THE BENEFITS OF SCHOOLING AND THE OPPORTUNITY COST OF EDUCATION ON THE FAMILY FARM: EVIDENCE FROM PAKISTAN

by

Gerald E. Cox

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Economics)
in The University of Michigan
1999

Doctoral Committee:

Professor David Lam, Chairperson
Professor Robin Barlow
Professor Charles Brown
Harold Alderman, Principal Economist, The World Bank

UMI Number: 9929805

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

for my parents	—	who, I believe, did a rather good job under some pretty tough conditions;
for the Abelsons	—	who, through their example, provided endless encouragement;
for Phuong Ha	—	who was always supportive of my graduate work, and who was occasionally patient with my progress;
and for Ed and Edna Cox	—	who assumed many of my responsibilities while I completed this dissertation.

Acknowledgements

I would like to thank the members of my committee for their strong support in the production of this dissertation. Charlie Brown made the initial commitment to backing my efforts and has been an unwavering advocate; I doubt that I would have produced a dissertation without his involvement. David Lam asked the important questions that oriented my work and offered encouragement when it was most needed. Harold Alderman provided me with a great deal of useful advice — advice that a wiser person would have followed more closely. Robin Barlow was kind to a person who he hadn't met.

Like so many others who have gone through the graduate program in Economics at the University of Michigan, I must offer special thanks to Mary Braun. She has fought tirelessly against the predisposition of graduate students to take themselves, and their work, too seriously.

I would also like to thank Dr. Laurie May and Dr. Kathy Utgoff at the Center for Naval Analyses for the remarkable support that they have given me in finishing my degree. I hope that, in time, they will be satisfied with their investment.

Since this dissertation is the final requirement in what is likely to be the final stage of my formal education, it seems appropriate to acknowledge several people who played important roles in my secondary and college education. These include Bill Herold, Gordon Daniels, Burt Saxon, Joan Hayes, Professor Warner Mills, and Professor Lester McAllister. My thanks to all of you.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

LIST OF APPENDICES

Appendix

CHAPTER I

CENTRAL ISSUES IN THE INTERACTION OF SCHOOLING AND THE USE OF CHILD LABOR IN RURAL PAKISTAN

Introduction

Many less developed nations continue to be characterized by low levels of school enrollment and widespread use of child labor. There are strong correlations between these phenomena over time: the decline in the use of child labor that is observed as nations develop almost always occurs along with an increase in school enrollment. These correlations also hold across regions as the use of child labor is higher in rural areas of LDCs and schooling attainment is lower in the countryside.

Although these simple correlations are uncontested, the direction of causality in these relationships is unclear. Several authors have suggested that the allocation of child time is largely determined by the benefits accruing to schooling and the use of child labor.[1] Others have stressed the importance of schooling availability and credit constraints in determining child-time allocation; they observe that poor parents in rural areas are less likely to have access to quality schools and will have less ability to borrow in order to finance investment in human capital.

This dissertation focuses principally on the interaction between investment in primary education and the use of child labor on the family farm. There have been a small number of studies that have examined this trade-off in urban areas, and in the rather uncommon rural areas in which there are child-labor markets. However, this issue has been virtually unexplored in the more typical rural environments in which

[1] See Vlassoff (1991) and Rosenzweig and Evenson (1977) for further discussions on the linkages between fertility, child labor, and schooling.

there is no market for child labor and in which children are employed exclusively on household activities. This lack of analysis is largely due to a scarcity of data since, in the absence of an explicit wage for child labor, analyzing the allocation of children's time between work and schooling requires extensive information on the economic conditions facing farm households and on families' stocks of human and physical capital.

The lack of information on this topic is troubling as the use of child labor on the family farm is far more common than the hiring-out of child wage labor. Moreover, the lessons that can be learned from analyses of child wage labor may tell us little about the use of non-wage child household labor, as the decision to employ children within the family is likely to be very different from the decision to employ them away from the household.

The principal objective of this study is to assess whether the low levels of enrollment and high levels of child labor utilization observed in a rural region of a less developed nation is a supply phenomenon — the result of inadequate availability of schooling and credit — or is demand related — the result of differences in households' capacity to either capitalize on the education of children or profit from the use of child labor. I approach this issue by exploring household demand for both schooling and child labor in agricultural production, and I address three separate questions: 1) whether using child labor on the family farm increases a household's agricultural profits; 2) whether enrollment reduces children's contribution to the household; and, 3) whether formal education benefits those who work in farming. My analysis also permits me to address other questions that are central to this issue: 1) which personal, household, and village characteristics most influence the decision to enroll children in school; 2) which characteristics influence the use of child labor; 3) which inputs to agricultural production act to raise the marginal value of child labor; 4) which policy variables related to the availability and quality of schools affect the decision to enroll children; 5) which family and school characteristics influence the production of cognitive skills; 6) whether schooling outcomes are useful in increasing a farmer's knowledge of agricultural methods; and, 7) whether households adjust fertility as a function of the marginal product of child labor.

There are several significant benefits to developing a better understanding of how families allocate children's time between household work and schooling. This allocation will impact both the wellbeing of the family and the immediate health and nutritional status of children. It will also have more long-lived consequences for the physical and psychological development of children and on their lifelong earnings. It may affect the wellbeing of subsequent generations within a family: if the use of child labor diminishes time spent on schooling, child laborers will likely parent families that are larger, in poorer health, and less educated. Finally, the allocation of child time can profoundly affect the development of national income, income distribution, wealth, and culture.

This analysis is conducted with survey data from rural Pakistan that include a wide range of information on both schools and household agricultural activity. Pakistan provides an ideal environment for examining the manner in which households allocate children's time between school and work, since the use of child labor is widespread throughout the country and primary-school enrollment is optional and far from universal. Moreover, findings of this analysis may have useful implications for many other less developed nations, as patterns of child labor use in Pakistan are similar to those found in other parts of south Asia and the problems the nation faces in improving its educational system are typical of many LDCs.

The Structure of the Dissertation

The first chapter of this dissertation provides information on the sample used in the current analysis, the specific conditions under which Pakistani children work and attend school, and the general issues relating to investment in schooling and the use of child labor in developing nations. I describe the study sample, the information that was gathered in our survey, the key economic and social characteristics of sample households, and the role of children within the Pakistani farm family. I also consider econometric issues with which one must be concerned when quantifying schooling and child labor and measuring the determinants of child-time allocation. Finally, I provide detailed descriptions of both the types of child labor and the characteristics of schooling that are specific to rural Pakistan, discuss the particular interrelationships between schooling and work that are found in this setting, and provide correlations between child labor, enrollment, household attributes, and school characteristics.

Building on the descriptive study of chapter one, in chapter two I provide regression analyses of the household decisions to educate and employ children. I frame this discussion with the specification of a simple, two-period model that predicts how investment in schooling and the use of child labor will respond to changes in prices, household attributes, and schooling characteristics. This model motivates analyses of primary school enrollment, schooling attainment, and the use of child labor. Explanatory variables in these analyses include household farm characteristics, family composition, a measure of human capital among household adults, characteristics of the local schools, and the isolation of the operational holding (as measured by distance to schools and markets). Among the econometric issues of concern are family fixed effects, arising from unobserved similarities among siblings, and the impact of heteroscedasticity in regression analyses of censored data. I compare the factors that drive schooling investment with those that motivate the use of boy labor and begin to sort out some of the income and substitution effects through which these influences affect the time allocation of children.

The third chapter considers the mechanisms through which schooling and child labor impact agricultural profitability. I estimate an agricultural profit function from which I determine the value of boy labor on the family farm, the loss of profits that occurs when boys are enrolled, and the marginal product of cognitive skills. I also estimate a cognitive skills production function from which I determine the rate at which time spent in school is transformed into reading skills and assess which household, village, and school characteristics contribute to the production of schooling outcomes. Since our estimated profit function expresses the costs and benefits of schooling in different units, I use a human capital production function to determine the rise in cognitive skills that results from time spent in education. Under some rather stringent assumptions, I can employ these results to estimate the rate of return to time spent in education for children in farm households.[2] The econometric issues of concern in these analyses include the effects of omitted variables.

In an effort to further specify the linkages between schooling investment and the role of human capital in agriculture, I analyze the results of an experimental test of agricultural knowhow. I assess whether cognitive skills make farmers more efficient in acquiring technical skills in farming, whether school attainment affects acquisition of these skills through avenues other than cognitive skills, and whether there are other characteristics of farmers, their households, or their villages that contribute to the production of farm knowhow.

[2] For discussions of rates of return to education in non-agricultural sectors of Pakistan, see Khan and Irfan (1985), Kozel and Alderman (1990), Shabbir (1994), and Alderman, Behrman, Ross, and Sabot (1996). For discussions of the rate of return to education in other nations, see Behrman, Birdsall, and Deolalikar (1993), and Walker and Ryan (1990).

In the final section of Chapter Three, I bring together the principal empirical results of the dissertation and consider what consistencies can be identified in the way characteristics of students, parents, households, villages, schools, and teachers affect the work-schooling tradeoff. The analyses presented throughout the dissertation will consider how these variables might impact various elements of child time allocation through income effects, substitution effects in agricultural production, and substitution effects in the production of cognitive skills. To close the dissertation, I consider whether my analyses yield a set of plausible empirical regularities and whether there are significant inconsistencies among my findings.

The Pakistan Survey Data

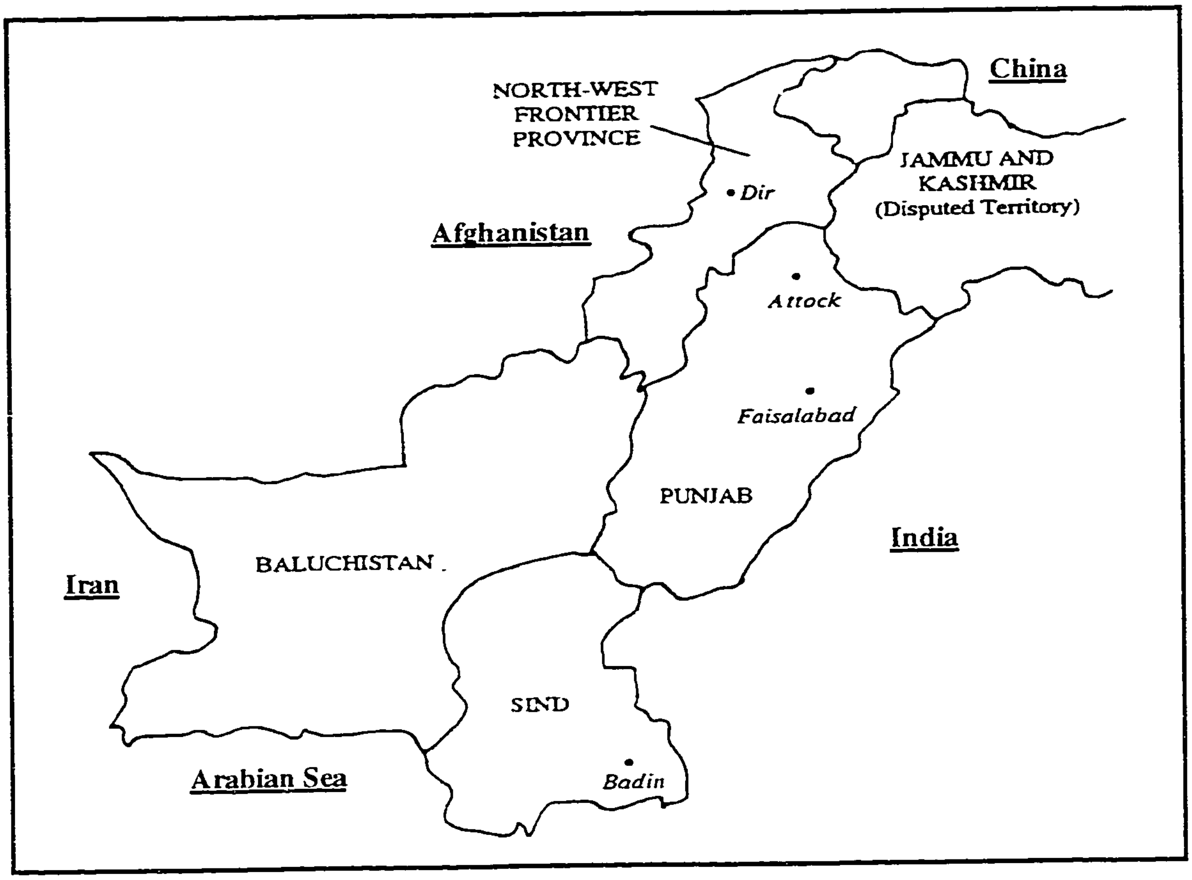
The data for this analysis were gathered by various researchers[3] and included information on income, expenditure, human capital and production among more than 700 households. The sample selection was designed to explore conditions among the poorest rural households in Pakistan. Initially, the poorest district was selected for the study from three of Pakistans four provinces: Attock in the Punjab, Badin in the Sind, and Dir in the Northwest Frontier Province. These districts were selected following work by Pasha and Hasan (1982) which ranked regions in Pakistan by income. One relatively rich district, Faisalabad in the Punjab, was also surveyed in order to provide a point of reference for the study.

Although the districts were chosen with the purpose of selecting the poorest of areas in Pakistan, the villages and households were chosen with a random sample. Within each district, two markets were chosen at random. Three lists of villages were then selected — those within 5 kilometers of the market, those within 5 and 10 kilometers, and those within 10 and 20 kilometers. Villages were then chosen randomly from these lists. Within these villages, households were chosen randomly from among all families.

The households were surveyed 14 times in the period 1986 to 1991. Each survey team included both male and female enumerators who filled out separate questionnaires on the activities of men and women in the household. Data were gathered on expenditures undertaken by the households, farm production, assets, and the work history and educational background of family members. Village level questions were also asked regarding prices, and distances to various markets, services, and schools.

[3] These included Harold Alderman, Marito Garcia, and this author.

Figure 1. The Sampled Districts



For those in the sample who were over the age of 12 and who had attended school for at least 4 years, exams were administered to asses the individual's native ability, and skills in mathematics and reading. Exams were also administered to teachers in regional schools and a descriptive survey was completed for these institutions.

While all of the villages in the survey are in rural areas, the households engage in a good deal of non-agricultural activity. Profits from crops and livestock account for about half of total income. The proportion of earnings coming from agriculture and livestock do not change significantly with the total income of the household but the proportion of income derived from non-farm activities (including construction, shop keeping, and government employment) is negatively correlated with total household income, while the proportion derived from rent is positively correlated. In contrast with other areas of south Asia, agricultural wage labor constitutes a very small share of household incomes, averaging less than 2 percent among the survey households.

Alderman and Garcia (1993) construct a range of poverty indicators from these data and they report that 19.2 percent of those in the survey can be considered poor by virtue of living in households in which the diet consists of less than 2,300 calories per-day adult equivalent, 23.6 percent live in households for which the average three-year consumption expenditure was below Rs. 2,000 per capita (approximately $80 in the mid 1990's), and 37.6 percent do not own land.

These authors also calculate how households invest and save their money across a range of options that include purchase of durables, land, livestock, investment in building, bank savings, and expenditures on education and medical services (considered investment in human capital). They report that the most common forms of saving fall in an 'other' category (this accounts for more than a quarter of saving and reflects spending on a wide range of durables such as weapons, jewelry, and chicken coops.), followed by building (about one-fifth of saving), and the purchase of animals and land (each accounting for about one-tenth of total saving). Dissaving typically occurs through taking on loans, and sales of animals.

Rather surprisingly, saving through monetary investment in schooling averages less than three percent of total saving across all households. Later in this chapter, it is demonstrated that the cost of properly outfitting children with uniforms, school supplies, transportation, and all required texts can place a heavy burden on poor families. The low level of saving through education reflects the fact that enrollment levels are low in Pakistan, and that households have a great deal of latitude in equiping their children.

The low level of investment in schooling is manifest in the nation's statistics for educational attainment: the country has enrollment and literacy rates that are far below other nations at a similar level of development. There has, however, been some small improvement in education over time and the level of schooling is higher among the younger cohorts in the survey. Less than one-quarter of the adult respondents report that their fathers had some education and less than 5 percent report that their mothers had schooling. Among the current cohort of adults, approximately one third report having had some schooling but education continues to be heavily weighted towards males.[4]

[4] Among the 20-24 age cohort, 58 percent of men report having had some schooling while only 14 percent of women had begun school. Among the 30-44 age cohort, these figures are 33 percent and 2 percent. For an analysis of the gender gap in Pakistan, see Alderman, Behrman, Ross, and Sabot (1996)

Defining and Measuring Child Labor and Schooling

Defining and Measuring Child Labor

In pursuing analysis on the interaction of child labor and schooling it is useful to distinguish among the many types of child labor that occur in less developed nations, and to consider the wide range of relationships that can exist between schooling and the various types of child labor. One must also be conscious that empirical regularities that emerge from one set of circumstances may not be evident in other environments. An especially useful framework for analysis of child labor issues has been put forth by Rodgers and Standing (1981) who distinguish among several types of activities on which children in developing countries can spend their time. I will describe several of these that have characteristics and consequences that may be unknown to those familiar only with labor markets in developed nations.

One important classification of work that appears in virtually every study of family time allocation is domestic employment. This rather general classification can be difficult to define, and to measure precisely, as it often involves activities, such as child care, that require little active involvement and that can be undertaken simultaneous with other work. While this sort of work may have a benign impact on children's immediate wellbeing, in that it does not expose them to harmful conditions outside of the household, those engaged in this activity may be required to work full time, and to forego schooling, in order to free other family members for more productive activities.

A second important classification of activities is non-domestic, non-monetary work. This includes activities that are often both full-time and time-intensive, such as tending livestock and protecting crops from birds and animals. Surveys of child labor utilization in south Asia, which are discussed in detail later in this chapter, indicate that a significant proportion of children, particularly boys, are engaged in this activity. Schultz (1964) has posited that among farm households engaged in traditional agriculture, this sort of activity is the principal method through which children are trained in agricultural techniques. It seems likely that artisans would employ their children for similar purposes.

A third class of child labor, and one that is common in south Asia, is that which is provided under obligations resulting from other, non-labor contracts. One example is when a child's labor is provided to a lender as a result of a family defaulting on a debt. This sort of activity is outlawed in almost every nation, but it is often difficult to assess the circumstances under which children come to be employed, and many governments have shown little determination in ending the practice. Another more subtle example of this sort of tied labor results from the manner in which tenants in peasant societies are selected for entering into rental contracts. Several authors (e.g, Nabi (1986)) have observed that one of the selection criteria for being able to rent land in Pakistan is the number of household members in a tenant family that can provide work on agricultural tasks. Because of this consideration, parents may be compelled to employ their children in order to retain rental rights on desired land.

A fourth class of occupations is in wage labor. Children in urban jobs are often engaged for wages (examples include the manufacture of soccer balls and carpets in Pakistan), while in rural areas of many nations it is common to see kids employed as part of a fixed wage arrangement when they are hired in a group with other family members. Another important example of wage labor employment is apprenticeship arrangements under which children are hired to work for reduced or negligible wages and receive, as part compensation, training in a trade.

It is also common for children to work in marginal employment and illegal occupations, especially in urban areas of LDCs. Many children are involved in street hawking, running errands, shoe shining, sorting garbage, petty theft, and prostitution. Children working in these occupations are often among the most poor and this work provides whatever they have of nutrition and clothing.

Rodgers and Standing (1981) suggest that, not only is the character of child labor in developing nations different from that in developed countries, but child idleness may also have different attributes. They point out that many children who do not attend school and who do not work should be considered unemployed since they would accept work if it were available. The authors also suggest that malnutrition, which typically affects children more acutely than adult populations, can preclude youngsters from either working or attending school. Later in this chapter, I present data that suggest that malnutrition is widespread among children in our sample.[5]

In addition to the specific attributes of child labor and idleness, the effect of employment on the immediate wellbeing of the child, on his future earnings, and on

[5] For a discussion of nutrition and income among Pakistani Farmers, see Behrman, Foster, and Rosenzweig (1996). For a related discussion on farmers in south India, see Deolalikar (1988).

the economic position of the household also depends on the claims that each family member has on any earnings of the child. There are many cultural settings in which it is acceptable for children to work only if there are significant gains from child employment and all of these accrue to the child (for example, many young children in the U.S. are encouraged to take paper routes in order to learn responsibility while they earn spending money). In other social settings, child labor is acceptable as long as the child receives more from the household than he contributes. In still other cultures, it is understood that family survival depends on children's labor and children have few, if any, claims on their earnings.

In evaluating how child labor affects child workers, one should also assess the extent to which work substitutes for school, complements school, or precludes school. This is, in part, determined by whether children work on a year-round or occasional basis, and whether they are employed full-time or part-time. Many tasks performed by children in rural areas need not be conducted on a full-time or year-round basis, but it is often the case that children are fully employed in order to release as many other family members as possible for work outside of the household.

The relationship between work and schooling may also be affected by the training component of a job. Families may view apprenticeship as a substitute for formal education, and employers may fear that children who attend school may leave for better work and take their acquired skills with them. On the other hand, students may find that work is complementary to attending school, either because work provides them with an opportunity to apply what they are learning or because the earnings from work are necessary to support their education.

An additional set of issues regarding the definition and measurement of child labor concerns the manner in which time-use data are collected and represented. There has been a good deal written about the poor reliability of time-use information that is taken from recall surveys — surveys in which people are asked to remember the distribution of time dedicated to various tasks. Direct observation of time-use provides a much more reliable measure of the allocation of time across tasks but even this technique fails to account for the level of effort that individuals exert during the time in which they work.[6] In addition, selecting only a specific, short period for observing time allocation can yield severely biased estimates. This

[6] One must also take care that the time spent on a task does not proxy unobserved variables that can bias the interpretation of time data. For example, farmers that spend more time in field preparation than similarly situated neighbors may be plowing especially rocky soil.

is especially true in rural communities in which both the type and intensity of work changes significantly through the growing seasons. Even in urban communities, however, one would like to have long-term observations of time-use in order to evaluate how involvement in particular activities predicts later employment and lifetime earnings.[7]

Defining and Measuring Education

As previously discussed, an important element of this dissertation is establishing if schooling makes a positive and significant contribution to farm profits. The principal difficulty in estimating the benefits of schooling is that investment in education is highly correlated with many other, often unobserved determinants of income and the effects of these missing variables are often attributed to education. These unobserved variables may be differences in the genetic endowments among children in a family, variation in the genetic, economic, or social backgrounds among households, regional divergence in the opportunities for using education, or dissimilarities among schools.

In addition, many types of household investments in education may themselves constitute important missing variables. These include the amount of time that children spend in school, the effort that parents make in instructing their children, the expenses that households bear in order to relocate near better schools, and household expenditures on tuition, books, uniforms, and other supplies. If, as seems likely, the various types of investment in education are positively correlated, failure to account for any of these could result in overstating the relationship between earnings and the available measure of education.

Behrman and Birdsall (1983) posit that studies which employ only the most common measure of education — years of schooling — in analyses of earnings may be subject to a predictable missing variables bias. They observe that households with access to high quality education will likely send their children to school for a longer period, as higher quality schools impose unambiguously lower opportunity costs for acquiring skills. As a consequence, in the estimation of an earnings function, the unobserved effects of school quality will be attributed to time spent in education. One can lessen the sources of missing variables bias if, in place of schooling inputs such as time spent in school, one uses measures of schooling outcomes, such as reading or math skills. These latter measures have the advantage of capturing the

[7] For example, it would be useful to know whether children who are removed from school to work during a family emergency are later able to return to their education.

quantities and qualities of all the inputs that went into creating the educational outcome. However, these measures of educational outcomes may still be subject to some sources of missing variables bias if the acquisition of cognitive skills is correlated with native intelligence or other difficult to measure factors that affect lifetime income.

For several reasons, missing variables bias may be of greater concern in rural areas of LDCs than in either urban areas of these nations or in developed countries. First, primary enrollment is optional in some developing nations and both enrollment and attendance are especially low in rural schools in LDCs. This implies greater self-selection in attending school. As the children who are most capable of capitalizing on education are most likely to be enrolled and to attend school regularly, failure to account for selection criteria may result in overstating the relationship between schooling and earnings.

Second, the availability and quality of schools is highly variable in rural areas of developing nations and one is likely to observe a larger variation in outcomes among those with a similar number of years of schooling. As a consequence, there is greater scope for the type of missing variables bias commented upon by Behrman and Birdsall (1983). A related type of missing variables bias, but one that operates in the opposite direction, arises if the educational system being considered is undergoing rapid improvements in quality. Since studies typically estimate returns to education for the current cohort of school children based on income and schooling data of older cohorts, unobserved improvements in school quality would act to understate the relationship between education and earnings.

Third, significant missing variables bias may arise in the more hierarchical developing societies where the reputation and connections of one's family may mean more than they do in developed nations, and where the skills that one brings to a job may mean less. Under these circumstances, much of the observed relationship between education and income may be spurious, and reflect only a positive correlation between schooling and intangibles such as a family's social position.

Fourth, in the countryside, the demand for schooling is likely to be closely tied to important classifications of household farm inputs that are difficult to measure. These can include soil quality on the family farm, the quality of irrigation, the types of information locally available on farming methods, the human capital stock of those who administer work on the farm, and the likely rate of depreciation of this human capital stock. To the extent that unobserved factor inputs are positively (negatively) correlated with schooling investment, their omission will result in overstating (understating) the effects of education on earnings.

Fifth, in estimating the relationship between schooling and earnings in rural areas one must be aware that there is a great deal of migration, on the part of the educated, out of the countryside. Sabot (1990) writes that "until quite recently, parents in rural areas viewed investment in education as a means of gaining access for their children to the urban labor market.... In the early stages of educational expansion, migration rates approached unity for primary as well as post-primary school completers." If selection for migration favors those who have characteristics that are positively linked to earnings (e.g., ambition or adaptability), and if one samples only those who remain on the farm, migration will exert a negative bias on estimates of the effect of schooling on earnings.

Aside from the potential for missing variables bias, there are several other characteristics common to educational systems in developing nations that may be unknown to those versed only in schooling in developed nations. One important issue is that there may be a smaller link between schooling and earnings in LDCs due to the inappropriateness of curricula and pedagogical methods. In many developing nations, schooling techniques and objectives were designed during the nation's colonial era and were intended to prepare a small number of the indigenous elite for administrative positions in the colonial government. While, it is often the case that these educational systems have expanded rapidly since colonial times, and have come to educate many who will enter trades or farming, the material being taught has not changed to reflect the needs of these new groups of students.

It is also the case that in developing nations, making changes in curricula, or in the quality of education, can affect equity among students in ways not evident in developing nations. T.P. Schultz (1988) points out that, because enrollment is often optional in LDCs, schools with a fixed budget may face a tradeoff between the quality of education they offer and the number of students they enroll. Since the marginal student (the student that would be omitted if the school improves quality) is likely to be from a poorer than average household, improving quality may reduce access to education for low income households. Similarly, since curricula are often set at the national level, undertaking system-wide changes in the material that is taught is likely to benefit some students at the expense of others, and may change enrollment patterns.

Finally, it should be noted that in LDCs, there may be a wider range of useful substitutes to formal schooling than is available in developed nations. In addition to the fact that education in LDCs is often poorly suited to the training needs of students, traditional methods of training, such as apprenticeship, are more common. At different times in a child's development, these alternatives to formal education can be either a substitute for, or a complement to, the skills gained through schooling.

Background on Pakistan

In the half century since Pakistan won its independence from Britain, it has shown healthy economic growth and the World Bank now speaks of the nation as being on the edge of moving from low income to middle income status. Nevertheless, when the country is evaluated on the basis of the provision of social services, education, literacy, access to clean water, child mortality, or the nutritional levels of the youngest children, Pakistan ranks with the poorest nations in the world. The demographic characteristics of the Pakistani family also resemble those of the poorest nations, as the country has seen only a small decline in fertility over the post-colonial era and continues to have one of the fastest growing populations in the world. The economic success that the nation has enjoyed, together with the poor social conditions which prevail, imply that Pakistan may be approaching a watershed in its development: much of the strong economic performance of recent decades has been predicated on the development of its agriculture and primary industry but further growth of per capita GDP will place greater demands on the social resources — particularly education — that have been so poorly developed.

Demographic Structure and Social Organization

At 126 million people, the population of Pakistan is ninth among the nations of the world and the rate of population growth, estimated at between 3.1 and 3.3 percent per year, ranks among the highest [Blood, 1995]. While almost all the people of Pakistan practice Islam (97 percent of the population is Muslim), there is significant ethnic diversity among the nation's regions. Punjabis, Baloch, Sindhis, and Pakhtuns, are concentrated in different parts of the nation and these groups are differentiated on the basis of language, cultural traditions, and ethnic aspirations. More than two-thirds of the population lives in rural areas but the rate of growth of the urban population is estimated by various sources at between 4.4 and 4.6 percent per year. Approximately one-third of this population is under the age of ten (United Nations, 1994).

Pakistan is unusual in having such a high population growth rate at its stage of economic development. While the country has experienced the fall in mortality that is typical of nations undergoing economic development, it has not observed the decline in fertility rates that normally accompanies this process. The fertility rate, which stood at 7.0 in 1980, declined to 6.1 in 1993 (The World Tables, 1995). Studies from several nations have shown strong linkages between improvements in the education and economic status of women and reductions in fertility, and Pakistan's slow rate of decline in fertility is widely thought to be the consequence of the poor status of women in this society. This inferior status is reflected in several dimensions: the literacy rate among women (24 percent) is less than half that of men; only 28 percent of working age females are in the labor force; and, Pakistan is one of the few nations in which the life expectancy of women is less than that of men, reflecting inferior access to health care.[8]

Along with rapid population growth, Pakistan has seen a great deal of migration both within the country and across the nation's borders, and has experienced significant transformations of its villages and cities. Many of the villages of Pakistan, particularly those in river valleys and in areas with reliable rain, are centuries old. Others can be dated to the opening of the nation's extensive canal system at the turn of this century. Still more recent villages were created by the massive influx of Muslims from India at the time of independence from Britain. Most recently, the wars in Afghanistan have produced significant migration into the Northwest Frontier Province and Baluchistan.

From the 1970's until the beginning of the Gulf War, Pakistan also saw a large temporary emigration of workers to the Persian Gulf states. In an effort to improve its balance of payments position, the Government of Pakistan arranged for more than two million workers to travel to these nations. The great majority of these returned home at the time of the Gulf war, however, and only a small portion have again emigrated.

While there has been a great deal of migration into and out of the countryside,

8 Blood (1995, 118) writes "Gender relations in Pakistan rest on two basic perceptions: that women are subordinate to men, and that a man's honor resides in the actions of the women of his family. Thus, as in other orthodox Muslim societies, women are responsible for maintaining the family honor. To ensure that they do not dishonor their families, society limits women's mobility, places restrictions on their behavior and activities, and permits them only limited contact with the opposite sex."

there is far less movement among villages. Girls will leave their home village if a marriage has been arranged for them in another community. Males, however, leave the village less frequently and seldom depart until they are adults. The principal reason for males leaving is that land fragmentation has resulted in their inheritance being insufficient to support a family, and they must find land in another village. However, patrilineal kinship ties are very strong in Pakistan and a man will continue to maintain close relations with those in the village in which he was born, and will retain certain rights in his original village (including first refusal on land being offered for sale). Moreover, it is very common for children to be married to cousins (more specifically, a child is often married to one of the father's brother's children) and, in so doing, patrilineal links can be continued across villages into a successive generation.

The typical Pakistani extended family is defined by the *biradari*, a group of male relatives with a common patrilineal root. It is typical that the majority of the *biradari* live within a single village. The members do not share property or income, but each bears an obligation to the others to uphold the honor of the extended family. A household is the most fundamental kinship unit and usually consists of a male head of household, his wife, his single daughters, his sons and his sons' wives, and any unmarried grandchildren of his sons' marriages. The household is dissolved when the head dies and each of the sons establishes his own family.

The Economy

Pakistan has enjoyed a healthy rate of economic expansion for more than two decades. In the period 1973 to 1993, the average rate of growth of real GDP averaged 5.7 percent (World Tables, 1995). Most of the resources to support this growth have come from the agricultural sector, which continues to employ more than half of the country's population and to contribute approximately 25 percent of product.[9] The nation's agricultural activity is centered around the Indus river plain in Punjab and Sind in which the British constructed the world's largest irrigation system. Primary crops include wheat, which is grown principally for domestic consumption, and cotton and rice (much of which are produced for export sale). While Pakistan's cotton crop yields are relatively high, yields of other crops are low by international standards and are thought to fall significantly short of the nation's potential. While the majority of farmers have adopted the modern high-

[9] Industry accounts for an additional 25 percent of GDP (18 percent of GDP is in manufacturing), and the broad services category accounts for half of national product.

yield variety seeds and use chemical fertilizer, agricultural production is constrained by the deteriorated condition of portions of the irrigation network,[10] the poor skills of farmers, inappropriate scale of operation among a large proportion of Pakistan's farms, and problems arising out of land tenure arrangements.

Many of the problems in agriculture arise from the highly inequitable distribution of land holdings that existed at the time of independence. In 1947, less than one percent of the nation's farms accounted for more than 25 percent of arable land. Most of the production on these farms was undertaken by sharecroppers or those who used the land under fixed rent arrangements. On the bottom of the distribution, approximately 65 percent of farmers worked only 15 percent of the land in holdings of 2 hectares or less. Absentee landlords often contributed a much smaller portion of inputs than their share of production output, and undertook few capital improvements of the land. As a consequence, suboptimal levels of factor inputs were employed, and the majority of tenants were undernourished, uneducated, and showed a low level of productivity. Since independence, there have been several attempts at land reform in Pakistan but these have succeeded in transferring only a small amount of land to a small number of farmers. While productivity of farmers has risen as a consequence of improvements in farming technology, many of the inefficiencies inherent in the landlord-tenant relation continue.

Although most of the resources used to support Pakistan's strong rate of growth have come from agriculture, it has been the industrial sector that has shown the most rapid expansion since independence. Part of this growth is a simple consequence of the fact that the nation started with a very small industrial base: in 1947 the country had virtually no manufacturing (less than five percent of imperial India's production capacity was in the area that is now Pakistan). Much of the growth, however, reflects truly impressive construction of industrial capacity. At present, industry contributes nearly a quarter of GDP (World Tables 1995) and employs one fifth of the labor force. Major industries are based on the production of primary materials (and the processing of these materials) and include food production, cotton yarn and cloth, cement, chemical fertilizer, and paperboard. The nation also has its own steel mill, automobile assembly plant, nuclear power plant, and system of hydroelectric dams.

[10] Although the Government of Pakistan is frequently criticized for poor maintenance of irrigation, it should be noted that, since independence, new public irrigation projects, together with the introduction of private tubewells, have increased the nation's arable land area by approximately one-third.

Social Conditions and Social Services

Pakistan stands among the poorest nations in the world in the provision of social services and conditions are especially bad for the nation's children. The World Bank (1988) indicates that in Pakistan, education expenditures as a percentage of GDP were only 1.6 percent in 1983 and 2.4 percent in 1988. This compares with an average level of 4.4 percent across all developing nations. As a percent of government expenditures, spending on education was only seven percent over the period 1978 to 1987, as compared to 14.7 percent for all developing nations.

Health conditions are also very poor for a nation at Pakistan's level of development. While health care is available at no cost to most of the people of Pakistan, this service is generally of poor quality. Infant mortality is 92 births per 1,000, compared with 30 per thousand in China. Fewer than half of those who reside in the countryside have safe drinking water, while less than one-tenth have access to adequate sanitation. The leading causes of death include gastroenteritis, respiratory infection, tuberculosis, malaria, and typhoid.

The World Bank (1996a) indicates that thirty percent of the population, and 40 percent of children under five, suffer from some degree of malnutrition. This is consistent with the findings of Alderman and Garcia (1993) who report that among children ages 0 to 5 in the Pakistan survey, between one-third and one-half are under-weight,[11] approximately one-half are stunted,[12] and about one-tenth are wasted.[13] These measures are, of course, highly correlated with household income, but even in the district with the highest average income (Faisalabad), approximately 30 percent of children are underweight.

Viewed over the last two decades, one can see clear improvements in the most dismal indicators of social wellbeing (of course, rapid growth is most easily attained when one is starting from a small base). Infant mortality has declined by a quarter since 1980, the percentage of the population with access to sanitation has doubled, and there has been a rise of almost one-third in the proportion of the population with access to health care (The World Bank, 1996a). Blood (1995) reports that more than 80 percent of infants now receive all recommended vaccines.

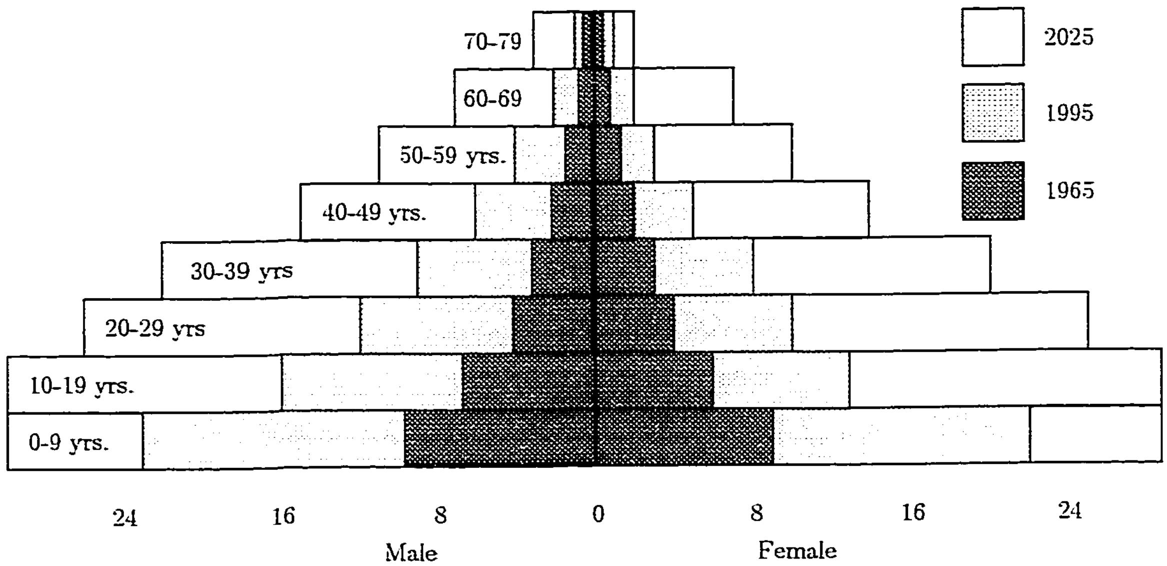
---

[11] This is defined as less than -2 standard deviation from the median weight-for-age as defined in the international standard used by the World Health Organization.

[12] This is defined as less than -2 standard deviation from the median height-for-age.

[13] This is defined as less than -2 standard deviation from the median weight-for-height.

Figure 2. Pakistan's Population, and Projected Population (in millions)



Source: *The Sex and Age Distribution of the World Populations, the 1994 Edition*, published by the United Nations. The projection for 2025 is based on the UN 'medium variant' and represents the population level that the UN believes to be most likely.

There are reasons to be optimistic that Pakistan can effect similar improvements in enrollment and school quality over the next three decades. The United Nations projects that the rates of growth of the primary-school aged cohort is slowing and this implies that current rates of growth in educational expenditures can support greater per-capita spending on education. Moreover, the dependency ratio is expected to decline over the next thirty years and providing services for children will impose a smaller burden on working aged adults. The growth in different cohorts over the last thirty years, and the projected growth over the next 30 years, is illustrated in figure 2.

There may also be latitude for realigning budget priorities in favor of education. At present, defense accounts for approximately one-third of government spending, one of the highest proportions in the world (The International Institute for Strategic Studies, 1995). If civilian rule continues and the military's influence over the government declines, it may be possible to redirect spending to education and other social services.

The Pakistani Educational System

Performance and Cross Country Comparisons

By virtually every indicator of performance, the educational system in Pakistan is among the worst in the world. The World Bank (1994) reports that only 46 percent of children of elementary school age are enrolled. Only five nations in the world have a poorer record and Pakistan's performance is especially weak for a nation at its level of development. India, from which Pakistan was separated in 1947, has a slightly lower level of per capita GDP and has been able to attain a primary enrollment rate of 98 percent. Bangladesh, which was part of Pakistan until 1971 and which has a per capita GDP that is about half that of Pakistan, has a primary enrollment rate of 77 percent.

Pakistan's record on education is also bleak when viewed across time. In the period 1970 to 1991, the primary enrollment rate in Pakistan increased from 40 percent to 46 percent. During the same period, the 22 nations that have lower per capita GDP than Pakistan, and for which educational data are available, had an average (unweighted) increase in primary enrollment of 39 percent, reflecting a rise in average enrollment from 46 percent to 68 percent.[14]

Table 1.1 Rural and Urban Enrollment by Gender Throughout Pakistan: Data for 1983

	Boys	Girls
	Percent	
Combined	63	32
Rural	58	20
Urban	77	68

Source: Asian Programme of Educational Innovation for Development.

Pakistan's educational performance is especially poor in regards to schooling girls. Only 32 percent of primary school aged girls are being educated.[15] There are only three nations in the world (Chad, Benin, and Yemen) in which there is a

[14] For a detailed discussion of how Pakistan's educational investments compare with those of other nations, see Behrman and Schneider (1993).

[15] For further discussion of the education of girls in Pakistan, see Alderman, Behrman, Khan, Ross and Sabot, R. (1995). For a discussion of non-economic returns to schooling of girls, see Haveman and Wolfe (1984) and King (1990).

greater gender gap in schooling. Some observers have posited that the bias against schooling girls is the result of cultural attributes stemming from the practice of Islam. However, there are several Muslim nations in which the enrollment of girls is universal or occurs at the same rate as for boys (examples include Jordan, Syria, Oman, and Saudi Arabia).

Table 1.1 points up that, in addition to the gender gap, primary school enrollment also shows sharp inequality in another dimension: rural boys are far less likely to be enrolled than boys living in cities, and enrollment for rural girls is only 30 percent that of urban girls.[16] This urban bias in enrollment is observed in many less developed nations and, although this author knows of no data that would permit a cross-country comparison of this phenomenon, anecdotal evidence suggests that the disparity is especially severe in Pakistan.

The low level of government investment in schooling undoubtedly accounts for much of the poor performance of Pakistan's educational system. However, the particular patterns of enrollment, retention, and schooling achievement that one observes in Pakistan are likely determined by the interaction of the supply of schooling (as measured by the availability and quality of schools) and the demand for schooling (as determined by, among other things, cultural norms regarding learning, and parents' ability to bear the material and opportunity costs of schooling). Under many circumstances, it is difficult to separate the effects of supply and demand. For example, much of the gender gap in schooling is likely due to past government policies of building more boys' schools than girls' schools. However, the low level of investment in girls' schools may have been a governmental response to perceived low demand for education of girls: in many areas in which girls' schools are available, parents often remove their daughters from classes in the middle of their primary education. These parents are apparently motivated by cultural norms which prescribe that when girls approach puberty, they not be allowed in the presence of males from outside of the family.

A similar phenomenon is found in the schooling patterns of boys. The survey data used for this dissertation indicate that more than 70 percent of six and seven year old boys are enrolled in school, but that attrition begins to rise sharply beginning in the third grade. While this suggests that the majority of rural parents find

---

[16] The 1983 data on rural-urban enrollment presented in table 1.1 is the most recent known to this author.

it both possible and desirable to enroll their youngest boys, they begin to remove boys from school before they have attained basic literacy and numeracy.

Table 1.2 Enrollment and Attrition by Age Throughout Pakistan: UNESCO Data for 1981-82

	Grade				
	I	II	III	IV	V
Number Enrolled	1,987,700	1,219,055	989,264	837,565	705,906
% of Grade I Enrollment	100	61	50	42	36

Table 1.2 shows UNESCO estimates for attrition among all children in Pakistan (urban and rural) in 1981-82 and Table 1.3 represents attrition among our survey sample for 1989. The UNESCO data show a significantly higher rate of attrition. The difference between these tables may, in part, reflect the fact that urban girls are more likely to be enrolled in first grade than those in the countryside, and that a larger portion are subsequently removed from school.

While it seems likely that cultural norms drive much of the attrition of girls, the reasons for the low retention of boys are less clear. There are several possible explanations. First, parents may enroll these children at the age of six in order to evaluate their performance as students, or to assess the quality of the instruction they receive. They may remove the boys from school if either they or their teachers prove to be disappointments. Alternatively, students may be sent to school in order to be socialized or supervised, and the need for these schooling functions may decline with age.[17] Finally, students may be removed from school when they become old enough to work, and there is significant evidence to suggest that boys as young as six or seven can make a significant contribution to the economic wellbeing of families.

Whatever the reasons for the high rate of attrition among primary school children, certain government investments in education may be able to improve enrollment and retention. Alderman, Behrman, Ross, and Sabot (1996a) suggest that

[17] The World Bank (1988) observes that "some rural parents perceive primary education as having a custodial rather than an educational objective. Thus, parents place underage children in grade one to protect them while the parents work, and withdraw the children from school as soon as they are old enough to fend for themselves."

Table 1.3 Enrollment by Age Among Children in Our Surveyed Households

	Girls		Boys	
Age	No.	%	No.	%
6	27/70	38.6	53/76	69.7
7	25/67	37.3	51/72	70.8
8	23/71	32.4	46/77	59.7
9	20/74	27.0	36/71	50.7
10	16/65	24.6	34/69	49.3
11	14/60	23.3	36/70	51.4
12	15/62	24.2	35/77	45.5
Enrolled/Total	139/469	30.0	291/512	56.8

the attrition rate of girls can be greatly reduced by improving the availability of schools to girls and by reducing the monetary costs of education that are borne by parents.

The government of Pakistan uses several policy instruments to influence outcomes in the nation's schools. These include undertaking construction of schools and capital improvement, provisioning of schools with supplies and teachers, establishing educational requirements for staff, determining standards for the training of teachers, providing supervision of faculty, setting the material costs and school fees that must be borne by parents, and establishing teachers' salaries and incentives. In this section, I examine these policy instruments and consider how they have affected the characteristics of Pakistan's primary schools, and the qualifications of the nation's primary school teachers. I also explore the correlations that are found among the attributes of schools and teachers in order to address questions that include i) whether the government allocates staff and other resources among schools equitably, ii) whether the newest schools constructed by the government are better able to meet students educational needs, and iii) whether the resources provided to girls' schools are different from those provided to boys' schools. I pay especially close attention to Pakistan's teacher certification process, the government's policies that determine teachers' pay, and the manner in which teachers are supervised. I then link the characteristics of schools and teachers, and the effects of other government policy initiatives, to the performance of the schools.

The data used for this dissertation allow analysis of these issues from two perspectives. First, the data include a detailed survey of 54 primary schools in rural Pakistan. This provides information on the physical resources of the school, the number of students, and the background of teachers. These data allow me to construct an unusually rich profile of Pakistani schools, and to link attributes of schools to the institution's rate of attrition (which, given the high rate of dropping-out among primary school children in Pakistan, should be considered a key indicator of school performance). The school-level survey, however, does not include detailed information on either the cognitive skills attained while students are in school, or the conditions of the region in which the school is located (in the majority of cases, one cannot match schools with the local growing environment, the wealth of the community, the availability of other services, etc.).

The Pakistan data also allow me to analyze schooling from the perspective of the households included in the survey. In addition to information on income, expenditures, agricultural conditions, and assets, this data set includes schooling information for every household member. There are also data on school availability and key measures of school quality for primary-school aged boys. From these data, one can link the household decision to enroll boys to growing conditions, family farm profitability, attributes of the local village, and school quality and availability.

The Structure of Pakistani Primary Schools

At present, almost all schools in Pakistan are public and there are no private schools in the villages sampled for this dissertation. While schools technically charge no tuition, the majority report charging various mandatory fees for admission and activities. Parents are expected to provide children with school supplies and uniforms. The schools in the survey indicated that the cost of providing a child with a uniform, school fees, and a single pen, pencil, and slate is about six dollars. This is equivalent to about 15 percent of a teacher's monthly pay or about three and a half day's wages for a hired construction laborer. The World Bank (1988) indicates that purchasing all the required texts for primary school would add another $12 to the cost of schooling. They observe that "the total private costs (books, uniform, transport), of having four children simultaneously in primary and middle school was estimated by the mission to be as high as 20 percent of the income of a poor family with annual earnings of about [$400]."

Pakistani primary schools often include children in preschool (*kachi*) and kindergarten (*pakki*) who are four and five years old. Formal primary education typically begins at the age of six and includes grades one through five. Primary school is followed by middle school (grades six through eight), matriculation (grades nine and ten), Fellow of Arts or Sciences (grades 11 and 12), and university. Almost all schools are single sex and, in rural areas, it is common for schools to have only one teacher. Because migration among rural areas is rare for both children and married adults, students almost always attend the primary and middle schools closest to the village in which their parents reside.[18]

The School Calendar

The 39 week school year typically begins on April 1, and for most schools the year includes approximately 120 to 130 days of instruction. In other developing nations, the school year often includes as many as 180 days of instruction per year.[19] Schools usually operate for eight 40 minute periods per day.

Syllabi and Examinations

Instruction in primary school is typically conducted in Urdu which, although the national language, is not the native language of the great majority of students. The curricula for primary and middle schools are set by the Federal government, are uniform across the nation, and allow for no diversification on the part of the student. Primary school children study language for eight hours per week, mathematics, science, and Islamic studies for four hours per week, and social studies, health, and art for two to three hours per week. Examinations for primary school children are typically set by the local school and are held annually in order to assess whether children should be advanced to the next grade. Some provinces administer an exam at the end of fifth grade to evaluate which students should be passed to middle school and to award merit scholarships.

Both the exams that are administered to Pakistani children and the pedagogical methods used in the classroom stress memorization from text books. Much of the instruction involves teachers reciting from texts and requiring repetition from

18 Alderman and Garcia (1993) indicate that fewer than 2 percent of rural residents in Pakistan who attend primary school do so away from the immediate vicinity of their village.

19 Part of the reason for the small number of days that students are taught results from a large number of public holidays in Pakistan and from schools being closed for bad weather. Among Pakistani primary schools surveyed for this dissertation, the average number of days lost to bad whether and other reasons was 17.7.

students. Various studies report that students are discouraged from asking questions in class and are seldom required to interpolate or extrapolate from the factual material they are taught.[20] Discipline in the classroom is strictly enforced and Warwick and Reimers report that, in a survey of more than 11,000 students, 83 percent reported that they were physically punished with some frequency and nine percent of fourth graders indicated that they were physically punished on a daily basis.

School Attributes

The Federal Government is responsible for financing the development expenditures for schools, while the Provincial government is responsible for supporting salaries and other recurrent outlays. While many policies, such as setting the syllabi and establishing qualifications for teachers, are set at the Federal level, others, such as determining the location of schools, seem to be collaborative efforts between the different levels of government.

The Pakistani primary schools are generally small, uncomfortable, and poorly equiped. Among 54 primary schools in our survey, the most likely staffing is two teachers (the mean is 3.4), no administrator (the mean is 0.13), no clerk (the mean is 0.06), and one other worker, typically a guard or laborer (the mean is 0.80). Student teacher ratios vary widely, from more than 100 to 1 to less than 10 to 1.[21] Many observers have commented on the rather paradoxical result that the lowest quality schools will often have the highest rates of attrition and, in turn, the lowest student-teacher ratios. The turnover among teachers is relatively low: among the 187 teachers across all schools, there were only seven reported resignations or departures in the previous year.

The majority of primary schools have either no classrooms (14 percent of the sample), one classroom (39 percent), or two classrooms (22 percent). Fifteen percent of the schools in the survey indicate that they typically hold all of their classes outside. Educational equipment is also scarce: only 4 percent of the schools sampled report that they have desks for every child, while 78 percent have no desks. Although those schools that have classrooms typically have a blackboard in every room, 30 percent of the schools indicate that they have no chalk.

---

[20] This is observed in several studies including Bhatti, et.al., (1988).

[21] The World Bank (1988) found a similar range of student teacher ratios

There are few resources dedicated to the safety, comfort, or nutritional needs of the children. Among the primary schools in our sample, 74 percent have toilets for both teachers and students, but only 39 percent have their own source of drinking water and fewer than one-fifth have electric power. The schools are not involved in providing children with meals or other, non-educational social services.

There are also few resources dedicated to the day-to-day provisions necessary for learning. None of the schools provide boys or girls with pens, pencils, or slates. While most schools require that student's wear uniforms, they do not require that students purchase texts or other school supplies and it is typically the case that students do not have the minimum tools necessary for learning. Many students do not have books of their own and it is common to see several children sharing a text. Moreover, observers of the Pakistani educational system point out that the texts that are available for children to purchase are often of low quality. They frequently stray far from the government's syllabus, use language that is of inappropriate complexity for the level of the student, and contain many factual errors.

Determining Who Gets a School

There are no explicit policies that define which villages and regions will receive schools, but the presence of primary schools is positively correlated with the existence of other infrastructure, the presence of political officials in the village, proximity to the nearest regional capital, population, and population density. Table 1.4 shows how the characteristics of villages differ between those that have a primary school and those that do not. It should be noted that, in most cases, one cannot assess any causal link between village characteristics and the presence of schools since the data do not inform us whether the observed village characteristics were present before construction of a local school.

Table 1.4 indicates that those villages that have a primary school are more likely to be electrified (a two-sided t-test shows this difference is significant at the ten percent level). Other infrastructure do not differ significantly between those villages that have schools and those that do not. It should be noted that the proportion of land that is under irrigation is virtually the same in villages that have schools and those that do not. This is an important result as irrigation is the most significant agro-climatic influence on Pakistani farming. The availability

Table 1.4 The Relationship Between the Presence of Schools and Other Village Attributes

	Mean Value in Villages without Schools (19 Cases)	Mean Value in Villages with Schools (23 Cases)	t-Stat.
Infrastructure In Village.			
Proportion of Vill. Land that Is Irrigated	0.6487	0.6108	0.26
Bin. Var. = 1 if Vill. Is Electrified	0.4211	0.6957	-1.80 *
Bin. Var. = 1 if Vill. Served by Pub.Transport	0.1579	0.3478	-1.43
Bin. Var. = 1 if Vill. Has Paved Roads	0.2632	0.2174	0.34
bin. Var. = 1 if Vill. Has Mech'l Thresher	0.7368	0.6087	0.87
Distance From Vill. to Local Resources			
Distance to Tehsi Capital	15.6842	10.3261	1.85 *
Distance to Procurement Center	18.2895	8.500	2.04 **
Distance to Fertilizer Sales	8.8684	7.2826	0.88
Population and Density			
Population of Vill.	1400.21	2078.35	-1.31
Ratio of Vill. Area (Acres) to Population	3.0087	2.0244	1.52
Political Officials Located in Vill.			
Bin. Var. = 1 if Union Official Lives in Vill.	0.3684	0.5625	-1.27
Bin. Var. = 1 if District Official Lives in Vill.	0.1052	0.0870	0.19
Bin. Var. = 1 if High Gov't Off'l Lives in Vill.	0.1053	0.3043	-1.63

* – Sign. at 10 percent level, two-sided test ** – Sign. at 5 percent level, two-sided test

of irrigation determines both the types of crops that can be grown and whether modern high-yield variety grain seeds can be effectively employed. The use of high-yield varieties, in turn, influences the degree to which education carries benefits in farming. (The linkages between the use of farming techniques and the benefits of education in farming are discussed at length below.) This result, therefore, suggests that regional differences in the benefits of education are unlikely to be linked with the availability of schools.

The table also shows that there are not statistically significant differences in either the existence of paved roads or access to public transit between those villages that have schools and those that do not. This may seem counterintuitive but improved transportation not only facilitates bringing children into town to be schooled, it also reduces the isolation of a village, enables children to be sent for education in other villages, and, thus, lessens the need for a village to have its own school.

Anecdotal evidence from our survey villages suggest that the presence of political leaders in a village is often linked with the construction of new schools, or the expansion of existing schools. The data indicate that those villages with schools are more likely to be home to a high government official, although this relation falls just short of statistical significance. However, one cannot determine from these data whether the school preceded the politician, or the politician predated the school.

The data also indicate that those villages that have schools are significantly closer to the both local Tehsi capital (the local government administrative center) and the local procurement center. The exact nature of these linkages, however, are not clear as these less isolated villages are more likely to have electric power and other infrastructure, and to be home to government officials.

Correlations Among School Characteristics

While the average school in rural Pakistan is of low quality, the conditions vary widely. Some schools have talented instructors, provide a comfortable and safe environment in which to conduct classes, and have many of the resources necessary for effective teaching. Others have some or none of these attributes. Looking at the correlations among the characteristics of schools, and examining how these have changed over time, allows one to explore the evolution of one aspect of government education policy.

One of the most striking relationships to emerge from these data is that the newer schools are far more likely to be for girls. Table 1.5 shows comparisons between those schools begun prior to 1964[22] and those opened subsequent to this date. Over the last two decades, lessening the gender gap in Pakistani primary schooling has been the focus of initiatives of a wide range of development agencies and the Government of Pakistan has frequently stated its goal to compensate for the previous biases in education expenditures that favored boys' schools. The table also indicates that new schools are far more likely to have women teachers, reflecting a government policy objective of placing many more women teachers into girls' schools.

These reforms, however, are associated with a significant degradation of the

[22] This is the median of the first year of operation among primary schools in our sample

quality of teachers at new schools. Although there is no difference between new schools and old in the proportion of teachers who have attained their certificate, teachers at new schools have lower levels of reading and math skills. This is consistent with observations made by UNESCO and others who have suggested that a major obstacle to improving the Pakistani educational system is recruiting adequate candidates into the teacher training programs and finding ways to allocate teachers more efficiently. In the 1970's there were multiple applicants for every opening in teacher training, but a deterioration in the relative pay and working conditions of teachers has resulted in there now being a shortage of qualified applicants. It has been difficult for the government to find teachers to serve in rural areas as adequate housing is often unavailable and salary incentives favor those who teach in urban areas. It has been especially difficult to find women teachers to serve in the countryside: because the level of schooling among rural women has been very low, there are few women living in the countryside who are qualified to teach. Moreover, single women from urban areas are hesitant to relocate to the countryside since women who live by themselves are afraid for their safety and their reputations.

It should also be noted that new schools are smaller than old schools (they have about one third fewer students entering the lower grades), have about one-third as many teachers, and are much less likely to have an on-site administrator. There is little difference, however, in the physical characteristics of the schools. Older schools are slightly more likely to have water and electricity but this difference is far from statistically significant. In addition, there is virtually no difference in how these schools are provisioned with books and desks.

Since this analysis suggests that the most significant changes in government policy regarding school development have concerned increasing the number of girls' schools, I provide an additional comparison of characteristics between primary schools for boys and for girls. These results, shown in Table 1.6, indicate that teachers at girls' schools are far more likely to be women, to have lower cognitive skills, to be inexperienced in teaching, and to be uncertified (this last difference falls short of significance at the 10 percent level). Girls' schools are also smaller, in that they have about two-thirds as many teachers and two-thirds as many students in the lowest grades (this difference also falls just short of significance at the 10 percent level). In keeping with the cultural norms, girls' schools are more likely to be walled-off from public access.

Table 1.5 Differences in Resources Between Schools Built Before and After 1964

	Mean Value Among Schools Built After 1964 (29 Cases)	Mean Value Among Schools Built Prior To 1964 (25 Cases)	t-Stat
No. of Visits By Gov't Supervisor	3.6897	5.2800	-1.24
Bin. Var. = 1 if Boys' School	0.4483	0.8400	-3.26 ***
Hours per Day School in Operation	5.3379	5.5600	-0.93
Bin. Var. = 1 if School Has Electricity	0.1034	0.2000	-0.97
Bin. Var. = 1 if School Has Walls	0.4483	0.3600	0.65
Bin. Var. = 1 if School Has Water	0.3448	0.4400	-0.70
Bin. Var. = 1 if School Has No Desks	0.7586	0.8000	-0.36
Attrition Rate at School	0.4672	0.3951	0.74
No. of Books Observed / No. of Students	56.5680	55.1132	0.31
Bin. Var. = 1 if School Has Administrator	0.0345	0.2400	-2.19 **
No. of Kids in Second Grade	18.3103	31.3200	-2.14 **
Average Reading Skills Score of Teachers	20.0345	22.0059	-1.66
Average Math Score of Teachers	14.5632	20.7106	-3.51 ***
Av. Native Intelligence Score of Teachers	26.5205	28.7402	-1.38
Proportion of Teachers with Certificate	0.8112	0.8190	-0.08
Av. Years Experience Teaching of Teachers	8.3235	10.4943	-1.38
Proportion of Teachers Who Are Male	0.5517	0.9200	-3.38 ***

Characteristics of Primary School Teachers

Primary school teachers in Pakistan are required to have a minimum of ten years of schooling and, while the majority meet this standard, it is often the case that those who enter teaching have left school with poor grades. Elementary school teachers are also required to hold certification which involves a one year course sponsored through a university, normal school, or secondary school. Both UNESCO and the World Bank have criticized these training programs as being of very low quality. Of the surveyed teachers who work at the 54 primary schools examined in this study, 81 percent had attained a teacher's certificate but only one-third had gone beyond tenth grade. They reported an average monthly salary of approximately 45 dollars, and 60 percent supplemented these earnings with a second job on the farm or in non-agricultural self employment. The low level of pay, together with the

Table 1.6 Differences in Resources Between Boys' Schools and Girls' Schools

	Mean Value In Girls' School (20 Cases)	Mean Value In Boys' School (34 Cases)	t-Stat
No. of Visits By Gov't Supervisor	3.8500	4.7647	-0.68
Hours per Day School in Operation	5.3550	5.4912	-0.63
Bin. Var. = 1 if School Has Electricity	0.1000	0.1765	-0.80
Bin. Var. = 1 if School Has Walls	0.6500	0.2647	2.88 ***
Bin. Var. = 1 if School Has Water	0.4000	0.3824	0.13
Bin. Var. = 1 if School Has No Desks	0.8000	0.7647	0.30
Year School Began	1975.9474	1957.7273	4.30 ***
Attrition Rate at School	0.4647	0.4156	0.47
No. of Books Observed / No. of Students	58.2280	54.5218	0.81
Bin. Var. = 1 if School Has Adminis'r	0.1500	0.1176	0.33
No. of Kids in Second Grade	18.5000	27.7647	-1.66
Average Reading Skills Score of Teach	20.8750	20.9896	-0.10
Av. Math Score of Teachers	14.1917	19.3019	-2.72 ***
Av. Native Intelligence Score of Teachers	25.2000	28.9294	-2.13 **
Proportion of Teachers with Certificate	0.7083	0.8775	-1.54
Av. Years Experience Among Teachers	6.3417	11.0854	-3.12 ***
Proportion of Teachers Who Are Male	0.4000	0.9118	-4.17 ***

inferior social status of primary school teachers and poor working conditions, have resulted in bad morale among educators in many areas. The average teacher is 32 years of age, has 10 years experience in teaching, and is the head of their household. At present, 19 percent of primary school teachers are women and this proportion has been growing steadily in recent years.

Correlations Among Teacher Characteristics

The weaker academic background of teachers at new schools and at girls' schools is worrisome as it has been observed that the skills and abilities of teachers are the school characteristic that best predicts schooling outcomes[23] There are two possible

[23] See World Bank (1988) and Harbison and Hanushek (1992).

Table 1.7 Differences in Characteristics Between Male and Female Teachers

	Mean for Women (25 Cases)	Mean for Men (104 Cases)	t-stat.
Reading Score	18.16	22.29	-3.48 ***
Raven Native Intel.	23.00	29.14	-4.17 ***
Math Score	11.28	20.73	-6.72 ***
Highest Educ'n*	3.16	3.62	-3.47 ***
No. Grade 1 Kids	24.84	40.39	-2.89 ***
Second Job = 1	1.00	0.62	N.A.
Certification = 1	0.92	0.77	2.18 **
Experience > 7 yrs	0.48	0.52	-0.35
Teacher Pay	1200.64	1327.00	-2.64 **
At Boys' School = 1	0.16	0.88	-8.76 ***

*2=8th Grade, 3=10th Grade, 4=12th Grade.

reasons why we are observing the poorer academic abilities among teachers at new schools and at girls' schools. First, the women teachers who are being recruited for service at girls' schools may have weaker academic backgrounds than their male counterparts. Since a greater proportion of new schools have been built for girls, the lower skills of female teachers may account for the poorer academic abilities among teachers at recently constructed schools. Alternatively, the lower levels of skills may be evident among both the men and women who have been most recently recruited. Since both new schools and girls' schools are allocated less experienced teachers, this may explain the poorer academic background of teachers at these institutions.

This distinction is important since an overall deterioration in teacher skills (one that is not gender-specific) might be remedied simply with higher wages. However, a deterioration that is gender-specific might indicate intractable supply constraints resulting from either the small number of educated women living in the countryside or deeply ingrained social norms. To examine this question, I consider how teacher gender, experience, and certification correlate with a range of teacher skills and attributes.

Table 1.7 compares male and female teachers for experience, skills, academic attainment, and certification. The data indicate that women teachers score signifi-

Table 1.8 Differences in Characteristics Between Experienced and Inexperienced Teachers

	Mean for Exp. < 7 (63 Cases)	Mean for Exp. > 7 (66 Cases)	t-stat.
Reading	22.14	20.86	1.56
Raven's	27.32	28.56	-1.18
Math	18.02	19.74	-1.33
Highest Education	3.44	3.61	-1.05
No. Grade Two Kids	40.30	34.59	1.05
Second Job = 1	0.70	0.68	0.20
Certification = 1	0.71	0.88	-2.34 **
Male = 1	0.79	0.82	-0.35
Teacher Pay	1084.81	1510.32	-11.61 ***
At Boys' School = 1	0.65	0.82	-2.17 **

cantly lower on tests of native intelligence, reading, and math and that they are less likely to have progressed past the tenth grade. They are, however, far more likely to have achieved certification.[24] It is also interesting to note that the women teachers in the sample are no less experienced than male teachers, but they are paid significantly less. Table 1.8 indicates that there is no significant difference in academic background, native ability, or cognitive skills among more experienced and less experienced teachers. This, together with previous findings, implies that the lowering of teacher quality has been the result of the government policy of introducing more women teachers.

Table 1.9 provides an additional comparison of teachers who have attained certification and those who have not. These data indicate that those teachers who have failed to gain their certificate are disproportionately male. They also suggest that uncertified teachers have sharply lower math skills, and academic inadequacies may make it more difficult for these teachers to attain the certificate. Uncertified teachers also have less time in the teaching profession and this could indicate that

[24] Although teachers at girls' schools are less likely to be certified, it is the male teachers at these schools who bring down this average.

Table 1.9 Differences in Characteristics Between Certified and Uncertified Teachers

	Mean for Uncertified Teachers (26 Cases)	Mean for Certified Teachers (103 Cases)	t-stat.
Reading	20.92	21.63	-0.67
Raven	27.15	28.16	-0.76
Math	16.73	19.45	-1.90 *
Highest Education	3.81	3.46	1.53
No. Grade Two Kids	38.81	37.02	0.24
Second Job = 1	0.42	0.76	-3.11 ***
Male = 1	0.92	0.78	2.17 **
Experience > 7 yrs	0.31	0.56	-2.44 **
Teacher Pay	1186.96	1331.68	-2.46 **
At Boys' School = 1	0.65	0.76	-0.99

teaching experience is useful in passing certification. Alternatively, less experienced teachers may simply have had less time to attend in-service certification courses.

Linking Teachers' Pay With Teacher Characteristics

The previous analyses have indicated that teacher pay is correlated with experience, certification, teacher gender, and whether the teacher is at a girls' school. However, since these latter variables are all strongly correlated among themselves, sorting-out the marginal effects of teacher attributes on pay requires regression analysis. The results of such an analysis are presented in Table 1.10.

The first column of this table shows the results of a regression that included, as independent variables, predetermined characteristics of the teacher (including years of education, reading ability, experience, and certification), exogenous personal attributes (teacher's gender), and features of the school at which the teacher is employed. Since it is unlikely that the allocation of teachers among schools is a random process, the school-related characteristics may be correlated with unobserved variables that affect the regression through the error term. For this reason, a second regression was estimated that excluded from the regressors all variables related to school characteristics. The results of this latter regression are shown in the second column of Table 1.10.

Table 1.10 Regression of Teacher's Pay Against Teacher and School Characteristics

No. Observations	129		
Mean of Dep. Var.	1302.51		
St. Dev. of Dep. Var.	300.00		
R Square	0.842	0.824	

	Coefficient (t-stat)	Coefficient (t-stat)	Mean S.D.
Constant	562.48	463.35	
	(6.87)	(5.752)	
Bin. Var. Equals One if	-13.86	4.47	0.80
Teacher is Certified	(-0.44)	(0.156)	*0.40*
Teacher's Native Ability Score	4.62	4.29	27.95
	(2.21)	(1.97)	*5.98*
Highest Education Level Attained	66.80	94.83	3.53
By Teacher	(4.41)	(7.01)	*0.88*
Number of Years Teaching	32.11	32.27	9.94
	(21.59)	(21.02)	*7.97*
Teacher's Reading Score	5.34	5.83	21.49
	(2.03)	(2.15)	*4.74*
Bin. Var. Equals One if	-45.92	-80.98	0.81
Teacher Is Male	(-1.07)	(-2.349)	*0.40*
Teacher Is at Boy's School	-74.21		0.74
	(-2.10)		*0.44*
Number of Children in School's	-0.88		37.38
Second Grade	(-1.87)		*30.58*
Number of Teachers at School	13.82		5.59
	(3.48)		*4.28*

These results indicate that more than 80 percent of the total variation in teachers' pay is accounted for by the small number of regressors used in these analyses. As one would expect, there is a large, positive, and significant relationship between a teacher's experience and his pay, such that each additional year of teaching is associated with an additional 2.5 percent of salary. The teacher's schooling attainment is also shown to affect pay and teachers who have completed twelfth grade earn between five and seven percent more than those who have gone only as far as tenth grade.

The results also suggest that teachers with greater native intelligence and better reading skills receive higher salary. However, once one controls for credentials and years of schooling, it is unclear through what mechanisms these other human capital characteristics would result in higher pay. Perhaps these human capital variables proxy unobserved qualities of job performance or additional responsibilities assumed by the teacher. Rather surprisingly, teacher certification does not appear to be linked to teachers' salary.

The second set of results shown in Table 1.10 suggest that, once one controls for a teacher's schooling, cognitive skills, experience, and certification, women teachers are paid six percent less than males. The linkage between gender and pay becomes statistically insignificant once other school related variables enter the regression. Since I have not found any reference to pay differentials based on the sex of the teacher, it seems possible that gender may proxy unobserved attributes of either the teachers or the schools to which they are assigned.

The Supervision of Schools

Since most schools in rural Pakistan have no on-site administrator, there is little day-to-day supervision of teachers. As a consequence, there are high levels of absenteeism among faculty and few checks on either poor methods of instruction or inappropriate behavior on the part of teachers. The District Education Officers (DEO's) are charged with providing occasional supervision of schools and they, in turn, delegate this function to a team of Assistant Education Officers who are responsible for visiting schools and ensuring teacher performance. UNESCO (1984) reports, however, that this system of supervision is crippled by the fact that each Assistant Education Officer is responsible for between 200 and 300 institutions. Among the 34 primary schools for boys examined in our survey, the median number of visits by government officials of any type was three times per year. Among the 20 girls' schools, the median was zero.

Table 1.11 shows the results of regressing the number of visits per year a school receives from a supervisor, or education official, on a set of independent variables related to the background of school teachers and the physical characteristics of the institution. This regression explains a surprisingly large amount of the variation in the number of visits from school officials (note the R-square of 0.78). Because of the small number of observations in the study, and a high degree of correlation among the regressors, estimated coefficients for several of the independent variables are highly sensitive to the inclusion or exclusion of other explanatory variables. To show the degree of consistency among regressions with different explanatory variables, three rather representative sets of results are presented in columns one to three of table 1.11.

In all of the regressions I have conducted, the proportion of certified teachers at a school has a large, negative, and highly significant effect on the number of visits from a supervisor. The expected number of visits that a school receives in a year increases more than 50 percent with a rise of one-half mean in the number of uncertified teachers. In many of the regressions, the presence of an on-site administrator has a positive and significant effect on the number of visits, but the estimated coefficient on this variable varies quite a bit among regressions. This result seems counterintuitive since it would seem that the presence of an administrator would lessen the need for outside supervision.

In all regressions, it is shown that boys' schools receive about two more visits per year than girls' schools, but this result becomes statistically insignificant when many variables related to the physical characteristics of schools are included as regressors. Given the poor conditions at many girls' schools, there is no obvious performance-related reason for supervisors to undertake fewer visits of girls' schools. However, it may be the case that the cultural norms on gender relations makes it more difficult for male inspectors to supervise these institutions.

The regressions also consistently show a positive and significant link between the number of children in the lower grades and the number of visits from government officials. If inspectors allocate their time in order to bring the greatest benefit to the greatest number of children, there would likely be economies of scale from visiting the largest schools. In addition, the results show a consistent, negative, and statistically significant relationship between a school having no desks and the number of inspection visits. Although this result is highly robust to the inclusion of other regressors related to the physical characteristics of schools, this author can think of no functional reason for the relationship.

Table 1.11 Regressing the Number of Supervisory Visits on School Characteristics

No. of Observations	54			
Mean of Dep. Var.	4.43			
Stand. Dev. of Dep. Var.	4.66			
R Square	0.79360	0.75840	0.64484	

	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Mean S.D.
Constant	33.362 (0.553)	10.718 (2.704)**	8.047 (6.448)***	
Proportion of Teachers at School Who Are Certified	-7.423 (-4.122)***	-6.882 (-4.149)***	-7.039 (-5.260)***	0.81 *0.36*
Bin. Var. Equals One if School Is For Boys	1.950 (1.214)	1.914 (1.326)	2.275 (2.738)***	0.63 *0.49*
Bin. Var. Equals One If There Is Administrator at School	2.542 (1.494)	2.840 (1.912)*	5.261 (3.838)***	0.13 *0.34*
Average Reading Score of Teachers at School	-0.013 (-0.089)	-0.004 (-0.035)		20.95 *4.47*
Average Years Teaching Experience of Teachers	0.081 (1.006)	0.039 (0.503)		9.33 *5.91*
No. of Children In Second Grade Of School	0.041 (1.855)*	0.044 (2.206)**		24.33 *22.21*
Bin. Var. Equals One If There Is Electric Power At School	-1.976 (-1.209)	-1.309 (-1.014)		0.15 *0.36*
Bin. Var. Equals One If School Has Walls	-0.235 (-0.201)	-0.706 (-0.679)		0.41 *0.50*
Bin. Var. Equals One If School Has No Desks	-3.506 (-2.627)**	-3.367 (-2.761)***		0.78 *0.42*
No. of Hours Per Day That the School Operates	-0.200 (-0.469)	-0.104 (-0.252)		5.44 *0.93*
Rate of Attrition At School	0.718 (0.467)	0.317 (0.238)		0.43 *0.36*
Proportion of Women Teachers * Bin. Var. = 1 if Boy School	-3.144 (-1.021)	-3.417 (-1.600)		0.06 *0.23*
Proportion of Women Teachers * Bin. Var. = 1 if Girl School	0.914 (0.431)	0.489 (0.266)		0.22 *0.42*
Average Raven's Score Score of Teachers at School	0.122 (1.401)			27.55 *6.05*
Average Math Score of Teachers at Score	-0.054 (-0.657)			17.41 *7.08*
Year the School Began	-0.014 (-0.467)			1964.38 *19.65*
Bin. Var. Equals One If School Has Safe Water	0.769 (0.679)			0.39 *0.49*
Books Observed At School Divided By No. of Children (%)	0.046 (1.719)*			55.89 *16.84*

Linking School Characteristics and Outcomes

In a nation such as Pakistan, where education is optional, enrollment and retention are key elements of schooling performance. In this section, I explore how the characteristics of schools and teachers affect attrition for both boys and girls, using school-level data that indicate the number of children enrolled in each grade in the surveyed primary schools. This analysis is based on a proxy for attrition that is equal to the difference in the number of students in grades one and five, divided by the number of students in grade one. (Thus, an attrition rate of zero indicates that all students in the first grade of a particular school can be expected to complete their primary education.)

Table 1.12 shows differences in characteristics between schools that have a low rate of attrition (below 0.35) and those with a high rate of attrition, and indicates with a t-test whether these differences are statistically significant. Tables 1.13 shows the results of regressing the attrition measure against the teacher and school attributes. Again, more than one set of regression results are included because the estimated coefficients in these regressions are sensitive to the inclusion and exclusion of explanatory variables. The high R-square for these regressions suggests that the characteristics of schools and of teachers play an important part in determining whether children drop out of primary school.

These results confirm the value of the government's efforts to hire more women teachers: irrespective of whether they are teaching boys or girls, the proportion of women teachers shows a large, negative, and significant effect on attrition. One must take care in interpreting these results, however, as the relationship between teacher gender and attrition may be due to biases arising from the manner in which teachers are selected into different types of schools. It is possible that women teachers are most easily recruited into the better girls' schools and that male teachers must be hired into schools with the most severe problems of attrition. The negative linkage between attrition and the presence of women teachers at boys' schools might be explained by the fact that women tend to teach at the largest and best equiped of these institutions.

In most of the regressions of attrition, the average reading score of teachers is shown to have a small, negative, and statistically significant effect on dropping out. This might argue against hiring women teachers, who typically have lower cognitive skills than male teachers, but the detrimental effects of the lower reading score among women are more than offset by the positive effects of gender.

Table 1.12 Characteristics of Schools with High and Low Rates of Attrition

	Mean for Schools w/ Low Attrition (25 Cases)	Mean for Schools w/ High Attrition (29 Cases)	t-stat.
No. of Visits By Gov't Supervisor	3.8800	4.8966	-.82
Bin. Var. = 1 if Boys' School	0.6400	0.6207	0.14
Hours per Day School in Operation	5.6560	5.2550	1.66
Bin. Var. = 1 if School Has Electricity	0.2400	0.0690	1.72 *
Bin. Var. = 1 if School Has Walls	0.3600	0.4483	-0.65
Bin. Var. = 1 if School Has Water	0.4800	0.3103	1.26
Bin. Var. = 1 if School Has No Desks	0.7600	0.7931	-0.29
Year School Began	1960.0000	1968.1429	-1.43
No. of Books Observed / No. of Students	60.0684	52.2963	1.80 *
Bin. Var. = 1 if School Has Adminis'r	0.1200	0.1379	-0.19
No. of Kids in Second Grade	25.6000	23.2414	0.38
Average Reading Skills Score of Teach	21.1444	20.7771	0.29
Av. Math Score of Teachers	17.6644	17.1892	0.24
Av. Native Intelligence Score of Teachers	27.2244	27.8272	-0.36
Proportion of Teachers with Certificate	0.8800	0.7586	1.27
Av. Years Experience Among Teachers	9.4067	9.2611	0.09
Proportion of Teachers Who Are Male	0.6400	0.7931	-1.23

The results are less reassuring about the government's efforts to increase certification among teachers: while the estimated coefficients on certification vary a great deal among regressions, they always fall short of statistical significance (they are often very far from significance). Warwick and Reimers (1995), UNESCO, and the World Bank have all made disparaging evaluations of Pakistan's certification process and the results from the current study seem to support the contention that teacher certification has no important effect in curtailing attrition.

In several regressions I included as an explanatory variable the number of visits by government officials, but this could never be shown to have an effect on attrition. However, as one would expect inspectors to spend more time in troubled schools, the estimate of this coefficient may carry a negative bias. It was also the case that teaching experience could not be shown to have any effect on attrition.

The results indicate that certain physical aspects of a school can have a significant effect on schooling completion. Introducing electricity to a school has the effect of reducing attrition from 0.43 to 0.13. The presence of walls, on the other hand, has a large, positive and significant effect on attrition. Although it is not shown in the attached table, this result holds whether we consider boys' or girls' schools. The most likely explanation of this is that walls are being constructed in areas in which parents or teachers perceive a threat to the safety or privacy of children and that these structures are only partially effective in eliminating the concern.[25]

A Summary of the Effects of School Characteristics on Attrition

Pakistan is anomalous among south Asian nations both in its low level of spending on education and in having no requirement for compulsory education. The low level of investment in education has resulted in poor availability of schools and in low quality primary institutions. This, in turn, has resulted in weak demand for schooling — the nations' rates of enrollment and retention are the lowest in the region.

The analysis indicates that schooling demand, as represented by attrition, is sensitive to several school-related variables including the physical infrastructure of a school, and the gender of the teachers at a school. Increasing the number of women primary school teachers appears to be especially important in retaining students but it seems possible that the government's efforts at recruiting more women are being constrained by the paucity of qualified female candidates — a consequence of the previous neglect of education for girls. The availability of texts also appears to enhance attendance but the availability of other learning resources (including desks) cannot be shown to affect attrition.

[25] For further discussion of the relation between school quality and performance in developing countries, see Lockheed and Hanushek (1988), Mingat and Tan (1988), Heckman, Layne-Farrar, and Todd (1994), and Behrman (1996).

Table 1.13 OLS Regressions of Attrition

No. of Observations	54			
Mean	0.43			
Standard Deviation	0.36			
R^2	0.574	0.442	0.332	

	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Mean *S.D.*
Constant	1.072	1.425	0.920	
	(0.159)	(3.497)***	(3.496)***	
Average Reading Score of Teachers	-0.031	-0.018	-0.020	20.95
at School	(-2.069)**	(-1.571)	(-1.699)*	*4.47*
Bin. Var. Equals One If There Is	-0.386	-0.326	-0.216	0.13
Administrator at School	(-2.168)**	(-1.958)*	(-1.600)	*0.34*
Bin. Var. Equals One If There Is	-0.301	-0.399	-0.408	0.15
Electric Power At School	(-1.721)*	(-2.898)***	(-3.053)***	*0.36*
Bin. Var. Equals One If School	0.218	0.251	0.339	0.41
Has Walls	(1.741)*	(2.173)**	(3.137)***	*0.50*
Proportion of Women Teachers X	-1.029	-0.491	-0.444	0.06
Bin. Var. = 1 if Boy School	(-3.488)***	(-2.061)**	(-1.923)*	*0.23*
Proportion of Women Teachers X	-0.388	-0.537	-0.438	0.22
Bin. Var. = 1 if Girl School	(-1.707)*	(-2.706)***	(-3.543)***	*0.42*
Proportion of Teachers at School	-0.293	-0.189		0.81
Who Are Certified	(-1.506)	(-0.981)		*0.36*
Average Number of Years Experience	0.005	0.006		9.33
of Teachers at School	(0.555)	(0.656)		*5.91*
Bin. Var. Equals One if School Is	-0.128	-0.189		0.63
For Boys	(-0.719)	(-1.135)		*0.49*
No. of Hours Per Day That the	-0.064	-0.060		5.44
School Operates	(-1.377)	(-1.252)		*0.93*
No. of Children In Second Grade	0.002	-0.000		24.33
Of School	(0.716)	(-0.184)		*22.21*
Bin. Var. Equals One If School	0.092	0.113		0.78
Has No Desks	(0.620)	(0.797)		*0.42*
Average Native Intell. (Raven's)	-0.002			27.55
Score of Teachers at School	(-0.187)			*6.05*
Average Math Score of Teachers	0.002			17.41
at Score	(0.218)			*7.08*
Year the School Began	0.000			1964.38
	(0.137)			*19.65*
Bin. Var. Equals One If School	-0.171			0.39
Supplied with Safe Water	(-1.393)			*0.49*
No. of Books At School Divided By	-0.003			55.89
No. of Children (percent)	(-0.960)			*16.84*

The processes of certification and inspection also seem to be ineffective. Teacher certification cannot be shown to improve retention and this implies that the system of visiting supervision, which focuses on schools with the fewest certified teachers, might be more effective if its efforts were more closely tied to measures of schooling performance. The presence of on-site administrators does appear effective in lessening attrition and this would imply that district education officials should look for better mechanisms for local supervision. Differentials in teachers' pay seem to be rational in that they reward some of the characteristics that positively affect schooling (there is higher pay for those with the best academic backgrounds) and ignore some attributes (such as certification) which seem to be irrelevant to teacher performance.

There are some policy instruments that cannot be evaluated using the data available for this study but which warrant further analysis. Among these is the effect of wages on the recruitment of qualified women teachers. It would also be of interest to determine how reductions in the fees charged by schools, and reductions in the costs of school supplies — including books — would influence enrollment and retention.

Child Labor Employment

Although there has been intensive media coverage of the widespread use of child labor in Pakistan, there is very little data on the frequency and intensity of child labor use in the nation. What statistics do exist vary widely from each other and none can be deemed reliable. The Economic Survey (1988-89) of the government of Pakistan offers estimates for the economic activity of older children (ages 10 to 14) and these suggest that 20 percent of the cohort are involved in work outside of the home while another 36 percent are engaged in housework. However, the Social Workers Association of Karachi has produced a survey of child labor that includes much younger children and they conclude that 20 percent of the cohort of all 5 to 14 year olds in Pakistan are employed outside of the home (Ahmad and Quasem 1991). Ahmad and Quasem also cite an additional survey from an unspecified source which indicates that closer to 40 percent of children ages 5 to 14 are employed outside of the home.

Media attention on the issue of child labor in Pakistan has typically focused on urban employment of youngsters because child labor use in factories is conspicuous and the conditions under which children work in manufacturing are often detrimental to their health. However, studies of other nations in south Asia suggest that the incidence of child labor is greater in rural areas and that children working in the countryside typically begin work at a younger age than their urban counterparts. While the conditions under which rural children are employed are less likely to have immediate harmful consequences than those found in the city, one must be concerned that rural child labor may preclude schooling and have long-term detrimental effects on children's development.

Given the poor quality of information on child labor participation in Pakistan, it is useful to consider how the data on child work utilization used for this dissertation compare with surveys from other nations with economic and cultural attributes that are similar to Pakistan. There are surveys on child labor employment in Bangladesh produced by Cain (1977), and Ahmad and Quasem (1991) that offer especially useful comparison since this nation was part of Pakistan until 1971 and the two countries share many cultural and religious characteristics. Data from India produced by Singh and Verma (1987) also provide a useful comparison since Pakistan and India share a common history and similar levels of per-capita GNP.

The Data Used for this Study

The Pakistan data set used for this dissertation includes information on the amount of time spent by household members on a list of select activities. The survey questions from which these data were taken asked male and female heads of household to recall the amount of time spent by family members on each of several important activities related to agricultural and the care of household animals. The period of recall varied over the survey, from two months to one year, depending on the length of time since the previous survey. The activities on which heads of household were queried included harvesting, threshing, irrigation, field preparation, planting, weeding, herding, poultry care, and fishing.

While this list of activities includes the most important agricultural tasks undertaken by family farm workers, it excludes the wide range of non-agricultural productive work (for example, handcrafts and marketing of produce) and household maintenance activities (e.g., cleaning, cooking, gathering water and firewood). As a consequence, the survey may offer a more-or-less complete estimate of work for those whose primary activities are in agriculture, but a very inadequate picture for those who are primarily engaged in domestic work. This distinction is significant for Pakistani farm households since there is a rigid division of labor based on gender. This reflects the Muslim practice of *purdha*, or seclusion of women within the household, which is commonplace in rural Pakistan.

Table 1.14 Average Number of Days (8 hour) Worked by Age and Sex Among 114 Bangladeshi Households

Activity	Ages 4–6 M	Ages 4–6 F	Ages 7–9 M	Ages 7–9 F	Ages 10–12 M	Ages 10–12 F
Agricultural Work	22.8	18.3	41.6	18.3	77.6	13.7
Off-farm Work	0.0	0.0	45.6	13.7	100.4	4.6
Animal Care	31.9	13.7	86.7	31.9	109.5	22.8
Housework	41.1	54.8	50.2	168.8	27.3	246.4
Other	0.0	0.0	4.6	0.0	13.7	18.3
Total Work	95.8	86.7	228.1	232.7	328.5	305.7

The Incidence and Intensity of Child Labor Use in Pakistan

Cain's Bangladesh study, which is one of only a few works to offer detailed time-allocation data related to the use of child labor in the sub-Continent, provides a useful point of comparison to the present analysis.[26] While Cain's data indicate that Bangladeshi children perform more work than do the Pakistani youngsters in our survey, his study suggests that tasks are distributed by age and gender in much the same fashion as in Pakistan (see table 6). In both the Pakistan and Bangladesh data, gender specialization of labor is evident as early as five and six years of age,[27] and much of the work performed by young boys is in animal care and herding.

Cain's study indicates that six year old boys contribute approximately 96 days of labor per year and their work is concentrated in agricultural activities, off-farm tasks, and caring for animals (these constitute 57 percent of time spent working, see table 1.14). Six year old girls contribute slightly less labor but are primarily

[26] Bangladesh provides an especially useful comparison as it was part of Pakistan until 1971 and the two nations share many common social characteristics.

[27] Young girls are used almost exclusively in tasks within the immediate vicinity of the home while boys are allowed to run errands, herd livestock, and work in fields that are far removed from the family dwelling

engaged in housework (this accounts for 63 percent of their time spent working). As children age, the amount of time spent in work increases and gender roles in labor become more pronounced: by the time that boys are 10 to 12, they contribute 329 days of labor and agricultural activities, off-farm tasks, and caring for animals constitute 88 percent of their total labor time. At this age, girls work an average of 306 days, of which 81 percent is in housekeeping.

Table 1.15 Average Days in Tasks for All Boys and Girls by Age

Age	Boy Days in Agriculture	Boy Days in Animal Care	Girl Days in Agriculture	Girl Days in Animal Care
6	0.8	19.2	1.6	0.0
7	5.8	40.6	0.4	3.2
8	2.1	42.7	3.0	4.6
9	9.1	41.1	1.8	4.2
10	17.9	48.0	5.0	0.0
11	21.9	73.0	2.6	0.0
12	24.6	66.8	1.4	0.0

The gender differences in labor use are also evident in the Pakistan data set. Table 1.15 shows the time spent on agricultural tasks and animal care by boys and girls. While boys dedicate large numbers of hours to these activities, girls contribute virtually no time to these tasks. Because of this sharp division of labor by gender, and because the only labor data available to this study reflects work that is almost exclusively engaged in by males, this dissertation will concentrate on the employment of boys and will largely ignore issues related to the use of girl labor.

Even though we have only partial data on the use of boy labor, several interesting insights emerge in comparing the activities of Pakistani boys with their Bangladeshi counterparts. Table 1.15 indicates that Pakistani boys provide less work in agriculture and animal care than Bangladeshi boys of a similar age. This may be due to the fact that the Bangladeshi households surveyed by Cain are poorer than those in the Pakistan data set (the per-capita income in Bangladesh is less than half that of Pakistan).

The Interaction of Schooling and Employment

Table 1.16 shows the number of children for whom animal care and agricultural activities constitute part-time and full-time work. These figures indicate that only

12 percent of six year olds are engaged in these types of work and that employment increases to 44 percent by the time boys reach the age of 12. These data, however, conceal the fact that the work load falls disproportionately on those boys who are not enrolled in school. From table 1.17, one can calculate that 51 percent of unenrolled boys are engaged in agricultural activities and animal care, while only nine percent of enrolled boys are employed in these tasks. While Cain does not differentiate the amount that children work on the basis of enrollment, a study of child labor in rural India by Kanbargi and Kulkarni (1985) finds that, among the children ages 5 to 14, those who are unenrolled work on average four times as much as those who are enrolled.

Table 1.16 The Number of Children for Whom Animal Care and Agricultural Tasks Constitute Part-Time and Full-Time Work

	No Work		P-T Work		F-T Work	
Age	No.	%	No.	%	No.	%
6	67	88.1	5	6.5	4	5.2
7	62	86.1	2	2.8	8	11.1
8	60	77.9	8	10.4	9	11.7
9	49	71.7	13	18.3	9	12.7
10	46	66.7	12	17.4	11	15.9
11	46	65.7	9	12.9	15	21.4
12	43	55.9	19	24.7	15	19.5
	373	72.9	68	13.3	71	13.9

The strong negative relationship between work and schooling may seem surprising since, in many environments, it is common for children to pursue both activities. Educational policy makers in many nations, including the U.S., have designed the school year so that farm households have their children available through important parts of the growing season. It has been even been suggested that, for children from poorer households, the ability to go to school may be increased by working since it is only through work that they can afford school supplies or a diet that is adequate for learning.

While there is nothing about the schooling environment in Pakistan, Bangladesh, or India that precludes an enrolled child from working on a part-time basis, the nature of the tasks in which boys are employed may make work and education mutually exclusive. Studies of child labor in south Asia consistently indicate that

Table 1.17 Work by Enrollment Among Our Sample of Boys Ages 6 to 12

Enrollment	None	Part Time	Full Time	Total
No	109	44	68	221
Yes	264	24	3	291
Total	373	68	71	512

tending livestock is the task in which young boys are most frequently engaged, and the Pakistan data indicate that more than 80 percent of the time that boys work on the family farm is spent in animal care. Since animals must be fed daily and must be moved continually to fresh grazing, this is a job which is typically undertaken for many hours each day. As a consequence, children who are used in this work are unlikely to be able to attend school. Agricultural tasks, such as field preparation and harvesting, can be undertaken on a part-time and occasional basis, but boys are not typically engaged in these jobs until they approach adolescence. Similarly, household chores and off-farm activities, on which boys spend significant time, can also be undertaken on a part-time basis, and it seems likely that, were data available on the time dedicated to these tasks, we would observe a less dramatic negative correlation between work and schooling.

To better understand the relationship between schooling and the use of child labor, it is useful to again consider how enrollment changes with age. The data shown in table 1.3 indicate that at six years old, the age at which children typically start the first year of school (following a year of kindergarten), enrollment among boys is about 70 percent. This figure holds constant through the age of seven, but drops significantly when children reach the ages of eight and nine. This decline occurs when boys are typically in the middle of their primary school education and at a time when they have not yet become fully literate. These enrollment figures, and particularly the sharp decline in boys' primary enrollment at ages eight and nine, are consistent with the findings of Warwick and Reimers (1995).

It is interesting to note that this decline in enrollment occurs at an age when boys are starting to make a significant contribution on the family farm. Based on the Bangladeshi data, Cain estimates that the productivity of boys, measured in terms of the productivity of an adult male, rises from approximately 30 percent for 4 to 6 year olds to 68 percent for 7 to 9 year olds, and 80 percent 10 to 12 year olds.[28] When Cain compares the production of boys with their average daily calorie consumption, he finds that boys become net producers (producing more than they consume) between the ages of 10 and 12.

Table 1.18 Number of Unenrolled Boys, Ages 6 to 12, in Part-time and Full-time Work by Age

Age	No Work No.	No Work %	P-T Work No.	P-T Work %	F-T Work No.	F-T Work %
6	17	73.9	2	8.7	4	17.4
7	12	57.1	1	4.8	8	38.1
8	19	61.3	3	9.7	9	29.0
9	18	51.4	8	22.9	9	25.7
10	14	40.0	10	28.6	11	31.4
11	12	35.3	7	20.6	15	44.1
12	17	40.5	13	31.0	12	28.6
	109	49.3	44	19.9	68	30.8

Among *unenrolled* Pakistani boys, almost one-third are engaged full-time on agricultural tasks and animal care, and fully one-half spend some amount of time on these activities. It is shown in table 1.19 that the amount of time that unenrolled boys spend on agricultural tasks and animal care is equal to 72 percent of the time dedicated by adult male household members: unenrolled boys work an average of about 128 days per year on these select tasks while adult males work approximately 175 days. The table also reveals that unenrolled girls provide very little labor to agriculture and animal care: the time they spend on these tasks is less than six percent of the time employed by unenrolled boys. Similarly, the amount of time that adult female household members spend on these tasks is less than 10 percent of that spent by adult male household members.

It is also shown that unenrolled boys spend *more* time in animal care than adult male household members but significantly less time in agricultural activities. The importance of animal care in child labor is verified by the other studies of child labor in Bangladesh and India. Cain finds that, although animal care is often undertaken by children as young as four to six years old, boys aged 10 to 12 are the household

[28] Cain estimates the difference of productivity of boys and men by comparing child wage rates for different ages with the adult wage rate. Since there was no market for rural child labor in the areas of Pakistan considered for this dissertation, it is not possible to estimate similar values for this study.

members most frequently engaged in this work: they contribute an average of 59.3 days per year to animal care. Once Bangladeshi boys reach their teens, however, the amount of time they spend on animal care falls by more than half and adult males are found to contribute no time to this activity.

Table 1.19 Days of Work on Agricultural Activities and Animal Care By Type of Family Member

Type of Activity	Men	Women	Unenrolled Boys	Unenrolled Girls
No. of Observations	2275	2236	221	329
Agricultural Activities	107.6	10.9	23.5	3.1
Animal Care	68.7	5.4	104.2	3.3

Table 1.20 provides a further breakdown of the types of tasks that are undertaken by boys at different ages. In this representation, agricultural work is decomposed into the tasks of field preparation, irrigation, field supervision, and construction and repair and the table indicates the number of boys of each age who contribute *any* time to a specific job. The most frequent activities for the youngest boys are animal care, field preparation, and planting, while the least frequent are irrigation, construction, repair, and farm supervision. These latter tasks often do not demand a great deal of physical strength but, rather, require mature judgement. Singh and Verma find that among the youngest Indian children who are involved with field preparation and planting, their tasks usually involve carrying small seedlings for transplantation, protecting young crops against pests, weeding around seedlings, and hoeing smaller clods of earth. Older children involved in field preparation are typically engaged in activities that call for more stamina and judgement such as transplanting paddy, ploughing, and distributing fertilizer. The youngest Indian children who undertake construction and repair are typically engaged in cleaning tools, weaving bamboo, and repairing fences.

In addition to the effects of gender and age, the use of rural child labor in Pakistan is also influenced by differences in household stocks of physical and human capital. This is due to the fact that many of the activities in which children engage require land, livestock and other inputs. It also reflects the fact that these assets proxy household wealth and income which, in turn, reflect children's health, nutritional status, and capacity for work.

Table 1.20 The Number of Boys (Enrolled and Unenrolled) Involved in Activity, by Age

Age	Herding & Animal Care	Field Prep. & Planting	Irri-gation	Harvest. & Thresh.	Farm Super-vision	Construc-tion & Repair	Non-working Boys / Working Boys
6.00	4	4	1	2	0	0	67/9
7.00	8	3	2	3	0	1	62/10
8.00	9	4	3	6	0	2	60/17
9.00	8	10	5	10	0	2	49/22
10.00	10	13	10	14	1	1	46/23
11.00	14	12	9	14	1	4	46/24
12.00	15	21	16	24	1	8	43/34

In table 1.21, households are divided at the median for owned stocks of assets, human capital, and number of family members. It is shown that the amount of time that children spend in work is negatively linked with the number of males in the household. This suggests either that adult male labor is a substitute for boy labor, or that the presence of an adult male in the household increases income and reduces the need for children to work. This latter effect, however, seems unlikely since the table also shows that adding an adult male to the household *reduces* the likelihood that a boy will be enrolled in school (although this relationship falls just short of significance). Land ownership is shown to have a similar ambiguous effect on work and schooling: while the ownership of land increases the chances of a boy attending school, land ownership cannot be shown to reduce the use of child labor (the use of boy labor is actually greater in households with more land, but this relationship is not statistically significant).

The data also indicate that the amount of boy labor is strongly and negatively linked to the maximum reading score among household adults. Since just slightly over half of the households in the sample have a maximum reading score of zero, the households are being divided into those that are literate and those that are not. Households in which at least one member can read use only one-third the boy labor of illiterate households. There are several possible explanations for this relationship. First, literate households may rely more on nonagricultural earnings, and maintain smaller farm operations. A second possibility is that literate farmers experience smaller benefits from child labor. It is possible that cognitive skills are a substitute for child labor or that, in areas that are unsuited for the use of child labor, the

Table 1.21 Differences in Boy Time Use by Household Characteristics

	No. Below/ No. Above Median	Average Below Median Value	Average Above Median Value	t-Stat.
No. of Adult Males in Household. Median Value: 2				
No. of Work Days in Ag. per Boy	205/307	16.7610	8.2638	1.68
No. of Work Days in Animal Care	205/307	56.9756	40.6189	1.44
Bin. Var. Equals 1 if Boy Enrolled	205/307	0.6098	0.5407	1.55
No. of Adult Females in Household. Median Value: 2				
No. of Work Days in Ag. per Boy	267/245	14.4007	8.6857	1.25
No. of Work Days in Animal Care	267/245	52.0599	41.8367	0.95
Bin. Var. Equals 1 if Boy Enrolled	267/245	0.5506	0.5878	-0.85
No. of Kids Aged 6 to 12 in Household. Median Value: 2				
No. of Work Days in Ag. per Boy	235/277	10.2979	12.8267	-0.55
No. of Work Days in Animal Care	235/277	49.3802	45.2958	0.37
Bin. Var. Equals 1 if Boy Enrolled	235/277	0.6383	0.5090	2.97
No. of Boys Aged 6 to 12 in Household. Median Value: 1				
No. of Work Days in Ag. per Boy	208/304	7.0481	14.8257	-1.80
No. of Work Days in Animal Care	208/304	54.5433	42.1217	1.11
Bin. Var. Equals 1 if Boy Enrolled	208/304	0.6298	0.5263	2.34
Total Acres of Land Owned by Household. Median Value: 1.6				
No. of Work Days in Ag. per Boy	257/255	9.5020	13.8132	-0.94
No. of Work Days in Animal Care	257/255	41.6275	52.6654	-1.02
Bin. Var. Equals 1 if Boy Enrolled	257/255	0.5310	0.6063	-1.72
Value of Mechanical Equip. Owned by HH. Median Value: 611 Rupees				
No. of Work Days in Ag. per Boy	256/256	11.3984	11.9336	-0.12
No. of Work Days in Animal Care	256/256	44.316	50.024	-0.52
Bin. Var. Equals 1 if Boy Enrolled	256/256	0.5461	0.5906	-1.02
Value of Livestock Owned by HH. Median Value: 10520 Rupees				
No. of Work Days in Ag. per Boy	259/253	11.4286	11.9091	-0.10
No. of Work Days in Animal Care	259/253	43.8031	50.6126	-0.63
Bin. Var. Equals 1 if Boy Enrolled	259/253	0.5869	0.5494	0.85

Continued

Table Continued

	No. Below/ No. Above Median	Average Below Median Value	Average Above Median Value	t-Stat.
Maximum Reading Score Among HH Adult Males. Median Value: 0				
No. of Work Days in Ag. per Boy	257/255	16.8327	6.4588	2.27
No. of Work Days in Animal Care	257/255	72.5486	21.5882	4.82
Bin. Var. Equals 1 if Boy Enrolled	257/255	0.4397	0.6980	-6.10
Distance to Nearest Fertilizer Sales. Median Value: 5 Km.				
No. of Work Days in Ag. per Boy	277/235	11.1264	12.3021	-0.26
No. of Work Days in Animal Care	277/235	42.0129	51.9371	-0.97
Bin. Var. Equals 1 if Boy Enrolled	277/235	0.5668	0.5702	-0.08
Distance to Prim. School Nearest Village. Median Value: 0.21 Km.				
No. of Work Days in Ag. per Boy	226/286	10.3811	13.2920	-0.61
No. of Work Days in Animal Care	226/286	38.6133	55.2587	-1.58
Bin. Var. Equals 1 if Boy Enrolled	226/286	0.6084	0.5177	2.06
Distance to Middle School Nearest Village. Median Value: 4 Km.				
No. of Work Days in Ag. per Boy	304/208	11.0197	12.6106	-0.34
No. of Work Days in Animal Care	304/208	41.9912	51.2587	-0.86
Bin. Var. Equals 1 if Boy Enrolled	304/208	0.5724	0.5625	0.22
Av. Reading Score of Teachers in Prim. School. Median Value: 11				
No. of Work Days in Ag. per Boy	252/260	8.1349	15.0885	-1.52
No. of Work Days in Animal Care	252/260	53.5002	41.0356	1.15
Bin. Var. Equals 1 if Boy Enrolled	252/260	0.5839	0.5532	0.69
No. of Books at Prim. School/No. of Students. Median Value: 54%				
No. of Work Days in Ag. per Boy	243/269	11.6379	11.6914	-0.01
No. of Work Days in Animal Care	243/269	53.3462	39.825	1.27
Bin. Var. Equals 1 if Boy Enrolled	243/269	0.5844	0.5539	0.69
Student Teacher Ratio at School Nearest Village. Median Value: 24				
No. of Work Days in Ag. per Boy	226/286	14.0245	8.6814	1.19
No. of Work Days in Animal Care	226/286	49.5988	45.2513	0.39
Bin. Var. Equals 1 if Boy Enrolled	226/286	0.5050	0.4933	1.31

current cohort of adult males are more likely to have been sent to school. Finally, literate households may be better informed about the benefits of schooling, or may be better placed to profit from schooling, than illiterate households. Table 1.21 indicates that children from literate households are far more likely to be enrolled in school but, again, it is unclear if this is motivated by greater benefits of education or lower opportunity costs.

Table 1.21 also divides households at the median for variables related to the availability and quality of schooling and provides simple t-tests of the effect of these variables on schooling and child labor. These indicate that households that are isolated from primary schools are less likely to enroll their boys. The distance to primary school is also positively correlated with the use of boy labor, although this relationship is just short of statistical significance at the ten percent level.

A Summary on Child Labor Use in Rural Pakistan

Despite the widespread use of child labor in Pakistan, there are no reliable nationwide data on this phenomena. The current study has only partial information on the allocation of children's time and these data are largely concerned with time spent in agricultural activities. However, the patterns that emerge from our data on child labor use are consistent with studies of the economic activities of children in Bangladesh and India.

One pattern that emerges quite clearly from our data is that there are sharp distinctions in child labor use based on gender and age. Boys are far more likely to be employed with animals and crops than are girls, and young boys are engaged almost exclusively in herding activities. There is also a sharp dichotomy in child labor use between enrolled and unenrolled boys: 51 percent of unenrolled boys work on at least a part-time basis, while this figure is only 9 percent among those who attend school. The amount of work performed by unenrolled boys is quite significant: the average boy in the 6 to 12 age group, who does not attend school, contributes 128 days of labor per year. This compares with 176 days per year among adult males in the household.

Based on simple pair-wise correlations, the use of child labor appears to be negatively linked with the human capital of household adults and the number of adult males in the household. There do not appear to be strong relationships between the intensity of child labor utilization and either the availability or quality of schools. Multivariate analyses of these relationships are presented in the next chapter.

CHAPTER II

EFFECTS OF HOUSEHOLD AND SCHOOL CHARACTERISTICS ON INVESTMENT IN PRIMARY EDUCATION AND THE USE OF CHILD LABOR

Introduction

The previous chapter presented evidence of a sharp decline in the demand for education among farm boys at the age at which, many believe, these children become useful in household production. Further evidence is needed to establish whether families are trading off the current value of child labor with the future value of schooling. I address this question explicitly in chapter three where I assess the effect on agricultural earnings of both boy labor and cognitive skills. In the current chapter, I focus on household behavior and on how the allocation of boys' time is influenced by a range of factors, including the quality and availability of local schools, characteristics of the household's agricultural operation, the family stock of human capital, and household composition. I estimate the determinants of both schooling and boy labor use and assess how educational policy instruments, such as the construction and provisioning of schools, can influence schooling attainment and the amount of work performed by boys. I also explore which household production characteristics most influence the schooling decision.

A great deal can be learned from comparing the analyses of schooling and the use of boy labor with the agricultural profits function and reading skills production function presented later in this study. Agricultural household models offer few unambiguous predictions for the manner in which productive assets and school characteristics affect the allocation of children's time; these determinants can operate through a number of mechanisms — including income effects, substitution effects in agricultural production, and substitution effects in the production of schooling outcomes — and these can either operate in consort or confound each other. By comparing the determinants of cognitive skills production, farm earnings, and household behavior in the allocation of child time, many of these individual effects can be isolated and identified.

Modelling the Household Allocation of Child Time

Works by Becker, Mincer, and Ben-Porath, provide the theoretical basis for most analyses of how households allocate children's time between schooling and employment. The focus of these models is on the private monetary demand for schooling, and the decision to invest in human capital is treated like investment in financial instruments and physical capital.[1] In making decisions on education, rational agents are assumed to assess the discounted present value of earnings from schooling and undertake this investment to the point that its marginal value equals its opportunity cost.

A complete application of this framework to the agricultural household would involve estimating a model of the joint time allocation of all household members. This would yield a full set of cross-elasticities for all activities in household production. However, such a time allocation of family members would be made simultaneous with a wide range of other household decisions on the crops to be grown, the physical inputs to be applied to crops, the off-farm activities to be pursued, etc..[2] Moreover, these decisions are typically made in environments in which there are few markets for inputs and outputs and, thus, few exogenous prices. As a consequence, it is not feasible to solve for an identified set of reduced-form demand equations that fully specify child-time allocation, without ignoring aspects of household decision mak-

---

[1] There are, however, differences between the way human capital and physical capital are traded, resulting from the fact that human capital is restricted to the person to whom it is embodied. Given that people cannot sell claims on their future earnings, the exchange of human capital services are typically taken to be rental market transactions.

[2] If one cannot assume recursiveness between consumption and production, due to the absence of markets, differences in the prices at which households can buy and sell products, or linkages between the productivity of household members and the distribution of consumption goods within the family, the time allocation decision will also be affected by consumer prices.

ing, imposing strong assumptions on household's utility and production functions, or prescribing other constraints in modeling household behavior.

I employ a model that is designed to be as simple and general as possible while still reflecting the most significant elements of the economic environment in which our survey households operate. Rosenzweig (1977) points out that 'a large number of household production models can be carved out of the general household production framework by both restricting the set of commodities... providing utility to the parental decision makers and/or by imposing restrictions on the characteristics of the household production relations.' In this study, I focus on the production value of schooling (as in most analyses of child time allocation, education is omitted from the household utility function) and express the cost of education solely in terms of the farm profits that are foregone while the student is enrolled (although the amounts paid for books and fees, and other costs of schooling, can be quite significant for Pakistani families, I have little information on these monetary costs and ignore these in my modeling). I also consider how the allocation of children's time is affected by two constraints that face Pakistani farm households: the inability to borrow and the unavailability of agricultural wage labor.[3] As a consequence of these market imperfections, household attributes that enter the agricultural production function, such as family composition, productive assets, and the human capital of family workers, affect the opportunity cost of schooling.

I assume that household preferences are autarchic,[4] that the family has a planning horizon of two periods (corresponding to when the children are of school age and when they are adults),[5] and that household fertility is exogenous.[6] The

---

3 While there is some hiring-in of labor in some villages in the sample survey used for this study, only a very small number are able to hire-in workers at planting and harvest, the time of greatest need for workers. This is discussed in Nabi, et. al. (1986).

4 Households are maximizing a single utility function that is assumed to represent the preferences of all household members or to be accepted by everyone in the family. Several authors have commented upon the importance of the distribution of resources within the family in evaluating household behavior: see Alderman, Chiappori, Haddad, Hoddinott, and Kanbur (1995).

5 This two period model is similar to those used by Eaton and Rosen (1980) and by Kodde and Ritzen (1985) in their analyses of schooling investment among households that sell labor in the wage market. I have modified this model to include household production. Generalizing this model to n periods yields very similar results.

6 At the time that the data for this dissertation were collected (1986 to 1991), Pakistan had yet to experience the transition to lower fertility that typically occurs with development, and the use of contraception was quite low. The fertility rate stood at 7.0 per 1000 in the mid 1980s (the World Bank, 1996a).

household utility function is assumed to be monotonic, twice continuously differentiable, strictly concave, and have as arguments a composite consumption good for each time period:

$$\max \ U(q_1, q_2) \tag{2.1}$$

The household production function is also assumed to be monotonic, twice continuously differentiable, and strictly concave. It takes as arguments a vector of fixed factors, child labor, human capital, and a purchased input.[7] Period one production is

$$f_1(F, L_1, HK_1, x_1) \tag{2.2}$$

and period two production is

$$f_2(F, L_2, HK_2, x_2) \tag{2.3}$$

where

- F is a vector of fixed factors that enters the household production function in both periods; (these factors include the irrigated and rainfed land owned by the household and the number of adult males in the family);
- L_1 is the labor input of the younger generation (boys) in period-one;
- L_2 is the labor input of the younger generation (young men) in period-two;
- HK_1 is the household's initial (period-one) stock of human capital (this stock is established prior to period one and is taken as exogenous); and,
- x_1 is a non-labor purchased input used in period one.

To create a point of orientation for this analysis, I first consider a model in which households are unconstrained in their ability to borrow and to market labor. This ability to market labor implies that families can determine the amount of schooling their children will receive independent of the decision of how much labor to employ on the family farm. In a second model, I eliminate the household's ability to hire-in child labor (this is consistent with conditions in our sample villages) so that, when allocating their boys' time, families are required to choose between schooling and the total amount of labor employed in the household's agricultural operations.

[7] Other assumptions implicit in this model are that the head of household controls how children allocate their time between schooling and work on the family farm, that children will remain on the farm when they complete their education, and that the returns to schooling are known with certainty.

Finally, in a third model I eliminate the household's ability to borrow: under such circumstances, the allocation of children's time can be an important determinant of a family's ability to transfer income across time.

Since I am concerned with the allocation of boy's time, when I model a perfect labor market, I focus on only the hiring-in and hiring-out of children (I assume that in both periods households dedicate the full time endowment of all adult males to farm production and this endowment is reflected in F, the vector of fixed factors).[8] The amount of child labor that a household dedicates to agricultural production is equal to the full time endowment of their boys, T^C, less the time that these children dedicate to schooling, L^{CE}, plus the net amount of market-boy labor that is hired-in, L^M (this final term is negative if households provide more boy labor to the market than they hire). Therefore, I can write $L_1 = T^C - L^{CE} + L_1^M$. In the second period, the labor spent on the farm is equal to the full time endowment of the older generation (again imbedded in F), plus the full time endowment of the younger generation (those who were children in period one), T^C, plus the net amount of labor that is hired-in, L_2^M (or, $L_2 = T^C + L_2^M$). Period two human capital can be written as $HK_2 = HK_1 + \delta L^{CE}$ where δ is an efficiency parameter that indicates how well time spent in school is transformed into those skills that are useful in farm production. In the case of perfect labor and capital markets, the full household model can be written as follows:

Model One: The Case of Perfect Labor and Capital Markets.

$$\begin{aligned} L = {} & U(q_1, q_2) \\ & - \lambda_1 (p_{q_1} q_1 + p_{L_1^M} L_1^M + p_{x_1} x_1 - p_{f1} f_1(F, T^C - L^{CE} + L_1^M, HK_1, x_1) - B) \\ & - \lambda_2 (p_{q_2} q_2 + p_{L_2} L_2^M + p_{x_2} x_2 \\ & \qquad - p_{f2} f_2(F, T^C + L_2^M, HK_1 + \delta L^{CE}, x_2) + B(1+r)) \end{aligned} \tag{2.4}$$

where

p_{q_1} is the price of the first-period composite consumption good;
$p_{L_1^M}$ is the first-period child wage;
p_{x_1} is the price of the first-period purchased input;

---

8 Willis (1974) also treats the time allocation of adult males as exogenous when modeling how parents invest in children's human capital.

p_{f1} is the first-period price of the household's production;

B is the amount borrowed or lent in the first period (borrowing in the first period implies a positive value for B); and,

r is the interest rate at which households can borrow and lend.

In my second model, I constrain the household farm labor input to the time endowment of family members. Even under this constraint, however, the labor factor remains endogenous in the first period: families allocate first-period child time between work and schooling and any time that a child spends in education reduces the total time the household dedicates to farming. Since this study is concerned with how households tradeoff current child labor with the future benefits of schooling, I ignore the allocation of time in the second period, and assume that households dedicate the full second-period time endowment of all males to agricultural activities. The model is as follows:

Model Two: The Case of Perfect Capital Markets but No Labor Market.

$$L = U(q_1, q_2) - \lambda_1(p_{q_1}q_1 + p_{x_1}x_1 - p_{f1}f_1(F, T^C - L^{CE}, HK_1, x_1) - B) \\ - \lambda_2(p_{q_2}q_2 + p_{x_2}x_2 - p_{f2}f_2(\mathrm{F}, \mathrm{T^C}, HK_1 + \delta L^{CE}, x_2) + B(1+r)). \quad (2.5)$$

In my third model, I limit both the household farm labor input and the household's ability to borrow. Credit constraints are a commonly cited reason for underinvestment in schooling: since human capital is embedded in the person who receives schooling, it cannot be used as collateral for investment financing. In developing nations, where credit markets are often far from perfect and where there is less wealth to support self-financing of the costs of schooling, this constraint is likely to be an especially great obstacle to education. In the following model, the household is constrained to borrow no more than $\overline{B}$ and, again, household farm labor is limited to the time endowment of male family members.

Model Three: The Case of No Capital Market and No Labor Market.

$$L = U(q_1, q_2) - \lambda_1(p_{q_1}q_1 + p_{x_1}x_1 - p_{f1}f_1(\mathrm{F}, \mathrm{T^C} - L^{CE}, HK_1, x_1) - \overline{\mathrm{B}}) \\ - \lambda_2(p_{q_2}q_2 + p_{x_2}x_2 - p_{f2}f_2(\mathrm{F}, \mathrm{T^C} + HK_1 + \delta L^{CE}, x_2) + \overline{\mathrm{B}}(1+r)) \quad (2.6)$$

where

$\overline{B}$ is the constraint on household borrowing.

First Order Conditions and Comparative Statics

The comparative statics for these three models are presented in tables 2.1 to 2.3 below and the derivation of the first and second order conditions for one of the models (model two) is included in appendix one of this dissertation. The single most important conclusion of this modeling exercise is that, even with a very simple representation of household decision making, there are few unambiguous relationships between household characteristics, school attributes, and the allocation of children's time.

Model One. This model yields a set of demand equations for consumption goods, for borrowing (or lending), and for production inputs (including first period hired child labor and second period human capital). The maximization conditions for the model are straightforward: households purchase productive inputs to the point that their marginal value products equal their prices, and they invest in schooling until the marginal value of human capital equals the child wage, discounted by the cost of borrowing.

The comparative static results are also simple, but many are ambiguous. The exogenous variables in this model include i) the price of the consumer good in each period, ii) the wage rate in each period, iii) the price of the purchased input in each period, iv) the initial stock of human capital, and v) the efficiency parameter that indicates how well time spent in schooling is transformed into the skills that are useful in agricultural production. Changes in the second-period wage, or in the price of the second-period non-labor input, may affect investment in schooling, but the signs of these effects will be determined by the degree of substitutability in production between human capital and the other factor inputs.[9] As we cannot anticipate, *apriori* whether factors are substitutes or complements, we cannot predict these comparative statics.

A change in the efficiency parameter, δ, produces more complex reactions in the allocation of boy time, but, again, this relationship is ambiguous. The comparative static will involve own-price effects that can be known with certainty. However, the reaction of schooling investment to a change in the efficiency parameter will also depend on the degree of substitutability between second-period human capital and the other factor inputs. We cannot anticipate the signs of the cross-product

[9] Since this model is recursive, changes in the price of the consumer good will not affect demand for either schooling or the other factor inputs.

substitution effects and cannot know if they will compound or offset the own-price effect. Again, it is not possible to anticipate whether the cross-product effects will reinforce or counteract the own-price effect.

Table 2.1 Signing Changes in the Time Spent in Education, L_1^{CE}, Resulting from Changes in Exogenous Variables: the Case of No Constraints in the Credit and Labor Markets

	Exogenous						
	P_{L_1}	P_{x_1}	F	T^c	HK_1	δ	r
Own Substitution Effect	–	0	0	0	0	+	0
Cross-Input Substitution Effect	0	0	?	?	?	?	0
The Income Effect	0	0	0	0	0	0	–
The Overall Effect	–	0	?	?	?	?	–

Among the comparative statics that we can anticipate are those for the price of the first-period purchased input and for the interest rate. For those households that are at an interior solution in the allocation of boy time (i.e., those that allocate boy time to both schooling and work), a small change in the price of the first-period purchased factor input will not affect the time spent in education. Such changes may impact the net *overall* use of child labor, but, as long as the child wage rate and the cost of borrowing remain constant, households will respond to such price changes by adjusting the net supply of child labor sent to the market; they will alter their total labor-use position without affecting the time their boys spend in school.

A rise in the interest rate will induce a reduction in schooling, and this effect will occur irrespective of a household's net position in the credit market. An increase in the interest rate will have an unambiguous effect on the credit activities of households that borrow: both an own-substitution effect and an income effect will impel greater borrowing. The schooling activities of such households are influenced only by an unambiguous income effect, however, and they will decrease their investment in schooling until the marginal value product of first-period child labor is equal to the marginal value product of second-period human capital, discounted at the new, higher cost of borrowing. Households that are initially net lenders may increase or decrease their lending (in this case the own-substitution effect acts in the opposite direction from the income effect). However, such households will adjust their human capital investment in the same manner as the households that borrow, and the time boys spend in school will decline.

Table 2.1 shows how the time boys spend in school, L_1^{CE}, is affected by some of the exogenous variables that appear in the empirical analysis, including the usefulness of education, δ, the household's endowment of fixed factors, F, and the initial human capital of the household, HK_1.

Model Two. In this model, households will again undertake investment in schooling to the point that the marginal value of child labor in first-period production is equal to the marginal value product of human capital in second period production, discounted by the cost of borrowing. Unlike the previous model, however, the marginal value product of child labor is no longer set by the child wage, and households no longer have the ability to adjust their overall first period labor position independent of the amount of time that boys spend on education. As a consequence, when the price of the first period purchased input changes, households will adjust their overall mix of first-period factor inputs and this, in turn, will alter both the marginal value product of boys and the household's investment in schooling. The sign of this comparative static cannot be anticipate.

Table 2.2 Signing Changes in the Time Spent in Education, L_1^{CE}, Resulting from Changes in Exogenous Variables: the Case of No Labor Market and a Perfect Credit Market

	Exogenous					
	P_{x_1}	F	T^c	HK_1	δ	r
Own Substitution Effect	0	0	0	0	+	0
Cross-Input Substitution Effect	?	?	?	?	?	0
The Income Effect	0	0	0	0	0	–
The Overall Effect	?	?	?	?	?	–

The comparative statics for the long-lived factor inputs (those that exist in both periods and that are represented by the vector F), become especially complex in the current model. Since variables enter the production functions in both periods, their comparative statics involve cross-product substitution effects relative to both first period child labor and second period human capital.[10]

[10] In appendix one, I provide a simplified mathematical example of the multiple substitution effects

While it is not represented in tables 2.1 to 2.3, comparative statics are also complex for households that are at a corner solution and that dedicate all of their children's time to either work or schooling. At an *interior* solution, the household will be indifferent between transferring income across time using the credit market or by adjusting the time children spend in schooling. However, the amount of income that the household can transfer by adjusting the allocation of children's effort is constrained by the number of children in the family. When this constraint is binding for a household, the returns to schooling may differ from the interest rate, even when perfect capital markets exist. In such a case, the household's allocation of children's time will be insensitive to small changes in the costs or benefits of schooling.

Model Three. In the third model, it is assumed that the household is constrained in the amount that it can borrow. When the credit constraint is binding, second period income can be transferred to first-period consumption only through an increase in the use of first-period child labor (which implies a reduction in first-period schooling) and this introduces income effects into the comparative statics.[11]

When, for example, there is an improvement in the efficiency parameter, δ, there is a rise in second period income for those households that are educating children, and these families will wish to transfer some of this increase from the second period to the first period. Given the constraint on borrowing, this transfer can only be effected by reducing the time children spend in school and increasing the time they spend in first period labor. Therefore, there will be a negative income effect associated with the rise in the efficiency of schooling and this will act to offset whatever positive substitution effects exist.

Similarly, when there is a decline in the efficiency parameter, there will be a fall in second period income and the household will wish to transfer earnings from the first period to the second period. If a household is fully 'loaned-up,' and is using some of its child time endowment in both labor and schooling, then it must be

associated with household characteristics that are fixed across periods.

11 Within the household model, the term 'income effect' can imply two phenomena. In the context of the current set of models, the term denotes the change in human capital investment that occurs as a result of the household's inability to transfer income across periods through the use of the credit market (e.g., families raise the time that children spend in labor (lower the time spent in school) to increase net transfers from the second period). In none of these models does the term 'income effect' imply that households are increasing their *consumption* of schooling as a result of higher income: schooling does not enter the utility function of the family.

the case that the returns to schooling are greater than, or equal to, the borrowing rate. As a consequence, to transfer income from the first period to the second, the household will increase the time children spend in school.[12]

While one can anticipate the income effects for those inputs that affect household production in only a single period, the income effects for longer-lived factors are ambiguous. If, for example, there is an increase in the household's stock of land, the family will enjoy greater income in both periods. It is not possible to anticipate if such a change will prompt the household to transfer income from the first period to the second, or from the second period to the first.

Table 2.3 Signing Changes in Time Spent in Education, L_1^{CE}, Resulting from Changes in Exogenous Variables: the Case of No Markets for Credit or Labor

	Exogenous					
	P_{x_1}	F	T^c	HK_1	δ	r
Own Substitution Effect	0	0	0	0	+	0
Cross-Input Substitution Effect	?	?	?	?	?	0
The Income Effect	–	?	?	?	–	–
The Overall Effect	?	?	?	?	?	–

Perhaps the single most important conclusion of this modeling exercise is that, even with a very simple representation of household decision making, there are few unambiguous relationships between household characteristics, school attributes, and the allocation of children's time. The model does, however, present us with several hypotheses that will be explored in this dissertation. Principal among these is that, in allocating children's time, households trade-off current, positive economic benefits of child labor against future, positive economic benefits of schooling outcomes. To establish the existence of such a tradeoff, I must establish all of the following: i) child labor contributes to household earnings; ii) enrollment of children reduces these earnings; and, iii) schooling outcomes raise family income.

In addition, the model also provides unambiguous signs for some of the separate

12 Note that when children's time is completely dedicated to labor and the household is credit constrained, it is not possible to know whether returns to schooling are greater than or less than the borrowing rate, and one can only state that the income effect is non-negative.

income and substitution effects through which changes in household and schooling characteristics affect the allocation of children's time. This analysis will allow me to disentangle and identify some of these individual effects and to verify the signs that are predicted by the model.

Previous Work on the Interaction of Schooling and Child Labor Utilization

Given that our simple model yields so few unambiguous relationships between household characteristics, school attributes, and the allocation of children's time, one might expect few empirical regularities to emerge from the literature. This is, in fact, the case as one does not observe an unequivocal relationship even between household income and the use of child labor. It has been commonly suggested that the use of child labor is a survival strategy employed by the poorest of households, and that children are less likely to be employed as household wealth and income increases. This has not been substantiated in the small number of studies that have explored child labor and schooling and which have used measures of the full income of households.[13] In a study of child labor in Malaysia, De Tray finds that "children from poor families neither participate more in productive activities, nor work longer hours when they do work, than children from more well-to-do families." Psacharopoulos and Arriagada find only a very small positive and significant relation between income and enrollment and a very small negative and significant link between child labor and income.

There are even more sharply conflicting results in the literature regarding the relationship between schooling, child labor utilization, household assets, and family composition. Again, the lack of consensus on these relationships might be expected since the influence of assets and family composition on the allocation of children's time can reflect offsetting income and substitution effects. A study by Cain (1977) finds that, among Bangladeshi male children under 10, those from landless households are more likely to work than boys from landed families. However, Rosenzweig and Evenson (1977) find that the probability of children being used in labor increases, and the probability of children being enrolled declines with both the size of a household's land holdings and the productivity of the family's land.

[13] Many studies represent income with assets but these can be poor proxies if they enter household production as factor inputs.

In a study of rural India, Kanbargi and Kulkarni (1985) suggest that the number of hours that children work is positively related to the number of hours of work performed by women. This result contrasts with that of Rosenzweig and Evenson (1977) who find that the amount of work performed by girls declines, and the likelihood of enrollment increases, with the adult female wage rate.[14] In a study of Brazilian children, Psacharopoulos and Arriagada (1989) find that both the likelihood of attending school and the probability that a child works are positively linked with the mother's employment.

The Schooling Decision

The Sample Used in the Schooling Analysis

In the current analysis, I examine the schooling decision from two perspectives, using data on two cohorts from the Pakistan survey. In the first approach, I use data on current enrollment for a cohort of 512 boys ages 6 to 12 from farm households. I examine the current enrollment status of these boys as a function of child-specific, household, and school-level regressors. As a second perspective, I employ data on the educational histories of rural Pakistani males, ages 18 to 29. Analyzing this older cohort is useful as there are data on this group that are not available for the primary-school aged boys, including the final level of schooling attainment and a measure of innate (preschool) ability.

I have defined this older cohort with a minimum age of 18, as virtually everyone in our rural households has completed their education by this age, and I am able to assess their final level of schooling attainment and cognitive skills. I have chosen the age of 29 as the upper sample bound since the village-level data I have on school availability and quality are contemporary, rather than historical, and are less likely to pertain to older members of the sample.[15] While the data available for the individuals in this older cohort include initial enrollment, schooling attainment, and other human capital variables, there is only a limited set of proxies available for the household attributes that pertained when these young men were of primary-school age.

14 In Rosenzweig (1982) this result could not be replicated using more recent data.

15 Strauss and Thomas (1995) observe that matching services to outcomes is a common problem in measuring the effects of both health interventions and schooling. For developed country studies that have sought to match schooling outcomes to conditions that prevailed when children were in school, see Card and Krueger (1992) and Orazem (1987). For a study in a developing nation, see Behrman and Birdsall (1983).

Enrollment Among the Cohort of Boys, Ages 6 to 12

Linking a Binary Dependent Variable with the Model

The enrollment data available for the current cohort of farm boys reflects whether a given child is enrolled *at present*. From these data, I construct a binary variable that equals one if a boy currently attends school. While this enrollment variable is ideal for comparing a boys current schooling activity with the amount of labor he is contributing to the household, the definition is unusual in that it reflects elements of both initial enrollment and schooling attainment, but is an imperfect measure of both. One cannot determine from the current enrollment of a boy whether the child was initially enrolled in school, and was later withdrawn. Moreover, one cannot determine from this variable the ultimate schooling attainment.

Since variables based on the current enrollment status bear little resemblance to the human capital demand function suggested by our model, it is worth considering how this binary variable can be related to our theoretical framework. It was observed that our model yields a demand equation for second period human capital that can be written as a function of the household's initial endowments of physical and human capital, prices in both periods, the efficiency of child labor, and the efficiency with which child time is converted into human capital. Relabeling the demand for second period human capital for boy i as y_i^*, one can write this as a function of $\mathbf{x}_i$, a vector of individual characteristics, prices, and household stocks of physical and human capital, and $\mathbf{q}_i$, a vector of the characteristics of local schools. One could then, at least theoretically, estimate a probabilistic model for schooling demand:[16]

$$y_i^* = \beta_{[x]}^{'}\mathbf{x}_i + \beta_{[q]}^{'}\mathbf{q}_i + u_i. \tag{2.7}$$

One does not, however, observe the actual demand for human capital, y_i^*, but observes some associated behavior (such as enrollment or time spent in school) or a proxy for schooling outcomes (such as test scores). In order to link the available measure of the demand for schooling (current enrollment) with the human capital demand function implied by the model, I assume that there exists a human capital production function, $hk = g(T, \mathbf{q})$, that is monotonic in both the inputs of time spent in education, T, and the vector of school quality variables, $\mathbf{q}$. I also assume

[16] The error term included in this estimation model reflects either errors in measuring the variables specified in the deterministic model or the effects of omitted variables.

that $hk = g(0, \mathbf{q}) = 0$, and that, given the characteristics of local schools, parents know the stock of human capital that will result from children spending any given time in education. Given these assumptions, there exists, for any set of school quality attributes, a unique, minimum time that a child must spend in school, T_i^*, such that the demand for second period human capital equals the human capital that is produced through schooling:

$$y_i^* = g(T_i^*, \mathbf{q}_i). \tag{2.8}$$

These assumptions allow one to write the optimal time a child spends in school as a factor input demand equation in terms of the household's demand for second period human capital and the school quality variables:

$$T_i^* = t(y_i^*, \mathbf{q}_i). \tag{2.9}$$

The optimal time a child spends in schooling is strictly increasing in the household's demand for second-period human capital and, conditional on the household's demand for education, is strictly decreasing in the quality of school. If one models the optimal time a child spends schooling in a linear, probabilistic model, and expresses the household's demand for a child's schooling as the right-hand side of equation (2.7), one can write

$$T_i^* = \alpha_{[x]}^{'} \mathbf{x}_i + \alpha_{[q]}^{'} \mathbf{q}_i + \varepsilon_i \tag{2.10}$$

where the vector of coefficients $\alpha_{[x]}^{'}$ reflects the effects of the regressors in $\mathbf{x}_i$ as they operate through the demand function for human capital, and the vector $\alpha_{[q]}^{'}$ reflects the effects of school quality and availability as they operate through both the demand function for human capital and the factor input demand function for time spent in school. The variable ε_i is a compound error term that is composed of the stochastic elements in the estimation models for the demand for human capital and the factor input demand for time spent in school. Equation 2.10 provides the link between the demand function for human capital, derived in our theoretical work, and two measures of schooling behavior that are explored in our empirical analysis: i) the binary variable indicating whether a specific boy is enrolled in school, and, ii) schooling attainment (the number of years of education).

It should be recalled from the modelling section that there is a positive own substitution effect associated with improvements in school quality (with an increase in δ). This may be offset, however, by cross product substitution effects that cannot be signed *apriori*. Moreover, improved quality of schooling has an unambiguous and *negative* effect on the time necessary to produce any level of human capital. Since the effects of school quality operate on time spent in school through both the demand function for human capital and the factor input demand function for time spent in school, one cannot anticipate the relationship between the quality of schooling and the time that children spend in school, and one cannot anticipate the signs of the coefficients in $\alpha'_{[q]}$. The variables in the vector $\mathbf{x}$, on the other hand, operate on the time spent in school only through the demand function for human capital (the variables $\mathbf{x}$ are not arguments in the human capital production function). This does not imply that one can anticipate the signs of the coefficients $\alpha'_{[x]}$, however, as the variables in $\mathbf{x}$ can also operate on the demand for schooling through cross-product substitution effects that cannot be anticipated.

There are several variables that can be used to proxy the optimal time children spend in school, T_i^*. One might use the last grade completed or, if students are thought to benefit from repeating grades, the number of years spent in class. Although the schooling data available for the cohort of farm boys do not provide reliable information on the present grade level of those who are currently enrolled, the age of an enrolled child is a good proxy for the number of years he has spent in school. Therefore, we will write the demand for schooling in terms of the age at which parents wish a child to complete his education.

If we define the current age of a boy as T_i, and the age at which parents wish him to complete his education as T_i^*, we can define a binary variable for the current enrollment of a boy, y_i, as

$y_i = 1$ if $T_i^* > T_i$ (the parents have chosen to enroll the boy in the current year)

$y_i = 0$ otherwise (the parents have chosen to end the boy's schooling).

Assigning these values to the binary variable, the expected value of y_i can be written as

$$E[y_i] = 1[\text{Prob}(y_i = 1)] + 0[\text{Prob}(y_i = 0)]. \tag{2.11}$$

If we combine the variables in $\mathbf{x}_i$ and $\mathbf{q}_i$ into a single vector, $\mathbf{z}_i$, and make use of equation 2.10, the probability of enrollment for a specific boy, with characteristics

$\mathbf{z}_i$, can be written as

$$
\begin{aligned}
E[y_i] &= \text{Prob}(y_i = 1) \\
&= \text{Prob}(\varepsilon_i > -\alpha'_{[z]}\mathbf{z}_i) \\
&= F(\alpha'_{[z]}\mathbf{z}_i)
\end{aligned}
\tag{2.12}
$$

where F(·) is an, as yet, unspecified cumulative distribution function for ε.

For each of the boys in the sample, the observed value of the binary variable for current enrollment, y_i, can be thought of as the outcome of a binomial process with parameters P_i (the probability that a boy, with the vector of characteristics z_i, will be enrolled) and n (the number of observations one has of the binomial process for individual i). Since $n = 1$ (the enrollment status of a boy is sampled only once), the probability mass function for this binomial random variable is

$$P_i(y_i) = P_i^{y_i}(1 - P_i)^{1-y_i}, \quad y_i = 0, 1 \tag{2.13}$$

Using this probability mass function, together with the expression for the probability that a boy is enrolled, found in equation 2.12, the likelihood function for the m boys in the sample can be written as

$$L = \prod_{i=1}^{m} [F(\alpha' z_i)]^{y_i} [1 - F(\alpha' z_i)]^{1-y_i}. \tag{2.14}$$

In this analysis, I assume that the error term, ε_i, in equation 2.12, is normally distributed, $\varepsilon_i \sim (0, \sigma^2)$. Given the value of the standard normal c.d.f.

$$F(\alpha' z_i) = \int_{-\infty}^{\alpha' z_i/\sigma} \frac{1}{(2\pi)^{1/2}} \exp\left(-\frac{t^2}{2}\right) dt, \tag{2.15}$$

the likelihood function for the probit can be written as

$$L = \prod_{i=1}^{n} \left[\Phi(\frac{\alpha' z_i}{\sigma})\right]^{y_i} \left[1 - \Phi(\frac{\alpha' z_i}{\sigma})\right]^{1-y_i}. \tag{2.16}$$

Here, Φ is the distribution function for the standard normal. From equation 2.12, we can write the marginal effect of a change in a regressor on the binary variable as

$$\frac{\partial E[y]}{\partial z} = \frac{dF(\alpha' z_i)}{d(\alpha' z_i)} \alpha = f[\alpha' z_i] \alpha \tag{2.17}$$

or, substituting the density function for the cumulative normal distribution,

$$\frac{\partial E[y]}{\partial z} = \phi \left[\frac{\alpha' z_i}{\sigma} \right] \alpha. \tag{2.18}$$

The Dependent Variable

The dependent variable used in this analysis indicates the current enrollment status among 512 boys ages 6 to 12 residing in farm households. This information was gathered in surveys of the male and female heads of household. The binary variable assumes a value of one if the boy is currently enrolled, and is otherwise set to zero. Of the 512 primary-school aged boys, 291 (or 56.8 percent) are enrolled.

The Independent Variables

Long-Lived Household Assets. Our model suggests that long-lived household characteristics (those that exist both when children are of primary-school age and when they are adults) have especially complex effects on the schooling and child-work decisions. In addition to income effects for those households that are credit constrained, long-lived characteristics will have cross-product effects in both periods.[17] There are three regressors in the current analysis that can be considered long-lived: land, the human capital of parents, and family composition.

Land. Separate variables indicate the acres of irrigated and rainfed land that are owned by the household. Both are taken as exogenous since Pakistani families seldom buy or sell this asset.It is not uncommon to take owned land as exogenous to household decision making. Thomas, Strauss, and Henriques (1991) assume this asset is exogenous in creating an instrument for total household income in Brazil. Because there is an active *rental* market for agricultural land in Pakistan, there is only a weak correlation between the amount of land that is worked by the household and the amount that is owned: many land owners rent-out all of their acres while many farmers, who have sizable operational holdings, own no land. It has been suggested by Nabi, et. al. (1986) and Bliss and Stern (1982), that the size of a household's operating holding is determined by the family's stocks of a range of productive assets including bullocks, that are used for traction, the family members

[17] The signs of these effects depend on the complementarity or substitutability among inputs and cannot be determined *apriori*.

who can be used as farm labor, the family's technical skills, its ability to finance the purchase of factor inputs, and its stock of owned land.

The effect of land ownership on school enrollment is ambiguous. In addition to other cross-product substitution effects, land ownership will affect the use of boy time through the degree of complementarity with both child labor and the human capital that children gain through schooling. Moreover, land ownership may act through income effects among credit constrained households.

There are several differences in the way rainfed and irrigated land will affect the allocation of child time. First, the more traditional farming methods that are typically used on rainfed land are thought to offer smaller returns to human capital than the modern methods that often require irrigation. In addition, rainfed land is typically worth less than irrigated land and will, therefore, carry a smaller income effect per acre. Finally, rainfed land is more often left fallow in the winter growing season and this may act in favor of schooling.

Cognitive Skills. The regressors include the maximum score earned on a test of reading skills among all the adults in the household. The effect of cognitive skills among family adults on the school enrollment of children is uncertain. A greater initial endowment of human capital implies greater income in both periods and this may imply an income effect among credit constrained households.

The cross-product substitution effect between the cognitive skills of the older generation and those that children gain in school are especially interesting in the context of the farm family. In studies of the effects of education in agriculture, it is typically assumed that human capital is a homogeneous input and that the knowledge and skills of one family member are perfect substitutes for those of another (this is implicit in the model used in the current study). However, it is not clear whether household production benefits from the human capital of all family members, or only from that of the person who has the highest level of skills. If a single educated family member can make all the critical decisions about production, and if other family-farm workers need only minimal cognitive skills to carry out these decisions, there may be virtually no substitutability among the human capital endowments of household members. Moreover, if the technical skills of the older family members are dated, but include knowledge of the specific farm environment, while the skills of the young are more modern but also more general, there may be a high degree of complementarity between the cognitive skills of the two generations.

Finally, if the technical skills of the older generation are suited to older farming methods, while those of the younger generation conform to modern ways, one could imagine that increasing the technical knowledge of one generation would impact technology used on the farm and could decrease the marginal product of the human capital of the other generation.

Family Composition. Since this study is concerned with the short-term distribution of child time between schooling and labor, I take the size and composition of the family as predetermined. Our model suggests rather complex interactions between family labor and other agricultural inputs, but it also ignores a number of effects of household composition. The model does not address the demands family members place on household product and on the time of other household members. The presence of a sibling that produces less than he consumes might be to increase the probability that a boy is employed on the farm and to reduce the likelihood of schooling. Alternatively, the dominant effect of a sibling might be to substitute for a boy's labor, and this could increase the likelihood of schooling.

While the model does not sign any of the cross-product effects for household composition, some can be anticipated from knowledge of the Pakistani family. Given the gender roles that are observed within Pakistani households, it seems likely that the presence of adult male family members would reduce the use of boy labor, and increase the demand for schooling, since adult male labor is likely to be a substitute for child labor and men can be expected to contribute more in farm labor than they require in household goods and services. The presence of adult females might be expected to reduce demand for education, since adult women contribute less labor on the farm than their male counterparts and are less likely to substitute for boy labor in agricultural work.

The assumption of exogeneity of family composition is open to criticism since there is evidence that child bearing among farm households may be correlated with the family's stock and quality of productive assets. Stys (1957) shows that, among rural households in southern Poland, peasants who own large amounts of land are more likely to have large families. Rosenzweig and Evenson (1977) find that the number of children per woman of child bearing age is positively and significantly linked to both the amount and productivity of household owned land.

In the context of the current study, there is some evidence that fertility is independent of the value and productivity of child labor in agriculture. We have seen that boys contribute a great deal more to farm labor than do girls. If boy labor drives household fertility, we would expect the ratio of boys to children in the family to be negatively correlated with the number of family children: households that have mostly girls for first children would be likely to have larger families in hopes of having more boys. Table 3.1 in Chapter III presents the results of regressing the boy surplus (the number of boys in the household minus the number of girls) against the number of children in the family. No linkage is found between the gender ratio and the size of the family, implying that the value of child labor in agriculture is not driving fertility.[18]

Other Farm Related Characteristics. The model indicates that farm related characteristics that enter the production function in only a single time period will affect child time allocation through singe-period, cross-product effects and through an income effect. The model does not predict signs for the substitution effects. There are three farm related characteristics that, I assume, enter the household production function and that maintain fixed values for a relatively short period of time: livestock, the value of mechanical equipment, and prices.

The Value of Livestock. This is the value of the household's larger animals, including bullocks, cattle, goats, and sheep, but excluding poultry. Pakistani farm households keep livestock for traction, as long-term saving, and as a hedge against variability in agricultural earnings. The most valuable animals, bullocks, are needed for draught as there are many areas in which traction rental is either unavailable or unreliable. I assume that this regressor is exogenous. While the model does not suggest signs for the cross-input substitution effects associated with livestock, herding is the principal work of young boys and it seems likely that this factor is complementary to boy labor. It is less clear the extent to which livestock is complementary to human capital.

It is worth considering the possible effects on our regression estimates if the value of livestock is endogenous or, stated in alternative form, if the value of this

[18] If the variable 'size of family' is endogenous and if the coefficient on this variable is subject to omitted variables bias in estimates of the demand for schooling (or in estimates of the demand for child labor), the direction of the bias is unclear. Unobserved complements to child labor (e.g., land quality) that motivate greater fertility would produce a negative bias on the estimated coefficient on 'number of children in the household' in the schooling demand function and a positive bias in the child-labor equation. On the other hand, if the higher demand for children results from unobserved aspects of income or wealth, and if schooling is a normal good, one would expect a positive bias on the coefficient in the demand for education and a negative bias in the demand for child labor.

asset is affected by omitted variables. It is possible that this regressor is correlated with unobserved aspects of either household wealth or the quality of inputs in household agricultural production (one can imagine that households with especially poor land might be more likely to concentrate on raising livestock). In either case, the estimated coefficient on the value of livestock would reflect the effects of these omitted variables. It should be noted, however, that the education policy variables (the availability and quality of schooling), which are of special interest in this portion of the dissertation, are unlikely to be closely correlated with either livestock or any omitted variables that might bias the coefficient on livestock.[19] As a consequence, the estimated coefficients on the school quality variables will be little affected by any omitted variable bias that affects the coefficient on the livestock regressor.

Prices. The prices of many of the most important agricultural inputs and outputs and consumer goods are held fixed by the government of Pakistan and vary among households only to the extent that families must transport product different distances to and from places of purchase. Examples of price-controlled products include nitrogenous and phosphorous fertilizers (the most commonly purchased agricultural inputs) and wheat (the most commonly grown crop). Transport costs for these goods are proxied with the distance (in kilometers) to the place nearest the village where fertilizer can be purchased. The effect of distance to markets on enrollment is uncertain and depends on whether purchased inputs are substitutes or complements of child labor.[20] It should be noted that no market exists for hiring child labor in the areas in which the survey sample was taken. As a consequence, no explicit wage rate is available for child labor.

Measures of the Quality and Availability of Schools. The model suggests an unambiguous sign for the cross-product substitution effects of school quality and school availability in the demand function for education. These operate in the opposite direction from the income effects for the school quality and availability variables, so the overall impact of these variables is ambiguous. Moreover, as previously discussed, these variables operate on current enrollment through both the demand for schooling and the factor demand function for time spent in education, and this implies further confounding affects in the way these regressors influence the dependent

---

19 Alderman, Behrman, Khan, Ross, and Sabot (1995) find that there are no significant correlations within regions between school availability and village characteristics. This suggests that household income or other demand side factors may not have significant effects on forming education policy.

20 Several studies have shown distance to market to be an important determinant of agricultural earnings. See Antle (1984) and Binswanger, Khandker, and Rosenzweig (1993).

variable.

Distance to the Primary School Nearest the Village. This is a village level variable indicating the kilometers from the village center to the nearest primary school. The human capital data gathered for this survey include the name of the primary school attended by most of the survey participants and the distance to this institution. While, in many villages, the primary school most commonly used changes over time, there is striking uniformity in the schools that are used within a cohort. The data suggest that, as new schools are opened, parents enroll their children at the school that is nearest the village. A decrease in the distance to primary school represents a reduction in the cost of schooling, in terms of the child-time endowment, but does not affect the amount of time necessary to produce human capital (assuming that children arrive by the beginning of the school day and remain until they are dismissed, regardless of the distance they travel to school). As a consequence, the distance to primary school is expected to be negatively linked to enrollment for households that are not credit constrained.

Distance to the Intermediate School Nearest the Village. The 5 to 12 year old children considered in this study are typically of primary school age. Some of the 12 year olds, however, may have completed the five years of primary schooling and may be eligible for enrollment in intermediate school. As a result, distance to intermediate schools may affect the allocation of time for older children. Moreover, if parents view primary schooling as a prelude to higher levels of education, the time allocation of younger children could also be influenced by this variable. It is anticipated that distance to intermediate school will be either negatively related or unrelated to enrollment among households that are not credit constrained.

Mean Reading Score Of Teachers at the Nearest Primary School. A World Bank study[21] relating school characteristics and schooling outcomes has suggested that the most important determinant of cognitive skills production is the human capital of teachers. The measure of school quality used for the current study is the result of administering a reading skills exam to all teachers in the most commonly used primary schools. A single primary school is assigned to each village (the same school that is assigned in calculating the distance to school variable) and the mean reading score of all teachers is calculated for this school. This measure of school quality can act on enrollment through both the household demand for human capital (improved quality will increase demand for schooling) and the production of schooling outcomes (less time will be required to produce any outcome). As a result, the

21 Fuller (1986). For a review of the literature on schooling inputs, see Harbison and Hanushek (1992).

effect of this variable on current enrollment is ambiguous.

The Student-Teacher Ratio at the Nearest Primary School. The student-teacher ratio is the number of students at the local primary school, divided by the number of teachers at this school. It seems intuitive that a higher student teacher ratio would both lessen the skills a student gains from time spent in school and reduce parents' investment in education. This effect may be offset, however, if crowding reflects higher demand for schooling resulting from the presence of high quality teachers or other educational resources. In their study of schooling in Pakistan, Warwick and Reimers (1995) report that 'achievement was [evaluated as] significantly higher when interviewers rated [a] school as crowded.' They observe that, because of the high rate of dropping out in many rural schools, it is not uncommon to see grades four and five with less than ten students each. While they report low quality teaching in these classrooms, and suggest that such classes lack the critical mass of students necessary for good teaching, it is also likely that the high rate of dropping-out results from the poor quality of teaching in these classes. The relationship between the student-teacher ratio and current enrollment is ambiguous.

The Ratio of Books to Students at the Nearest Primary School. This is the number of books available at the primary school nearest the village, divided by the number of students (this value is multiplied by 100). Various sources have suggested that in Pakistan, primary schools lack sufficient books and the quality of the available texts is substandard. In 1990, a report from the World Bank indicated that only half of the primary-aged children had access to text books and reported that 'textbooks contain a high proportion of factual and grammatical errors, significant deviations from the specifications set by the Curriculum Bureau of the Textbook Board, and language that differs significantly in difficulty from one grade to another and from subject to subject.'[22] Since books are the principal educational aid used in Pakistani schools, it is expected that there will be a positive and significant link between the number of books at the local primary school and the demand for schooling. This effect may be confounded if improved quality lowers the time needed to educate children to the level desired by their parents.

Boy's Age. As was shown in chapter one, current enrollment declines sharply with a child's age. While 70 percent of six year old boys attend school, only 46 percent of 12 year olds are enrolled. The relationship between enrollment and age, originally

---

[22] Warwick and Reimers (1995, 82)

Table 1.3 Enrollment by Age Among Boys in the Sample of Rural Households.

Age	No.	%
6	53/76	69.7
7	51/72	70.8
8	46/77	59.7
9	36/71	50.7
10	34/69	49.3
11	36/70	51.4
12	35/77	45.5
Enrolled/Total	291/512	56.8

presented in table 1.3, is shown again in the following:

While the descriptive statistics show a strong negative correlation between age and enrollment, our model does not ensure an unambiguous relationship between these variables. Age indicates the strength and maturity that a boy can bring to his work, but it also defines the types of work in which he will be engaged. While unlikely, there is nothing to preclude the value of boy labor declining as these children outgrow their suitability for specific tasks.

Regression Results

Table 2.4 presents the results of the probit analysis of current enrollment for all boys aged 6 to 12 in farm households, the descriptive statistics for the independent variables, and the associated marginal effects of the regressors on the probability of enrollment. The probit accounts for a modest amount of the variation in the dependent variable (a pseudo R^2 of 0.16 is reported for the regression), and correctly predicts 127 of 221 unenrolled boys and 225 of 291 enrolled boys.

The key findings in these regressions are that the household decision to enroll boys is sensitive to the availability of school (as measured by distance to school), the availability of books at school, crowding at the local school, household ownership of irrigated land, and the family's human capital stock. I have explored the sensitivity of these results to the selection of functional form, and to the inclusion (and exclusion) of independent variables, and the reported findings appear to be highly robust.

Land. The acres of irrigated land owned by the household is found to have a small positive, and significant effect on enrollment of family boys. Increasing the number of acres of irrigated land owned by the household from the mean of 4.00 to 16.59 acres (a change of one standard deviation of the independent variable), results in the likelihood of enrollment rising from 56.8 percent to 67.25 percent. These results are consistent with the expectation that a rise in irrigated land would induce enrollment through either an income effect (since land acts as a proxy for wealth) or an interaction with human capital in agricultural production (since the availability of irrigation acts as a proxy for the use of HYV techniques).

The coefficient on acres of rainfed land is not statistically different from zero at the 10 percent level. This is consistent with the expectation that rainfed land has a smaller income effect, and induces less investment in human capital than irrigated land.

Livestock. The value of livestock carries a negative coefficient in this enrollment regression but falls just short of significance at the ten percent level. This lack of significance is surprising as tending animals is one of the principal activities of Pakistani boys. However, a strong income effect may be confounding the expected complementarity between boy labor and livestock.

Household Composition. The coefficients on all of the household composition variables fall short of significance at the ten percent level. While the model for boy-time allocation suggests that the size and composition of the household have ambiguous effects on enrollment, this finding is somewhat surprising as other studies have shown a tradeoff between the quantity and quality of children in a household. This result may be partially explained by the fact that larger Pakistani households often include more than one nuclear family (as explained in chapter one, married boys will only form their own households after their father's death) and, as a consequence, larger families can result from higher fertility, or from men marrying at a younger age or living to an older age.

Other Household Variables. Neither the value of mechanical equipment nor the distance to fertilizer sales affect current enrollment.

Distance to the Schools Nearest the Village. The estimated coefficients for the distance to primary school is negative and highly significant, while the distance to intermediate school does not affect enrollment. The average primary school is 1.89 km., or 1.21 miles from the village and, if a child walks at a strong pace of 3 miles per hour, he can travel this distance in 24 minutes. Adding one standard deviation

Table 2.4 A Binomial Probit of Current Enrollment Among Boys Ages 6 to 12

Observations	512
Mean of Dep. Var.	0.5687
Std. Dev. of Dep. Var.	0.4958
Log-Likelihood	-285.3556

Probability of Correctly Predicting Outcome for Unenrolled Boys: 125/221
Probability of Correctly Predicting Outcome for Enrolled Boys: 225/291

	Coeff. (t-stat)	Mean Stand. Dev.	Marginal Effect
Constant	0.1650 (0.25)		
Acres of Owned Irrigated Land	0.0213 (3.47)	4.00 *12.59*	0.0083
Acres of Owned Rainfed Land	-0.0006 (-0.08)	2.52 *9.04*	-0.0002
Value of Livestock	-9.9E-06 (-1.58)	12522.10 *10452.00*	-3.9E-06
Value of Mechanical Equipment	-2.4E-06 (-0.49)	6300.62 *19394.00*	-9.5E-07
Distance to Fertilizer Sales	-0.0047 (-0.32)	7.67 *6.29*	-0.0019
Max. Reading Among Family Ad.	0.0477 (2.86)	7.60 *8.88*	0.0187
No. of Adult Males in HH.	-0.0719 (-1.48)	3.07 *1.83*	-0.0281
No. of Adult Females in HH.	0.0667 (1.27)	2.73 *1.58*	0.0261
No. of Kids in HH.	-0.0463 (-0.65)	3.00 *1.44*	-0.0181
No. of Boys in HH.	-0.0772 (-0.83)	2.05 *1.01*	-0.0302
Distance to Primary School (km.)	-0.1362 (-3.07)	1.89 *4.38*	-0.0533
Distance to Intermed. School (km.)	-0.1306 (-1.47)	6.58 *8.60*	-0.0511
Student-Teacher Ratio–Pri.	0.0056 (2.44)	44.90 *43.87*	0.0022
Teacher Reading Score–Pri.	0.0714 (1.13)	13.54 *7.27*	0.0279
Ratio of Books/Students * 100	0.0237 (2.89)	54.15 *9.16*	0.0093
The Child's Age	-0.1429 (-4.59)	8.98 *2.02*	-0.0559

of distance (4.38 km. or 2.8 miles) increases the travel time to 80 minutes each way and reduces the likelihood of enrollment from 56.87 percent to 33.52 percent.

School Quality Variables. The ratio of books to students at the nearest primary school also has a positive and significant effect on enrollment, and increasing the ratio of books from 0.5415 to 0.6331 (a change of one standard deviation in the dependent variable) results in the enrollment rate increasing from 0.5687 to 0.6538 (a change of 17.18 percent of a standard deviation of the dependent variable). The student-teacher ratio is also shown to have a modest positive and significant effect on enrollment: increasing the student teacher ratio from 44.90 to 88.77 (a change of one standard deviation in the dependent variable) results in the enrollment ratio increasing from 0.5687 to 0.6652 (a change of 19.5 percent of a standard deviation of the dependent variable). Given that crowding can be expected to lower outcomes resulting from the time spent in school, this result is contrary to intuition. However, as previously discussed, the student-teacher ratio may be a proxy for unobserved aspects of school quality which result in greater demand for education at crowded schools. Contrary to expectation, the cognitive skills of teachers could not be shown to have a significant effect on enrollment.

Household Effects

The enrollment analysis has been conducted on 512 boys from 304 households. Because the sample includes siblings, it is possible that the error term in 2.10 includes a component that is specific to households (perhaps family wealth or native intelligence). If such a household-specific error component exists, then both the household specific effect and the coefficients on the independent variables are unknown parameters that must be estimated in a discrete choice model. However, unlike linear regression models, in a probit it is not possible to use MLE methods to estimate the coefficients on the regressors independent of an estimate for the household-specific error component. Various methods are available for estimating a random effects probit and these differ principally in the correlation structure that is hypothesized for the error terms among observations. Table 2.5 below shows the result of a probit regression using the generalized estimating equation of Liang and Zeger (1986). Here, the within-household correlation structure is assumed constant across households and is represented by

$$\alpha = \sum_{I=1}^{m} \left[\frac{\sum_{j=1}^{n_i} \sum_{k=1}^{n_i} e_{i,j} e_{i,k} - \sum_{j=1}^{n_i} e_{i,j}^2}{n_i(n_i - 1)} \right] / \left[\sum_{i=1}^{m} \frac{\sum_{j=1}^{n_i} e_{i,j}^2}{n_i} \right] \tag{2.19}$$

where n_i is the number of boys in each household and m is the number of households. For the random effects enrollment probit, the correlation within-household is estimated at 0.1977. Because the estimated coefficients and z-statistics in the random effects model are similar to those in the simple probit, I provide no further comment on the results.

Partitioning the Cohort of Boys

In Chapter One I indicated that, as boys age from six to twelve, there are significant changes in the likelihood that they will attend school, in the types of work they perform, and in the average amount of time they spend working. One might expect, therefore, that the effects of the regressors in the probit analysis of current enrollment might also change as boys age. To explore this question, I have partitioned the cohort of 512 boys into two age groups and, to each, applied the same probit model that was previously used for the entire cohort. These cohorts are defined as i) those boys ages 6 through 9, and ii) those ages 10 through 12. Tables 2.6 and 2.7 are the regression results for each of these groups.

Although I cannot reject the joint hypothesis that the coefficients in the two regressions are identical, in tests of individual coefficients two interesting results emerge. First, the distance to primary school has a large, negative, and significant effect on the schooling of older boys, but has no impact on the schooling of younger boys. This is surprising: given that the greatest decline in enrollment comes when boys are between the ages of seven and nine (when enrollment falls from 71 to 51 percent), one might expect differences in travel costs to impact enrollment of the younger children. Current enrollment for boys in the 10 to 12 year age group, however, is highly sensitive to school availability, as an increase in the distance to primary school of 1.04 miles (equal to one-fourth of a standard deviation) reduces the probability of attending school from 0.486 to 0.3572 (a decline in the dependent variable equal to 25.9 percent of a standard deviation).

Second, there are significant differences between the two groups in how enroll-

Table 2.5 A Random Effects Probit of Current Enrollement Among Boys Ages 6 to 12.

Number of Observations:	512
Number of Households:	304
Within Category Correlation:	0.1977
Chi 2(16)	77.02

	Coeff. (t-stat.)	Mean Std. Dev.	Marginal Effect
Constant	0.1369		
	(0.21)		
Acres of Owned Irrigated Land	0.0181	4.00	0.0071
	(2.74)	*12.59*	
Acres of Owned Rainfed Land	-1.2E-05	2.52	-4.5E-06
	(-0.001)	*9.04*	
Value of Livestock	-1.0E-05	12522.10	-3.9E-06
	(-1.49)	*10452.00*	
Value of Mechanical Equipment	-1.4E-06	6300.62	-5.5E-07
	(-0.27)	*19394.00*	
Distance to Fertilizer Sales	-0.0034	7.67	-0.0013
	(-0.21)	*6.29*	
Max. Reading Among Family Ad.	0.0478	7.60	0.0186
	(2.63)	*8.88*	
No. of Adult Males in HH.	-0.0723	3.07	-0.0282
	(-1.38)	*1.83*	
No. of Adult Females in HH.	0.0571	2.73	0.0223
	(1.00)	*1.58*	
No. of Kids in HH.	-0.0262	3.00	-0.0102
	(-0.33)	*1.44*	
No. of Boys in HH.	-0.1045	2.05	-0.0408
	(-0.99)	*1.01*	
Distance to Primary School (km.)	-0.1439	1.89	-0.0562
	(-2.99)	*4.38*	
Distance to Intermed. School (km.)	-0.1264	6.58	-0.0493
	(-1.40)	*8.60*	
Student-Teacher Ratio	0.0058	44.90	0.0023
	(2.24)	*43.87*	
Teacher Reading Score	0.0690	13.54	0.0269
	(1.00)	*7.27*	
Ratio of Books to Students	0.0248	54.15	0.0097
	(2.73)	*9.16*	
The Child's Age	-0.1418	8.98	-0.0553
	(-4.75)	*2.02*	

Table 2.6 A Binomial Probit of Current Enrollment for Boys Ages 6 to 9

Observations:	296
Mean of Dependent Variable:	0.6284
Standard Deviation of Dependent Variable:	0.4861
Log Likelihood	-157.9676
Probability of Predicting Outcome for Unenrolled Boys:	49/110
Probability of Predicting Outcome for Enrolled Boys:	158/186

	Coeff. (t-stat.)	Mean Std. Dev.	Marginal Effect
Constant	0.4163		
	(0.44)		
Acres of Owned Irrigated Land	0.0122	3.62	0.0045
	(1.28)	*10.39*	
Acres of Owned Rainfed Land	-0.0177	1.96	-0.0065
	(-1.49)	*7.62*	
Value of Livestock	-1.2E-05	12145.12	-4E-06
	(-1.42)	*10296.39*	
Value of Mechanical Equipment	1.51E-06	5854.02	5.5E-07
	(0.21)	*19026.04*	
Distance to Fertilizer Sales	-0.0068	7.79	-0.0025
	(-0.35)	*6.48*	
Max. Reading Among Family Ad.	0.0478	7.42	0.0175
	(2.10)	*9.22*	
No. of Adult Males in HH.	-0.0647	3.00	-0.0237
	(-0.98)	*1.77*	
No. of Adult Females in HH.	0.0816	2.74	0.0300
	(1.17)	*1.59*	
No. of Kids in HH.	0.0153	3.00	0.0056
	(0.16)	*1.44*	
No. of Boys in HH.	-0.0992	2.07	-0.0364
	(-0.77)	*1.01*	
Distance to Primary School	-0.0382	1.92	-0.0140
	(-0.63)	*4.54*	
Distance to Intermed. School	-0.1306	6.88	-0.0479
	(-1.24)	*9.06*	
Student-Teacher Ratio	0.0059	46.40	0.0022
	(1.52)	*44.00*	
Teacher Reading Score	0.0789	14.04	0.0290
	(0.84)	*7.41*	
Ratio of Books/Students * 100	0.0183	53.99	0.0067
	(1.65)	*9.13*	
The Child's Age	-0.1933	7.48	-0.0710
	(-2.58)	*1.12*	

Table 2.7 A Binomial Probit of Current Enrollment for Boys Ages 10 to 12

Observations:	216
Mean of Dependent Variable:	0.4861
Standard Deviation of Dep. Var.:	0.5010
Log Likelihood:	-120.2390

Probability of Correctly Predicting Outcome for Unenrolled Boys: 78/111
Probability of Correctly Predicting Outcome for Enrolled Boys: 68/105

	Coeff. (t-stat)	Mean *Stand. Dev.*	Marg'l Effect
Constant	-1.7692		
	(-1.09)		
Acres of Owned Irrigated Land	0.0327	4.53	0.0130
	(3.68)	*15.09*	
Acres of Owned Rainfed Land	0.0149	3.29	0.0060
	(1.40)	*10.66*	
Value of Livestock	-6.7E-06	13038.74	-2.7E-06
	(-0.68)	*10663.14*	
Value of Mechanical Equipment	-9.9E-06	6912.61	-3.9E-06
	(-1.20)	*19914.72*	
Distance to Fertilizer Sales	-0.0018	7.51	-0.0007
	(-0.07)	*6.03*	
Max. Reading Among Family Ad.	0.0519	7.85	0.0207
	(1.95)	*8.41*	
No. of Adult Males in HH.	-0.1121	3.17	-0.0447
	(-1.45)	*1.90*	
No. of Adult Females in HH.	0.0594	2.72	0.0237
	(0.71)	*1.56*	
No. of Kids in HH.	-0.1252	3.01	-0.0499
	(-1.11)	*1.44*	
No. of Boys in HH.	-0.0105	2.03	-0.0042
	(-0.07)	*1.00*	
Distance to Primary School	-0.3099	1.85	-0.1236
	(-4.26)	*4.17*	
Distance to Intermed. School	-0.1453	6.16	-0.0579
	(-0.87)	*7.94*	
Student-Teacher Ratio–Pri.	0.0050	42.84	0.0020
	(1.51)	*43.71*	
Teacher Reading Score–Pri.	0.0707	12.85	0.0282
	(0.71)	*7.03*	
Ratio of Books/Students * 100	0.0349	54.38	0.0139
	(2.70)	*9.23*	
The Child's Age	0.0361	11.04	0.0144
	(0.30)	*0.82*	

ment changes with the age of the child. The sharpest declines in current enrollment occur between the ages of seven and nine, and we see in the probit regression among the youngest boys that the probability of attending school falls by almost one tenth with each year of age (the probability of enrollment among the younger group of boys is 62.8 percent and the probability declines by 7.1 percent with each additional year). As current enrollment is relatively stable for those in the older group, one would expect enrollment for older boys to be less sensitive to age, and the probit results indicate that age has no influence on the likelihood of these children attending school.

Initial Enrollment of Adult Rural Males

The Pakistan data allow analysis of the enrollment and schooling attainment decisions that were made by the parents of a group of young rural men. This cohort is comprised of males who were between the ages of 18 and 29 at the time of the survey. The education data for this older group are more complete than those available for the children, in that they include information on whether an individual was ever enrolled, the number of years of schooling attained, and individual measures of native ability and cognitive skills. These data permit a more precise separation of the enrollment and attainment decisions than is possible for the cohort of young boys, and provide a second perspective from which to analyze the way individual, household, village, and school characteristics influence schooling at different ages.

While the educational data for the young men include several useful variables that are unavailable for boys, some aspects of these data may be less reliable than those used in the previous enrollment regressions. The current (ongoing) enrollment data for the cohort of boys was verified by making inquires of multiple family members, and by checking responses for consistency over time (in various rounds in the survey, parents were asked if children were enrolled, and the principal activities on which they spent their time since the last survey). For the older cohort, however, the enrollment data are based on the response of the single relevant individual regarding his activities when he was a child, and these responses could not be checked with other family members or verified across survey rounds.

The current analysis employs a binary dependent variable that equals one if the adult respondent indicated that he had completed at least one year of schooling. As we change our binary dependent variable from one that reflects current enrollment to one that reflects initial enrollment, we may observe differences in the way the regressors relate to these measures of schooling. One reason is that the two binary variables reflect schooling decisions for different age groups of children. Since the great majority of those sent to school begin their education when they are around six years of age, the initial enrollment variable reflects families' educational decisions for their youngest school-aged boys. The current enrollment variable, however, reflects families' schooling decisions for boys of ages six to twelve.

A second reason to expect different empirical results is that, in altering the definition of the binary dependent variable, we have changed the manner in which our empirical work relates to our model. School variables influence *current* enrollment through both i) the demand for second period human capital, and, ii) the production of human capital. However, when we regress a binary variable for *initial* enrollment against these regressors, their effects operate only through the household demand for second period human capital — the production function for human capital has no effect on initial enrollment.

To illustrate this, I make use of the notation employed in the previous section and define the binary variable for initial enrollment as y_i. This variable can be defined relative to the latent demand for human capital, $y*$, rather than the optimal time spent in school, T^*:

$y_i = 1$ if $y_i^* > 0$ (and the parents choose to enroll the boy in school)

$y_i = 0$ otherwise (the parents choose to never enroll the boy in school).

If we define $\mathbf{z}_i$ as the vector of all individual, household, village, and school characteristics that influence how parents allocate the time of their boys, the demand for second period human capital presented in equation 2.7 can be rewritten as

$$y_i^* = \beta'_{[z]}\mathbf{z}_i + u_i \tag{2.20}$$

and, following the earlier discussion for the derivation of equation 2.12, one can write the probability of enrollment for a specific boy, with characteristics $\mathbf{z}_i$, as

$$\begin{aligned} \mathrm{E}[y_i] &= \mathrm{Prob}(y_i = 1) \\ &= \mathrm{Prob}(u_i > -\beta'_{[z]}z_i) \\ &= 1 - \mathrm{F}(-\beta'_{[z]}z_i) \end{aligned} \tag{2.21}$$

where F(·) is a cumulative distribution function for u. If we assume that this error term has a normal distribution, then the likelihood function for the probit is as shown in equation 2.16. Estimating the marginal effects of the regressors on initial enrollment then follows as in the analysis of current enrollment. Since the effects of regressors operate on initial enrollment only through the household demand for second period human capital, the effects of school quality variables will be unambiguous in the present analysis.

Sample Selection Issues

The purpose of the current section is to use the educational experience of the cohort of young men to learn more about current household behavior in the allocation of boys' time. This approach requires that the schooling investments that were undertaken for the young men in our sample are representative of those that are made for rural boys. However, as was discussed in chapter one, there has been significant migration in many areas of Pakistan. If there is a high rate of migration in our sample area, and if migration of the young is selective of human capital, there would be the potential for selection bias were we to estimate the determinants of enrollment and schooling attainment from a sample of those who remained in their home villages.

The scope of the sample selection issue can be assessed by comparing the size of the cohort of young boys in our sample with the size of the cohort of middle-aged men. In sampling our random draw of households in 1991, we found 690 boys between the ages of 0 and 4. Within these households there were 160 men between 40 and 44 years of age. A simple comparison of these two cohorts implies a population growth rate of 3.7 percent per year.

The World Bank estimates that the population of Pakistan grew at an annual rate of 3.1 percent through the 1980's.[23] It seems likely that the growth rate among our survey households might have been higher than the national average, since the sample used in this dissertation is weighted towards impoverished villages. However, were we to assume that the population in our sample area did grow at the national average of 3.1 percent, an initial base of 203 would have been necessary to produce the current population of boys of 690. This implies a *maximum* emigration

[23] The United Nations' (1994) indicates that over the period 1950 to 1990, the population grew at 3.2 percent per year.

of 21 percent from our sample area.

There is evidence that emigration from rural Pakistan is not correlated with schooling. Using binary regressions of the migration decision, Nabi, Hamid, and Zahid (1986) find that a family's farm output per capita, farm acreage, sharecropper status, and non-farm income are all negatively correlated with the probability of migration, while indebtedness is positively linked to migration. Once one controls for these other factors, neither the education of individuals, nor the education of other family members, affect the probability of a person migrating. Given the modest rate of migration from our sample area and the evidence that migration is not selective of human capital, there seems to be little need for concern that sample selection may bias our analysis of the schooling decision for the cohort of young men.

The Dependent Variable

Of the 388 men aged 18 to 29 from rural households who were sampled for the analysis of initial enrollment, 53 percent indicated that they had at least one year of schooling. This is slightly less than the rate of *current* enrollment among the cohort of five to twelve year olds analyzed in the previous section, and suggests, as one would expect, that the likelihood of a boy attending school has been increasing since the current cohort of young men were of primary-school age. (For any cohort, one would expect the percent of those who are currently enrolled to be equal to, or less than, the percent of those who have ever been enrolled.)

The Independent Variables

The Pakistan survey includes a small number of questions on the assets and farming methods of the respondent's father at the time the respondent was in elementary school, and on the educational background of the respondent's parents. These historical variables are used as regressors in the enrollment function along with current data on the availability and quality of schooling. These latter measures serve as proxies for the schooling characteristics that existed when the men in the sample were of school age. The Pakistan data also include a measure of native intelligence (results of the Raven's exam) which, some authors have suggested, provides an indication of innate ability that is independent of schooling.

One shortcoming of the Pakistan data set is that it does not include information on the number of siblings, non-sibling children, or non-parent adults who were present in the household when the cohort of young men were of primary school age. Since the number of family members can proxy household income and wealth, and can also reflect family labor availability, omission of information on family composition may create missing variables bias. This bias may be especially worrisome for the coefficients on variables that are closely correlated to the number of family members, such as the size of the operational holding (the amount of land that a family farms is highly correlated with the availability of family labor). However, since individual native intelligence, school quality, and school availability are less likely to be correlated with family composition, one would not expect omitted variables bias to affect the coefficient estimates for these characteristics.

Long-Lived Household Assets. As previously discussed, our model predicts complex and ambiguous comparative statics for long-lived household characteristics (those that are fixed from the time a boy is in elementary school through the time he becomes a working adult). In the current analysis, only two variables seem to fall into this category: the initial human capital of the household (represented by a binary variable indicating whether the young man's father had attended school) and the native ability of the young man (as measured by the Raven's progressive matrices exam). These variables can be expected to impact the schooling decision with cross-product substitution effects in the agricultural production functions of both periods, and with income effects for those households that are credit constrained. In addition, the native intelligence variable will affect the allocation of boys' time as an input in the production of cognitive skills.

Father's Education. This binary variable equals one if the respondent's father had any education. The variable is intended as a proxy for the household's understanding of the process of formal education. This measure, however, may be subject to two shortcomings. First, it can reflect unobserved differences in the family's ability to afford the material costs of schooling, to bear the opportunity cost of enrolling children, or to profit from education. Second, it is possible that the factors that drove the decision of whether to enroll the father are highly correlated with those that motivate the schooling decision for the current cohort of young men, and that these determinants may be captured by other regressors in the analysis. In such a case, the regressions might indicate a linkage between parental education and children's schooling that would be spurious and only the result of a correlation between the father's schooling and the variables that are truly motivating the education of younger family members. For these reasons, the analysis includes regressions with and without the father's education variable.

Native Ability. Data for this cohort include results of the Raven's Progressive Matrices Examination, a measure of native intelligence. This exam, which can be administered to those who cannot read or write, presents subjects with matrices, or designs, that require completion. The testee chooses, from multiple-choice options, that design which 'best fits' — that is, it best performs one of the following functions: a) completes a pattern, b) completes an analogy, c) systematically alters a pattern, d) introduces systematic permutations, or e) systematically resolves figures into parts.

While it is a point of controversy, some researchers suggest that the Raven's exam, as a proxy for native intelligence, is not affected by schooling experience. This would imply that the Raven's exam that was administered to the 18 to 29 year old males in our sample is a good indication of the native intelligence that existed for these children at the time the enrollment decision was made.[24] While it would be desirable to develop an instrument for native intelligence to be used in the enrollment and attainment regressions, it does not seem possible to identify any variable that influences a person's innate ability without also affecting schooling investment, independent of native intelligence. Lacking such an instrument, I will undertake regressions both with and without the native intelligence measure to determine if the estimated coefficients on other regressors are subject to missing variables bias resulting from the omission of innate ability as an independent variable.

Other Farm Related Characteristics. The model suggests that household characteristics that enter the agricultural production function in only a single time period will affect the allocation of children's time through single-period, cross-product substitution effects, and through an income effect. The cross-substitution effects cannot be signed. We have data on four farm related characteristics that enter the agricultural production function and that can be expected to maintain fixed values for only a relatively short period of time: i) the amounts of irrigated and rainfed land in the father's operational holding; ii) whether the father owned bullocks; iii) whether the father used high-yield variety seeds; and, iv) the distance to the nearest fertilizer

---

24 Alderman, Behrman, Ross, and Sabot (1996) have used the Raven's as a measure of native intelligence. This approach has been questioned by Khan (1993).

sales depot.

The Amounts of Irrigated and Rainfed Land in the Father's Operational Holding. These variables indicate the acres of irrigated and rainfed land farmed by the respondent's father when the respondent was of primary school age. The operational holding includes both land that was rented-in and owned-land that was cultivated by the family. As has been previously discussed, a family's ability to rent-in land is a function of the number of persons in the household who can be employed as laborers, and the stocks of other farming inputs. This implies that the size of a household's operational holding is likely to proxy both assets used in agricultural production and the overall level of household wealth, and may affect schooling through an income effect, or through substitution effects relative to other farm inputs.

Since we cannot observe the number of persons in the household when the young men were children, it is not possible to know whether a larger operational holding implies a greater area per-family member and a greater need for farm labor. The ambiguity associated with this variable is compounded by the fact that land is not homogeneous. Many authors have suggested that there is a negative correlation between the size of an operational holding and the quality of soil. Sen (1964) points out that land with better soil can support more children per acre and this may result in a smaller inheritance of land for each child. Similarly, Bhagwati and Chakravarty (1971) have suggested that households will be most likely to sell poor quality land during times of financial distress.

Whether the Father Owned Bullocks. This is a binary variable indicating whether the respondent's father owned plow animals. The ownership of these animals is a key determinant of the household's ability to rent-in land, and also serves as an important store of wealth and a hedge against agricultural production risk. As a consequence, bullock ownership can affect schooling through an income effect or substitution effects relative to child labor and human capital.

Whether the Father Used High Yield Variety Seeds. The men in the 18 to 29 year cohort were of primary school age between 1965 and 1983. The introduction of HYV seeds into Pakistan occurred in the mid 1970's and did not become widespread until the mid-1980's. Only seven percent of the respondents indicated that their fathers used HYV seed when they were of primary school age.

It is likely that this variable proxies human capital, access to agricultural extension, initiative, and risk taking. Although it is possible that the use of HYV could affect schooling through a substitution effect relative to child labor, it seems more likely that the use of modern varieties would act as a complement to schooling in agricultural production. Therefore, it seems reasonable to expect that this variable would carry a positive coefficient in the enrollment function.

Distance To The Nearest Fertilizer Sales Depot. As in the analyses in the previous section, this is a proxy for transport costs and the availability of purchased agricultural inputs. The effect of distance to markets on enrollment is uncertain and depends on whether purchased inputs are substitutes or complements of child labor.

School Quality and Availability. The measures reflecting school availability (distance to the nearest primary and intermediate schools) and quality (the mean teacher reading score in the nearest primary school, the ratio of books to students, and the student-teacher ratio) are the same as those used in the current enrollment analysis and reflect conditions that prevailed at the time the data were gathered. Since the initial enrollment decision for the sample cohort was made 13 to 25 years prior to the time of data collection, these variables are intended to serve as proxies for conditions that prevailed when these young men were five or six years old. Some of these variables can be expected to be better proxies than others. The distance to intermediate school, for example, is likely to be a good indication of past conditions as construction of these schools occurs only occasionally in our sample area (over the last generation, most of Pakistan's capital budget for education has been directed towards the construction of new primary schools). The distance to primary schools is likely to be a somewhat less reliable proxy as the median year of construction for primary schools in our sample area is 1964 (this implies that almost half of the elementary schools in our survey area were constructed since our 29 year olds were first-graders).

While it seems likely that schools that received high quality teachers and school inputs in the past will be the best provisioned in the present, our proxies of school inputs will not be capturing the same resources that existed when our cohort of young men were school boys. We saw in chapter one that the median teacher in our school sample has only about nine years teaching experience (and his length of time at his current school is slightly less than this), so our survey of reading skills of teachers at the nearest primary school includes few of the teachers who instructed our cohort. Perhaps the least reliable proxies are those of the student-teacher ratio and the ratio of books to students, as these can change markedly from year to year. These measures of school quality and availability have been previously defined and described, and I will not expand further on their roles in the enrollment decision except to repeat that, because of the manner in which we have defined the dependent variable in the current analysis, any improvements in the quality or availability of schooling will have an unambiguously positive impact on initial enrollment.

Regression Results

Tables 2.8 and 2.9 are the results of a probit analysis of initial enrollment for the 388 males aged 18 to 29 living in farm households. The regression in table 2.8 includes all regressors with the exceptions of the Raven's and the 'Fathers Education' variables. The first regression in table 2.9 omits only the native intelligence variable, while the second regression in this table includes all variables.

Household Physical Assets. Under different specifications of the enrollment function, both 'Acres of Irrigated Land in the Operational Holding' and 'Acres of Rainfed Land' exert small positive effects. These variables are sensitive, however, to the inclusion of Raven's and the binary variable indicating if the father attended school. These results stand in contrast to the regressions of current enrollment in which we found that irrigated land had a positive and significant effect on the schooling of older boys, but had no impact on the schooling of younger boys. Rainfed land had no affect on the current enrollment of either group.

None of the other variables related to the availability of factor inputs could be shown to affect initial enrollment. This might be expected for variables related to agricultural production, such as the use of HYV or distance to the nearest fertilizer depot, since younger boys are unlikely to work in agricultural tasks. However, one might expect that the presence of bullocks would reduce the likelihood of initial enrollment since herding activities compete with school attendance in the time allocation of young boys. It is unclear, however, whether six year-old boys are mature enough to care for these very large draught animals, or whether possessing bullocks is highly correlated with ownership of other types of livestock, such as goats and sheep (for example, farm households that raise livestock exclusively, and undertake no agriculture, would have no need for the traction services of bullocks).

School Quality and Availability. The distance to primary school does not affect initial enrollment. This is consistent with our analysis of *current* enrollment among the youngest boys where we saw no effect from variation in the distance to primary education.

Table 2.8 A Binomial Probit of Initial Enrollment for Farm Males Ages 18 to 29, Specifications 1 and 2.

Observations	388			
Mean of LHS	0.5309			
Std.Dev of LHS	0.4997			
Log-Likelihood	-230.0370		-218.6339	
Unenrolled Correctly Predicted	110/182		116/182	
Enrolled Correctly Predicted	170/206		162/206	
	Coeff. (t-stat)	Marg'l Effect	Coeff. (t-stat)	Marg'l Effect
Constant	0.1954		0.1314	
	(0.550)		(0.364)	
Acres of Irrigated Land	0.0094	0.0038	0.0097	0.0039
in Oper'l Holding	(1.476)		(1.499)	
Acres of Rainfed Land	0.0209	0.0083	0.0197	0.0078
in Oper'l Holding	(2.097)		(1.930)	
= 1 if Father Owned	-0.0595	-0.0237	0.0030	0.0012
Bullocks	(-0.304)		(0.015)	
= 1 if Father Used	-0.1740	-0.0693	-0.1347	-0.0534
High Yield Variety	(-0.622)		(-0.475)	
Distance to Fert. Sales	0.0202	0.0080	0.0189	0.0075
Nearest Village	(1.165)		(1.067)	
Distance to Prim. School	-0.0157	-0.0063	-0.0092	-0.0036
Nearest Village (km.)	(-0.600)		(-0.350)	
Distance to Int. School	-0.0543	-0.0216	-0.0508	-0.0202
Nearest Village (km.)	(-4.000)		(-3.736)	
Student-Teacher Ratio in	-0.0075	-0.0030	-0.0069	-0.0027
Nearest Prim. Sch.	(-2.851)		(-2.555)	
Av. Reading of Teachers,	-0.0023	-0.0009	-0.0071	-0.0028
Nearest Prim. Sch.	(-0.153)		(-0.456)	
Ratio of Books/Students at	0.0063	0.0025	0.0042	0.0017
Nearest Prim. * 100	(1.744)		(1.142)	
= 1 if Father Attended			0.8486	0.3365
School			(4.618)	

Table 2.9 A Binomial Probit of Initial Enrollment for Farm Males Ages 18 to 29, Specification 3

Observations	388
Mean of LHS	0.5309
Std.Dev of LHS	0.4997
Log-Likelihood	-187.9552
Unenrolled Correctly Predicted	135/182
Enrolled Correctly Predicted	161/206

	Coeff. (t-stat)	Mean *Stand. Dev.*	Marg'l Effect
Constant	-1.4244		
	(-3.270)		
Acres of Irrigated Land	0.0127	6.5928	0.0051
in Oper'l Holding	(1.826)	*13.997*	
Acres of Rainfed Land	0.0108	3.6389	0.0043
in Oper'l Holding	(0.978)	*10.027*	
= 1 if Father Owned	0.0265	0.5155	0.0106
Bullocks	(0.125)	*0.5004*	
= 1 if Father Used	-0.2230	0.0722	-0.0888
High Yield Variety	(-0.781)	*0.2591*	
Distance to Fert. Sales	0.0218	7.3582	0.0087
Nearest Village	(1.101)	*5.7527*	
Distance to Prim. School	-0.0103	1.4763	-0.0041
Nearest Village (km.)	(-0.366)	*3.1834*	
Distance to Int. School	-0.0651	6.7332	-0.0259
Nearest Village (km.)	(-4.029)	*8.1870*	
Student-Teacher Ratio in	-0.0073	40.352	-0.0029
Nearest Prim. Sch.	(-2.526)	*34.198*	
Av. Reading of Teachers,	-0.0152	14.844	-0.0060
Nearest Prim. Sch.	(-0.917)	*7.0478*	
Ratio of Books/Students	0.0023	54.564	0.0009
at Nearest Prim. * 100	(0.582)	*10.660*	
= 1 if Father Attended	0.7046	0.2242	0.2805
School	(3.515)	*0.4176*	
Raven's Score, Measured	0.0900	21.379	0.0358
as Adults	(7.273)	*6.9945*	

In contrast, the distance to intermediate school has a strong, negative, and significant effect on initial enrollment. This relationship could be the result of credentialism: if attending middle school carries a significantly greater value in the job market than primary school completion, parents may assess the cost of sending kids to intermediate school when making the decision to enroll their children in first grade. It is more likely, however, that the distance to intermediate school provides a good proxy for the availability of *all* types of education at the time the cohort of young men were initially enrolled. We know that there has been significant construction of new elementary schools in the decades prior to our survey, but little building of middle schools. If, as seems probable, the distance to middle school was highly correlated with the distance to primary school when our young men were children, the distance to intermediate school is a good proxy for past availability of education through the eighth grade.

One difference between the regressions of initial enrollment and current enrollment is the effect of the student teacher ratio. In table 2.4 it was shown that the student teacher ratio has a small, positive, and significant effect on current enrollment and, following Warwick and Reimers, it was suggested that this variable might be a proxy for unobserved differences in quality that result in greater demand for education at more crowded schools.[25]

In the analysis of initial enrollment, however, there is a small *negative* and significant coefficient on the student-teacher ratio. The contradiction in these findings may be due to some combination of three effects. First, in the analysis of initial enrollment, the impact of the student-teacher ratio operates only through the demand for schooling, while in the regressions for current enrollment, the student teacher ratio operates through both demand for schooling and the production of human capital. If a higher student-teacher ratio results in a small reduction in the demand for education, and a large increase in the time necessary for the production of human capital, one would observe that the regressor is negatively linked with initial enrollment but positively linked with current enrollment. Second, the student-teacher ratio can assume different meanings in different contexts. If there is greater demand for attending superior schools, this regressor can proxy unobserved aspects of school quality. In other environments, a high student-teacher ratio may simply denote less personal attention being paid to each student. Since we did not

25 Note that the significance of this relationship fell below the ten percent level in those regressions that analyzed current enrollment separately for young and old boys.

take the same number of observations from sample villages when constructing our two cohorts, it is possible that the former effect dominates among the younger group while the latter effect prevails among the older cohort. Finally, it is possible that the cause of school crowding has changed over time. If school administrators tend to provide better school inputs to more crowded schools, the demand for crowded schools may increase across generations.

When Raven's and father's education are excluded as regressors, the ratio of books-to-students is significant at the ten percent level. The effect of this variable, shown in the first column of table 2.8, is rather small: increasing the number of books per-student from 0.546 to 0.6526 (an increase of one standard deviation in the independent variable) raises the probability that a boy attends school from 53.1 percent to 54 percent. This result also stands in contrast to the analysis in the previous section where the books-to student-ratio did not influence the current enrollment of younger children. It should also be recalled that, in the analysis of attrition presented in chapter one, the ratio of books-to-students could not be shown to affect the rate of retention. In neither the regressions for initial enrollment, nor in those for current enrollment, could the reading score of teachers be shown to have an effect.

Household Human Capital Assets. Both the measure of native ability, and the father's educational status have large, positive and significant effects on enrollment. An increase of one standard deviation in the Raven's score (a rise of 7.0 points), is associated with a rise in the probability of enrollment from 53.1 percent to 78.1 percent. Similarly, having a father who attended school increases the probability of enrollment from 53.1 percent to 81.2 percent.

Schooling Attainment of Adult Rural Males

The data available for the cohort of 18 to 29 year old rural males includes the highest grade level achieved by these men and, with this, I can examine the determinants of schooling attainment. There are several approaches which I could use for this sort of study. I could extend the binomial analysis of the previous section and examine various levels of attainment (e.g., no schooling, primary schooling, intermediate schooling, etc.). This method is attractive as one could interpret different levels of attainment as being discrete entities with different attributes and costs. Alternatively, I could undertake an analysis in which attainment is defined as a continuous variable. Such an approach would require the use of censored regression methods, as almost half of the sample has never attended school. Candidates for this sort of analysis include the Tobit and the two-step method proposed by Heckman.

I have chosen to use the Tobit for the attainment analysis for practical, computational reasons. Any of the candidate models would be subject to bias in the estimation of both coefficients and standard errors if there is correlation between the variance of the disturbance term and the independent variables in the regression. Heteroscedasticity does, in fact, turn out to have a significant effect on our analysis. Among the models for qualitative or censored data, only the Tobit has an adjustment for heteroscedasticity that can be implemented with the particular characteristics of my data set.

The Tobit is also useful as it allows me to determine how regressors affect both the qualitative and quantitative aspects of the schooling decision (initial enrollment and attainment conditional on enrollment). With the adjustment for heteroscedasticity, I can produce unbiased estimates of how the regressors impact the desired level of attainment among the entire sample, observed schooling attainment among the entire cohort, and schooling attainment conditional on enrollment.

Linking the Model to a Tobit Analysis

As in the probit analysis of *current* enrollment, grade attainment is a proxy for the optimal length of time spent in schooling. The latent variable underlying the Tobit analysis of schooling attainment is the same as in the analysis of current enrollment and can be expressed as the probabilistic model in equation 2.10. If we define $\mathbf{z}_i$ as the vector of all individual, household, village, and school characteristics that influence how parents allocate the time of their boys, the equation for the optimal time that boy i spends in schooling can be rewritten as

$$T_i^{*} = \alpha'_{[z]}\mathbf{z}_i + \varepsilon_i. \tag{2.10}$$

At the desired level of grade attainment, the time-discounted marginal value of second period human capital, gained from sending a boy to school in the first period, equals the current marginal value of child labor. For those households that enroll their boys, the desired attainment equals the observed attainment, $T_i^* = T_i > 0$.

Households that do not enroll their boys experience a corner solution in that, when observed grade attainment takes on its minimum value of $T_i = 0$, the marginal value of child labor is greater than the time discounted marginal value of second period human capital. The desired level of attainment for these households is less than the observed level of attainment of zero, $T_i^* < T_i = 0$, and these families would like to continue trading-off grade attainment for child labor up to some negative level of attainment. Therefore, the relation between the latent variable, T_i^*, and the observed data is

$$\begin{aligned} T_i &= 0 \text{ if } T_i^* \leq 0 \\ T_i &= T_i^* = \alpha' z_i + \varepsilon_i \text{ if } T_i^* > 0. \end{aligned} \tag{2.22}$$

The key insight of the Tobit is that, when one's sample includes observations for which the latent variable can be either above or below the censoring limit, the expected value of the observed data is equal to the probability that the observed data is above the censoring limit, times the expected value of the observed data, given that it is above the censoring limit:

$$\begin{aligned} E\left[T_i\right] &= P\left[T_i > 0\right] * E\left[T_i|T_i > 0\right] + P\left[T_i = 0\right] E\left[T_i|T_i = 0\right] \\ &= P\left[T_i > 0\right] * E\left[T_i|T_i > 0\right] \end{aligned}$$

Denoting the density function and the distribution function of the standard normal as $\phi(\,)$ and $\Phi(\,)$, the expected value of the observed data can be written as:

$$\begin{aligned} \mathrm{E}\left[T_i\right] &= \Phi\left(\frac{\beta' z_i}{\sigma}\right) * \left[\beta' z_i + \sigma \frac{\phi\left(\frac{\beta' z_i}{\sigma}\right)}{\Phi\left(\frac{\beta' z_i}{\sigma}\right)}\right] \\ &= \Phi\left(\frac{\beta' z_i}{\sigma}\right) * \beta' z_i + \sigma\phi\left(\frac{\beta' z_i}{\sigma}\right) \end{aligned} \tag{2.23}$$

The likelihood function of the Tobit can be written in terms of two commonly used expressions: i) a truncated regression for those observations that are not at the censoring limit, and ii) the probability of being at the censoring limit:

$$\mathrm{L} = \prod_{\text{Not Censored}} \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{1}{2\sigma}(y_i - \beta' z_i)^2\right) \prod_{\text{Censored}} \left(1 - \Phi\left(\frac{\beta' z_i}{\sigma}\right)\right). \tag{2.24}$$

The first expression on the right-hand side of 2.24 is the likelihood function for the truncated regression, while the second expression captures the probability that a boy is not enrolled, which one would find from applying a probit analysis to the entire cohort of young men.

If the error term in equation 2.10 conforms to all the assumptions of classical linear regression, the maximization of equation 2.24 provides three useful marginal effects, and these will be reported with our findings from the Tobit:

i) the effect of the regressors on the latent variable:

$$\frac{\partial E\left[T_i^*\right]}{\partial z_i} = \beta, \tag{2.25}$$

ii) the effect of the regressors on observed attainment, irrespective of whether attainment is at or above the censor limit:

$$\frac{\partial E\left[T_i\right]}{\partial z_i} = \beta\Phi\left(\frac{\beta' z_i}{\sigma}\right), \tag{2.26}$$

and, iii) the effect of the regressors on observed attainment, given that the realization of attainment is above the censor limit:

$$\frac{\partial \mathrm{E}\left[T_i | T_i^* > 0\right]}{\partial z_i} = \beta\left|1 - \alpha\frac{\phi(\alpha)}{\Phi(\alpha)} - \left(\frac{\phi(\alpha)}{\Phi(\alpha)}\right)^2\right| \tag{2.27}$$

where

$$\alpha = \frac{\beta' z_i}{\sigma}.$$

It may not be obvious why we should be concerned with the distinction between the desired and observed levels of attainment, since these are only unequal when the household wishes to engage in trades that cannot be undertaken. However, a household's desire to trade at a negative level of attainment suggests important information about the way families would behave in the absence of market imperfections. If one assumes that the human capital stock of a household is comprised of the sum of homogeneous contributions from both generations, and also assumes that all child labor is equivalent, one can think of families with negative desired attainment as wishing to acquire additional boy labor in exchange for sacrificing some of the initial endowment of human capital that it would otherwise carry forward into the second period. Expressed in perhaps more useful terms, one can think of a negative level of desired attainment as capturing the extent to which the household would wish to rent-out its initial stock of knowhow in the second period in order to pay for the hiring-in of non-family child labor in the first period. Such desired exchange may be prohibited by a combination of factors, including the absence of markets for knowhow, an absence of markets for child labor, and imperfect capital markets. When the Tobit indicates how changes in regressors would act on desired attainment, T_i^*, it informs us of how households would behave in the absence of these market imperfections.

While the empirical model underlying the Tobit analysis is similar to that seen in the analysis of current enrollment, there are important dissimilarities. In the case of current enrollment, we seek to find the age at which parents want children to complete their education, while in the present instance, we are looking for the optimal grade attainment. One would expect regressors to exert similar effects in these two empirical models, but it should be remembered that the length of time in school and the age at which children finish their education can be increased by either completing additional grades or repeating grades. Although we do not have reliable information on the incidence of repetition for our sample, the World Bank (1988,17) estimates that approximately 9 percent of all boys in Pakistan repeat at least one grade. The distinction between the two proxies of time spent in school can be important since, if repetition is sufficiently common, one can imagine a change in school quality that could simultaneously increase (reduce) the amount of time boys spend in school and reduce (increase) their average grade attainment.

An additional reason why we may observe differences in the effects of the independent variables in the regressions for current enrollment and for schooling attainment is a consequence of the manner in which we define our samples for analysis. The analysis of current enrollment considers only the schooling decisions made for 6 to 12 year old boys, and these decisions concern education only through fifth or sixth grade. The schooling attainment analysis, however, reflects the ultimate grade completed for the cohort of 18 to 30 year olds and, among those young men who were initially enrolled, the *average* schooling attainment is eighth grade. As the determinants of child-time allocation are likely to change with age, one can expect significant differences in the two sets of regression results.

The Dependent Variable

For this analysis, the dependent variable is the highest grade completed for each of the 388 rural males. Table 2.10 shows the distribution of schooling attainment among the men in the sample. The concentration of observations at the fifth, eighth, tenth, and twelfth grades correspond to the final years of primary school, middle school, matriculation, and Fellow of Arts or Sciences. Of the 388 young men, 240, or 53.1 percent, report attending at least one year of primary school. This is roughly consistent with the participation rates reported by other sources for rural schools in the early 1980's, when many of this cohort were of elementary school age. However, of the 206 young men who started elementary school, only 28 (or 13.6 percent) reported dropping-out prior to completion of the primary grades. This is a significantly smaller attrition rate than has been reported for rural primary schools in Pakistan.

The reason for this low level of observed primary attrition is likely to be errors in reporting attainment on the part of respondents. It was pointed out in a previous section that the data for schooling attainment were gathered by asking a single individual the highest grade he had attended, and we were unable to confirm this information from other sources. It is likely that many of the respondents engaged in some face-saving obfuscation and reported primary school attendance as primary school completion. Such mis-reporting would imply errors in our dependent variable for schooling attainment which would be incorporated into the error term in our stochastic model. These errors in measurement would imply that there is little variation in primary school attainment among our sample. As a consequence, the results of our attainment regressions may be largely driven by differences in enrollment and in higher levels of attainment, and not by elementary school attrition.

The Independent Variables

The current analysis employs the same set of independent variables used in the probit regressions of initial enrollment and these are described in a previous section. As in the probit analysis, we cannot anticipate the signs on most of the estimated coefficients in our regressions. Household and village characteristics can have ambiguous influences on attainment as they operate through income effects and substitution effects relative to farm inputs. Unlike the analysis of initial enrollment, however, both the native intelligence of the child and the school quality variables

Table 2.10 Frequency of Grade Attainment Among Farm Males Ages 18 to 29

Grade	Frequency	Percent	Cumulative Percent
0	182	46.9	46.9
1	3	.8	47.7
2	5	1.3	49.0
3	10	2.6	51.5
4	10	2.6	54.1
5	37	9.5	63.7
6	7	1.8	65.5
7	9	2.3	67.8
8	34	8.8	76.5
10	49	12.6	89.2
12	29	7.5	96.6
14	13	3.4	100.0
Total	388	100.0	

affect attainment through both the demand for second period human capital and the human capital production function. As was discussed in the derivation of equations 2.9 to 2.10, this implies that the school quality variables can have positive or negative effects on grade attainment.

Regression Results

The results of the Tobit are presented in tables 2.11 through 2.13. Of the household agricultural inputs, only the land variables and the distance to fertilizer sales have significant effects on attainment, and the estimated coefficients on these variables are sensitive to the inclusion of 'Fathers Education' and the Raven's score. The Tobit results in table 2.13 indicate that a 10 acre increase in the amount of rainfed land in the family's operational holding (a rise of one standard deviation of this regressor) will increase expected attainment by 0.55 years among the entire cohort of young men (a rise of 12 percent of a standard deviation). The effects of the land variables change markedly when we include the Raven's score among our regressors: rainfed land no longer affects attainment, but irrigated land has a moderate and significant impact on schooling. The results in table 2.15 indicate that increasing the amount of irrigated land in the family's operational holding by 14 acres (one standard deviation) reduces attainment by 0.48 of a year (equal to 10.4 percent of a standard deviation in attainment). We will see in the next section that the volatility of these variables disappears once we control for the effects of heteroscedasticity in our Tobits.

The distance to the nearest fertilizer sales depot has a modest effect on attainment. This relationship, however, rises to significance at the ten percent level only when father's education and Raven's are excluded from the regressors.

Both the distance to intermediate school and the student-teacher ratio have sizable, negative, and significant affects on attainment, and these results are robust to the inclusion of other variables. An increase in distance to intermediate school of 8.2 kilometers (one standard deviation) is associated with a fall in attainment of 1.95 years among the entire cohort of boys (40 percent of a standard deviation in schooling). Similarly, a rise in the student teacher ratio from 0.4035 to 0.745 (a rise of one standard deviation) results in a decline in attainment of 0.77 years (one-sixth of a standard deviation in the dependent variable).

Finally, the father's education and Raven's score have very large, positive, and significant effects on attainment. A boy whose father is educated can be expected to receive one and a half more years of education. A one standard deviation increase in the Raven's score (equal to seven points on this 30 point scale) is associated with an additional two years of schooling (44 percent of a standard deviation in attainment).

Estimating Schooling Attainment Adjusted for Heteroscedasticity

To this point, the attainment functions have been estimated on the assumption of spherical error terms. It seems plausible, however, that the variance of the disturbance terms in the schooling demand functions might be correlated with the independent variables. For example, we have suggested that household productive assets might act on the demand for schooling through both an income effect, that increases the demand for schooling, and a cross-substitution effect relative to child labor that, perhaps, decreases the demand for schooling. While the income effect

Table 2.11 A Tobit Analysis of Grade Attainment for Farm Males Ages 18 to 29, Specification 1

Observations	388		
Mean of LHS	4.2912		
Std.Dev of LHS	4.6992		
Log-Likelihood	-819.8545		

	Coeff. (t-stat)	Marg'l Effect on y	Marg'l Effect on y Given $y* > 0$
Constant	4.0730		
	(1.931)		
Acres of Irrigated Land	0.0454	0.0250	0.0177
in Oper'l Holding	(1.169)		
Acres of Rainfed Land	0.1120	0.0553	0.0391
in Oper'l Holding	(2.028)		
= 1 if Father Owned	-0.5959	-0.1453	-0.1027
Bullocks	(-0.521)		
= 1 if Father Used	-1.6923	-0.7940	-0.5615
High Yield Variety	(-0.965)		
Distance to Fert. Sales	0.1710	0.0864	0.0611
Nearest Village	(1.653)		
Distance to Prim. School	-0.1882	-0.0694	-0.0491
Nearest Village	(-1.238)		
Distance to Int. School	-0.4323	-0.2269	-0.1605
Nearest Village	(-4.912)		
Student-Teacher Ratio in	-0.0464	-0.0226	-0.0160
Nearest Prim. Sch.	(-2.909)		
Av. Reading of Teachers,	-0.0194	-0.0270	-0.0191
Nearest Prim. Sch.	(-0.224)		
Ratio of Books/Students at	0.0201	0.0041	0.0029
Nearest Prim. * 100	(0.947)		
σ	7.1379		
	(18.132)		
α	0.18957		
$\lambda(\alpha)$	0.68125		
$\Phi(\alpha)$	0.57518		

Table 2.12 A Tobit Analysis of Grade Attainment for Farm Males Ages 18 to 29, Specification 2

Observations	388		
Mean of LHS	4.2912		
Std.Dev of LHS	4.6992		
Log-Likelihood	-808.3993		

	Coeff. (t-stat)	Marg'l Effect on y	Marg'l Effect on y Given $y* > 0$
Constant	3.6314		
	(1.783)		
Acres of Irrigated Land	0.0435	0.0253	0.0179
in Oper'l Holding	(1.161)		
Acres of Rainfed Land	0.0961	0.0559	0.0395
in Oper'l Holding	(1.802)		
= 1 if Father Owned	-0.2525	-0.1468	-0.1037
Bullocks	(-0.229)		
= 1 if Father Used	-1.3804	-0.8023	-0.5666
High Yield Variety	(-0.817)		
Distance to Fert. Sales	0.1503	0.0873	0.0617
Nearest Village	(1.506)		
Distance to Prim. School	-0.1206	-0.0701	-0.0495
Nearest Village	(-0.823)		
Distance to Int. School	-0.3945	-0.2293	-0.1619
Nearest Village	(-4.679)		
Student-Teacher Ratio in	-0.0392	-0.0228	-0.0161
Nearest Prim. Sch.	(-2.538)		
Av. Reading of Teachers,	-0.0469	-0.0273	-0.0193
Nearest Prim. Sch.	(-0.560)		
Ratio of Books/Students at	0.0071	0.0041	0.0029
Nearest Prim. * 100	(0.345)		
= 1 if Father Attended	4.4121	2.5644	1.8111
School	(4.814)		
σ	6.8648		
	(18.181)		
α	0.20504		
$\lambda(\alpha)$	0.67210		
$\Phi(\alpha)$	0.58123		

Table 2.13 A Tobit Analysis of Grade Attainment for Farm Males Ages 18 to 29, Specification 3

	Coeff. (t-stat)	Marg'l Effect on y	Marg'l Effect on y Given $y* > 0$
Observations	388		
Mean of LHS	4.2912		
Std.Dev of LHS	4.6992		
Log-Likelihood	-757.0971		
Constant	-5.9118		
	(-2.989)		
Acres of Irrigated Land in Oper'l Holding	0.0617	0.0348	0.0247
	(1.930)		
Acres of Rainfed Land in Oper'l Holding	0.0335	0.0189	0.0134
	(0.746)		
= 1 if Father Owned Bullocks	-0.4611	-0.2605	-0.1847
	(-0.497)		
= 1 if Father Used High Yield Variety	-1.2294	-0.6944	-0.4924
	(-0.893)		
Distance to Fert. Sales Nearest Village	0.1270	0.0717	0.0509
	(1.460)		
Distance to Prim. School Nearest Village	-0.0616	-0.0348	-0.0247
	(-0.499)		
Distance to Int. School Nearest Village	-0.4216	-0.2381	-0.1689
	(-5.397)		
Student-Teacher Ratio in Nearest Prim. Sch.	-0.0319	-0.0180	-0.0128
	(-2.464)		
Av. Reading of Teachers, Nearest Prim. Sch.	-0.0731	-0.0413	-0.0293
	(-1.046)		
Ratio of Books/Students at Nearest Prim. * 100	-0.0027	-0.0015	-0.0011
	(-0.157)		
= 1 if Father Attended School	2.6404	1.4914	1.0575
	(3.415)		
Raven Score, Measured as Adults	0.5216	0.2946	0.2089
	(10.333)		
σ	5.6735		
	(18.419)		
α	0.16327		
$\lambda(\alpha)$	0.69693		
$\Phi(\alpha)$	0.56485		

may dominate in some households and the cross-substitution effect may dominate in others, the more of this asset a family has, the greater the scope for this regressor acting on the household demand for schooling — and the greater the scope for household behavior deviating from the estimated schooling demand function.

Heteroscedasticity is especially concerning when employing probit or Tobit analyses. Unlike linear regression analysis, when a probit or Tobit has heteroscedastic disturbances, the estimated coefficients are biased.[26] To illustrate this in the case of the Tobit, suppose that we erroneously assume that the vector of expected values of the proxy variable is as specified in equation 2.23 (these equations express the vector of expected values in terms of the parameters β and σ, where the standard deviation of the error term is assumed to be constant across observations), and also erroneously assume that our data can be represented by the maximum likelihood function in equation 2.24.[27] If the true model is heteroscedastic, with parameters β_0 and $\sigma_{(0,i)}$, where $\sigma_{(0,i)}$ varies across observations, the true vector of the expected values for the proxy variable is

$$\mathrm{E}_0\left[T_i\right] = \Phi\left(\frac{\beta_0' z_i}{\sigma_{(0,i)}}\right) * \beta_0' z_i + \sigma_{(0,i)}\phi\left(\frac{\beta_0' z_i}{\sigma_{(0,i)}}\right) \tag{2.28}$$

We can see from a comparison of equations 2.24 and 2.28 that if $\sigma_{(0,i)} \neq \sigma_{(0,j)}$ for any $i \neq j$, and if there is any degree of censoring of the data, the parameters estimated by the Tobit maximum likelihood method will differ from their true values.

Adjusting either the probit or Tobit for heteroscedasticity is straightforward and requires i) the specification of a general relationship between the disturbance term for each observation and the regressors, such that $\sigma_i^2 = f(\delta' \mathbf{w}_i)$,[28] ii) substituting this relationship into the maximum likelihood function, and iii) simultaneously estimating the parameters of the errors function and the maximum likelihood parameters for the model. If the relationship between the error terms and the regressors has been correctly specified, the point estimates derived from this maximum likelihood function will be consistent.

---

[26] Maddala, G.S. and F. Nelson (1974). "Switching Regression Models with Exogenous and Endogenous Switching." *Proceedings of the American Statistical Association* (Business and Economics Section), pp 423–426.

[27] This discussion follows Maddala (1983)

[28] Here, the vector $\mathcal{W}$ is the same as $\mathcal{Z}$, except that it omits the constant term. Greene (1992) observes that, since σ is a free parameter, a constant would be a redundant variable in the variance model and would result in a singular covariance matrix.

It is also straightforward to use the modified maximum likelihood function to test the null hypothesis that the disturbance terms are homoscedastic (under the particular model that one has specified to link the variance of the error terms to the regressors). Since the estimates of the parameters of the errors function are imbedded in the maximum likelihood equation for the model which has been adjusted for heteroscedasticity, one can test the null hypothesis of homoscedasticity by comparing the log-likelihood for the unadjusted model with the log-likelihood for the model that is adjusted for heteroscedasticity. This is equivalent to a joint test that all coefficients in the errors function are equal to zero, $\delta = 0$.

While, in theory, adjusting the probit and Tobit for heteroscedasticity is simple, the practical application of the adjustment has not been straightforward: I have been unable to estimate adjusted probits for either current enrollment or initial enrollment. Using standard statistical packages,[29] I have specified several functional forms for the relationship between the regressors and the error terms. Under all specifications, I have included the full range of regressors, except for the constant. In every instance, the probits have failed to converge to a solution.[30]

The Tobit model adjusted for heteroscedasticity, however, converges rapidly to a solution. In tables 2.14 to 2.16, I present both the Tobit regressions initially included in tables 2.11 to 2.13 and the regressions adjusted for heteroscedasticity. The adjustments are based on the following general function that links the standard deviation of the error term to the regressors:

$$\sigma_i = \sigma * \exp[\delta' \mathrm{w}_i] \tag{2.29}$$

Under all three specifications of the Tobit, the likelihood ratio tests allow us to reject, at the one percent level, the null hypothesis that the error terms are homoscedastic.

Regression Results

The principal sources of heteroscedasticity in the Tobit for grade attainment are the student-teacher ratio at the nearest primary school and the binary variable

29 Stata 5.0 and Limdep 7.

30 I believe that the issue here is that we are simultaneously estimating the probit function and the disturbance function with the same regressors and relying on functional form for identification of the principal equation. The authors of the Stata software caution that defining the disturbance as a function of the same set of variables that serve as regressors in the main equation of the probit results in strong correlation in the estimated coefficients in the two equations, and may preclude a solution.

for the father's educational status. The standard deviation of the error term is positively and significantly related to the student-teacher ratio, in two of the three regressions. This suggests that when local schools are crowded, there is a great deal of variation in household demand for human capital. I have previously speculated that school crowding may indicate either a poor learning environment (if a higher student-teacher ratio is a supply phenomenon resulting from too few teachers being employed) or a superior atmosphere for schooling (if crowding is a demand-driven phenomenon resulting from unobserved differences in the quality of education). In fact, across all of our survey villages, the student-teacher ratio may reflect both of these phenomena, and this may be why households will deviate a great deal from the estimated schooling demand function when this regressor takes on large values.

Adjusting for heteroscedasticity results in sizable changes in the estimated coefficients in the Tobit regression of attainment for two of our regessors. In contrast to the previous results, the amount of rainfed land cannot be shown to affect attainment once the adjustment is made for heteroscedasticity. The current results are more in agreement with our expectations, as there is not believed to be a great deal of complementarity in agricultural production between rainfed land and human capital.

The estimates adjusted for heteroscedasticity also indicate a much more negative relationship between schooling and the student-teacher ratio. An increase in the student teacher ratio from 0.40 to 0.74 (a change of one standard deviation in this regressor) is now estimated to reduce attainment by 1.83 years (equal to 46 percent of a standard deviation). Decreasing the distance to middle school by one standard deviation (8.19 miles) increases attainment by 2.60 years (equal to 55 percent of a standard deviation).[31]

A Summary of Findings on the Demand for Schooling

In synthesizing the findings from the analyses of initial enrollment, current enrollment, and grade attainment, an interesting picture emerges. We have seen that

---

31 It should be noted that the marginal effects in the Tobit adjusted for heteroskedasticity are more complex than those in the unadjusted model. In the adjusted model, the marginals reflect both the effects of the regressors on the mean of the dependent variable and the their effects on the variance. For those variables that are included in both the main equation and the equation for the variance of the disturbance term, these effects are summed. The marginal effects reported here are calculated using Limdep 7.0.

Table 2.14 Tobit Models of Attainment Under Assumptions of Homoscedastic and Heteroscedastic Disturbances, Specification 1

Observations	388	
Mean of LHS	4.2912	
Std.Dev of LHS	4.6992	
Log-Likelihood	-819.8545	-807.9804

	Homoscedastic	Heteroscedastic		
		β	δ	Marginal
Constant	4.0730	3.4198		
	(1.931)	(1.488)		
Acres of Irrigated Land	0.0454	0.1236	-0.0081	0.0363
in Oper'l Holding	(1.169)	(2.643)	(-1.058)	(1.322)
Acres of Rainfed Land	0.1120	0.0322	-0.0004	0.0148
in Oper'l Holding	(2.028)	(0.433)	(-0.034)	(0.256)
= 1 if Father Owned	-0.5959	-1.5195	0.0579	-0.5732
Bullocks	(-0.521)	(-1.259)	(0.297)	(-0.628)
= 1 if Father Used	-1.6923	0.8092	-0.2432	-0.3376
High Yield Variety	(-0.965)	(0.419)	(-0.772)	(-0.314)
Distance to Fert. Sales	0.1710	0.1669	-0.0041	0.0699
Nearest Village	(1.653)	(1.458)	(-0.235)	(0.831)
Distance to Prim. School	-0.1882	-0.1203	-0.0123	-0.0964
Nearest Village	(-1.238)	(-0.886)	(-0.519)	(-0.819)
Distance to Int. School	-0.4323	-0.6226	0.0227	-0.2380
Nearest Village	(-4.912)	(-3.645)	(1.493)	(-3.997)
Student-Teacher Ratio in	-0.0464	-0.1468	0.0060	-0.0541
Nearest Prim. Sch.	(-2.909)	(-3.482)	(1.325)	(-3.447)
Av. Reading of Teachers,	-0.0194	0.2119	-0.0179	0.0501
Nearest Prim. Sch.	(-0.224)	(2.047)	(-1.016)	(0.647)
Ratio of Books/Students	0.0201	0.0394	-0.0052	0.0037
* 100 at Nearest Prim.	(0.947)	(1.798)	(-1.254)	(0.201)
σ	7.1379	9.6897		
	(18.132)	(2.232)		

$\chi^2 = 2*(-807.9804 - (-819.8545)) = 23.74819$

χ^2 (23.74819, 10) = 0.9917024

Table 2.15 Tobit Models of Attainment Under Assumptions of Homoscedastic and Heteroscedastic Disturbances, Specification 2

Observations	388			
Mean ofLHS	4.2912			
Std.Dev of LHS	4.6992			
Log-Likelihood	-808.3993	-790.6004		

	Homoscedastic	Heteroscedastic		
		β	δ	Marginal
Constant	3.6314	4.5628		
	(1.783)	(2.244)		
Acres of Irrigated Land	0.0435	0.0964	-0.0067	0.0270
in Oper'l Holding	(1.161)	(2.261)	(-0.952)	(1.115)
Acres of Rainfed Land	0.0961	0.0145	-0.0024	-0.0000
in Oper'l Holding	(1.802)	(0.228)	(-0.219)	(-0.001)
= 1 if Father Owned	-0.2525	-0.7922	-0.0373	-0.4959
Bullocks	(-0.229)	(-0.685)	(-0.192)	(-0.603)
= 1 if Father Used	-1.3804	0.9958	-0.2826	-0.3526
High Yield Variety	(-0.817)	(0.605)	(-0.933)	(-0.333)
Distance to Fert. Sales	0.1503	0.2288	-0.0115	0.0773
Nearest Village	(1.506)	(1.970)	(-0.608)	(1.015)
Distance to Prim. School	-0.1206	-0.0960	-0.0074	-0.0685
Nearest Village	(-0.823)	(-0.721)	(-0.287)	(-0.596)
Distance to Int. School	-0.3945	-0.5301	0.0185	-0.2031
Nearest Village	(-4.679)	(-3.505)	(1.185)	(-3.571)
Student-Teacher Ratio in	-0.0392	-0.1534	0.0082	-0.0504
Nearest Prim. Sch.	(-2.538)	(-3.937)	(2.170)	(-3.338)
Av. Reading of Teachers,	-0.0469	0.1265	-0.0115	0.0275
Nearest Prim. Sch.	(-0.560)	(1.427)	(-0.783)	(0.410)
Ratio of Books/Students	0.0071	0.0016	-0.0016	-0.0039
* 100 at Nearest Prim.	(0.345)	(0.077)	(-0.416)	(-0.226)
= 1 if Father Attended	4.4121	4.8363	-0.4772	0.9388
School	(4.814)	(5.609)	(-3.125)	(1.406)
σ	6.8648	8.2066		
	(18.181)	(2.548)		

χ^2 = 2*(-790.6004-(-808.3993)) = 35.59767

χ^2 (35.59767, 11) = 0.9998026

Table 2.16 Tobit Models of Attainment Under Assumptions of Homoscedastic and Heteroscedastic Disturbances, Specification 3

Observations	388			
Mean of LHS	4.2912			
Std.Dev of LHS	4.6992			
Log-Likelihood	-757.0971	-742.8879		
	Homoscedastic	Heteroscedastic		
		β	δ	Marginal
Constant	-5.9118	-5.4874		
	(-2.989)	(-2.664)		
Acres of Irrigated Land	0.0617	0.1038	-0.0029	0.0480
in Oper'l Holding	(1.930)	(2.869)	(-0.470)	(2.258)
Acres of Rainfed Land	0.0335	-0.0241	0.0013	-0.0096
in Oper'l Holding	(0.746)	(-0.399)	(0.115)	(-0.205)
= 1 if Father Owned	-0.4611	-1.0323	-0.0292	-0.6155
Bullocks	(-0.497)	(-1.064)	(-0.158)	(-0.894)
= 1 if Father Used	-1.2294	-0.1856	0.0960	0.1288
High Yield Variety	(-0.893)	(-0.100)	(0.282)	(0.127)
Distance to Fert. Sales	0.1270	0.1357	-0.0149	0.0365
Nearest Village	(1.460)	(1.508)	(-0.895)	(0.542)
Distance to Prim. School	-0.0616	0.0581	-0.0208	-0.0184
Nearest Village	(-0.499)	(0.590)	(-0.860)	(-0.217)
Distance to Int. School	-0.4216	-0.5168	0.0177	-0.2317
Nearest Village	(-5.397)	(-4.494)	(1.419)	(-4.775)
Student-Teacher Ratio in	-0.0319	-0.1086	0.0070	-0.0410
Nearest Prim. Sch.	(-2.464)	(-3.626)	(1.743)	(-2.822)
Av. Reading of Teachers,	-0.0731	0.0780	-0.0114	0.0142
Nearest Prim. Sch.	(-1.046)	(0.984)	(-0.765)	(0.271)
Ratio of Books/Students	-0.0027	0.0058	-0.0008	0.0011
at Nearest Prim. * 100	(-0.157)	(0.311)	(-0.216)	(0.073)
= 1 if Father Attended	2.6404	2.7676	-0.2468	0.8813
School	(3.415)	(3.765)	(-1.709)	(1.550)
Raven's Score, Measured	0.5216	0.4941	-0.0030	0.2544
as Adults	(10.333)	(9.414)	(-0.294)	(6.254)
σ	5.6735	6.6247		
	(18.419)	(2.222)		

χ^2 = 2*(-742.8879-(-757.0971)) = 28.41838

χ^2 (28.41838, 12) = 0.9951973

initial enrollment among the cohort of young men is highly sensitive to the availability of schooling. However, among our cohort of children ages six to nine, *current* enrollment status is unaffected by the distance to school. While initial enrollment and current enrollment are measuring somewhat different things, the likely explanation for this divergence in results is that there has been a good deal of primary school construction over the last generation, there is now greater initial enrollment, and distance is now less of a barrier to schooling for six year old boys. Our results also indicate that only one of the school quality variables (the ratio of books-to-students) affects current enrollment for young boys, and this variable has only a modest influence.

The observation that the school variables have little effect on current enrollment for young boys has important implications for our analysis. Human capital theory tells us that children leave school when the marginal cost of education equals whatever marginal benefits they, or their families, take from schooling. We have observed that there is a very high level of attrition among boys in the six to nine year age group, but that little of this school-leaving is explained by the quality of education. This would suggest that either our school quality variables are uncorrelated with the educational outcomes that are valued by parents, or that attrition among the youngest boys is largely explained by increasing opportunity costs of schooling.

Our findings also suggest that there is little additional scope for the government of Pakistan to improve enrollment in early primary years by using the policy instruments upon which it has relied in the past. Since school quality and availability have little effect on schooling attainment among the youngest boys in Pakistan, further improvement in enrollment for this age group may require the introduction of compulsory education.

Our results yield a significantly different picture for older boys. Among those in the 10 to 12 age group, the distance to primary school has a very large, negative, and highly significant effect on current enrollment. Moreover, the age of the boy (which can proxy unobserved elements of either the benefits or costs of schooling) is not significant. Taken together, these results suggest that unobserved elements of the opportunity cost of education may have a smaller impact on schooling among older primary school boys. (Perhaps those who leave school to work on the family farm have already been withdrawn by this age). Our results also suggest that it may still be possible to raise enrollment for this age group by improving the quality and availability of primary schools.

Our analysis of schooling attainment among the cohort of young men also suggest that improving the quality and availability of schools increases the demand for education, but one must exercise caution in interpreting these results. Whether we should expect these relations to prevail at present is largely a question of whether the our contemporary measures of school quality and availability are capturing the conditions that prevailed one generation in the past. In Chapter One, I indicated that the average distance to primary school has likely declined for our villages, as there has been a significant amount of new construction of elementary schools over the last generation. However, I also demonstrated that the existing quality of these new primary schools is significantly worse than the quality of older schools, and that Pakistan's recent educational investments have been concentrated on improving the quantity, rather than the quality, of primary education. Since neither the quality of primary schooling nor the availability of post-primary education have improved greatly over the last generation, the attainment results for the older cohort are likely to be representative of conditions that exist for young boys at present. Again, this suggests that better quality primary schooling, and better access to intermediate education, can still have significant affects on grade attainment.

The Use of Child Labor

The theoretical model developed for this dissertation simplified the child-time allocation decision by assuming that there is no leisure for boys and that schooling and work exhaust all of a child's time endowment. This was thought to be a useful approximation of what one observes in rural Pakistan since there is a strong negative relationship between employing a child on the family farm and enrolling him in school. In this analysis, I continue to assume that the demand for boy labor is linked to the demand for second period human capital by the requirement that the child's time endowment is exhausted on work and schooling. This allows me to write

$$L^{CW} = (\overline{T} - L^{CE}(\mathbf{x}, \mathbf{q})) \tag{2.30}$$

where L^{CW} is the amount of the child's time that families wish to devote to work, $\overline{T}$ is the child's time endowment, L^{CE} is the amount of the child's time that families wish to devote to schooling, $\mathbf{x}$ is a vector of individual, household, and village characteristics that enter the demand for schooling, and $\mathbf{q}$ is a vector of school quality variables.

Despite the close relationship between child labor use and time spent in schooling, there are practical reasons why, given the results of our schooling demand regressions, we cannot anticipate the coefficients in the stochastic representation of child labor demand. One reason is that schooling and work do not, in actuality, exhaust the child time endowment: there are many boys (21.3 percent) who are neither enrolled nor used on those tasks for which we have data. Given the observations of Rodgers and Standing, we must consider the possibility that many of these may be sick, have long-term physical or mental disabilities, or suffer from malnutrition. Moreover, it seems likely that many *enrolled* boys spend part of their time endowment in non-productive activities: schooling can occupy only a portion of a child's time over the year, and we observe that few of the boys who are currently enrolled are used in farm labor (see table 1.19).

A second reason we cannot anticipate the households' use of boy labor from our estimated demand functions for schooling is that we do not have a sufficiently detailed accounting of the use of children's time. Our enrollment and attainment regressions evaluated only the probability that schooling investment is at the censoring limit, and the grade attainment that a boy is likely to achieve. We do not have data on the amount of time that children spend in school or on school-related activities. Detailed time-use data is available for child labor, however, and these permit us to assess how our explanatory variables impact the amount of time that boys spend on agricultural activities.

Estimating the Use of Child Labor

Linking the Model to Probit and Tobit Analyses of Child Labor Use

In a previous section, I examined the current enrollment status of farm boys ages 6 to 12 using a binary variable defined in terms of a boy's age, T_i, and the age at which parents wish the boy to complete his education, T_i^* such that

$y_i = 1$ if $T_i^* > T_i$ (the parents choose to enroll the boy in the current year)

$y_i = 0$ otherwise (the parents have ended the child's education).

Given that $y_i = 1$ when a boy is engaged in *any* amount of schooling, a strict counterpart to the current enrollment binary variable would measure whether a boy works on a full-time basis. I write equation 2.30 as a stochastic model and take this as the index function for a binary analysis of full-time work

$$L^{CW} = \beta_x' \mathbf{x} + \beta_q' \mathbf{q} + v. \tag{2.31}$$

I define the binary variable, w_i, to equal one when boy i is employed full-time and to otherwise equal zero. Using notation from equation 2.30, the binary variable can be defined as follows:

$$\begin{aligned} w_i = 1 \quad & \text{if } L^{CW} = \overline{T} \\ w_i = 0 \quad & \text{if } L^{CW} < \overline{T}. \end{aligned} \tag{2.32}$$

I assume that the disturbance term in equation 2.31 is normally distributed with parameters 0 and σ. This allows me to employ a probit model in a regression of boys' full-time work status using the same independent variables and the same sample employed in the probit analysis of current enrollment.

I have also undertaken a probit regression in which the dependent variable takes on a value of one if a boy is employed for *any* time on the tasks for which we have data. Denoting this binary variable as v_i, this is defined as

$$\begin{aligned} v_i = 1 \quad & \text{if } L^{CW} > 0 \\ v_i = 0 \quad & \text{if } L^{CW} = 0. \end{aligned} \tag{2.33}$$

Finally, I analyze the level of child labor utilization, defined as the number of days per year that boys are employed on the family farm. These data are censored at zero for 373 of the 512 boys in our sample and are censored at 365 for 71 of the 512 boys. For this reason, I use a Tobit model with double censoring for this analysis and define the dependent variable , denoted L, in terms of the index function as follows:

$$\begin{aligned} L &= 0 && \text{if } L^{CW} \leq 0 \\ L &= L^{CW} = \beta_x' \mathbf{x} + \beta_q' \mathbf{q} + v && \text{if } 0 < L^{CW} \leq 365 \\ L &= 365 && \text{if } L^{CW} > 365 \end{aligned} \tag{2.34}$$

Table 2.17 presents the results of the probit analysis of whether boys are employed on a full-time basis and table 2.18 show the results of the binary analysis of whether boys are employed on *at least* a part-time basis. Tobit analyses of hours worked by all boys are presented in table 2.19. These analyses use the same sample, and the same explanatory variables, as the probit analyses of current enrollment (see table 2.4 above). In the analysis of current enrollment, I discussed how these regressors can be expected to affect the allocation of boy time. Since the index function underlying the child labor regressions is the mirror image of that used in our analysis of current enrollment, one can anticipate from these previous discussions the model's predictions for the effects of the regressors on child labor utilization.

As in the analyses of enrollment and schooling attainment, there is reason to be concerned with heteroscedasticity in the probit and Tobit estimates of the use of child labor. I have attempted to adjust my regressions for heteroscedasticity and again have found computational difficulties: neither the probits not the Tobit model with double censoring will converge to a solution when I attempt to adjust for heteroscedasticity. As a result, I present both the probits and the Tobit without such an adjustment.

Results of the Probit Analyses of Boy Labor Use

The binary analyses of full-time employment, and the analysis of 'at least part-time' employment, provide interesting counter-points to the probit of current enrollment presented earlier in this chapter. However, the explanatory power of these regressions is relatively low; the models correctly predict only 18 of the 71 boys who are employed full-time and 45 of the 139 who are employed on at least a part-time basis. Several of the individual significant coefficients are interesting, however, as they carry opposite signs from their counterparts in the current enrollment regressions. The probit results in table 2.17 indicate that the likelihood of working on a full-time basis is lower for younger boys, for boys living in villages that are close to schools, and for boys living among adults with higher levels of cognitive skills. (All of these explanatory variables have the opposite effect on the probability of current enrollment.) The cognitive skill of household adults has an especially large impact on full-time child labor: increasing the maximum reading score among family members from 8 to 17 points (one standard deviation), lowers the probability of full-time employment from 0.14 to 0.06. The distance to school has a more modest effect; increasing the distance to primary school by 4.4 km. (one standard deviation) raises the probability of full-time work from 0.14 to 0.16. Increasing the distance to middle school by 9 km. (one standard deviation) results in a similar rise in the likelihood of full-time employment. Finally, adding a year to a boy's age has a modest but highly significant effect on child labor: an additional year of age

Table 2.17 A Probit Analysis of Full-Time Labor Participation Among Boys Ages 6 to 12

Observations	512
Mean of LHS	0.2715
Std.Dev of LHS	0.4452
Log-Likelihood	-139.4686

Probability of Predicting Correct Outcome for Non-Working Boys: 429/441
Probability of Predicting Correct Outcome for Working Boys: 18/71

	Coeff. (t-stat)	Mean *Stand. Dev.*	Marg'l Effect
Constant	-1.9697		
	(-2.11)		
Acres of Owned Irrigated Land	0.0459	4.00	0.0039
	(3.78)	*12.59*	
Acres of Rainfed Land	0.0505	2.52	0.0042
	(3.96)	*9.04*	
Value of Owned Livestock	1.7E-05	12522.10	1.4E-06
	(1.80)	*10452.00*	
Value of Household Mechanical Equipment	-6.6E-05	6300.62	-5.6E-06
	(-2.40)	*19394.00*	
Distance to Nearest Fertilizer Sales	-0.0013	7.67	0.0026
	(-0.08)	*6.29*	
Maximum Reading Score Among Household Males	-0.1020	7.60	-0.0096
	(-3.05)	*8.88*	
No. of Adult Males in Household	-0.0305	3.07	-0.0045
	(-0.79)	*1.83*	
No. of Adult Females in Household	-0.1276	2.73	-0.0087
	(-1.60)	*1.58*	
No. of Kids in Household	-0.0542	3.00	0.0059
	(-1.18)	*1.44*	
No. of Boys in Household	0.0983	2.05	0.0002
	(0.94)	*1.01*	
Distance to Nearest Elementary School	0.0602	1.89	0.0051
	(1.87)	*4.38*	
Distance to Nearest Intermediate School	0.0269	6.58	0.0023
	(1.90)	*8.60*	
Student-Teacher Ratio In Nearest Primary School	0.0005	44.90	4.3E-05
	(0.33)	*43.87*	
Average Reading Score Among Primary Teachers	-0.0525	13.54	-0.0044
	(-0.60)	*7.27*	
Ratio of Books/Students at Nearest Primary School * 100	0.0012	54.15	0.0001
	(0.18)	*9.16*	
Boy's Age	0.1807	8.98	0.0152
	(4.12)	*2.02*	

Table 2.18 A Probit Analysis of At Least Part-Time Labor Participation Among Boys Ages 6 to 12

Observations	512
Mean of LHS	0.2715
Std.Dev of LHS	0.4452
Log-Likelihood	-239.81

Probability of Predicting Correct Outcome for Non-Working Boys: 350/373
Probability of Predicting Correct Outcome for Working Boys: 45/139

	Coeff. (t-stat)	Mean *Stand. Dev.*	Marg'l Effect
Constant	-1.4673		
	(-2.14)		
Acres of Owned Irrigated Land	-0.0064	4.00	-0.0019
	(-0.70)	*12.59*	
Acres of Rainfed Land	0.0137	2.52	0.0041
	(1.56)	*9.04*	
Value of Owned Livestock	1.5E-05	12522.10	4.4E-06
	(2.03)	*10452.00*	
Value of Household Mechanical Equipment	-2.0E-05	6300.62	-5.9E-06
	(-1.46)	*19394.00*	
Distance to Nearest Fertilizer Sales	-0.0010	7.67	-0.0003
	(-0.06)	*6.29*	
Maximum Reading Score Among Household Males	-0.0205	7.60	-0.0061
	(-1.90)	*8.88*	
No. of Adult Males in Household	-0.0328	3.07	-0.0098
	(-0.72)	*1.83*	
No. of Adult Females in Household	-0.0576	2.73	-0.0171
	(-1.03)	*1.58*	
No. of Kids in Household	0.0642	3.00	0.0191
	(0.95)	*1.44*	
No. of Boys in Household	-0.0977	2.05	-0.0290
	(-0.90)	*1.01*	
Distance to Nearest Elementary School	0.0766	1.89	0.0228
	(2.39)	*4.38*	
Distance to Nearest Intermediate School	0.0196	6.58	0.0058
	(1.85)	*8.60*	
Student-Teacher Ratio In Nearest Primary School	-0.0017	44.90	-0.0005
	(-0.82)	*43.87*	
Average Reading Score Among Primary Teachers	-0.0487	13.54	-0.0145
	(-0.73)	*7.27*	
Ratio of Books/Students at Nearest Primary School * 100	-0.0050	54.15	-0.0015
	(-0.56)	*9.16*	
Boy's Age	0.1995	8.98	0.0593
	(5.89)	*2.02*	

increases the likelihood of full-time employment from 0.14 to 0.155.

The probit regressions also indicate that the value of household livestock has a small, positive, and significant effect on the likelihood that a boy is fully employed on the family farm. This is consistent with our observation that herding and animal care are the most common employment for young boys.

In the probit analysis of whether boys spend *any* time working on agricultural activities, the effects of the value of livestock, the distance to both types of schools, and the age of the boy have much larger marginal effects than in the probit of full-time employment. It should be noted that for each year that a boy ages, the likelihood of his being employed on at least a part-time basis increases at almost the same rate that his probability of enrollment decreases. This is consistent with the sharp dichotomy that we observe between schooling and employment.

Three other inputs (mechanical equipment, irrigated land, and rainfed land) have significant effects on the likelihood of full-time employment, but these effects are not evident in the probit for 'at least part-time' employment; among these three inputs, only rainfed land is significant in the Tobit regression of boy labor.

Results of the Tobit Analyses of Boy Labor Use

The Tobit presented in table 2.19 shows the effects of our regressors on the time spent in agricultural work by all boys.[32] Among our household attributes, both the number of acres of rainfed land and the value of household livestock affect the number of days spent in work. Increasing the number of acres of rainfed land from 2.52 to 11.56 (one standard deviation), raises the number of days that boys spend in labor from 53.8 to 67.7. (This stands in contrast to the results of the enrollment probit shown in table 2.4 which indicated that rainfed land had no effect on the current schooling status of boys.) The positive effect of ownership of rainfed land in the current analysis is consistent with a substitution effect between this input and child labor. The value of livestock has an especially strong effect on boy labor: increasing this asset by 10,452 Rupees (equal to one standard deviation) raises the time spent in work from 53.8 to 66.34 days per year. This is consistent with our expectations given that tending animals is the principal work activity of young boys.

The availability of both primary and intermediate schools has a strong effect on the time spent in labor. An increase of four kilometers in the distance to primary

32 I partitioned this sample and attempted to conduct separate Tobits for young boys and old boys. However, these separate regressions would not converge to solutions.

Table 2.19 A Tobit Estimation (Double Censored) of Days of Labor on Agricultural Activities Among Boys Ages 6 to 12

Observations	512		
Mean of LHS	53.7832		
Std.Dev of LHS	125.5968		
Log-Likelihood	-1651.468		

	Coeff. (t-stat)	Mean *Stand. Dev.*	Marg'l Effect
Constant	-142.40		
	(-1.644)		
Acres of Owned Irrigated Land	1.4251	4.00	0.5316
	(0.635)	*12.59*	
Acres of Rainfed Land	4.1287	2.52	1.5400
	(2.027)	*9.04*	
Value of Owned Livestock	0.0033	12522.10	0.0012
	(2.177)	*10452.00*	
Value of Household Mechanical	-0.0036	6300.62	-0.0020
Equipment	(-1.411)	*19394.00*	
Distance to Nearest Fertilizer	-0.8260	7.67	-0.3081
Sales	(-0.440)	*6.29*	
Maximum Reading Score Among	-1.5577	7.60	-0.5810
Household Males	(-0.121)	*8.88*	
No. of Adult Males in Household	-7.6547	3.07	-2.8552
	(-0.820)	*1.83*	
No. of Adult Females in Household	-17.1836	2.73	-6.4095
	(-1.331)	*1.58*	
No. of Kids in Household	3.1559	3.00	1.1771
	(0.184)	*1.44*	
No. of Boys in Household	-3.6630	2.05	-1.3663
	(-0.173)	*1.01*	
Distance to Nearest Elementary	14.2951	1.89	5.3321
School	(2.028)	*4.38*	
Distance to Nearest Intermediate	5.6412	6.58	2.1042
School	(2.822)	*8.60*	
Student-Teacher Ratio In Nearest	-0.2018	44.90	-0.0753
Primary School	(-0.378)	*43.87*	
Average Reading Score Among	-9.7205	13.54	-3.6257
Primary Teachers	(-0.098)	*7.27*	
Ratio of Books/Students at Nearest	0.1203	54.15	0.0449
Primary School * 100	(0.182)	*9.16*	
Boy's Age	36.0949	8.98	13.4634
	(4.010)	*2.02*	
σ	136.45		
	(19.577)		

school (equal to one standard deviation) raises the time spent in work by the average boy by 21 days. (We have previously seen that increasing the distance to primary school reduces the probability of current enrollment among the cohort of 10 to 12 year olds, but has no effect on the younger boys.) Similarly, an increase of 9 kilometers to intermediate school increases the time spent in work by 18 days. (We have seen that current enrollment is insensitive to this variable.)

Finally, the Tobit indicates that, with each additional year of age, the average time spent in work rises by 13.5 days. As in the schooling demand regressions, this variable captures unobserved elements of both a boy's ability to perform work and the opportunity cost of child labor (for example, the positive coefficient may represent a decline in the benefits forgone from additional schooling as boys age).

Disentangling Effects in the Allocation of Boy Time

One of the objectives of this dissertation is to separate and identify the various income and substitution effects through which household characteristics act on the allocation of boy time. In the analysis of the demand for schooling, I have been unable to separate these effects, since all household assets that have a significant impact on education act to increase the demand for human capital. Such positive coefficients may indicate an income effect for households that are credit constrained, a substitution effect between the asset and the use of child labor in agricultural production, complementarity between the asset and the human capital that children gain through schooling, or a positive effect from the asset in the production of schooling outcomes. (Similarly, when an asset affects the use of boy labor with a negative coefficient, it is not possible to separate these various effects.)

To this point in my analysis, the only regressor for which I can make some inference about the relative magnitudes of these effects is the value of livestock. This asset acts to raise the time spent in labor by boys and this suggests that it acts through the agricultural production function either as a complement to boy labor or as a substitute for human capital. This asset cannot be shown to affect enrollment or attainment, however, and this suggests that there exist smaller countervailing effects in the demand for schooling. The analysis in the next chapter will provide a good deal of additional evidence on the signs and relative magnitudes of these effects.

CHAPTER III

THE VALUE OF BOYS' TIME AND COGNITIVE SKILLS IN HOUSEHOLD AGRICULTURAL PRODUCTION

Introduction

To this point in my analysis, I have taken several steps towards explaining the determinants of schooling enrollment and child labor participation. I have identified characteristics that impact the allocation of boy time, and have found that the effects of these characteristics are consistent with an economic tradeoff between schooling and the use of boy labor in agricultural activities. I have not, however, demonstrated that such a tradeoff exists. Nor have I identified the underlying causal structure through which our explanatory variables affect the values of boy labor and schooling outcomes.

In the current chapter, I pursue three objectives: determining whether there is a tradeoff in the farm earnings of Pakistani farm families between increasing a their stock of human capital and increasing the time their boys spend in labor; quantifying any such tradeoff with an explicit rate of return to time spent in education; and identifying the mechanisms through which personal, household, village, and farm characteristics affect the allocation of boy time. To pursue the first of these objectives, I estimate an agricultural profit function and determine the change in farm earnings that result from additional cognitive skills. This analysis is similar the studies reviewed in Jamison and Lau (1982) and my results are consistent with those that have been found by other authors. I also use the agricultural profit function to estimate the changes in earnings that result from adding a boy to a farm household and from enrolling him in school. This latter value is of special interest as it provides an explicit estimate of the opportunity cost of schooling for those engaged in household agriculture. This author is unaware of any other study that has attempted to produce such an estimate.

Since the results of the agricultural production function express the costs and benefits of schooling in different units, I use a human capital production function to determine the rise in cognitive skills that result from time spent in schooling. Under some rather stringent assumptions, I use these results to produce an explicit estimate of the rate of return to time spent in education for boys in farm households.

To pursue the third objective of this chapter, I bring together the results of our previous analyses of the demand for schooling and the use of child labor with our findings from the agricultural profit function and cognitive skills production functions. This allows me to check for consistency among my results and to make some qualitative assessments about the mechanisms through which our individual and household characteristics drive the allocation of child time. I can, for example, determine whether a household characteristic that increases schooling investment is acting as a complement to cognitive skills in farm production, a substitute to child labor on the family farm, a household input in the production of cognitive skills, or whether it is working through an income effect. As a further step in separating and identifying the effects of our explanatory variables, I present an analysis of an experimental exam of technical knowledge in agriculture that was administered to 145 farmers in our sample. This analysis is intended to identify how schooling outcomes, personal attributes, and household characteristics affect the acquisition of skills that farmers use in working the land.

Estimating the Effects of Cognitive Skills and Child Labor on Agricultural Profitability

We have seen that agricultural household models offer few unambiguous predictions for the manner in which productive assets and school characteristics affect the allocation of children's time. Rosenzweig (1982, 226) has noted the difficulties of estimating demand equations for schooling and child labor use among farm families, and has suggested that future work in this area should assess how schooling and the use of child labor impact the profitability of agricultural households. To test the proposition that parents are allocating children's time to balance the production benefits of schooling and child labor, I consider whether increased cognitive skills and increased availability of child labor raise profitability, and whether enrollment of children reduces farm earnings. In estimating farm profits, I am also able to determine how the effects on earnings of child labor and cognitive skills interact with prices, assets, and household composition.

The Role of Cognitive Skills in Agricultural Production

In chapter one, I described the role of children in Pakistani household agriculture. I have not, however, discussed the other half of the schooling and child-labor tradeoff: the role of education in agricultural production. This topic has a large literature as much of the microeconomic research on the returns to human capital have focused on the role of schooling in the farm environment. Researchers in human capital have been especially interested in agriculture because it is among the few activities in which workers with a wide range of education make decisions about all aspects of production and distribution, including purchasing and allocating inputs, and storing and marketing output. It is also one of the few occupations in which the great majority of workers are self-employed. This implies that a worker's marginal product does not have to be assessed from his wage but, rather, can be estimated directly from production function or profit function analyses.

Among the first of the modern works on education and farm efficiency was Schultz's (1964) seminal contribution on the efficiency of small farmers in traditional agriculture. This work proposed the 'poor-but-efficient' hypothesis which suggested that traditional agriculture is a static technology, that knowledge of this technology has been refined over generations through trial and error, and that the skills necessary to be fully efficient are typically handed down from father-to-son as they work together in the fields. The implication of this hypothesis is that there exists only small returns to education in traditional agriculture and that large productivity gains in farming would only be forthcoming through the introduction of new inputs and improved methods.

Within a few years of Schultz's work, there began a significant transformation in agriculture, as new inputs and technologies were introduced. By the late 1970's most regions in South Asia, including most of Pakistan, had seen widespread adoption of semi-dwarf rice and wheat varieties. This improvement in technology greatly increased the potential returns to education in agriculture, at least over the short-term. By 1982, Jamison and Lau were able to catalog 31 studies in which all but three indicated that agricultural efficiency benefits from education (they found that four years of education resulted in an unweighted mean increase in productivity of 8.7 percent across these studies). At about the same time, the World Bank (1980) estimated percentage increases in annual farm output resulting from four years of schooling of more than 10 percent in several farming environments. Other notable studies showing a positive return of human capital in agriculture are those by Yotopoulos (1967), Lockhead, Jamison, and Lau (1980), Ram (1980), and Jamison and Moock (1981).

There is some disagreement about the character and scope of education's effects on agriculture over the long-term. Rogers (1971) suggests that much of the benefit to formal education is the result of accelerating the diffusion of new technologies: literate farmers are better able to assess the benefits of new farm methods and are more capable of adapting the new technologies to the specific characteristics of their holdings. Welsh (1978) implies that the returns to education may be limited once farmers adopt the most important sources of green revolution productivity growth and become familiar with using the new techniques on their holdings. However, Byerlee (1987) opines that there has been a permanent increase in the returns to education. He writes that the green revolution has not been a single change in technique but, rather, 'a series of increasingly complex changes as new inputs and cropping patterns [have been] introduced.' He suggests that farming technologies have become highly complex and dynamic, that farmers must frequently revise their techniques if they are to remain efficient, and that this requires sufficient education to rapidly acquire and evaluate information on agricultural technology.

Studies by Vyas (1983) and Huke (1982) indicate that many of the most frequently cited sources of green revolution productivity growth have already been exploited in Pakistan. This is consistent with the data used for this dissertation which indicate that more than 85 percent of farm households had adopted HYV seed by 1987. The great majority had also adopted the use of nitrogenous fertilizer, phosphatic fertilizer, mechanized traction, and thresher services, and there had been significant expansion of irrigation and improved water control.

Byerlee (1987) suggests that there are a number of lesser known, 'second generation,' innovations that have yet to be widely adopted, that can produce significant increases in productivity, and that frequently require a relatively high level of formal schooling to be effectively implemented. These include techniques that enhance the use of multiple cropping sequences in which farmers raise two or three crops per year on the same land (both cotton-wheat and rice-wheat are common in Pakistan). Successful implementation of multiple cropping requires a high degree of technical skill in agriculture as each crop must be brought to harvest as rapidly as possible in order for the other to have a sufficiently long growing season. There is a wide array of technological options available to help meet these precise timing requirements (early maturing varieties, the use of micro-nutrients, and enhanced soil and water management) but farmers must be aware of important interactions among the options. Moreover, farmers must stay abreast of a rapidly expanding array of options and must be able to evaluate the applicability of these choices to local conditions. Byerlee asserts that the rapidly expanding technical demands of agriculture require farmers to be able to rapidly access and evaluate information from extension services, sales agents, the news media, and other sources of farm information.

Byerlee's position is consistent with works by Butt (1984) and Heyneman (1983) which suggest that current agricultural technologies employed in many LDC's require education through secondary school in order to achieve full efficiency. It is also consistent with a study of Pakistani rice farmers by Ali and Flynn (1989) that indicated a gap of 28 percent between best practice and average farmers' output and that suggested that much of this is attributable to disparity in schooling.

Linking the Model to an Analysis of Agricultural Profitability

The household maximization problem presented in Chapter II contains a period-one profit function that has as arguments period one prices, exogenous fixed factors, the household's initial stock of human capital, the efficiency with which children work on the family operation, and various classifications of household labor. Among the labor categories, I include both the number of boys in the family and the number of boys who are enrolled in school. The estimated coefficient on the enrollment variable provides a measure of the opportunity cost of schooling in terms of foregone household profits.

Our model does not suggest any specific functional form for the profit function and a generalized, or Taylor series, approximation seems appropriate. However, we have too many potential explanatory variables to permit the use of such an approximation with the number of observations in our sample. Moreover, because realizations of both dependent and independent variables assume negative values, we are precluded from using a log-log (e.g., Cobb-Douglas) function. As a result, in my first set of estimates of the profit function, I employ an arbitrary linear form that is taken as a first-order approximation of the unknown equation, and this is expressed as

$$\pi = \alpha_0 + \alpha_1 P + \alpha_2(K_o) + \alpha_3(HK_o) + \alpha_4(HHM) + \alpha_5(CLE) + \alpha_6(E_s) + u \tag{3.1}$$

where π is household agricultural profits, K_o represents the physical fixed factors of first-period production, HK_o is the household's initial stock of human capital, CLE contains characteristics that influence the efficiency of child labor employed in the household operation, HHM contains the number of household members and other exogenous regressors related to first period household composition, and E_s is the number of children, reported in HHM, who are enrolled in school. In addition to this simple linear form, I attempt to capture the interplay among regressors by employing a more parsimonious set of independent variables and introducing multiplicative interactions among these terms. This functional form is useful in assessing the specific mechanisms through which the exogenous variables operate on the allocation of child time, as the interaction terms allow one to determine the signs of substitution effects that operate on both human capital and child labor.

Issues of Concern in Estimating an Agricultural Profit Function

The three results of greatest interest in the analysis of farm profits are the effect of reading skills, the effect of adding a boy to the household, and the effect of changing the status of a boy from unenrolled to enrolled. In my initial regressions, I assume that the error term u in equation 3.1 is the result of errors in measuring farm earnings, or unexpected climatic events, and that it is uncorrelated with any of the regressors. However, while reading skills of household adults are predetermined, and therefore exogenous, it is not clear that the household composition and the enrollment status of boys should be taken as independent variables. One can imagine that the families make decisions about the number of children to be born, and the number of children to be enrolled, simultaneous with decisions about the purchase of farm inputs. Stated in equivalent fashion, there may exist omitted variables that are correlated with the dependent variable (farm earnings), the number of boys in the household, and the number of boys who are enrolled. I address the potential for omitted variables bias associated with these two regressors with different techniques.

Omitted Variables and Enrollment

In the case of enrollment, I reduce the potential for omitted variables bias through the use of an instrumental variables (IV) technique. If the decision to enroll children in school and household agricultural profitability are affected by unobserved variables, an OLS estimate of (3.1) is inappropriate because our regressors and our error term will be correlated through the inclusion of enrollment as an explanatory variable, and the inclusion of the unobserved variables in the error term. Consistent estimates may be obtained with the use of instrumental variables and in the current analysis I employ a two-stage least squares estimator. As a first stage, I use OLS to regress the number of household boys enrolled against a matrix of instruments, $\mathbf{W}$, that includes all of the independent variables previously used in the analysis of current enrollment.[1]

In the second stage of the two-stage least squares, household agricultural profits are regressed on the exogenous and predetermined values in $\mathbf{W}$, together with the fitted value for the number of household-boys enrolled taken from the first stage (I denote the set of regressors in the second stage estimation as $\mathbf{X}$). The two stage least squares approach to instrumental values places an additional requirement on the set of instruments, $\mathbf{W}$: it must be justifiable to exclude some of these instruments

[1] I employe an OLS regression in analyzing enrollment, despite the fact that primary school attendance is less than universal and our sample is censored (there is a clustering of observations at zero boys enrolled). As a consequence of this censoring, OLS parameter estimates are inconsistent. However, this inconsistency is unimportant in the context of providing predicted values of enrollment to be used as an instrument in the farm profit function: the IV technique requires only that the predicted values of enrollment are correlated with actual enrollment and are uncorrelated with the error term in the profit function. We are not concerned with the point estimates of the enrollment regression.

from the second stage regressors, **X**, in order to identify the agricultural profits equation. For this analysis, I identify the agricultural profits function by excluding the attributes of the local schools. The use of these identifying variables is based on the assumption that the characteristics of schools affect household farm profits only through their impact on the enrollment status of children.

Omitted Variables and Fertility

I use the labor allocation characteristics of the Pakistani farm family, together with the results of the estimated profit function, to test for the presence of omitted variables that are correlated with both farm earnings and the number of boys in the household. This test proceeds with the following argument. First, it is known from the analyses presented in chapter one that girls spend little time on agricultural activities, and therefore make little contribution to agricultural profits. Second, it can be demonstrated that the ratio of boys-to-girls is exogenous to the household (see table 3.1).[2] This implies that any omitted variables that are correlated with both farm earnings and fertility would have the same impact on the variables 'number of boys' and 'number of kids.' Finally, if the results of the profit regression do not permit us to reject the null hypothesis that girls make no contribution to farm profits, this argues against the existence of important omitted variables that are correlated with both farm earnings and the number of boys in the household.

A Test of Overidentifying Restrictions.

For least squares methods, one can test the appropriateness of the instruments and the identifying variables used in two-stage regressions. Breusch and Godfrey (1981) demonstrate that such a test can be implemented with the statistic

$$\frac{||\mathbf{P}_{\mathrm{W}}(\mathbf{y}-\mathbf{X}\tilde{\beta})||^2}{||(\mathbf{y}-\mathbf{X}\tilde{\beta})||^2/n} \sim \chi^2(\ell - k). \tag{3.2}$$

[2] While this may seem self-evident, it has been observed that, in nations in which male children are more valued than female children, families may continue to give birth until they achieve some desired number of boys. Under such circumstances, one would see a low boy/kid ratio in families with many children and a high boy/kid ratio in families with few children. Such circumstances would also imply that there could be unobserved variables that jointly influence fertility and profits and that could produce bias in the estimated coefficient of 'number of kids.' To test for this possibility, I have regressed boy surplus against the number of kids in the household and have found that one cannot reject, at the one percent level, the hypothesis that the number of children in the household is independent of the gender ratio of children.

where $\mathbf{y}$ is the dependent variable and $\mathbf{P}_W$ is the matrix that projects onto the subspace spanned by $\mathbf{W}$. This statistic is equivalent to n times the uncentered R^2 associated with a regression of the residuals from the second stage of the two-stage least squares against the full set of instruments.[3] This test can fail either because $\mathbf{W}$ is correlated with the disturbance terms in our estimate of agricultural profits (indicating that $\mathbf{W}$ is not a valid set of instruments), or because some of the identifying variables cannot justifiably be excluded from $\mathbf{X}$ (indicating that the identifying variables are inappropriate). I have regressed the disturbance terms from the second stage of the two-stage least squares estimation of agricultural profits, applied the test statistic (equation 3.2) and cannot reject, at the one percent level, the null hypothesis that the dependent variable in the second stage of the two-stage least squares is independent of $\mathbf{W}^*$. This suggests that our instruments and identifying variables are appropriate.[4]

The Sample and Variables Used In the Study

This analysis employs the sample of 304 households that are engaged in agricultural production and that have at least one boy. This is the same sample used in the analyses of current enrollment and the use of boy labor in Chapter II. Because this study focuses on how farm households allocate children's time, and because only male children provide labor on agricultural activities, I have excluded those households that engage in farming but that have no boys. Among the households included in this analysis, there is an average of one girl and 1.7 boys per family.

The Dependent Variable

The measure of agricultural profitability used in this study is equal to revenues from all sales of agricultural crops, plus the imputed market value of crops consumed by the farm household, less the value of all purchased inputs, less the imputed value of all inputs produced by the family *with the exception* of owned land, the services of bullocks owned by the family, and family labor. In other words, the variable is equal to the value of agricultural crop production net of all costs except those of own land, own bullock traction, and own labor.

---

[3] This discussion follows Davidson and MacKinnon (1993, 236)

[4] A test of joint significance for all the identifying variables in the first-stage regression yields an F-statistic of 11.05.

Table 3.1 Boy Surplus as a Function of Number of Children
Dependent Variable: Boy Surplus
(= Number of Boys in Household Minus Number of Girls.)
Mean of Dependent Variable: 0.05
Standard Deviation of Dependent Variable: 1.53
R^2: 0.00643
Number of Observations: 561
F=0.39646 (Signif. of F = 0.9369)

	Coefficient (t-statistic)	Mean *Standard Deviation*
Constant	-0.013158	
	(-0.106)	
= 1 If HH Has 2 Children	0.117204	0.3084
	(0.686)	*0.46*
= 1 If HH Has 3 Children	0.183890	0.2193
	(0.987)	*0.41*
= 1 If HH Has 4 Children	-0.013869	0.1319
	(-0.064)	*0.34*
= 1 If HH Has 5 Children	-0.039474	0.0337
	(-0.106)	*0.18*
= 1 If HH Has 6 Children	0.013158	0.021
	(0.029)	*0.14*
= 1 If HH Has 7 Children	-0.320175	0.005
	(-0.357)	*0.07*
= 1 If HH Has 8 Children	-0.986842	0.0036
	(-0.902)	*0.06*
= 1 If HH Has 9 Children	-0.986842	0.0036
	(-0.902)	*0.06*
= 1 If HH Has 10 Children	0.013158	0.0018
	(0.009)	*0.04*

Although changes in the value of household livestock are an important component of farm profitability, they are not included in this measure of farm earnings since they are a function of several factors that are difficult to assess — including changes in the fitness of livestock and changes in animal weight. It should be noted that the value of fodder grown as feed for household animals is included in agricultural revenues (valued at market prices) and, since own-grown fodder constitutes the principal cost of raising animals in Pakistan, it is likely that our values for agricultural profitability are highly correlated with livestock value. It should also be noted that for more than 20 percent of households, this measure of household profits is non-positive. Poor growing conditions prevailed in parts of the survey area in the year for which profits are calculated and many households produced very small harvests.

The Independent Variables

This analysis uses the same independent variables that were employed in the studies of current school enrollment and the use of boy labor in the previous chapter. Since these regressors have already been described in detail, my discussion of these variables in the current section is limited to their impact on the production of agricultural profits.

Land. The land variables indicate the acres of irrigated and rainfed land that were owned by the household. As was previously observed, among the full sample of Pakistani households, there is only a weak correlation between the amount of land that is worked by families and the amount of land that they own. However, since we have selected our sample conditional on the household being involved in farming, it is expected that acres of operational holding will be positively linked with agricultural net revenues. In the profit function, one would expect a larger coefficient on irrigated acres, than on rainfed acres, as farmers must have access to some form of irrigation in order to make use of the chemical fertilizers that are essential for the growth of HYV varieties.

Household Composition and Family Labor Availability: Household composition is represented by the number of adult males (aged 13 and older), adult females, kids (aged 5 to 12), boys, and enrolled boys in the household. Because farm work is done almost exclusively by males, one would expect that the coefficient on the variable 'number of men' should be positive and significant. If boys are making a real economic contribution through their labor (as opposed to being sent to the fields to be supervised), one would also expect a positive and significant coefficient on the variable 'number of boys.'

The coefficient on the variable 'number of boys enrolled' is central to this analysis as it provides a measure of the opportunity cost of schooling. While it seems likely that the coefficient on this variable will be non-positive, one cannot anticipate whether the opportunity cost of schooling will be significantly different from zero. This is because one cannot anticipate whether enrolling boys in school results in a significant reduction in the time that these children spend working on the farm.

In many countries, including the United States, the school year is planned in such a way that farm families have use of their children during important parts of the growing season. As a result, farming and schooling need not be mutually exclusive activities. Despite the fact that children in many nations are able to both attend school and work in agriculture, there is a long-held belief that sending children to school competes with their use on the family farm. A 1837 report to the House of Commons observed this phenomenon in Australia when it commented that "even at six years of age the services of children become valuable, and with many of the lower classes of settlers this might operate against their will to send them to school".[5]

As explained above, a coefficient on 'number of kids' that is statistically different from zero would point towards the possibility that fertility and profits are being jointly affected by missing variables. It would also suggest that the estimated coefficient on 'number of boys' is suspect since this variable is so highly correlated with fertility.

Cognitive Skills. This is the maximum value earned on an exam of reading skills among all household adult males (this exam is described and analyzed in a later section of this dissertation). While we have data on the amount of time that men spend on various agricultural tasks, we cannot tell which family members are making the decisions regarding farm management, and which are simply following directions of others. For this reason, I assume that the person with the highest cognitive skills is directing the family operation and that only this person's stock of human capital influences farm earnings.

The Value of Livestock. This is the value of the household's larger farm animals. Rosenzweig and Wolpin (1993) and Vaidyanathan (1988) have documented that South Asian households invest in livestock both for farm traction and to provide a liquid vehicle for savings that can buffer against economic distress. In this study, I have taken the value of livestock to be exogenous. However, as households may determine their investment in animals simultaneous with their investment in primary education, I have tested the robustness of my principal results to the exclusion of this variable. As explained in the description of the net revenues variable, livestock value operates on farm profitability through the production of fodder. While it seems likely that families with more livestock will enjoy greater earnings, it is pos-

[5] Report on the Select Committee on Transportation to Australia, the House of Commons, July 14, 1837, cited in Clark (1967).

sible that households are more likely to raise livestock if their land is less suitable for growing crops.

Prices. The prices of many of the most important agricultural inputs and outputs are held fixed by the government of Pakistan and vary among households only to the extent that families must transport product different distances to and from places of purchase. Examples of controlled-priced products include nitrogen and phosphorous fertilizers (the most commonly purchased agricultural inputs) and wheat (the most commonly grown crop). Transport costs for these goods are proxied with the distance (in kilometers) to the place nearest the village that fertilizer can be purchased. It is expected that 'the distance to fertilizer sales' will be associated with lower profits as isolated households will pay more for their inputs, and may receive less for their output (farm-gate prices are used for valuing the market price of crops when deriving agricultural net revenues but one can expect that these farm-gate prices will be negatively linked to distance to market).

Regression Results

Regression Set I: OLS, Using a Linear Functional Form. Column one of Table 3.2 presents the results of applying OLS estimation to a linear functional form for the profit and enrollment functions. The regression shows three important results: i) the number of unenrolled boys in the household makes a large and significant contribution to farm earnings; ii) enrolling boys in school greatly reduces the positive effect that boys have on farm earnings; and, iii) cognitive skills have a positive and significant effect on farm profitability. Taken together, these findings are consistent with our hypotheses that households are trading-off current benefits of child labor with future benefits of education, and that lagging enrollment in rural areas of LDC's is at least partially attributable to the opportunity costs of schooling.

The Effects of Household Composition on Profits: As expected, the regressions indicate that male family members have a positive and significant effect on farm earnings. Adding either an adult male or a boy to the household is shown to increase profits by approximately 16 percent. While it is surprising that these coefficients are of similar magnitude, these results do not imply that boys are capable of contributing the same amount of effort as men. Rather, boys are used in activities, such as herding, that require little physical strength, but which can free adult males to undertake more rigorous work. Moreover, the fact that the point estimates are similar does not imply statistical equivalence: the 90 percent confidence interval for the 'number of boys' ranges from 90.42 to 2714.70, while that for number of men ranges from 57.72 to 2615.12.

A central result of this study is that changing the status of a household boy from enrolled to unenrolled completely eliminates a boy's economic contribution to the household (enrollment reduces household earnings by 23). While the magnitude of the effect may seem surprising, it is consistent with the fact that herding, the principal employment of boys, is typically a full-time, day-long occupation. Taken together, the facts that boys make a sizable contribution to the wellbeing of the family, and that enrollment of boys eliminates this contribution, points to a high opportunity cost of schooling.

It should also be noted that, as anticipated, neither the coefficient on adult females nor on kids can be shown to be significantly different from zero. As previously discussed, this latter result is reassuring since it implies that fertility is not being affected by unobserved variables that are correlated with the error term of the profit function.

The Effects of Human Capital on Profits: The maximum reading skills among household adults is shown to have a large, positive and statistically significant effect on profitability. These results suggest that increasing the household's maximum reading scores by nine points (one standard deviation) above the mean of 7.5 (on a 30 point scale) yields a rise in profits of 1768 rupees (equal to 22 percent of average earnings). An important caveat must be mentioned in interpreting this result. First, because the variable is a *maximum* test score, it is not clear whether providing children with cognitive skills less than this maximum contributes to farm earnings.

The Effects of Household Productive Assets on Profits: Neither rainfed land nor mechanical equipment can be shown to have a positive effect on profits. However, both the value of livestock and the number of acres owned of irrigated land have large positive and significant effects on household profitability. Increasing the number of acres of irrigated land by 11 acres (one standard deviation) results in a 42 percent rise in profits (5929 rupees). Household livestock is shown to have a return of 0.41[6] — a high, but not implausible, rate of earnings on an asset.This result is of

[6] This may somewhat overstate the rate of return on this asset as animals that have been purchased or

particular interest in the context of this study as it indicates that Pakistani farm children are most intensively employed in an activity that carries a very high rate of return to the household.[7]

The Effects of Prices on Profits: While the coefficient on 'distance to fertilizer sales' carries the expected sign, it is not significant at the ten percent level. This may be due to the fact that many of the households in the sample produce their own inputs (e.g., seeds, traction, and fodder) and consume the majority of their production.

Regression Set II: Two-Stage Least Squares. Since schooling may be a proxy for a large number of other effects in the profit function estimation, it is useful to consider whether the significant coefficient on the enrollment variable actually represents the opportunity cost of schooling, or is the consequence of some missing variables bias. There are four classifications of variables which seem to be possible sources of omitted variables bias in the regressions of the profit function. The first among these is household resources. One might expect that household demand for schooling would be positively correlated with measures of household income, wealth, native ability, or status within the community. In addition, unobserved school characteristics may bias our results. Enrollment could be expected to be positively correlated with school quality which, in turn, might be positively linked with the income of the community. Household location may also be associated with missing variables bias. Schooling can be expected to be negatively linked with the household's isolation (as measured in travel time from schools, markets for agricultural inputs and outputs, and other infrastructure) and isolation is likely to be negatively correlated with profitability (since input prices are likely to increase, and output prices are likely to decline, with the time that it takes to reach market). It should be noted that if schooling is correlated with the error term in the profit function because of the omission of any of these three types of variables, the likely result would be a *positive* bias on the coefficient for 'Number of Boys Enrolled.' Given that our regressions yield a *negative* coefficient on 'number of boys enrolled,' it seems unlikely that the

that have been born, but that have not survived, are excluded from the value of livestock. Moreover, we are measuring livestock's impact on farm profitability through a somewhat imprecise valuation of fodder. Nevertheless, Alderman and Garcia (1993) show that, among our sample households, the value of livestock has a large and significant effect on household consumption. They find that a positive and significant effect of livestock on consumption in two of the three provinces in our survey. In these two provinces, a one rupee increase in the value of household livestock is associated with an average of a 0.15 rupee increase in consumption.

[7] In alternative specifications of the profit function (not shown), I excluded the livestock regressor. None of the coefficients on the other explanatory variables changed in either sign or significance.

significance of the enrollment variable is the result of omitting these classifications of variables.

The final potential source of missing variables bias is household production characteristics. If there are households which experience some unobserved problem that lowers both farm profitability and the marginal product of child labor,[8] omitting this characteristic from the earnings estimation could result in its detrimental effect being attributed to greater enrollment, or reduced use of child labor, and this would create a negative bias on the coefficient for 'number of boys enrolled.' Alternatively, if households are endowed with some unobserved resource that increases both profitability and the marginal product of child labor,[9] omitting this variable from the estimation of the profit function could result in its beneficial characteristic being attributed to greater use of child labor or reduced enrollment: again this implies a negative bias in the estimation of the coefficient of 'number of enrolled boys.'[10]

I address the potential for missing variables bias by using two-stage least squares to estimate the agricultural profit function. These results are presented in the second column of table 3.2. The fitted value for 'number of boys enrolled' is taken from the OLS regression shown in table 3.3. The results of the two stage least squares estimation are very close to those of the OLS estimation shown in the adjoining column of table 3.2. This suggests that there is little correlation between the error term and the variable 'number of enrolled boys in household' in the OLS regression. Since the two sets of estimates are so similar, I will provide no further discussion of these results.

<u>The Robustness of the Regression Results.</u> In order to explore the robustness of the most important results discussed above, I have undertaken additional regressions that employ alternative functional forms, and which include and exclude different sets of regressors (including various consumer prices). Among all of these regressions, there is a great deal of consistency in how profits respond i) to adding an additional boy to the household, ii) to changing the enrollment status of a boy, and iii) to increasing the maximum reading score among adult males. One such

---

8 Perhaps the illness of household livestock

9 Perhaps loamy soil that children are better able to farm.

10 It should be noted that missing production variables can also create a positive bias on the coefficient. For example, if children are especially adept at weeding, weed infestation could be an unobserved variable that increases the marginal product of child labor and lowers farm profitability.

alternative functional form of the profit function is discussed in the next section.

Regression Set III: Introducing Interactions in the Profit Function. From the previous regressions, that have employed simple linear functions, we have been able to determine the contribution to profits of cognitive skills and boy labor, and have established the overall effects of various exogenous variables on the decision to enroll boys in school. We now wish to introduce interaction terms into the profit function in order to determine which inputs act as substitutes or complements for boy labor and cognitive skills. With this information, we can then reconsider the results of the enrollment regressions and separate-out some of the income and substitution effects through which the exogenous variables operate on the schooling investment decision.

There are, however, obstacles to finding an applicable form for the profit function. First, the small size of the sample — only 304 observations — implies that whatever model is employed must be parsimonious in variables and this precludes the use of the most flexible functional forms (e.g., the second-order Taylor series approximation) with the full set of regressors that were employed with the linear functional form. In addition, for many observations, the independent variables take on zero values and the dependent variable takes on negative values (indicating that the household suffered a net loss in agricultural production); as a consequence, it is not possible to use log-linear forms.

We can, however, make use of our previous findings, which indicate that several independent variables are unlikely to interact with boy labor and with cognitive skills, in order to reduce the set of regressors that we must include in the profit function. In neither the enrollment regressions nor the profit regressions can one find any effect from the variables 'number of women in household,' 'number of kids in household,' 'distance to fertilizer sales' or 'value of mechanical equipment.' For this reason, these variables will be omitted from the profit function with interactions. Moreover, the previous results indicate that enrolled boys can be expected to make no contribution to agricultural profitability. This permits us to redefine the measure of boy labor as 'number of unenrolled boys in household' and to omit the variable 'number of enrolled boys' from the profit function. Given these changes in the set of regressors, we can express a profit function with interactions as shown in table 3.4.

F-tests at the five percent level suggest that, for all six factor inputs (irrigated land, rainfed land, adult males, unenrolled boys, livestock, and reading), the coeffi-

Table 3.2 Estimated Agricultural Profit Functions Using a Simple Linear Form: OLS and 2SLSQ Results

	OLS	2SLSQ
R Square	0.4459	0.4331
Mean of Dependent Variable	8188.83	8188.83
Standard Deviation of Dep. Variable	14060	14060
No. of Observations	304	304

Variable	Coefficient t-statistic	Coefficient t-statistic	Mean Stand. Dev.
Constant	-3718.01 (-0.704)	-3821.98 (-0.719)	
Acres of Owned Irrigated Land	539.53 (5.751)	544.66 (5.804)	3.695 *11.038*
Acres of Owned Rainfed Land	-162.86 (-1.488)	-150.01 (-1.363)	2.308 *7.763*
Value of Livestock	0.4103 (5.544)	0.4112 (5.553)	12163.63 *10241.49*
Value of Mechanical Equipment	0.0281 (0.552)	0.0296 (0.573)	6355.65 *20493.62*
Distance to Fertilizer Sales	28.004 (0.256)	31.187 (0.2807)	7.632 *6.243*
Max. Reading Among Family Adult	196.45 (2.278)	174.4 (1.984)	7.457 *8.943*
No. of Adult Males in HH.	1336.42 (1.714)	1381.63 (1.775)	2.961 *1.842*
No. of Adult Females in HH.	-387.01 (-0.746)	-394.19 (-0.763)	2.770 *1.606*
No. of Kids in HH.	55.921 (0.079)	72.917 (0.1035)	2.625 *1.297*
No. of Boys in HH.	1402.56 (1.753)	1377.95 (1.713)	1.684 *0.843*
No. of Enrolled Boys	-2036.18 (-2.354)		0.957 *1.012*
Pred'd No. of Enr'd Boys in HH.		-1975.62 (-1.693)	0.957 *0.521*

Table 3.3 An OLS Estimate of the Number of Boys Enrolled per Household: the First Stage of a Two Stage Least Squares Procedure

R Square	0.3834
Mean of Dependent	0.9571
Standard Deviation of Dependent	1.0114
No. of Observations	304

Variable	Coefficient t-statistic	Mean Stand. Dev.
Constant	-0.7412 (-1.981)	
Acres of Owned Irrigated Land	0.01296 (2.3022)	3.695 *11.038*
Acres of Owned Rainfed Land	0.00041 (0.0750)	2.308 *7.763*
Value of Livestock	-0.4587E-5 (-1.098)	12163.63 *10241.49*
Value of Mechanical Equipment	-0.3328E-05 (-1.136)	6355.65 *20493.62*
Distance to Fertilizer Sales	-0.0032 (-0.352)	7.632 *6.243*
Max. Reading Among Family Adult	0.0265 (2.309)	7.457 *8.943*
No. of Adult Males in HH.	-0.0422 (-1.463)	2.961 *1.842*
No. of Adult Females in HH.	0.0328 (1.009)	2.770 *1.606*
No. of Kids in HH.	-0.0008 (-0.021)	2.625 *1.297*
No. of Boys in HH.	0.4882 (7.427)	1.684 *0.843*
Distance to Primary School	-0.1148 (-3.174)	2.066 *4.590*
Distance to Intermed. School	-0.0724 (-1.471)	6.577 *8.530*
Student-Teacher Ratio – Primary	0.0031 (2.419)	43.771 *43.036*
Teacher Reading Score – Primary	0.0367 (1.014)	13.626 *7.419*
No. of Books – Primary	0.0169 (3.116)	54.579 *8.840*

Table 3.4 An Estimated Agricultural Profit Function with Interactions Among Regressors: OLS Results

R Square	0.5930
Mean of Dependent	8188.83
Standard Deviation of Dependent	14060
No. of Observations	304

Variable	Coefficient	t-stat	Mean	Std. Dev.
Constant	4083.89	1.457		
Acres of Owned Irrigated Land	-875.409	-4.088	3.695	11.038
Acres of Owned Rainfed Land	-888.317	-3.610	2.308	7.763
Value of Livestock	0.271	1.843	12163.63	10241.49
Max. Reading of Ad. Males	-128.76	-0.782	7.457	8.943
No. of Ad. Males in HH.	-195.97	-0.310	2.961	1.842
No. of Unenrolled Boys in HH.	-1786.32	-1.414	0.727	0.775
Unenr. Boys * Irrigated	165.27	1.664	1.777	7.701
Unenr. Boys * Rainfed	65.328	0.916	4.945	15.013
Unenr. Boys * Livestock	0.1672	2.186	7290.3	14782
Unenr. Boys * Reading	11.879	0.139	3.434	10.046
Unenr. Boys * Men	32.514	0.100	3.125	4.835
Men * Irrigated	158.87	4.320	12.359	49.982
Men * Rainfed	6.6718	0.155	15.692	40.855
Men * Livestock	0.0185	0.553	35759	55854
Men * Reading	91.586	2.298	19.998	35.025
Irrigated * Rainfed	106.32	1.723	1.557	9.276
Irrigated * Livestock	0.0195	2.846	78699	339270
Irrigated * Reading	36.012	5.484	24.095	124.51
Rainfed * Livestock	0.0104	0.912	19330	80247
Rainfed * Reading	25.018	2.446	27.997	126.42
Livestock * Reading	-0.0148	-1.948	72895	162200

cient on each of the factors, together with coefficients on all interaction terms that incorporate that factor, are jointly significant. The total marginal effect of each factor is calculated using the estimated coefficients for the input and for the related interaction terms, and are shown in table 3.5.

Table 3.5 Total Marginal Effect of Variables in Profit Function with Interactions, Evaluated at Mean of Regressors (Avg. Profits in Rupees)

	Total Marginal Effect
Owned Irrigated Land	465.74
Owned Rainfed Land	-115.23
Livestock	0.4324
Max. Reading Score	162.45
Adult Males	1340.08
Unenrolled Boys	1194.04

The total marginal effects presented in Table 3.5 are similar to those estimated using the simple linear forms and reported in Table 3.2. Several of the interaction terms shown in Table 3.4 reveal interesting complementarities among factor inputs. As one would expect, the marginal product of reading skills is shown to be enhanced by ownership of both irrigated and rainfed acres. Land ownership is positively correlated with the size of the operational holding in this sample and it seems reasonable that one would get greater benefits from education when it is applied over a larger holding. The effect of reading is also shown to be enhanced by a greater number of men in the household. This again seems reasonable if the maximum cognitive skills in the household are held by those who supervise household labor, since the value of cognitive skills in administration would likely increase with the number of workers. It is interesting to note, however, that there is no interaction between reading and the number of unenrolled boys in the household; this may imply that boys are working separately from those with higher cognitive skills (boys may be working unsupervised in tending livestock). The value of livestock can be shown to have a negative and significant effect on the marginal product of cognitive skills. This suggests that reading ability may make a smaller contribution to raising livestock than to farming.

The value of boy labor is enhanced by the amount of livestock that is owned by the family. This is consistent with our expectations as herding animals is one of the principal occupations of boys who work on the family farm. Boy labor is also enhanced by the amount of irrigated land owned by the household. This is somewhat surprising as irrigated land is a proxy for the use of modern technologies and one might expect that there would be smaller scope for the use of child labor in 'high-tech' farming. However, the regression also shows that the profitability of livestock is enhanced by irrigated land and, thus, irrigation may be increasing the value of boys' herding activities.

Estimating a Cognitive Skills Production Function

The Pakistan data include the results of a reading skills exam that was administered to all respondents who were over the age of 12 and who had completed at least four years of education. In this section, I use the reading scores for the cohort of 388 young rural males previously examined in the analysis of schooling attainment and explore how various school attributes, and time spent in education, affect the production of reading skills.

The theoretical underpinnings of this study are straightforward and have been developed in the various analyses of schooling investment presented above. I again express the demand for second period human capital for individual i in terms of the time spent in school, $T_i^* = T(\mathbf{X}_\mathrm{i}, \mathbf{q}_\mathrm{i})$, where $\mathbf{X}_\mathrm{i}$ is a vector of individual, household, and village characteristics, and $\mathbf{q}_\mathrm{i}$ is a vector of school quality characteristics. I assume that there is a human capital production function that is monotonic in the inputs T, $\mathbf{q}$, $\mathbf{X}$ (the characteristics in $\mathbf{X}$ and $\mathbf{q}$ affect cognitive skills production both directly, as factor inputs, and indirectly, as determinants of the time boys spend in school.) I can therefore write a reading skills production function as

$$r_i = g(T_i, \mathbf{X}_i, \mathbf{q}_i). \tag{3.1}$$

In order to estimate reading skills production, conditional on schooling attainment, I define a stochastic representation of this technology as

$$\begin{aligned} r_i &= \beta'_{[T]} T_i + \beta'_{[\mathrm{q}]} \mathbf{q}_i + \beta_{[\mathbf{X}]} \mathbf{X}_\mathrm{i} + u_\mathrm{i} \\ &= \beta'_{[\mathrm{Z}]} \mathbf{Z}_i + u_\mathrm{i} \end{aligned} \tag{3.2}$$

where $\mathbf{Z}_i$ is a vector comprised of T_i, $\mathbf{X}_i$ and $\mathbf{q}_i$

Statistical Issues in Estimating A Cognitive Skills Production Function

There are two principal issues of concern in estimating the cognitive skills production function. First, the reading test result is zero for a large portion of the sample observations, and this suggests that the estimation of reading skills production should be undertaken with a censored data model: I employ a Tobit model for this purpose. In addition, using schooling attainment as a regressor in this analysis may be problematic as there are likely to be variables that have been omitted from our analysis and that are correlated with both years of education and the error term in the estimated reading skills function.[11] In such a case, the effects of the omitted variable would be ascribed to years of education and the estimated coefficients from our regressions would be inconsistent. One can anticipate that omitted variables would likely lead to a positive bias on the coefficient for years of education, as household and school-related factors that act to increase the efficiency with which children learn can be expected to increase parents' investment in schooling.[12]

To lessen the potential for omitted variables bias, I employ a two-stage least squares Tobit model in which the score on the reading skills exam is regressed on a set of exogenous and predetermined values, together with a fitted value for years of education. I identify reading skills production by excluding both the distance to primary school and the distance to intermediate school from the second stage estimation. The rationale for using these identifying variables is straightforward. The distance to school reflects both the monetary and time costs of transporting children to classes. While these costs will likely affect the household demand for schooling (as reflected in schooling attainment), costs are not taken as inputs in production functions and are, therefore, excluded from our analysis of cognitive skills.[13]

It would be useful to test the appropriateness of the instruments and identifying variables employed in the Tobit regressions of cognitive skills. However, the test

[11] Further discussions on the importance of selection in estimating cognitive skills production functions is presented in Glewwe and Jacoby (1994) and Alderman, Behrman, Ross, and Sabot (1996).

[12] This assumes that the omitted variable is likely to be a complement to child time in the production of cognitive skills and that the substitution effect of lowering the cost of acquiring education dominates whatever income effect may exist. While it seems unlikely, there is nothing to preclude an omitted variable from exerting a negative bias on the coefficient for years of education.

[13] One might argue that the distance variables proxy the time spent in school. The use of these identifying variables assumes that, irrespective of how far children travel, they will begin classes with their peers and will remain in class through the end of the school day.

of overidentifying restrictions, which was described in detail in a previous section, is applicable only to least-squares methods and this author knows of no analogous procedure that can be applied to a two-stage Tobit. For this reason, I have undertaken an additional estimation of the cognitive skills production function using a two-stage OLS, and conducted a test of overidentifying restrictions using the error terms from the second stage of this estimation. Employing the test statistic in equation 3.2, I am unable to reject the use of these instruments and identifying variables.[14] (This test was conducted at the one percent level. The two-stage OLS, and the regression of the error term against the full set of instruments, are presented in table 3.6.)

The Variables Used in Estimating Cognitive Skills Production

The Dependent Variable

The measure of cognitive skills used in this analysis is the grade earned on a test of reading skills that was designed by the Educational Testing Service and translated into local languages. This test was administered to every person in our sample who was over twelve years of age and who had at least four years of schooling. The data is censored at zero for a large portion of the sample. This test has been used in analyses of schooling and labor markets in several developing nations (see Glewwe and Jacoby, 1994) and sample test questions are available in Knight and Sabot (1990).

The Independent Variables.

Years of Education. The current study explores the production of reading skills, conditional on the time that children spend in school. Our measure of schooling attainment is a fitted value taken from an OLS regression that employs the same dependent variables used in the Tobit analyses of grade completion presented in the previous chapter. As the relationship between these instruments and schooling attainment have already been discussed in detail, I will present no further description of how these regressors affect grade completion.

Household Agricultural Variables. These include the irrigated and rainfed land worked by the father, the father's ownership of bullocks, and experience with HYV.

---

14 However, a test of joint significance for two identifying variables in the first-stage regression yields an F-statistic of only 2.12, which falls short of significance at the 10 percent level.

Because these variables also appear as regressors in the first stage estimation of schooling attainment, predicted attainment captures how these instruments affect household demand for human capital. As a result, when we enter these household agricultural variables into the cognitive skills production function, along with predicted years of education, their estimated effects will reflect only how these explanatory variables perform as inputs in the production of reading skills. Household agricultural characteristics can proxy wealth or income, and can reflect unobserved purchases of materials and services useful in the production of cognitive skills. Therefore, one would expect non-negative coefficients on all these variables.

Schooling-Related Variables. As these variables also serve as regressors in the first stage, their effects in the second stage will reflect only their performance as inputs in the production of reading skills. One would expect that the reading skills of teachers, the ratio of books-to-students, and predicted years of education would all have positive effects on the production of schooling outcomes, while the student-teacher ratio would carry a negative effect. However, there have been a large number of cognitive skill production functions estimated in both developed and less developed nations — most of which have included schooling related variables that are similar to those used in this analysis — and few empirical regularities have emerged from these works. Harbison and Hanushek (1992) reviewed 187 published articles which estimated cognitive skills production in public school systems in the United States and found several relevant results: the student-teacher ratio was significant, with the expected sign, in fewer than one-fifth of the studies (14 of the 152 analyses that employed this variable); the coefficient on teacher education was significant and positive in less than 10 percent of the cases (8/113); and expenditure per student was positive and significant in less than one-quarter of the analyses (13/65). (Teacher experience was positive and significant in 40 of the 140 studies in which it appeared but Harbison and Hanushek point out that this may be due to more experienced teachers finding ways to be assigned to better students.)

Results of the Two-Stage Tobit Analysis of Cognitive Skills Production

Tables 3.7 and 3.8 present the results of the two-stage least squares Tobit regression of reading skills. In the regression shown in table 3.7 I have included all independent variables with the exception of the Raven's test result, while in table 3.8 the Raven's is included. The results in these two tables are very similar and in the current discussion, I will focus on those in table 3.8. A principal interest

Table 3.6 A Two-Stage Least Squares Estimate of Reading Skills Production Among Our Cohort of Young Men and a Test of Overidentifying Restrictions

	Reading	Years of Education	Disturbance
Mean of Dependent Variable	6.36856	4.29124	0.24645
Std. Dev. of Dep. Variable	8.6057	4.6992	5.2262
Observations	388	388	388
R-squared	0.63037	0.40477	0.00201
Log-L	-1186.0160	-1049.7898	-1191.2876
Constant	-10.854		
	(-0.990)		
Acres of Irrigated Land	0.1019	0.0050	0.0005
in Oper'l Holding	(2.122)	(0.287)	(0.019)
Acres of Rainfed Land	0.1521	-0.0120	-0.0011
in Oper'l Holding	(2.118)	(-0.458)	(-0.030)
= 1 if Father Owned	-1.2141	0.2795	0.0262
Bullocks	(-1.374)	(0.526)	(0.034)
= 1 if Father Used	-0.0131	-1.4250	-0.1338
High Yield Variety	(-0.008)	(-1.887)	(-0.122)
Distance to Fert. Sales	0.0147	0.0658	0.0062
Nearest Village	(0.278)	(1.527)	(0.099)
Student-Teacher Ratio in	-0.0159	-0.0200	-0.0019
Nearest Prim. Sch.	(-1.344)	(-2.759)	(-0.178)
Av. Reading of Teachers,	0.3154	-0.0421	-0.0040
Nearest Prim. Sch.	(1.130)	(-1.309)	(-0.085)
Ratio of Books/Students	0.0470	-0.0105	-0.0010
at Nearest Prim.	(0.677)	(-1.423)	(-0.092)
= 1 if Father Attended	0.6849	1.8090	0.1699
School	(0.710)	(3.834)	(0.245)
Raven's Score	0.1489	0.3048	0.0286
	(1.050)	(12.343)	(0.678)
Predicted Years of Education	1.4751		-0.0939
	(4.966)		(-1.263)
Distance to Primary School		-0.0885	-0.0083
		(-1.262)	(-0.082)
Distance to Intermediate		-0.1468	-0.0138
School		(-4.935)	(-0.311)

Table 3.7 A Two-Stage Tobit Estimate of Reading Skills Production Among Our Cohort of Young Men, Specification One

	Reading Score Tobit Equation	Years of Education OLS
Number of observations	388	
Log likelihood function	-1036.555	
Variance estimates:		
$\sigma^2(1)=$	70.21437	
$\sigma^2(2)=$	17.51618	
Rho=	0.00347	
Constant	-17.077	5.1905
	(-2.880)	(4.455)
Acres of Irrigated Land	0.1604	0.0043
in Oper'l Holding	(2.599)	(0.186)
Acres of Rainfed Land	0.2581	0.0329
in Oper'l Holding	(2.461)	(1.042)
= 1 if Father Owned	-1.1610	0.1487
Bullocks	(-0.709)	(0.233)
= 1 if Father Used	-1.0381	-0.8352
High Yield Variety	(-0.456)	(-0.746)
Distance to Fert. Sales	-0.0447	0.0788
Nearest Village	(-0.322)	(1.333)
Student-Teacher Ratio in	-0.0376	-0.0219
Nearest Prim. Sch.	(-1.142)	(-2.534)
Av. Reading of Teachers,	0.2192	-0.0115
Nearest Prim. Sch.	(1.692)	(-0.243)
Ratio of Books/Students	0.0105	0.0010
at Nearest Prim.	(0.313)	(0.089)
= 1 if Father Attended	1.9796	2.7721
School	(0.726)	(5.079)
Years of Education	2.7691	
	(3.231)	
Distance to Prim. School		-0.1001
Nearest Village		(-1.168)
Distance to Int. School		-0.1531
Nearest Village		(-3.298)
$\sigma12/\sigma22$	0.0069	
	(0.008)	
$s[\epsilon 1 \mid \epsilon 2]$	8.3794	
	(13.936)	

Table 3.8 A Two-Stage Tobit Estimate of Reading Skills Production Among Our Cohort of Young Men, Specification Two

	Reading Score Tobit Equation	Years of Education OLS
Number of observations	388	
Log likelihood function	-979.7541	
Variance estimates:		
$\sigma^2(1)=$	69.86636	
$\sigma^2(2)=$	13.09224	
Rho=	-0.03617	
Constant	-18.126	-0.8145
	(-3.562)	(-0.669)
Acres of Irrigated Land	0.1627	0.0086
in Oper'l Holding	(2.551)	(0.446)
Acres of Rainfed Land	0.2523	-0.0075
in Oper'l Holding	(2.469)	(-0.253)
= 1 if Father Owned	-1.2386	0.2227
Bullocks	(-0.724)	(0.398)
= 1 if Father Used	-0.8413	-1.3328
High Yield Variety	(-0.327)	(-1.704)
Distance to Fert. Sales	-0.0479	0.0655
Nearest Village	(-0.340)	(1.339)
Student-Teacher Ratio in	-0.0365	-0.0200
Nearest Prim. Sch.	(-1.123)	(-2.637)
Av. Reading of Teachers,	0.2176	-0.0225
Nearest Prim. Sch.	(1.651)	(-0.514)
Ratio of Books/Students	0.0100	-0.0052
at Nearest Prim.	(0.301)	(-0.506)
= 1 if Father Attended	1.7271	1.7914
School	(0.802)	(3.658)
Raven's Score	0.0524	0.3141
	(0.184)	(9.727)
Years of Education	2.7880	
	(3.127)	
Distance to Prim. School		-0.0817
Nearest Village		(-1.115)
Distance to Int. School		-0.1479
Nearest Village		(-3.913)
$\sigma 12/\sigma 22$	-0.0835	
	(-0.092)	
$s[\epsilon 1 \mid \epsilon 2]$	8.3531	
	(14.115)	

in these results is finding the rise in reading skills that results from sending a boy to school for a year, as this value is necessary to complete our calculation of the returns to schooling. Among the 388 young men in our sample of reading skills testees, the average grade attainment is 4.3 years and the mean reading score is 6.4 on a 30 point scale. (See table 2.10 for descriptive statistics for other regressors.) The effect of time spent in school is highly significant, and increasing schooling by one year (about one-fifth of a standard deviation in attainment) raises reading by 1.78 points (about one-fifth of a standard deviation in the reading exam).[15]

Of the schooling-related variables, only the reading skills of teachers is seen to affect the cognitive skills of our test-takers and this effect is small. A seven point increase in this regressor (one standard deviation) is associated with a 15 percent rise in our students' reading skills (0.96 points. It is interesting to note that that we found no effect from this regressor in the analysis of grade attainment in the previous chapter. (Also, the student teacher ratio, which was seen to reduce attainment, has a negative coefficient in our estimate of the cognitive skills production function but falls short of statistical significance.)

The amount of irrigated and rainfed land in the father's holding both have significant but modest effects on cognitive skills production. A one standard deviation rise in irrigated land (14 acres) is associated with a 22 percent rise in reading (1.415 of a point). A one-standard deviation increase in rainfed land produces a one-quarter increase in reading (1.63 points). Again, as these variables proxy household wealth and income, it is likely that they reflect purchased inputs in the production of human capital.

Estimating the Rate of Return to Schooling

The results of the two-stage least squares regression of agricultural profits, shown in the previous chapter, indicates that a one point increase in the *maximum* reading score among household adults increases farm earnings by 174.4 Rupees (from the mean of 8189). This regression also indicated that enrolling a boy for a year of schooling reduces farm profits by 1976 Rupees. Given that one year in school is seen to increase reading skills by 1.78 points, this implies a rate of return

15 The marginal effect in the current analysis reflects how the regressors act on reading skills, conditional on literacy. The marginal values are not included in table 3.8 but are approximately equal to 0.63 the coefficient values.

to schooling of 15.7 percent.[16] However, this estimate should be taken as an upper bound on the returns to schooling as it is based on a number of highly stringent assumptions, and the violation of any of these assumptions would act to diminish the value of education.

One important assumption underlying this estimate is that an additional year of schooling will increase the maximum cognitive skills among family members. If there are others in the household who have human capital stocks that are greater than those that would result from sending the boy to school for a year, our analysis does not indicate whether the household would experience any benefit from additional education for the child. In addition, the analysis presupposes that the child who receives the education will remain on the family farm. If there is not enough land for all children to be productive on the family farm, or if the benefits from education are greater in urban areas, children may leave the household and the benefits from investment in schooling may not accrue to the family.

Violation of these assumptions can greatly reduce the returns to schooling a child, and farming households may find negative returns, in terms of household production, from educating some portion of their children. However, many agricultural households may find that investment in education for specific children carries returns that approach the estimated upper bound. Certainly, there are many households in Pakistan in which all adult males are illiterate and any schooling investment would raise the maximum cognitive skills of the household. Parents in such households may be able to reduce the likelihood that an educated child leaves the countryside by tailoring bequests of land, or other agricultural assets, to favor those who work the farm.

This analysis raises several questions that are beyond the scope of our study. Perhaps the most important is why, given the high rates of return to schooling, there is an apparent under-investment in education (there are many households that enroll no children in school and it is unlikely that they have other investment opportunities that have the potential yield of education). The most frequently cited explanation for a family's failure to invest is that it is credit constrained and cannot forego the earnings generated by the labor of school-aged boys. A contributing factor may be that there is no available substitute for family labor. It is also possible that many of the unenrolled are sick, disabled, or malnourished and are unable to benefit from schooling.

---

[16] At an interest rate of 15.7 percent, one can purchase, for a price of 1976, an infinitely lived annuity that pays 310.43 per-year (310.43=1.78*174.4).

This study also leaves unanswered other important questions regarding the linkages between education and farm earnings. It would be worthwhile to determine the value of schooling for those intra-marginal household members who have less than the maximum amount of human-capital. One would also like to know the aspects of farming operations that most benefit from education (technical expertise in combining farm inputs, selection of the mix of crops, marketing activities, risk-hedging, adoption of new technologies, etc.).

Estimating the Production of Technical Skills in Wheat Farming

The Pakistan data include the results of a short exam of technical knowledge of agriculture that was administered to 145 farmers in our sample. The test was designed to evaluate knowledge of several important techniques including the use of chemical fertilizer, the application of irrigation, the control of weeds, and the optimal timing of harvesting. The test-takers were selected from among adult males who were raised in farm households. Because much farming knowhow is crop specific, the technical skills exam was administered only to farmers who keep a significant portion of their operating holding planted in wheat. I selected this common crop because it is grown in all parts of our sample area, and because technically demanding, high-yield varieties are being used throughout Pakistan. While, in most regards, the sample of test takers is similar to the larger sample of Pakistani rural residents, the testees come from households that have larger operating holdings and that are more remote.

The theoretical model that I use to motivate the analysis of technical skills acquisition follows directly from both the cognitive skills production function and the schooling attainment function presented in previous sections. Throughout this study I have assumed that households invest in schooling in order to generate cognitive skills which, in turn, are used as factor inputs in the production of those technical skills that are relevant to the family's productive activities. I assume that the production of technical skills can be written as

$$S_i = S(r_i, T_i, \mathbf{X}_i),$$

where S_i is the farming knowhow of individual i, r_i is his level of cognitive skills, T_i is his schooling attainment, and $\mathbf{X}_i$ is a vector of his personal, household, and village characteristics such as age, native intelligence, and the attributes of the family's operational holding. I include both the cognitive skills and the schooling attainment of the individual as arguments in this function as education may generate capabilities that are not fully captured in the reading exam or in other measures of cognitive ability. A stochastic representation of this function can be expressed as

$$s_i = \beta_0 + \beta_r r_i + \beta_T T_i + \beta_X X_i + \epsilon_i$$

where ϵ_i reflects measurement error or the effects of omitted variables.

There are several issues with which one needs to be concerned in estimating this relationship. The first is possible sampling bias arising from the fact that we have chosen our test takers from among those farmers who have self-selected into the production of wheat. If wheat production is selective of human capital, persons who are especially adept at transforming cognitive skills into farming knowhow would be more likely to choose the production of this crop. In such a case, selection bias – or omitted variables bias – would understate the effect of cognitive skills on the production of technical ability in agriculture.

There is evidence, however, that factors other than human capital are motivating farmers to select into the production of wheat. Among all households in the Pakistan survey, 68 percent produce wheat. However, those that choose not to grow this crop are concentrated in a district in which agriculture occurs almost exclusively on rainfed land (Attock). Excluding the households from this district, 92 percent of our farm families grow some amount of wheat. (Note that, because residence in Attock is highly correlated with farming on rainfed land, I have not included geographical location among the regressors in the technical skills production function.)

A second concern in estimating the technical skills production function is identifying variables that reflect the exogenous aspects of the testee's production environment. A farmer's knowledge of farming technique is likely to be influenced by the agro-climatic conditions he faces, the availability of various factor inputs, and his initial endowments of physical and human capital. The most obvious proxies for these characteristics are the factor inputs employed by the farmer on his operational holding. It seems likely, however, that these are determined simultaneous with the decision to invest in the acquisition of technical skills. For this reason, I use measures of the farm inputs used by the fathers of our test takers at the time our respondents were in elementary school. These measures, which were employed in the schooling attainment analysis in the previous chapter, reflect the acres of irrigated land and rainfed land in the father's operational holding, and whether the father used HYV seed.[17]

An additional difficulty in estimating this relationship is the lack of data on the supply of information on this subject. In our previous analysis of the production of cognitive skills, we had measures that reflected both the supply of reading skills (measured by the availability and quality of schooling) and the demand for these skills (the characteristics of individuals, household operations, and family structure were all assumed to affect demand by influencing either the costs or benefits of acquiring skills). In the current analysis, however, supply measures are unavailable for the production of technical skills as we have no information on the nature of either the agricultural extension network or the less formal sources of information such as neighbors, brochures, the radio, or the distributors of inputs. For this reason, we assume equal supply of information across all individuals in our analysis.

Perhaps the most difficult issue in this analysis relates to the influence of omitted variables in estimating the effects of schooling and cognitive skills in the production of farm knowhow. I previously speculated that a person's schooling attainment and his cognitive skills might be correlated with unobserved elements of family income, inputs into agricultural production, or an individual's work ethic. If these omitted variables are also correlated with a person's technical skills, their effects could be ascribed to schooling and reading. The obvious method for addressing this issue is with the use of instrumental variables. I have not, however, been able to identify suitable instruments for this purpose and this analysis is presented with the caveat that omitted variables may be influencing my results.[18]

Variables Used in the Analysis of Technical Skills Acquisition

The Dependent Variable

The dependent variable in this analysis is the unweighted score earned on an exam of technical skills in wheat farming. The test, which was developed by this author and staff at the Pakistan Agricultural Research Center (PARC), includes 14 items. These address several aspects of farming and are of various levels of difficulty.

17 The analysis in the previous chapter also used a binary variable indicating if the father owned a bullock, but in the current instance this is equal to one for every observation.

18 It seems plausible that schooling availability and quality might affect the production of technical skills only in so far as they influence the time spent in school and the production of cognitive skills. I used these variables as instruments in a two-stage least squares regression of technical skills production, but a test of overidentifying restrictions indicated that the instruments were inappropriate.

The exam was administered orally in the local languages.

An English translation of the exam, together with the correct answers, is provided in Appendix II. Table 3.9 indicates the proportion of the respondents who gave the correct answer for each test item and a measure of item consistency which is defined as i) the proportion of the upper third of test takers who got the item right minus ii) the proportion of the lower third of test takers who got the item right.[19] For exams in which one wishes a two-thirds pass rate, it is desirable for this item consistency measure to lie between 0.4 and 0.7.[20]

Two of the questions on the exam, items four and five, have very low consistency measures due to the fact that few of the respondents provided a correct answer (although, all those who did give correct answers were among the top third of test takers). These questions, which were expected to be difficult, tested knowledge that is central to a farmer's ability to correctly combine the main sources of nitrogen and phosphate fertilizers. This is a skill that the experts at PARC believe is critical to efficient farming and is lacking among Pakistani farmers. Item eight also has a low consistency measure due to the fact that relatively few of the better test takers got this answer right. I have checked the validity of this item and I can see no reason for this poor result. All three of these questions were retained in the overall technical skills results examined in this analysis.[21]

The Independent Variables

Individual Human Capital Characteristics The principal issue in this analysis is how various elements of human capital affect the acquisition of technical skills. Our regressors include the measures of human capital that have been employed in previous sections of this dissertation: the score on the exam of reading skills, schooling attainment, and the Raven's test of native intelligence. In addition, I also include the test-taker's age as a proxy for experience. From our previous discussion of the role of human capital in agriculture, we can anticipate the effects of these human capital attributes on the acquisition of technical skills. First, all the attributes can be expected to lower the costs of acquiring production-related information as those

---

19 The upper third of test takers is the 48 respondents who scored the highest on the technical skills exam. The lower third consists of the 49 respondents with the lowest overall scores.

20 For a discussion of item-discrimination indices for exams, see Allen and Yen (1979).

21 I conducted regressions (not shown) in which these items were omitted from the dependent variable. Under the alternative specifications, there were only small differences in the values and standard errors of the estimated coefficients.

Table 3.9 Descriptive Statistics for Test Items in the Exam of Technical Knowledge in Wheat Farming.

No. of Observations 145.00

Variable	Mean	Std Dev	Consistency Measure	Results in High Group	Results in Low Group
Q1	0.72	0.45	0.54	48/48	21/49
Q2	0.61	0.49	0.46	40/48	17/49
Q3	0.60	0.49	0.61	45/48	15/49
Q4	0.02	0.14	0.06	3/48	0/49
Q5	0.03	0.16	0.08	4/48	0/49
Q6	0.83	0.37	0.38	49/48	30/49
Q7	0.54	0.50	0.46	38/48	15/49
Q8	0.37	0.49	0.22	23/48	12/49
Q9	0.62	0.49	0.54	46/48	19/49
Q10	0.51	0.50	0.57	39/48	11/49
Q11	0.80	0.40	0.42	47/48	26/49
Q12	0.54	0.50	0.63	41/48	10/49
Q13	0.61	0.49	0.56	45/48	17/49
Q14	0.19	0.40	0.47	23/48	0/49

with greater human capital will need to spend less time learning skills. Cognitive skills are presumed to enter directly into the technical skills production function and to allow farmers to acquire technical knowledge from written materials and to compute the appropriate quantities of various inputs. In order to make use of written materials, and to make simple calculations, uneducated farmers would need to seek help from others, thereby raising their costs of skill acquisition.

Increasing the human capital stock of an individual can also raise the benefits of specific skills as those with greater human capital may be more adept at combining their knowledge to achieve superior outcomes. Education may also enable farmers to more easily search out sources of information on agriculture since familiarity with the learning process, and in particular with learning in an institutional setting, will allow one to better discriminate between high and low quality sources of information.[22] This capacity to evaluate the quality of information and

[22] Educated farmers may also have better access to extension services and other sources of information than their uneducated counterparts. Extension services are usually available, in principle, on an equal basis to all farmers. However, given resource constraints, governments in many LDC's target

to integrate concepts may be among the bi-products of schooling that act on the production of technical skills independent of a student's ability in reading, math, or other specific abilities.

The expected effect of age, as a proxy for experience in farming, is ambiguous. It is possible that experience in agriculture can substitute for formal schooling if, with trial and error, an uneducated farmer can learn the same skills that others acquire through the application of their schooling. On the other hand, older farmers may have experienced depreciation in their human capital if their skills are related to outmoded technologies or they have forgotten the lessons they gained in schooling.

Household Characteristics. Our analysis of technical skills acquisition uses the same household regressors employed in our study of schooling attainment (the amount of irrigated and rainfed land in the father's operational holding and his use of HYV). However, the effects of these explanatory variables may be very different in these two analyses. In the schooling attainment analysis, household productive assets and household farm characteristics could act on the demand for human capital through three principal avenues: i) an income effect, as households with larger holdings or better methods might be more able to bear the opportunity cost of schooling; ii) a substitution effect relative to the cognitive skills that children gain in school, as farmers using modern methods are likely to have higher returns to schooling; and iii) a substitution effect relative to the use of child labor, as various inputs could act to raise or lower the value of this input. There were two other mechanisms — perhaps of second order — through which these characteristics could influence our statistical analysis of attainment: i) as proxies of wealth or income, they could reflect household inputs in the production of schooling outcomes (e.g., the ability to purchase books, hire tutors, etc.); and, ii) as direct inputs into the production of technical skills (e.g., children from households on canal systems could have advantages in learning about irrigation).

In the current analysis, I have specified a functional form in which household productive assets and farm characteristics enter the technical skills production function along with measures of both the cognitive skills of our test takers and the time that our respondents have spent in school. Both of these schooling related regressors will reflect how our household characteristics influence the demand for human capital. Moreover, the cognitive skills variable will capture differences in family-

those regions where extension is likely to have a greater pay-off. Such regions are those in which farmers are more likely to apply (and benefit from) new technical information. Farmers in high pay-off areas generally have higher incomes and more education.

Table 3.10 Descriptive Statistics for the Variables Used in Technical Skills Production Function.

No. of Observations 145.00

Variable	Mean	Std Dev	Min.	Max.
Technical Skills Test Score	6.99	2.66	1.00	14.00
Acres Irrigated in Father's Holding	9.94	11.69	.00	80.00
Acres Rainfed in Father's Holding	7.88	13.25	.00	50.00
Father Used HYV	.10	.30	.00	1.00
Distance to Fertilizer Depot	8.57	5.47	.50	20.00
Age in 1986	40.72	16.64	9.00	72.00
Reading Score	4.99	8.35	0	29
Bin. Var. = 1 if 0 > Reading > 16	.14	.35	.00	1.00
Bin. Var. = 1 if 15 > Reading	.17	.37	.00	1.00
Years of Education	3.06	3.93	0	14
Bin. Var. = 1 if Only Prim. School	.26	.44	.00	1.00
Bin. Var. = 1 if School > Prim.	.22	.42	.00	1.00
Raven's Test Score	19.86	6.83	6	34
Bin. Var. = 1 if Father Attended School	.10	.30	.00	1.00

related inputs in the production of schooling outcomes. Given this specification of the technical skills production function, the estimated effects of the household characteristics will largely reflect how these regressors perform as direct inputs in the production of farm knowhow.

It seems likely that farmers who were raised in households in which there is experience with HYV seeds will have had greater opportunities to gain skills in modern wheat farming and I expect a positive estimated coefficient for this variable. The effects of our land variables are more difficult to anticipate. I expect that the marginal benefits of farm skills will increase with farm size as technological innovation in agriculture is typically land enhancing. This would suggest positive coefficients on both of our land variables. Alternatively, we have suggested that the availability of irrigation is a prerequisite for the use of many of the modern farming methods and farmers on rainfed land would have less incentive to invest in the acquisition of skills.

Distance from the Village to the Nearest Fertilizer Sales Depot. In our previous analyses, this variable has been used to proxy the availability and price of inputs into agricultural production. As such, it seems likely that technical skills acquisition will be negatively correlated with isolation as farmers with poor access to modern inputs will have less incentive to learn modern methods. In addition, it seems likely that this measure of isolation could proxy the availability of information on farming as more isolated farmers could have poor access to farm extension services. This would compound the negative relation between isolation and technical skills.

Results of OLS Estimation of the Technical Skills Production Function

The Human Capital Variables. Table 3.11 presents the results of OLS estimations of the technical skills production function. Because the measures of reading skills, schooling attainment, and native intelligence are closely correlated, these are introduced one-by-one in separate regressions. The overall explanatory power of these regressions is relatively low, as less than a quarter of the variation in the dependent variable is explained by our independent variables. This is, perhaps, not surprising given the small size of our sample and the fact that our regressors tell us little about the technical skills information available to our respondents.

The results indicate that investment in schooling may increase technical skills. The estimated coefficients for the reading variable are highly significant, but the effect of literacy is shown to have only a modest effect on learning about farming. Increasing a farmer's reading score by 8 points (one S.D. in this variable) is associated with a one-third standard deviation rise in the technical skills grade. Two possible explanations suggest themselves for the weak effect of cognitive skills in the production of farming knowhow. First, the agricultural information that is available to our farmers may be of low quality, or may be transmitted orally, and literate farmers may have no advantage in learning in such an environment.

A second possibility is that the advantages of reading may only exist for those who achieve a relatively high level of cognitive ability, and this non-linear relationship may be obscured by the simple linear form used in this estimation of the technical skills production function. To test for this possibility, in table 3.12 I have decomposed the continuous reading skills variable into two binary variables for high reading achievement (between 16 and 30 points) and low reading achievement (between 1 and 15 points). These regressions indicate that those farmers with low reading skills enjoy no advantage in learning technical skills over illiterate farmers. However, farmers who achieve at least sixteen points on the reading test have scores

Table 3.11 OLS Estimates of the Production Function of Technical Skills in Wheat Farming: Four Specifications

Number of Observations	145			
Mean of Dep. Var.	6.99			
S.D. of Dep. Var.	2.66			
R Square	0.21003	0.21008	0.21722	0.22995
Constant	5.8434	5.8151	5.1848	5.0780
	(7.806)	(7.200)	(5.261)	(5.162)
Acres Irrigated	0.0187	0.0186	0.0169	0.0102
in Father's Holding	(0.894)	(0.888)	(0.806)	(0.479)
Acres Rainfed	-0.0276	-0.0276	-0.0320	-0.0329
in Father's Holding	(-1.505)	(-1.498)	(-1.701)	(-1.758)
Father Used HYV	-0.2410	-0.2324	-0.3499	-0.2451
	(-0.328)	(-0.313)	(-0.467)	(-0.327)
Distance to Fertilizer Depot	-0.0822	-0.0820	-0.0724	-0.0687
	(-2.135)	(-2.114)	(-1.826)	(-1.737)
Age in 1986	0.0338	0.0341	0.0325	0.0347
	(2.508)	(2.442)	(2.315)	(2.466)
Reading Score	0.1070	0.1040	0.1039	0.0970
	(3.981)	(2.488)	(2.489)	(2.320)
Years of Education		0.0087	-0.0244	-0.0285
		(0.096)	(-0.254)	(-0.298)
Raven's Test Score			0.0392	0.0388
			(1.114)	(1.105)
Bin. Var. = 1 if				1.1179
Father Attended School				(1.494)

Table 3.12 OLS Estimates of the Production Function of Technical Skills in Wheat Farming: Four Additional Specifications

Number of Observations	145			
Mean of Dep. Var.	6.99			
S.D. of Dep. Var.	2.66			
R Square	0.21602	0.22068	0.22887	0.24635
(Constant)	6.0999	6.1076	5.4089	5.305227
	(7.806)	(7.045)	(5.175)	(5.107)
Acres Irrigated	0.0249	0.0247	0.0229	0.014927
in Father's Holding	(1.204)	(1.176)	(1.092)	(0.700)
Acres Rainfed	-0.0217	-0.0211	-0.0257	-0.026348
	(-1.164)	(-1.128)	(-1.348)	(-1.391)
Father Used HYV	-0.4065	-0.3983	-0.5054	-0.388408
	(-0.552)	(-0.537)	(-0.678)	(-0.523)
Distance to Fertilizer Depot	-0.0920	-0.0915	-0.0812	-0.077683
	(-2.363)	(-2.338)	(-2.031)	(-1.954)
Age in 1986	0.0307	0.0305	0.0289	0.030893
	(2.221)	(2.072)	(1.955)	(2.102)
Bin. Var. = 1 if	0.0256	-0.1407	-0.1792	-0.359375
0 > Reading > 16	(0.041)	(-0.180)	(-0.230)	(-0.461)
Bin. Var. = 1 if 15 < Reading	2.3586	2.0305	1.9921	1.840880
	(3.936)	(2.481)	(2.436)	(2.256)
Bin. Var. = 1 if Only		-0.1303	-0.1924	-0.195121
Prim. School		(-0.208)	(-0.306)	(-0.313)
Bin. Var. = 1 if		0.4734	0.1491	0.083300
School > Prim.		(0.562)	(0.169)	(0.095)
Raven's Test Score			0.0423	0.042481
			(1.193)	(1.206)
Bin. Var. = 1 if				1.316552
Father Attended School				(1.756)

Table 3.13 OLS Estimates of the Production Function of Technical Skills in Wheat Farming for Illiterate Farmers

No. of Observations = 45			
Mean of Dep. Var.	7.84		
S.D. of Dep. Var.	*2.98*		
R Square	0.37584	0.47965	
			Mean *Std. Dev.*
Constant	2.2281	0.8196	
	(1.154)	(0.426)	
Acres Irrigated	-0.0423	-0.0420	13.07
in Father's Holding	(-1.041)	(-1.082)	*15.05*
Acres Rainfed	-0.1379	-0.1123	9.15
in Father's Holding	(-3.038)	(-2.471)	*14.76*
Father Used HYV	0.6686	1.9982	0.02
	(0.244)	(0.762)	*0.15*
Distance to Fertilizer Depot	0.1983	0.1311	7.18
	(1.433)	(0.966)	*4.17*
Age	0.0620	0.0518	33.13
	(2.423)	(2.129)	*15.61*
Raven's Test Score	0.1650	0.1434	23.87
	(2.639)	(2.317)	*6.40*
Reading Test Score		0.1594	16.07
		(2.587)	*6.79*
Years of Education		-0.0108	7.82
		(-0.076)	*3.02*

that are almost one-half standard deviation higher on the technical skills exam.

The experience of the farmer, as proxied by age, is also seen to have a highly significant but modest effect on farming knowhow. Raising the average age of the respondent by 17 years (one standard deviation) increases the technical skills result by seven percent. Employing alternative specifications of the technical skills production function (not shown) I found that this result for age, and those for reading, are highly robust to the inclusion and exclusion of other regressors.

Neither years of schooling nor native intelligence can be shown to have an effect on technical skills acquisition, once we control for reading ability and experience.

Table 3.14 OLS Estimates of the Production Function of Technical Skills in Wheat Farming for Literate Farmers

No. of Observations = 100

Mean of Dep. Var.	6.61	
S.D. of Dep. Var.	2.43	
R Square	0.10861	
		Mean *Std. Dev.*
Constant	6.3691	
	(5.481)	
Acres Irrigated	0.0474	8.53
in Father's Holding	(1.554)	*9.57*
Acres Rainfed	-0.00069	7.30
in Father's Holding	(-0.030)	*12.54*
Father Used HYV	-0.5120	0.13
	(-0.658)	*0.34*
Distance to Fertilizer Depot	-0.0865	9.20
	(-1.956)	*5.87*
Age	0.0196	44.14
	(1.175)	*16.02*
Raven's Test Score	-0.0090	18.06
	(-0.223)	*6.26*

This latter result is surprising as more than half of our test takers are illiterate and one might expect that native intelligence would be especially important in skills acquisition for this group. This result suggests the possibility that literate and illiterate farmers may use different processes to acquire farm knowhow and that it might be appropriate to make separate estimates of technical skills acquisition for these groups. In tables 3.13 and 3.14 I present separate technical skills production functions for the 45 literate and 100 illiterate farmers in our test sample. Rather surprisingly, these results show that while native intelligence has no effect on the technical skills production for the illiterate, it does impact the results for the literate group, even when one controls for schooling and reading ability.

Summary and Conclusions

The principal objective of this dissertation has been to assess whether the low levels of enrollment and high levels of child labor utilization observed in rural Pakistan are a supply phenomenon — the result of inadequate availability of schooling or credit constraints — or is demand related — the result of differences in households' capacity to either capitalize on the education of children or profit from the use of child labor. I have approached this question by examining whether households face trade-offs in agricultural earnings between using child labor and acquiring additional human capital. This analysis has found a large and significant increase in farm earnings resulting from improving the cognitive skills of family members. This result is consistent with the benefits found in previous studies that have examined the relationship between human capital and farm productivity.

This study has also found, however, that boys engaged in farm labor can make a large contribution to the economic wellbeing of their family, and that this contribution is largely eliminated when children are enrolled in school. It seems likely that the high opportunity cost of schooling boys derives from their being especially suited for tending animals, from the fact that keeping livestock has a high rate of return, and from the full-time, year-round nature of employment in animal care which precludes schooling. I have found that once one accounts for the cost of schooling, the returns to education in terms of household farm profitability are positive but modest.

My principal econometric concern in this analysis has been omitted variables bias. Unobserved characteristics of the family farm may be correlated with both agricultural earnings and the enrollment status of boys. I have used instrumental variables to control for this possibility: I have regressed the number of boys enrolled in a family on household, village, and school characteristics and used predicted enrollment as a regressor in the agricultural profit function (agricultural profits are identified by the quality and availability of schools, which are assumed to affect farm operations only insofar as they influence enrollment.) I find very little difference between the OLS and the two-stage least squares regressions, suggesting that there is little correlation between the error term and the enrollment variable. I have also tested for the possibility that omitted variables affect household child bearing behavior and, in turn, bias my estimates of the value of boy labor. However, once again my tests do not suggest the presence of missing variables bias.

A second objective of this dissertation has been to explore the determinants of schooling investment and the use of child labor, and to identify the mechanisms through which various personal, household, village, and school characteristics act on the allocation of boy time. Specifically, I have considered four ways that explanatory variables can act on boy time allocation: i) through an income effect, ii) as a substitute for boy labor in household agricultural production, iii) as a complement to human capital in farm activities, or iv) as an input in the production of human capital (either cognitive skills or technical knowledge of farming).

Each of these four mechanisms has been examined separately, but I have yet to compare the results of my various analyses to evaluate their consistency. As a first step in such a comparison, I have applied a rather narrow standard and defined my results to be *inconsistent* if household behavior, in either investment in education or the use of boy labor, is incompatible with the technical relationships embodied in the creation of agricultural profits or the production of human capital. For example, it would be inconsistent for households to decrease the use of boy labor because of the presence of a factor input that i) had a positive interaction with the use of boy labor in the agricultural profit function and that ii) was associated with smaller returns to schooling.

Because my model of household behavior produces complex and ambiguous predictions, this standard for consistency is relatively weak. The four mechanisms through which an explanatory variable can act on boy time can work in the same direction or can offset each other, and the results of my analyses do not indicate the relative magnitude of these effects. This means that for an estimated coefficient to be inconsistent with our model, its sign needs to be at variance with all four mechanisms acting on the allocation of boy time. Not surprisingly, by this definition, none of the estimated coefficients in the analyses of schooling and boy-labor use can be classified as inconsistent.

A more detailed examination of our results suggests a rather high degree of cohesion among several of our findings. One of the most striking results is the effect of livestock on the allocation of boy time. In chapter two, I observed that this asset acts to raise the time spent in labor by boys, and I hypothesized that this asset acts through the agricultural production function, either as a complement to boy labor or as a substitute to human capital. In the estimated agricultural profit function presented in table 3.4, I found a positive and significant interaction between the number of unenrolled boys and the value of livestock, and a negative and significant interaction between reading and livestock.

My analyses of household behavior, however, found no relationships between the value of livestock and either the likelihood of enrollment or a person's schooling attainment. While one would expect that an asset which impels the use of child labor would act to reduce schooling, the insensitivity of schooling investment to the value of livestock may be the consequence of an income effect offsetting the impact of the cross-input effects that we have observed. Households that have more (less) first period livestock and which are excluded from the credit market, might be expected to reduce (raise) their use of boy labor and increase (lower) their schooling investment in order to transfer resources to (from) the second period.

There appears to be even greater complexity in the relationship between ownership of irrigated land and the allocation of boy time. Our profit functions suggest that this factor input is a complement to both boy labor and human capital. These conflicting cross-input relationships may explain why we observe little effect from the ownership of this asset on the use of boy labor. While this asset has a small positive and significant impact on the likelihood of full-time employment, in neither the probit of at-least part time employment nor the Tobit of days worked, does the coefficient on this regressor reach significance at the ten percent level.

There may be a still more complex relationship between ownership of irrigated land and schooling. This asset both raises the likelihood of current enrollment for older boys and increases grade attainment. This is contrary to the complementarity between boy labor and ownership of this asset. However, the relationship *is* consistent with both the complementarity between human capital and irrigated land and an income effect (if households are seeking to transfer resources to (from) the second period due to greater (lesser) stocks of this asset in the first period).

Some of the school-related variables also have significant effects on the allocation of boy time. Among these are the distance to primary school and the distance to intermediate school. Both carry large, positive, and significant coefficients in the probit analyses of labor participation and in the Tobit analysis of days worked. The distance to primary school also has a large, negative, and significant coefficient in the probit regression of current enrollment among boys 10 to 12. These distance variables do not affect the production of cognitive skills beyond their influence on schooling attainment,[23] and this would suggest that their impact is solely on the opportunity costs of schooling.

---

[23] See the discussion of the test of overidentifying restrictions for the cognitive skills production function.

Among the school quality variables, only the reading skills of teachers can be shown to influence the allocation of boy time, and this is limited to a small positive effect in one specification of the Tobit estimate of grade attainment. This positive result may be explained by the finding that the reading ability of teachers has a positive and significant effect in the production of cognitive skills. A higher student-teacher ratio was found to be associated with a lower level of grade attainment among our cohort of young men, but with a higher probability of current enrollment among the cohort of boys. While this variable could not be shown to affect the production of cognitive skills, it is positively and significantly correlated with the variance of the error term in the Tobit regression of grade attainment. This suggests the possibility that the student-teacher ratio is capturing aspects of both the quality of schools and the demand for quality schooling. None of the school quality variables could be shown to influence the probability that boys work, or the amount of work being performed by boys.

Although this analysis has taken an agnostic view of the social value of schooling and child labor, a study of this type invariably has implications for those pursuing particular policy objectives. We have observed that there is a sharp reduction in the enrollment of boys between the ages of 6 and 9, but this analysis suggests few policy remedies for those who would wish to curtail the high rate of primary school leaving in rural Pakistan. While the availability of books has been shown to reduce the drop-out rate for this cohort, neither greater availability of schools nor improvements in the other measures of school quality can be shown to affect enrollment for the youngest of school boys. Improving the availability of schools would, however, act to lessen the use of boy labor and to increase the likelihood of ongoing enrollment among those boys who have remained in school to the age of 10. Since the allocation of time among the youngest boys is largely insensitive to the existing educational policy instruments, those favoring greater schooling among Pakistani children might wish to pursue mandatory enrollmeant, at least through fourth grade.

Not only has this analysis purposely avoided issues related to the social values of schooling and the use of child labor, it has also left open the question of whether households are acting in their own best interests when they keep young children from school in order to work on the family farm. A definitive statement on this latter issue would require a better understanding of the mechanisms through which cognitive skills operate on farm profitability and more insight on how resources are allocated over time within the Pakistani household. Among the questions that need to be addressed are the following: the extent to which the human capital of farm workers complements (or substitutes for) the knowledge of their co-workers (e.g., does a household benefit from having more than one educated member); how does schooling affect the allocation of tasks within the household; how does education impact the likelihood of pursuing work outside of the household operation; and how do parents adjust the allocation of resources within the household to complement, or compensate for, the way in which they distribute their human capital investments among their children. It would also be useful to further explore what levels of schooling (primary or secondary) and what elements of schooling (literacy or numeracy) make the greatest contribution to household earnings.

The greatest obstacle to exploring these questions is the lack of useful information to support analysis. The data used in the current study are among the richest ever gathered on household behavior in a developing nation. Nevertheless, the high cost of collecting this information required limiting our sample to only a few hundred households, and this small sample size greatly constrained what could be attempted in this investigation. The value of future work on human capital investment, and the value of collecting the data necessary to support this work, should be viewed in the context of improving the efficiency with which developing nations spend the more than $100 billion dollars per year in education, health, and other human resource investments.

APPENDICES

Appendix I

Deriving the Comparative Statics for the Model of Boy Time Allocation

The First Order Conditions

This appendix shows the derivation of the first and second order conditions and factor demand equations for model two of chapter two. The household's constrained maximization problem is as shown in the Lagrangian in equation 2.5. Setting the price of second period production equal to one and differentiating the Lagrangian with respect to the endogenous variables and the Lagrangian constraints produces the following first order conditions:

$$\frac{\partial L}{\partial q_1} = U_1 - \lambda_1 P_{q_1} = 0$$

$$\frac{\partial L}{\partial q_2} = U_2 - \lambda_2 P_{q_2} = 0$$

$$\frac{\partial L}{\partial x_1} = -\lambda_1 P_{x_1} + \lambda_1 P_{f_1} \frac{\partial f_1}{\partial x_1} = 0$$

$$\frac{\partial L}{\partial x_2} = -\lambda_2 P_{x_2} + \lambda_2 \frac{\partial f_2}{\partial x_2} = 0 \qquad (AI.1)$$

$$\frac{\partial L}{\partial L_1^{CE}} = -\lambda_1 P_{f_1} \frac{\partial f_1}{\partial L_1} + \delta \lambda_2 \frac{\partial f_2}{\partial HK_2} = 0$$

$$\frac{\partial L}{\partial B} = \lambda_1 - \lambda_2(1+r) = 0$$

$$\frac{\partial L}{\partial \lambda_1} = -P_{q_1}q_1 - P_{x_1}x_1 + P_{f_1}f_1(F, T^C - L^{CE}, HK_1, x_1) + B = 0$$

$$\frac{\partial L}{\partial \lambda_2} = -P_{q_2}q_2 - P_{x_2}x_2 + f_2(F, T^C, HK_1 + \delta L^{CE}, x_2) - B(1+r) = 0$$
$$(AI.1\ Cont'd)$$

This model yields a set of demand equations for the consumption goods, for borrowing (or lending), and for the production inputs (including child labor and second period human capital). The allocation of child time between schooling and labor is determined by the production decisions made by the household in both periods and can be written as a function of the household's initial endowments of physical and human capital, prices in both periods, the interest rate, and the efficiency with which child time is converted into the human capital that is useful in agriculture. Since the demand for the other factor inputs, x_1 and x_2, are determined simultaneous with the allocation of child time, all factor demand equations can be written as functions of the same exogenous variables:

$$\begin{aligned} L_1^{CE} &= h_{L_1^{CE}}(HK_1, P_{q_1}, P_{q_2}, P_{x_1}, P_{x_2}, P_{f_1}, P_{f_2}, r, \delta) \\ x_1 &= h_{X_1}(HK_1, P_{q_1}, P_{q_2}, P_{x_1}, P_{x_2}, P_{f_1}, P_{f_2}, r, \delta) \qquad (AI.2) \\ x_2 &= h_{X_2}(HK_1, P_{q_1}, P_{q_2}, P_{x_1}, P_{x_2}, P_{f_1}, P_{f_2}, r, \delta) \end{aligned}$$

The Second Order Conditions

Totally differentiating the first order conditions with respect to exogenous and endogenous variables yields the following:

$$\begin{bmatrix} U_{1,1} & U_{1,2} & 0 & 0 & 0 & 0 & -P_1 & 0 \\ U_{2,1} & U_{2,2} & 0 & 0 & 0 & 0 & 0 & -P_2 \\ 0 & 0 & A & 0 & C & 0 & 0 & 0 \\ 0 & 0 & 0 & D & E & 0 & 0 & 0 \\ 0 & 0 & C & E & H & 0 & I & J \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & -(1+r) \\ -P_{q_1} & 0 & 0 & 0 & I & 1 & 0 & 0 \\ 0 & -P_{q_2} & 0 & 0 & J & -(1+r) & 0 & 0 \end{bmatrix} \begin{bmatrix} dq_1 \\ dq_2 \\ dx_1 \\ dx_2 \\ dL_1^{CE} \\ dB \\ d\lambda_1 \\ d\lambda_2 \end{bmatrix} = \mathbf{Z} \quad (AI.3)$$

where

$$\text{A} = \lambda_1 P_{f_1}\frac{\partial^2 f_1}{\partial \text{x}_1^2} \qquad \text{C} = -\lambda_1 P_{f_1}\frac{\partial^2 f_1}{\partial x_1 \partial L_1^{CW}} \qquad D = \lambda_2\frac{\partial^2 f_2}{\partial x_2^2}$$

$$E = \delta\lambda_2 \frac{\partial^2 f_2}{\partial x_2 \partial HK_2} \qquad H = \lambda_1 P_{f1} \frac{\partial^2 f_1}{\partial {L_1}^2} + \delta^2 \lambda_2 \frac{\partial^2 f_2}{\partial HK_2^2} \qquad I = P_{f1} \frac{\partial f_1}{\partial L_1}$$

$$J = \delta \frac{\partial f_2}{\partial HK_2}$$

For illustrative purposes, I assume that δ is the only exogenous variable, so the matrix $\mathbf{Z}$ can be written as

$$\mathbf{Z}^{\mathbf{T}} = [0, 0, 0, \alpha, \beta, 0, 0, \Delta]$$

where

$$\alpha = -\lambda_2 L_1^{CE} \frac{\partial^2 f_2}{\partial x_2 \partial HK_2}$$

$$\beta = -\lambda_2 \delta L_1^{CE} \frac{\partial^2 f_2}{\partial HK_2^2} - \lambda_2 \frac{\partial f_2}{\partial HK_2} \qquad \Delta = -L_1^{CE} \frac{\partial f_2}{\partial HK_2}$$

Applying Cramer's rule yields

$$\frac{\partial L^{\mathrm{CE}}}{\partial \delta} = (-1)^9 \alpha \frac{|D_{4,5}|}{|D|} + (-1)^{10} \beta \frac{|D_{5,5}|}{|D|} + (-1)^{13} \Delta \frac{|D_{8,5}|}{|D|}$$

where $|D|$ is the determinant of the bordered Hessian matrix and $|D_{ij}|$ is the co-factor of row i and column j. The concavity conditions ensure that $|D| > 0$. This comparative static can be rewritten as

$$\frac{\partial L_1^{CE}}{\partial \delta} =$$

$$- \frac{\alpha}{|D|} \Big(AE\{P_{q_2}^2 U_{1,1} - 2(1+r) P_{q_1} P_{q_2} U_{1,2} + (1+r)^2 P_{q_1}^2 U_{2,2} \Big) \quad \Big\} \text{Subs. Effect w.r.t. } x_2$$

$$+ \frac{\beta}{|D|} \Big(AD \big[P_{q_2}^2 U_{1,1} + P_{q_1}^2 (1+r)^2 U_{2,2} - 2 P_{q_1} P_{q_2} (1+r) U_{1,2} \big] \Big) \quad \Big\} \text{Own Subs. Effect}$$

$$- \frac{\Delta}{|D|} \Big((1+r) I + J \Big) (U_{1,1} U_{2,2} - U_{1,2}^2) \quad \Big\} \text{Income Effect} \qquad (AI.4)$$

Interpreting the Comparative Statics

Each of the three terms on the right hand side of Equation $AI.4$ can be interpreted as a specific substitution or income effect. The first term is the cross substitution effect relative to the second period purchased input. If the efficiency of schooling is increased, the cost of the human capital input declines relative to the cost of the second period purchased inputs. The sign of this effect depends on whether the purchased input is a substitute or a complement to human capital in second period production (the sign of the term E depends on whether inputs are substitutes or complements).

The second term can be thought of as the 'own substitution effect' of the change in education efficiency in that it indicates how the household responds to the change in what it must pay to acquire human capital — without reference to any changes in relative prices of inputs or changes in income that result from altered input prices. This effect can be signed as unambiguously positive.

The third term is the second period income effect. Improving the efficiency of schooling results in greater second period production for households that undertake investment in human capital. If consumption is a normal good in both periods, the household will shift some of the increase in production capacity to first period consumption through increased borrowing or reduced human capital investment. Given that the improvement in the efficiency of education implies an increase in the returns to schooling, households will transfer income from the second period to the first period by lessening the amount that it lends (or increasing the amount that it borrows) in the capital market, but will not alter schooling investment as a consequence of a change in income. Thus, the second period income effect will equal zero, and the overall effect of the change in schooling investment as a result of improved schooling efficiency is positive. (Note that, when the household is not constrained in borrowing, the first order conditions ensure that $(1+r)I+J=0$.)

Appendix II

The Exam of Technical Skills in Agriculture

(Correct answer denoted with asterisk)

---

1. Some fertilizers help only the part of a plant above the soil. Other fertilizers help only the roots of a plant. Which part of the plant does UREA help?

   a. The part above the soil.* b. The roots. c. Don't know.

2. Some fertilizers remain in the soil and help plants for only a few weeks, while other fertilizers remain and help plants for a amuch longer time. Of the following, which fertilizer remains in the soil for the shortest time?

   a. Urea* b. DAP c. Manure d. Don't Know

3. Some fertilizers can benefit wheat only if they are applied by planting time, while other fertilizers can help wheat even if they are applied after planting time. Of the following, which fertilizer is useless to wheat if it is applied after planting?

   a. Urea b. DAP* c. Don't Know

4. What is the main chemical ingredient of DAP? (Phosphate)

5. What is the main chemical ingredient of Urea? (Nitrogen)

6. When is it most likely that wheat seed will shatter?

   a. When the wheat is harvested early

   b. When the wheat is harvested on time

   c. When the wheat is harvested late*

   d. Don't Know

7. If the soil at planting time is dryer than normal, you should

   a. Plant deeper than you normally do*

   b. Plant shallower than you normally do

   c. Don't know

8. If the soil at planting time is wetter than normal and you cannot wait for the field to dry, you should

   a. Increase the amount of seed that you sow*

   b. Decrease the amount of seed that you sow

   c. Use the usual amount of seed

   d. Don't know

9. If you wish to keep some wheat seed from one year to be used for planting in the next year, what special treatment should you give to the seed? (Thresh separately or clean)

10. If you fertilize with DAP and Urea, you will have more weeds than if you fertilize with manure.

a. True b. False* c. Don't Know

11. Which will result in more weed problems?

a. Growing wheat during every Rabi season?*

b. Growing wheat in some Rabi seasons and other crops in other Rabi seasons

c. Don't Know

12. Mixing mustard with your wheat crop will reduce the yield of your wheat harvest.

a. True* b. False c. Don't Know

13. If there are areas on your field with bad drainage, the chemical composition of these areas can change over time and reduce the yields on these parts of your land. What is the harmful chemical that builds up in areas with bad drainage? (Saline)

14. There is another chemical which can be applied to get rid of this problem. What is its name? (Gypsum)

BIBLIOGRAPHY

BIBLIOGRAPHY

Ahmad, A. and M.A. Quasem (1991), *Child Labor in Bangladesh,* The Bangladesh Institute of Development Studies.

Alderman, H., Behrman, J.R., Khan, S., Ross, D.R., and Sabot, R. (1995). "Public Schooling Expenditures in Rural Pakistan: Efficiently Targeting Girls and a Lagging Region," in van de Walle, K. and Nead, K. (eds.), *Public Spending and the Poor: Theory and Evidence,* The Johns Hopkins Press for the World Bank, Baltimore.

Alderman, H., J.R. Behrman, D.R. Ross, and R.H. Sabot (1996) "The Returns to Endogenous Human Capital in Pakistan's Rural Wage Labour Market," Oxford Bulletin of Economics and Statistics, 58.

Alderman, H., P. Chiappori, L. Haddad, J. Hoddinott, and Ravi Kanbur (1995) "Unitary versus Collective Models of the Household: Is It Time to Shift the Burden of Proof?" *The World Bank Research Observer*, vol. 10, No. 1, February.

Alderman, H., and M. Garcia (1993) *Poverty, Household Food Security, and Nutrition In Rural Pakistan,* The International Food Policy Research Institute, Research Report 96.

Ali and Flynn (1985) "Profit Efficiency Among Basmati Rice Producers in Pakistan Punjab." Paper presented to the National Rice Seminar, Islamabad.

Allen, MJ and WM Yen (1979) *Introduction to Measurement Theory,* Brooks/Cole Publishing Company, Monterey, California.

Azhar, R.A. (1991) "Education and the Technical Efficiency during the Green Revolution in Pakistan," Economic Development and Cultural Change.

Barichello (1984) "The Productive Value of Schooling in Canadian Agriculture", Yale University Economic Growth Center Paper.

Becker, G. (1964) *Human Capital,* Inst. Publ. Admin., Univ. Michigan, Ann Arbor.

——, (1981) *A Treatise on the Family,* Cambridge, Mass., Harvard University Press.

Ben-Porath, Yoram (1967) "The Production of Human Capital and the Life Cycle of Earnings," *The Journal of Political Economy* vol. 75.

Behrman, J. (1990) "The Action of Human Resources and Poverty on One Another: What We Have Yet to Learn", Living Standards Measurement Study No. 74 of the World Bank.

Behrman, J. (1996) "Measuring the Effectiveness of Schooling Policies in Developing Countries: Revisiting Issues of Methodology," *Economics of Education Review,* Vol. 15, No. 4.

Behrman, J., and N. Birdsall (1983) "The Quality of Schooling: Quality Alone Is Misleading," *American Economic Review* vol 73.

Behrman, J., N. Birdsall, and A. Deolalikar (1993) "Marriage Markets, Labor Markets, and Unobserved Human Capital: An Empirical Exploration for South-Central India." A University of Pennsylvania Working Paper.

Behrman, J.R., Ross, D.R., Sabot, R. and Tropp, M. (1994), "Improving the Quality Versus Increasing the Quantity of Schooling," the University of Pennsylvania, Philadelphia, PA, mimeo.

Behrman, J.R. and Schneider, R. (1993) "An International Perspective on Pakistani Human Capital Investments in the Last Quarter Century," *Pakistan Development Review,* Vol. 32, pp 1-68.

Bhagwati, J.N., and Chakravarty, S. (1971) 'Contributions To Indian Economic Analysis', *American Economic Review*, Supplement, Vol. 59.

Bhatti, M.A., M.M. Afzal, M. Nadeem, et.al. (1986) *Primary Education Improvement: Desired Measures.* National Education Council, Islamabod.

Bhatti, M.A., et.al. (1988) *Female Teachers in Rural Areas of Pakistan.* National Education Council, Islamabad.

Bliss, G.J. and N.H. Stern (1982) *Palanpur: the Economy of An Indian Village*, Clarendon Press, Oxford.

Blood, Peter (1995) *Pakistan: a Country Study,* Federal Research Division, the Library of Congress, Washington, DC.

Bound, J., Jaeger, D.A. and Baker, R., (1993) "The Cure Can be Worse than the Disease: A Cautionary Tail Regarding Instrumental Variables," Research Technical Paper 137, Cambridge, BA: National Bureau of Economic Research.

Brown, Charles (1976) "A Model Of Human Capital Accumulation and the Wages of Young High School Graduates," *The Journal of Political Economy*, vol. 84, no. 2.

Breusch, T.S. and Godfrey, L.G. (1981) "A Review of Recent Work on Testing for Autocorrelation in Dynamic Simultaneous Models," in *Macroeconomic Analysis*, edited by D. Currie, et. al., Croom Helm, London.

Butt, M.S. (1984) "Education and Farm Productivity in Pakistan," *Pakistan Journal of Applied Economics.*

Byerlee, Derek (1987) "Maintaining the Momentum in Post-Green Revolution Agriculture: A Micro-Level Perspective from Asia," MSU International Development Paper, No. 10, The Department of Agricultural Economics, Michigan State University.

Cain, Mead T. (1977) *The Economic Activities of Children, Village Fertility Study Report No. 3,* Bangladesh Institute of Development Studies.

Card, D. and Krueger, A.B. (1992) "Does School Quality Matter? Returns to Education and the Characteristics of Public Schools in the United States," *Journal of Political Economy,* Vol. 100.

Chiang, A.C. (1992) *Dynamic Optimization,* McGraw-Hill, New York.

Clark, Colin (1967) *Population Growth and Land Use*, St. Martin's Press.

Davidson, R. and J.G. MacKinnon (1993) *Estimation and Inference in Econometrics*, Oxford University Press, New York.

Deaton, A. (1997) *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy,* The Johns Hopkins University Press for the World Bank, Baltimore.

Deolalikar, A.B. (1988), "Nutrition and Labour Productivity in Agriculture: Estimates for Rural South India," *Review of Economics and Statistics,* Vol. 70.

De Tray, D. (1983) " Children's Work Activities in Malaysia," *Population and Development Review,* Vol. 9, No. 3, 437-456.

Foster, A. and Rosenzweig, MR (1995) "Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture," *Journal of Political Economy,* 103, 1176-1209.

Fuller, Bruce (1986) *Raising School Quality In Developing Countries: What Investments Boost Learning?* The World Bank, Washington, D.C.

Gertler, P. and J. van der Gaag. (1990) *The Willingness To Pay For Medical Care,* The World Bank, Washington, D.C.

Glewwe, P. and H. Jacoby (1992) *Estimating the Determinants of Cognitive Achievement in Low-Income Countries,* Living Standards Measurement Study Working Paper No. 91, The World Bank.

Glewwe, P. and H. Jacoby (1994) "Student Achievement and Schooling Choice in Low Income Countries: Evidence from Ghana," *Journal of Human Resources,* Vol. 29.

Greene, W.H. (1990) *Econometric Analysis,* Macmillian Publishing Company, New York, NY.

—— (1992) Limdep 6.0 *User's Manual and Reference Guide,* Econometric Software, Inc., Bellport, NY.

Haley, William (1973) "Human Capital: The Choice Between Investment and Income," *The American Economic Review* vol 63, no. 5.

Haley, William (1976) "Estimation of the Earnings Profile From Optimal Human Capital Accumulation," *Econometrica* vol. 44, No. 6.

Harbison, R.W. and E.A. Hanushek (1992), *Educational Performance of the Poor: Lessons from Rural Northeast Brazil,* Oxford University Press for the World Bank, New York.

Haveman, R. and Wolfe, B.L. (1984) "Education and Wellbeing: the Role of Non-Market Effects," *The Journal of Human Resources,* Vol. 19.

Haveman, R. and Wolfe, B.L., (1993) "Children's Prospects and Children's Policy," *The Journal of Economic Perspectives,* Vol. 7.

Heckman, James (1976) "A Life Cycle Model of Earnings, Learning, and Consumption," *Journal of Political Economy* vol. 84, no. 4, pt. 2.

Heckman, J.J., Layne-Farrar, A., and Todd, P. (1994) *Does Measured School Quality Really Matter? Understanding the Empirical and Economic Foundations of the Evidence,* University of Chicago Press, Chicago.

Heckman, J.J. and Polachek, S. (1974), "Empirical Evidence on the Functional Form of the Earnings–Schooling Relationship," *Journal of the American Statistical Association,* Vol. 69.

Heyneman, S.P. (1983) "Improving the Quality of Education in Developing Countries," *Finance and Development* 20.

Hsiao, C. (1986) *Analysis of Panel Data,* Cambridge University Press, Cambridge.

Huke, R.E., Cordova, V., and Sardido, S. (1982) "San Bartolome: Beyond the Green Revolution," Research Report 74, IRRI, Los Banos.

Instituto del Tercer Mundo (1996), *The World: A Third World Guide.*

International Institute for Strategic Studies (1995) *The Military Balance 1995-1996,* Oxford University Press, London.

Jacoby, Hanan G. (1994) "Borrowing Constraints and Progress Through School: Evidence From Peru," *The Review of Economics and Statistics,*, February.

Jamison, D.T. and L.J. Lau (1982) *Farmer Education and Farmer Efficiency,* Johns Hopkins Press, Baltimore.

Jamison and Moock (1981) "Farmer Education and Farm Efficiency in Nepal: The Role of Schooling, Extension Services, and Cognitive Skills" in *World Development*, Vol. 12, No. 1, pp 67-86.

Kanbargi, R. (1991) *Child Labour in the Indian Subcontinent: Dimensions and Implications*, Sage Publications.

Kanbargi, R. and P.M. Kulkarni. (1985) *Child Labour, Schooling, and Fertility in Rural Karnataka, South India*, Bangalore, Institute for Social and Economic Change, mimeo.

Khan, S.R. and Irfan, M. (1985), "Rates of Return to Education and the Determinants of Earnings in Pakistan," *Pakistan Development Review*, Vol. 24.

Khandker, Shahidur Rahman (1986) "Farmer Education and Farm Efficiency: The Role of Education Revisited" Yale University Economic Growth Center, Center Discussion Paper No. 506.

King, E.M. (1990) *Educating Girls and Women: Investing in Development*, The World Bank, Washington, D.C..

Knight, J.B. and Sabot, R.H. (1990). *Educational Productivity and Inequality: the East African Natural Experiment*. Oxford University Press, New York.

Kodde, D., and J. Ritzen (1985) "The Demand for Education Under Capital Market Imperfections," *European Economic Review*,, August.

Kozel, V. and Alderman, H. (1990), "Factors Determining Work Participation and Labor Supply Decisions in Pakistan's Urban Areas," *Pakistan Development Review*, Vol. 29.

Lam, D. and R.F. Schoeni (1993) "Effects of Family Background on Earnings and Returns to Schooling: Evidence From Brazil," *Journal of Political Economy*, vol. 101, no. 4.

Lipton, M. (1977) *Why Poor People Stay Poor: Urban Bias in World Development*, London, Temple Smith.

Lockheed, M.E. and Hanushek, E. (1988) "Improving Educational Efficiency in Developing Countries: What Do We Know?" *Compare* Vol. 18.

Lockheed, M., Jamison, D., and Lau, L. (1980) "Farmer Education and Farm Efficiency: A Survey" in *Economic Development and Cultural Change.*

Maddala, G. (1983) *Limited Dependent and Qualitative Variables in Econometrics*, Cambridge University Press, Cambridge.

Mingat, A. and Tan, J. (1988) *Analytical Tools for Sector Work in Education*, Johns Hopkins Press, Baltimore.

Nabi, I., Hamid, N., and Zahid, S. (1986) *The Agrarian Economy of Pakistan: Issues and Policies*, Oxford University Press, Karachi.

Naidu, D. (1981) "Child Labour Participation in India: A Statewise Census Analysis," *Journal of Family Welfare*, Vol. 27, No. 4.

Nag, M, R.C. Peet, and B. White (1977) "Economic Value of Children in Two Peasant Societies," *Proceedings of International Population Conference*, Mexico City, Liege, IUSSP.

Nag, M. B. White, and R.C. Peet (1978) "An Anthropological Approach to the Study of Economic Value of Children in Java and Nepal," *Current Anthropology*, Vol. 19, No. 2.

Orazem, P. (1987) "Black-White Differences in Schooling Investment and Human Capital Production in Segregated Schools," *American Economic Review*, Vol 77.

Pasha, H., and Hasan, T. (1982) "Development Ranking of Districts in Pakistan." *Pakistan Journal of Applied Economics* 1, (Winter), pp 157-192.

Pitt, M.M. and Sumodiningrat, G. (1991) "Risk, Schooling, and the Choice of Seed Technology in Developing Countries: A Meta-Profit Function Approach," *International Economic Review*, Vol. 32.

Psacharopoulos, G. and A Arriagada (1989) "The Determinants of Early Age Human Capital Formation: Evidence from Brazil," *Economic Development and Cultural Change* Vol. 37, No. 4, 683-708.

Psacharopoulos, G. and M. Woodhall (1985) *Education For Development*, The World Bank.

Raven, J.C. (1956). *Guide to Coloured Progressive Matrices,* Lewis, London.

Ram, Rati (1980) "The Role of Education in Production: A Slightly New Approach" in *Quarterly Journal of Economics.*

Rogers, E.M. (1983) *Diffusion of Innovations,* Free Press, Glencoe, NY.

Rodgers, G. and Standing, G. ed. (1981) *Child Work, Poverty, and Underdevelopment,* International Labour Office, Geneva.

Rosenzweig, M.R., (1977) "The Demand for Children in Farm Households," *Journal of Political Economy,* vol. 85, no. 1.

Rosenzweig, M.R., (1980) "Neoclassical Theory and the Optimizing Peasant: an Econometric Analysis of Market Family Labor Supply in a Developing Country," *Quarterly Journal of Economics,* 95: 31-55.

Rosenzweig, M.R., (1982) "Agricultural Development, Education, and Innovation," in *The Theory and Experience of Economic Development: Essays in Honor of W. Arthur Lewis,* Edited by Mark Gersovitz, et. al., Allen and Unwin, Boston.

Rosenzweig, M.R., (1982a) "Educational Subsidy, Agricultural Development, and Fertility Change," *Quarterly Journal of Economics* 97, 67-88.

Rosenzweig, M.R., (1986) "Birth Spacing and Sibling Inequality: Asymmetric Information within the Family," *International Economic Review,* 27, 55-76.

Rosenzweig, M.R. (1995) "Why are there Returns to Schooling?" *American Economic Review,* 85, 153-158.

Rosenzweig, M.R. and Evenson, R.E. (1977) "Fertility, Schooling, and the Economic Contribution of Children in Rural India: an Econometric Analysis" in *Econometrica,* Vol. 45, No. 5.

Rosenzweig, M.R., and Schultz, T.P. (1982) "Market Opportunities, Genetic Endowments, and Intrafamily Resource Distribution: Child Survival in Rural India," American Economic Review, Vol. 72, 803-15.

Rosenzweig, M.R., and K.I. Wolpin (1993), "Credit Market Constraints, Consumption Smoothing and the Accumulation of Durable Production Assets in Low Income Countries: Investment in Bullocks in India." *The Journal of Political Economy*, vol. 101, no. 2.

Sabot, Richard (1990) "Human Capital Accumulation in Post-Green Revolution Pakistan: Some Preliminary Results," a presentation to Sixth Annual General Meeting of the Pakistani Society of Development Economists.

Safilios-Rothschild, C. (1980) "The Role of the Family: A Neglected Aspect of Poverty." In *Implementing Programs of Human Development*, ed. Peter Knight. World Band Staff Working Paper Number 43. Washington, D.C.

Schultz, T.P. (1988) "Education Investments and Returns" in *The Handbook of Development Economics*, edited by H. Chenery and T.N. Srinivasan, Elsevier Science.

Schultz, Theodore W. (1964) *Transforming Traditional Agriculture*, Yale University Press, New Haven.

Schultz, T.W. (1975) "The Value of the Ability To Deal With Disequilibria," *Journal of Economic Literature*, No. 13.

Sen, A.K. (1964) 'Size of Holding and Productivity', *Economic Weekly*, Vol. 16.

Shabbir, T. (1994), "Mincerian Earnings Functions for Pakistan," *Pakistan Development Review*, Vol. 33.

Shaw, Kathryn (1989) "Life-Cycle Labor Supply With Human Capital Accumulation," *International Economic Review* vol 30., No. 2.

Singh, I. L. Squire, and J. Strauss, (1986) *Agricultural Household Models: Extensions, Applications, and Policy*, Johns Hopkins Press, Baltimore.

Strauss, J. and Thomas, D. (1995) "Human Resources: Empirical Modeling of Household and Family Decisions," in *Handbook of Development Economics*, Volume III, Ed. by J. Behrman and T.N. Srinivasan, Elsevier Science.

Thomas, D., Strauss, J. and Henriques, M-H, (1990) 'Child Survival, Height for Age and Household Characteristics in Brazil,' *Journal of Development Economics*, 33.2:197-234.

Todaro, M.P. (1985) *Economic Development in the Third World*, Longman.

United Nations. (1958) *Demographic Aspects of Manpower: Sex and Age Patterns of Participation in Economic Activities*, Report 1, New York.

UNESCO (1991). *World Education Report.* UNESCO, Paris.

UNESCO (1993). *World Education Report.* UNESCO, Paris.

United Nations (1994) *The Sex and Age Distribution of the World Populations: the 1994 Revision*, The Department for Economic and Social Information and Policy Analysis, Population Division. The United Nations, New York.

Vlassoff, C (1990) "The Value of Sons in an Indian Village — How Widows See It," *Population Studies*, Vol. 44, Iss 1, 5-20.

Vyas, V.S. (1983) "Asian Agriculture; Achievements and Challenges" *Asian Development Review.*

Walker, T. and Ryan, J. (1990) *Village and Household Economics in India's Semi-Arid Tropics*, Johns Hopkins Press, Baltimore.

Wallace, T., and L. Ihnen (1975) "The Theory and of Human Capital Accumulation with Alternative Loan Markets," Journal of Political Economy 83, 157-184.

Wallace, T.D., and L.A. Ihnen (1975) "Full-Time Schooling in Life-Cycle Models of Human Capital Accumulation," *Journal of Political Economy* vol 83., no. 1.

Warwick, D.P., and F. Reimers (1995) *Hope of Despair: Learning in Pakistan's Primary Schools.* Praeger, Westport, CT.

Welsh, F. (1970) "Education in Production," *Journal of Political Economy*, Jan-Feb., pp 35-59.

Welsh, F. (1978) "The Role of Investments in Human Capital In Agriculture," in Theodore W. Schultz, ed., *Distortions of Agricultural Incentives*, Indiana University Press. pp 259-81.

Willis, R.J. (1974) " Economic Theory of Fertility Behavior," in *The Economic of the Family: Marriage, Children, and Human Capital,* T.W. Schultz, ed., the University of Chicago Press, Chicago.

World Bank (1980) *Education.* Sector Policy Paper, Washington, D.C.

World Bank (1980) *World development Report, 1980*, Oxford University Press, New York.

World Bank (1988) *Pakistan: Education Sector Strategy Review.* The World Bank, Europe, Middle East, and North Africa Region. Washington, D.C.

The World Bank (1995) *World Tables,* the Johns Hopkins University Press, Baltimore, Maryland.

World Bank (1996) *Trends in Developing Economies.* The World Bank, Washington, D.C..

World Bank (1996a) *Social Indicators of Development, 1996,* the Johns Hopkins University Press, Baltimore.

Yotopoulos, P.A. (1967) "The Greek Farmer and the Use of His Resources," *Balkan Studies*, Vol. 8, pp. 365-86.

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989