	58.5	59.6	59.3	59.2	59.8	64.4	56.3	61.6
High	85.7	50.0	52.6	59.4	66.7	37.5	35.3	45.9
<i>Total</i>	51.7	63.1	55.6	55.6	47.3	55.7	50.6	50.0
Mother's	Percentage with high education at age							
Low	9.4	13.0	38.5	11.7	10.3	17.9	17.9	12.4
Medium	12.3	23.2	33.3	20.9	16.1	16.9	31.3	18.6
High	14.3	33.3	42.1	34.4	8.3	50.0	58.8	40.5
<i>Total</i>	9.9	17.8	37.5	15.0	11.1	18.4	32.5	15.0

Source: NLC 1997

(a) Some of the percentages for mother's education = high are based on very small cell size

This table shows there is a relationship between mother's and father's education and education at 25. For example, we can look at males whose mother has a low education. Overall, 34 per cent of these males – a relatively high percentage – had a low education at age 25. However, when looking more closely at these respondents, the percentage having a low education is quite different for different levels of father's education – if father also had a low education 41 per cent had a low education at age 25 while if father had a high education only 8 per cent had a low education at age 25. To show that both mother's and father's education are important, these respondents can be compared to those whose mother had a medium education. Overall 20 per cent of these respondents had a low education. Of those with low father's education and medium mother's education 29 per

cent had a low education at age 25 – a much lower percentage than those with low father’s education and low mother’s education.

For females, there is also a relationship between these variables, but mother’s education possibly exerts a stronger influence. For example, look at the case where father’s education is high but mother’s education is low. Within this cell, 29 per cent of females had a low education and 18 per cent had a high education. In comparison, for males with the same combination of mother’s and father’s education 8 per cent had a low education and 39 per cent had a high education. It appears that the mother’s education is more influential relative to the father’s for the females in this case than it is for the males.

There are many patterns evident in this table that warrant further attention. The multinomial logistic model enables a closer examination of how the mother’s and father’s education influence the pattern of educational attainment, also allowing for other variables to be controlled for.

Multinomial Logistic Regression

A number of different models were fitted in order to investigate how mother’s and father’s education explains the variation in educational attainment at age 25. A summary of these models and their diagnostics is given in Table 4. The model parameters (the Exp(B) value and significance) for each model are summarised in Table 2.1 in Appendix 2. The results are discussed in turn below.

Model 1 (Control variables) does not explain a great deal of the variation in education at age 25 but is significant for both males and females. Even at this simple level the models look quite different for males and females. The birth cohort variable is important for females, reflecting improvements in educational attainment for females over time, while it is not significant for males (it is nevertheless included in the model to enable comparisons with the female model). Residing in the city during secondary school was more important for males in explaining higher levels of educational attainment than for females. These relationships were as expected from the bivariate analysis.

Table 4: Model summary statistics

Male				
Model	-	df	Cox&Snel Pseudo Square	Nagelkerk Pseudo Square
1. Residence + Birth	42.00	4	3.6	4.2
2. Model 1 + Mother's	88.69	8	7.4	8.6
3. Model 1 + Father's	96.94	8	10.6	12.4
4. Model 1 + Mother's and Father's	186.09	12	11.6	13.6
5. Model 4 + Occupation	575.41	20	13.1	15.3

Female				
Model	-	df	Cox&Snel Pseudo Square	Nagelkerk Pseudo Square
1. Residence + Birth	44.08	4	1.8	2.0
2. Model 1 + Mother's	107.85	8	6.9	7.9
3. Model 1 + Father's	106.03	8	5.7	6.6
4. Model 1 + Mother's and Father's	216.30	12	8.6	10.0
5. Model 4 + Occupation	636.23	20	12.3	14.3

Model 2 includes the control variables plus mother’s education while **Model 3** includes the control variables plus father’s education. These separate models have been developed to investigate how mother’s and father’s education might separately be associated with education levels for each sex. In explaining the educational attainment of both males and females, there were clear relationships with either parent’s education level. In examining the pseudo R-square values for these models, however, it is clear that for males the model of father’s education provides a better fit to the data (Nagelkerke R-square of 12.4 compared to 8.6 for the model of mother’s education), while for females the model of mother’s education provides a slightly better fit (Nagelkerke R-square of 7.9 compared to 6.6 for the model of father’s education). The $-2LL$ statistic also supports this finding.

Model 4 is the final model used in the analysis below. It combines the effects of mother’s and father’s education in the one model. It is a significantly better model than the father education or the mother education models alone for both males and females. The model fitted for females was markedly improved having both mother’s and father’s education level in the model compared to those ones containing only mother’s or only

father's education. To examine the parameters of this model more closely the parameters have been used to calculate predicted probabilities for various combinations of variables. This is described further below.

Model 5 has been included for comparison to see how the occupation variables add further to the model. While these variables improve the fit of the model, it is beyond the scope of this study to examine their effects in detail.

Predicted Probabilities from the Parental Education Model

As mentioned in the earlier section, to see the effect of each of the parameters in this model, predicted probabilities were calculated and have been presented in the Table below. These probabilities have been calculated by substituting the sample means (calculated separately for males and females) into the model equations for all variables except the one under examination, for which the values representing each category were entered. This shows the effect of the one variable while holding all others constant. For more detail about the formulae used see Appendix 3.

The predicted probabilities in Table 5 are quite similar to the actual probabilities reported in Table 2. Looking at the results above, and the magnitude and significance of the parameters given in Appendix 2, we are able to clearly see the effect of mother's and father's education on predicting a high educational attainment. For males, the strongest factor is father's education – it is particularly influential where the father has a high education. Also very important for males is mother's education – particularly when mother's education is high. For females also having a mother with high education is very influential, as is having a father with a high education. For females, having a mother with a high education is the factor with the highest weight.

Table 5: Predicted education at age 25 by characteristics and sex

	Males			Females		
	Predicted Education at age 25			Predicted Education at age 25		
	Low	Medium	High	Low	Medium	High
	<i>per cent</i>			<i>per cent</i>		
Birth cohort						
Born in or before 1960	27.4	58.8	13.8	37.2	48.8	13.9
Born after 1960	26.0	59.6	14.4	29.4	55.5	15.1
Residence while at secondary school						
City	22.3	61.7	15.9	31.9	53.4	14.7
Country	35.2	53.7	11.1	37.0	49.0	14.0
Mother's education						
Low	30.0	57.6	12.4	39.5	47.5	13.0
Medium	22.1	60.1	17.7	21.9	62.0	16.1
High	10.7	67.4	22.0	17.9	49.6	32.4
Father's education						
Low	35.1	54.2	10.7	38.1	50.1	11.8
Medium	20.0	63.6	16.4	28.0	53.9	18.1
High	9.7	57.9	32.5	22.7	50.1	27.3
Total	26.8	59.1	14.0	33.8	51.8	14.5

Source: NLC 1997

The parameter estimates are less useful in trying to interpret probabilities for medium and low education so we focus on Table 5. For males, both mother's and father's education appear to be strongly related to the probability of having a low education – as mother's education decreases, the probability of having a low education increases, and likewise for father's education. This relationship also exists for females, but females are more likely to be in the low education group, even when their father or mother has a high education.

To see how the effects of mother's and father's education work together, the charts on the following page show predicted probabilities with either high, medium or low educational attainment for various combinations of mother's and father's education.

Figure 1. Predicted percentage with high education: Males

As discussed above, father's education has a strong effect – there is a much higher proportion predicted to have a high education amongst those with a highly educated father. The distinction between those with a medium education and a low educated father is not as great, but certainly exists. Comparing across the chart, mother's education is less important, but again there is a discernable relationship between a higher maternal education and a higher educational attainment.

Figure 2. Predicted percentage with high education: Females

This chart demonstrates the strong influence of both father's and mother's education in predicting high levels of educational attainment for females. The difference by father's education is large, but more noticeable is the difference across levels of mother's education. Unlike for males, females who have a highly educated mother, have a relatively high probability of being highly educated themselves.

Figure 3. Predicted percentages with low education: Males

Where both parents have a low education the probability of having a low educational attainment is greatest. If mother's education is low, but father's is not, the proportion with a low education decreases significantly. The father's education has a strong effect. Where father's education is low but mother's is not, there is also a strong effect – educational attainment increases with the level of the mother's education.

Figure 4. Predicted percentages with low education: Females

The first thing you notice about this chart in comparison to the male chart is that the proportions predicted to have a low education are much higher in all categories. While the pattern of educational attainment is the same as for the males, the father's education does not appear to have quite as much influence as does mother's education – particularly the influence of mother being low educated. Where fathers are low educated, the proportion predicted to be low educated is far greater in the category where mothers are also low educated. The difference between father having a medium or a high education is not very great in all categories of mother's education.

Figure 1. Males: Predicted percentage with high education

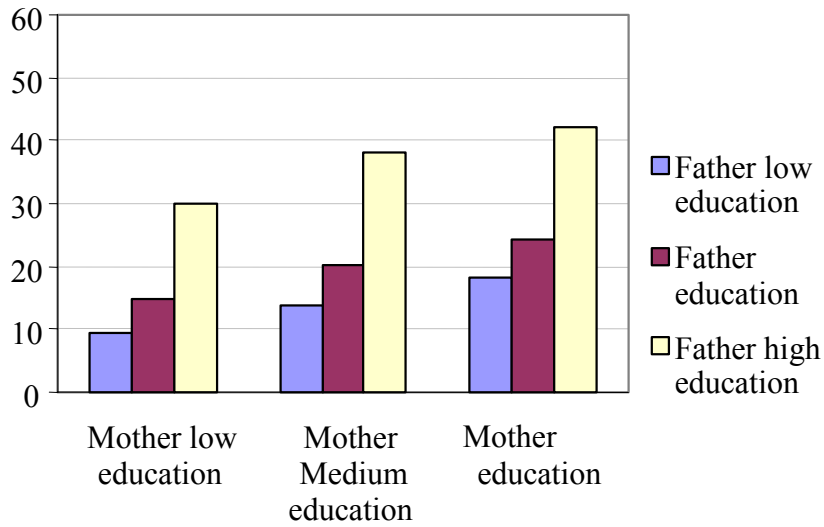


Figure 2. Females: Predicted percentage with high education

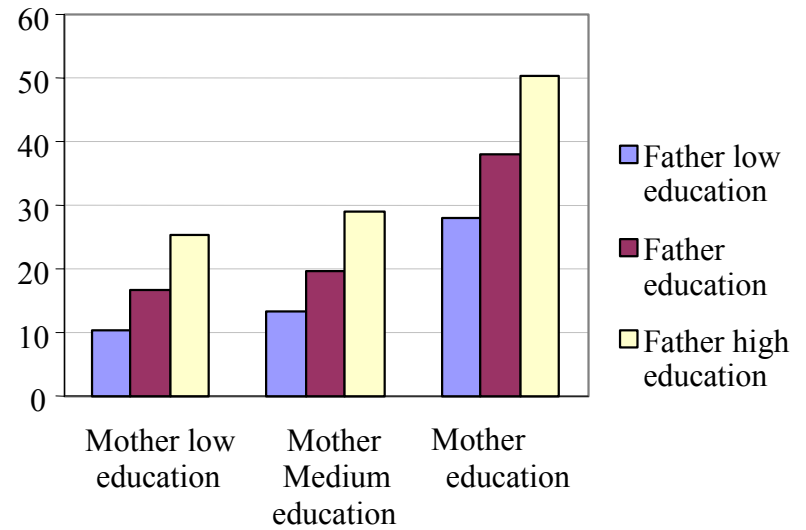


Figure 3. Males: Predicted percentage with low education

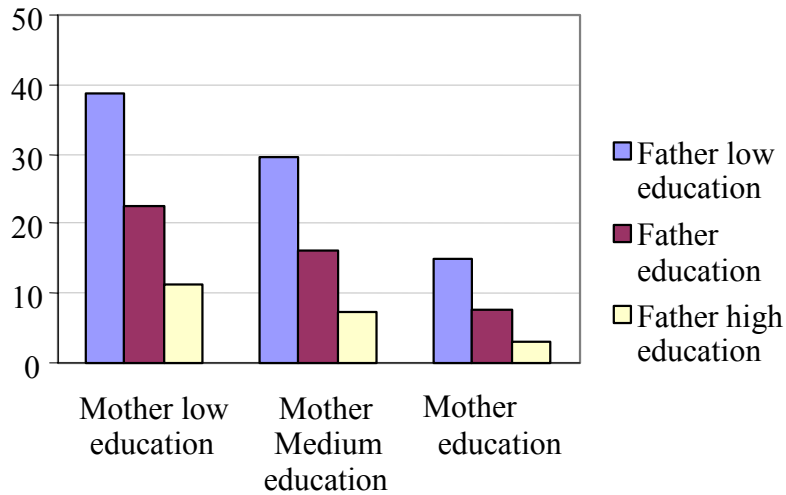
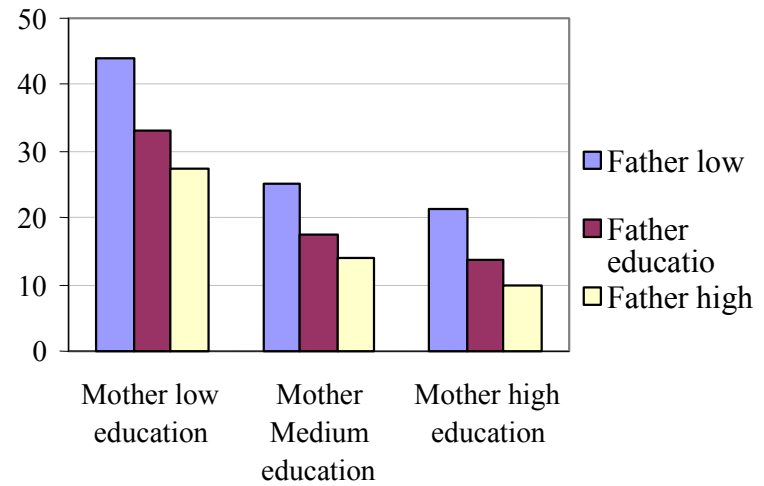


Figure 4. Females: Predicted percentage with low education



Summary and Discussion

This study aims to look closely at the relationship between educational attainment and parental education, focusing on how mother's and father's educational attainment affects educational attainment differently for males and females. This was done by examining the relationship between the education at age 25 and mother's and father's education for males and females separately. Bivariate and multivariate techniques were used in order to understand this relationship.

For males and females both mother's and father's education was associated with educational attainment. The higher the mother's or father's education, the more likely the respondent was to have a high education. The results also show clear relationships with both parents' education level, not just the mother and not just the father. We can see that taking only the mother's education level or only the father's education level would conceal more complex relationships that occur between both parents and the educational attainment.

Overall, parental education was a significant predictor of educational attainment. Consistent with other studies, it did not explain a large amount of variation in educational attainment – in this case the chosen model which included control variables and the parental education variables explained only (approximately) 14 and 10 per cent respectively of the variation in male and female educational attainment. No doubt a large amount of this unexplained variation is related to variation in intelligence or ability, or school/class/teacher effects. It is interesting that the degree of explained variation for males is so much higher than for females. Perhaps females are more highly influenced by other factors relating to family background, or to other variables not used in this analysis.

That there is some relationship with parental education does support the notion of social groups reproducing themselves to a small extent. In relation to education, where parental education fully explains educational attainment, we would be concerned that society was not open enough to allow people to move out of some pre-determined social group or

social class. The large amount of unexplained variation in this model suggests that people are moving out of their parents' class where class is defined solely on education level. For example, respondents whose father had a low education may have a relatively high probability of having a low education themselves, but a large number of them succeeded in reaching higher levels of education (of those with low father's education over half achieved a medium education or higher).

The results of analysing educational attainment determinants by sex produced some interesting results. The control variables, birth cohort and residence while at secondary school behaved differently for males and females. Birth cohort was not a significant variable in the male model, while it was for females, particularly in looking at the probability of having a medium education rather than a low education. The treatment of birth cohort in this analysis was less than ideal because of the need to avoid very small cell size as occurs when the data is divided into too many categories. Various forms of this variable were modelled, and the result was never a significant value for males. If the dataset was larger and we were able to separately analyse the youngest respondents we may have seen some birth cohort effect as education levels rose for both males and females from the 1980s.

The residence where growing up was not significant for females, although there were more females with a low education in the country. For males the differences were greater by residence, with males who went to secondary school in the city more highly educated.

When comparing how mother's education or father's education alone explained the variation in educational attainment, female educational attainment was best explained by mother's education and male educational attainment was best explained by father's education. Neither model fitted particularly well, although they were significant. They provide some support for the sex role theory – that girls are more influenced by their mothers and boys by their fathers. However, these models were improved by the addition of the opposite-sex parent. In particular the models for girls was quite a bit better after the inclusion of father's education. It appears that quite complex processes underlie the

relationship between parental education and educational attainment. The individual model, where both mother and father have some influence, appears to be the closest explanation of this data, with some influence also from the sex-role theory.

In looking more closely at how mother's and father's education interact for each sex we can see some subtle differences. Whether or not the father has a high education appears to be the most influential factor in determining whether a male will have a high education. For girls, this is also a very important factor, but whether or not the mother has a high education is also a strong factor.

In looking at the probability of having a low education, for males father's education and mother's education are important. Particularly, when the father has a low education, the education level of the mother can moderate this effect, to reduce the probability of having a low education. For females who have a mother of low education, father's education helps to reduce the probability of having a low education but to a lesser extent. Regardless of the level of education of the father, females with a mother with low education have the highest probabilities of having a low education.

In summary, to answer my original research questions. Mother's and father's education do help to explain educational attainment. Put together in a model they explain more of the variation than a model with only one of these variables, with more variation in educational attainment being explained for males than for females. More importantly, without the inclusion of both mother's and father's education, important information on the socio-economic background is being ignored, and in fact the result may be the chosen indicator is biased either to a level lower or higher than is actually experienced.

There are certainly differences in the relationship between these variables for males and females. It is likely that models which do not allow for different effects of sex by parental education may be missing some important information, and those that find the effect of mother's education insignificant, may need to consider how this variable interacts with sex.

There has been a great deal of variety in the results of analyses similar to this one. As reported earlier, some have found mother's education to be not significant, while others find it significant. There are certainly examples of studies that analyse directly the effects of mother's education and father's education by sex. They report complex relationships, and often do find that both mother's and father's education is important, and that there are differences by sex. The following result by Korupp et al. identifies the same result as this paper has highlighted:

'The mother's educational and occupations status have, net of the father's SES influence, considerable effects on the son's and daughter's educational attainment. Concerning trends of parental status transfer on the child's educational attainment it cannot be maintained that by adding the mother's influence, the directions of this trend changes. Still, the omission of either of the parent's characteristic as predictor produces a small but significant bias in the estimated trends in status reproductions' (Korupp et al., 2002:38)

The use of education at age 25 was conceptually an improvement on other analyses that focus on educational attainment at survey date, as it focused the analysis on education gained in early adult-hood, removing any possible effects of different determinants of mature age study. The models discussed in this paper were actually repeated for education at survey date, and there were quite large differences in some of the parameter estimates on mother's and father's education (results are available on request but have not been included here). As hypothesised, it does appear that the influence of factors on educational attainment does change over the course of life, and that this needs to be considered when deciding on a unit of measurement.

This dataset was not ideal for analysing educational attainment given that a number of the data items usually analysed in this area of research were simply not collected. Further research could be done with this data to analyse further the relationship between mother's and father's occupation statuses and educational attainment. However, it may be more useful to analyse this topic, focusing on parental education and possibly also parental

occupation, using one of the other main sources of data for educational attainment and participation, that is, the International Social Science Survey or the Longitudinal Survey of Australian Youth. The latter of these appears particularly useful given the large range of data items relating to not only background factors but also to educational outcomes. A more comprehensive analysis of the subject covered in this paper could have better controls for changes over time (or could focus on a particular birth cohort), better controls for background factors, specifically ethnicity, family size and school type, and could analyse the relationship between parental education and ability or intelligence.

In summary, the most important findings of this research are that both mother's and father's education are important determinants of educational attainment, and that the relationship between these variables and educational attainment is likely to be different for males and females.

References

- ABS. (1998). Educational Attainment: Gender differences in educational achievement, *Australian Social Trends 1998*. Canberra: Australian Bureau of Statistics.
- Biblarz, T. J., & Raftery, A. E. (1999). Family Structure, Educational Attainment, and Socioeconomic Success: Rethinking the "Pathology of Matriarchy". *American Journal of Sociology*, 105(2), 321-365.
- Blau, P., & Duncan, O. D. (1967). *The American Occupational Structure*.
- Clifton, R. A., Williams, T., & Clancy, J. (1991). The Academic Attainment of Ethnic-Groups in Australia - a Social Psychological Model. *Sociology of Education*, 64(2), 111-126.
- Collins, C. W., Kenway, J., & McLeod, J. (2000). *Factors influencing the educational performance of males and females in school and their initial destinations after leaving school*. [Canberra] :: Dept. of Education, Training and Youth Affairs.
- Ensminger, M. E., & Slusarcick, A. L. (1992). Paths to High School Graduation or Dropout: A Longitudinal Study of a First-Grade Cohort. *Sociology of Education*, 65(2), 95-113.
- Evans, M. D. R., & Kelley, J. (2000). Does mothers' employment affect children's education? *Australian Social Monitor*, 3(1), 6-14.
- Evans, M. D. R., Kelley, J., Borgers, M., Dronkers, J., & Rollenberg, L. (1995). Parental Divorce and Children's Education: Australian Evidence. *Worldwide Attitudes*, 1995 0717, 8.
- Evans, M. D. R., Kelley, J., & Wanner, R. A. (2001). Educational attainment of the children of divorce : Australia, 1940-90. *Journal of Sociology*, 37(3), (275)-297.
- Gallagher, M. (2000). *Overview of Symposium*. Paper presented at the Educational Attainment and Labour Market Outcomes: Factors affecting boys and their status in relation to girls, Melbourne.
- Ganzach, Y. (2000). Parents' education, cognitive ability, educational expectations and educational attainment: Interactive effects. *British Journal of Educational Psychology*, 70, 419-441.
- Hauser, R. M., & Featherman, D. L. (1977). *The process of stratification: Trends and analyses*. New York: Academic Press.
- Haveman, R., Wolfe, B., & Spaulding, J. (1991). Childhood Events and Circumstances Influencing High School Completion. *Demography*, 28(1), 133-157.
- Kelley, J. (2001). Changing educational attainments of women and men in twentieth century Australia. *Australian Social Monitor*, 4, 63-66.
- Korupp, S. E., Ganzeboom, H. B. G., & Van der Lippe, T. (2002). Do mothers matter? A comparison of models of the influence of mothers' and fathers' educational and

- occupational status on children's educational attainment. *Quality & Quantity*, 36(1), 17-42.
- Le, A. T., & Miller, P. W. (2002). *Educational Attainment in Australia: A Cohort Analysis* (Longitudinal Surveys of Australian Youth Research Report Number 25). Camberwell: Australian Council for Educational Research.
- Long, M., Carpenter, P., & Hayden, M. (1999). *Participation in Education and Training 1980-1994* (Longitudinal Surveys of Australian Youth Research Report Number 13). Camberwell: Australian Council for Educational Research.
- Marks, G. N., & Fleming, N. (1999). *Early School Leaving in Australia: Findings from the 1995 Year 9 LSAY Cohort* (11). Camberwell, Vic: Australian Council for Educational Research.
- Marks, G. N., Fleming, N., Long, M., & McMillan, J. (2000). *Patterns of participation in Year 12 and Higher Education in Australia: Trends and Issues* (17). Camberwell, Vic: Australian Council for Educational Research.
- Miller, P., Mulvey, C., & Martin, N. (2001). Genetic and environmental contributions to educational attainment in Australia. *Economics of Education Review*, 20, 211-224.
- NCVER. (2002). *Issues affecting skill demand and supply in Australia's education and training sector*. Kensington Park: The National Centre for Vocational Education Research Australian National Training Authority.
- O'Connell, A. A. (2000). Methods for Modeling Ordinal Outcome Variables. *Measurement and Evaluation in Counseling and Development*, 33(3), 170.
- Peck, B. (2001). The poor stay poor and the rich stay rich. *Issues in Educational Research*, 11, 20.
- Rowe, K. J. (2000). *Exploring "Real" Effects from Evidence-Based Research in Teacher and School Effectiveness*. Paper presented at the Educational Attainment and Labour Market Outcomes: Factors affecting boys and their status in relation to girls, Melbourne.
- Sewell, W. H., & Shah, V. P. (1968). Parents' Education and Children's Educational Aspirations and Achievements. *American Sociological Review*, 33(2), 191-209.
- Sieben, I., Huinink, J., & de Graaf, P. M. (2001). Family Background and Sibling Resemblance in Educational Attainment. Trends in the Former FRG, the Former GDR and the Netherlands. *European Sociological Review*, 17(4), 401-430.
- SPSS. (2002). *SPSS Base Guide* (Version 11.0).
- Watts, M. (1997). Gender Segregation in Higher Educational Attainment in Australia 1978-94. *Higher Education*, 34(1), 45-61.
- Williams, R. (2002, Spring 2002). *Brief Overview of Multinomial and Ordered Logit Models*. University of Notre Dame. Accessed, October 2002: <http://www.nd.edu/~rwilliam/xsoc593/lectures/l26.pdf>

Appendix 1. Qualifications Gained Before and After Age 25

Table 1.1: Age group of respondents by sex and whether they gained educational qualification after age 25

	Male		Female	
	Total Number	Percentage gained a qualification after age 25	Total Number	Percentage gained a qualification after age 25
25-29	130	15.4	148	7.4
30-34	136	14.7	197	23.9
35-39	152	25.0	199	25.6
40-44	154	38.3	166	27.7
45-49	95	36.8	144	29.2
50 +	86	32.6	108	36.1
Total	753	26.6	962	24.5

Table 1.2: Edu. at age 25 compared with edu. at survey date

Education (%) at:				
Education at age	Low	Medium	High	Total
Male				
Low	90.0	9.0	0.9	100.0
Medium		88.5	11.5	100.0
High			100.0	100.0
Female				
Low	89.3	10.1	0.6	100.0
Medium		86.9	13.1	100.0
High			100.0	100.0

Appendix 2. Multinomial Logistic Regression Details

Table 2.1: Model Parameters (Exp(B) and sig. levels

Exp (B) Parameters and significance levels: reference category is low education	Males				Females			
	High Education	sig.	Medium Education	sig.	High Education	sig.	Medium Education	sig.
<i>Model 1</i>								
Lived in the city while at secondary school ^(a)	2.937	0.000	2.074	0.000	1.507	0.051	1.362	0.035
Born after 1960 ^(b)	1.301	0.270	1.146	0.431	1.651	0.013	1.554	0.003
<i>Model 2</i>								
Lived in the city while at secondary school ^(a)	2.809	0.000	2.034	0.000	1.396	0.120	1.328	0.057
Born after 1960 ^(b)	1.175	0.500	1.094	0.609	1.460	0.068	4.462	0.011
Mother education high ^(c)	14.218	0.001	5.515	0.023	8.665	0.000	2.647	0.060
Mother education medium ^(c)	2.991	0.000	1.842	0.004	3.040	0.000	2.699	0.000
<i>Model 3</i>								
Lived in the city while at secondary school ^(a)	2.225	0.002	1.804	0.001	1.233	0.333	1.243	0.144
Born after 1960 ^(b)	1.136	0.607	1.092	0.619	1.463	0.067	1.486	0.007
Father education high ^(c)	17.305	0.000	2.262	0.000	6.383	0.000	1.811	0.000
Father education medium ^(c)	3.240	0.000	5.142	0.001	2.555	0.000	2.329	0.012
<i>Model 4</i>								
Lived in the city while at secondary school ^(a)	2.259	0.002	1.810	0.001	1.217	0.368	1.261	0.125
Born after 1960 ^(b)	1.094	0.720	1.065	0.722	1.370	0.135	1.440	0.015
Mother education high ^(c)	4.997	0.054	3.297	0.125	5.500	0.002	2.303	0.115
Mother education medium ^(c)	1.945	0.023	1.419	0.119	2.238	0.002	2.358	0.000
Father education high ^(c)	11.020	0.000	3.881	0.007	3.893	0.001	1.679	0.138
Father education medium ^(c)	2.694	0.001	2.060	0.001	2.102	0.002	1.467	0.029
<i>Model 5</i>								
Lived in the city while at secondary school ^(a)	2.319	0.002	1.753	0.001	1.278	0.271	1.307	0.082
Born after 1960 ^(b)	1.050	0.847	1.017	0.927	1.510	0.060	1.547	0.005
Mother education high ^(c)	4.539	0.077	3.177	0.142	3.431	0.038	1.765	0.302
Mother education medium ^(c)	1.810	0.047	1.353	0.185	1.801	0.028	2.084	0.000
Father education high ^(c)	8.403	0.000	3.794	0.009	2.323	0.044	1.125	0.745
Father education medium ^(c)	2.529	0.002	2.109	0.000	2.068	0.003	1.416	0.051
Father professional/managerial ^(d)	1.921	0.016	1.161	0.438	3.033	0.000	2.107	0.000
Father had no occupation ^(d)	0.729	0.597	1.107	0.754	1.472	0.324	0.719	0.250
Mother professional/managerial ^(d)	0.966	0.929	0.973	0.921	1.821	0.087	1.370	0.257
Mother had no occupation ^(d)	0.742	0.285	0.681	0.045	1.054	0.823	0.975	0.875

(a) living in the country is the reference category

(b) born in or before 1960 is the reference category

(c) low education is the reference category.

(d) working, not manager or professional is the reference category.

Appendix 3. Calculation of Estimated Probabilities

P_1 Estimated probability of high education

P_2 Estimated probability of medium education

P_3 Estimated probability of low education (reference category)

$$\log \frac{P_1}{P_3} = a_1 + b_1 X_1 + c_1 X_2 + \dots$$

$$\log \frac{P_2}{P_3} = a_2 + b_2 X_1 + c_2 X_2 + \dots$$

$$P_1 + P_2 + P_3 = 1$$

Therefore the predicted probabilities can be calculated as follows:

The values of a, b, c etc are the parameter estimates and the values of X are chosen according to which variable is under examination. Where a variable is not under examination, the mean values are entered.

$$P_1 = \frac{\exp(a_1 + b_1 X_1 + c_1 X_2 \dots)}{(1 + \exp(a_1 + b_1 X_1 + c_1 X_2 \dots)) + \exp(a_2 + b_2 X_1 + c_2 X_2 \dots)}$$

$$P_2 = \frac{\exp(a_2 + b_2 X_1 + c_2 X_2 \dots)}{(1 + \exp(a_1 + b_1 X_1 + c_1 X_2 \dots)) + \exp(a_2 + b_2 X_1 + c_2 X_2 \dots)}$$

$$P_3 = 1 - P_1 - P_2$$

Each term on this page was calculated separately for males and females in this analysis.