The Trade-Off Between Child Quantity and Quality: Some Empirical Evidence

Hanushek, Eric A.

Working Paper No. 97
September 1987.

The Trade-off Between Child Quantity and Quality:
Some Empirical Evidence

by Eric A. Hanushek*

Working Paper No. 97

August 1987

ABSTRACT

Alternative models of parental time allocation to children's education form the basis for an empirical investigation of trade-offs between number of children and their scholastic performance. The econometric evidence, based upon a detailed investigation of longitudinal data on families, suggests that family size directly affects children's achievement. Parents, however, do not allocate time to maximize achievement but instead appear either to act in a compensatory manner or to be completely nondiscriminatory in time devoted to their children. While parents show no favoritism to first born children, there remains a distinct advantage to being early in the birth order. This advantage comes entirely from the higher probability of being in a small family. The enormous changes in family composition over the last two decades are shown to be potentially important in explaining the aggregate test score changes of the period. Finally, other important family factors that have undergone large secular changes--divorce or market work by mothers--have no apparent impact on children's scholastic achievement.

*Helpful comments were provided by Stanley Engerman. This work was partially supported by the National Institute of Education.

The Trade-off Between Child Quantity and Quality:

Some Empirical Evidence

by Eric A. Hanushek

Economists have increasingly turned their attention to behavior within families. This interest is not particularly surprising given the direct implications for such diverse issues as population growth, intergenerational transfers of wealth, human capital accumulation, and macroeconomic policy. While this analysis can be related to each of these issues, it is easiest to motivate it in terms of modern economic demography which concentrates on parental trade-offs between the number and quality of children. This theory, advanced by Becker[1970], Becker and Lewis[1973], and Willis[1973], explains among other things how birth rates could fall with increasing income even though children are not inferior goods. However, direct evidence on this hypothesized trade-off is scant, owing both to a lack of suitable data on child quality and to considerable ignorance about the "production function" for child quality.

This paper extends the basic model of home production of child quality and presents empirical evidence on the magnitude of quantity-quality trade-offs. The theoretical model highlights the allocation of time to children. The empirical analysis employs data on scholastic achievement of children to consider the effects of varying family sizes and structures. An exceptionally rich body of data permits disentangling the impact of family size ("quantity effects") from a variety of potentially confounding factors including other family attributes and exogenous school inputs.

Empirical analysis of the achievement of children has been approached from a variety of research and policy perspectives. At the aggregate level, the declines in performance on the Scholastic Aptitude Tests (SAT) have been related to changing fertility patterns (Zajonc[1976], Easterlin[1978]). In particular, the 10 percent decline in SAT performance between 1963 and 1977 occurred at the same time that average birth order went from 2.4 to over 2.9, and Easterlin suggests that these are causally related.[1] At the micro level, psychologists have long been interested in the effects of family size, birth order, and child spacing on academic achievement (see, for example, Zajonc and Markus[1975] or Belmont and Marolla[1973]). Typically, however, only passing attention has been given to other factors that might affect scholastic achievement, suggesting the possibility for biased estimates of family size effects. For example, income measures are frequently omitted from birth order and family composition studies, even though most theoretical and empirical analyses of fertility decisions suggest that family size is related to income levels of families. If family income is systematically related to student achievement, this omission will lead to estimation bias.

Educational production studies, following a different tradition, have highlighted the importance of schools and teachers in determining the scholastic performance of students.[2] Consideration of school resources has important implications for estimating family effects, because school

---

[1]Average birth order is typically interpreted as a measure of family size and not the importance of being in different relative positions within a family.

[2] This inquiry is typically traced back to Coleman <u>et al.</u> [1966]. However, many subsequent studies have investigated school effects (see Hanushek [1986]).

choices are related to family circumstances. This implies that ignoring schools will lead to overstating systematically the importance of family factors including family size and composition.

Interest in the effects of families on students' achievement has also been heightened by overall changes in society. In particular, the rise in female labor force participation and in the incidence of one parent families raises concerns about long-run impacts on children and future generations. These concerns appear especially relevant for low income families, where the disadvantages of poverty already operate to lower children's achievement.

This analysis integrates the various analyses of children's scholastic performance.

I. A Formal Model of Family Effects

An important theoretical innovation in consideration of family behavior is the introduction of a production function for home activities. In the context of fertility decisions, families are seen as maximizing utility (which has arguments of the quantity and quality of children along with other goods). This maximization is subject to the production function for child quality, a budget constraint, and a time constraint. The trade-off between child quantity and quality enters essentially because parents' time and resources must be spread thinner with more children.

The theoretical model here considers parental time allocations to education but differs from previous analyses by recognizing that time is not homogenous. Parents make a series of optimizing decisions about allocations of two types of educational inputs--"public" time and "private" time.[3] The notion of public time is analogous to a pure public good--all children share in this, and "consumption" of public time by one child does not lower the amount available to other children. Public time relates to group activities within the family and is most important in setting the general educational tenor of the family, basic motivation toward schooling and careers, transmittal of language, and so forth. Private time on the other hand is child specific and includes direct help with homework and other activities with no spillovers to other children in the family. It is natural to think that private time has greater educational value, but it is also more expensive since private time for any child subtracts from the total time available to other children. Parents are viewed as optimizing in the division of time, given the contemporaneous structure of the family. This section considers three alternative models of family time allocation.

a. Nondiscriminatory Time Allocation. The simplest model is one of nondiscriminatory time allocations to children; i.e., all children receive the same amount of individual attention. Parents decide upon the split between public and private time for some period (during which the number of children is fixed). The decision problem is to maximize average achievement,[4] subject to the production function and a total time

---

[3] This view is eluded to by Hill and Stafford[1974] in their analysis of time budget data. However, they do not fully develop the implications for children's performance. Consideration of public time does suggest serious difficulties in the direct measurement of time allocations from time budget surveys.

[4] The objective function can differ with the same qualitative conclusions as long as it is increasing in terms of achievement of the individual children. Further, while attention is focused on the scholastic achievement of children, each of the formulations can be related to an overall intergenerational utility maximization problem of the Becker/Tomes type (see Becker and Tomes[1976, 1979, 1986]) or Behrman, Pollak, and Taubman[1982].

constraint. In particular, the problem for a given family is:

$$(1) \qquad \max_{p,h} V = \sum_i A_i \quad \text{s.t.} \qquad \begin{aligned} &\text{i)} \;\; A_i = \Phi(p, h_i;\, S_i,\, X_i) \\ &\text{ii)} \;\; T = p + \sum_i h_i \\ &\text{iii)} \;\; h_i = h_j \quad \text{for } i \neq j. \end{aligned}$$

where (i) is the production function for achievement of child i (A_i) and (ii) and (iii) are the constraints on time available for children's education. Achievement is determined by public time (p), private time (h_i), school inputs (S_i) and other, exogenous inputs (X_i) such as "ability" or characteristics of other students in school. With nondiscriminatory provision of inputs, the time budget constraint reduces to T=p+nh, and the number of children (n) operates simply as the "price"of individual time relative to public time. From this maximization problem, assuming that the marginal products of public and private time are decreasing, the ratio of average marginal products for public and private time will be equated to 1/n, the ratio of marginal time costs. That is, maximization implies that:

$$(2) \qquad \sum_i (\partial A_i/\partial p) / \sum_i (\partial A_i/\partial h_i) = 1/n.$$

This maximization process implies that families will adjust to more children by shifting from individual to public time. Because of this optimization, achievement of any child will decline with the addition of more children, but the decline will be less than linear because of the changing allocation of time within the family.

b. Achievement Maximization. Equal time allocations among children will, in general, not maximize average achievement of children. In particular, if the last constraint (iii) is removed, the marginal products of individual time are equated across children (which was not the case previously); i.e.,

$$(3) \qquad \partial A_i/\partial h_i = \partial A_j/\partial h_j \quad \text{for all } i \neq j.$$

The division between public and private time is determined again by setting the ratio of average marginal products for public and private time equal to 1/n. Here, however, the average marginal product of private time is equal to the marginal products for each child which are equated on the margin. For the plausible case that parents' time is complementary to exogenous factors (such as individual ability), this implies that achievement is maximized by reinforcing prior differences in achievement of children.[5]

c. Compensatory Education. The final model of parental behavior assumes that parents are concerned about both average achievement and the distribution of achievement across children. In other words, parents tend to be "egalitarian in outputs" instead of just inputs as in case (a).

A variety of objective functions capture this notion.[6] For example, one

---

[5] Becker and Tomes[1976] assume complementarity and essentially conclude that this type of behavior is most likely. Achievement maximization is a special case of "reinforcing strategy" as described in Behrman, Pollak, and Taubman[1982]. Note that families may still be "egalitarian" with respect to their children. Families can maximize aggregate welfare of children by giving time (education) to those who most benefit in terms of achievement and money (perhaps through bequests) to those who benefit less from time. Alternatively, parents may be able to "force" nonaltruistic children to act in an altruistic manner toward siblings; cf. Becker[1974,1981].

[6] As noted above, maximizing achievement in Case (b) can be consistent with egalitarian behavior in terms of childrens' income or utility if parents plan to transfer income to those who benefit less from time investments in human capital production. One interpretation of the compensatory model is that parents perceive limits on their ability to transfer income to other siblings (which may be particularly relevant in

simple form of this is that the objective function includes both average achievement and its variance such as:

$$(4)\quad V = \sum_i A_i - \mu(\mathrm{var}(A_i)) .$$

where μ is the coefficient of compensatory treatment. In this case, the distribution of private time across children is governed by two opposing forces. Maximizing average achievement dictates (with complementarity) spending more time with the more able (the "efficiency" effect), while minimizing the variance dictates taking time away from the most able and giving it to the least able (the "wealth" effect). The objective function is maximized when private time is allocated across children such that:

$$(5)\qquad \partial A_i/\partial h_i \; (1 - 2\mu\frac{(n-1)a_i}{n^2}) = \partial A_j/\partial h_j \; (1 - 2\mu\frac{(n-1)a_j}{n^2})$$

where $a_k=(A_k-A)$ is the deviation of individual k's achievement from the family mean achievement. Thus, in the normal case private time will be devoted in greater amounts to the less able than would be the case with achievement maximization. All other things equal, however, the amount of compensatory adjustment will be less in larger families.

In all cases, achievement of each child will fall with the addition of more children. However, in the first case ("nondiscriminatory time allocation"), the achievement of any particular child will not depend upon the distribution of achievement of other children in the family; in the second case ("achievement maximization"), achievement will be higher both

---

lower income families). Case(c) is also consistent with the "child neutral" case of Becker and Tomes[1976].

An alternative form of the utility function is that used by Behrman, Pollak, and Taubman[1982].

with higher own ability and lower relative ability of siblings; and, in the last case ("compensatory"), an individual who is smarter than his siblings may receive less attention than in the second case with the amount depending upon the distaste for intrafamily differences (μ) and the magnitude of within family differences.

In this structure, attention focuses on parental time allocations in any period. Parents are assumed to treat all children "evenhandedly"--no special attention is given to the first born or to the "baby" of the family. But this doesn't imply that the achievement of all children in a family will be equal. Educational inputs accumulate so that, independent of ability differences or different profiles of school inputs, children in different birth order positions will have different amounts of family inputs, arising simply from the sequential nature of births. Similarly, while the age distribution of children does not enter into the optimization at any point in time, different child spacings will imply different accumulated family inputs. Importantly, the structure of the model with respect to each of these aspects is testable. The implications of each is discussed in Section IV.

II. Empirical Implementation

The theoretical model concentrates upon the allocation of time across children, emphasizing how a fixed quantity of time is optimally allocated within the household. The flow of student achievement will be affected by the number of children in the household and the distribution of achievement in the family as well as the production relationships and choice parameters for the household. These factors determine parental time allocations to their children's education. While the actual time allocations, particularly when private and public time are distinguished, are difficult to observe directly, their underlying determinants can be observed and the relevant relationships can be estimated.

The empirical analysis utilizes data generated by the Gary Income Maintenance Experiment. As part of this experiment, data about family characteristics, parental work behavior, incomes, and so forth were collected over a four year period. These data were merged with information about school experiences of children from the experimental families between 1971 and 1975. Some families received payments under alternative negative income tax schemes, while others were part of the experimental control group. All families had relatively low incomes; the average income of sampled families (in 1974 dollars) was approximately \$6,500, somewhat above the 1974 poverty line for an urban family of four which stood at \$5,038. All families were black. The schooling information included data on specific teachers along with test scores from the Iowa Reading Comprehension and Vocabulary tests. (Descriptive statistics are found in Appendix A). The longitudinal nature of the data is unique and particularly important. The observation over time of school performance, school resources, and family circumstances permits accurate measurement of educational inputs and the possibility of isolating the independent contributions of each to childrens' achievement.

The theoretical model focused on the "instantaneous" flow of achievement. The optimal allocation of time will change with variations in exogenous factors, with variations in family size and structure, etc.

Thus, in terms of the level of achievement, the entire past history, including the time path of inputs and family decisions will be relevant. Furthermore, because the short run and long run impacts of both family and nonfamily factors may differ significantly, accurate identification of the time profile of these is essential. Indeed, one of the most significant difficulties in interpreting past analyses of educational production functions has come from imprecise measurement of educational inputs over time (Hanushek 1978). Aggregation of inputs across time, which is frequently done by relying exclusively upon contemporaneous values of inputs in a cross-sectional analysis of achievement, becomes a classic errors in variables problem.

Past consideration of measurement and estimation problems, while focusing on the contribution of school inputs, has demonstrated that analysis of "value-added", or achievement growth, over a restricted period of time can be used to circumvent the most serious difficulties. In particular, if the achievement of the ith student at time t (A_{it}) is a function of the cumulative inputs of families ($F_i^{(t)}$) and schools ($S_i^{(t)}$) along with the cumulative inputs of other exogenous factors ($X_i^{(t)}$), the level of achievement at any point will simply be:

$$(6) \qquad A_{it} = \Phi(F_i^{(t)}, S_i^{(t)}, X_i^{(t)}).$$

If achievement at a previous time (t*) is also observed, it is possible to concentrate on value-added over the intervening period, such as:

$$(7) \qquad A_{it} = \varphi(F_i^{(t-t*)}, S_i^{(t-t*)}, X_i^{(t-t*)}, A_{it*}).$$

In this formulation, the entire past history of inputs is not needed;

instead, just data on inputs over the limited interval (t-t*) are needed.[7] This also matches the previously discussed family time allocation problem (which enters into the family inputs, F); in that, it was assumed that family size and structure were constant for the decision period. Such a formulation will be more feasible both for reasons of data availability and for reasons of analytical tractability (see Hanushek[1978, 1986]).[8]

Empirical implementation, which utilizes data on inter- as well as intrafamily variations in achievement, must consider three possible modifications to the basic theoretical structure: 1) the amount of total time to be allocated (T) may differ across families; 2) the quality of the time allocated to children may also differ across families; and, 3) other exogenous factors almost certainly influence children's achievement.

---

[7] It is generally preferable to include the initial achievement measure as one of the inputs, instead of simply include change in achievement as the dependent variable. There are three reasons for doing this: (1) empirically, output measurements, particularly test scores in different grades, may be scaled differently; (2) levels of starting achievement may influence achievement gain; and (3) correlated errors in achievement measurement may suggest such a formulation (Cronbach and Furby [1970]). However, the latter argument suggests that further corrections for errors in the exogenous variables--probably based upon test reliability measures--are also needed since such errors, even if they have zero means, will yield inconsistent estimates; see below. This general formulation of the "value added" specification lessens the data requirements, but it does so at the expense of some additional assumptions about the relationships; see, for example, Ragosa and Willett [1985].

This approach would suffer if prior inputs had a lasting effect over and above any effect on initial achievement levels. This is, for example, one interpretation that could be given to some of the analyses of preschool programs where persistent and long lasting outcome differences are observed even though early IQ effects of preschool disappear. The evidence is, however, quite indirect; see Darlington et al. [1980] and Berrueta-Clement [1984].

[8] The value added formulation also accounts for any fixed, but unmeasured, effects such as differences in innate ability, motivation, and so forth as long as they have a proportional effect on achievement (in the logarithmic models estimated below).

Two major systematic differences across families in total time available are considered. These are the presence or absence of a father[9] and the work behavior of the parents. Analyses of these also provides information about the potential long run effects of increased divorce rates and the dramatic changes in female labor force participation rates of the past two decades.

While the quality of parental time is difficult to observe directly, several measures of family socio-economic status (SES) provide proxies. Since the quality of time as related to child rearing practices would be expected to evolve slowly over time, long run measures of the SES of the family seem most appropriate and two alternative measures are used: "permanent" income and parental education levels. Distinctions between permanent and current family circumstances have not consistently been made in past work, but it seems important to do so from both an analytical and a policy view. Contemporaneous measures, such as current income, will not only be noisy measures of fundamental quality differences but also will confuse current conditions--such as changes in labor force behavior or changes in the number of parents--with longer run quality considerations. To the extent that short run conditions enter, quite different policies might be called for.[10] These distinctions are tested below.

The distinction between quantity and quality of parental time is somewhat blurred. Direct analyses of reported time allocations, in

---

[9] Within the sample for the empirical analysis, all one parent families are headed by a female.

[10] Particularly at lower income levels, severe short run deprivation--the absence of adequate food or shelter, for example--may have some direct impact on students' achievement.

particular the work of Hill and Stafford[1976, 1980], suggest that quantity of time may vary directly with socio-economic status. Further, income can clearly enter directly into the achievement relationships through material advantages or purchased inputs. For this analysis, however, where quality of time is assumed to augment the amount of available time, the distinctions are not important.

The most important exogenous factors to be considered relate to school inputs. Although a variety of approaches to the measurement of school resources have been taken in past work, the most common approach has been to specify a small set of measured factors which capture the largest systematic effects. This list invariably includes class sizes, teachers' experience, and teachers' education levels. Then, subject to data availability, a variety of other factors such as time spent on different activities, attitudes of school personnel, intelligence of teachers, and so forth are appended to the list. These studies have failed to provide a simple list of factors that systematically distinguish good teachers from bad and good schools from bad (see Hanushek[1986]).

While significant differences in teacher and school quality exist, the differences cannot be easily captured by a parsimonious list of attributes. In this analysis, a particularly simple (and general) formulation of school effects is employed: Teacher quality is viewed as being idiosyncratic. To capture this view of differences in teachers and schools, a covariance structure is employed. In this, mean differences in student achievement growth across schools and teachers are extracted by including separate dummy variables for each teacher in the sample.[11]

III. Empirical Results

The estimation is divided into two parts: preschool and school. For the preschool period, where no measures of prior achievement (A_{it*}) are available, value-added models cannot be estimated, and specifications like Equation 6 are employed. For the school period, value-added models are consistently estimated.

A. Achievement Growth during Schooling. Achievement growth for grades 2 through 6 are specified in value-added form like Equation 7. The individual grade level samples and different school years are pooled, although separate intercepts and coefficients on beginning achievement are estimated for each grade. All of the estimates still refer to change in achievement across a single grade level (for example, achievement growth from the end of the fourth through the end of the fifth grades). The estimation is done in log-log form so that the parameters have the usual elasticity interpretation. The distribution across grades and calendar years of the 1,920 students for whom complete data are available is displayed in Appendix Table A-1.

Because of the possibility of measurement errors on the tests, the models are estimated using maximum likelihood methods that allow for the

---

[11]A description of the estimation methods and interpretation can be found in Hanushek[1986]. This structure does restrict the sample since the teacher estimates are based upon common achievement gains across students with the same teacher. Therefore, students are included in the sample only if at least two other sampled students had the same teacher. Because of the underlying sampling of students, there is no reason to believe that this biases the estimation of family effects.

error variance in the prior achievement measures. In this, the prior achievement level is viewed as an error prone measure of "true" ability such as:

(8) $\mathcal{A}_{it*} = A_{it*} + \epsilon_{it*}$

where $\mathcal{A}_{it*}$ is measured prior ability which includes error, ϵ_{it*}. For the estimation, ϵ_{it*} is assumed to have mean zero with a constant variance (σ^2) and to be independent of the true ability (A_{it*}). The published reliability coefficients for the specific test and grade level (which range from .86 to .94) are used to estimate the error variances (σ^2).[12]

Table 1 provides variable definitions, and Table 2 displays the estimation results. The first two models for each test (columns [1] and [2] for Vocabulary achievement and columns [4] and [5] for Reading achievement) include a series of dummy variables for specific teachers and schools, while the last models (column [3] and [6]) ignore differences in school inputs. Within this sample, teacher differences are very important, raising the R-squared by a third and dramatically altering the achievement of individual students. Nevertheless, their inclusion has little systematic effect on the remaining coefficients. This finding of little bias from omitting school inputs, however, could well be an artifact of the specific sample. All children are drawn from the same school system, thus limiting the variation in school inputs and the range of correlation between family and school characteristics.

---

12 The reliability coefficients should be interpreted as providing a lower bound on the error variance, since they assume no systematic individual component to the errors. Further, there is no information on the "external validity" of the tests. Reliability coefficients for the different grade levels are given in Appendix Table A-1.

Table 1. VARIABLE DEFINITIONS

Dependent Variables

READING	Log of Iowa Reading Comprehension Test
VOCABULARY	Log of Iowa Vocabulary Test

Independent Variables

PRE(n)	Log of Iowa Reading Comprehension or Vocabulary Test--grade n
GRADE n	Dummy variable: =1 for grade n and =0 for all other grades
PERM	Log of "permanent" income (average income 1970-1975)
FALL	Dummy variable: =1 if pretest taken in Fall; =0 if taken in Spring
FEMALE	Dummy variable: =1 if girl; =0 if boy
KIDS	Number of children
FAMTEST	Dummy variable: =1 if test scores for other members of family; =0 if not available
RELFAM	Performance of siblings relative to specific child; mean test scores for siblings (in terms of standard deviations from overall test mean) minus pretest performance of specific child (relative to overall test mean)
AVERKIDS	Average number of kids in family, birth to grade 1
YOUNGER	Dummy variable: =1 if younger siblings present; =0 otherwise
NUMYNG	Number of younger siblings present

Astericks in variable names denote logarithms of variables.

Table 2: Achievement Growth Models (Grades 2-6)

	Dependent Variable					
	Vocabulary*			Reading*		
Variable	[1]	[2]	[3]	[4]	[5]	[6]
KIDS*	-.028	-.038	-.027	-.025	-.030	-.029
	(-2.3)	(-3.5)	(-2.1)	(-2.1)	(-2.9)	(-2.3)
PERM*	.035	.037	.029	.017	.028	.028
	(2.8)	(3.0)	(2.2)	(1.4)	(2.3)	(2.3)
FEMALE	.002	.000	.017	.028	.041	.041
	(0.2)	(0.1)	(1.4)	(2.6)	(3.7)	(3.7)
FAMTEST	-.017	---	-.001	-.011	---	-.006
	(-1.2)		(-0.1)	(-0.8)		(-0.4)
RELFAM*	.075	---	.108	.013	---	.031
	(2.5)		(3.3)	(0.4)		(1.0)
FALL	-.213	-.215	-.210	-.178	-.177	-.161
	(-6.6)	(-6.7)	(-7.6)	(-5.5)	(-3.5)	(-6.1)
Grade Level and Entering Ability						
GRADE 2	.296	.319	.228	.244	.248	.185
	(3.6)	(3.9)	(2.8)	(2.9)	(3.0)	(2.2)
GRADE 3	.377	.351	.365	.138	.245	.128
	(4.1)	(4.3)	(4.5)	(1.7)	(3.0)	(1.6)
GRADE 4	-.157	-.165	-.042	-.058	-.142	.161
	(-2.0)	(-2.0)	(-0.5)	(-0.7)	(-1.7)	(2.0)
GRADE 5	-.049	-.056	-.162	.029	-.059	.065
	(-0.6)	(-0.7)	(-2.0)	(0.3)	(-0.7)	(0.8)
PRE2*	.675	.642	.636	.497	.491	.508
	(9.4)	(9.1)	(8.5)	(7.4)	(7.4)	(7.4)
PRE3*	.610	.582	.707	.517	.513	.596
	(12.1)	(11.8)	(13.6)	(10.5)	(10.7)	(12.3)
PRE4*	.536	.504	.575	.444	.438	.381
	(11.7)	(11.5)	(10.9)	(10.7)	(11.0)	(9.2)
PRE5*	.505	.473	.624	.441	.436	.490
	(11.3)	(11.0)	(14.2)	(10.0)	(10.3)	(11.7)
PRE6*	.548	.516	.591	.556	.550	.595
	(13.7)	(13.5)	(14.2)	(12.1)	(12.5)	(12.6)
INTERCEPT	.574	.606	.601	.690	.693	.529
	(4.7)	(5.0)	(4.9)	(5.6)	(5.7)	(4.5)
TEACHERS	yes	yes	no	yes	yes	no
df	1,760	1,762	1,902	1,760	1,762	1,902
R-squared	.66	.66	.50	.65	.65	.55

The systematic effects of families are portrayed in the top portion of the table. In the log-log formulations that include entering levels of achievement (PRE variables for each grade), the coefficients indicate how annual achievement growth is affected by family inputs.

The elasticity with respect to number of children (KIDS) is approximately -.03 for both achievement measures. Thus, annual achievement growth of each child in a family will fall by 1.5 percent when a second child is added and .6 percent when a sixth child is added. This provides confirmation of the fundamental trade-off between quantity and quality of children.

At the same time, there is confirmation of the basic structure of the model that emphasizes aggregate competition for parental time. Specific position in the birth order (that is, being first born or last born) provided no additional information in explaining achievement growth. Neither did the age distribution of children as measured by the presence and number of preschool children. The average spacing of children within each family also had no bearing on educational growth. In sum, the number of children in the family completely characterizes the effects on scholastic achievement of family size and composition.

With one important exception, the results for the two alternative test measures are quite similar. The exception is found in the effect of intrafamily achievement differences. RELFAM measures variations in performance <u>within families</u>. By comparing the average performance of siblings relative to the initial performance of the specific child, it is possible to separate differential treatment of siblings from the absolute level of achievement across students and families.[13] For the vocabulary model (Col. [1]), these is a positive and statistically significant relationship indicating that, everything else equal, an individual with brighter siblings has higher achievement. This, in terms of the alternative models presented above, suggests compensatory behavior on the part of parents.[14] With reading achievement, this intrafamily relationship is less apparent. While still positive, the magnitude of the coefficient is much smaller, and it is no longer significant. (No relationship between intrafamily differences and an individual child's achievement would be consistent with nondiscriminatory time allocations). It neither case is there any support for achievement maximization behavior of the parents.

Achievement is systematically related to permanent income (PERM).[15] The magnitude of the elasticity estimate is roughly the same as that for number of children (with the opposite sign), but caution is required in its interpretation. Permanent income indexes the educational environment of the home and the quality of parental time, suggesting that the naive policy

---

[13] In this, performance across tests and grade levels are averaged in terms of standard deviations away from the sample mean. These are then converted to grade level equivalents for the grade of the specific child under consideration. FAMTEST, a dummy variable indicating whether sibling's performance is measured, is included to separate families where relative performance data are available from those where it is not. There is no prior on the sign or the magnitude of this effect, and it is uniformly insignificantly different from zero.

[14] An alternative explanation is that siblings contribute to education (cf. Zajonc[1976]). In such a case, the absolute level of siblings' achievement, instead of the relative performance, would be the relevant factor. However, in the multiplicative formulations here, it is difficult to distinguish between these hypotheses.

[15] Permanent income is measured by average total family income over the five years for which data are available. Therefore, it will include both past and future income at any given school year.

option of simply adding money may have little effect unless there is a concomitant change in behavior and educational interactions. In the presence of permanent income, measures of parental education added no information. Further, current income (in the year studied) was insignificantly related to achievement growth, reinforcing the interpretation that this is an index of underlying educational quality of the home and not specific material advantages.

Girls systematically outperform boys in reading growth, while the differences in vocabulary performance are small and insignificant. The advantage in reading scores is 3-4 percent.

With the exception of one school year, the pretest scores represent achievement of the student at the end of the previous grade. In the first year of the data, however, the pretest of the sixth grade came in October of that year instead of May of the previous academic year. The dummy variable (FALL), identifying this situation, indicates that achievement grows 16-21 percent over the summer.[16]

Throughout, no matter how it was specified, the estimation indicates that the work behavior of mothers has no effect on achievement. Neither the act of working nor differential amounts of time spent in the labor

---

[16]The interpretation of these gains depends upon assumptions about the pace of learning during the school year, since the tests were given in May and in October. If one presumes that not much learning goes on during June and September, these estimates indicate noticeable learning over the summer months. If, however, growth through the year is roughly linear from September through June, one would expect June and September to contribute 15-20 percent to performance, implying no learning in the summer. There is in either case no evidence of the fall off in achievement suggested by some (see review by Heyns[1978]).

Specific year dummies for the remaining years were consistently insignificant, reinforcing the view that this is a time of testing effect and not a specific year effect.

force systematically affect childrens' achievement.[17] This is very important for assessing the potential for long run effects of increased female labor force participation: Negative effects on children's learning do not appear to be a problem. This is consistent with the general findings in other studies, which find no systematic positive or negative effect of mother's work behavior on children's development (Kamerman and Hayes[1982]; Hayes and Kamerman[1983]). While data on the kind or quality of any child care services used are unavailable, the services chosen do not systematically deter childrens' achievement.

Somewhat more surprising is the finding that the presence or absence of an adult male in the family appears to have no effect--at least when income is held constant. This appears true in both the short and the long run. There appears to be no achievement affect involved with the splitting up of a family. During the year of change (from a two adult to a one adult family or vice versa), there is no systematic impact on the scholastic performance of children. Nor is there a systematic difference between families with one and families with two parents throughout the period. This may simply reflect the fact that qualitative aspects of any family split or creation dominate. The finding does differ from other studies which tend to find a negative effect on achievement of single parent families; these previous studies, however, frequently do not adequately control for differences in income and race (see CBO[1987]).

---

[17]Models were specified in which mother's work behavior was measured as a dummy variable (work or not), as linear and logarithmic hours, and as a variety of nonlinear expressions that allowed differential effect for different numbers of hours.

Finally, changing schools doesn't systematically affect children, at least in the short run. Over the longer run, it matters considerably which teacher a student has and, therefore, changes in schools could have a large effect. This simply states that, holding constant the specific teachers and schools resources at the classroom level, the change of schools within the system has no independent effect on achievement.

Each of these findings tell a consistent story: Children are quite resilient to changes in their environment and, presumably, a variety of things such as divorce or changing schools can be compensated for so that there is no systematic effects.

B. Preschool Achievement. The preschool models can be viewed as models of "entering" school achievement and are based upon the cumulative inputs before school. Because of difficulties in measuring achievement at the very beginning of schooling, however, "entering" achievement is taken to be achievement at the end of the first grade. This does allow for differences among first grade teachers, and therefore the models employ a covariance structure similar to that in the achievement growth models.

For the preschool achievement, family inputs must be accumulated across time. This is done by reconstructing the family composition through each child's preschool years and calculating the average number of kids faced by each. (This calculation uses the specific family history on number of children and the spacing between each child). Furthermore, for preschoolers the optimization model is altered because the time constraint for dealing with children in and out of school is undoubtedly different from that in the theoretical derivation. Since mothers can, if not working, spend time during the school day with preschoolers but not with schoolers, the effective time constraint differs across children in the family. While all children can be viewed as competing for nonschool time, only nonschoolers compete for time during the school day. Therefore, some consideration must be given to the age distribution of the children[18]. In the empirical analysis, the existence and the number of younger siblings is included.

These results are shown in Table 3. Performance is measured by tests of Word Knowledge and Reading Preparedness--tests designed for younger students. The effects of family inputs on preschool achievement are very similar to those for achievement growth during the school years. Larger families depress achievement, and this effect is even stronger if there are younger siblings competing for attention. Higher permanent income leads to higher initial achievement.

The magnitudes of the estimated family effect elasticities are larger than those previously obtained in the achievement growth models. This is consistent with the longer time period for the effects to take place during preschool years as compared to individual school years.

As previously noted, work behavior of mothers or single parent families has no effect on performance (although the number of working mothers is

---

[18] Such considerations are clearly relevant in analyzing time allocations to both school and preschool children, because of the possibility of sequencing the provision of private time to match each child's available time during the day. This is tested in the empirical work, and it appears the school/preschool distinction only matters for preschoolers--i.e., that school time is a "bonus"to preschoolers and that sequencing of attention does not have a strong influence on the achievement of older children.

Table 3: Preschool Achievement Models

Variable	Word Knowledge*	Reading Preparedness*
AVER KIDS*	-.097 (-2.9)	-.055 (-1.7)
YOUNGER	.001 (1.0)	.004 (0.1)
NUMYNG*	-.071 (-1.6)	-.112 (-2.7)
PERM*	.090 (2.8)	.091 (3.0)
FEMALE	.060 (1.8)	.048 (1.5)
Intercept	-.008 (-0.0)	-.110 (-0.4)
TEACHERS	yes	yes
df	230	230
R-squared	.25	.20

*Asterisk indicates natural logarithm.

low). Further, child spacing per se has no effect on preschool achievement.[19]

IV. Family Size, Birth Order, and Child Spacing

The previous results provide considerable confirmation of the basic dynamic time allocation model. Achievement growth through the schooling period is primarily affected by the number of "competing" siblings and the quality of parental time.

In the estimated value-added models, position in the birth order (being first born or last born), sibling spacing, and age structure of the family have no effect on achievement growth after considering just the total family size. But this does not mean that these factors have no impact on the ultimate distribution of achievement in the family and in the population. Increasing child spacing implies that the average family size through the completion of schooling is smaller. Further, because each child faces a different pattern of family structure dictated by position in the birth order, all children in the family will not end up with the same achievement--even given nondiscriminatory time allocations during each period throughout schooling.

The interplay of these factors becomes apparent when expected achievement differences are calculated for families of varying sizes and child spacing. The estimated models in Table 2 and Table 3 provide the basis for calculating the advantages of being in families of differing size

---

[19]The presence and number of younger siblings will implicitly reflect position in the birth order and child spacing.

and composition. For each completed family size and a given child spacing, the number of children in the family can be determined for all children in the family at each grade level. Achievement levels at the sixth grade are then calculated by analyzing expected entering achievement and the achievement growth throughout elementary schooling. Children of differing birth orders obviously face a different time pattern of family compositions so that expected achievement will vary systematically within families. In each, comparisons are made to an only child, holding constant all other relevant attributes of families and the student.

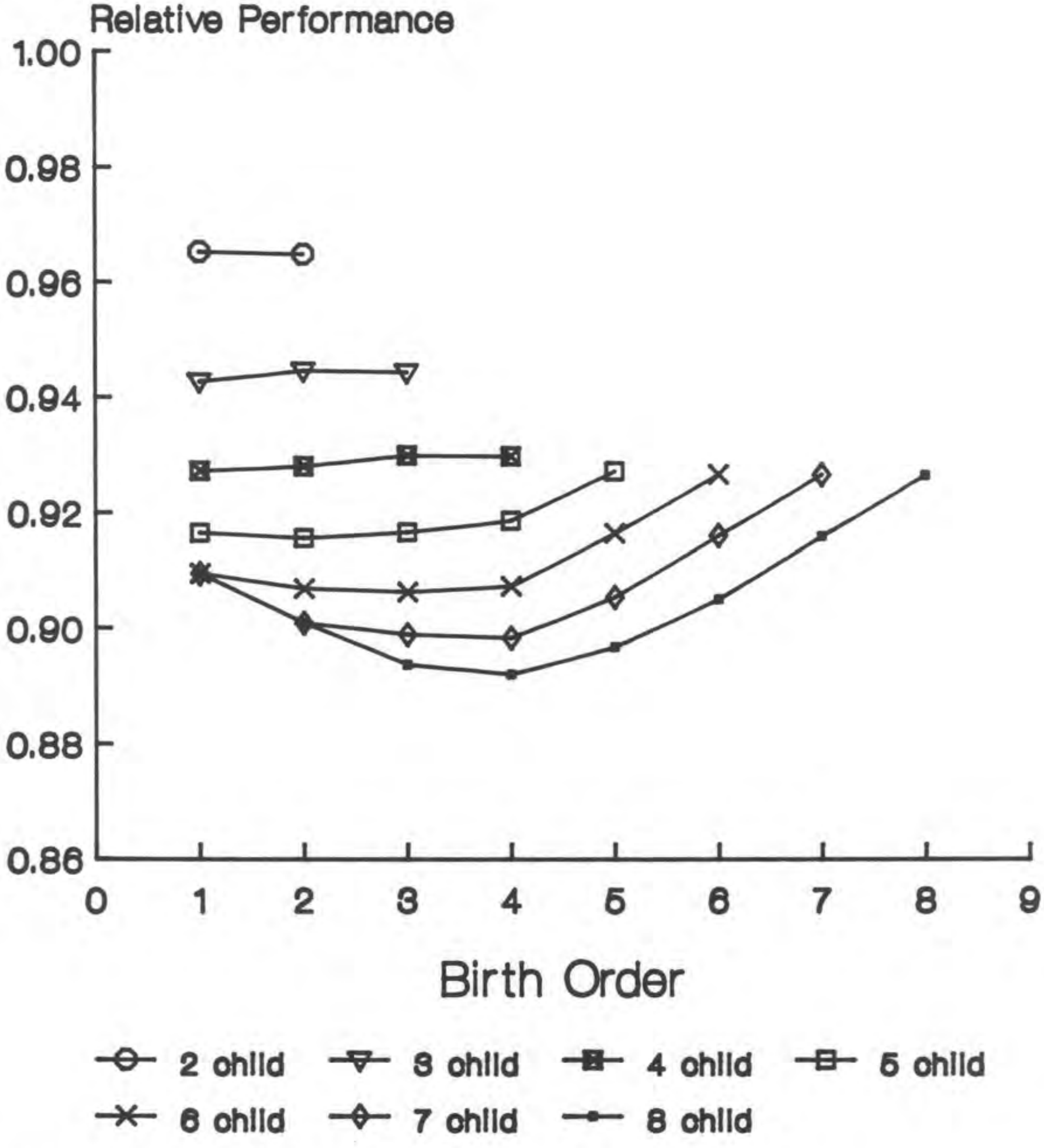
Figures 1 and 2 display the relative performance of children of differing birth order by completed family size.[20] The dominant factor is clearly total number of children, which is not particularly surprising given the form of the final estimates. Within families--particularly smaller families--position in the birth order has a very minor effect on performance. Figure 1 indicates that, compared to an only child, the children in a two-child family would each achieve about 3.5 percent less in reading scores by the end of the sixth grade. The drop with increased family size would be even more severe in vocabulary scores (Figure 2).

---

[20]These results are based upon an average spacing of 24 months. Increased child spacing acts, as one would expect, like a reduction in family size. Spacing does tend to differ both between children in a family and across families of differing sizes; the median spacing is larger for the last child in any completed family size than for earlier children, and the average spacing will be less in larger families than in smaller families. (U.S. Bureau of the Census[1984]).

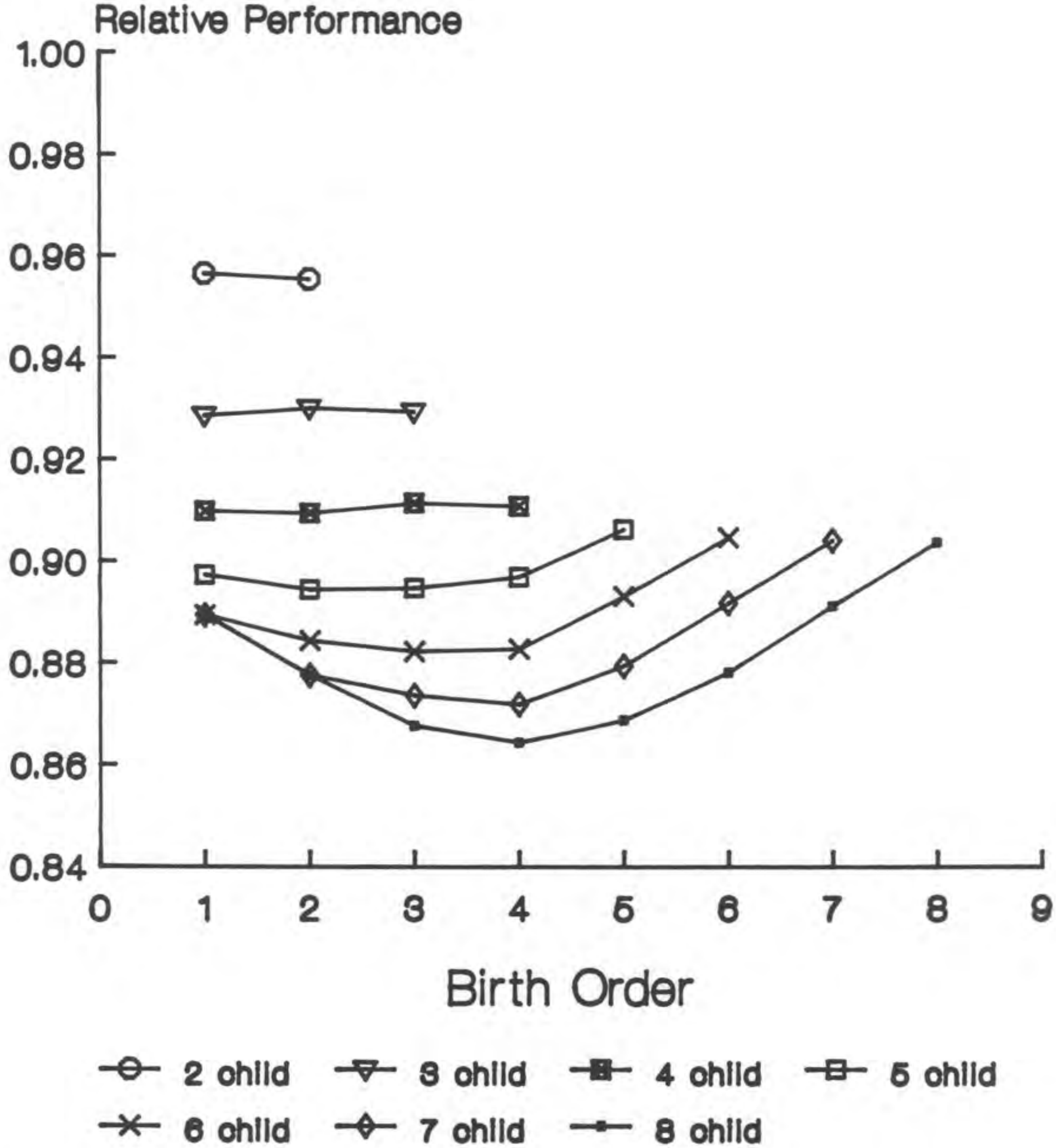
With more time between children, a first born is an "only child" for a longer period, and, at the other end, later born children face smaller families as the early born leave home. The patterns discussed here hold across child spacings of 18 to 42 months, and the quantitative differences are relatively small with different spacing.

Figure 1: Family Size Effects
6th Grade Iowa Reading Achievement
by Birth Order within Families



Comparisons with only child
24 month child spacing

Figure 2: Family Size Effects
6th Grade Iowa Vocabulary Achievement by Birth Order within Families



Comparisons with only child
24 month child spacing

In large families, it becomes better to be last born, rather than first born. The reason is simple: the first born has an advantage (a smaller family and thus more attention) early in life, but the last born has the same advantage later in life. Moreover, the last born doesn't have younger children competing for the preschool time of the mother. Indeed, as shown in the figures, the last born in families of four or more children achieve at approximately the same level, because they face approximately the same family configuration through their schooling years.[21] Similarly, the next-to-last in families of five or more achieve at similar levels, regardless of completed family size.

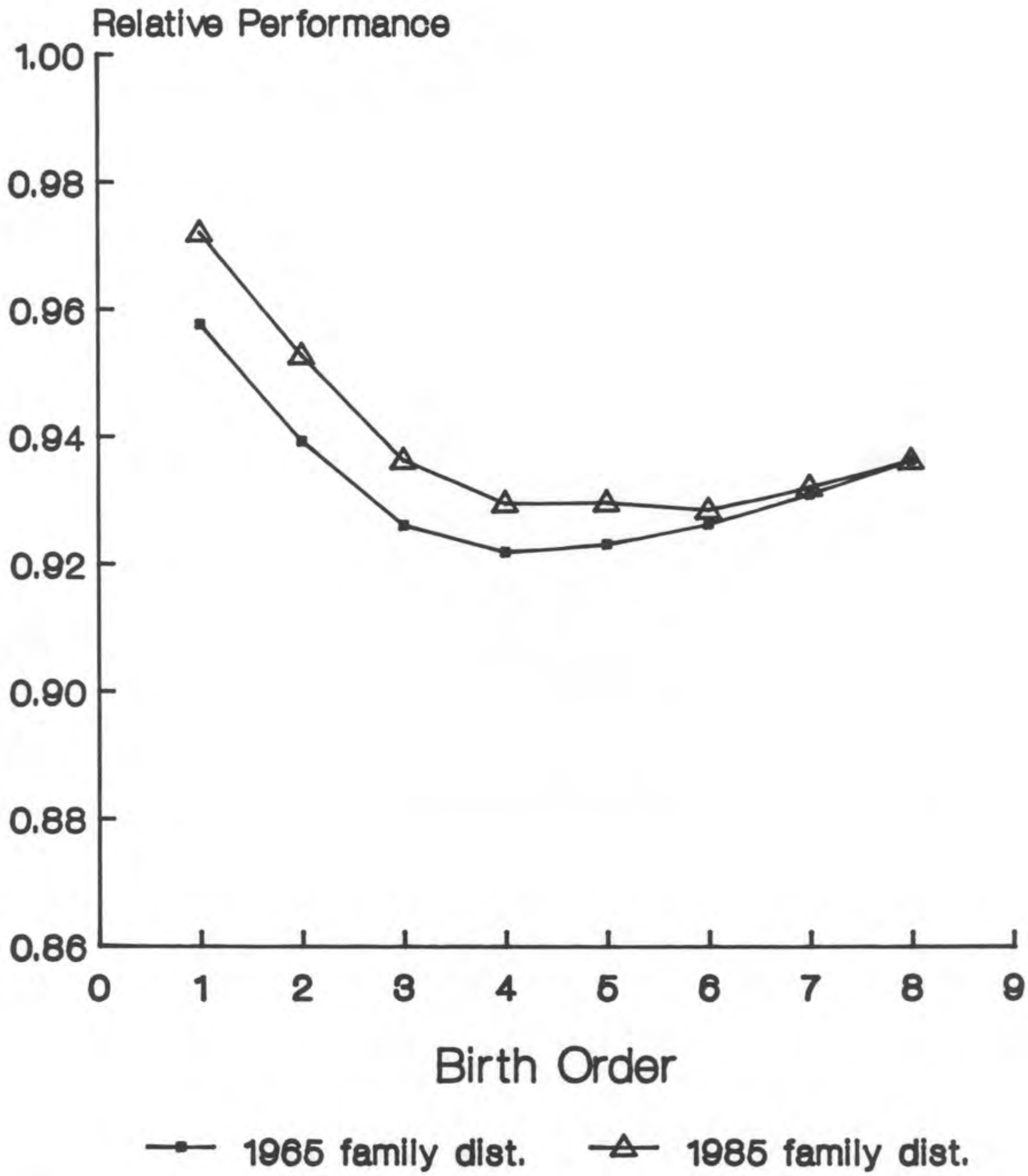
Many previous authors have advanced reasons for first-born children outperforming later born children and, in fact, have produced evidence indicating higher performance by children earlier in the birth order. These explanations have involved special attention to first born, a variety of biological explanations, parental age, and so forth. The evidence here does not support these explanations.

There is, nevertheless, a distinct advantage of being first born: The first born has a higher probability of being in a smaller family than those born later in the birth order. This advantage can be seen by merging data on the family size distribution with the performance data of Figures 1 and 2. Figures 3 and 4 display the relative achievement of children at different places in the birth order based upon the Black family

---

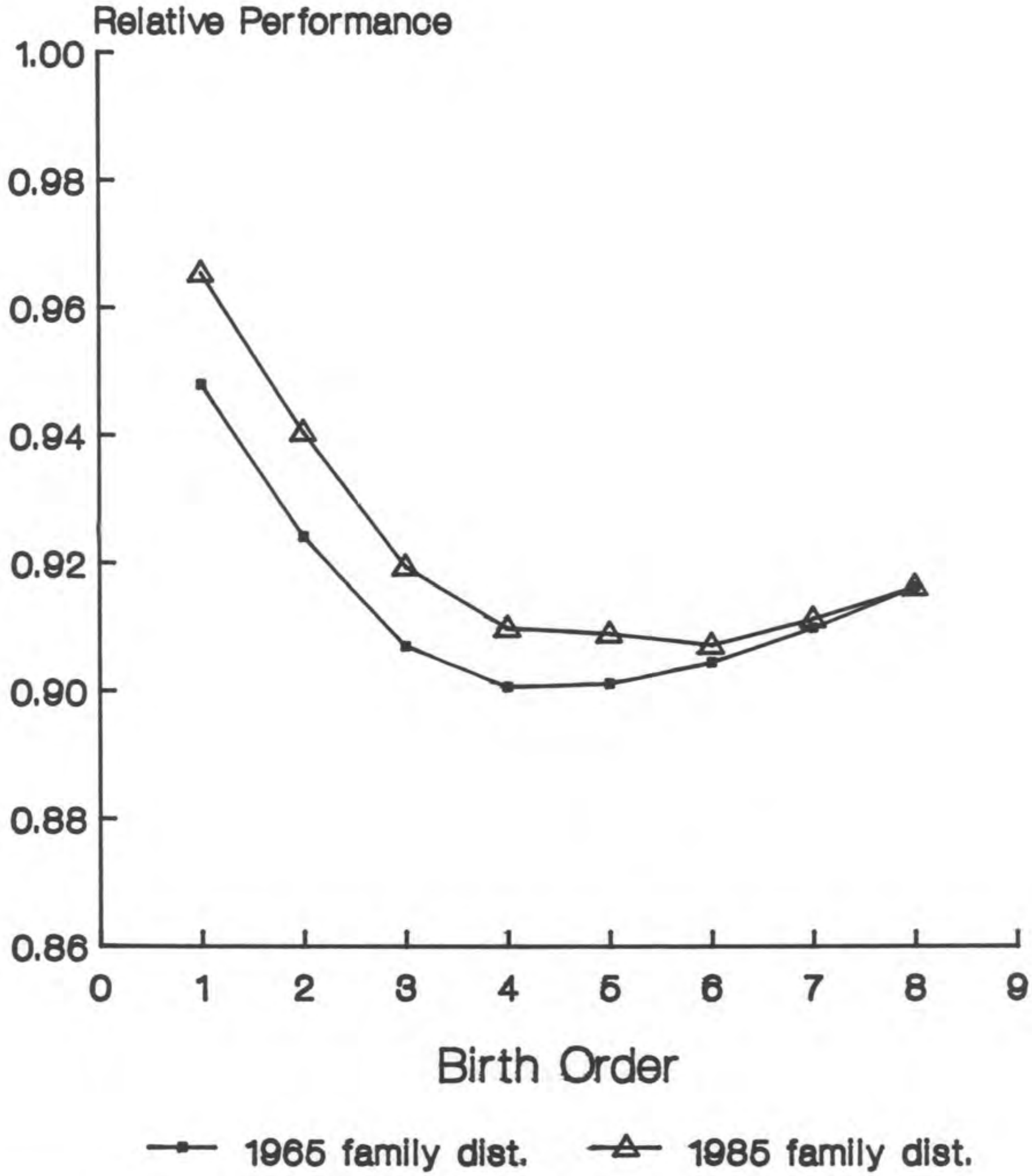
[21]The family size at which achievement levels out is clearly a function of child spacing. With larger spacing, equality of last borns comes in smaller families and vice versa.

Figure 3: Performance by Birth Order
6th Grade Iowa Reading



Comparisons with only child
30 month child spacing

Figure 4: Performance by Birth Order
6th Grade Iowa Vocabulary



Comparisons with only child
30 month child spacing

distributions in 1965 and 1985.[22] Being early in the birth order has a dramatic effect on performance--but this comes entirely from the family size effect.

Between 1965 and 1985, there was a dramatic shift toward smaller families. (The change in distribution of families is shown in Appendix Table A2). For Black families, the mean number of children for families having children fell from 2.93 to 1.99. This fall has the effect of increasing the performance throughout the birth order and of flattening the relative performance curve. The potential magnitude of these changes is indicated by the comparisons of different family size distributions found in Figures 3 and 4.

The sample used here--low income Black students from Gary, Indiana--is clearly not representative of the entire population. On the other hand, the available data are superior to those available in virtually any other schooling situation. The longitudinal collection of detailed home and school information allows much more precise estimates of family composition effects than previously possible.

These data indicate that the aggregate effects of changing family composition probably has contributed to the observed aggregate changes in test scores, although the exact magnitude of any such effects is difficult to estimate precisely. The most noted change was the fall in the Scholastic Aptitude Test (SATs) that occurred between 1965 and 1980; however, this fall was observed in many other tests, including the Iowa

---

[22] Data on family distributions come from U.S. Bureau of the Census[1966, 1986]. Proportions for 6, 7, and 8 children are estimated using an exponential extrapolation of the published data which just reports an open ended category of 6 or more children under age 18.

achievement tests, over this period (CBO[1986]). Some have suggested that this decline in academic performance was caused by the changes in family composition (e.g., Zajonc[1976], Easterlin[1978]).

To illustrate the potential effects of a changing family size distribution, we can calculate the effect of the substantial sizeable changes in family composition that occurred between the mid-1960s and the mid-1980s. (Note that these changes are virtually the mirror image of those affecting the SAT-taking population over the period, and that the results overstate the effects on any specific birth cohort.[23]) The most straightforward interpretation of the results is that they indicate the potential effects of family size change for low income, urban Blacks. However, if we assume that the estimated models provide an index of the total effect that might be observed for a national sample, we can (with considerable caution) go further to bound the potential national effects.

Table 4 displays the aggregate achievement comparisons based upon the alternative family size distributions of 1965 and 1985 by race. The steady state movement from the large families of 1965 to the smaller ones of 1985 yield, by these estimates, a 1.5 to 1.9 percent improvement in achievement for the population as a whole. Blacks have had larger families--which are

---

[23]The calculations are best thought of as indicating the magnitude of achievement change when going between two steady states. The distribution of family sizes, which reflect the number of resident children age 18 or under, in a given year includes children of 18 separate birth cohorts. When the distribution of families is changing over time, each of those birth cohorts will face a different pattern of family sizes, and the pattern existing at the time a cohort takes the SATs will not necessarily be a good indicator of the history faced by that cohort. Average family size rose through the 1950s until 1965 and subsequently fell. The cohort reaching 18 at the peak in family sizes will have experienced smaller family sizes over its schooling years than a later cohort that tends to be born into larger families and to experience these larger families throughout the school years.

detrimental to their achievement--but their improvement over time is greater. Thus, the achievement gap due to larger families has lessened noticeably.

The independent effect of family size and composition on achievement extrapolated in Table 4 from this analysis, when converted to standard deviations of test performance, range from .063 to .085 standard deviations of within sample sixth grade Iowa Reading and Vocabulary test scores.[24] (This implies that the median person in the 1965 distribution would perform at the level of the 46th to 48th percentile in the 1985 distribution.) The decline in SAT scores from peak to trough for verbal was .48 standard deviations and for math was .28 standard deviations (CBO[1986]). On the other hand, the decline in sixth grade Iowa Vocabulary tests for the nation as a whole was only .10 standard deviations while that for Reading was .17 standard deviations.[25] While the use of within sample standard deviations undoubtedly exaggerates the effects, family factors can clearly play a significant role in the aggregate test score changes. Changes in family size of the magnitude observed over the past two decades could explain half or more of the aggregate changes in sixth grade Iowa achievement tests and 15-20 percent of the SAT verbal performance if the differentials remained through all grades.

---

[24]To compare across tests, it is convenient to translate the estimated effects into standard deviations. However, the within sample standard deviations, which come from the severely truncated samples in this analysis, will undoubtedly underestimate the population standard deviations.

[25]As described in CBO[1986], virtually all tests exhibited a decline in the late 1960s and into the 1970s with the SAT changes being largest. The Vocabulary test showed the most stability of all of the IOWA tests, and the sixth grade drop was less than that at higher grades.

Table 4. Aggregate Achievement for Alternative Family Distributions (Relative to 1965 Total Population Distribution)[a]

Family Size Distribution	Reading	Vocabulary
1965 Total Population	1.000	1.000
1965 Black Population	.991	.988
1985 Total Population	1.015	1.019
1985 Black Population	1.011	1.014

Note: a. Based upon 30 month child spacing.

V. Conclusions

A distinct trade-off between quantity and quality of children is found to exist. The theoretical model, extending the basic analyses in economic demographic, considers the allocation of time to children and describes the implications of alternative within-family allocation schemes. The fundamental influence of families on the education of children is then investigated using data from the Gary Income Maintenance Experiment. These data are particularly rich, allowing for the separation of family factors from schools, innate ability differences, and other exogenous influences on performance. The sample is, however, restricted to low income Black families and students.

The empirical analysis suggests that parents act in a compensatory manner, favoring lower ability children within the family, or in a neutral manner. There is no evidence of achievement maximization by parents.

Families differ significantly in terms of the quality of inputs as measured by permanent income. There is, at the same time, no evidence that changing the immediate circumstances of the family will have any effect on student performance. The work behavior of the mother has no influence on the educational performance of children. Neither does the absence of a father. These findings, which are generally consistent with other research (CBO[1987]), are encouraging since they indicate that the massive societal changes of the past two decades will not have a noticeable negative effect on human capital formation.

While it is always better to be in a smaller family, there is no particular advantage to being first or last born when family size is held constant. However, necessarily, being first born increases the chances of being in a small family. Therefore, the average first born will outperform the average second born, and so forth through the birth order.

The dramatic changes in family size and composition of the past two decades are shown to be large enough to affect noticeably aggregate performance. In terms of the Iowa tests, the movements in family size could potentially explain over half of the observed (peak to trough) change. Extrapolating these results to potential SAT effects--a highly uncertain extrapolation--suggests that varying family size could potentially have effects on the order of 15-20 percent of the highly publicized decline of the 1970s.

BIBLIOGRAPHY

Becker, Gary S. "An Economic Approach to the Analysis of Fertility," in Demographic and Economic Change in Developed Countries. Universities-National Bureau of Economic Research Conference Series 11 (Princeton: Princeton University Press, 1960).

Becker, Gary S. and H. Gregg Lewis. "On the Interaction between the Quantity and Quality of Children," Journal of Political Economy. (March/April 1973, PT. II)

Becker, Gary S. and Nigel Tomes. "Child Endowments and the Quantity and Quality of Children," Journal of Political Economy, 84 (August 1976, Part 2), p. S143-S162.

Becker, Gary S. and Nigel Tomes. "An Equilibrium Theory of the Distribution of Income and Intergenerational Mobility," Journal of Political Economy, 87(6), (December 1979), p. 1153-1189.

Becker, Gary S. and Nigel Tomes. "Human Capital and the Rise and Fall of Families," Journal of Labor Economics, 4(3), Part II (July 1986), p. S1-S39.

Behrman, Jere R.; Paul Taubman; and Robert A. Pollak. "Parental Preferences and Provision for Progeny," Journal of Political Economy, 90(1), (February 1982, p. 52-73.

Behrman, Jere R. and Paul Taubman. "Birth Order, Schooling, and Earnings," (mimeo), October 1984.

Belmont, Lillian and Francis A. Marolla. "Birth Order, Family Size, and Intelligence," Science (December 14, 1973).

Berrueta-Clement, John R. et al. Changed Lives: The Effects of the Perry Preschool Program on Youths through Age 19. (Ypsilanti, MI: The High/Scope Press, 1984).

Breland, Hunter M. "Birth Order, Family Configuration, and Verbal Achievement," Child Development, 45,(December 1974).

Coleman,James S. and others. Equality of Educational Opportunity. Washington: U.S. Government Printing Office, 1966.

Congressional Budget Office. Trends in Educational Achievement: (Washington, DC: Congressional Budget Office, 1986)

Congressional Budget Office. Educational Achievement: Explanations and Implications of Recent Trends (Washington, DC: Congressional Budget Office, 1987)

Cronbach, Lee J. and Lita Furby. "How Should We Measure 'Change'--or Should We?" Psychology Bulletin (1970).

Darlington, Richard B. et al. "Preschool Programs and Later School. Competence of Children from Low-Income Families," Science, 208, April 11, 1980, p. 202-204.

Easterlin, Richard A. "What Will 1984 Be Like? Socioeconomic Implications of Recent Twists in Age Structure," Demography, (November 1978).

Hanushek, Eric A. "Conceptual and Empirical Issues in the Estimation of Educational Production Functions," Journal of Human Resources, 14(3), (Summer 1979), p. 351-388.

Hanushek, Eric A. "Throwing Money at Schools," Journal of Policy Analysis and Management, 1(1), (Fall 1981), p. 19-41.

Hanushek, Eric A. "The Economics of Schooling: Production and Efficiency in Public Schools," Journal of Economic Literature, 24 (September 1986), p. 1141-117.

Hayes, Cheryl D. and Sheila B. Kamerman (ed.). Children of Working Parents: Experiences and Outcomes (Washington, DC: National Academy Press, 1983).

Hayes, Donald P. and Judith Grether. "The School Year and Vacations: When Do Students Learn?" Washington: Urban Institute, 1969.

Heyns, Barbara. Summer Learning and the Effects of Schooling (New York: Academic Press, 1978).

Hill, C. Russell and Frank Stafford. "Allocation of Time to Preschool Children and Educational Opportunity," Journal of Human Resources 9 (Summer 1974): 323-41.

Hill, C. Russell and Frank Stafford. "Parental Care of Children: Time Diary Estimates of Quantity, Predictability, and Variety," Journal of Human Resources, 15(2), (Spring 1980), p. 219-239.

Kamerman, Sheila B. and Cheryl D. Hayes (ed.). Families That Work: Children in a Changing World (Washington, DC: National Academy Press, 1982).

Leibowitz, Arleen. "Home Investments in Children," Journal of Political Economy 82 (March/April 1974, Pt. II).

Lindert, Peter. "Sibling Position and Achievement," Journal of Human Resources, (Spring 1977)

Murnane, Richard J.; Rebecca A. Maynard; and James C. Ohls, "Home Resources and Children's Achievement," Review of Economics and Statistics 58 (August 1981), p. 369-377.

Olnick, Michael R. and David B. Bills, "Family Configuration and Achievement: Effects of Birth Order and Family Size in a Sample of Brothers," Social Psychology Quarterly 42 (June 1979), p. 135-148.

Ragosa, David R. and John B. Willett. "Understanding Correlates of Change by Modeling Individual Differences in Growth," Psychometrika, 50(2), (June 1985), p. 203-228.

Stafford, Frank P. "Women's Work, Sibling Competition, and Children's School Performance," (Mimeo), University of Michigan, April 1987.

U.S. Bureau of the Census. "Household and Family Characteristics: March 1965", Current Population Reports, P-20, No. 153, August 1966.

U.S. Bureau of the Census. "Child Spacing Among Birth Cohorts of American Women: 1905-1959", Current Population Reports, P-20, No. 385, February 1984.

U.S. Bureau of the Census. "Household and Family Characteristics: March 1985", Current Population Reports, P-20, No. 411, September 1986.

Willis, Robert J. "A New Approach to the Economic Theory of Fertility Behavior," Journal of Political Economy, (March/April 1973, Pt. II).

Zajonc, R.B. "Family Configuration and Intelligence," Science (April 16, 1976).

Zajonc, R.B. and Gregory B. Markus, "Birth Order and Intellectual Development," Psychological Review 82 (January 1975), p. 74-88.

TABLE A1. MEANS AND STANDARD DEVIATIONS (IN PARENTHESES)
by Grade Level

VARIABLE	1	2	3	4	5	6
READING-POST	1.92 (.6)	2.51 (.7)	3.31 (1.0)	3.99 (1.1)	4.43 (1.2)	5.11 (1.2)
READING-PRE	- -	1.98 (.6)	2.54 (.7)	3.26 (1.0)	3.86 (1.1)	4.71 (1.3)
VOCAB-POST	2.04 (.6)	2.97 (1.1)	3.43 (1.0)	4.17 (1.2)	4.65 (1.5)	5.45 (1.6)
VOCAB-PRE	- -	2.13 (.7)	2.93 (1.0)	3.39 (.9)	3.96 (1.2)	4.76 (1.5)
Number kids in family (KIDS)	4.29 (2.3)	4.41 (2.3)	4.47 (2.1)	4.47 (2.1)	4.46 (2.1)	4.61 (2.2)
Mother educ. (years)	10.61 (1.6)	10.55 (1.7)	10.62 (1.7)	10.57 (1.7)	10.40 (1.7)	10.18 (1.8)
Permanent Income (PERM)	\$5877 (2674)	\$6135 (2777)	\$6628 (3107)	\$6492 (3059)	\$6499 (3041)	\$6619 (3013)
Hours worked (all mothers)	3.87 (10.4)	4.07 (10.7)	5.22 (12.4)	3.87 (10.8)	4.62 (11.6)	5.69 (12.9)
Hours worked (w/job)	24.01 (13.7)	26.04 (12.6)	28.72 (13.3)	27.73 (13.5)	28.09 (12.9)	30.11 (12.0)
Age	7.24 (.4)	8.32 (.5)	9.39 (.5)	10.46 (.5)	11.53 (.6)	12.59 (.6)
Working Mother	.16	.16	.18	.14	.16	.19
Male present	.34	.34	.42	.39	.39	.40
Change male	.08	.08	.12	.06	.06	.04
Change school	.05	.06	.05	.04	.04	.05

Table A1 (cont.)

VARIABLE	1	2	3	4	5	6
School year						
1972	–	–	–	–	–	.27
1973	.59	–	.36	.37	.35	.19
1974	.34	.75	.39	.36	.39	.31
1975	.07	.25	.25	.26	.26	.24
Reliability Coefficients[a]						
Reading Comprehension	.92	.92	.93	.93	.93	.91
Vocabulary	.87	.88	.88	.89	.89	.90
No. observ.	210	192	391	415	441	473
No. teachers	95	107	114	113	101	84
$\geq$ 5 students	10	12	22	26	32	31
$\geq$ 3 students	28	25	41	46	44	47

Note: a. Iowa Tests of Basic Skills, Manual for Administrators (Grades 3-6), 1964.

Table A2. Distribution of Families by Number of Resident Children Age 18 and Under: by Race and Year

A. BLACK FAMILIES (proportions)

	Year				
No. Children	1965	1970	1975	1980	1985
1	0.280	0.291	0.347	0.379	0.406
2	0.231	0.243	0.269	0.325	0.342
3	0.165	0.165	0.168	0.164	0.157
4	0.121	0.131	0.104	0.080	0.057
5	0.079	0.077	0.056	0.031	0.025
6	0.055	0.042	0.028	0.012	0.007
7	0.040	0.030	0.017	0.006	0.004
8	0.029	0.022	0.011	0.003	0.002

A. ALL FAMILIES (proportions)

	Year				
No. Children	1965	1970	1975	1980	1985
1	0.313	0.326	0.365	0.401	0.421
2	0.297	0.310	0.334	0.370	0.374
3	0.195	0.189	0.173	0.151	0.144
4	0.101	0.096	0.077	0.053	0.043
5	0.051	0.042	0.030	0.017	0.012
6	0.022	0.019	0.012	0.005	0.003
7	0.014	0.011	0.006	0.002	0.001
8	0.009	0.006	0.003	0.001	0.001
9	0.000	0.000	0.000	0.000	0.000

Source: U.S. Bureau of Census[1966, 1986] with extrapolation above six children.

Rochester Center for Economic Research
University of Rochester
Department of Economics
Rochester, NY 14627

1986-87 DISCUSSION PAPERS

WP#33 OIL PRICE SHOCKS AND THE DISPERSION HYPOTHESIS, 1900 - 1980
by Prakash Loungani, January 1986

WP#34 RISK SHARING, INDIVISIBLE LABOR AND AGGREGATE FLUCTUATIONS
by Richard Rogerson, (Revised) February 1986

WP#35 PRICE CONTRACTS, OUTPUT, AND MONETARY DISTURBANCES
by Alan C. Stockman, October 1985

WP#36 FISCAL POLICIES AND INTERNATIONAL FINANCIAL MARKETS
by Alan C. Stockman, March 1986

WP#37 LARGE-SCALE TAX REFORM: THE EXAMPLE OF EMPLOYER-PAID HEALTH INSURANCE PREMIUMS
by Charles E. Phelps, March 1986

WP#38 INVESTMENT, CAPACITY UTILIZATION AND THE REAL BUSINESS CYCLE
by Jeremy Greenwood and Zvi Hercowitz, April 1986

WP#39 THE ECONOMICS OF SCHOOLING: PRODUCTION AND EFFICIENCY IN PUBLIC SCHOOLS
by Eric A. Hanushek, April 1986

WP#40 EMPLOYMENT RELATIONS IN DUAL LABOR MARKETS (IT'S NICE WORK IF YOU CAN GET IT!)
by Walter Y. Oi, April 1986

WP#41 SECTORAL DISTURBANCES, GOVERNMENT POLICIES, AND INDUSTRIAL OUTPUT IN SEVEN EUROPEAN COUNTRIES
by Alan C. Stockman, April 1986

WP#42 SMOOOTH VALUATIONS FUNCTIONS AND DETERMINANCY WITH INFINITELY LIVED CONSUMERS
by Timothy J. Kehoe, David K. Levine and Paul R. Romer, April 1986

WP#43 AN OPERATIONAL THEORY OF MONOPOLY UNION-COMPETITIVE FIRM INTERACTION
by Glenn M. MacDonald and Chris Robinson, June 1986

WP#44 JOB MOBILITY AND THE INFORMATION CONTENT OF EQUILIBRIUM WAGES: PART 1, by Glenn M. MacDonald, June 1986

WP#45 SKI-LIFT PRICING, WITH APPLICATIONS TO LABOR AND OTHER MARKETS
by Robert J. Barro and Paul M. Romer, May 1986, revised April 1987

WP#46 FORMULA BUDGETING: THE ECONOMICS AND ANALYTICS OF FISCAL POLICY UNDER RULES, by Eric A. Hanushek, June 1986

WP#48 EXCHANGE RATE POLICY, WAGE FORMATION, AND CREDIBILITY by Henrik Horn and Torsten Persson, June 1986

WP#49 MONEY AND BUSINESS CYCLES: COMMENTS ON BERNANKE AND RELATED LITERATURE, by Robert G. King, July 1986

WP#50 NOMINAL SURPRISES, REAL FACTORS AND PROPAGATION MECHANISMS by Robert G. King and Charles I. Plosser, Final Draft: July 1986

WP#51 JOB MOBILITY IN MARKET EQUILIBRIUM by Glenn M. MacDonald, August 1986

WP#52 SECRECY, SPECULATION AND POLICY by Robert G. King, (revised) August 1986

WP#53 THE TULIPMANIA LEGEND by Peter M. Garber, July 1986

WP#54 THE WELFARE THEOREMS AND ECONOMIES WITH LAND AND A FINITE NUMBER OF TRADERS, by Marcus Berliant and Karl Dunz, July 1986

WP#55 NONLABOR SUPPLY RESPONSES TO THE INCOME MAINTENANCE EXPERIMENTS by Eric A. Hanushek, August 1986

WP#56 INDIVISIBLE LABOR, EXPERIENCE AND INTERTEMPORAL ALLOCATIONS by Vittorio U. Grilli and Richard Rogerson, September 1986

WP#57 TIME CONSISTENCY OF FISCAL AND MONETARY POLICY by Mats Persson, Torsten Persson and Lars E. O. Svensson, September 1986

WP#58 ON THE NATURE OF UNEMPLOYMENT IN ECONOMIES WITH EFFICIENT RISK SHARING, by Richard Rogerson and Randall Wright, September 1986

WP#59 INFORMATION PRODUCTION, EVALUATION RISK, AND OPTIMAL CONTRACTS by Monica Hargraves and Paul M. Romer, September 1986

WP#60 RECURSIVE UTILITY AND THE RAMSEY PROBLEM by John H. Boyd III, October 1986

WP#61 WHO LEAVES WHOM IN DURABLE TRADING MATCHES by Kenneth J. McLaughlin, October 1986

WP#62 SYMMETRIES, EQUILIBRIA AND THE VALUE FUNCTION by John H. Boyd III, December 1986

WP#63 A NOTE ON INCOME TAXATION AND THE CORE by Marcus Berliant, December 1986

WP#64 INCREASING RETURNS, SPECIALIZATION, AND EXTERNAL ECONOMIES: GROWTH AS DESCRIBED BY ALLYN YOUNG, By Paul M. Romer, December 1986

WP#65 THE QUIT-LAYOFF DISTINCTION: EMPIRICAL REGULARITIES by Kenneth J. McLaughlin, December 1986

WP#66 FURTHER EVIDENCE ON THE RELATION BETWEEN FISCAL POLICY AND THE TERM STRUCTURE, by Charles I. Plosser, December 1986

WP#67 INVENTORIES AND THE VOLATILITY OF PRODUCTION by James A. Kahn, December 1986

WP#68 RECURSIVE UTILITY AND OPTIMAL CAPITAL ACCUMULATION, I: EXISTENCE, by Robert A. Becker, John H. Boyd III, and Bom Yong Sung, January 1987

WP#69 MONEY AND MARKET INCOMPLETENESS IN OVERLAPPING-GENERATIONS MODELS, by Marianne Baxter, January 1987

WP#70 GROWTH BASED ON INCREASING RETURNS DUE TO SPECIALIZATION by Paul M. Romer, January 1987

WP#71 WHY A STUBBORN CONSERVATIVE WOULD RUN A DEFICIT: POLICY WITH TIME-INCONSISTENT PREFERENCES by Torsten Persson and Lars E.O. Svensson, January 1987

WP#72 ON THE CONTINUUM APPROACH OF SPATIAL AND SOME LOCAL PUBLIC GOODS OR PRODUCT DIFFERENTIATION MODELS by Marcus Berliant and Thijs ten Raa, January 1987

WP#73 THE QUIT-LAYOFF DISTINCTION: GROWTH EFFECTS by Kenneth J. McLaughlin, February 1987

WP#74 SOCIAL SECURITY, LIQUIDITY, AND EARLY RETIREMENT by James A. Kahn, March 1987

WP#75 THE PRODUCT CYCLE HYPOTHESIS AND THE HECKSCHER-OHLIN-SAMUELSON THEORY OF INTERNATIONAL TRADE by Sugata Marjit, April 1987

WP#76 NOTIONS OF EQUAL OPPORTUNITIES by William Thomson, April 1987

WP#77 BARGAINING PROBLEMS WITH UNCERTAIN DISAGREEMENT POINTS by Youngsub Chun and William Thomson, April 1987

WP#78 THE ECONOMICS OF RISING STARS by Glenn M. MacDonald, April 1987

WP#79 STOCHASTIC TRENDS AND ECONOMIC FLUCTUATIONS by Robert King, Charles Plosser, James Stock, and Mark Watson, April 1987

WP#80 INTEREST RATE SMOOTHING AND PRICE LEVEL TREND-STATIONARITY
by Marvin Goodfriend, April 1987

WP#81 THE EQUILIBRIUM APPROACH TO EXCHANGE RATES
by Alan C. Stockman, revised, April 1987

WP#82 INTEREST-RATE SMOOTHING
by Robert J. Barro, May 1987

WP#83 CYCLICAL PRICING OF DURABLE LUXURIES
by Mark Bils, May 1987

WP#84 EQUILIBRIUM IN COOPERATIVE GAMES OF POLICY FORMULATION
by Thomas F. Cooley and Bruce D. Smith, May 1987

WP#85 RENT SHARING AND TURNOVER IN A MODEL WITH EFFICIENCY UNITS OF HUMAN CAPITAL
by Kenneth J. McLaughlin, revised, May 1987

WP#86 THE CYCLICALITY OF LABOR TURNOVER: A JOINT WEALTH MAXIMIZING HYPOTHESIS
by Kenneth J. McLaughlin, revised, May 1987

WP#87 CAN EVERYONE BENEFIT FROM GROWTH? THREE DIFFICULTIES
by Herve' Moulin and William Thomson, May 1987

WP#88 TRADE IN RISKY ASSETS
by Lars E.O. Svensson, May 1987

WP#89 RATIONAL EXPECTATIONS MODELS WITH CENSORED VARIABLES
by Marianne Baxter, June 1987

WP#90 EMPIRICAL EXAMINATIONS OF THE INFORMATION SETS OF ECONOMIC AGENTS
by Nils Gottfries and Torsten Persson, June 1987

WP#91 DO WAGES VARY IN CITIES? AN EMPIRICAL STUDY OF URBAN LABOR MARKETS
by Eric A. Hanushek, June 1987

WP#92 ASPECTS OF TOURNAMENT MODELS: A SURVEY
by Kenneth J. McLaughlin, July 1987

WP#93 ON MODELLING THE NATURAL RATE OF UNEMPLOYMENT WITH INDIVISIBLE LABOR
by Jeremy Greenwood and Gregory W. Huffman

WP#94 TWENTY YEARS AFTER: ECONOMETRICS, 1966-1986
by Adrian Pagan, August 1987

WP#95 ON WELFARE THEORY AND URBAN ECONOMICS
by Marcus Berliant, Yorgos Y. Papageorgiou and Ping Wang, August 1987

WP#96 ENDOGENOUS FINANCIAL STRUCTURE IN AN ECONOMY WITH PRIVATE INFORMATION
by James Kahn, August 1987

WP#97 THE TRADE-OFF BETWEEN CHILD QUANTITY AND QUALITY: SOME EMPIRICAL EVIDENCE
by Eric Hanushek, September 1987

WP#98 SUPPLY AND EQUILIBRIUM IN AN ECONOMY WITH LAND AND PRODUCTION
by Marcus Berliant and Hou-Wen Jeng, September 1987

WP#99 AXIOMS CONCERNING UNCERTAIN DISAGREEMENT POINTS FOR 2-PERSON BARGAINING PROBLEMS
by Youngsub Chun, September 1987

To order copies of the above papers complete the attached invoice and return to Christine Massaro, W. Allen Wallis Institute of Political Economy, RCER, 109B Harkness Hall, University of Rochester, Rochester, NY 14627. Three (3) papers per year will be provided free of charge as requested below. Each additional paper will require a $5.00 service fee which must be enclosed with your order. For your convenience an invoice is provided below in order that you may request payment from your institution as necessary. Please make your check payable to the **Rochester Center for Economic Research**. **Checks must be drawn from a U.S. bank and in U.S. dollars**.

W. Allen Wallis Institute for Political Economy

Rochester Center for Economic Research, Working Paper Series

OFFICIAL INVOICE

Requestor's Name ______________________________

Requestor's Address ______________________________

____

____

____

Please send me the following papers free of charge **(Limit: 3 free per year)**.

WP# ______ WP# ______ WP# ______

I understand there is a $5.00 fee for each additional paper. Enclosed is my check or money order in the amount of $__________. Please send me the following papers.

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______