

# A test of the sorting model of education in Australia

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## Abstract

In this paper we test the hypothesis advanced by Weiss (J. Economic Perspectives 9(4)(1995)133) that under sorting models the return to schooling across identical twins would decline over time compared to the return for the population as a whole. The analyses undertaken on a relatively large sample of Australian twins are consistent with this proposition. The pure effect of education on earnings declines with time in the labour market. This presumably occurs because with time in the labour market firms learn more about the workers and so can set pay assigning more weight to the information they acquire.

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## 1. Introduction

One of the strongest empirical regularities in the labour market is the positive relationship between educational attainment and earnings. This relationship is generally explained using human capital theory. Human capital theory suggests that education represents “value added”. Workers with higher levels of education have acquired skills while enrolled at school, college or university. These skills make them more productive, and this is why they earn more.

A number of studies have provided evidence on whether the higher wages of the better educated are a reward to skills learned while undertaking formal studies. Among these are Kang and Bishop (1986), Altonji (1995) and Chiswick, Lee, and Miller (2003). In these studies the conventional human capital earnings function is augmented with measures of courses taken, and skills learned as part of the formal studies (Altonji,

1995; Kang & Bishop, 1986) or with skills that were most likely learned as part of these studies (Chiswick et al., 2003). These studies show that courses completed during formal programs of study have little impact on wages, and that the greater part of the wage increments associated with years of education remain when skills (literacy and numeracy) learned (Altonji, 1995; Kang & Bishop, 1986) or which were likely to have been learned while studying (Chiswick et al., 2003) were taken into account. This evidence calls into question the empirical relevance of the human capital explanation of the links between education and wages.

Alternative explanations of the positive links between the level of education and wages have been provided by signalling and sorting models. Formal statements of the processes described under these alternative explanations can be found in Spence (1973), Riley (1975) and Stiglitz (1975), among others. At the risk of simplification, these models suggest that the level of education is correlated with unobserved innate productivity differences (due to differences in ability, perseverance, conscientiousness, for example). Firms use education levels to infer these unobserved traits. Knowing that this is how firms make their decisions,

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young people have an incentive to signal their innate ability by completing given levels of education. The end result is a positive correlation between education and wages, and between wages and productivity. But clearly the process through which these correlations arises is vastly different from the process suggested by human capital theory.

If sorting is a consideration that needs to be taken into account when examining the relationship between wages and education, then the private and social returns to education may differ. There may be either over-investment or under-investment of public funds in education.<sup>1</sup> The level of education acquired by individuals will exceed the socially optimal level when the private return to education exceeds the social return. Weiss (1995) argues that this might arise where individuals invest too much in education as a means of signalling their love of learning, or where firms' hiring mechanisms set the threshold for entry into screened jobs higher than is required for the job to deter applications from those people who have difficulty succeeding in school. Sorting may, however, improve the match between workers and jobs. This would be associated with the social returns to education being greater than the private returns, and a socially inefficient under-investment in education.

Various tests of the correlation between years of education and wages have been proposed. It has been argued that if education is only a screen an individual who is self-employed all his or her working life should have had little incentive to signal their ability to potential employers and thus should undertake relatively little education. The self-employed should therefore have less education than wage and salary earners (see Cohn, Kiker, & De Oliveria, 1987; Grubb, 1993; Katz & Ziderman, 1980; ; Wolpin, 1977). This test has been criticised on various grounds, including that the self-employment decision is often made after the individual has completed their education, and even if a student intended to enter self-employment, they may undertake schooling as insurance in case they should at some stage enter wage and salaried employment (see Wolpin, 1977). However, the test continues to be used (e.g., Alba-Ramirez & Segundo, 1995; Brown & Sessions, 1999), and has formed the basis for several further tests. Thus, as an extension of the comparison of the characteristics of the self-employed and wage/salaried workers, Riley (1979) suggests that the wage determination processes in screened and unscreened occupations may be examined (Psacharopoulos, 1979; Riley, 1979). Comparisons between the public and private sec-

tors have also been conducted (see Alba-Ramirez & Segundo, 1995; Arabsheibani & Rees, 1998; Brown & Sessions, 1999).

The variation in the effect of education on earnings with experience can also be examined in an attempt to provide information on the relative merits of the human capital and sorting explanations of the earnings premiums of the better educated. Under the typical sorting model, employers use educational attainment to index ability/productivity at the time of hire. However, once an individual has commenced employment with a firm, the employer should acquire information on the worker's performance which is more accurate than that revealed by the index of educational attainment. Accordingly, while there might be considerable earnings differentials by education level among recent hires, these should narrow with labour market experience, as firms learn about the worker's true productivity. The hypothesis here is that sorting models, but not human capital models, are associated with a narrowing of earnings differentials by educational attainment with increases in labour market experience (see Layard & Psacharopoulos, 1974; McNabb & Richardson, 1989).

The tests noted above have been implemented by various authors for a range of countries and time periods, and the findings are largely inconclusive. Other tests, reviewed in Weiss (1995) (for example, the effect of class size, teacher salaries and the individual's birth-date on returns to schooling) are equally inconclusive.

One test where there is no empirical evidence is that based on twin studies outlined by Weiss (1995). He argues "If the sorting model is correct we would expect the return to schooling across twins would decline over time compared to the return for the population as a whole." Weiss (1995) used data from Ashenfelter and Krueger's (1994) study to examine this proposition, but reported that the data were not sufficient to measure the decline accurately.

In this paper we use the relatively large samples from the twins study by Miller, Mulvey, and Martin (1995) to implement a test in the spirit of Weiss' (1995) proposition. The structure of the paper is as follows. Section 2 outlines a model that can be used to explore the basis of the relationship between level of education and earnings. Section 3 describes the data and Section 4 presents the empirical results. Concluding comments are provided in Section 5.

## 2. Model

A model along the lines of Layard and Psacharopoulos (1974) will assist understanding of this test of the empirical relevance of the sorting and human capital theories proposed here.

Assume that firms cannot observe a worker's true productivity ( $P$ ). Rather they predict this using infor-

<sup>1</sup> There might also be over-investment or under-investment in education in the absence of sorting issues if there are externalities associated with education.

mation on the level of schooling ( $S$ ), information on the worker's family background ( $F$ ), and another proxy ( $A^F$ ) for the factors (e.g., innate ability, perseverance and conscientiousness) that contribute to productivity differences across workers and which are both unobserved at the time of labour market entry and not caused by schooling. The true value of these ability-related factors will be denoted by  $A$ .  $A^F$  is simply the non-schooling information used to predict  $A$ . Workers are paid ( $Y$ ) according to the predictions from the production relationship that firms have in mind. Let the predictor used by firms be linear:

$$Y_i = \hat{P}_i = \hat{\alpha}_0 + \hat{\alpha}_1 S_i + \hat{\alpha}_2 F_i + \hat{\alpha}_3 A_i^F \quad (1)$$

At the time of labour market entry, firms might pay workers simply according to  $S$  and  $F$  (if they have no other reliable information on  $A$ ). That is, they use  $S$  and  $F$  as indicators of the unobserved factors that are held to be linked to productivity differences. With time in the labour market, however, firms will acquire information on the “ $A$ ” traits that are unobserved at the time of labour market entry. Hence when paying more experienced workers, firms should assign a greater weight to  $A^F$  and less weight to  $S$  and  $F$ . In comparison, if the higher wages paid to better educated workers reflect the productivity differences attributable to skills learned in school rather than the use of  $S$  as an index of unobserved productivity differences, the weight assigned to  $S$  in the model of pay determination need not diminish with labour market experience.

In empirical work on earnings determination, researchers generally have information on earnings, level of schooling, some measures of family background, and in some cases, a measure of ability. They thus estimate:

$$Y_i = \beta_0 + \beta_1 S_i + \beta_2 F_i + \beta_3 A_i^R + u_i \quad (2)$$

where  $A^R$  is the value of a variable that is held to affect productivity differences and which is observed by the researcher (e.g., a measure of IQ) and  $Y$  is the value obtained from the firms' predictor given by Eq. (1). In the more usual case the researcher will not have a useful variable to use for  $A^R$ , in which case it will be omitted from the estimating equation. Accordingly, the conventional estimate of the returns to schooling will be biased through the omission of the non-schooling information used to predict  $A$ .

Estimates of the return to schooling that are free of the bias associated with omission from the specification of the factors incorporated in  $A$  can, in principle, be obtained using a sample of twins. The starting point for this approach is a general model of the earnings determination process of the form:

$$Y_i = \beta_0 + \beta_1 S_i + \beta_2 F_i + \beta_3 A_i + v_i \quad (3)$$

When applied to twins, the difference in the earnings of members of a set of twins is related to differences in the values of the explanatory variables. This is referred to as a fixed effects or within-twins estimator. Obviously any explanatory variables that have the same value for each twin will drop out of the estimating equation. As monozygotic (MZ) or identical twins reared together have the same innate ability and family background, the ability ( $A$ ) and family background ( $F$ ) terms drop out of the fixed-effects version of the model of earnings determination. Hence, for identical twins, the estimating equation is as follows,<sup>2</sup> where the subscript  $j$  refers to the family, and  $\Delta$  indicates the difference in the values of the particular variable for the members of the set of twins in family  $j$

$$\Delta \ln Y_j = \beta_0 + \beta_1 \Delta S_j + \Delta v_j \quad (4)$$

The underlying equation for the within-twins model for dizygotic (DZ) or non-identical twins is given as:

$$\Delta \ln Y_j = \beta_0 + \beta_1 \Delta S_j + \beta_3 \Delta A_j + \Delta v_j \quad (5)$$

With non-identical twins who are reared together, the term in “Family” will disappear from the fixed-effects version of the model. However, as non-identical twins are no more alike genetically than non-twin siblings, they will differ in genetic ability. In the absence of direct measures of this ability, the term  $\Delta A_j$  cannot be incorporated into the estimating equation. Consequently, while the estimates obtained for non-identical twins with the within-twin model will be free of bias associated with the absence of controls for common family background influences, they will be subject to biases associated with the absence of measures for ability.

There are several issues relating to these fixed-effects models that need to be discussed. First, as well as the genetic ability and environmental factors generally discussed in the literature (see Behrman, Taubman, & Wales, 1977), the fixed effects noted above may also encompass factors such as “conscientiousness” and “perseverance” raised in the sorting literature, as these appear to be partly genetically determined.<sup>3</sup> In line with the twins literature, and to avoid confusion, these factors will be referred to as “ability” in this study.

<sup>2</sup> A constant term is included in the model to capture any effects associated with non-random selection of the twin to be the first twin for the within-twins difference operator. The first member of a twin pair encountered in the data set is designated the first twin.

<sup>3</sup> These traits are moderately heritable. See Cloninger (1988, 1994) for a general discussion, and Gillespie, Cloninger, Heath, and Martin (2002) for recent estimates of the importance of the heritability of the traits. There is no evidence, however, that shared environmental factors affect these traits.

Second, there is the issue of accounting for differences in educational attainment within pairs of identical twins if such twins are exactly alike. Martin, Boomsma, and Machin (1997) present an overview of factors that might make MZ twins less than fully identical. They argue that a wide range of antenatal genetic and environmental influences can cause genotypic divergence. Included are (pp. 390, 392) "...endogenous accidents of development and differentiation, from perturbations in the gradients of developmental fields to somatic mutation, somatic recombination, differences in tissue-specific methylation patterns and the time of such events". For example, Martin et al. (1997) note that there is only one optimal placental implantation site, and it is unlikely that both twins in a di-chorionic pair would be able to benefit from this site. At a more general level, Ashenfelter and Rouse (1998) also examine a range of issues that could give rise to ability differences within twin pairs and hence lead to differences in levels of education. These include birth order and the possibility that twins are treated differently and so end up with different non-genetic abilities. They also canvass direct evidence (through a survey question) on why twins differ in the amount of schooling obtained. In the vast majority of cases, one twin received more schooling than the other for non-ability-related reasons, such as marriage or career interests. Ashenfelter & Rouse (1998: p. 279) conclude, that "These results provide further evidence that the within-twin schooling differences are not solely determined by within-twin ability differences and that within-twin estimates of the return to schooling contain less ability bias than cross-sectional estimates."

The advantage of the within-twin estimate of the returns to schooling obtained from a sample of identical twins (Eq. (4)) is that it provides, implicitly, the same controls for ability that would be obtained from a multiple regression equation that included a true measure of ability. This return to schooling can be expressed in the standard format as the ratio:

$$\beta_1 = \frac{\text{the net of ability covariation between workers' pay and schooling}}{\text{net of ability variation in schooling}} \quad (6)$$

If sorting is prevalent in the labour market, firms should place less emphasis on schooling in pay determination (Eq. (1)) among experienced workers than for labour market entrants. Thus, the net of ability covariation between workers' pay and schooling should be smaller for more experienced workers than for labour market entrants. As most schooling is obtained prior to labour market entry, the net of ability variation in schooling should not vary greatly with experience, implying that the estimated return to schooling in Eq. (4) should decline over time.

The return to schooling obtained from a sample of identical twins can be compared to the conventionally

estimated returns to schooling which, because of omitted variables bias, include the indirect effects of the factors included in "A". The estimated impact of schooling on earnings obtained from samples of individuals (using Eq. (3)) need not exhibit a decline of the same extent as that obtained for identical twins (using Eq. (4)), as the omitted variables component of the estimated return when using Eq. (3) with a sample of individuals would rise as firms ascribe greater importance to the non-schooling factors.

Where the positive correlation between schooling levels and wages is largely the result of skills learned in school rather than the level of schooling being used to index unobserved productivity differences, there is no strong reason to believe that the effects of schooling on earnings obtained from a sample of MZ twins will change with time in the labour market in a way that is systematically different from the returns for the total population. Where a more prominent role is ascribed to the sorting explanation, however, there is the expectation outlined above that the return to schooling that is purged of the effects attributable to innate ability will decline as firms learn more about the workers and so can set pay assigning more weight to the newly acquired information (see Eq. (1)).

### 3. Data

This study uses data from the Australian Twin Registry which were gathered in two surveys, in 1980–82 and 1988–89. This survey contains an exceptionally large sample of twins—around 3000 in all. The starting point for the data is a 12-page questionnaire mailed out to all 5967 twins aged over 18 years enrolled in the Australian National Health and Medical Research Council Twin Registry in 1980–82. Joining this registry and responding to the survey were both voluntary, but the twins were otherwise unselected. Replies were received from 3808 complete pairs (a 64% response rate). In 1988–89 this sample was followed up and 2943 twin pairs responded (a conditional response rate of 78%, and an unconditional rate of 49%). All the data other than for zygosity determination used in the current study are from the 1988–89 follow-up survey.

The Australian Twin Registry is a reasonably rich data set, and contains information on a wide range of family background, demographic and labour market variables. It also contains large samples of both MZ and DZ twins. Zygosity determination for same-sex pairs was done on the basis of two self-report items in the 1980–82 survey (Jardine, Martin, & Henderson, 1984). If there were any inconsistencies with unequivocal zygosity assignment in the responses of the twins, they were contacted for further information and frequently supplied photographs which assisted in making the decision.

These data have been used in a number of analyses of labour market and social outcomes (see Miller et al., 1995, Miller, Mulvey, & Martin, 1996, Miller, Mulvey, & Martin, 1997, Miller, Mulvey, & Martin, 2001). They are described in detail in Miller et al. (1995). It is noted in this earlier study that the average educational attainment of the twins is a little more than one year higher than the national average recorded in the 1986 Australian Census of Population and Housing. The twins are, on average, one year younger than the general population of 20–64 year olds, and are more likely to be married than the total population (74.1% compared to 67.4%). The samples used by Ashenfelter and Krueger (1994) and Behrman et al. (1977) also have mean educational attainments above the national average.

Both males and females are included in the analyses presented below. Conducting separate analyses for males and females (see Miller et al., 1997) involves a trade-off of a diminution of sample size and the better estimates that might be obtained where the samples are more homogeneous with respect to the measurement of the experience variable. Given that the sample needs to be partitioned by age in the current study, having as large an initial sample as possible is paramount.<sup>4</sup>

There is one aspect of the data that requires comment. Due to limitations on the earnings data collected, the dependent variable in the analysis needs to be defined as the mean earnings of the occupation of employment (see also Miller et al., 1995). Hence the analysis is able to capture the inter-occupational earnings effects of schooling, but not the intra-occupational earnings effects. Analyses by Miller, Mulvey, and Martin (2003), however, indicate that the use of mean occupational earnings in place of a measure of individual earnings when the latter are not available is a defensible research strategy when the focus is on the economic returns to schooling. It has been argued that this reflects Groshen's (1991) argument that most of the earnings increments associated with extra years of education come about through job classification rather than intra-occupational channels.

#### 4. The return to education

Miller et al. (1995) present a range of analyses for twins aged 20–64 years. Table 1 presents estimates of models of log annual earnings for individuals, identical twins and non-identical twins from their study. Both OLS and IV estimates are presented.<sup>5</sup> The IV estimates

for the fixed effects models have been obtained using the estimator proposed by Ashenfelter and Krueger (1994) that takes account of the correlation between the errors of measurement in the respondent's report of their own and their co-twin's levels of schooling.<sup>6</sup> The estimating equation used in these analyses only includes a limited set of control variables. This reflects the focus of the survey on medical rather than economic issues, and the finding of prior research that family background variables (e.g., information on parents, siblings) were statistically insignificant, or where statistically significant, economically unimportant (see Miller, Mulvey, & Martin, 1994). Lee (2003) shows that the addition of variables for alcohol consumption to the model of earnings determination estimated using these data has little impact on the estimates of the returns to schooling.

The estimates in Table 1 have several key features. These are discussed in Miller et al. (1995), and only brief comments are provided here. First, in order to provide a benchmark set of results, the data were pooled across identical (MZ) and non-identical (DZ) twins and each member of a twin pair treated as a separate observation (see also Ashenfelter & Krueger, 1994 for this type of analysis). These results are broadly the same as have been obtained in studies of earnings determination in the Australian labour market based on other data sets (see, for example, Preston, 1997). These results are presented in the first set of columns of Table 1. They show that the return to education in Australia, when the sample is treated as one of individuals, and before any adjustment for ability or family effects bias, is around 7%. This is lower than the return usually reported for the US labour market, and this difference is generally attributed to the more centralized system of wage determination in Australia and the more egalitarian distribution of income that results from it.

Second, the estimated return to education from the fixed-effects model for identical (MZ) twins is only 2.5% (OLS) or 4.5% (IV). As noted above, as identical twins, reared together, have, by definition, the same innate ability and family background, relating the difference in the incomes of such twins to the difference in their educational attainments provides an estimate of

<sup>4</sup> Ashenfelter and Krueger (1994) also conduct the analyses in their important study of twins on samples pooled across males and females.

<sup>5</sup> Attention has been drawn to the similarity of the standard errors for the OLS and IV methods of estimation for all variables other than the education variable that is instrumented. This pattern is also evident in Ashenfelter and Krueger (1994).

<sup>6</sup> Ashenfelter and Krueger (1994) show that a consistent estimator in the presence of a common measurement error in the reports (report on own and on co-twins' schooling) on schooling provided by an individual is obtained by expressing the earnings difference as a function of the difference between the respondent's own level of education and his or her report on the co-twin's level of education, and instrumenting this using the difference between the co-twin's report on the first twin's level of schooling and the co-twin's report on his or her own level of schooling.

Table 1  
Estimates of models of log annual earnings, Australian twins sample

Variable	Individuals <sup>a</sup>		MZ twins <sup>b</sup>		DZ twins <sup>b</sup>	
	OLS	IV	OLS	IV	OLS	IV
Constant	8.989 (0.033)	8.831 (0.038)	0.011 (0.010)	0.004 (0.009)	0.032 (0.012)	0.008 (0.012)
Own education	0.065 (0.002)	0.076 (0.002)	0.025 (0.005)	0.045 (0.009)	0.045 (0.005)	0.074 (0.009)
Age/10	0.020 (0.006)	0.026 (0.006)	<sup>c</sup>	<sup>c</sup>	<sup>c</sup>	<sup>c</sup>
Married	0.019 (0.010)	0.022 (0.010)	0.037 (0.020)	0.034 (0.020)	–0.016 (0.020)	–0.022 (0.021)
Male	0.223 (0.009)	0.213 (0.009)	<sup>c</sup>	<sup>c</sup>	0.226 (0.020)	0.229 (0.021)
Sample size	2340	2340	602	602	568	568

Note: Figures in parentheses are heteroscedasticity-consistent standard errors.

<sup>a</sup> Dependent variable in standard earnings function is the log of the mean occupational earnings of the individual.

<sup>b</sup> Dependent variable in the fixed-effects model is the difference in the logs of the mean occupational earnings of members of a pair of twins.

<sup>c</sup> Variable not relevant in fixed-effects model, as it has the same value for each member of a pair of twins.

the impact of education on income that is not biased by the omission of ability and family background factors.

Third, the estimated return to education from the fixed-effects model applied to data from non-identical (DZ) twins is 4.5% (OLS) or 7.4% (IV). As shown in Section 2, the estimated return to schooling for non-identical twins who were reared together provides an estimate of the effect of education on income which will be biased by the omission of individual ability but not biased by the omission of family background.

Fourth, focusing on the estimates obtained from the IV estimator that is robust to correlated measurement errors, the analyses suggest that there is little role for family background in the determination of the returns to schooling in the Australian labour market (i.e., the results for non-identical twins are similar to those for individuals).

Fifth, the application of this IV estimator also indicates that genetic factors may have a modest impact on the relationship between schooling and earnings in Australia (i.e., the estimates for identical twins are only slightly less than those for non-identical twins).

Sixth, the within-twins estimates presented in Miller et al. (1995) were consistent with the findings presented by Ashenfelter and Krueger (1994) to the effect that there is little upward bias in the typical OLS estimate of the return to education.

Finally, the gender, age and marital status variables yield interesting findings. They show that there is a female earnings differential of around 20%, a figure that is comparable to the estimates reported in previous studies that have examined variations in annual earnings (see Miller et al., 1995). The age effects are quite modest, and this appears to be attributable to the use of the average earnings of the occupation as the depen-

dent variable, which will tend to dilute the independent effect of a variable unless there is a high degree of occupational segregation on the basis of the characteristic. There is a different pattern of marriage effects for DZ (insignificant effect) and MZ (positive impact) twins. Lee (2003) argues that this may arise because MZ and DZ twins differ with respect to various family characteristics. In particular, Lee notes that while MZ births occur randomly, DZ births vary by race, and age of the mother. As a consequence, it is argued that DZ twins are more likely to be Catholic and have marriage patterns that may generate the different marriage premiums evident in Table 1.

To examine the changes in the returns with additional labour market experience, the samples of twins were separated on the basis of age, and separate equations estimated for samples of younger twins and of older twins. There is no natural age to use to separate the samples in this way, so two alternatives were considered. First, twins less than 35 years were separated from twins 35 or more years. This division provides samples of younger and older twins that are approximately of equal size. Second, twins 30–34 were then omitted from the younger sample, and twins 35–39 omitted from the older sample. This gives a 10-year age gap between the two samples, which may increase our ability to discern any differences between the estimates of the returns to education for the two samples. There is the possibility that the analysis will be affected by cohort effects. However, the influence of these effects is likely to be minimal, for two reasons. The first of these is that studies of cohort effects in the context of the performance of immigrants in the Australian labour market has shown these to be negligible (see McDonald & Worswick, 1999a,b). Second, emphasis is placed on the change in the return to school with

Table 2  
Return to education for MZ twins and DZ twins, by age group<sup>a</sup>

Coefficient on own education	MZ twins		DZ twins	
	<35 years	35 + years	<35 years	35 + years
OLS	0.042 (0.009)	0.015 (0.006)	0.037 (0.007)	0.051 (0.007)
IV	0.063 (0.014)	0.032 (0.012)	0.069 (0.011)	0.076 (0.012)
	<30 years	40 + years	<30 years	40 + years
OLS	0.048 (0.012)	0.015 (0.008)	0.037 (0.009)	0.057 (0.008)
IV	0.078 (0.024)	0.031 (0.015)	0.076 (0.015)	0.077 (0.014)

<sup>a</sup> Estimates for different age groups for identical twins are significantly different from each other at the 10% level or better: estimates for different ages groups of non-identical twins are not significantly different. Figures in parentheses are heteroscedasticity-consistent standard errors. The dependent variable in these fixed-effects model is the difference in the logs of the mean occupational earnings of members of a pair of twins.

experience for identical twins compared to non-identical twins. Unless cohort effects disproportionately affect one of these groups they will be netted out of the comparison. There is no reason to believe that cohort effects will vary according to zygosity.

Results of the analyses by age groups are presented in Table 2.

The first section of Table 2 contains results from the analyses where the samples are separated into two, approximately equal-sized, sub-samples. These results reveal a difference between the two age groups of around three percentage points in the return to schooling for MZ twins, and of around one percentage point in the return to schooling for DZ twins. Note that whereas the return for MZ twins in the older age group is lower than that for the younger age group, the return for DZ twins in the older age group is greater than that for the younger age group. As outlined above, the estimate obtained for MZ twins records the pure effect of schooling. These results show therefore, that the net impact that schooling has on earnings is lower among older age groups than among younger age groups. The estimates for DZ twins record the effects of schooling and the ability bias. The difference between the estimates for MZ and DZ twins therefore provides an indication of the role of ability. Similarly, changes in the estimates for MZ and DZ twins between the younger and older cohorts provide an indication of changes in the role of ability with time in the labour market. The widening of the gap between the estimates of the return to schooling for MZ and DZ twins between the younger and older cohorts in Table 2 is indicative of a strengthening of the role of ability in the earnings determination process.

The second section of Table 2 contains the results from the analyses where individuals aged 30–39 years are excluded from the analysis in an attempt to sharpen the distinction between the age groups examined. The

findings are very similar to those discussed in relation to the first section of the table. They reveal a difference in favour of the younger cohort of around four percentage points in the return to schooling for MZ twins, and a difference in favour of the older cohort of two percentage points (OLS estimates) or a negligible 0.1 percentage points (IV estimates) in the case of DZ twins. Again, the pattern is one where the pure effect of education is less, and the role of ability is stronger, among the older age groups.

These findings are consistent with Weiss' hypothesis.

To examine this issue further, the analysis was repeated by progressively changing the age groups.<sup>7</sup> Hence, in the first instance only individuals aged less than 30 years were included in the analysis. Then the sample was expanded to also include individuals aged 30–34 years (i.e., a sample of 20–34 year olds was used). Following this individuals aged 35–39 were added to the analysis (i.e., the sample used comprised 20–39 year olds). This process was continued until the sample contained all individuals aged 20–64. It will be apparent that this estimation process is a form of recursive estimation. It shows how the arrival of the information that firms acquire with the time workers spend in the labour market and use in pay setting (via Eq. (1)) affects the estimates of the return to education.<sup>8</sup> Key features of the results are presented in Figs. 1–3.

<sup>7</sup> The analysis was also repeated with the Table 1 sample including an interaction term between age and the schooling variable. The findings support the discussion in the text, in that the age–schooling interaction was insignificant for individuals, but negative and significant for identical twins.

<sup>8</sup> Extensions of Table 2 to consider estimates for each of the 5-year age groups are not possible owing to the small samples in each of the 5-year age brackets.



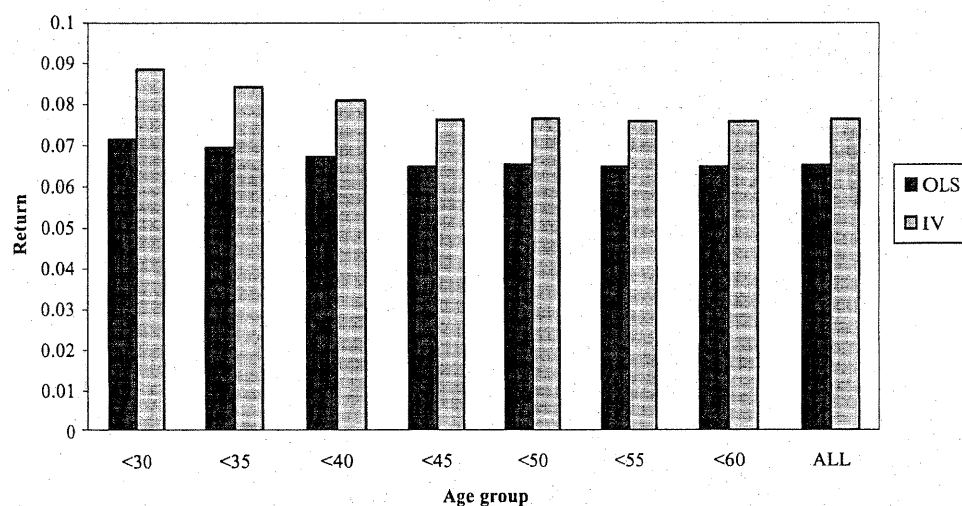


Fig. 1. The return to education by age group: individuals.

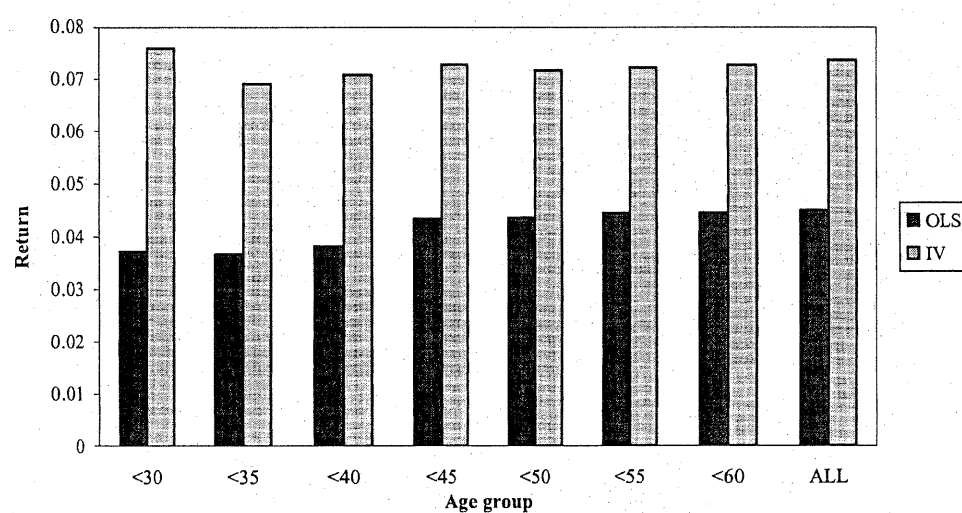


Fig. 2. The return to education by age group: DZ twins.

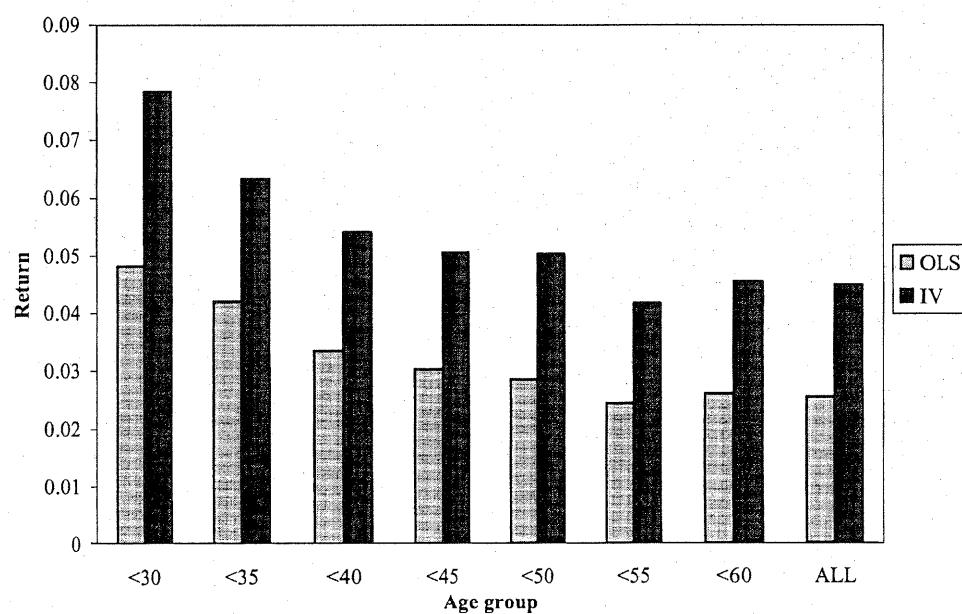


Fig. 3. The return to education by age group: MZ twins.



Fig. 1 presents the return to education for individuals. These show that as the sample is progressively altered to focus more on older age groups, the estimated return to education falls (see also McNabb & Richardson, 1989). The fall is in the order of one percentage point: from 7.1% to 6.5% in the OLS estimates, and from 8.9% to 7.6% in the IV estimates. These estimates confound the pure effect of schooling, the effect of family background and the effect of ability. It is unclear which of these three factors changes as the age mix of the sample changes.

Fig. 2 presents the returns to education obtained from fixed-effects estimators applied to the sample of DZ twins reared together. This provides an estimate of the return to schooling when shared family background but not ability is taken into account. It is apparent from this figure that there is little change in the estimate of the return to schooling as the age mix of the sample changes. The diminution of the measured effect of education on earnings among the older age groups recorded in Fig. 1 would appear, therefore, to be due to a reduction in the effect that family background has on earnings.

Fig. 3 presents the returns to education from fixed-effects estimators applied to the sample of MZ twins. These are estimates of the return to schooling when ability and shared family background are taken into account. It is apparent from Fig. 3 that the pure effect of education diminishes as the sample is expanded to include older age groups and to reflect the additional information ( $A^F$ ) that firms will have acquired on the productivity differences among older workers. Specifically, the pure return to education declines from 4.8% to 2.5% with the OLS estimator, and from 7.8% to 4.5% with the IV estimator. As the pure effect of education (Fig. 3) declines by several percentage points while the effect that is biased by the omission of a measure of ability (Fig. 2) does not change as the older age groups are included in the analysis, it can be inferred that there is a strengthening of the role of ability as workers spend more time in the labour market.

## 5. Conclusion

Separate study of the determinants of earnings for identical and non-identical twins has the potential to provide insights into the roles of ability, shared family environment and education in the earnings determination process. Incorporating a time dimension to such study offers the potential to provide insights into the relative merits of human capital and sorting models as explanations of the positive correlation between earnings and education level. In this paper we test the hypothesis advanced by Weiss (1995) that under sorting models the return to schooling across identical

twins would decline over time compared to the return for non-identical twins.

The analyses show that the return to education among older groups of identical twins is lower than that among younger groups of identical twins. This suggests that the pure effect of education on earnings declines with time in the labour market. The estimates of this return are negligible among the oldest groups of MZ twins. In comparison, the return to education among older groups of non-identical twins is typically higher than that among groups of younger non-identical twins. As the return to education for DZ twins but not that for MZ twins is biased by the omission of a measure of ability, the widening of the gap between the estimates of the returns to schooling for MZ and DZ twins is indicative of a strengthening of the role of ability in the earnings determination process with time in the labour market. This is consistent with the predictions from sorting models.

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