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Ability, Schooling and Earnings: Are Twins Different?

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Abstract

This paper presents new evidence which suggests that there are significant differences between twins and non-twins in terms of measured ability, schooling and the economic gain from years of schooling. Limited evidence also exists for differences between twins in their measured ability. While this does not necessarily imply that recent estimates of the economic returns to schooling based on twin studies are biased, it calls into question the interpretation of these estimates as an accurate measure of the social gains from incremental investment in years of education.

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This study addresses the issue of the relationship between ability, schooling and earnings, using data from a remarkably detailed study of a group of individuals -- *all* children born in Great Britain in one week in March 1958. Together with their parents, spouses and children, this group of individuals - the National Child Development Study (NCDS) - has been studied at birth and subsequently at ages 7, 11, 16, 23 and 33 (1). This paper presents information from the first four sweeps as well as the initial birth survey -- known as the Perinatal Mortality Study (PMS). By definition all multiple births which took place in this reference week became members of the cohort study (2), enabling us to pay particular attention to the links between differences in measured ability, schooling, employment, unemployment and earnings for twins and non-twins.

The use of data on twins from this source is of interest for a variety of reasons. First, the issue of measurement error in schooling and employment differences within twin pairs as well as between twins and non-twins can be addressed via the refined data collection techniques which were employed, facilitating elaborate cross-checking of the timing of events to derive a consistent picture of the employment history of the individual. Secondly, ability measures, consisting of a range of reading comprehension and math tests were standard for each sweep of the birth cohort and were repeated (in appropriate age-related formats) at ages 7, 11 and 16. These tests were conducted within the schools, by a teacher familiar to the cohort study member, under examination style conditions. The fact that identical tests were administered at the same time andunder similar conditions to all study members is of value in addressing the issue of ability versus schooling in the determination of earnings. Secondly, the twins observed

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[1]. Relevant data from the most recent sweep are still under preparation.

[2]. With the exception of two multiple births, for which in each case one twin was born within the reference week and one outside the reference week

in this study are unlike most other groups studied, in that they are the same age. Results obtained from studies of the economic returns to schooling based upon schooling differences between twins, where the sample consists of pairs with widely differing ages, may be difficult to interpret due to variation in ages between sets of twins. Earlier UK studies of the return to higher education, unadjusted for ability (see, for example, Katz, Loveman and Blanchflower, 1992 and Schmitt, 1992) indicate a rapid decline in the return to higher education as the supply of persons with higher level qualifications was expanded in the 1970s and then a subsequent increase in rate of return in the 1980s (3). If schooling differences are age-related, failure to account for this effect could bias the estimated economic return to the difference in schooling levels. Finally, and most importantly, these data give rise to a 'built-in' comparative study which can be run alongside an examination of twins. Twins and non-twins in the NCDS have been subject to the same tests and identical questioning. Throughout this paper non-twins are presented as a 'yardstick' against which the examination of twins can proceed.

Interest in the economic status of twins in general and monozygotic (identical) twins in particular stems principally from the difficulty of conducting randomized experiments to determine the marginal influence of the educational process. Put simply, we can observe a positive correlation at the level of the individual between educational input and economic output, but this correlation cannot be interpreted as causative due to the presence of selection or screening processes. Individuals with higher ability levels will receive higher levels of education (either through self-selection into higher levels of education or through ability-based screening mechanisms) and may receive higher economic rewards for such investments. In the absence of controls for ability, the observed correlation between years of schooling and economic returns does not, therefore, translate into a measure of the social value of marginal expansion of the provision of education.

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3. A similar pattern is observed in the US. See, for example, Katz and Murphy (1992) and Bound and Johnson (1992).

Ideally, an experimental approach to this problem would assign people at random to various levels of schooling and observe the outcomes. While there have been such experiments to evaluate special interventions in the labour market (e.g. Bloom et al. 1992), in the field of general education such an approach finds little support, for strong ethical and obvious practical reasons. Consequently, twins present the so-called 'natural-experiment' to study differences in schooling and earnings controlling for genetically-based characteristics and childhood socialisation effects.

There are a number of major problems which beset such studies. First, it has been demonstrated (Griliches, 1977, 1979) that statistical analyses of the differences between individuals are highly sensitive to measurement error. This problem relates particularly to the measurement of schooling, usually defined in the US studies as 'grade achieved', which crudely translates into a duration measure of full-time education. For monozygotic twins, such differences between the pairs are usually quite small and consequently are particularly susceptible to measurement error.

A second problem relates to the implicit assumption within such studies that 'ability' equates with some combination of the genetic endowment of the individual and their family background. Evidence for this assertion can be found in the many studies of ability test score associations between twins, siblings, parents and offspring, usefully reviewed by Bouchard and McGue (1981). For monozygotic twins reared together, the median correlation between ability test scores from all studies reviewed in their work is .86 (ranging from .58 to .95). For monozygotic twins reared apart the median correlation from various studies is .67 (ranging from .62 to .76) (4). For sibling non-twins reared together the median correlation is .47. While such correlations indicate that the abilities of monozygotic twins (as measured by various tests of IQ etc.) are generally closer than that of any other two family members, the association is far from perfect. This raises the question of whether or not there are systematic differences

[4]. Not including the controversial associations reported by Burt (see Dorfman, 1979).

between the abilities of 1) twins and non-twins 2) the twin pairs themselves and, if so, whether these are correlated with education, employment and earnings.

I. The Data

The National Child Development Study (NCDS) is a major investigation of the medical, social, psychological and economic developmentof a large group of individuals all born between the 3rd and the 9th March 1958. The study began as an investigation of perinatal mortality, and covered well over 95 per cent of estimated births in the reference week. Subsequent recontacting of this birth cohort at ages 7, 11, 16, 23 and, most recently, at age 33 years, has yielded a significant research resource for the modelling of longitudinal processes over a lengthy time span (5).

In addition to those born during the first week of March 1958, all immigrants who arrived in Britain after 1958 and before 1974 and had been born during that week were added to the sample. Information was solicited not only from the repondent but also from the respondents' parents, teachers, and doctors. Response rates to the various sweeps of the surveys are reported in Table 1. The size of the original cohort was 18, 559. For further information on these data see Elias and Blanchflower (1989).

Contact has been maintained with a relatively high number of the original cohort. High response rates to the first three sweeps of the survey were achieved primarily because of the cooperation of the state school system. However, it proved more difficult to obtain responses when the cohort reached the age of twenty three, when many had left their original family home and started families of their own. The 1981 survey, which took place between August 1981 and March 1982 when the respondents were 23, contained a total of 12,537 interviewees or approximately 68 percent of the original target sample of 18, 559. Elias and Blanchflower

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[5]. These data have also been used by Micklewright (1989), Robertson and Symons (1990) and Blanchflower and Elias (1987), Blanchflower and Lynch (1993) and Blanchflower and Oswald (1990)

(1989) provide evidence of response bias: individuals with the lowest levels of attainment on the early ability tests were most likely not to respond to subsequent sweeps of the survey.

Of the 18, 559 individuals in our sample 438 were twins or 2.36% of the total. Of these, 112 were monozygotic -- henceforth MZ -- (55 pairs plus the two singletons referred to above) and 320 individuals (160 pairs) were dizygotic twins -- henceforth DZ -- (6). In addition there were 4 sets of triplets which we excluded from our subsequent analysis. As can be seen from Table 2, approximately one in 25 of all subjects died before the age of seven, the vast majority of whom did not survive the first week (7). The neo-natal mortality rate for MZ twins was marginally higher than average, but for DZ twins the rate was three times higher than average. In the first month following their birth 50 twins, or more than 11% of all twins, had died. In 14 instances both dizygotic twins died within the first month.

Table 3 provides information on the main differences between twins and non-twins. On average twins have lower ability scores and lower levels of schooling than non-twins (8).

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6. The determination between dizygotic and monozygotic twin was made by the doctor at the time of birth. From the documentation we have available to us we are unclear how such designations were made in practice.

7. The incidence and causes of death were as follows

	Non-twins	Twins
Stillbirth macerated over 24 hrs pre-labor (antepartum)	131	6
Stillbirth macerated peripartum (intrapartum)	24	1
Stillbirth macerated (unspecified when)	29	2
Stillbirth fresh (1st stage)	90	8
Stillbirth fresh (2nd stage)	93	4
Neonatal death < 30 minutes	9	-
Neonatal death < 7 days	186	26
Neonatal death 7-28 days	55	3
Died after 4th week	81	3
Total	698	53

8. Because ability is related to birth order and family size (Zajonc, 1976), the differences in ability between twins and non-twins could result from these factors. However, very similar results were also obtained when we restricted the non-twin sample to families that had at least one other sibling.

Average birth weight of twins (86 oz.) is considerably less than birth weight for non-twins (117 oz.). There are also marked differences in gestation periods between twins and non-twins (264 days and 280 days respectively).

As a check on the overall representativeness of the NCDS, in columns 5-8 of Table 3 we report means of a series of variables using data from the General Household Survey of 1981 (columns 5-6) and the much larger Labour Force Survey from that year. For purposes of comparison with the NCDS4 (age 23 years) data we separate out individuals aged 22-24. The mean earnings level in the NCDS is the same as it is in the GHS. Blacks and the least qualified are under-represented in the NCDS sample.

An important aspect of the data available from the sweeps of the birth cohort at ages 7, 11 and 16 relates to the information on math, reading and IQ scores obtained from tests which were administered to cohort members. Table 4 presents correlations between the various ability tests undertaken by the survey participants. In the first panel of the Table correlations through time are reported. For example, math tests taken at ages 7 and 16 have a correlation of .49, whereas reading scores taken at the same times are more highly correlated (.62). In the second panel we report the means and standard deviations of the variables along with the minimum and maximum values, the number of cases and a brief explanation.

Finally, in the third panel intrapair difference in the scores across twins are reported. IQ tests taken at at 11 have a correlation of .8 for MZ twins compared with .6 for DZ's. Maths, IQ and reading scores have higher correlations than the motor tests (Copying Design and 'Draw-a-Man' tests). There is a very high correlation between the months of post-compulsory schooling within the twin pairs: for MZ twins the correlation coefficient is just under .9 and for DZ's slightly over .83. This is a considerably higher correlation than was found by Ashenfelter and Krueger (1992) in their study of adult twins in the US.

In Table 5 we examine further the extent to which twins perform differently on the various ability tests than is the case for non-twins. Because differences in ability scores between twins and non-twins may emerge simply because of differences in birth weight, we include this as an additional explanatory variable. In every case we present results with and without controls for father's occupation in 1958, the year the respondents were born. The dependent variable is the test score standardised to have a mean of zero and a standard deviation of 1. We find evidence that twins perform significantly worse than non-twins on both math and reading tests taken at ages 7 and 11, controlling for birth weight and fathers' social class. MZ twins appear to perform especially badly on these tests. The effect is somewhat weaker on these tests by age 16 and on IQ tests (verbal+non-verbal) at age 11. Controlling for ability, MZ twins appear to have higher schooling than non-twins or DZ twins.

At every age we find evidence that birth weight has a strongly significant *positive* effect on test scores. This is also true for years of schooling without controls for ability. When ability scores are added the birth weight variable becomes negative [9].

II. The Relationship Between Ability, Schooling, Qualifications and Earnings

Much of the US literature on the relationship between ability, schooling, experience and earnings is grounded in a simple 'Mincerian' framework which relates the number of years of full-time education and the number of years of full-time work experience to current earnings. We must modify the simple model because we utilise information from a birth cohort, in which each respondent has the same potential work experience, an account of schooling and periods not working will fully characterise the work history.

Table 6 presents the results of estimating a series of earnings equations on a sample of nearly 9600 observations. The sample consists of individuals who were employed at the date of the survey as well as those who were not working but had held at least one job since leaving school. The latter group reported earnings in their last job. For purposes of comparability the earnings figures they report are deflated by the Retail Price Index for the month in which they completed that job, yielding a dependent variable which is the log of real (1981) hourly

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9. Math and reading scores (and IQ at age 11) are summed. Where missing values are present these are imputed using parental social class and gender as controls. The variables are then standardised to a mean of zero and a standard deviation of one.

earnings. Included in all regressions is a variable 'not-working' to identify individuals who were not employed when interviewed. We include a small number of other controls (gender, union status, part-time work and the log of the county unemployment rate) as well as information on the number of months the cohort member was employed since completion of post-compulsory schooling at age 16 up to the date of the survey. The first column of the Table is a log earnings equations run without controls for ability. The various controls take on plausible values [10]: the coefficient on the years of schooling is approximately .06. This should not be interpreted as a rate of return to schooling, rather it is the increase in earnings from a year of schooling compared with a year of employment, *ceteris paribus*.

In columns 2-4 we include standardised test scores taken at ages 7, 11 and 16 respectively. Where there were missing values on these tests we imputed values using the method outlined in footnote 9 above. In all regressions that follow a dummy variable was also included to flag such occurrences. The addition of these ability scores drives down the coefficient of the schooling variable from .06 to between .043 and .05. When all three are included the coefficient drops to around 0.04. To allow for the possibility of measurement error in the test scores, in column 6-8 we instrument the test taken at sixteen using the earlier tests as instruments (see Griliches, 1979).

We now test whether the coefficient on the schooling variable different for twins given the differences in ability identified above. In column 9 we include an interaction term between years of schooling and being a twin, along with the test score at 7 variable (the result was the same with the other scores) suggesting that the coefficient on schooling for the twins is significantly higher [11]. Further evidence in support of a higher coefficient for twins is reported in Table 7. The first four columns are similar to columns 1 and 6-8 respectively in table 6 for

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[10]. A positive coefficient on the part-time variable is not surprising given the lack of fringe benefits available to these workers at this time.

[11]. The twin dummy itself was never significant and hence was excluded.

the total sample. In columns 5-7 of Table 7 the twins' score are used as instruments. In all cases the coefficient on the schooling variable is lower than in column 1 when ability scores are not included.

In summary, these data indicate the importance of including ability measures when estimating the relationship between schooling and earnings. The results indicate that estimated economic gains from an additional year of schooling, as opposed to employment, may be overstated by as much as 30% if ability measures are excluded. This result holds with the wide variety of ability test scores we have examined, from simple tests of arithmetic and word recognition at age 7 to the more elaborate tests of mathematics and verbal reasoning at age 16. Some surprising results emerge for the twins captured in the study. Their ability test scores are consistently lower than for non-twins, a difference which remains in the presence of controls for birthweight, but which gradually reduces with age. Identical twins have lower ability test scores than fraternal twins. Other differences between twins and non-twins relate to the amount of schooling they receive upon completion of compulsory schooling. There is some evidence to indicate that identical twins receive more schooling. Surprisingly, the economic gains from years of schooling are significantly higher for twins than non-twins.

Figure 1. Differences in Earnings and Schooling - All Twins

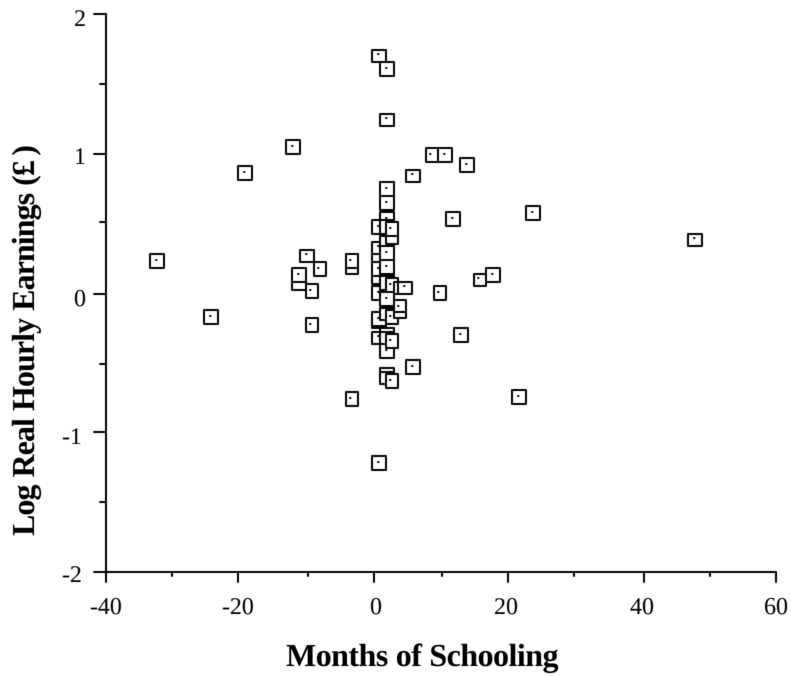
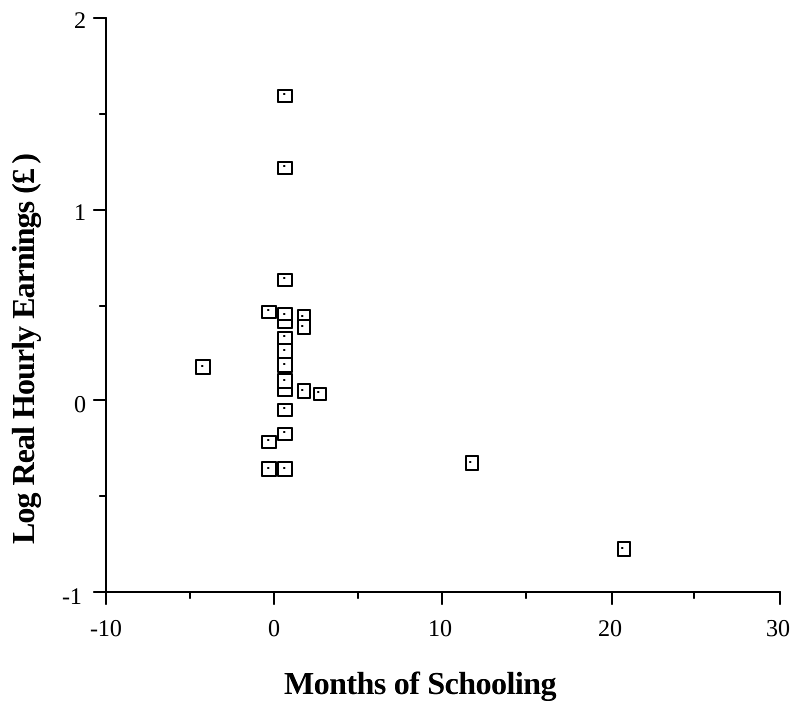


Figure 2. Differences in Earnings and Months of Schooling - Identical Twins



III Intrapair Twin Differences

Our initial purpose had been to estimate regressions of differences in earnings on differences in schooling and ability scores for our samples of MZ and DZ twins. Unfortunately, we were unsuccessful because of a) the high degree of correlation in the months of schooling within twin pairs and b) the small sample sizes encountered. Figures 1 and 2 present scatter plots of earnings against months of schooling for all twins and then separately for identical twins.

We now turn to examine the extent to which *differences* in test scores for any given pair of respondents are significantly correlated through time. The shift in emphasis to the study of differences in ability scores relates to a central assumption underlying the use of data on twins -- that such data provide the so-called 'natural experiment' facilitating the examination of the effect of education on earnings. In this 'natural experiment' an important factor which correlates with both the extent of an individual's education and their earnings is assumed constant. Ability in this context is defined as the extent to which an individual can benefit from an extended education. Individuals with higher levels of ability will, on average, receive a longer education than individuals of lesser ability, because of the screening mechanisms used to restrict access to higher education, the more positive in such education among the more able students or for both these reasons. Simply relating the duration of educational experience to later earnings will not indicate the rate of return to such experience but confounds the effects of ability and education. The interest in such data on twins, particularly identical twins, arises through the assumption that ability influences can be eliminated from the relationship between education and earnings. Given that MZ twins are genetically identical and have had a similar upbringing in the same family environment, the ability of identical twins is assumed equal. Therefore, differences in the amount of schooling these twins receive, compared with differences in their post-school labor incomes, should indicate that economic return to marginal investments in additional educational experience.

Critical to the 'natural experiment' is the assumption that identical twins are equally able. This was investigated by 'pairing' all individuals in the NCDS. Each twin was paired with his or sibling. Non-twins were paired using a randomization procedure. For MZ, DZ twin and non-twin pairs, the differences in their math and reading test scores at ages 7, 11 and 16 were computed. A key feature of these data is the ability to correlate differences in test score data through time for the same pairs of individuals. Table 8 shows the relationship between test scores at ages 16, 11 and 7, separately for non-twin random pairs, DZ pairs and MZ pairs. In Table 8 differences in various math and reading scores are regressed on differences in the same tests taken years earlier. In each part of the Table results are reported separately for DZ and MZ twins as well as for our 'control' group of non-twins who were matched randomly. There does appear to be evidence that differences in earlier test scores are positively and significantly correlated with later outcomes. This is true for both twins and non-twins for reading as well as math tests. The results for twins are weaker when two earlier scores are included, presumably because of a shortage of degrees of freedom. Our results suggest that there are differences in ability between both MZ and DZ twins. These differences correlate across a 9 year period covering the compulsory education of these pairs of individuals [12].

We have investigated for possible links between intrapair differences in ability scores and subsequent economic status. Here we encounter a problem with the number of pairs of twins (particularly MZ twins) for whom we have relevant data (only 26 pairs of MZ twins have work history information). Unfortunately there is insufficient information to measure the impact of intrapair ability or schooling differences on earnings

V. Assessing the Results

[12]. We were concerned also about 'test/retest' correlations affecting the results shown in Table 8, although this phenomenon is more usually revealed in tests which are taken within a short space of time. To investigate this further, we used the age 7 math and reading test scores to predict age 16 scores (both math and reading), based upon information from all respondents who took the tests at age 7 and 16. For MZ twins, differences in actual tests scores at age 16 were compared with the predicted differences. For both math and reading score differences at age 16, there was a significant correlation between diffeerences between actual and predicted scores.

Two main findings emerge from the study. The first confirms earlier research on the relationship between schooling and earnings, showing the importance of including ability scores in such studies. In line with other work, we show that the inclusion of ability test score information reduces the economic gain from a year of schooling by as much as 30%. More important, however, is the evidence we present relating to twins. In comparison with non-twins of the same age, brought up in a similar social and macroeconomic environment, twins appear to be different. They do not score as well on tests of ability, they participate to a greater extent in post-compulsory education and they gain more from each additional year of education in terms of earnings at age 23. There is also some evidence to suggest that there exist important differences between identical twins which are measurable and correlated through time.

These are interesting result that warrant further exploration. Unfortunately, we have not been able to address directly the issue of the estimated rate of return to education given that these data contain insufficient observation on the earnings and schooling of identical twins. Nevertheless, the results indicate that considerable caution must be exercised in the interpretation of information on the earnings and schooling of identical twins in the absence of childhood measures of ability, and that results obtained from studies of twins relating to the economic gains from schooling may not be generalized to the population of non-twins.

References

Ashenfelter, O. and Krueger, A. (1992), 'Estimates of the economic return to schooling from a new sample of twins', Working Paper No. 304, Industrial Relations Section, Princeton University.

Behrman, J., Hrubec, Z., Taubman, P. and Wales, T. (1980), Socioeconomic success: a study of the effects of genetic endowments, family environment and schooling, North-Holland, Amsterdam

Blanchflower, D.G. and Elias, P. (1987), 'Local labour market influences on early occupational achievement,' in Ian Gordon (Ed.), Unemployment, regions and labour market reactions to recession. Pion Press.

Blanchflower, D.G. and Lynch, L. (1993), "Training at work: a comparison of US and British youths', forthcoming in International Comparisons of Private Sector Training edited by Lisa Lynch and published by University of Chicago Press and NBER.

Blanchflower, D.G. and Oswald, A.J. (1990), 'The wage curve.' Scandinavian Journal of Economics , 92, pp. 215-235. Reprinted in Unemployment and wage determination in Europe, edited by B. Holmlund and K.G. Lofgren, Basil Blackwell.

Bloom, H.S., L.L. Orr, G. Cave, S.H. Bell and Doolittle, F. (1992). The national JTPA Study. Impacts on earnings and employment at 18 months, ABT Associates Inc., Bethesda, Maryland.

Bouchard, T.J. and M. McGue (1981). 'Familial studies of intelligence: a review', Science, 212, 4498, pp. 1055-1059.

Bound and Johnson (1992), 'Changes in the structure of wages in the 1980's: an evaluation of alternative explanations', American Economic Review, June, 82, no. 3, pp. 371-392.

Dorfman, D.D. (1979). 'The Cyril Burt question: new findings', Science, 201, 4362, pp. 1177-1186.

Elias, Peter and Blanchflower, D. (1988), The occupations, earnings and work histories of young adults - who gets the good jobs?, Research Paper no. 68. London: Department of Employment.

Griliches, Z. (1977), 'Estimating the returns to schooling - Some Econometric Problems', Econometrica, 45, pp. 1-22.

Griliches, Z. (1977), 'Sibling models and data in economics: beginnings of a survey', Journal of Political Economy, 87, (Supplement), pp. S37-S64.

Katz, L., Loveman, G., and Blanchflower, D.G. (1992), 'A comparison of changes in the structure of wages in four OECD countries', forthcoming in Differences and Changes in Wage Structures edited by Larry Katz and Richard Freeman and published by University of Chicago Press and NBER.

Katz and Murphy (1992), Changes in relative wages, 1963-1987: supply and demand factors', Quarterly Journal of Economics, February, 428(1), pp. 1-34.

Micklewright, John (1989), 'Choice at sixteen', Economica, 56, pp. 25-40.

Robertson, D. and Symons, J., (1990), 'The occupational choice of British children' Economic Journal, vol. 100, no. 402, pp. 828-841.

Schmitt, J. (1992), 'The changing structure of male earnings in Britain, 1974-1988', forthcoming in Differences and Changes in Wage Structures edited by Larry Katz and Richard Freeman and published by University of Chicago Press and NBER.

Zajonc, R.B. (1976), 'Family configuration and intelligence', Science, 192, pp. 227-236.

Table 1. The National Child Development Study: Sources, Data Instruments and Cohort Attrition

Source	Birth 1958	Seven 1965	Eleven 1969	Sixteen 1974	1978	Twenty-three 1981	Thirty-three 1991
Parents	Interview	Interview	Interview	Interview			
Medical	Records	Examination and history	Examination and history	Examination and history			
Schools		Questionnaire	Questionnaire	Questionnaire			
		Tests	Tests	Tests	Exam results (CSE, O-levels and A-levels)		
Subjects			Questionnaire	Questionnaire		Interview	Interview
						Census-based area data	
Spouses							Interview
Children							Tests
N	18,559	15,468	15,503	14,761	14,370	12,537	11,363

Table 2. Sample Attrition in the NCDS, by Birth Category

	Single births		MZ Twins		DZ Twins	
Status	**M**	**F**	**M**	**F**	**M**	**F**
Death						
before age 7	4.4	3.8	6.6	7.5	14.2	13.9
between 7-11	0.1	0.1	1.6	-	-	-
between 11-16	0.2	0.1	-	-	-	-
Emigrant						
before age 11	4.2	3.4	3.3	-	1.2	2.5
between 11-16	0.5	0.5	-1.6	-	-0.6	-1.3
Refusal	5.7	6.8	3.3	3.8	6.8	10.8
In NCDS at 16	84.9	85.2	86.9	88.7	78.4	74.1
Total (=100%)	9367	8734	61	53	162	158

Note: For 4 dizygotic twins, all of whom died before age 7, gender was not recorded.

Table 3. A Comparison of the Means and Standard Deviations of Selected Variables: Twins and Non-twins

	Twins NCDS	MZ NCDS	DZ NCDS	Non-twins NCDS	22-24 GHS 1981	16-69 GHS 1981	22-24 LFS 1981	16-69 LFS 1981
Reading score at 7	21.1	20.7	21.2	23.4	-	-	-	-
	(7.66)	(7.53)	(7.72)	(7.12)				
Maths score at 7	4.29	4.13	4.37	5.13	-	-	-	-
	(2.29)	(2.07)	(2.38)	(2.49)				
IQ score at 11	39.2	38.2	39.6	43.0	-	-	-	-
	(15.59)	(15.71)	(15.56)	(16.15)				
Math score at 11	13.3	12.2	13.7	16.7	-	-	-	-
	(9.64)	(10.17)	(9.39)	(10.36)				
Reading score at 11	13.9	13.1	14.2	16.0	-	-	-	-
	(6.07)	(6.16)	(6.02)	(6.29)				
Math score at 16	11.6	11.0	11.9	12.8	-	-	-	-
	(6.31)	(5.81)	(6.53)	(7.01)				
Reading score at 16	23.9	22.9	24.34	25.3	-	-	-	-
	(7.47)	(7.98)	(7.22)	(7.08)				
Age of mother at birth	28.6	27.2	29.1	27.4	-	-	-	-
	(5.49)	(5.26)	(5.49)	(5.73)				
Age of father at birth	31.7	31.3	31.9	30.5	-	-	-	-
	(6.61)	(7.16)	(6.40)	(6.44)				
Birth weight (oz.)	86.3	84.2	87.1	117.0	-	-	-	-
	(20.83)	(17.19)	(21.98)	(20.31)				
Gestation period (days)	264.4	266.0	263.8	280.4	-	-	-	-
	(34.2)	(49.75)	(26.03)	(14.1)				
Single (%)	52.8	58.0	50.5	51.7	49.0	23.0	50.4	23.6
	(0.5)	(0.5)	(0.5)	(0.5)				
Male (%)	51.4	53.1	49.5	51.7	47.3	49.0	50.0	49.3
	(0.50)	(0.5)	(0.5)	(0.49)				
Black (%)	2.1	0	3.4	3.9	4.7	3.8	-	-
	(0.15)		(0.18)	(0.19)				

Present in NCDS4 only

Months of Schooling	12.9	16.0	11.6	16.2	14.9	10.9	11.5	11.2*
	(20.0)	(25.0)	(17.4)	(22.7)				
A-levels (%)	12.0	11.1	12.4	16.6	15.1	6.2	13.7	7.5*
	(0.33)	(0.32)	(0.33)	(0.37)				
College (%)	15.0	19.8	12.9	18.5	15.0	11.0	12.2	11.5*
	(0.36)	(0.40)	(0.34)	(0.39)				
Employed in 1981 (%)	70.0	66.6	71.5	73.4	68.4	63.3	68.5	63.2
	(0.46)	(0.47)	(0.45)	(0.44)				
Self-employed (%)	3.8	3.8	3.8	5.7	4.3	9.0	4.8	9.3
	(0.19)	(0.19)	(0.19)	(0.23)				
Union (%)	46.8	40.7	48.9	44.0	-	-	-	-
	(0.5)	(0.5)	(0.5)	(0.5)				
Hourly Earnings (£)	2.53	2.35	2.59	2.56	2.55	2.80	-	-
	(1.01)	(0.80)	(1.05)	(0.99)				
Months unemployed	5.1	8.1	3.9	4.2	-	-	-	-
	(10.6)	(14.7)	(7.88)	(9.37)				
N	267	81	186	18,117	1,329	21,641	9,729	157,423

Notes: * data only available for individuals born from 1921-1965 (ages 16-60).
Standard deviations in parentheses

Table 4. Ability Score Correlations.

A) Correlation coefficients of scores over time

i) All respondents

VARIABLES	IQ2	R3	R2	R1	M3	M2	M1	CD2	CD1	DM2
IQ2	1									
R3	.722	1								
R2	.744	.796	1							
R1	.647	.617	.623	1						
M3	.683	.654	.649	.498	1					
M2	.808	.702	.747	.607	.767	1				
M1	.524	.480	.483	.534	.489	.572	1			
CD2	.350	.290	.313	.261	.302	.339	.234	1		
CD1	.403	.346	.331	.331	.342	.374	.312	.338	1	
DM2	.407	.365	.360	.358	.314	.363	.333	.281	.371	1
SCHOOL	.454	.460	.495	.324	.601	.525	.310	.207	.211	.225

ii) MZ twins

VARIABLES	IQ2	R3	R2	R1	M3	M2	M1	CD2	CD1	DM2
IQ2	1									
R3	.655	1								
R2	.722	.740	1							
R1	.577	.655	.681	1						
M3	.632	.475	.618	.418	1					
M2	.853	.719	.747	.616	.752	1				
M1	.516	.568	.536	.631	.421	.569	1			
CD2	.410	.374	.412	.332	.273	.405	.181	1		
CD1	.520	.382	.400	.367	.311	.521	.314	.505	1	
DM2	.484	.318	.358	.373	.353	.475	.345	.210	.407	1
SCHOOL	.462	.475	.553	.434	.595	.669	.353	.255	.247	.271

B) Variable Definitions

Variable	**Cases**	**Mean**	**Std Dev**	**Min.**	**Max.**	**Explanation**
IQ2	14134	42.94	16.14	0	40	IQ test age 11
R3	11987	25.30	7.09	0	35	Reading test age 16
R2	14133	15.97	6.29	0	35	Reading test age 11
R1	14931	23.33	7.14	0	30	Reading test age 7
M3	11921	12.75	6.99	0	31	Math test age 16
M2	14129	16.62	10.35	0	40	Math test age 11
M1	14898	5.11	2.49	0	10	Math test age 7
CD2	14104	8.33	1.49	0	12	Copying Design test age 11
CD1	14871	7.01	2.00	0	12	Copying Design test age 7
DM1	14648	23.84	7.08	0	53	Design a man test age 7
SCHOOL	12507	16.12	22.73	0	93	Months FT post-compulsory schooling

C) Intrapair Correlation of Ability Scores for Twins

VARIABLES	**IQ2**	**R3**	**R2**	**R1**	**M3**	**M2**	**M1**	**CD2**	**CD1**	**DM**	**SCHOOL (months)**
1) MZ	.8002	.7948	.7835	.7537	.7143	.8738	.7127	.5586	.4626	.4754	.8996
N. of pairs	42	36	42	47	34	42	47	41	47	47	33
2) DZ	.5997	.6214	.6403	.6471	.6888	.6912	.4945	.4042	.2480	.3902	.8336
N. of pairs	98	81	98	110	80	98	111	97	110	105	74

Table 5. Standardised Ability Scores and Twins

Dependent Variable	**Maths**		**Reading**		**Maths**		**Reading**		**IQ**	
Age	**7**		**7**		**11**		**11**		**11**	
Identical Twins	-.255	-.255	-.212	-.229	-.252	-.202	-.359	-.329	-.158	-.117
	(2.47)	(2.46)	(2.08)	(2.27)	(2.33)	(1.96)	(3.34)	(3.21)	(1.47)	(1.13)
Fraternal twins	-.138	-.164	-.121	-.174	-.111	-.139	-.127	-.169	-.053	-.092
	(2.01)	(2.39)	(1.77)	(2.60)	(1.53)	(2.00)	(1.76)	(2.45)	(0.73)	(1.32)
Male	.054	.055	-.288	-.288	-.006	-.002	-.051	-.047	-.180	-.178
	(3.17)	(3.26)	(17.12)	(17.46)	(0.35)	(0.13)	(2.91)	(2.82)	(10.33)	(10.63)
Birth weight	.005	.005	.005	.005	.006	.006	.005	.005	.006	.005
	(12.06)	(10.94)	(11.89)	(10.30)	(13.13)	(11.94)	(11.46)	(9.98)	(12.06)	(10.91)
Social class (13)	-	-		-		-		-		
Constant	-.662	-.827	-.480	-.634	-.722	-.878	-.600	-.682	-.556	-.681
F	49.7	41.2	104.3	76.6	51.6	110.1	42.9	105.1	60.1	94.9
$\bar{R}^2$	.013	.049	.029	.087	.015	.127	.013	.122	.018	.112
N	13909	13585	13942	13618	13001	12696	13005	12700	13007	12702

Dependent Variable	**Maths**		**Reading**		**Schooling (years)**			
Age	**16**		**16**					
Identical Twins	-.175	-.196	-.104	-.135	.174	.255	.513	.502
	(1.50)	(1.76)	(0.88)	(1.21)	(0.65)	(1.03)	(2.30)	(2.31)
Fraternal twins	.001	-.049	.007	-.082	-.283	-.3052	-.248	-.247
	(0.01)	(0.67)	(0.08)	(1.10)	(1.61)	(1.87)	(1.70)	(1.74)
Male	-.016	-.011	.160	.169	-.060	-.047	-.157	-.139
	(0.84)	(0.60)	(8.34)	(9.35)	(1.42)	(1.21)	(4.41)	(4.01)
Birth weight	.006	.005	.005	.005	.006	.004	-.002	-.002
	(11.26)	(10.17)	(10.36)	(9.24)	(5.36)	(3.51)	(1.88)	(1.97)
Social class (13)	-		-		-		-	
Ability scores	-	-	-	-	-	-		
Constant	-.652	-.763	-.715	-.871	.879	.858	1.820	1.842
F	35.2	87.3	53.5	110.4	8.97	135.5	832.81	340.0

$\bar{R}^2$	.012	.121	.019	.150	.003	.169	.342	.377
N	10829	10624	10829	10566	11476	11214	11214	11214

Notes: social class is father's occupation at the respondent's birth, taken from parental responses in (1958).
ability scores include test scores taken at ages 7, 11 and 16.

Table 6. Log Earnings Equations : All workers.

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) IV	(7) IV	(8) IV	(9) OLS
Schooling (years)	.0595	.0496	.0442	.0438	.0397	.0436	.0489	.0424	.0493
	(18.09)	(14.55)	(12.50)	(12.23)	(10.97)	(12.30)	(14.32)	(11.97)	(14.45)
Schooling*twin	-	-	-	-	-	-	-	-	.0249
									(2.09)
Test Score (7)	-	.0438	-	-	.0217	-	-	-	.0457
		(10.33)			(4.22)				(3.82)
Test Score (11)	-	-	.0504	-	.0238	-	-	-	-
			(11.22)		(3.81)				
Test Score (16)	-	-	-	.0476	.0222	.0697	.0887	.0786	-
				(10.43)	(3.78)	(11.15)	(10.19)	(11.87)	
Union	.1796	.1792	.1786	.1795	.1789	.1783	.1765	.1784	.1790
	(20.63)	(20.69)	(20.65)	(20.74)	(20.72)	(20.62)	(20.37)	(20.64)	(20.67)
Female	-.1600	-.1728	-.1632	-.1567	-.1665	-.1544	-.1495	-.1528	-.1732
	(19.95)	(21.41)	(20.48)	(19.63)	(20.53)	(19.34)	(18.58)	(19.14)	(21.46)
Empt. (mths)	.0043	.0040	.0040	.0039	.0038	.0044	.0058	.0044	.0040
	(14.34)	(13.21)	(13.21)	(13.10)	(12.57)	(14.65)	(16.29)	(14.61)	(13.23)
Unempt. rate	-.1608	-.1642	-.1574	-.1538	-.1576	-.1447	-.1375	-.1604	-.1639
	(11.62)	(11.91)	(11.45)	(11.15)	(11.42)	(10.45)	(9.82)	(11.67)	(11.91)
Not working	-.0478	-.0458	-.0425	-.0423	-.0421	-.0236	-.0038	-.0430	-.0457
	(3.97)	(3.83)	(3.56)	(3.53)	(3.52)	(1.94)	(0.30)	(11.97)	(3.82)
Part-time	.1355	.1406	.1424	.1447	.1453	.1564	.1684	.1423	.1416
	(6.58)	(6.87)	(6.96)	(7.06)	(7.11)	(7.61)	(8.12)	(6.96)	(6.91)
$\overline{R}^2$	.2030	.2118	.2135	.2124	.2167	.2137	.2120	.2150	.2119
F	350.69	287.57	290.99	289.11	205.63	291.28	288.44	293.60	288.28
N	9614	9614	9614	9614	9614	9614	9614	9614	9614

Notes: equations also include a dummy variable to indicate where the test score(s) was imputed plus a constant

Col 6 instrumented on 11 year old score

Col 7 instrumented on 11 year old score which in turn instrumented on 7 year old score

Col 8 instrumented on 11 and 7 year old scores.

dependent variable log real hourly earnings

Table 7. Log Earnings Equations for All Twins

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV	(7) IV
Schooling (years)	.1135	.0841	.0951	.0791	.0822	.0866	.0777
	(5.02)	(3.29)	(3.83)	(2.96)	(3.11)	(3.31)	(2.90)
Test Score (16)	-	.1116	.1002	.1088	.1051	.1115	.1119
		(2.36)	(1.76)	(2.32)	(2.20)	(1.97)	(2.39)
Union	.1842	.1861	.1833	.1826	.1835	.1799	.1824
	(3.21)	(3.29)	(3.22)	(3.12)	(3.13)	(3.06)	(3.12)
Female	-.1840	-.1971	-.1984	-.1863	-.1841	-.1877	-.1867
	(3.50)	(.3.77)	(3.75)	(3.49)	(3.45)	(3.49)	(3.50)
Empt. (mths)	.0061	.0052	.0053	.0048	.0050	.0048	.0047
	(3.26)	(2.78)	(2.79)	(2.45)	(2.57)	(2.40)	(2.41)
Unempt. rate	-.0515	-.0489	-.0630	-.0486	-.0439	-.0612	-.0494
	(0.61)	(0.58)	(0.75)	(0.56)	(0.50)	(0.70)	(0.57)
Not working	.0015	-.0012	-.0004	.0223	.0225	.0276	.0236
	(0.02)	(0.01)	(0.01)	(0.29)	(0.29)	(0.35)	(0.30)
Part-time	.6572	.6457	.6190	.6085	.6232	.5835	.6052
	(2.61)	(2.59)	(2.46)	(2.43)	(2.49)	(2.31)	(2.42)
$\bar{R}^2$	.291	.3069	.2983	.3051	.3033	.3063	.3063
F	13.01	12.35	11.89	11.76	11.66	11.82	11.82
N	206	206	206	206	197	197	197

Notes: Col 2 instrumented on 11 year old score

Col 3 instrumented on 11 year old score which in turn instrumented on 7 year old score

Col 4 instrumented on 11 and 7 year old scores.

Cols 5-7 as for columns 2-4 but also including the twins' score on the same test as instruments

dependent variable log real hourly earnings

Table 8. Intrapair Ability Score Differences

	Non-twin	Non-twin	DZ	DZ	MZ	MZ
1. Dependent variable = Math score at age 16						
Maths score at age 11	.484	.508	.283	.317	.191	.220
	(46.76)	(63.67)	(3.41)	(4.15)	(1.33)	(1.63)
Maths score at age 7	.208	-	.032	-	.328	-
	(4.67)		(0.11)		(0.63)	
Constant	.127	.140	-.092	-.198	-.468	-.659
	(1.03)	(1.23)	(0.15)	(0.35)	(0.61)	(0.87)
$\bar{R}^2$	.580	.579	.157	.200	.035	.052
n	2499	2952	59	66	30	30
2. Dependent variable = Reading Score at age 16						
Reading score at age 11	.703	.880	.644	.727	.499	.485
	(42.51)	(69.09)	(3.93)	(5.30)	(1.61)	(1.90)
Reading score at age 7	.262	-	.102	-	-.035	-
	(17.43)		(0.71)		(0.13)	
Constant	-.027	.053	.360	.214	1.070	.962
	(0.24)	(0.48)	(0.46)	(0.33)	(0.92)	(0.97)
$\bar{R}^2$	.650	.615	.236	.291	.042	.052
n	2542	2989	59	67	30	30

Appendix 1. Log Earnings Equations : All workers.

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV
Schooling (years)	.0599	.0897	.0450	.0713	.0713	.0525
	(16.41)	(14.08)	(5.86)	(10.44)	(10.97)	(7.00)
Test Score (16)	-		.0531	.0695	.0704	.0723
			(10.13)	(8.74)	(7.12)	(9.18)
Union	.1730	.1792	.1704	.1694	.1658	.1698
	(18.28)	(20.69)	(17.91)	(17.79)	(17.40)	(17.84)
Female	-.1569	-.1429	-.1547	-.1432	-.1373	-.1431
	(17.92)	(15.96)	(17.03)	(16.06)	(15.30)	(16.05)
Empt. (mths)	.0043	.0040	.0043	.0052	.0066	.0052
	(14.34)	(13.21)	(7.50)	(9.43)	(12.40)	(9.26)
Unempt. rate	-.1639	-.1460	-.1503	-.1410	-.1325	-.1413
	(10.76)	(9.38)	(9.71)	(9.09)	(8.46)	(9.11)
Not working	-.0440	.0096	-.0295	-.0046	.0259	-.0063
	(3.32)	(0.59)	(1.77)	(0.28)	(1.58)	(0.39)
Part-time	.1497	.1787	.1670	.1811	.1964	.1810
	(6.76)	(7.84)	(7.37)	(7.99)	(8.60)	(7.99)
$\bar{R}^2$	.2028	.1958	.2062	.2036	.2010	.2043
F	286.42	274.12	227.66	224.03	220.47	225.13
N	7855	7855	7855	7855	7855	7855

Notes: equations also include a dummy variable to indicate where the test score(s) was imputed plus a constant
Cols 2-6 schooling is instrumented on teachers' assessment of extent of schooling.
Col 4 ability score is instrumented on 11 year old score
Col 5 ability score is instrumented on 11 year old score which in turn instrumented on 7 year old score
Col 6 ability score is instrumented on 11 and 7 year old scores.
dependent variable log real hourly earnings