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Factors That Explain Changes in the Level of Human Capital of Children with Disabilities

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FACTORS THAT EXPLAIN CHANGES IN THE LEVEL OF HUMAN CAPITAL OF CHILDREN WITH DISABILITIES

by

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ABSTRACT

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by

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This dissertation combines concepts from the human capital and early intervention literature to develop a theoretical and empirical model of child development relationships. This model is empirically estimated using data from the Early Intervention Research Institute's Longitudinal Study on the effects of intervention for young children with disabilities. The model is estimated using Ordinary Least Squares (OLS) relating the Battelle Developmental Inventory (BDI) scores to child, family, and early intervention variables. These relationships are also examined using a type of Sequential Method of Moments (SMM) estimation strategy that accounts for data and other problems such as endogeneity, censoring, and selectivity. The OLS and SMM estimates are compared to evaluate the influence of variables such as age, birth order, ethnicity, gender, education of the mother, income, number of siblings, and hours of early intervention service, among other forces, on the development of infant and preschool children with moderate to severe disabilities.

(116 pages)

CHAPTER I

INTRODUCTION

Human capital development is characterized by a complex set of relationships. The difficulty in achieving an understanding of the factors that influence human development cannot be overstated. Many child, family, and school variables have been included in models of human achievement. This dissertation combines ideas from the human capital model of development with an early intervention framework to build a theoretical foundation that is sensitive to both the economic underpinnings of observed change and to the factors unique to the development of young children with disabilities. Human capital and early intervention models and literature are brought together to form a model that is empirically estimated using data from the Early Intervention Effectiveness Institute's Longitudinal Studies. This model provides empirical information on the influence of intervention, family, and child characteristics on child development. The specific objective of the study is to examine the influence of a variety of family, child, and intervention variables on child development of young children with disabilities.

Child development in this study is measured using Battelle Developmental Inventory (BDI) Scores (Newborg, Stock, Wnek, Guidubaldi, & Svinicki, 1984), which measure adaptive, motor, personal social, cognitive, and communication abilities of young children. Child characteristics include Pretest BDI scores, gender, ethnicity, birth order, and chronological age of the subject. A number of variables in the family characteristics category are examined, including number of siblings of the subject, whether or not the child is living with both parents, household income, education of the mother, total number of hours the mother is employed outside the home each week, and the Family Support Scale Total Score (Dunst, Jenkins, & Trivette, 1984). Early intervention is measured by both a variable that represents amount or quantity of intervention and by intervention program variables that are assumed to partially measure the quality of intervention. Total number of hours the child attended early intervention from initiation of intervention (pretest) to the first assessment after intervention began (posttest) is used as the measure of amount of development intervention. Quality is differentiated by whether the child (the unit of observation) was observed to be in a program where professionals administered the intervention or whether such intervention was carried out by paraprofessionals. Additional quality differentiation was made with respect to whether these services were carried out in a home-based program where a 1:1 child:staff ratio existed or whether services were rendered in a center-based program.

CHAPTER II

LITERATURE REVIEW

Human capital theory suggests that the accumulation of human ability depends on the quality and quantity of inputs that enter into the development process; both time and market inputs influence this process. In the present analysis, the effect of those inputs on the human capital development of young children with disabilities is examined. The primary inputs theorized as affecting child development are innate abilities, family background, peer influences, and school inputs (Hanushek, 1978). This theory allows examination of the extent to which inputs, such as schooling, affect the human capital development of children with disabilities. Family, peer, and child inputs may operate individually or interactively with the intervention to alter developmental functioning.

The most frequent method used in economics to examine the relationships between human capital development and explanatory factors that affect development is the educational production function. Hanushek summarized results of efforts to develop and estimate 147 different educational production functions for assessing the impact of various factors on human development (Hanushek, 1978). The economic literature, however, has not addressed the factors that affect development for children with disabilities. In human capital and educational production function estimates of achievement, the disabled have been removed from empirical applications of development models.

Educational production function was developed in the literature to examine the allocation of resources, such as school and student inputs, as they affect measures of school output or productive capacity (Bowles, 1970; Hanushek, 1978). Measures of productive capacity used are school achievement or labor force productivity. The emphasis of this dissertation is on student achievement as measured by test scores. Consequently, the literature review focuses on explanations of differences in school rather than in labor force achievement.

One of the early estimates using the educational production function was conducted by the Coleman Commission (Coleman et al., 1966), which investigated the distribution of educational resources in the United States. This study, similar to many undertaken later, collected information on the relationship between developmental outcomes produced in school and the allocation of school resources. The survey of 3,100 schools and 645,000 pupils from the 1st, 3rd, 6th, 9th, and 12th grades was funded to determine the extent of racial and ethnic inequality as well as the impact of inequality on achievement. The controversial conclusion of the Coleman report was that school resources did not significantly impact cognitive achievement. This result was based on a multiple regression analysis of the effects of home background variables, school resources, and child attitudes on the dependent variable (cognitive achievement).

The Coleman estimates suggested that background variables were statistically significant but that school resources were not. The policy implications were that cognitive achievement would not be changed by directing more school resources into resource-poor schools. However, critics of the Coleman report (Bowles & Levin, 1968a) argued that there were a number of problems with the data analyzed in that report. They further argued that there were problems with the method of analysis relative to the impact of school versus family background on achievement. According to Bowles and Levin, the importance of school resources was understated because of multicollinearity between family background and school inputs. The addition to variance from either variable will depend on the order of entry of those variables into the regression analysis. A few months later, Bowles and Levin (1968b) presented results from estimations of the data, with some of the variables in the Coleman report model removed. Results of their analysis of the data suggested that school inputs, such as teacher quality and verbal ability, were related to student achievement.

A succinct overview of the educational production function literature was provided in Murnane (1975). He first reviews Coleman by describing the data, results, and shortcomings of the research. Specifically, no microdata were used to relay information about individual school experiences. Because aggregate data were used, variance within school was impossible to analyze. Hanushek (1986) found that quality of school is reflected in differences in teacher skills and is not necessarily reflected in school expenditures.

The current research examines family, child, and early intervention inputs within a human capital framework. Inputs that affect child development are examined to determine the efficacy of recent policy developments, such as P.L. 99-457. Passed in 1985, this federal law mandates preschool services for children with disabilities and their families. Past research on inputs that affect student achievement, such as the Coleman report and work reviewed by Hanushek, have resulted in mixed signals to policymakers about the optimum allocation of public resources to education. This dissertation will seek answers to some of these complex issues for a young disabled population which has received various types and quantities of early intervention services.

Conceptual Framework of Child Development Relationships

The model of child development that will be estimated combines early intervention, family, and child characteristics and uses the BDI as the measure of outcome. The BDI is a norm-referenced measure of child developmental functioning appropriate for children with or without disabilities whose developmental age ranges from 0 to 96 months. Following the models of Becker (1981) and others, the basic relationship investigated in the study is given by

BDI = f(**intervention, child and family characteristics**),

where f(.) is functional relationship notation. The intervention influence is represented by attendance at intervention sessions (**Attendance**), whether the intervention was center- or home-based (**Base**) and whether paraprofessionals or professionals provided the intervention (**Para**). Child characteristics are represented by the measure of severity of disability, the pre-intervention BDI score, the chronological age of the child (**Age**), birth order (**Birth Order**), ethnicity (**Ethnicity**), and gender (**Gender**) of the child who participated in the intervention. Family factors are measured by the number of siblings (**Siblings**), annual household income (**Income**), the mother's education level (**Mother's Education**), the hours of market work of the mother (**Mother's Work**), whether or not the child is living with both parents (**Intact**), and the Family Support Scale (**FSS**) (Dunst et al., 1984).

The nonlinearity of the model is indicated from previous estimates of schooling relationships (Heckman & Palachek, 1974). Mincer (1972) and Becker and Chiswick (1966) argue that the human capital model is best estimated using a logarithmic regression equation. For this reason the model is examined with and without the polynomials of attendance as explanatory variables. The inclusion of attendance, and its square and cube, in the model allows examination of how different quantities of intervention impact children with disabilities. The effects of the interaction of attendance with other intervention characteristics (**base** and **para**) are also examined. The latter provide an empirical mechanism to indicate the impacts of professional and home-based programs on child outcomes as the hours of intervention change.

Past research examined the relationship between earnings as the dependent measure and schooling as an explanatory variable. Heckman and Palachek (1974) found evidence that the Mincer schooling and experience model is preferred and that a linear and quadratic experience term was preferred to the natural logarithm of experience depending on the data set. When they examined hourly wage rates and omitted the number of weeks worked as a regressor, they found no statistically significant difference between the linear and quadratic modelings of experience.

Family Characteristics

Higher quality and quantity time inputs by parents into child development are associated with higher levels of parent education (Leibowitz, 1974a) and that more educated mothers provide better learning opportunities that aid child development (Ramey, Sparling, & Wasik, 1981). Ramey et al. (1981) suggested that children who have mothers with relatively high education levels have higher test scores because educated mothers are more competent, particularly in using more efficient speech. Blau and Grossberg (1990) recently provided some evidence that maternal verbal ability related positively to child cognitive achievement, although children with disabilities were excluded from the study.

The literature on the effects of siblings on child development, which is quite extensive, suggests that there are direct effects, through direct interaction between the siblings, and indirect effects, through the effect that siblings have on relationships with members of the family. It has been suggested that a sibling without a disability aids the socialization of the child who is disabled, serving as a positive peer model (Stoneman & Brody, 1982). However, most of the research on siblings of persons with disabilities has focused on effects that the child with a disability has on the sibling without a disability (Boyce & Barnett, 1991).

Human capital literature implies a negative quantity of time effect of siblings on child development as they compete for the time and other resources of the family. The effects of nondisabled siblings on disabled siblings may be analogous to the existence of a more educated mother. Given the intensity of the relationship between family members, a nondisabled sibling may have a positive effect on the ability of the sibling with a disability.

The human capital model views the family as a decision-making unit that responds rationally to economic considerations (Becker, 1975;

Schultz, 1973). The model has been used to help explain family decisions regarding home and market production, as well as other issues related to home and market production. Developing estimates of the woman's value of time has helped explain investments in children because the main cost of raising children in the early years is the woman's time. This investment grows larger with income. Due to lower developmental functioning, children are particularly time intensive in the early years because they are more dependent on their parents. Children with disabilities may be considered particularly time intensive because they develop slowly. Many never develop the independence that nondisabled children achieve. Schultz argued that disentangling the housewife's value of time is difficult because it affects so many aspects of the family's life (e.g., choice of mate, preference for children, labor force participation issues such as earnings, and household productivity).

This dissertation examines mothers' labor force participation to determine the relationship between hours worked by the mother and the child's developmental functioning. One of the difficulties in interpreting variables like "education of the mother" is its correlation with income and other socioeconomic traits of families. Desai, Chase-Lansdale, and Michael (1989) examined the differential impact of mother's work by looking at time versus income effects of labor force participation. This research suggested that the effects of labor force participation on children depend on family income level. For high-income families, the effects of mothers' employment were negative, while for low-income families, this variable showed positive effects on child development. The income effect outweighed the time effect for low income families while the reverse was true for higher income families.

Gronau (1973) estimated the shadow price of children using 1960 census data. The effect of both the husband's and wife's age, education, and income, along with the number and ages of children on the shadow price of time in rearing, were estimated. Results showed that the greatest impact on the value of a woman's time was her educational level and that a husband's characteristics had a much smaller impact on the shadow price of children. The effect of children varied by their age and the mother's education level. The presence of young children and higher mother's education levels increased the value of the woman's time. The income elasticity of the price of time was low but positive.

In a time diary analysis, Hill and Stafford (1980) found that mothers with some college spent about 25% more time in child care with babies than mothers with grade or high school educations. For preschoolers, they found that mothers with college or high school spent about twice as much time with their children as mothers with grade school educations.

An investigation into the relationship between wives' level of schooling and their time inputs into household production suggested that the amount of time devoted to various activities varied with the level of education (Leibowitz, 1974b). In this model, which incorporated the effects of genetics, income, schooling, and home investments, Leibowitz found that more educated women devoted more time to child care and less time to other household activities than their less educated counterparts. This result was found even though the time represents a greater opportunity cost for more educated women. Time inputs into child-related activities were found to be positively related to the number and age of children. Husband's time input, while only weakly related to the number and ages of children, served as a substitute for the woman's time. Less educated mothers reduced the amount of time spent in child care as family size increased, which was associated with shorter intervals between births for less educated mothers. This was not true for higher educated groups. Leibowitz concluded that the increased time investment of higher educated mothers represented a higher human capital investment and helped to explain the greater achievement observed for children of better educated mothers.

Wilson (1983) studied the relationship between the home environment and mental development. Weak relationships were found between variables such as education of the mother and mental development of children under 8 years of age. Wilson concluded that the principal link between the intelligence of parents and their children is genetic.

Datcher-Loury (1988) found that a mother's education impacted maternal child care time by more than three times that of a father's. She suggested that the positive effects of the mother's education on the time that mothers spend with their child or children may reflect better quality child care by mothers with higher education levels.

The efficiency of a woman's time spent in the home, relative to time in the labor force, is the subject of considerable debate in the literature. Economists have made some efforts to examine the relationship between maternal labor supply and children's development, but no consensus has been reached. Leibowitz (1977) found no statistically significant effects of the mother's employment on standardized scores of the Peabody Picture Vocabulary Test for a sample of three- to five-year-olds, while Datcher-Loury (1988) found that maternal labor force participation had no effect on educational attainment for a sample of grown children ages 20 to 26. However, time spent by the mother in child care increased the years of schooling attained by children if the mother had more years of education. Each additional year of the mother's education raised schooling of boys by .16 years and of girls by .04 years. Fleisher (1977) found a positive effect of mother's home time on high school IQ for a sample of males. Krein and Beller (1988) identified a negative influence of mother's labor force participation on educational achievement of boys at age 26. More recently, Desai et al. (1989), using the National Labor Supply Youth Cohort data for 1986, found that standardized Peabody Picture Vocabulary scores for 4-year-old boys in high income households were negatively affected by market hours of the mother.

The literature on the effects of family characteristics on child development provides little evidence regarding the relationships of these variables to the development of children with disabilities. There is evidence that family characteristics, such as mother's education, are correlated to the development of children without disabilities, suggesting complex interactions of these family characteristics with other variables.

Child Characteristics

The results of most of the early intervention research suggest that the more severe the impairment of the child, the less developmental progress the child will make over time. By evaluating pre- and posttest differences, Bricker and Sheehan (1981) and Bailey and Bricker (1985) found that the less severe the disability, the greater developmental progress was achieved. Gordon (1977) studied the impact of severity on child progress by using three categories of degree of disability. He found that child and family characteristics such as age, sex, SES, and race did not differ by category, although growth was greater for children with less severe disabilities.

Other research (Goodman, Cecil, & Barker, 1984) found that the effects of treatment did not vary by severity. They also found that the higher the pre-intervention (pretest) score, the higher the child's IQ in the post-intervention period (posttest). Mahoney and Snow (1983) and Shapiro, Gordon, and Neiditch (1977) examined whether initial levels of development affect the difference between pre- and posttest scores. Both studies found that higher functioning children made the greatest gains.

Another study (Bricker & Dow, 1980) examined the impact of intervention and other characteristics on the progress of 40 severely disabled children by using multiple regression analyses for each developmental domain and for an overall measure of developmental functioning. They found that pretest scores most strongly predicted posttest functioning and that those subjects with higher pretest scores showed the greatest developmental gain. Age of the child at pretest was the second strongest explanatory variable in the model of development. This was confirmed in a study by Scherzer, Mike, and Ilson (1976), where child's age and severity of disability were found significant in affecting child development; that is, older children had higher test scores while the more severely disabled children in the study showed less developmental progress.

MacCoby and Jacklyn (1974), who examined the influence of gender differences on cognitive abilities, concluded that girls' verbal ability measures higher than boys; while boys performed better in mathematics and visual-spatial tasks than adolescent girls. This study was not conducted on a sample of children with disabilities. They demonstrated no evidence that heredity or environmental factors impact boys or girls differentially.

Summers and Wolfe (1977) estimated the effects of genetic endowments, school inputs, peer effects, and socioeconomic factors on student achievement. Using an input-output relationship and change in achievement over three years, they found that 1st grade IQ strongly affected achievement growth over time. This confirms other work in the early intervention literature that higher IQs in one time period result in higher IQs at a later period and more growth over time. In a review of the early intervention literature, Dunst, Snyder, and Mankinen (1989, p. 272) concluded that "the most consistent finding in all studies was that developmental status at the beginning of intervention was the best indicator of amount of progress."

Sattler (1988), who devoted a chapter to assessment issues with minority children, argued that controlling for differences in economic and social class variables still leaves unexplained important lifestyle and experience differences between ethnic groups. Studies conducted on a variety of IQ and achievement tests (Bossard, Reynolds, & Gutkin, 1980; Hall, Huppertz, & Levi, 1977; Reschly & Sabers, 1979; Reynolds & Hartlage, 1979) support the hypothesis that a variety of tests are equally good predictors of intelligence for black, Hispanic-American, and white children. Another study by Broman and Nichols (1975) compared test results for 14,665 white children and 16,293 black children at 8 months, 4 years, and 7 years. They found that black children achieved lower IQs than white children at 4 and 7 years as measured by the Stanford Binet (given at 4 years) and the WISC (given at 7 years).

Sattler (1988, p. 51) suggested that all test scores are, to some degree, influenced by the child's cultural and other learning experiences, although he concluded in a review of the research on cultural bias in testing that "there is little, if any evidence to support the position that intelligence tests are culturally biased." These results, while not conclusive, indicate no a priori reason to expect differences to result because of cultural or gender bias in the BDI. These results suggest that the observed differences are less likely the result of cultural bias in the BDI than the result of small, significant differences in severity by ethnic group.

Existing evidence on the effects of birth order on development suggests that first-born and only children score higher on measures of communication development than later-born children (Dunn, 1983). Other studies suggest that first borns have greater opportunities for teaching younger siblings, resulting in higher cognitive development (Zajonc & Markus, 1975). It has also been shown that interactions between children of different cognitive levels benefit both younger and older children as measured by cognitive gains (Doise & Mugny, 1981).

The literature on child characteristics provides strong evidence that severity of disability is a strong predictor of child development.

Children with more moderate disabilities make greater gains on IQ and achievement tests than children whose impairments are relative more severe. In addition, age of the child has consistently been shown as positively related to developmental outcome for children with disabilities. Other child variables, such as gender, birth order, and race, have not been shown as consistent or strong predictors of child development for children with disabilities.

Early Intervention

The social systems theory of child development (Bronfenbrenner, 1979) implied broad effects and outcomes as characteristic of the child's development. It has been suggested that early intervention research resulted in a number of conclusions that are not credible because they lack theory in the design and analysis of programs (Dunst, 1986). A simple model of child development suggests that parent, family, or child functioning depends on intervention, social support, and family and child characteristics (Dunst et al., 1989). The early intervention characteristics include age at entry into the program, intensity of early intervention, parental involvement characteristics, and others. This model will examine the separate and combined impacts of explanatory variables on changes in the level of development. Much of past early intervention research has neglected to examine the interactions between variables as they impact both the child and family that receive early intervention services (Dunst et al., 1989).

Ramey, Bryant, Sparling, and Wasik (1985) reviewed studies of intervention with at-risk children that were designed to prevent child development from dropping below that observed in populations who are not at-risk. Based on these studies they concluded that educational treatments were positively related to child development for those children who were high-risk.

Ramey et al. (1981), using data from Project Care, evaluated variables that predict school achievement, in particular, socioeconomic variables such as mother's education and ethnicity. They found that differences in intelligence among social classes do not appear in the first year of life but begin to appear in year two and in the child's school years. They suggested that lower scores of children from low socioeconomic status (SES) were due to lower language scores. The Project CARE study focused on changing parent child interaction in order to improve communication development of at-risk children. Another report of the Project Care findings by Ramey et al. (1985) found that multiple environmental factors influenced child development and that multiple child services were more helpful to development. The intervention focused on developing middle-class forms of interaction with families of young children who were at-risk. They compared a general population sample to a parent intervention program provided without other child services to a daycare program combined with parent intervention. The daycare component in conjunction with parent intervention was necessary to keep the at-risk children's IQ levels near those of the general population sample IQ levels. Differences between the parent intervention group and the parent intervention and daycare group were about 12 points on the Stanford-Binet Test. Thus, they concluded that intense intervention prevents at-risk children from declining below the level of functioning of children who are not at risk.

Much of the evidence in support of early intervention, as in the Project Care studies, has come from studies of at-risk children. What is the evidence with respect to studies undertaken with young children with disabilities? In a recent review of programs that varied the intensity of intervention for young children with disabilities, Innocenti and White (in press) concluded that intensive interventions are not clearly more effective. Intensive early intervention for economically disadvantaged children may be beneficial, although even this evidence seemed inconclusive. After reviewing 11 experimental studies comparing intensity differences for children with disabilities, they found no evidence to support the proposition that more intervention is better than less for young children with disabilities.

Studies of the efficacy of early intervention with at-risk populations provide some evidence that intervention with parents and children can be beneficial to child development. Similar evidence does not exist for children with moderate to severe developmental delays. None of the early intervention studies has examined whether the types of early intervention services are related to variables such as severity and SES of families and children who receive services. This study examines the relationships between the intensity and characteristics of intervention and child developmental outcomes by using a large sample of subjects with measurable developmental delays who received early intervention services. Evidence will also be provided about the nature of the relationship between the variables. The endogeneity of intervention and family characteristics is investigated, and the results are presented and discussed.

CHAPTER III

METHODS

Data

The data reported here represent a subset of data from a series of studies conducted by the Early Intervention Research Institute longitudinal study from 1985-1990 (see White, 1991, for a complete description of those studies). Children in the data subset participated in intervention programs in New York, New Orleans, Utah, Arkansas, Illinois, and Iowa. This subset provides more homogeneous data with respect to age, disability, and the type of intervention provided than the data from the total 16 sites taken together.

Random Assignment

All of the studies used stratified random assignment of subjects to different groups within each site, where the groups offered various intensities of service. The children--stratified by age and developmental delay--then randomly assigned to either a high-intensity treatment or one of lower intensity. Parents of subjects were given information about the intervention and research that would take place and were told that their child could be assigned to either more or less intensive intervention. Some parents chose not to enroll their child in either intervention, although very few parents opted not to participate since the low-intensity intervention was at least as much, and often more, intervention than their child would have received had they not been part of a research project.

Eligibility for early intervention service at a particular site was generally determined by age and severity criteria. These varied between sites, depending on the types of services and programs that were provided, but not within a site. Services were usually offered in a center-based setting if the children were of preschool age, usually age 3-5. Center-based programs provided services to children in classrooms. Younger children were often served at home, where a 1:1 child:staff ratio existed, and families interacted in the home with the interventionist. Center-based programs, as a rule, provide more hours of service than home-based programs. The Arkansas intensity study provided home-based services once every two weeks to children in the lower intensity intervention, while services were provided twice per week to children of comparable age who were randomly assigned to the high-intensity group. Home-based services were provided by paraprofessionals. The Jordan Intensity Study compared center-based services low-intensity (3 days per week, 2 hours per day) to a high-intensity center-based treatment (5 days per week, 2 hours per day). Services were provided to both groups by professionals. The New Orleans program provided services 5 days per week, 6 hours per day center-based intervention to both groups. Services were provided to one group of children by paraprofessionals and to the other group by paraprofessionals who received training from professional consultants in the classroom. The Utah and Iowa programs offered professional, center-based services to children in more- and less-intensive interventions. A parent training component was available for parents of children in the more intensive programs at each site. All children in the New York early intervention services received full-day, professional, center-based services. The intensity of the parent involvement varied for the families who participated in the New York intervention.

Three early intervention programs were provided to children in the Chicago suburbs where children received either 1 hour per week of intervention or a more intensive 3-hour-per-week program. Services to all children were provided by professionals and were home-based.

Assessment

Some measures were common across all studies in the EIRI sites, and others were unique to a particular study. Raw scores from the Battelle Developmental Inventory (**BDI**) (Newborg et al., 1984) were used in each site to measure child achievement. In addition, the Family Support Scale (**FSS**) (Dunst et al., 1984), which measures the degree to which different sources of support are helpful to families with young children, was included as an explanatory variable in the model of child development.

Child development is evaluated using the Battelle Developmental Inventory (**BDI**) Raw Scores. The BDI provides an estimate of development of children with and without disabilities from birth to age 8. The BDI is administered using a structured test format, interviews with parents and/or caregiver, and natural observation. The BDI is divided into five developmental areas or domains: personal-social, adaptive, motor, communication, and cognitive. The total BDI raw score is a simple summation of the domain raw scores. BDI scores were gathered before intervention (pretest) and at approximately one year following intervention (posttest one).

The BDI was selected for this study because of its appropriateness for the age level included in the study and because it has a strong record of validity and reliability. This test can also be used to calculate both age equivalent and developmental quotient scores. The age equivalent BDI gives a measure of achievement in months (e.g., a BDI age equivalent score equal to 36 suggests that the child is functioning at the equivalent of a 3-year-old). The developmental quotient of the BDI takes into account the child's chronological age at the time of the test so that a BDI DQ score equal to 65 implies that the child ranks approximately two standard deviations below the norm for other children of similar age. All of the core family measures and the BDI have uniform administration, objective scoring, and results that are quantifiable; psychometrically, this yields results that have much smaller measurement error than informal testing methods. Norms are established by administering the test to a relatively large sample group of children. Scores derived when the test is administered to individual children can then be evaluated as they compare with scores in the norming sample.

The BDI norm sample was stratified by gender and ethnicity. Differences by ethnicity were found on the 800 child BDI norming sample, where Caucasian children scored higher than non-Caucasians, although these differences were not statistically significant.

The BDI was administered by examiners who had received extensive training on the instrument. All BDI examiners were "blind" to the group assignment of the subjects in the study; that is, examiners did not know which type or quantity of intervention the children received. In addition, approximately 10% of all BDI test administrations were "shadow scored" (i.e., scored by another trained examiner concurrently) to ensure that all examiners scored the tests similarly. The shadow scores resulted in reliability estimates that were consistently greater than 80%, suggesting that the results of a subjects' score did not diverge greatly with the examiner.

The Family Support Scale (FSS) assesses the availability of sources of support and the degree to which sources are perceived as helpful to families with young children. The items include six support systems: informal kinship, social organizations, formal kinship, nuclear family, specialized professional services, and generic professional services. Normative information was obtained on 139 parents of preschool disabled, mentally retarded, and developmentally at-risk children. Test-retest reliability was .75 for separate items and .91 for the total scale scores. FSS validity was evaluated by its ability to predict family well-being using factor analysis (Dunst et al., 1984).

A great deal of data were collected both at pretest and posttest. Pretest administrations of the core measures and demographic instruments were given so that differences in families and subjects prior to the intervention could be accounted for in later statistical analyses. Data collected prior to initiation of intervention included data on (a) family background (education and race) and (b) family and child scores on all core measures such as the BDI.

Family data collection included a family demographic questionnaire that was completed at pre- and posttest. Questions on family patterns, socioeconomic status, ethnicity, and age of parents or primary caregivers were used. The parent satisfaction questionnaire asked parents of subjects to evaluate the teacher, goals, and activities of the intervention program, services, and other items. The primary intervenors also completed annual descriptions of parent involvement, giving their perceptions about the level of attendance of parents at meetings and conferences, knowledge of the child's condition, and parent participation in supportive activities.

Treatment Verification and Cost Data

Treatment verification data were also collected to ensure that treatment was delivered as intended. Data on the child included monthly child attendance records that all intervenors (e.g., therapists, teachers, and others) kept, and additional services data that parents provided. Attendance data were available through home-based and center-based classes attended between the pre- and post-intervention periods. In addition, the total number of center and home-based classes available to the child was coded by site. The additional services form gathered information on the total number of service hours that the subject received outside the intervention program. Specific categories included speech therapy, physical/occupational therapy, and respite care hours that the subject received.

An analysis of the cost of early intervention services was included. These data were collected using the ingredients approach (Levin, 1989), a procedure selected for its ability to identify all of the social costs of a program, both contributed and governmental. Contributed resources included the costs of parent and volunteer time which, while necessary to implementation of some of the early intervention programs, was not reimbursed. After compiling an exhaustive list of resources used by each alternative, each ingredient was valued according to assigned market values or opportunity cost. The total cost of the services provided at the site was calculated and then divided by the total number of children who received services to obtain the average cost per child of the intervention. The average cost per child was the same for all subjects in a given group at a particular site (e.g., one cost per child at the Jordan Site in Utah was calculated for all subjects in the high-intensity intervention [10 hours per week] and another was calculated for all subjects in the low-intensity intervention [6 hours per week]). Detailed data were collected on early intervention staff certification, educational, and other qualifications of personnel who participated.

Descriptive Data

Table 1 presents descriptive data for the variables and subjects examined. The developmental level of the children in this study is about 35% below the level of children without disabilities as measured by the BDI scores.

Intervention is measured using the attendance records of each child in the seven studies included in the data set. Attendance reflects the number of hours the child attended early intervention services. The intervention data for the primary program is based on records of attendance that were obtained at a post-intervention test after approximately one year of intervention, at posttest one.

The quality and quantity of intervention services varied across sites. The attendance data in Table 1 represents the number of hours

Table 1

Descriptive Data for Variables Included in the Model*

Explanatory variables	$\bar{x}$**	Minimum	Maximum	SD***
Child Characteristics				
Pretest BDI	240	9	550	122
Posttest BDI	287	9	597	123
Age in months	35	2	72	17.1
Birth order	2.2	1	8	1.3
Gender				
Male	58%			
Female	42%			
Ethnicity				
Caucasian	83%			
Non-Caucasian	17%			
Family Characteristics				
Mother's years of education	12.9	4	17	2.1
Annual household income	$25,147	0	$75,000	$20,637
Mother's hours/week employed	9.8	0	80	15.9
Number of siblings	1.5	0	8	1.3
Intact	78%			
Not intact	22%			
Early Intervention				
Professional center-based	389	60	728	176
Paraprofessional center-based	922	318	1,638	333
Professional home-based	53	10	157	34
Paraprofessional home-based	36	5	120	24

(table continues)

Explanatory variables	$\bar{x}^{**}$	Minimum	Maximum	SD^{**}
Hours of attendance Pre- to post-intervention	357.9	5	1,638	334.3
Professional	69%			
Paraprofessional	31%			
Home-based	32%			
Center-based	68%			

* N = 434   ** $\bar{x}$ = Mean   *** SD = Standard Deviation

of primary intervention the child received between tests, normally 12 months. The mean attendance between pretest and Posttest 1 is 350.2 hours. Many of the children in the study received only one year of intervention in conjunction with this research project, although they continued to complete BDI and other assessments.

While the attendance data reflect quantitative differences of treatment, attendance does not capture possible differences in the quality of intervention provided to children in different groups and at the different sites. For this reason, variables were created that reflect qualitative differences between early intervention services provided.

Professional services were provided by certified teachers who had achieved a minimum of a Bachelor's degree in Special Education or in a related area. Often professional teachers have paraprofessional aides. Paraprofessional staff were not certified and did not have Bachelor's requirements to provide services. Subjects who received services from professional staff were coded 1 (**PARA = 1)**, while paraprofessional services were coded as 0 (**PARA = 0**). Thirty-one percent of the subjects received paraprofessional services, while 69% received professional services. The variable base was created such that children who received services one-on-one with staff were assigned **base** = 1 (home-based). Children who received services in a group setting were assigned a value for **base** = 0 (center-based). Services were either professional and center-based, paraprofessional and center-based, professional and home-based, or paraprofessional and home-based. The breakdown of attendance hours for each of the four types of early intervention services is given in Table 1.

The family characteristics category includes data on the mother's education, family income, mother's labor force participation, whether or not the family was intact at the time intervention began, the number of siblings of the child who participated in the early intervention research, and the FSS. The education of the mother or primary guardian is measured by the highest grade completed, and the mean was 12.9 years. Family income was obtained in categories and recorded using the midpoint of each category, resulting in a mean of $25,157. Mother's labor force participation was measured using the total number of hours per week that the mother works outside the home, averaging 9.9 hours per week at pretest. The number of siblings and birth order of the subject were also reported by the parent and averaged 1.5 at pretest. All family characteristics data are from the pretest survey, which was completed by a parent or guardian, usually the subject's mother.

The child's BDI scores at pretest and chronological age at pretest represent the pre-intervention condition of the child. Pretest BDI score is the variable in this data set that best represents severity of disability of the subject. Child characteristics also include gender, ethnicity, and birth order of the subject. Ethnicity of the child is coded as a categorical variable, with 0 for Caucasian subjects and 1 for Black, Native American, Hispanic, Asian, and other ethnic groups. Eighty-three percent of the subjects in the sample were Caucasian and 17% were non-Caucasian. Male subjects were coded as 0 and females as 1. Fifty-eight percent of the sample was male while 42% was female. The birth order reflects whether the child was born first or later, and the mean for this sample was 2.2.

CHAPTER IV

ESTIMATION STRATEGY

Initially, we will consider variants of the regression model

$$BDI_{it}=\mathbf{X}_i\beta_t+\theta BDI_{it'}+\mu_i+v_{it'} \quad (1)$$

where t refers to the post-intervention BDI (posttest) and t' refers to the pre-intervention BDI (pretest), given that t > k > t' and that the intervention is given during the period k. The vector **X** contains the intervention, family, market goods, and child condition variables which influence human capital development as here measured by the BDI. The variables in the vector $\mathbf{X}_i$ do not vary over the periods t' to t, but the coefficients may differ for different periods. Given the above model, the error term is partitioned into an unobserved child specific effect and a general error term (μ_1 and V_{it}) having zero mean and assumed to be uncorrelated across observations or with the $\mathbf{X}_i$.

Under the restriction, $\theta = 0$, the pre-intervention BDI does not influence the current BDI. Ordinary least squares estimates of the BDI relationship for each period allow estimates of β_t for t = t, t'. Under the restriction, $\theta = 1$, the β_t vector itself is assumed to measure the influence of $\mathbf{X}_i$ on growth. In this case, the child-specific effects are interpreted as growth-rate specific effects. $\mathbf{BDI}_{it'}$ in (1) serves as a proxy for child-specific human capital factors. In this model, we cannot interpret the parameter $\hat{\theta}$ as a measure of direct causation from child-specific human capital to growth in human capital, since $\mathbf{BDI}_{it'}$ and μ_i are potentially correlated, and estimates of θ (and perhaps β) may not be consistent.

The model given in (1) resembles the nonexperimental estimators for the impact of training programs as developed by Heckman and Hotz (1989) and Heckman and Robb (1986), except that this study contains no data on a comparison group for each intervention site receiving no intervention. Early intervention services for children with disabilities similar to those examined here have become so widely available that finding a comparison group with intervention services is difficult. Furthermore, the problem of selection into the intervention groups is presumed to have been corrected by the matching and random assignment carried out to set up the intervention study. The influence of selection into intervention versus exclusion could still remain a problem. However, there are no data on human capital development of non-participants who were excluded from the intervention at each site.

The growth model is given by

$$BDI_{it}-BDI_{it'}=(\beta_t-\beta_{t'})X_i+(\theta-1)BDI_{it'}+\mu_i+v_{it}. \quad (2)$$

This differs from equation 1 in that it is in differential form, although X_i is the same in both models. For the intervention explanatory variable, the $\beta_{t'} = 0$, since intervention did not exist in the time period t'. This model, under the restriction $\theta = 1$, provides estimates of $\beta_t - \beta_{t'}$, the effect of the X_i on growth.

Ordinary Least Squares Regression

Several estimations of (1) using ordinary least squares (OLS) are made. Pretest/posttest and growth relationships are estimated. In addition, computed growth coefficients are calculated by subtracting the OLS coefficient estimates from the pretest BDI scores from the OLS coefficient estimates from the post-intervention (posttest) scores. Ordinary least squares regression is used to estimate pretest, posttest, and growth scores for each of the five BDI domains and total raw scores for the following relationships:

Pretest BDI = f **(AGE, GENDER, SIBLINGS, INTACT, BIRTH ORDER, INCOME, EDUCATION, HOURS WORKED, FAMILY SUPPORT SCALE),**

Posttest BDI = f **(AGE, GENDER, SIBLINGS, BIRTH ORDER, INCOME, EDUCATION, HOURS WORKED, FAMILY SUPPORT SCALE, ATTENDANCE, PARA, BASE, ATTENDANCE X PARA, ATTENDANCE X BASE),**

Posttest BDI - Pretest BDI = f **(AGE, GENDER, Pretest BDI, SIBLINGS, BIRTH ORDER, INCOME, EDUCATION, HOURS WORKED, FAMILY SUPPORT SCALE, ATTENDANCE, PARA, BASE, ATTENDANCE X PARA, ATTENDANCE X BASE)**

where child characteristics include

Age = Chronological age at pretest,

Gender = Zero for males and 1 for females,

Pretest BDI = Total raw score on the BDI at pretest,

Birth Order = Birth order of the child,

Ethnicity = Zero for Caucasian, 1 for other;

and family characteristics include

Siblings = Total number of siblings,

Income = Household income,

Education = Total number of years of education mother completed,

Hours Worked = Total number of hours mother is employed outside home each week,

Family Support Scale = Family Support Scale Total Score,

Intact = Whether both parents are present in the child's home; and intervention includes

Attendance = Total number of hours the child attended early intervention between pretest and posttest 1,

Para = Professional early intervention personnel (1) or paraprofessional (0),

Base = Whether the early intervention setting was home-based (1) or center-based (0).

Parameter estimation provides estimates of the relationships of $\mathbf{BDI}_{it}$ and $\mathbf{BDI}_{it'}$ to the vector of variables contained in the **X**. Differences between the estimated coefficients for the post and pre-intervention period, t and t', provide estimates of the growth in the scores as influenced by **X**. The model is also estimated with the polynomials of attendance to determine the effect of very high hours of early intervention service on child outcomes.

The joint problems and influence of endogeneity, selectivity bias and censoring on child development are suspected. Endogeneity and censored explanatory variables and the presence of selection bias, such as selection into programs, are common in unit record data. Endogeneity of censored variables usually results from the use of questionnaire-based data, such as that completed by parents of participants in these types of studies. Several potential factors exist that influence selection or self-selection in the sample and data used in this analysis.

Selectivity, Endogeneity, and Censoring

Employed mothers are a self-selected group of labor force participants. Economic theory suggests that participation decisions are made on the basis of comparisons between home and market productivity. Thus, employed and nonemployed mothers may differ in unmeasured characteristics related to their production of child quality, even given the disabilities of children as measured in this sample. As a result, if unmeasured characteristics of the mothers associated with their production of child quality are correlated with measures of the quantity of maternal time inputs, then the estimated coefficients on maternal labor supply will be biased. On the one hand, if women who remain at home are a self-selected group with exceptionally high home productivity (which may vary by intervention site location), the coefficient on maternal employment will be biased downward. Some of the adverse effects of maternal employment may be due in part to the higher home productivity of nonemployed mothers. On the other hand, if labor force participants are a self-selected group of exceptionally able women receiving high wages, the bias could be reversed.

Selectivity bias may also be embedded in the early intervention variables used in the model. Early intervention services that a child receives depend on certain child characteristics. Younger children are more likely to be served in home-based, rather than in center-based intervention programs, relative to older children. Further, home-based programs typically offer fewer service hours, so that the program variable represented by **BASE** could be expected to relate to the attendance variable. There is also a tendency for home-based programs to use paraprofessional personnel, while center-based programs often have certification requirements that translate into professionally provided services. These relationships suggest the possibility of selectivity and/or endogeneity of certain early intervention variables. In particular, children may be selected into certain types of programs because of child characteristics such as age or severity. These relationships also suggest that interactions between intervention variables are likely.

Endogeneity in the labor force participation variables is suspected (i.e., hours worked by the mother and income) because variables exogenous to the model described in the vector $\mathbf{X}_i$ may explain these two variables. Other early intervention variables, **para** and **base**, are binary dummy variables that may also be endogenous and subject to selection bias if they themselves are related to outcomes in the model or if the selection into those programs is not fully random or observed. Some of the variables in the vector $\mathbf{X}_i$ are censored. The variables **para** and **base** are dichotomous variables, and the mother's hours worked is censored since the mother chooses (selects) to be employed or not to be employed, perhaps responding to wages above and below a certain participation threshold wage that is unobserved.

Endogeneity and selectivity affect the parameter estimates in a similar way (i.e., they may result in inconsistent estimates if the OLS estimator is used). The influence is similar because in neither case is the variable (such as **PARA** or **BASE**) independent of predetermined variables and the disturbance term in the model, in this case the child-specific disturbance term. If the estimated parameter is not consistent, then it does not approach the true value of the parameter as the sample size increases. The results are an increase in Type II errors and a decrease in the power of the test used to determine significance of the estimated parameter. Estimation procedures, selected to address these problems, are described in more detail in the next section.

Instrumental Variables Estimator

The above issues present problems in statistical estimation of forces that influence the Battelle score outcome. A form of an instrumental variables estimator can be used to account for such problems, except that possible joint problems (i.e., endogeneity, selectivity, and censoring) must be accounted for in the explanatory variables.

To correct for potential heterogeneity bias in the model developed here, the basic post-intervention BDI equations are estimated using an instrumental variables type estimator. This estimator is assumed to incorporate both the labor participation choice of the mothers and the endogeneity of early intervention participation, as well as to account for the correlation of the pre-intervention BDI with the error term in the basic post-intervention BDI equations developed previously. The approach generalizes the instrumental variable method and provides a unifying framework for handling the joint problems of selectivity, endogeneity, and censoring.

Most of the work to date has handled these issues separately. Simultaneous limited dependent variable models have been considered by Amemiya (1978), Heckman (1978), Lee (1978), and Nelson and Olson

(1978), who examined maximum likelihood estimators for the reduced form parameters in probit and tobit models (censored or truncated models). Newey (1987) generalized the two-stage and Amemiya Generalized Least Squares (GLS) estimates to obtain asymptotically efficient estimates for the parameters in the structural equations of limited dependent variable models with endogenous explanatory variables. Smith and Blundell (1986), Rivers and Vuong (1988) and Blundell and Smith (1989) handled the instrumental variables and selectivity problems in a conditional maximum likelihood framework, assuming a normal distribution for the error terms involved in the simultaneous selection system.

Attributing cause-effect relationships accurately becomes complicated in the presence of selectivity. The presence of a trait, such as age or severity of the child, may be associated with treatment, and, therefore, with the outcome, making efforts to capture the causal effect of treatment difficult. Heckman (1976, 1978, 1979) developed econometric techniques, applied to labor force issues, to address the bias that arises in such estimation. Barnow, Cain, and Goldberger (1981) and Garen (1984) used a linear form which incorporates information from all observations to show how selection bias may be resolved when the observations subject to selectivity bias are unknown. A generalization of this modeling framework is the one used here.

Consider an R equation model of one structural and R-1 reduced form equations:

$$R_i=\alpha'X_i+\Sigma\beta_jY_{ji}+V_i \quad (3)$$

$$Y^*_{ji}=\gamma_j'Z_i+V_{ji}, \quad (4)$$

where R is the dependent variable in the equation of interest. The Y_{ji} are observed variables representing some measure Y_j (actual decision regarding treatment), which may be an unobserved endogenous variable. **X** and **Z** are vectors of exogenous variables on n individuals in the sample.

The latent variables may be defined as censored by functions h_j, such that the $\mathbf{Y_{ji}}$ are observed, and $\mathbf{Y_{ji}}$ may or may not be observed, as in

$$Y_{ji}=h_j(Y^*_{ji}) \quad (5)$$

The triplet (X_i, V_i, V_{ji}) is identically and independently distributed (i.i.d.) by the usual assumption. Also generally assumed is that $\mathbf{V_i}$, $\mathbf{V_{ji}}$ are, conditional on X_i, jointly normal with zero means and covariance matrix:

$$\begin{vmatrix} \sigma^2 & \sigma_{12} \\ \sigma_{21} & \Sigma \end{vmatrix}$$

assuming the parameters of the model are identified. There may be other forms of (5) to identify observations $\mathbf{Y_{ji}}$.

If conditional expectations are calculated as follows (since the expectations model is to be empirically estimated),

$$E(R_i|Y_{ji})=E(\alpha'X_i+\Sigma_j\beta_jY_{ji}|Y_{ji})+E(V_i|Y_{ji}),\ i=1,\ldots n,\ j=1,\ldots m-1 \quad (6)$$

$$E(Y^*_{ji}|Y_{ji})=E(\gamma'_j Z_i|Y_{ji})+E(V_{ji}|Y_{ji}) . \quad (7)$$

Thus, the expected values of the error terms, which are now conditional on the value of Y_{ji}, can be described as generalized errors in the sense of Cox and Snell (1968), who developed generalized residuals as residuals with applications to nonlinear models. The values of these generalized residuals, here denoted ϵ_i and ϵ_{ji}, are dependent upon the form of censoring, or the function h_j. By employing joint normality and the law of iterated expectations, ϵ_i can be expressed as

$$E(E(V_i|V_{ji})|Y_{ji})=\sigma_{12}\Sigma^{-1}E(V_{ji}|Y_{ji})=\sigma_{12}\Sigma^{-1}\epsilon_{ji}=\lambda'\epsilon_{ji} \quad (8)$$

where λ is a jx1 vector with λ_j as the j element. Now (3) is expressed as

$$E(R_i|Y_{ji})=E(\alpha'X+\Sigma_j\beta_j Y_{ji}+\lambda'\epsilon_{ji}|Y_{ji}) \quad (9)$$

which has estimable form as

$$R_i=\alpha'X+\Sigma_j\beta_j Y_{ji}+\lambda'\epsilon_{ji}+\eta_i, \quad (10)$$

where η_i is a zero mean error term independent of the regressors in (8) by construction. Consistent estimation of α, β, and λ is now possible by OLS.

After the R_i, Y_i* functions (3) and (4) are specified, the generalized residuals for the Heckman two-step estimator (Heckman, 1979) or the Barnow et al. (1981) selectivity bias estimator can be derived as special cases. Or,

$$R_i=\beta'X+\delta Y_i+\mu_{1i}, i=1,...n \quad (11)$$

$$Y_i^* = \alpha' Z + \mu_{2i} \qquad (12)$$

where M_{1i} is $\sim N(0,\sigma_1^2)$, η_{2i} $\sim N(0,\sigma_2^2)$ (i.e., distributed normal), and the covariance is σ_{12}. Otherwise, censoring takes the form $Y_i = 1$ if $Y_i^* > 0$, $Y_i = 0$. The generalized residuals are given by

$$\hat{\epsilon}_{2i} = E(\mu_{1i}|Y_i) = (Y_i - \hat{\Phi}_1)\,\theta_i(1-\hat{\Phi}_i)^{-1}\phi_i, \qquad (13)$$

where ϕ and θ are the cumulative and density functions, respectively, of the N(0,1) evaluated at, for example, the probit estimates $\hat{\alpha}/\sigma_2$. Then,

$$E(\mu_{1i}|Y_i) = \lambda\hat{\epsilon}_{2i}, \quad where\ \lambda = \sigma_{12}/\sigma_2^2. \qquad (14)$$

Then rewrite (11) in terms of its conditional expectation

$$E(R_i|Y_i) = E(\beta' X + \delta Y_i + \lambda\epsilon_{zi}|Y_i) \qquad (15)$$

which is estimated by OLS to get β, δ, λ. This estimator is the one used in the selectivity bias literature (Heckman, 1978; 1979). In such a case, X does not contain an intercept, and only values of R corresponding to specific values of Y are observed (i.e., this becomes the two-step estimator). Equation (15), as given here in general form, is actually the equation proposed by Barnow et al. (1981) and used in the estimation. This approach also produces the continuous selectivity bias estimator of Garen (1984). In Garen's model, the dependent variable in the selection equation (12) takes a continuum of values over a given range and is uncensored. To estimate (12), use OLS, which corresponds to the maximum likelihood estimator.

In summary, the steps outlined in equations (3) through (15) provide a means of estimating α, β, and λ. First, estimate R - 1 reduced form equations to obtain estimates of γ by MLE, using the observed Y_{ji} in place of Y_{ji}* by incorporating expectations from Y_{ji}. The forms of the likelihood functions are determined by the functions h_j. Then transform the V_i and V_{ji} conditional residuals to get estimates of the generalized errors, which are then inserted into the structural equation [most explicitly given by (10)] to obtain α, β, and λ estimates by OLS.

The class of model described above is a member of the Generalized Method of Moments models examined by Newey (1984). This special sequential estimator is termed a Sequential Method of Moments Estimator by Pagan and Vella (1989). Therefore, the covariance matrix can be estimated in a similar manner as outlined by Newey (1984) and by Pagan (1986), which enables adjustment for heteroskedasticity, if it is suspected, as done in the GMM case outlined by Newey (1985).

Implementation of the sequential procedure used here requires estimates of the generalized errors, as obtained through the results of Gourieroux, Monfort, Renault, and Trognon (1987). The Gourieroux et al. results, as applied to OLS, Probit, and Tobit h_j functions or reduced form equations, are used here. They showed that the score of the latent likelihood for Y_j* equals the score of the observed likelihood of Y_j. Once the scores are derived (i.e., d[likelihood]/dβ, where β represents the parameter vector), the generalized residual estimates follow directly.

The approach to testing for the presence of endogeneity is similar to Hausman (1978), Newey (1985), and Tauchen (1985). The Hausman test compares the distance of a consistent estimator (say, an instrumental variables estimator) under both the null and alternative hypotheses to the efficient estimator under the null hypothesis in order to determine the presence of endogeneity in some of the explanatory variables.

Another approach is to test for endogeneity while accounting for the correlation that exists between equations, some of which are explanations of both the endogeneity and selectivity. This is precisely the approach adopted in the conditional maximum likelihood literature on such tests (Blundell & Smith, 1989; Smith & Blundell, 1986). These tests, however, are restricted to bivariate normal models.

One problem with the sequential moment estimates is that, in general, the distribution of η_i is not normal or, in fact, even known; thus, the conditional MLE approach of Smith and Blundell (1986), Blundell and Smith (1989), and Rivers and Vuong (1988) will not be applicable. The conditional MLE is appropriate for Y_i^* uncensored, producing generalized residuals that coincide with OLS residuals, which then result in $\eta_i \sim \mu(0, \Sigma)$; hence, normality restricts the uncensored dependent variable. Semiparametrics or nonparametrics could be used to estimate the structural equation, but some restrictions on the errors apply in these cases as well.

As shown above, however, a consistent estimate of λ_j is possible. The estimate, λ_j, captures the correlation between the structural equation error and the errors associated with the other reduced form equations. Thus, an alternative approach is to perform a test under the null hypothesis that the correlation of these errors is equal to zero, once an estimate of the variance of λ_j is found. Since the model is of the sequential method of moments class, this latter estimate is obtained as the covariance matrix estimate of Newey (1984) and Pagan

(1986). By estimating under this null hypothesis, maximum likelihood estimates of each of the reduced form equations can be obtained since the error term distribution of each is known. The test then becomes a test of weak exogeneity ($\lambda_j = 0$) in the conditional moment framework of Newey (1985) and Tauchen (1985) in relation to the limited dependent variable case of Pagan and Vella (1989). Given this result, along with the fact that generalized residuals can be estimated (consistently) using the results of Gourieroux et al. (1987), the sequential method of moments estimator (as a generalization of the instrumental variables estimator) and the test of weak exogeneity are complete. A test of weak exogeneity is a test that $\lambda_j = 0$ (i.e., that no correlation exists between reduced form and structural errors).

This strategy yields less restrictive conditions than those implied by the usual approach of assuring conditional homoscedastic normality. The test of weak exogeneity used here provides a similar test to the orthogonality conditions between residuals and instruments as proposed by Newey (1985, 1987) in his development of the GMM estimator. The maximum likelihood estimates of probit, tobit, or even least squares equations can be used to develop empirical estimates of the generalized residuals that are used in the structural equation and that are also used to make the test of weak exogeneity.

CHAPTER V

RESULTS

The pre- (pretest) and post-intervention (posttest) results are discussed in separate sections below. The differences between the OLS and SMM estimates are outlined for the child, family, and early intervention variables in the models. Any differences between the OLS and SMM estimates at pretest must be attributed to the effects of the generalized residuals of one of two labor force variables (i.e., **income** or **mother's hours worked**).

The early intervention variable residuals for **para** and **base**, which are incorporated in the posttest SMM estimates, will impact only the SMM estimates for the posttest equations. Consequently, the results of the tobit estimates on **mother's hours worked** and for the OLS reduced form on **income** are presented in the section on pretest results. The estimates from the probits on center-based and on professional early intervention programming will be presented and discussed in the posttest results.

The explanatory variables that are statistically significant using a distribution test value of p=.10 or less are selected for specific discussion. In the following tables, the symbol B is used to represent the vector of estimated coefficients.

Tobit Estimates of Mother's Hours Worked Reduced Form

Three of seven variables in the tobit on **mother's hours worked** are statistically significant. The variable **south** is included to reflect regional differences in wage rages for mothers who work. Table 2 shows

Table 2

Tobit Estimates of Mother's Hours Worked Reduced Form^

Variable	B
Mother's education	1.61784 (1.556)
Ethnicity	2.76866 (.366)
Intact	11.6744* (1.821)
South	3.52690 (.499)
Siblings	-3.47295* (-1.803)
Handicapped siblings	-13.4140*** (-2.443)
Intercept	-37.7555*** (-2.634)
Log likelihood	-875.96

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

that the total number of siblings and the number of handicapped siblings are both negative. The sign for these variables is consistent with the human capital theory of labor market participation, which suggests that both time and income influence participation. More siblings, and in particular, more handicapped siblings, increase the opportunity cost of mothers' work outside the home because children are time-intensive goods. Whether or not the child was living with both parents (**intact**) is significantly positive. Single parents are less likely to work than dual parent families with a handicapped child present. The competing effects of time and income differentially affect these families. One important explanatory variable was missing (i.e., mothers' wage rates, and this may account for the low R^2 for this variable).

OLS Estimates of the Reduced Form for Income

The results of the reduced form estimate for **income** (Table 3) show one negative, statistically significant influence (**ethnicity**) and two that are positive (**mother's education** and **intact**). Lower incomes for non-Caucasians who live and work in the United States may be explained by any number of labor hypotheses, among them the "dual labor market"

Table 3

Estimations from the Reduced Form on Income^

Variable	B
Mother's education	4329.19*** (11.453)
Ethnicity	-6256.35** (-2.347)
Intact	13927.9*** (6.398)
South	1053.3 (.381)
Siblings	312.357 (.489)
Intercept	-40225*** (-8.076)
Log Likelihood	-4813.60

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance att .01 or less

hypothesis. This hypothesis suggests that the labor market is segmented into noncompetitive labor forces. It has been suggested that discrimination by characteristics such as race perpetuates this division (Levitan, Mangum, & Marshall, 1981). **Mother's education** has an expected positive influence on income. The influence of **intact** is also expected because two-parent households have higher earning capability than those where only one parent is present.

Influences on Pre-Intervention BDI Scores

The OLS and SMM estimates for the total BDI raw scores at pretest provide an overview of the variables that influence child outcomes prior to early intervention services. The pretest total BDI estimates for B_t are given in column 1 of Table 4, with the SMM estimates in column 2. The results for the OLS and SMM estimates on the BDI pretest domain scores are given in Tables 5-9. These parameter estimates provide measures of the effects of the X_i on pretest BDI scores.

The OLS and SMM results are presented together so that effects of the generalized residuals on the estimates can be ascertained. An hypothesis test where H_0: $\lambda = 0$, H_a: $\neq 0$ provides a test of weak exogeneity. Only one of the pretest generalized residual estimates is statistically significant, that for **income** in the motor domain. **Income** and **mother's hours worked**, generalized residuals in the estimate for the pretest BDI total score (Table 4), have relatively small estimated t-statistics, .454 and .439, respectively. Both estimates fall below the critical value for the t-statistic. Little divergence between the pretest OLS and SMM estimates is anticipated due to evidence of weak

Table 4

Ordinary Least Squares Regression and Sequential Method of Moments Estimates for Pretest BDI Total Raw Scores^

Explanatory variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-12.65776** (-2.038)	-15.2987* (-1.651)
Age	5.85049*** (29.861)	5.83954 (32.694)
Birth order	-8.22571 (-1.392)	-7.91623 (-1.348)
Ethnicity	-22.95589** (-2.516)	-25.9887 (-1.472)
FAMILY CHARACTERISTICS		
Mother's	.82510 (.481)	5.63693 (0.692)
Mother's hours worked	-.18832 (-.953)	-1.29581 (-.508)
Family Support Scale	.08744 (.318)	0.109188 (.371)
Income	1.229592E-04 (.634)	-.777977E-03 (.375)
Siblings	9.91915* (1.708)	7.49466 (1.165)
Intact	1.10489 (.123)	18.1367 (.743)
RESIDUALS		
Income		.93263E-03 (.454)
Mother's hours worked		1.12619 (.439)
INTERCEPT	33.7593	-4.12139 (0.046)
R2	.74044	.74197
F-TEST	119.24288	100.8837

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 5

Ordinary Least Squares Regression and Sequential Method of Moments Estimates for Pretest BDI Personal/Social Raw Scores^

Explanatory variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-1.65374 (-.819)	-2.32110 (-.722)
Age	1.75458*** (27.562)	1.75465*** (30.264)
Birth order	-3.42670* (-1.785)	-3.34230* (-1.722)
Ethnicity	-10.25256*** (-3.458)	-7.66480 (-1.224)
FAMILY CHARACTERISTICS		
Mother's education	1.24178** (2.227)	.483404E-01 (.017)
Mother's hours worked	-.06621 (-1.032)	-.356737 (-.404)
Family Support Scale	.18016** (2.016)	.192113 (2.062)
Income	6.550528E-05 (1.040)	.392765E-03 (.531)
Siblings	3.60403* (1.910)	3.11876 (1.344)
Intact	-2.89799 (-.990)	-6.05573 (-.714)
RESIDUALS		
Income		-.318160E-.03 (-.432)
Mother's hours worked		.289109 (-.326)
INTERCEPT	-7.64198	4.61050 (.147)
R2	.71018	.709685
F-TEST	102.42779	85.7625

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 6

Ordinary Least Squares Regression and Sequential Method of Moments Estimates for Pretest BDI Adaptive Domain Raw Scores^

Explanatory variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-1.66698	-3.33870
	(-1.373)	(-1.552)
Age	1.6099***	1.06076***
	(27.713)	(29.369)
Birth order	-.87700	-.772056*
	(-.759)	(-.665)
Ethnicity	-2.33946***	-1.47753
	(-1.312)	(-.305)
FAMILY CHARACTERISTICS		
Mother's education	.04924**	.694106
	(.147)	(.286)
Mother's hours worked	-.04462	-.658681
	(-1.156)	(-1.051)
Family Support Scale	.01054	.111695E-01
	(.196)	(.197)
Income	4.536134E-05	-.297450E-05
	(1.197)	(-.005)
Siblings	1.32931*	.215973
	(1.172)	(.155)
Intact	.04574	2.98951
	(.026)	(.417)
GENERALIZED RESIDUALS		
Income		.57730E-04
		(.092)
Mother's hours worked		.618696
		(.984)
INTERCEPT	9.47027	7.78695
		(.294)
R2	.70500	.708556
F-TEST	99.89473	85.2941

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 7

Ordinary Least Squares Regression and Sequential Method of Moments Estimates for Pretest BDI Motor Domain Raw Scores^

Explanatory variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-5.84868*** (-2.930)	-5.09314* (-1.734)
Age	1.57400*** (25.001)	1.55995*** (29.545)
Birth order	.15319* (.081)	.110889* (.056)
Ethnicity	-4.35950*** (-1.487)	-12.9258** (-2.170)
FAMILY CHARACTERISTICS		
Mother's education	-.31722** (-.575)	5.80011** (2.154)
Mother's hours worked	-.02113 (-.333)	.155154 (.191)
Family Support Scale	-.16275* (-1.841)	-.147864* (-1.646)
Income	4.317157E-05 (.693)	-.137612E-02* (-1.999)
Siblings	1.18260 (.634)*	1.07821 (.516)
Intact	.99599 (.344)	20.1711** (2.499)
GENERALIZED RESIDUALS		
Income		.143054E-02** (2.095)**
Mother's hours worked		-.162890 (-.200)
INTERCEPT	17.46413	-40.6042 (-1.363)
R2	.66832	.673518
F-TEST	84.22545	72.3754

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 8

Ordinary Least Squares Regression and Sequential Method of Moments Estimates for Pretest BDI Communication Domain Raw Scores^

Explanatory Variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-1.30279 (-1.198)	-1.60716 (-.969)
Age	.78994*** (23.028)	.792127*** (21.797)
Birth order	-2.98725** (-2.887)	-2.91336*** (-2.707)
Ethnicity	-3.28458** (-2.056)	-2.56825 (-.807)
FAMILY CHARACTERISTICS		
Mother's education	-.13381 (-.445)	-.400469 (-.290)
Mother's hours worked	-.02119 (-.613)	-.146045 (-.330)
Family Support Scale	.04803 (.997)	.440595E-01 (.941)
Income	-1.54229E-05 (-.454)	.700781E-04 (.196)
Siblings	2.81044*** (2.764)	2.53637** (2.094)
Intact	1.00429 (.636)	.298211 (.074)
RESIDUALS		
Income		-.835070E-04 (-.235)
Mother's hours worked		.124891 (.282)
INTERCEPT	9.04274	12.3497 (.803)
R2	.64255	.644374
F-TEST	75.13952	63.5691

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 9

Ordinary Least Squares Regression and Sequential Method of Moments Estimates for Pretest BDI Cognitive Domain Raw Scores^

Explanatory variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-2.14184*** (-2.341)	-3.02533** (-2.311)
Age	.67003*** (23.218)	.670700*** (21.831)
Birth order	-1.06006 (-1.218)	-.973450 (-1.050)
Ethnicity	-2.70702** (-2.014)	-1.13694 (-.457)
FAMILY CHARACTERISTICS		
Mother's education	-6.98036E-03 (-.028)	-.552030 (-.459)
Mother's hours worked	-.03281 (-1.128)	-.332770 (-.946)
Family Support Scale	9.159974E-03 (.226)	.791513E-02 (.180)
Income	-1.63019E-05 (-.571)	.156913E-03 (.521)
Siblings	1.00084 (1.170)	.490073 (.527)
Intact	1.91970 (1.446)	.604433 (.170)
RESIDUALS		
Income		-.172850E-03 (-.582)
Mother's Hours Worked		.302326 (.857)
INTERCEPT	5.32722	12.4666 (.964)
R2	.63740	.639381
F-TEST	73.47827	62.2030

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

exogeneity of **income** and **mother's hours worked** to the model of child development.

Child Characteristics

Results in Table 4 show that age of the child at pretest is a strong predictor of pretest BDI scores, that is, the older the child the higher the score. Girls score significantly lower on total, motor, and cognitive scores than boys, although gender is less significant in the SMM estimates. **Birth order** and **ethnicity** are significant for some of the estimates, although no variable other than **age** consistently influences on scores across all domains.

Caucasian children scored significantly higher on the total BDI and on the personal social, communication, and cognitive domains in the OLS estimates. These differences do not appear in the SMM pretest estimates. The SMM results show a statistically significant influence by **ethnicity** only in the motor domain where the income residual is statistically significant. The OLS reduced form on **income** shows that **ethnicity** is negatively related to **income.**

The effects of **birth order** are consistent in the SMM and OLS estimates. Higher personal social and communication scores are achieved by children with a lower birth order. This variable is stronger in the communication domain than in the personal social domain although the differences do not significantly affect BDI total scores.

Family Characteristics

None of the family characteristics significantly affects BDI total scores, as shown in Table 4. Isolated differences in this category of variables appear; for example, **mother's education** is statistically significant in the personal social domain OLS estimate but not for the SMM estimate for this domain.

Mother's education, **income**, and **intact** show a positive influence on a child's motor skills, as reflected in the SMM estimates. None of these variables is significant in the OLS estimates. **Mother's education** and **intact** are significantly positive in the OLS reduced form for **income**, and the **income** generalized residual estimate, as mentioned previously, is statistically significant in the motor equation, providing a logical explanation for this finding.

The **Family Support Scale** is significantly positive in the OLS and SMM estimates for personal social skills and negative for the motor domain estimates. Children with relatively more siblings show higher communication scores in the OLS and SMM estimates and in the OLS estimates for personal social skills.

Probit on Center-Based Early Intervention Programming

Table 10 gives results of the probit on center-based programming (**base** = 1). A child has a greater probability of being in center-based programs when he or she is from a non-Caucasian ethnic group, when only one parent is living with the child, and when the mother has achieved a relatively high level of education. Children in center-based programs are also older and exhibit higher BDI scores at pretest. Center-based programs are generally designed to serve older children who would have higher BDI scores at pretest and mothers who are older, with more years of education than their home-based counterparts.

Table 10

Estimations from the Probit on Center-Based Early Intervention Programming^

Variable	B
Mother's education	.170315*** (4.375)
Ethincity	1.21480*** (4.904)
Gender	.151456 (.941)
Intact	-.631925*** (-2.768)
Age	.044957*** (4.971)
Pretest total BDI	.003748*** (2.949)
Intercept	-3.65155*** (-6.424)
Log Likelihood	-165.13

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Probit on Professional Early Intervention Programming

The results of the estimated probit for para are given in Table 11. Four of the instrumental variables are statistically significant in identifying selection into professional programs. These variables include **mother's education**, **gender**, and **pretest total BDI**, which are

Table 11

Estimations from the Probit on Professional Early Intervention Programming^

Variable	B
Mother's education	.179603*** (4.912)
Ethnicity	-.93623*** (-4.616)
Gender	.2435* (1.628)
Intact	-.099481 (.015)
Pretest total BDI	.0053857*** (4.460)
Intercept	-2.80478*** (-5.454)
Log likelihood	-197.59

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

positive, and **ethnicity**, which is negative. When combined with the findings from the probit on center-based programs, these results suggest that children are more likely placed in professional and center-based programs as **mother's education** and **pretest BDI scores** increase. **Gender**, which was not significant for center-based selection, affects whether the child is in a professional program, with girls more likely than boys to receive services from professionals. The results by **ethnicity** derive from the New Orleans site, the only one in the sample that is center-based and paraprofessional and has the vast majority of the ethnic children in the sample.

Post-Intervention

Applying the test of weak exogeneity to the posttest BDI SMM residual estimates provides evidence that **para** and **base** are endogenous while **income** and **mother's hours worked** are not. Table 12 shows the parameter and t-statistic estimates for the posttest BDI total score where the OLS results are found in column 1 and the SMM estimates in column 2. The results for the BDI domain scores are presented in Tables 13-17.

The estimated t-statistic of the **base** generalized residual for the posttest BDI total score is 5.347, with a significance level of .005. There is evidence that a child's placement in center-based programs is endogenously determined with outcome and that selection may not be random. Similarly, the estimate for the **para** residual t-statistic equals -6.780, a clear rejection of the null hypothesis. These results, in statistical significance and sign, are consistent across domains.

The results from the generalized residual estimates suggest that the post-intervention OLS estimates are biased, whereas the SMM estimates, because they adjust for the unobserved factors that select children into different early intervention programs, provide consistent estimates of the explanatory forces in the model. One of the most significant variables in the **para** and **base** probits, which is not directly incorporated into the estimates in the SMM posttest equations, is the pretest BDI total raw score. The generalized residuals

Table 12

Ordinary Least Squares and Sequential Method of Moments Estimates for the Posttest BDI Total Raw Score^

Explanatory Variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-17.2231** (-2.231)	-12.8334* (-1.854)
Age	4.66387*** (17.634)	4.28913*** (14.926)
Birth Order	-6.51979 (-.924)	-4.00881 (-.619)
Ethnicity	-15.6141 (-1.083)	6.85151 (.306)
FAMILY CHARACTERISTICS		
Mother's Education	1.69782 (.787)	-7.62245 (-.747)
Mother's Hours Worked	.0640011 (.239)	-3.65210 (-1.187)
Family Support Scale	-.131022 (-.380)	.028639 (.096)
Income	-.000292 (-1.359)	.000884 (.339)
Siblings	10.0081 (1.399)	-.920322 (-.121)
Intact	9.03794 (.807)	20.1096 (.662)
EARLY INTERVENTION		
Attendance	-.14680 (-1.325)	-.122709 (-1.335)
Para/Professional	43.5997* (1.733)	90.9901*** (3.900)
Base	-10.7066 (-.382)	126.646*** (4.568)
Base x Attendance	16.7854 (1.335)	.158414 (1.516)
Para/Professional x Attendance	.017885 (.516)	-.007912 (-.269)

(table continues)

Explanatory Variable	OLS B	SMM B
RESIDUALS		
Base		-134.204*** (-8.830)
Para/Professional		-57.0503*** (-4.526)
Income		-.001214 (-.470)
Mother's Hours Worked		4.05997 (1.312)
INTERCEPT	87.0645*** (2.692)	50.1721 (.441)
R2	.60093	.69140
F-TEST	41.9618	48.8171

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 13

Ordinary Least Squares and Sequential Method of Moments Estimates for the Posttest BDI Raw Score Personal/Social Domain^

Explanatory Variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-2.82313 (-1.179)	-3.77002* (-1.656)
Age	1.26439*** (12.565)	.853629*** (7.077)
Birth Order	-3.78418* (-1.709)	-3.47704 (-1.636)
Ethnicity	-5.02320 (-1.242)	3.73399 (.440)
FAMILY CHARACTERISTICS		
Mother's Education	1.28302** (1.927)	-2.88337 (-.708)
Mother's Hours Worked	-.000997 (-.012)	-.816390 (-.680)
Family Support Scale	.075485 (.751)	.100301 (1.014)
Income	-.000026 (-.377)	.006563 (.620)
Siblings	3.63899 (1.565)	1.73848 (.627)
Intact	5.44118 (1.536)	1.20505 (.104)
EARLY INTERVENTION		
Attendance	-.094320* (-1.718)	-.062177 (-1.169)
Para/Professional	7.19584* (1.693)	27.9059*** (5.058)
Base	1.30015 (.213)	13.7699** (2.226)
Base x Attendance	.098808* (1.754)	.070704 (1.30)
Para/Professional x Attendance	.013649 (1.435)	.007976 (.906)

(table continues)

Explanatory Variable	OLS B	SMM B
RESIDUALS		
Base		-16.6106*** (-4.237)
Para/Professional		-19.8780*** (-5.181)
Income		-.000686 (-.654)
Mother's Hours Worked		.843229 (.700)
INTERCEPT	11.6188 (1.194)	48.18 (.978)
R2	.588106	.62839
F-TEST	39.7883	36.8454

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 14

Ordinary Least Squares and Sequential Method of Moments Estimates for the Posttest BDI Raw Score Adaptive Domain^

Explanatory Variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-1.66625 (-1.158)	-2.36483* (-1.772)
Age	.813031*** (14.672)	.488456*** (6.971)
Birth Order	.425930 (.297)	.652781 (.478)
Ethnicity	-1.68870 (-.663)	3.36907 (.735)
FAMILY CHARACTERISTICS		
Mother's Education	.145103 (.348)	-1.64504 (-.740)
Mother's Hours Worked	-.013391 (-.269)	-.976953 (-1.453)
Family Support Scale	-.011675 (-.178)	.020358 (.330)
Income	-.000027 (-.707)	.000217 (.378)
Siblings	.951251 (.665)	-1.10072 (-.668)
Intact	2.29040 (1.106)	4.31617 (.677)
EARLY INTERVENTION		
Attendance	-.070202* (1.880)	-.042031 (-1.282)
Para/Professional	5.48824** (2.017)	21.0560*** (5.949)
Base	-4.41371 (-1.141)	5.73772 (1.512)
Base x Attendance	.076126** (1.989)	.051625 (1.540)
Para/Professional x Attendance	.004758 (.790)	-.000072 (-.013)

(table continues)

Explanatory Variable	OLS B	SMM B
RESIDUALS		
Base		-13.1072*** (-5.791)
Para/Professional		-14.9970*** (-6.213)
Income		-.000241 (-.424)
Mother's Hours Worked		.989904 (1.468)
INTERCEPT	20.0638*** (3.348)	36.8254 (1.513)
R2	.560677	.631607
F-TEST	35.5642	37.3579

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 15

Ordinary Least Squares and Sequential Method of Moments Estimates for the Posttest BDI Raw Score Motor Domain^

Explanatory Variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-7.20111*** (-3.024)	-8.41301*** (-3.847)
Age	1.15333*** (12.279)	.636868*** (5.562)
Birth Order	-.317322 (-.139)	-.096160 (-.045)
Ethnicity	.617610 (.132)	5.24554 (.644)
FAMILY CHARACTERISTICS		
Mother's Education	-.181945 (-.271)	.529902 (.143)
Mother's Hours Worked	.015993 (.198)	-1.11837 (-1.054)
Family Support Scale	-.231901** (-2.224)	-.160814* (-1.676)
Income	-.000012 (-.190)	-.000520 (-.546)
Siblings	1.93149 (.868)	-.735032 (-.293)
Intact	-.236151 (-.068)	13.5710 (1.262)
EARLY INTERVENTION		
Attendance	-.171591*** (-2.632)	-.118430** (-1.991)
Para/Professional	10.6933** (2.315)	38.9798*** (6.731)
Base	-13.5120** (-2.114)	1.40169 (.215)
Base x Attendance	.176681*** (2.642)	.129979** (2.136)
Para/Professional x Attendance	.012974 (1.288)	.004049 (.452)

(table continues)

Explanatory Variable	OLS B	SMM B
RESIDUALS		
Base		-18.4097*** (-4.934)
Para/Professional		-27.4862*** (-7.125)
Income		.000519 (.549)
Mother's Hours Worked		1.18386 (1.114)
INTERCEPT	46.2607*** (4.779)	35.3753 (.88)
R2	.509307	.593746
F-TEST	28.9237	31.8457

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 16

Ordinary Least Squares and Sequential Method of Moments Estimates for the Posttest BDI Raw Score Communication Domain^

Explanatory Variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-2.69459** (-1.980)	-3.29213*** (-2.576)
Age	.656006*** (11.648)	.423878*** (5.743)
Birth Order	-2.46128** (-1.988)	-2.34357** (-1.927)
Ethnicity	-4.90408** (-2.093)	-.311324 (-.061)
FAMILY CHARACTERISTICS		
Mother's Education	-.114669 (-.320)	-1.68425 (-.675)
Mother's Hours Worked	.044652 (1.010)	-.189286 (-.282)
Family Support Scale	.023923 (.401)	.042027 (.725)
Income	-.000073* (-1.777)	.000088 (.137)
Siblings	2.47813** (1.961)	1.78327 (1.154)
Intact	.650613 (.313)	.331864 (-.047)
EARLY INTERVENTION		
Attendance	-.015555 (-.503)	.005029 (.193)
Para/Professional	7.30672*** (3.204)	20.8426*** (7.390)
Base	-1.28000 (-.380)	5.07549 (1.458)
Base x Attendance	.019448 (.616)	.001257 (.047)
Para/Professional x Attendance	-.001517 (-.282)	-.005132 (-1.023)

(table continues)

Explanatory Variable	OLS B	SMM B
RESIDUALS		
Base		-8.30629*** (-3.704)
Para/Professional		-13.0999*** (-6.499)
Income		-.000163 (-.256)
Mother's Hours Worked		.251365 (.374)
INTERCEPT	17.4687*** (3.213)	28.6184 (1.062)
R2	.497291	.550787
F-TEST	27.5663	26.7164

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

Table 17

Ordinary Least Squares and Sequential Method of Moments Estimates for the Posttest BDI Raw Score Cognitive Domain^

Explanatory Variable	OLS B	SMM B
CHILD CHARACTERISTICS		
Gender	-3.16946*** (-2.825)	-3.58018*** (-3.353)
Age	.647130*** (13.015)	.483367*** (7.655)
Birth Order	-1.70837 (-1.508)	-1.63098 (-1.455)
Ethnicity	-2.26959 (-1.199)	.686514 (.179)
FAMILY CHARACTERISTICS		
Mother's Education	.069706 (.232)	-.732356 (-.400)
Mother's Hours Worked	.003889 (.106)	-.264109 (-.504)
Family Support Scale	-.030413 (-.584)	-.014457 (-.286)
Income	-.000057* (-1.872)	.000002 (.005)
Siblings	1.67827 (1.508)	1.02195 (.804)
Intact	2.55467 (1.561)	3.49295 (.664)
EARLY INTERVENTION		
Attendance	-.034145 (-1.184)	-.018949 (-.707)
Para/Professional	7.86525*** (4.093)	17.2607*** (6.766)
Base	-6.51293** (-2.293)	-1.98858 (-.667)
Base x Attendance	.039538 (1.343)	.002616 (.960)
Para/Professional x Attendance	.001332 (.302)	-.001315 (-.314)

(table continues)

Explanatory Variable	OLS B	SMM B
RESIDUALS		
Base		-5.82028*** (-3.213)
Para/Professional		-9.11894*** (-5.142)
Income		-.000058 (-.125)
Mother's Hours Worked		.281427 (.538)
INTERCEPT	10.4341** (2.364)	16.0464 (.819)
R2	.553573	.586778
F-TEST	34.5549	30.9413

^ T-statistics are presented in parentheses
* Significance at .10 or less
** Significance at .05 or less
*** Significance at .01 or less

estimated from the probit auxiliary equations are also statistically significant in the structural equation. Thus, differences observed at posttest may be traced back to the influence of factors like pretest scores that are now indirectly incorporated into the estimates through these residuals.

Child Characteristics

Children who were older at pretest have higher scores at posttest, a finding that is consistent across all domains for all OLS and SMM estimates. Girls in the sample scored significantly lower than boys in all of the posttest analyses except the OLS personal social and adaptive domains. None of the other child characteristic variables is statistically significant for posttest BDI total scores, although **birth order** is significant in the personal social OLS estimate and in the OLS and SMM estimates for the communication domain. Similar to the pretest results, the relationship between BDI scores and **birth order** is negative. The relationship of **ethnicity** to posttest scores is weakened in comparison with the pretest findings showing significance only in the OLS regression on communication scores.

Family Characteristics

None of the family characteristics variables is statistically significant in the posttest total BDI estimates, as shown in Table 12. **Siblings** has a significant negative influence on cognitive and communication scores in the OLS regression estimates, although this significance disappears in the SMM estimates. The OLS estimates also indicate a negative relationship between **income** and communication scores and a positive relationship between personal social skills and **mother's education** at posttest that do not appear in the SMM model. In fact, the only family characteristic that is statistically significant in the SMM estimates is the **FSS**, which is negative in the OLS and SMM motor domain.

Early Intervention

The SMM and OLS estimates of **attendance** suggest that changes in attendance do not significantly affect BDI total scores. The OLS parameter estimates for **attendance** are significant in the OLS personal social, adaptive, and motor BDI domains, although these estimates may be biased because of the endogeneity of **para** and **base**. Only the SMM estimate for the motor domain is statistically significant, and it is negative.

The influence of changes in attendance for children in professional programs, represented by **para x attendance,** is not significant. Increasing service hours in professional programs has no significant influence on BDI scores. However, the interaction between **attendance** and **base** is statistically significant and positive for each of the estimates for which the direct effect of **attendance** is significant. This suggests that although increased attendance has some negative influence on scores, influence is positive for center-based programs.

Para is the early intervention variable that is most consistent in sign and significance. All estimates of the effects of professional programs are significantly positive. The SMM results in increased significance for this variable when compared with the OLS model. Early intervention services provided by professionals have a positive influence on child outcomes.

The personal social and total BDI scores of children in center-based programs are significantly higher than those of children in home-based programs, as measured by the SMM parameters for those scores. The OLS estimates for **base** are significantly negative for the motor and cognitive domains, while the SMM estimates are not statistically significant. Communication and adaptive skills are not significantly influenced by center-based early intervention services in either the OLS or the SMM estimates.

Discussion

The OLS and SMM models, if examined separately, lead to different conclusions about some of the child, family, and early intervention variables that influence child outcomes. Conclusions drawn from the OLS estimates provide different signs, significance levels, and channels of influence than those suggested by the SMM estimates. For example, Table 16 gives the posttest BDI communication estimates. The OLS parameters for **ethnicity** and **income** are negative, while **siblings** is positive. Ethnic children and those from families with lower income have lower communication scores, while children with greater numbers of siblings have higher scores. The OLS estimates may lead to the conclusion that communication scores are lower for ethnic children because of language barriers or because of cultural bias in the BDI communication domain.

The SMM results for **income, ethnicity**, and **siblings** are not significant. The only significant effects of those variables is through the **income, para**, and **base** auxiliary equations. Children who are not Caucasian are selected into paraprofessional, center-based programs, and they come from families with lower income. However, neither **income** nor **ethnicity** has a significant direct effect on communication skills. The conclusion from the SMM results is that ethnicity affects communication skills only indirectly through the auxiliary equations.

The differences between the OLS and SMM estimates show the importance of accurately identifying those that which are truly exogenous from those that are not. It also emphasizes the importance of gathering data that can model those endogenous forces. The SMM estimates presented here may not fully capture the endogeneity of the labor market, however, because the wage rate is not included in the auxiliary equation estimates of **income** and **mother's hours worked.**

There are two possible conclusions that may be reached regarding the observed changes in the OLS estimates when the auxiliary equations are incorporated into the SMM estimates through the generalized residuals. First, the SMM estimates do not fully incorporate the endogeneity of the labor force participation of mothers or family income; like the OLS estimates, they are biased. Second, the SMM estimates are unbiased. Where endogenous forces exist, they have been incorporated into the model and the estimates adjusted by the effects of the generalized residuals. Either of these choices leads to the conclusion that there is evidence of bias in all of the OLS posttest estimates and in the OLS pretest motor domain. Such evidence of bias does not exist for the SMM estimates.

Child Characteristics

Girls score significantly lower than boys on the BDI motor, cognitive, and total scores at pretest and on all BDI measures at posttest. This may be the result of sampling fluctuation, where the girls are more severely disabled than the boys in the sample. It is also possible that gender affects development.

Becker (1975) suggested that investment in human capital occurs up to the point where the marginal cost of investing equals the marginal return. Given evidence of inequalities in the wage rate by gender, where males earn more than females, parents may invest more in male children because the expected return to their investment is greater.

Age of the child is strongly related to BDI scores, and its significance and sign are invariant from the OLS to the SMM estimates. The early intervention literature suggests that age and pretest scores are the two strongest predictors of later child outcomes (Bricker & Dow, 1980; Scherzer et al., 1976; Dunst et al., 1989). Pretest age and BDI scores are incorporated into the model to reduce the bias that occurs for other regression parameters when a relevant explanatory variable is excluded, rather than for the information provided about the effects of these two child characteristic variables on outcomes.

Birth order of the child is one of the relatively invariant variables when the OLS and SMM results are compared. This invariance is not surprising since it is not specified in the auxiliary labor force or early intervention equations. There is evidence that a lower birth order is associated with higher communication scores at pre and posttest. The personal social pretest SMM estimate is also significant and negative.

The fact that the communication domain shows the strongest coefficient lends credibility to a relationship between **birth order** and development because literature supports this finding. A literature review on sibling relationships stated that numerous birth order studies have shown that first-born and only children score higher on communication measures than other children (Dunn, 1983). At least one study found differences in cognitive scores, with first-born and only children scoring higher than those who were born later (Zajonc & Marcus, 1975). While the cognitive domain results are equivocal for

birth order, the communication domain results suggest that low birth order benefits children with disabilities.

Birth order studies have suggested that a first-born or only child has better communication skills than a child who has older siblings because they benefit from more adult attention. This implies that a child's communication with a parent is more stimulating to language development than that of an older sibling. Two studies that have examined differences between parents' address to children and children's address to other children found many similarities and some important differences. Mothers asked more questions than children. Mothers also made fewer statements when talking with their child than the children who were caregivers (Harkness, 1977; Snow & Ferguson, 1977). Harkness suggested that the questioning style of mothers required more speech of their child and thus enhanced language development.

The OLS estimates for **ethnicity** at pretest are significant for all of the domains except adaptive and motor, while the SMM pretest shows significance only in the motor domain. None of the SMM posttest results is significant. Also, **ethnicity** is significant in the **income** reduced form equation. However, **income** does not significantly effect these areas of child development so the link between personal social, cognitive, and communication development and ethnicity is broken. **Income** and **ethnicity** are significant in the SMM pretest motor domain. Pretest motor scores are jointly determined by **ethnicity** and **income.** Also, **ethnicity** affects pretest motor scores directly and through its effect on **income.**

Family Characteristics

Very few of the estimated parameters for the family characteristics variables are statistically significant. The estimates for the **Family Support Scale** (FSS) are invariant in the OLS and the SMM models. While higher pretest BDI personal social skills are associated with lower scores on the FSS, the opposite is true for the pre- and posttest motor domain scores.

The differences for personal social skills are not maintained at posttest, which may reflect random fluctuation in the sample. This possibility is also supported by the fact that most of the estimates, at pre- and posttest, are not statistically significant, although there is strong correlation between the BDI domains. The FSS measures the number of sources of support that the family receives and the degree of helpfulness of those sources. The early intervention services that are included in the posttest estimates are possible sources of support for the families at posttest. The influence of the early intervention variables may begin to capture the variance in personal social skills that were explained by the FSS at pretest.

The motor score estimates suggest that families who have children with relatively severe motor delays have more sources of support. While the authors of the FSS suggest a positive relationship between more supportive social networks and child development, the number of sources of support and degree of helpfulness of those sources may possibly increase for more severely impaired children. Severe motor impairment usually implies more intensive child services, such as physical and occupational therapy. The FSS asks specifically about the degree of helpfulness of professional helpers (social workers, therapists, teachers, etc.), school/day care center, professional agencies (public health, social services, mental health, etc.) and specialized early intervention services.

In a study of the effects of social support on developmental progress, Dunst, Trivette, and Cross (1986) concluded that number of sources of support was positively related to the progress of children with disabilities. This study deviates from the Dunst et al. (1986) study in that the measure of child outcome is not the gain score but raw scores. Estimates of the effects of the FSS on BDI gain scores that were made show no statistically significant effect of the FSS on child developmental progress as measured by the difference between pre- and posttest BDI scores. Also, the psychometric properties of the measure used by Dunst et al. (1986) are not known. They administered the five Questionnaire on Resources and Stress child characteristics scale to families, which includes questions on physical, social, and behavioral problems as well as on use of community resources.

Education of the mother is significant in all of the auxiliary equations except **mother's hours worked.** Families with higher educated mothers have higher income, and their children are more likely in professional, center-based early intervention programs. **Mother's education** has little direct influence on child outcomes. The SMM estimate is significant and positive only in the motor domain at pretest.

Income and **pretest motor BDI scores** are jointly determined by **mother's education, intact,** and **ethnicity.** These socioeconomic variables are not statistically significant in any of the other SMM estimates. They are significant in the one equation where there is evidence of the endogeneity of **income**. Why are motor skills more subject to the influence of socioeconomic variables than the other skills assessed by the BDI? Why are posttest motor skills not significantly affected by **income**, **intact**, **ethnicity**, and **mother's education**?

One answer to both of these questions is that the motor estimates reflect random fluctuation in the sample. In support of this answer is the argument that motor skills are an important influence on other areas of development, such as adaptive and cognitive behavior. Differences in other skills are not observed for children in the sample by socioeconomic status (SES). A different explanation may be that low SES causes medical complications that are sources of motor delay. Since SES and motor impairment are not related at posttest, this explanation implies that motor delays and SES factors that are the source of those delays are remediated by the early intervention services provided between pre- and posttest scoring. There is evidence that premature births and medical complications, such as intraventricular hemorrhage (IVH) and low birthweight, are related to prenatal care, ethnicity, and other SES factors. Low birthweight, IVH, and other neurological problems show a high incidence of developmental delay. More severe hemorrhage is correlated with significant motor impairment. There is also evidence that severe hemorrhage is associated with low average cognitive scores. Some evidence exists to suggest that physical as well as cognitive delays can be remediated by early intervention services. For more information on this literature, see Infant Health and Development Program (1990); Resnick, Eyler, Nelson, Eitzman, and Bucciarelli (1987); Elghammer (1988); Millard

(1987); and Wingate-Corey (1988). In sum, the second answer is possible, although its credibility lessens when no significant differences on cognitive or other domains are apparent.

The fact that socioeconomic factors, such as **income, intact, ethnicity**, and **mother's education**, do not greatly affect child development is not surprising when considering the sample population. Broman and Nichols (1975) examined the relationships between mental development in preschool and school-age children and social indicators for black and white children. They found a curvilinear relationship between socioeconomic status and IQs. Specifically, when the child's disability was severe, families had higher socioeconomic indices than families with children of moderate or mild delay. They concluded that this relationship likely resulted from profound delays that are genetically based and independent of SES, **mother's education**, and other demographics, while mild disabilities are not independent of these factors. The population that is the focus of this study includes children with relatively severe disabilities. The results of this analysis indicate that the abilities of the children in the sample do not vary significantly with respect to socioeconomic variables. The estimated influence of SES forces may be biased if they are endogenous to child outcomes. Endogeneity could also explain the results in the literature because the studies of the influence of SES on child development for children with disabilities have not tested the endogeneity of those factors.

Siblings has a statistically significant influence on Pretest BDI Communication Scores in four of the OLS estimates but in only one of the SMM estimates. **Siblings** is also statistically significant in the

mother's hours worked auxiliary equation; however, no evidence exists that **mother's hours worked** affects child outcomes, either directly or indirectly. In her review of the sibling literature, Dunn (1983, p. 800) concluded that we are in no position to draw clear conclusions about the "developmental significance of sibling caregiving, teaching, language, or attachment." She also cites a few studies that have found a negative correlation between the time children spend with other children, as opposed to time spent with adults, and language development. Birth order and sibling studies provide some evidence that adult-to-child communication benefits child communication development more than child-to-child interaction. However, very little is known about the effects of nondisabled siblings on the development of their disabled siblings (Boyce & Barnett, 1991). The results presented here suggest that the impact of **siblings** is very small in comparison with other variables such as precondition of the child.

Early Intervention

The posttest BDI results, Tables 12-17, show relationships between the early intervention variables and child outcomes. The test of weak exogeneity of **para** and **base**, discussed earlier, provides evidence that the posttest BDI OLS results are biased. The discussion that follows will focus on the SMM results for the early intervention variables, since there is no evidence of bias in those estimates.

All of the signs for **attendance**, except in the communication domain, are negative, and none is statistically significant except in the motor domain. Without differentiating the type of services provided to children (i.e., whether provided by professionals or paraprofessionals and whether provided in a center- or home-based setting), early intervention service hours have little impact on child outcomes.

The motor domain shows a decrease in scores as service hours are increased. The interaction between **base** and **attendance** is significant and positive. Motor scores increase as center-based attendance increases; thus, implying that the negative relationship between attendance and motor scores occurs for children in home-based programs. It is possible that increased severity in the motor domain resulted in an increase in the number of service hours for children in home-based programs. This provides a logical explanation for the negative relationship between **attendance** and **posttest BDI motor** scores. This is the only domain where the interaction of **attendance** with either **para** or **base** is statistically significant. Changing the number of service hours for children in programs that are center-based professional or paraprofessional or home-based professional or paraprofessional has little impact on posttest scores. This result is limited to the range of service hours examined in this data set. The range is 60 to 728 hours for professional, center-based services and 318 to 1638 hours for paraprofessional, center-based services. Home-based service hours range from 10 to 157 hours for professional programs and from 5 to 120 hours for paraprofessional programs. The results presented here provide no evidence about the effects of early intervention services that fall outside of these service hour patterns.

Elasticities of **posttest BDI** with respect to **attendance** total scores were calculated in order to evaluate the overall influence of a change in attendance hours for children in different types of early intervention programs. These elasticities were calculated at the mean values of **attendance** and **posttest BDI total** scores for children in the four program types--center-based professional, center-based paraprofessional, home-based paraprofessional and home-based professional. The results show positive, although small, elasticities for center-based programs. The center-based professional program elasticity is .03, while the center-based paraprofessional program elasticity is .17. The elasticity for home-based professional programs is -.04 and for home-based paraprofessional programs -.02.

These elasticities support the conclusion that changes in **attendance** have a very small influence on posttest BDI total scores. They also support the conclusion, discussed above for the motor domain results, that increasing the hours of service has a positive effect on the scores of children in center-based programs and a negative effect on the scores of children in home-based programs. These influences are very small because the estimated coefficients for **attendance** and for the interactions between **attendance** and the variables, **para** and **base**, are very small. The parameter estimate for the direct effects of **para** and **base** are much larger but are not contained in the differentiation of BDI scores with respect to **attendance.**

The largest estimated elasticity is for the children who attended paraprofessional, center-based programming in New Orleans. Estimates of the child, family, and early intervention characteristics, which include the square and cube of **attendance,** support that result. The SMM BDI total score estimates, with the polynomials included, show statistical significance for the cubic attendance term (p-value = .03), although the parameter estimate is very small, so the inclusion of the polynomials does not significantly alter the elasticity estimates discussed earlier. The estimates, with the attendance polynomials, are positive for the linear **attendance** term and negative for quadratic **attendance** term, although neither is statistically significant. The result for the cubic **attendance** term provides some support for the "threshold hypothesis," which suggests that only at very high levels of early intervention service provision are child scores significantly affected by services. The paraprofessional, center-based services provided in New Orleans were the most intensive since services were available to children 6 hours per day, 5 days per week.

The relationship between **attendance** and **posttest BDI total** scores is shown in a scatter plot in Figure 1. This figure includes all of the children in the sample and gives some indication of how the data influence the relationships that are obtained in the SMM coefficient estimates with attendance polynomial terms included in the model. Posttest BDI scores increase in attendance to a point, then decrease, but then increase again at very high levels of attendance. Figures 2-5 show the relationship between **posttest BDI total** scores and **attendance** for children in the four different program types. Figure 2 plots the relationship between **attendance** and **posttest BDI scores** for Program 1, which includes those subjects in professional and center-based programs. Figure 3 incorporates the relationship between **posttest BDI scores** and **attendance** for paraprofessional, center-based programs (Program 2); Figure 4 shows the same relationship for professional home-based programs (Program 3); and Figure 5 plots the relationship for paraprofessional home-based programs (Program 4). Comparison of Figure 2 with the other three figures confirms that the BDI scores of

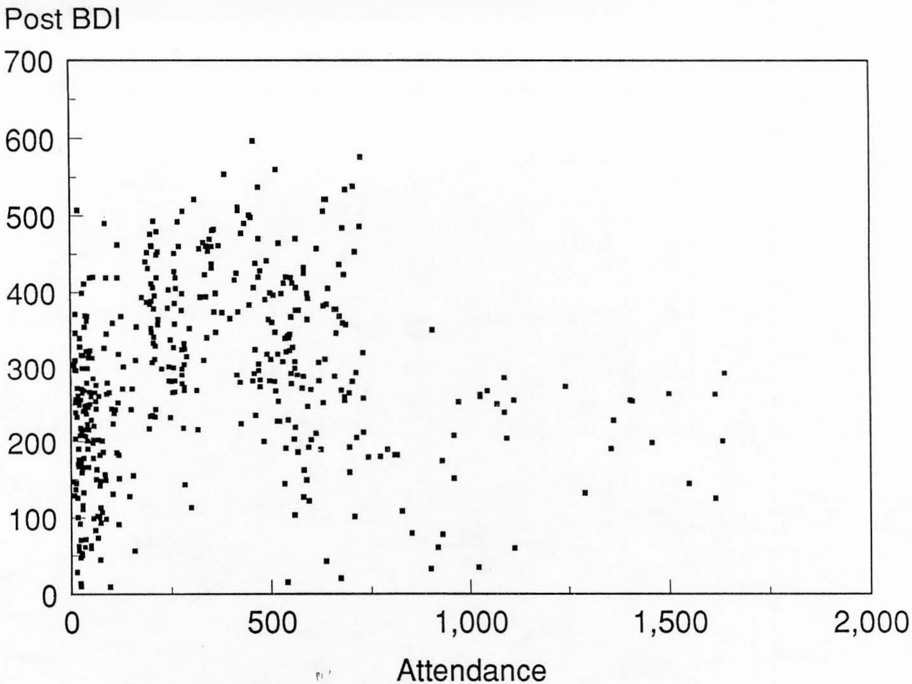

Figure 1. Relationship of post BDI and attendance

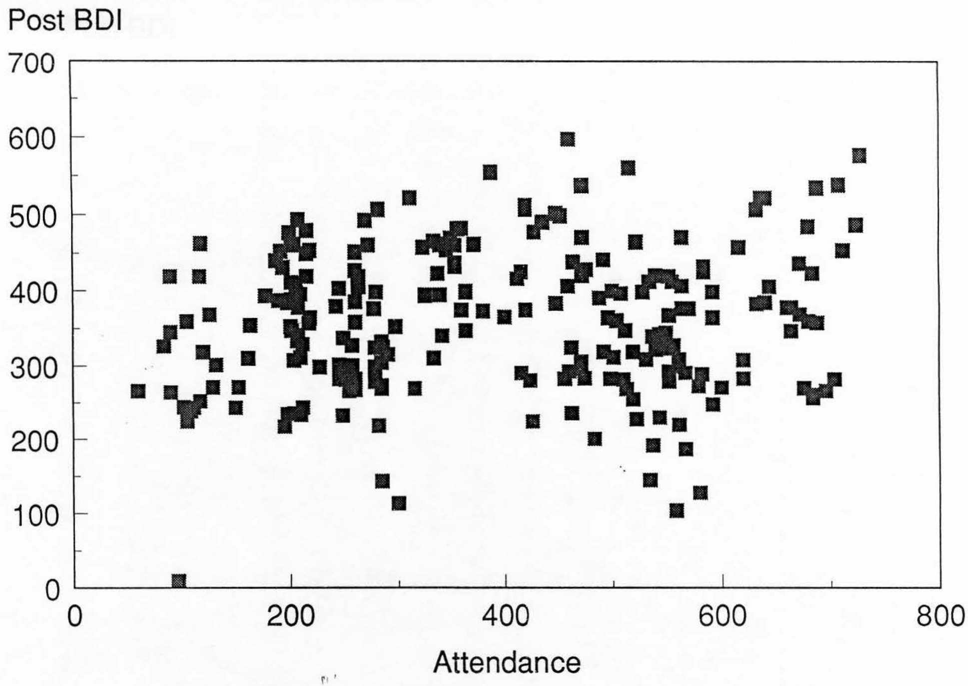

Figure 2. Plot of post BDI and attendance--Program 1

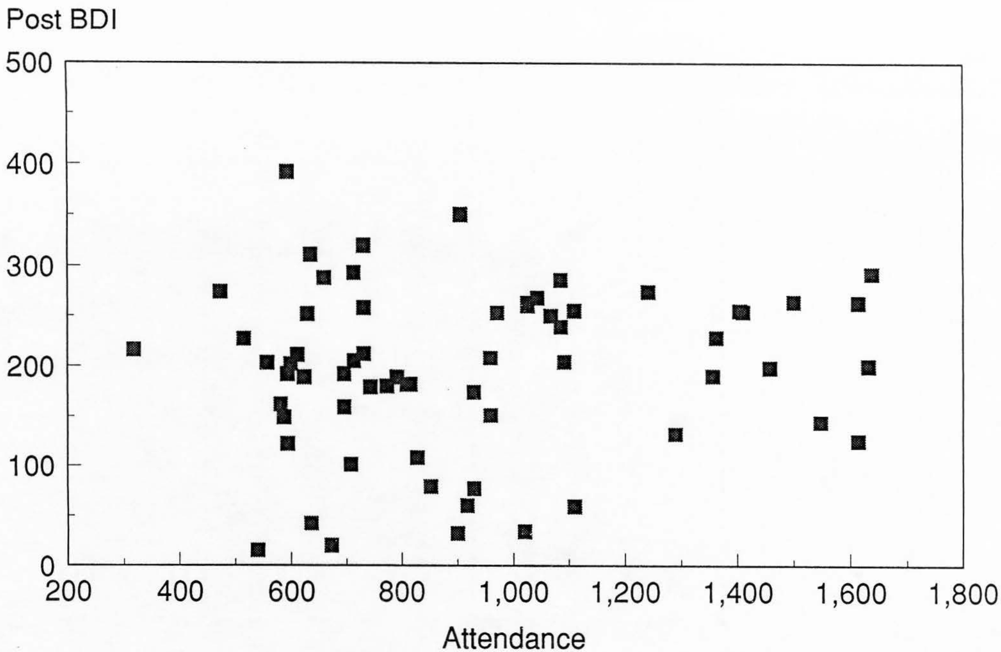

Figure 3. Plot of post BDI and attendance--Program 2

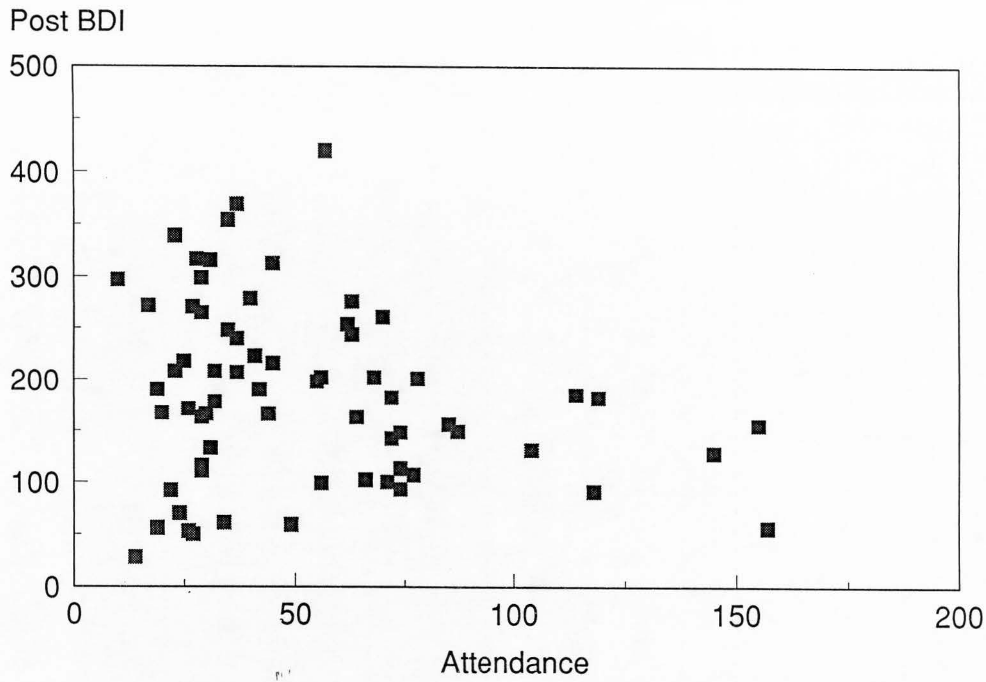

Figure 4. Plot of post BDI and attendance--Program 3

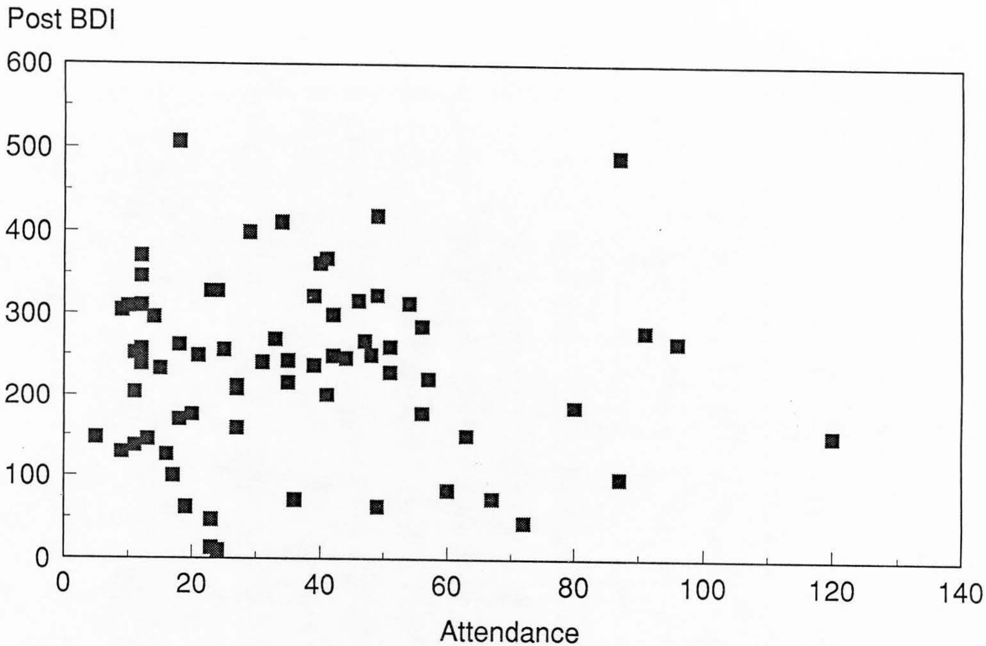

Figure 5. Plot of post BDI and attendance--Program 4

children in professional, center-based programs are above those of children in the other programs. The plots also show the absence of a strong relationship between **posttest BDI scores** and **attendance.**

The data provide clear evidence that children who received early intervention services from professionals have significantly higher scores in all areas of the BDI, relative to children who received services from paraprofessionals. **Mother's education**, **ethnicity**, **gender**, and **pretest total BDI** scores positively influence a child's selection into professional programs. Since professional programs and posttest BDI scores are related, then all four of these significant variables in the **para** auxiliary equation indirectly influence posttest scores (i.e., all of these variables influence the probability of being in a program with professionals who administer the intervention services). Children with milder delays, who are female and Caucasian, and whose mothers have higher education levels are more likely to be observed in professional programs and show higher BDI posttest scores.

One of the issues that has received much attention in the educational production function literature is whether the distribution of school resources has a significant impact on child and on adult achievement later. Inequalities in the provision of education in the United States exist. Some schools and the children they serve have the latest equipment, modern facilities for classes, and low student: teacher ratios, whereas others are characterized by high rates of crime, teacher shortages, and outdated equipment. A direct relationship from such inequalities to student achievement is difficult to determine, as shown by the debate that surrounded the findings of the Coleman Commission in the 1960s (Coleman et al., 1966; Bowles &

Levin, 1968a, b). The importance of school resources and family background is difficult to separate since they may be intercorrelated.

Assuming that **para** accurately reflects differences in school resources, then the relationship between achievement, family SES, and school inputs can be drawn for the families and children in this data set. Paraprofessionals, rather than professionals, provide services when there are personnel shortages or when there are insufficient funds to cover the cost of more expensive professional employees. The schools that are most likely affected by personnel shortages, which put upward pressure on wages, are those with a lower tax base and fewer resources to expend on more expensive professional staff. Many variables reflect school inputs that are missing from the data, such as program cost, quality of educational staff as reflected in experience, salaries, and more. However, the statistically significant estimates for SES variables in the **para** auxiliary equation and for **para** in the SMM results at posttest may provide evidence of an empirical link from differences in family background to changes in child outcomes.

Children whose mothers are more educated, who live with one parent, who are older, who have higher pretest BDI scores, and who are not Caucasian are more likely to be selected for center-based programs. These child and family characteristics combine with center-based programs to jointly and positively influence posttest BDI total and personal social skills. In general, center-based programs are designed for older children who, all other things being equal, have higher BDI scores at pretest. Older children are more likely to have older parents who have completed more years of education. New Orleans, where most of the ethnic families reside, provided center-based early intervention services.

Home-based programs usually require the presence of parents, while center-based do not. This means that center-based programs provide respite or "free" daycare for families. Children in center-based programs were bused to schools, then went to classrooms with other children. This interaction with children of similar age could improve the personal social skills of children in center-based programs relative to those in home-based intervention where such interaction with peers would not always occur. It is a little surprising that BDI total scores are significantly different given that only one of the domains shows significant differences. This result probably derives from the combination of personal social skill differences and the adaptive and communication domains which, while not statistically significant, show strong positive relationships to **base.**

CHAPTER VI

CONCLUSIONS

The early intervention literature for children with disabilities suggests that the strongest predictors of child outcomes are age and severity of delay. The findings presented here do not refute those results, although they suggest that age, severity, and certain SES variables are not separate from the type of early intervention programming that a child receives. The type of programming combines with severity, age, and socioeconomic variables to determine the child's personal social, adaptive, motor, cognitive, and communication functioning.

Differences in SES have little direct influence on child outcomes, although isolated differences appear for other child and family variables. Some evidence exists that **birth order** affects communication and personal social scores, which is consistent with previous findings in the literature for nondisabled children. Parents interact with first-born children differently than they interact with those who are born later and in a way that positively influences these skills. This finding suggests that parent interaction styles significantly influence child communication functioning. Capturing that difference and teaching parents to use it with later-born children may be the policy prescription from this finding. Investigation of the relationship between **birth order** and child outcomes in future studies with children who have disabilities is needed before clear conclusions can be drawn from this result. The effects of **birth order** were found at pre- and posttest in only the communication domain and were not verified in the other skill areas measured by the BDI.

Girls have lower BDI scores at pre- and posttest than boys. Girls are also more likely in professional programs than boys. There are several possible explanations for this result. First, the difference may be due to random fluctuation in severity. The greater severity in the girls included in this sample may not be fully adjusted at posttest by incorporating pretest BDI total scores in the axillary equation. There is no adjustment for differences in severity at pretest, either directly or indirectly, due to the correlation of pretest scores to the child-specific error term. Second, the literature suggests that labor market participation of mothers differentially impacts girls and boys. There is also evidence that the effects of labor force participation vary depending on the income of the family (Desai et al., 1989). It is possible that these labor force influences are not fully incorporated into the model since the labor market axillary equation registers a very low R^2 that does not include information about the wage rate, an important labor market indicator. Third, there may be greater investment in the human capital for boys relative to girls because the expected rate of return is higher for boys. This possibility loses some credibility here since girls are more likely to be placed in professional programs than boys.

The influence of **attendance** confirms earlier work done at the Early Intervention Research Institute (White, 1991). The latter results were based on test score comparisons within each site for children in two groups, representing two intensities of early intervention services. Analysis of covariance resulted in few positive effects of the different early intervention treatment on families and children; however, the analysis was not made across sites nor did it address factors other than early intervention service differences.

This study did not examine whether some quantity of intervention is preferred to no intervention. All of the children in the sample received intervention services. The evidence suggests that more intervention, in terms of increased attendance, shows no positive or significant influence on BDI scores. There is some evidence that more service hours began to have a positive influence when provided in very large quantities (i.e., 6 hours per day, 5 days per week). Variations in program intensity, as measured by the number of service hours, have a significant positive relationship to motor functioning for center-based programs. This relationship may possibly result from differences in home-based occupational and physical therapies that are provided more intensively to children who have more severe motor impairment. All of the elasticities of scores with respect to **attendance** are less than one and at least half are negative. The largest elasticity is .17, providing little support for the proposition that increased attendance positively influenced the BDI scores.

The current, cross-site analysis was necessary to incorporate the comparison of professional and paraprofessional early intervention program services and center- versus home-based services. Results show that the early intervention program variable with the strongest influence on development is professional service delivery, but selection into such programs appears to be jointly determined with the BDI outcome. Center-based programs are related to some areas of child functioning when combined with certain child and family characteristics.

Most of the family characteristics examined do not directly influence child outcomes. The effects of differences in **ethnicity** and **mother's education** on outcomes are through their effect on the type of service the child and family receive.

The results provide evidence that professional programs are related to higher outcomes for families and children with relatively well-educated mothers, mild disabilities, and families that are Caucasian. The data do not provide evidence of the efficacy of services provided by professionals to relatively severely disabled children from families who are not Caucasian and whose mothers are less well educated. Whether professional programs are equally beneficial to children of different severity or to families of different SES is unclear because these factors are not separable for this data set. Previous research suggests that schools may identify or screen more able students rather than changing the abilities of students (for more information on this literature see, Hanushek, 1978). The selection of disabled children into professional programs by SES and severity may be a screening mechanism of early intervention programs.

This study has incorporated measures of qualitative and quantitative differences in educational services. The variables include **para**, **base**, and **attendance.** While these variables provide information about how different services influence child outcomes and which children and families are in different types of programs, they cannot capture all of the qualitative differences in the seven programs in the data set. Evidence about the effects of qualitative differences in schooling is scarce in the literature (Hanushek, 1978). The incorporation of variables, such as cost per child and teacher experience, would provide valuable evidence missing in this study. The evidence for **para** does not conclusively show that professional programs should be provided to all children with disabilities and that an increased role for state and federal government is needed to ensure that resources are distributed more equally; however, it does suggest that further investigation of the relationship between early intervention resources, SES, and child outcomes is needed.

Several questions must be investigated before the full policy implications of these findings can be determined. First, are professional programs equally effective for children of differing SES and severity levels? Second, are professional program services cost-effective for children and families? A program is cost-effective if, for a given cost, it results in higher outcomes or if the same outcome can be achieved at a lower cost than an alternative program. Cost-effectiveness studies, which stratify by severity and SES and then randomly assign children to professional and paraprofessional program services, could help answer these questions.

The SMM estimation procedure helped to account for differences in severity of the child. There is evidence that the reduced forms for **para** and **base** are jointly determined with the posttest BDI outcome. A child's selection into a professional, center-based program occurs simultaneously with a higher BDI score. The SMM helps address the problem by incorporating the effects of severity, as measured by pretest BDI scores, indirectly through the axillary equation estimates; however, the SMM estimates do not fully address the problems of the data. First, the labor force participation of mothers is not fully explained in the Tobit estimate of hours worked by the mother. The lack of wage rate data may result in an inability to fully describe this variable. Second, the influence of severity may not be fully explained by using pretest BDI scores as instruments in the axillary equations. The main effects of pretest BDI were not controlled, in either the OLS or SMM estimation results. Third, the pretest estimates assume that the influence of early intervention prior to pretest at zero. It is beyond the scope of this study, but an investigation should be made of estimation of the average treatment effect of these types of intervention programs, including an examination of intervention relative to a control group without intervention. In addition, different forms of control samples need to be investigated relative to the case where intervention follows stages of intervention intensity on a continuum. Some methodological suggestions along these lines are now appearing in the literature (Angrist & Imbens, 1991), but considerably more conceptualization must be done.

Early intervention programs are particularly difficult to evaluate because they provide services to very young children. The age of these children limits the measures of outcome that are available. There are no immediate measures of market success, such as wage rate or productivity in the labor market. While test scores are widely used to measure school output, no clear evidence exists that links test scores to later achievement (Hanushek, 1986). In fact, Bowles and Gentis (1976) found that cognitive differences or IQs do not explain much of the observed variation in individual earnings. Longitudinal studies of early intervention are one way to address these issues. Following children from birth through their entry into the labor market could address several issues, including the relationship of test scores to later achievement and the efficacy of early intervention and other educational services to child IQ, labor market productivity, SES, and other issues; however, such data are costly and available only for a small sample of children. The type of multivariate analysis undertaken here would be difficult, if not impossible, because of the loss of degrees of freedom in the analysis.

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Goetze, L. (1990, April). Child and family effects and costs of a parent involvement curriculum. Paper presented at the National Association of School Psychologists.

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PUBLICATIONS AND REPORTS

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