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Family Size and Child Achievement

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Abstract
Using data from the British National Childhood Development Study, this paper examines the quality-quantity trade-off in fertility in multiple measures of child achievement. The results exhibit three characteristics: 1) Family-size effects appear very early in child development–as early as age two, 2) the effects are found in a broad array of achievement measures: labor market, cognitive, physical, and social, and 3) by age 16, the effects of family size stop growing (and what little evidence there is of change is as likely positive as negative). The paper argues that these results are inconsistent with preference-based explanations of the trade-off and point to some family resource constraint. However, the relevant constraint appears more likely to be temporal than financial.

I. Introduction

The last 15 years have seen substantial progress in our understanding of intergenerational inequality. The measurement problems raised by transient earnings (see Solon 1992 and Mazumder 2005) and life cycle changes in earnings variance (see Jenkins 1987, Creedy 1988, Grawe forthcoming, and Haider and Solon 2004) have been carefully explored. And new, larger data sets now permit us to compare mobility across a modest sample of countries in a meaningful way. (See Solon 2002 and Corak 2004 for surveys.) These advances in measurement have paved the way for studies attempting to discern the determinants of intergenerational inequality and how sound policy might create efficient outcomes. While economic theory speaks to more than one cause of intergenerational correlations, credit limitations have received the greatest attention.[1]

The seminal work of Becker and Tomes (1986) presents a model in which borrowing constraints create greater persistence in earnings across generations. If credit constraints limit educational choice, expansions in education subsidies and student loan guarantees simultaneously increase intergenerational equality and efficiency, but determining whether credit constraints bind is difficult. For instance, Björklund and Jännti (1997) find more mobility in Sweden than in the United States. While this might suggest mobility-restricting credit market failure in the US, it may just as easily reflect Sweden's inefficiently high public investment in education (free education through university).[2] While cross-country comparisons like Björklund

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[1]The rate of return on human capital investments is one notable alternative determinant. See Solon (2004) for a detailed discussion.

[2]While it is tempting to view over-investment as clearly preferable to under-investment, a closer examination raises doubts. Because high-ability individuals are likely to benefit most

and Jännti, Couch and Dunn (1997), or Grawe (2004a) may be suggestive, credible conclusions are more likely to stem from studies which examine theory in more detail to find variables which signal credit market failure or access.

Toward this end, recent work has looked for correlations between the intergenerational earnings elasticity and financial bequest receipt (Mulligan 1997 and 1999), net worth (Mazumder 2005), and parent earnings (Grawe 2004b). Grawe and Mulligan (2002) survey this literature and find little evidence of credit market failure in developed countries. It is possible that the large education subsidies found in developed economies have achieved their goal, largely eliminating the effects of credit constraints. While this conclusion may be comforting, there is another less appealing possibility. Han and Mulligan (2001) demonstrate with calibrated simulations that the positive correlation between child ability and parent earnings may make it very difficult to detect credit constraints using intergenerational earnings elasticities.

Recognizing this limitation, our understanding of intergenerational earnings elasticities may grow by studying a distinct, yet related, aspect of intergenerational economics–family-size (or sibship) effects. Research has consistently confirmed a negative relationship between number of children and child achievement. (See Blake 1989 for a summary of early studies.) The theory of fertility posited by Becker and Lewis (1973) and Willis (1973) (hereafter BLW) suggests that this "quality-quantity trade-off" might be explained by credit constraints which restrict the child's educational opportunity. This paper exploits the broad set of achievement measures contained in the British National Child Development Study (NCDS), probing the timing and

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from education subsidies, over-investment can easily decrease both intergenerational equality and efficiency by encouraging supra-efficient levels of education for high-ability, high-earning individuals.

breadth of the family-size effect to provide additional evidence on the importance of intergenerational credit constraints.

Section II briefly outlines three alternative economic interpretations of the quality-quantity trade-off: credit market failure, scarcity of parent time, and intergenerational transmission of preferences. While all three explanations ultimately predict a trade-off between family size and child achievement in adulthood, they differ in predictions of when and where the trade-off develops and whether family-size effects increase or decrease as the child ages. Section III describes the NCDS data while Section IV presents three findings: 1) Family-size effects appear very early in child development–as early as age two, 2) the effects are found in a broad array of achievement measures: labor-market, cognitive, physical, and social, and 3) by age 16, the effects of family size stop growing (and what little evidence of change there is after that is as likely positive as negative). Section V argues none of these results is consistent with preference-heterogeneity explanations of the quality-quantity trade-off. Further, while limited credit might possibly explain the observed effects, an interpretation based on scarce parent time better fits the data.

II. Economic Interpretations of Family-size effects

The dominant economic model of fertility (proposed by Becker and Lewis 1973 and Willis 1973) posits that a quality-quantity trade-off naturally emerges due to scarcity of resources. To begin, suppose all inputs into child human capital are market goods which the parent must purchase. The cost of making a given *per capita* investment in child quality naturally increases as fertility rises and vice versa. This interaction between quality and quantity in the budget constraint is reinforced by the utility maximizing decisions of parents resulting in a negative correlation between child achievement and family size. Borrowing constraints play a central role in the BLW model. If parents were able to borrow against the children's future incomes to finance educational investments, parents would invest in human capital up to the point where the marginal benefit higher future earnings just equaled the marginal cost ($1+r$ where r is the interest rate). As a result, additional siblings should not alter the human capital investments. And so in the absence of credit constraints, while greater fertility may reduce per capita child consumption, family size does not affect earnings or human capital measures of child quality.

It might seem that the absence of a quality-quantity trade-off under perfect credit markets is driven by the assumption that all human capital inputs must be purchased. For instance, if parent time is an input, does the finite nature of parent time produce a sibship-effect despite functioning financial markets? Grawe (2005b) shows this to be incorrect in the context of the BLW model. Because the model implicitly assumes a constant opportunity cost of parent time, parents can easily "borrow time" by working less today and financing current purchases and investments with additional work tomorrow. However, Grawe goes on to show that the trade-off returns even under perfect credit markets when the BLW model is altered to incorporate an increasing opportunity cost of time at home.

Where BLW and Grawe (2005b) focus on resource scarcity (financial and temporal respectively), Easterlin (1973) emphasizes the role of preferences in fertility choice. It is easy to construct a simple intergenerational model of preference formation which creates the illusion of a trade-off between child quality and family size. In brief, perhaps children born into large families acquire a taste for fertility. Anticipating a life with many children, these individuals make education and job choices consistent with this future life. The end result is a negative relationship between family size and adult achievement.

While all three approaches ultimately predict a negative relationship between family size and child earnings in adulthood, following estimates of the family size effect in Sections III and IV, Section V below argues that the models differ in their predictions of how and when the trade-off develops. Differentiating among these three alternative explanations of sibship-effects is not merely an academic question. In particular, if credit constraints are responsible then an expansion in education financing are warranted on efficiency grounds. On the other hand, if either preference heterogeneity or temporal constraints are the cause, it is not clear that such programs are desirable. Moreover, if credit constraints are present, it is important to determine whether they are relevant at university age (the typical assumption) or earlier on in a child's development. Failure to understand the timing of financial hardship could lead public finances to be wasted on ineffectual programs which exacerbate inequality without reducing inefficiencies.

III. Data

Commenced in 1958, the National Child Development Study (NCDS) follows all individuals born in Britain during the first full week of March 1958. In addition to a pre-natal survey, the NCDS contains contemporaneous and retrospective data gathered from parents, teachers, and doctors when the subjects were ages seven, 11, and 16. These early waves also include standardized test scores for reading, math, general ability, and social adjustment. Follow-up surveys conducted at ages 23, 33, and 41 include observations of labor market achievement.

The advantages of using the NCDS for the present purpose are several. First, it allows for estimates of the family-size effect at multiple ages in a single population. This mitigates confounding effects caused by different sample selection rules or populations. Second, because the sample contains measures of achievement at multiple points in the life cycle, it is possible to estimate both static and dynamic effects of family size. Third, while most studies based on census files only contain a few indicators of achievement (typically education and/or labor market attainment), the NCDS includes a wide range of performance measures. The concluding section argues that this may be useful in distinguishing among the three models described in the previous section. Finally, the fact that the NCDS is drawn from the British population is important. Corak (2004) reports that, controlling for study methodologies, the rate of intergenerational earnings persistence is higher in the United Kingdom than in any other country for which we have intergenerational data. This suggests that credit constraints are more likely to be found in a British sample than elsewhere. Failure to find evidence of credit constraints here may indicate a fairly robust credit markets in developed countries as a whole.

The available measures of achievement in the NCDS fall into four categories: labor market, cognitive, physical, and social. The first and second categories most closely match those used in previous economic studies and include adult income and standardized cognitive test scores (at ages seven, 11, and 16). Aspects of physical development observed include birth weight (whether below 88 ounces), walking and talking by appropriate ages (18 and 24 months respectively), difficulties in speech and toilet training, and poor physical coordination as rated by a teacher. One social achievement measure notes whether the child's doctor reports evidence of emotional maladjustment at age seven. This measure is augmented with teacher-generated Bristol Social-Adjustment Guide (BSAG) standardized test scores (at ages seven and 11) which evaluate the number of social syndromes for which the child is potentially susceptible.

(Syndromes include depression, hostility toward adults, and anxiety for acceptance by children to name but a few.)

Kessler (1991), Hanushek (1992), and Black et al. (2005) (among others) note that birth order may affect achievement independent of family size. To avoid an omitted variables bias, regressions include dummy variable controls for being born in positions two through six and seven or greater.[3] In addition, a last-born dummy variable captures relative birth order effects, distinguishing between a child who is, say, third of three as opposed to third of four. Mother's education is also included to avoid the endogeneity resulting from the connection between mother's ability and the opportunity cost of fertility.[4] Finally, regressions include a dummy variable noting whether the individual is a twin. To avoid confounding effects of family structure, the sample includes only those who are living with both their natural mother and father in all three initial waves of the NCDS (1965, 1969, and 1974).[5] Table 1 presents summary statistics of all variables separately for men and women.

[Table 1 goes here]

[3]Because the NCDS does not include dates of birth for siblings, family size and birth order are identical at ages younger than seven. As a result, birth order controls are excluded in regressions for child achievement prior to age seven.

[4]Assuming assortative matching in the marriage market a la Becker (1973), father's education may also serve as a measure of mother's human capital. The results remain qualitatively unchanged when this control is added.

[5] This restriction reduces the sample size by roughly 20-25 percent. Relaxing this selection rule does not meaningfully alter any coefficient estimates. No statistically significant coefficients cease to be significant in this larger sample. Only one statistically insignificant coefficient rises to a level of significance (at the 10% level): age-16 math for boys in the achievement growth regression. The larger sample size not surprisingly decreases the p-values associated with statistically significant coefficients.

IV. Family-Size Estimates

A. Cumulative Effects

The first estimates considered explore the cumulative effects of family size on child achievement.[6] Achievement at time *t* is regressed on family size at time *t* along with controls:

$$Achievement = \alpha + \beta_1 Family\ Size + \beta_2 Birth\ Order + \beta_3 Mother\ HK + \beta_4 Multiple\ Birth + \epsilon. \quad (1)$$

Due to data set limitations, this is the type of family-size effect estimated in nearly all existing studies. Table 2 presents estimates of the quality-quantity trade-off for each achievement measure.[7]

[Table 2 goes here]

The results evidence a significant trade-off between fertility and child quality which extends to labor market, cognitive, physical, and social measures of achievement. Each additional sibling corresponds to an earnings loss on the order of three or four percent. (The

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[6]Child spacing may also affect achievement. The NCDS does not give detailed information about spacing, but responses to questions such as "How many children under 21 reside in the household?" asked in several waves can be used to group sibling births into several time periods. Specifically, if one assumes that mothers with children born after 1965 did not also have children before 1949, then it is possible to infer how many siblings were born within the seven years after and the four years before the birth of the NCDS subject child. The analysis was replicated replacing total family size with the number of siblings in this 11-year span (hereafter, 'near siblings'). Under this alternative definition, family-size effects are generally smaller and several family size coefficients cease to be statistically significant–most notably the age-31 income of men in the achievement growth regression. It seems likely that the crude measure of near siblings available in the NCDS is simply too broad to capture the additional impact predicted by theory and observed in other studies. In total, the alternative definition appears to create measurement error in the total siblings measure and thus bias estimates toward zero.

[7]Coefficient estimates for control variables are suppressed to conserve space and are available from the author upon request.

magnitude of these earnings losses is very similar to that reported by Hanushek 1992 who studies the effect of siblings using data from Gary, Indiana.) This finding is corroborated by results for cognitive achievement where each additional sibling corresponds with a score reduction of one- to two-tenths of a standard deviation. Regressions not reported here show that cognitive losses of this magnitude predict an earnings loss of between two and four percent. It is notable that the effect of siblings is observed as early as age seven and that these early effects are at least as large (in terms of standard deviations) as those found at later ages.

The results additionally demonstrate that the effects of family size extend well beyond the cognitive and labor market measures of achievement studied by much of the existing literature. Children from large families are more susceptible to social adjustment syndromes and are more likely to be emotionally maladjusted and to struggle with poor coordination in pre-teen years. (Recall that the BSAG score is the one achievement indicator for which a higher score corresponds to lower well being. Thus, a quality-quantity trade-off is seen in the positive coefficient estimate.) Even very early physical developments such as talking and toilet training appear stunted. While the other early physical development measures do not exhibit statistically significant effects, it should be noted that all estimated coefficient signs are consistent with a quality-quantity trade-off. It may be that the crudeness of the early achievement measures reduces the power of these tests.[8]

B. Dynamic Effects

These estimates of cumulative family-size effects tell us something of the unfolding

[8]Creating a large sample by combining girls and boys in the case of pre-school achievement measures does not produce more statistically significant coefficients, however.

impact of siblings, but do not reveal much about the genesis of the trade-off. For instance, a sibship-effect in adult earnings can either indicate that family size directly influences labor market outcomes or simply that consequences of previous losses are visible in earnings. Following the spirit of Hanushek (1992), the effect of family size on achievement evolution is considered in this section by controlling for prior levels of achievement:

$$Achievement_t = \alpha + \beta_1 Family\ Size_t + \beta_2 Birth\ Order + \beta_3 Mother\ HK + \beta_4 Multiple\ Birth + \beta_5 Achievement_{pre\ t} + \epsilon \qquad (2)$$

where $Achievement_{pre\ t}$ includes all measures of achievement from periods prior to time t.[9] (Table 3 lists the assumed achievement ordering.) The resulting family-size coefficient measures the effects of siblings on achievement growth during the time period between current and prior observation.[10]

[Table 3 goes here]

The results in Table 4 reveal a family-size effect which develops very early in life with

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[9]Hanushek also includes measures of the change in family size between achievement measures, distinguishing between the effects of siblings and the effects of changes in family size. The results presented here were generally insensitive to the inclusion of a change in family size variable. Reading (age 11 and 16) and math (age 16) test scores for girls did suggest family-size changes were especially detrimental to achievement growth. It is plausible that the insignificance of family-size changes stems from the length of time between achievement measurement in the NCDS. Full results from these additional regressions are available from the author upon request.

[10]Hanushek notes that ordinary least squares (OLS) produces biased estimates due to measurement error in prior achievement. Intuitively, the effects of unmeasured prior achievement are picked up by OLS as effects of family size on current achievement. Because the measure of achievement used by Hanushek is a standardized test with known reliability coefficients, he is able to address this concern with a maximum likelihood estimator. The achievements considered in this paper contain measurement error of unknown variance which makes it impossible to follow Hanushek's example. Instead, estimates are constructed with OLS recognizing that estimates may overstate the effects of family size on achievement growth.

significant effects on both cognitive and social achievement.[11] However, siblings appear to have less and less impact on achievement growth as children age.[12] For instance, by age 16 siblings have no impact on math scores above and beyond that already reflected in age-11 achievement. And while age-16 reading scores continue to exhibit statistically significant sibship effects, the magnitude of the effect is reduced to less than one-twentieth of a standard deviation. Adult earnings generally show little to no effect of family size–only age-33 male earnings show any sign of statistical significance.[13] In total, it appears that the effects of family size are primarily felt early in child development. Then these early effects play themselves out over the life cycle, affecting outcomes through adulthood.

[Table 4 goes here]

An alternative specification, however, suggests family size may continue to affect achievement into adulthood–but effects may be positive as well as negative. Equation (2) assumes that the effects of family size are independent of previous achievement levels. If siblings' impacts are felt more acutely by those with higher or lower than average achievement,

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[11]Table 4 excludes the low birth weight regression because no prior measures of achievement exist. As in Table 2, coefficients for control variables are suppressed to conserve space and are available from the author upon request.

[12]To ensure these results are not driven by attrition the analysis was repeated using only those respondents with observations of all achievement measures. While the smaller sample produces fewer statistically significant coefficients, the general pattern remains: a statistically significant trade-off is evident in childhood, diminishes through teen years (of the age-16 cognitive scores, only boys' math tests show a significant family-size effect), and then disappears (no earnings measure shows significant effects of sibship).

[13]In regressions not reported here, the age-41 equations were re-estimated without controls for age-33 earnings to see whether the lack of additional family effects in these regressions followed from the correlation in earnings in the two periods. The results, however, are not sensitive to this change.

we should like to include interactions between family size and previous achievement:

$$Achievement_t = \alpha + \beta_1 Family\ Size_t + \beta_2 Birth\ Order + \beta_3 Mother\ HK + \beta_4 Multiple\ Birth + \beta_5 Achievement_{pre\ t} + \beta_6 Family\ Size * Achievement_{pre\ t} + \epsilon. \quad (3)$$

The inclusion of these interaction variables does not generally alter the patterns observed in Table 4. The effects of family size on achievement growth conditional on previous achievement (β_1) are substantial and statistically significant at young ages, but diminish to small and statistically insignificant effects in late teen years and beyond. The "return" to previous achievement (β_6), however, continues to vary with family size into mid-life.

[Table 5 goes here]

Table 5 presents the most notable results–those for adult earnings. (All other regression results are available from the author upon request.) The first row shows the direct effect of siblings on earnings. For both men and women the effect is negative at age 33 and positive at age 41, though none of the estimates are statistically significant. The remaining coefficients show the effect of family size on the returns to all previous achievements. While family size does appear to affect returns to some earlier achievements, fully half of the statistically significant coefficients indicate that larger families actually increase returns. It is also worth noting that only two of the ten significant coefficients pertain to cognitive measures of achievement. While the addition of family size-achievement interactions yields some interesting results, it does not appear to substantially alter the conclusions drawn from Table 4.

V. Connections with Theory

The previous sections of this paper explore when and how family size affects child achievement. Using data from the National Child Development Study, the paper finds that family-size effects can be found as early as age two and across a wide array of achievement measures including physical, cognitive, and social development. While this paper does find a quality-quantity trade-off in adult earnings, all of the observed sibship-effect is explained by the effects of family size upon the child at age 16 or younger. After a child reaches age 16, family size does not appear to have any additional impact.

These findings can be used to differentiate among the three competing models of family-size effects offered in Section II above. Do sibship-effects flow from constraints of scarcity (whether financial or temporal) or, as the preference heterogeneity model suggests, is the quality-quantity trade-off an illusion which appears simply because children from large families choose lower levels of education and earnings in anticipation of higher future fertility? It seems a little extreme to assume that children as young as seven would shirk on their math in anticipation of a life surrounded by children. Consequently, under the preference heterogeneity model, we should expect the effects of family size to appear only very late in life when children from large families ultimately choose different careers, pass up promotions which require substantially greater work commitments, and the like. Yet the data show exactly the opposite pattern of family-size effects–early effects which essentially disappear after age 16.

In addition to this timing evidence, the breadth of development skills retarded by family size also points away from an explanation based on unconstrained choice. While preference for children might reasonably cause an individual to forgo graduate school or choose a particular career path, it is hard to fathom why preference for children would lead someone to limit investments in social skills or basic physical development. The data show family-size affects on multiple measures of both social and physical achievement. In total, the early and broad impacts of sibship suggest the trade-off is real and so is likely the effect of some constraint.

But is the constraint financial or temporal? Here again, the breadth and timing of the observed family-size effects provide guidance. The fact that these effects are observed in physical and social skills presents some difficulty for the credit constraint explanation. It is easy to see how financial hardship could affect cognitive development. Many private inputs into education like books, quiet homes, tutors, or even educational vacations cost significant sums of money. It would seem that inputs into social and physical development would be less goods-intensive. Social effects of sibship might flow from credit market failure if they derive from embarrassing shortfalls in cognitive development which in turn stem from credit constraints. However, regressions not presented here but available from the author show that the results are unchanged when contemporaneous measures of cognitive ability are added to the social development regressions. Even if the social effects are dismissed as derivative, it remains difficult to understand family-size effects on talking, physical coordination, and toilet training in this manner.

The timing of family-size effects is even more problematic for the credit constraint explanation. Many researchers have studied the effect of family background at different points in childhood, arguing that family background effects are largest when resource constraints are tightest. (See Behrman and Taubman 1990 and Duncan and Brooks-Gunn 1997, for example.) In the results of this paper, the effects of family size all but disappear after a child reaches age 16 (and are as likely to be positive as negative after that point). To fit the model of credit market failure to this data, it must be that young families face borrowing constraints which are overcome with rising earnings by the time children reach university age. While this story is possible, one would think that credit constraints would be at their peak at the point of university attendance decisions because even when tuition is free the implicit costs of attendance (lost earnings) are substantial.

By contrast, the model with temporal constraints appears entirely consistent with the findings. Parent time is an input in all areas of child development and so the addition of siblings slows progress cognitively, physically, socially, and (ultimately) financially. This time is never more important than in the initial, formative years. Thus, the effects of sibship occur very early in life before diminishing to nothing by the late teen years.

Clearly, these results are not definitive and must be interpreted within the context of other existing and future works. In US and British data Grawe (2005a and 2005b), for instance, find no evidence that family size effects are smaller among high income families than among lower earning families as we would expect if credit constraints were responsible for the negative effect of siblings. Similarly, Grawe (2005a) finds no smaller family size effect in families in which children receive large bequests, families which presumably have access to credit. Distinguishing financial constraints from temporal is potentially important to public policy debates. First, it is not clear that the intergenerational persistence of earnings results primarily from financial constraints. As a result, additional subsidies for higher education expenditures may simply exacerbate intergenerational inequalities by subsidizing those who are already likely to earn relatively high incomes. Second, if financial constraints are relevant in Britain the results suggest they must affect early development and are less relevant to university attendance. This may justify the recent push to increase university tuition to a few thousand pounds while simultaneously expanding early childhood programs.

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Table 1
Summary statistics

Variable	Men mean (variance)	Men min/max	Women mean (variance)	Women min/max
Labor Market Achievements				
Log income (age 33)	9.38 (0.44)	6.66/12.47	8.57 (0.78)	5.33/14.08
Log income (age 41)	9.72 (0.66)	6.42/15.17	8.93 (0.81)	2.48/13.68
Cognitive Achievements				
Reading score (age 7)	-0.01 (0.97)	-3.27/0.93	0.22 (0.88)	-3.27/0.93
Math score (age 7)	0.10 (0.98)	-2.05/1.96	-0.00 (0.97)	-2.05/1.96
Reading score (age 11)	0.09 (1.02)	-2.54/3.02	0.09 (0.95)	-2.54/3.02
Math score (age 11)	0.13 (1.01)	-1.61/2.36	0.08 (0.97)	-1.61/2.26
General ability (age 11)	0.03 (0.98)	-2.66/2.23	0.17 (0.95)	-2.66/2.23
Reading score (age 16)	0.13 (0.97)	-3.57/1.37	0.11 (0.91)	-3.57/1.37
Math score (age 16)	0.22 (1.03)	-1.82/2.61	0.14 (0.96)	-1.82/2.61
Physical Achievements				
Birth weight (1 if >=88 ounces at birth)	0.96 (0.20)	0/1	0.94 (0.24)	0/1
Walking (1 if walking by age 18 months)	0.95 (0.22)	0/1	0.96 (0.20)	0/1
Talking (1 if talking by age 2 years)	0.92 (0.28)	0/1	0.95 (0.22)	0/1
Physical coordination (1 if "poor physical coordination" does not apply, age 7)	0.84 (0.39)	0/1	0.90 (0.30)	0/1
Speech impediment (1 if *never* stammered and *never* had other speech problem)	0.82 (0.39)	0/1	0.89 (0.31)	0/1

(table 1 cont.)	Men		Women	
Variable	mean (variance)	min/max	mean (variance)	min/max
Toilet training (1 if *no* toilet training problems)	0.86 (0.34)	0/1	0.88 (0.32)	0/1
Emotional Achievements				
Bristol Social-Adjustment Guide (total syndrome score, age 7)	0.07 (1.02)	-0.99/6.22	-0.21 (0.86)	-0.99/6.11
Bristol Social-Adjustment Guide (total syndrome score, age 11)	0.06 (1.03)	-0.95/5.29	-0.25 (0.82)	-0.95/5.40
Emotional maladjusted (1 if *no* emotional maladjustment, age 7)	0.93 (0.25)	0/1	0.94 (0.23)	0/1
Independent Variables				
Ultimate family size (age-16 number of siblings+1)	3.33 (1.70)	1/13	3.33 (1.68)	1/15
Birth order = 2	0.36 (0.48)	0/1	0.35 (0.48)	0/1
Birth order = 3	0.13 (0.34)	0/1	0.15 (0.35)	0/1
Birth order = 4	0.05 (0.22)	0/1	0.06 (0.24)	0/1
Birth order = 5	0.02 (0.13)	0/1	0.02 (0.13)	0/1
Birth order = 6	0.01 (0.09)	0/1	0.01 (0.07)	0/1
Birth order = 7	0.00 (0.06)	0/1	0.00 (0.04)	0/1
Last born (1 if last born)	0.25 (0.44)	0/1	0.27 (0.44)	0/1
Multiple birth (1 if a multiple)	0.02 (0.13)	0/1	0.02 (0.15)	0/1
Mother's education (years)	9.97 (1.61)	5/19	10.05 (1.73)	5/19

Note: The sample includes only those respondents for whom data on mother's education is available.

Table 2
The effect of family size on various measures of child achievement

Dependent Variable	Men Estimated coefficient (|t-stat|)	Men R^2 [N]	Women Estimated coefficient (|t-stat|)	Women R^2 [N]
Labor Market Achievements				
Log income (age 33)	-0.03*** (3.03)	0.04 [2054]	-0.037** (2.08)	0.05 [1709]
Log income (age 41)	-0.01 (0.68)	0.02 [2070]	-0.03* (1.79)	0.02 [2074]
Cognitive Achievements				
Reading score (age 7)	-0.14*** (6.24)	0.08 [3843]	-0.16*** (7.53)	0.09 [3696]
Math score (age 7)	-0.08*** (3.17)	0.05 [3828]	-0.09*** (3.85)	0.04 [3689]
Reading score (age 11)	-0.15*** (8.66)	0.12 [3677]	-0.15*** (9.81)	0.17 [3553]
Math score (age 11)	-0.13*** (7.51)	0.11 [3676]	-0.13*** (7.97)	0.13 [3551]
General ability (age 11)	-0.13*** (7.64)	0.10 [3677]	-0.16*** (10.10)	0.13 [3553]
Reading score (age 16)	-0.16*** (9.62)	0.14 [3275]	-0.17*** (11.44)	0.17 [3176]
Math score (age 16)	-0.13*** (7.25)	0.13 [3265]	-0.10*** (6.23)	0.15 [3160]
Physical Achievements				
Birth weight (1 if >=88 ounces at birth)	0.02 (0.79)	0.07 [3824]	0.03 (1.22)	0.09 [3667]
Walking (1 if walking by age 18 months)	-0.03 (1.13)	0.01 [3940]	-0.15 (0.51)	0.00 [3779]
Talking (1 if talking by age 2 years)	-0.02 (1.07)	0.01 [3940]	-0.05* (1.72)	0.00 [3779]

(table 2 cont.)

Variable	Men: Estimated coefficient (|t-stat|)	Men: R^2 [N]	Women: Estimated coefficient (|t-stat|)	Women: R^2 [N]
Physical coordination (1 if "poor physical coordination" does not apply, age 7)	-0.06* (1.68)	0.00 [3839]	-0.07* (1.77)	0.01 [3699]
Speech impediment (1 if *never* stammered and *never* had other speech problem)	-0.04 (1.09)	0.01 [3929]	-0.00 (0.02)	0.01 [3766]
Toilet training (1 if *no* toilet training problems)	-0.07* (1.89)	0.01 [3940]	-0.03 (0.85)	0.01 [3779]
Emotional Achievements				
Bristol Social-Adjustment Guide (total syndrome score, age 7)	0.11*** (4.45)	0.02 [3833]	0.13*** (6.22)	0.03 [3698]
Bristol Social-Adjustment Guide (total syndrome score, age 11)	0.13*** (7.16)	0.03 [3679]	0.12*** (7.96)	0.04 [3553]
Emotional maladjusted (1 if *no* emotional maladjustment, age 7)	-0.09* (1.94)	0.00 [3919]	-0.12*** (2.73)	0.02 [3757]

Note: All regressions include controls for birth order, twinning, and mother's education. Regressions using bivariate dependent variables estimated by probit regression; in these cases, reported R-squares are "pseudo R-squares."

** Statistically significant at 10% level.*

*** Statistically significant at 5% level.*

**** Statistically significant at 1% level.*

Table 3
Assumed order in which achievements take place

Stage	Achievement Concerns
1	Low birth weight
2	Walk by 18 months
3	Talk by 24 months
4	Speech impediment, toilet training, physical coordination
5	Age 7: math and reading scores, doctor evaluation of emotional adjustment, and Bristol Social Adjustment Guide score
6	Age 11: math, reading, and general ability scores, Bristol Social Adjustment Guide score
7	Age 16: math and reading scores
8	Age 31: earnings
9	Age 41: earnings

Table 4
The effect of family size on various measures of child achievement conditional on past achievement

Dependent Variable	Men: Estimated coefficient (|t-stat|)	Men: R^2 [N]	Women: Estimated coefficient (|t-stat|)	Women: R^2 [N]
Labor Market Achievements				
Log income (age 33)	-0.02* (1.69)	0.15 [1550]	-0.00 (0.14)	0.14 [1266]
Log income (age 41)	0.01 (0.62)	0.24 [1171]	-0.01 (0.62)	0.28 [939]
Cognitive Achievements				
Reading score (age 7)	-0.13*** (5.59)	0.16 [3699]	-0.14*** (7.12)	0.18 [3560]
Math score (age 7)	-0.05** (2.19)	0.09 [3698]	-0.08*** (3.30)	0.07 [3564]
Reading score (age 11)	-0.08*** (5.13)	0.45 [3419]	-0.08*** (6.19)	0.45 [3307]
Math score (age 11)	-0.04*** (3.18)	0.49 [3418]	-0.05*** (3.77)	0.46 [3305]
General ability (age 11)	-0.05*** (3.80)	0.48 [3419]	-0.08*** (5.71)	0.47 [3307]
Reading score (age 16)	-0.04*** (3.50)	0.68 [2861]	-0.03*** (3.27)	0.70 [2777]
Math score (age 16)	-0.02 (1.34)	0.64 [2852]	0.00 (0.14)	0.61 [2764]
Physical Achievements				
Walking (1 if walking by age 18 months)	-0.03 (1.16)	0.01 [3824]	-0.01 (0.44)	0.00 [3667]
Talking (1 if talking by age 2 years)	-0.01 (0.53)	0.04 [3824]	-0.04 (1.54)	0.06 [3667]

(table 4 cont.)	Men		Women	
Variable	Estimated coefficient (|t-stat|)	R^2 [N]	Estimated coefficient (|t-stat|)	R^2 [N]
Physical coordination (1 if "poor physical coordination" does not apply, age 7)	-0.05 (1.26)	0.02 [3727]	-0.06 (1.38)	0.03 [3591]
Speech impediment (1 if *never* stammered and *never* had other speech problem)	-0.02 (0.65)	0.04 [3814]	0.00 (0.01)	0.03 [3655]
Toilet training (1 if *no* toilet training problems)	-0.07** (1.94)	0.01 [3824]	-0.03 (0.69)	0.02 [3667]
Emotional Achievements				
Bristol Social-Adjustment Guide (total syndrome score, age 7)	0.09*** (3.52)	0.13 [3688]	0.11*** (5.31)	0.16 [3558]
Bristol Social-Adjustment Guide (total syndrome score, age 11)	0.09*** (5.00)	0.21 [3418]	0.07*** (4.62)	0.20 [3308]
Emotional maladjusted (1 if *no* emotional maladjustment, age 7)	-0.06 (1.22)	0.06 [3700]	-0.12** (2.45)	0.04 [3559]

Note: All regressions include controls for birth order, twinning, and mother's education in addition to all measures of achievement from early in life. Regressions using bivariate dependent variables estimated by probit regression; in these cases, reported R-squares are "pseudo R-squares."
** Statistically significant at 10% level.*
*** Statistically significant at 5% level.*
**** Statistically significant at 1% level.*

Table 5
The effect of family size on various measures of child achievement conditional on past achievement, including family size-achievement interactions

	Men		**Women**	
	Age-33 log income	Age-41 log income	Age-33 log income	Age-41 log income
Family size	-0.02 (0.99)	0.03 (0.97)	-0.01 (0.36)	0.05 (1.59)
Interaction of family size with...				
Birth weight (1 if >=88 ounces at birth)	-0.03 (0.86)	0.06 (0.88)	0.01 (0.11)	-0.00 (0.03)
Walking (1 if walking by age 18 months)	0.06 (1.51)	-0.03 (0.50)	0.05 (0.53)	-0.14* (1.83)
Talking (1 if talking by age 2 years)	-0.01 (0.14)	0.01 (0.09)	-0.03 (0.38)	0.18** (2.32)
Physical coordination (1 if "poor physical coordination" does not apply, age 7)	-0.03 (1.58)	0.03 (1.08)	0.03 (0.67)	-0.06 (1.45)
Speech impediment (1 if *never* stammered and *never* had other speech problem)	0.07*** (3.65)	0.04 (1.40)	0.01 (0.15)	0.02 (0.50)
Toilet training (1 if *no* toilet training problems)	0.03* (1.79)	-0.00 (0.13)	-0.04 (0.87)	-0.07* (1.83)
Bristol Social-Adjustment Guide (total syndrome score, age 7)	0.01 (1.40)	-0.01 (0.92)	0.00 (0.15)	-0.02 (0.83)
Emotional maladjusted (1 if *no* emotional maladjustment, age 7)	-0.06** (2.21)	-0.09** (2.35)	0.01 (0.24)	0.02 (0.31)
Bristol Social-Adjustment Guide (total syndrome score, age 11)	-0.01 (0.88)	-0.00 (0.07)	-0.00 (0.05)	-0.03* (1.91)
Reading score (age 7)	-0.01 (0.65)	0.00 0.08)	0.01 (0.34)	0.00 (0.16)

(table 5 cont.)	**Men**		**Women**	
	Age-33 log income	Age-41 log income	Age-33 log income	Age-41 log income
Math score (age 7)	-0.00 (0.04)	0.01 (0.40)	0.00 (0.16)	0.00 (0.04)
Reading score (age 11)	-0.00 (0.06)	0.00 (0.15)	0.00 (0.06)	-0.02 (0.69)
Math score (age 11)	0.01 (0.99)	-0.00 (0.06)	0.06** (1.98)	-0.03 (1.10)
General ability (age 11)	0.01 (1.10)	-0.02 (1.10)	-0.04* (1.65)	0.02 (1.04)
Reading score (age 16)	0.01 (1.02)	0.01 (0.29)	-0.03 (1.26)	0.01 (0.50)
Math score (age 16)	-0.02** (2.23)	0.00 (0.04)	-0.01 (0.64)	0.00 (0.14)
R-square	0.17	0.09	0.15	0.09
Sample size	1550	1537	1266	1562

Note: All regressions include controls for birth order, twinning, and mother's education in addition to all measures of achievement from early in life.
** Statistically significant at 10% level.*
*** Statistically significant at 5% level.*
**** Statistically significant at 1% level.*