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Natural Resource Collection and Children's Literacy

Empirical Evidence from Panel Data in Rural Ethiopia

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Abstract

Few studies have examined the dynamic aspect of the effect of natural resource collection on child education. This paper looks into the effect of resource collection on child education using panel data collected in four rounds from rural Ethiopia. We model resource work participation and child literacy as a joint decision. Mundlak's approach is employed in order to exploit the panel nature of the data. Unlike other related studies, we separately analyzed the effect of collection of water and fuel on child education. We find that, in general, natural resource scarcity, in addition to its direct impact on households, negatively contributes to child education by increasing the work burden on children in rural Ethiopia. In particular, children's participation in fetching water is found to be one of the most important factors that reduce children's ability to read and write. In addition to the effect of resource collection on children's literacy, this study also examined the role of other factors, such as household characteristics, child characteristics and access to schools. The policy implications of the findings are also presented.

Key Words: child labor, literacy, natural resource scarcity, panel, rural Ethiopia

JL Codes: Q12, Q56

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1. Introduction

Child labor is one of the biggest failures of development in sub-Saharan Africa. While children's work is declining in the Asia-Pacific region and Latin America and the Caribbean, it is increasing in sub-Saharan Africa, from 49.3 million working children in in 2004 to 65 million in 2010 (ILO 2010). About 25 percent of the children in sub-Saharan Africa are child laborers. In Ethiopia, 53% of children aged 5-14 are engaged in labor: 59% of girls and 46% of boys (UNICEF 2012). A number of studies indicate that the work burden on children affects their education (Cockburn and Dostie 2007). However, the literature focuses on domestic and farm work, with less attention to the participation of children in the collection of natural resources. The present paper focuses on the effect of environmental resource collection on child education. Moreover, the effect of child labor on child education can be measured using different indicators (e.g., enrollment, attendance, or achievement). Several studies have shown that working children remain enrolled in school but may not attend regularly (Orazem and Gunnarsson 2003). We argue that, by looking at the effects on children's reading and writing ability, we can contribute to the debate on child labor and child education. This study uses four waves of panel data from rural Ethiopia to evaluate the effect of child labor in collecting water and fuel on children's ability to read and write.

In Ethiopia, one of the most important functions of children, especially girls, is domestic work activities. There is also evidence that children participate in the most laborious activities, such as farm work. Given the role of agriculture in the household economy in rural sub-Saharan

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Africa, the participation of children in farm work is not surprising. For example, households in rural Tanzania increase child labor to mitigate the consequences of large crop losses (Beegle et al. 2006). In addition to domestic and farm work, it is common to find children collecting fire wood, fetching water, herding, etc. in rural Africa. When environmental resources such as forests, water, pasture, etc. are degraded, the burden on rural households, especially on children and women, will increase. Increasing natural resource scarcity, i.e., deterioration of forest resources and fuel scarcity, in many poor countries has resulted either in long hours of work being spent by women and children in collection of fuel and other forest products or in a switch to other, lower quality fuel sources. Similarly, degradation of water resources has resulted in a heavy work burden on women and children, especially on girls. Through competition for family labor, this in turn has serious consequences on time spent on domestic work and agricultural productivity. In addition to this, several sources of evidence indicate that children's participation in various activities decreases the likelihood of attending school. For example, one of the reflections of the heavy burden on children is the low rate of school enrollment in Ethiopia, a rate that is one of the lowest in the world (Senbet 2010).The present paper aims to address this with a focus on the effect of environmental resource collection on child education.

On average, children spent about seven hours on firewood collection, one hour on water collection, and three hours on fodder collection per week in the northern part of Ethiopia (Gebru and Bezu 2013). This may indicate that scarcity of natural resources requires an increase in the demand for child labor, which will create an additional burden by reducing the time they might have for education. Hence, it is necessary to address the question separately for children and other household members, as they may be affected differently due to the degradation of environmental resources.

In this study, we consider the effects of resource collection on a child's ability to read or write or both. Simple descriptive statistics of the last wave that we use for this study show that more than 94% of those children who can read and write are currently in school. This shows that there is a high correlation between school attendance and ability to read and write. Therefore, our objective is to examine the role of children's participation in and intensity of resource collection work, as well as other factors that hinder children's literacy, by looking at whether or not the child is able to read and write. Our study uses four waves of data collected over the period 2000-2007 from the Amhara region of Ethiopia.

This study contributes to the literature in several ways. First, it contributes to the limited empirical evidence on the link between resource collection and schooling in developing countries in general and Ethiopia in particular (a few exceptions are Nankhuni and Findeis 2004; Gebru

and Bezu 2013; and Ndiritu and Nyangena 2010). Second, related studies on child labor (for example, Nankhuni and Findeis 2004; Cockburn and Dostie 2007; Gebru and Bezu 2013; Admassie and Bedi 2003) are all based on cross-sectional data. Our study is different from these studies in that we used panel data collected in four waves (2000, 2002, 2005 and 2007). Because unobserved heterogeneity is a problem of non-experimental research, use of panel data allows us to control for unobserved household heterogeneity. Moreover, the large number of observations from different waves of data collected gives more degrees of freedom, less collinearity and more variability, and hence we get more efficient estimates. In addition, unlike most other similar studies, we have included and separately examined two different types of resources. These are energy collection and fetching water. Water scarcity severely affects the lives of rural households, especially women, as female family members are traditionally responsible for water collection (Hossain and Shimelles 2009). In Ethiopia, overgrazing, heavy stocking, and unavailability of livestock feed are also important problems which result in a shortage of grazing land. However, we were unable to include the effect of grazing land shortages in this analysis due to lack of data. Therefore, given the importance of child labor for the health, education and psychological condition of children in Africa, in Ethiopia in particular, this study attempts to address an important issue for researchers, policy makers and development agents working in rural development. By analyzing the relationship between child education on the one hand and collection of different types of natural resources on the other, the findings of this study will enable governmental and non-governmental organizations to understand the role of children's involvement in collection of fire wood and water on their education.

The rest of the paper is organized as follows: Section 2 briefly reviews the literature on child work in developing countries with a focus on sub-Saharan Africa. Section 3 presents the nature and sources of data and some descriptive statistics. The empirical strategies for estimating the determinants of child literacy and natural resource work participation are presented in Section 4. Section 5 discusses the estimation results. Conclusions and policy implications of the findings of this study are presented in Section 6.

2. Literature Review

The literature on child labor focuses on understanding the effect of child labor on children's education and/or health. A number of these studies indicated that there is a huge work burden on children which affects their education. Cockburn and Dostie (2007) related poverty with child work in rural Ethiopia. They argue that the demand for child labor plays a major role in child time use decisions and that this demand varies substantially between households

according to their asset profiles and household composition. Admassie and Bedi (2003) investigated whether the number of hours worked by children has an effect on school attendance and on their reading and writing ability. Their results show that there is a non-linear relationship between hours of work and school attendance of children. While initially schooling and working are positively correlated, beyond 22 hours per week, both school attendance and ability of children to read and write will suffer.

Household characteristics and household composition variables are also included in most related empirical studies on child labor. By separately estimating the effect of household composition and other variables on school attendance, Assefa and Bedi (2003) show that family size, number of infants in the household and number of female members have no effect on school attendance of boys. But a larger family size and a greater number of infants have a negative effect on school attendance of girls, while more female members in the household encourage girls' school attendance. Similarly, Senbet (2010) finds that the presence of infants increases the probability of girls working in rural Ethiopia. Findings of Nankhuni and Findeis (2004) also support the negative relationship between infants and the likelihood of school attendance, but having more children aged 1-5 years does not have a significant effect on children's school attendance in Malawi. Gender differences are also included in the analysis of child education but the literature show mixed results. Unlike the findings of Nankhuni and Findeis (2004), Assefa and Bedi (2003) find that a male child has a higher probability of attending school than girls in Ethiopia. The probability of attending school also increases with age. We also expect a greater number of dependents and school attendance to be negatively correlated. But, according to Nankhuni and Findeis (2004), more women (aged 25-64) and elderly women(>65 years) increase the likelihood of children attending school due to the involvement of women in the domestic work activities, which reduces the burden on children. Direct offspring (biological children) of the household are more likely to engage in schooling (Senbet 2010).

The effect of socioeconomic indicators such as ownership of livestock on child schooling has also been studied by several scholars. For example, a study by Gebru and Bezu (2013) shows that livestock increases the probability of attending school. Similarly, boys in wealthier households seem to engage in working at the cost of schooling. But other findings by Admassie and Bedi (2003) and Woldehanna et al. (2008) from Ethiopia show that there is a negative relationship between ownership of livestock and child schooling. In general, improvements in the socioeconomic status of the household may affect child labor in many ways. For example, one of these effects is that the child's productivity in other activities, such as schooling, might improve

because the family might be able to afford the cost of schooling, such as school fees and textbooks (Edmonds and Pavcnik 2005).

Most child-related studies (e.g., Ersado 2005, Admassie and Bedi 2003) emphasize the importance of parental education for children's education. Those parents with secondary or higher education have a stronger positive effect on child schooling. This may be because educated parents have a better understanding of the importance and value of education compared to non-educated parents. Several authors emphasize the role of parental education, particularly of the mother, on child education. Mani et al. (2009), using panel data from 15 rural villages in Ethiopia, found that parental schooling is positively associated with enrollment but its estimated effects decline overtime.

Supply side factors or facilities such as availability of school, distance to town, etc., at the community level can affect child education in many developing countries. For example, based on findings from three developing countries, Ersado (2005) indicated that availability of school can affect the prevalence and intensity of child labor and improve the likelihood that children stay in school.

We note that there is a growing body of literature on the effect of child labor on schooling (e.g., Ersado 2005; Ilahi 2001; Edmonds 2006; Assaad et al. 2003; Beegle et al. 2009). However, the available literature on the link between resource collection and child schooling is still very limited. The works by Nankhuni and Findeis (2004), Gebru and Bezu (2013) and Ndiritu and Nyangena (2010) are empirical studies from Africa that tried to link resource collection and child schooling. Nankhuni and Findeis (2004) find that environmental factors are a significant determinant of resource collection behavior of farm households in Malawi. Compared to the less degraded areas, children from the most environmentally degraded districts in Malawi are less likely to attend school (Nankhuni and Findeis 2004). A related study by Gebru and Bezu (2013) on child schooling and resource collection in Northern Ethiopia revealed that a 50% increase in hours per week spent on collection activities is likely to reduce children's enrollment at school by 12%. Ndiritu and Nyangena's (2010) findings from the Kiambu District of Kenya show that being involved in resource collection reduces the likelihood of a child attending school. The results further show that involvement of a child's mother in resource collection increases school attendance.

There seems to be an agreement among the limited research findings with regard to the negative effect of collection intensity on schooling (e.g., Nankhuni and Findeis 2004; Gebru and Bezu 2013; Ndiritu and Nyangena 2010). However, to our knowledge, all available studies on

resource collection and child schooling are based on cross-sectional data and try to understand the relationship at a point in time. Moreover, the effect of participation of children in resource collection has not been analysed separately for each type of resource. In this study, we show the separate role of firewood collection and fetching water on children's school attendance using panel data. Separate analysis of the effect of fuel and water collection on child education will help policy makers identify the relative importance of environmental resources as they affect child schooling, which may help in prioritizing actions to be taken. Thus, we believe this study's use of panel data will add to the limited literature on the link between natural resource collection and child education in rural Ethiopia.

3. Data Source and Description

3.1 The Nature and Source of Data

We use panel data collected in the years 2000, 2002, 2005 and 2007 from a sample of rural households in the East Gojjam and South Wollo zones of the Amhara region of Ethiopia. This data is part of a longitudinal survey conducted through a collaborative research project of the economics department at Addis Ababa University and the University of Gothenburg, financed by Sida. The selection of the sites was deliberate to ensure variation in the characteristics of the sites, including agro-ecology and vegetative cover. A simple random sampling technique was employed to select households from each site. Data at both household and community levels were collected. The survey has detailed information on household's socioeconomic characteristics, input use and production activities, consumption expenditure, energy collection and consumption, etc. In addition, different location indicators, such as distance to main road, distance to the nearest market and district offices, etc., were collected. However, because the survey's main objective was to study sustainable land management in rural Ethiopia, we could not find detailed information on child activities such as hours spent by children for domestic work. This is one of the limitations of this study, as other activities by children are also important to fully understand the extent of the work burden and hence its relationship with child education.

Different explanatory variables are included in the analysis. Household characteristics such as age, sex and education of the household head, household wealth indicators such as livestock and whether or not the household has corrugated roof, number of adult members of the family by sex, and number of elderly dependents (those above age 65 years) are all included. Child individual characteristics included in the analysis are age of child, sex of child, and

number of children below age five. In order to understand the effect of the location of the school on child education, we have also included distance to both primary and secondary schools. Differences in environmental and agro-ecological characteristics are captured by including site dummies (with a value of 1 if the child is in East Gojjam). Presence of piped water in the community/kebele[1] and presence of a community forest in the kebele are included to show the link between these variables and children's participation in collection of natural resources. Based on related literature, important variables that should have been included in the analysis are education of mother and father[2] and biological relation of the child with the head. But these are not included, as the available data was not clear and does not allow us to address these issues.

Our dependent variables include child literacy (a binary variable)[3] resource work participation; and total hours spent in resource collection. The resource collection (for both energy and water) is measured in terms of time spent in hours per week. As described earlier, in rural Ethiopia, children participate in different kinds of activities, such as farm work, herding or keeping animals, domestic activities such as cooking, etc. Because our main objective is to understand the impact of children's involvement in resource collection on their education, the subsequent discussion focuses on child activities in resource work only. Due to lack of complete information on all kinds of child work activities, we focus on two kinds of resource collection activities: collecting fuel (mainly firewood) and fetching water.

Children aged 6 to 17 years are included in the analysis. We took six years as a lower limit because most children begin attending elementary education when they are six years old or older. It is also known that there are situations where children under 6 also get involved in work, but almost all child labor occurs in the age group 5-17 (ILO 2010).

In a survey data set such as the one used for this study, a researcher may encounter several problems. For example, some of the information is missing or incomplete. Lack of consistency in measurement units and other related problems might affect the reliability of our estimation efforts. We have tried to minimize all these problems with careful examination of the data. For example, we used local conversion factors to convert the amount of resource collected,

1 *Kebele* is the lowest administrative unit in Ethiopia.

2 However, education of the head, which in most cases is the father of the child, is included in the empirical analysis.

3 This variable is constructed by asking the household head about the ability of the child to read and write in Amharic. If the child cannot at least read, then he/she is considered as illiterate.

reported in local units, into standard measures. Some outliers were replaced by median values of the respective sites. Some missing observations were omitted. Note that data are examined via box plot to identify outliers before the data are used for the empirical analysis. The sample size, which was originally 13,164, reduces to 12,955 after excluding or dropping observations with inconsistent or missing data.

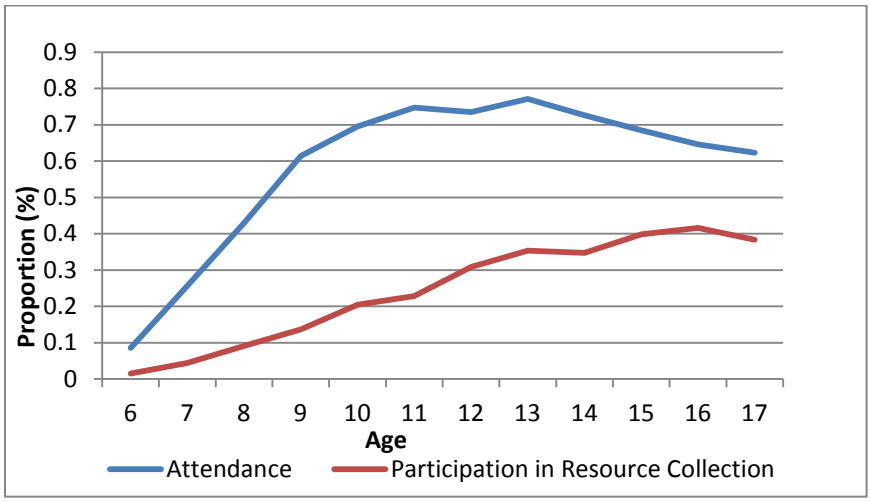
3.2 Descriptive Statistics

Table 1 shows the descriptive statistics on children's participation in resource collection and children's literacy. Close to 60% of the children in the sample can read or both read and write. This suggests that a significant proportion of children are not attending school for various reasons. Based on the survey results of the last round,[4] this might be due to participating in different activities such as household chores or farm work, as well as the unavailability of a school near their community. Other reasons mentioned by the respondents include participation in income generating employment, health related problems, early marriage, family cannot afford the cost of education, and the opinion of some families that children between 6-8 years are too young to go to school. This implies that policy makers need empirical evidence that identifies the constraints and takes corrective measures which could enhance child education in rural Ethiopia. On the other hand, a relatively small proportion of the sample children participate in resource collection (24%). Note that this percentage could have been much higher had we included other activities of children such as herding or keeping animals.[5] On average, a child spends 7.37 and 4.09 hours per week fetching water and collecting fire wood, respectively. This includes both travel time and collection time.

4 Unlike the last round, the previous three waves do not contain detailed information on child education.

5 In their study of child work and school attendance, Assefa and Bedi (2003) show that children in rural Ethiopia who attend school spend 14 hours on herding and those who do not attend school spend 8 hours per week on herding.

Figure 1. The relationship between child age, child literacy and participation in resource collection



Though not the focus of this study, the above figure show that child education is higher at the age of 11-14 years and lower in the upper and lower categories, suggesting that there is a need to focus on these two groups. As described earlier, changing the attitude of parents regarding the school age of children needs special emphasis.

Table 1. Descriptive statistics of child literacy and resource collection

Variable	Mean	Std. Dev.
Water collection time per week in hours (N=2215)	7.37	10.86
Energy collection time per week in hours (N=2286)	4.09	8.51
Child collects water or not (N=13164)	0.168	0.37
Child collects energy or not (N=13164)	0.174	0.38
Child collects resources or not (N=13164)	0.241	0.43
Total resource collection time per week in hours (N=3177)	8.076	12.33
Child literacy(N=13164)	0.586	0.49

The descriptive statistics of the explanatory variables included in the empirical analysis are presented in Table 2. Around 53% are boys while the rest are girls. The average age of children is 11.4 years. While more than 43% of the sample children are between 6 and 10 years old, around 33% belong to age category 11-14, and the remaining 24% belong to age category 15-17.

Table 2. Descriptive statistics of the explanatory variables (N=13157)*

Variable	Mean	S. D.	Min	Max
Sex of child (=1 if male)	0.53	0.50	0	1
Child age is between 6 - 10 years old	0.43	0.50	0	1
Child age is between 11 - 14 years old	0.33	0.47	0	1
Child age is between 15 - 17 years old	0.24	0.42	0	1
Number of male children below 5	0.40	0.60	0	4
Number of female children below 5	0.19	0.46	0	3
Household head (=1 if male, 0 otherwise)	0.87	0.33	0	1
Age of household head in years	49.69	13.13	15	102
Number of dependents (age>=65)	0.35	0.64	0	8
Number of livestock in TLU[6]	4.13	3.39	0	39.34
If the household is literate (=1, 0 otherwise)	0.50	0.50	0	1
Number of adult males (above 17 years of age)	1.75	1.05	0	9
Number of adult females (above 17 years of age)	1.65	0.90	0	8
House has corrugated roof (=1 if yes, 0 otherwise)	0.65	0.48	0	1
Availability of piped water in the community (=1 if available, 0 otherwise)	0.55	0.50	0	1
Availability of community forest in the Kebele (=1 if available, 0 otherwise)	0.58	0.49	0	1
Distance to primary school (in minutes)	36.87	19.44	10	90
Distance to secondary school (in minutes)	77.64	36.90	30	240
Total resource collection time per week in hours	8.08	12.33	0.00	227.88

Note: *The number of observations for the variables sex, age and education of the head is 12,955.

More than 87% of the sample are male headed households. More than 50% of the sample households have literate heads that can read and write. On average, children have relatively better access to primary education than secondary education, which is measured based on the distance of the schools from the household.

6 TLU refers to Tropical Livestock Units.

Figures 2.A-2.C show the data over the period 2000-2007 on the following variables: the proportion of children participating in resource collection (Fig. 2.A), collection time spent per week (Fig. 2.B) and child literacy rate (Fig. 2.C).

Fig. 2.A. shows that the rate of participation seems unchanged between 2000 and 2007 in the study area. While the average collection time per week continued to increase between 2000 and 2005, it is decreasing in 2007. This is difficult to explain. As shown in Fig. 2.C, the literacy rates improve over the study period, from 46% to 66%.

Figure 2.A. Participation in resource collection

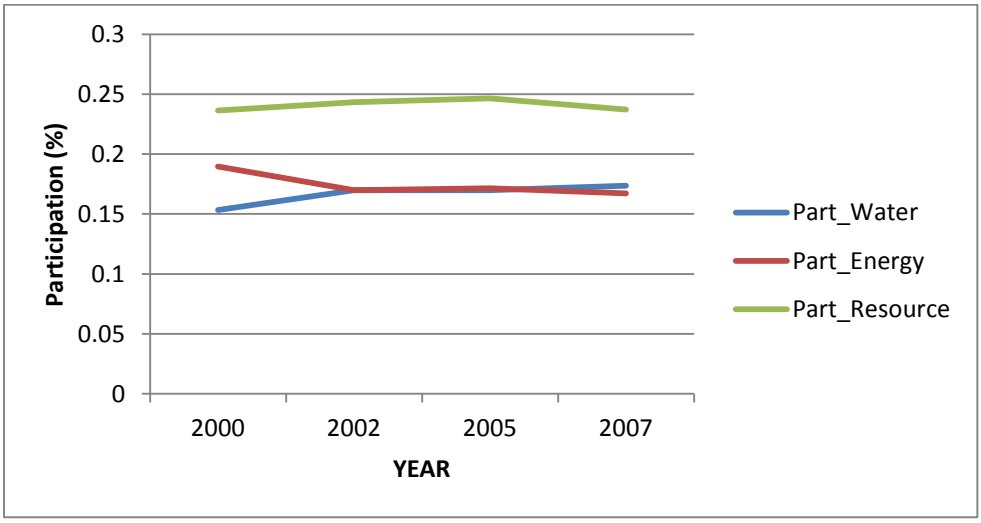


Figure 2.B. Resource collection time

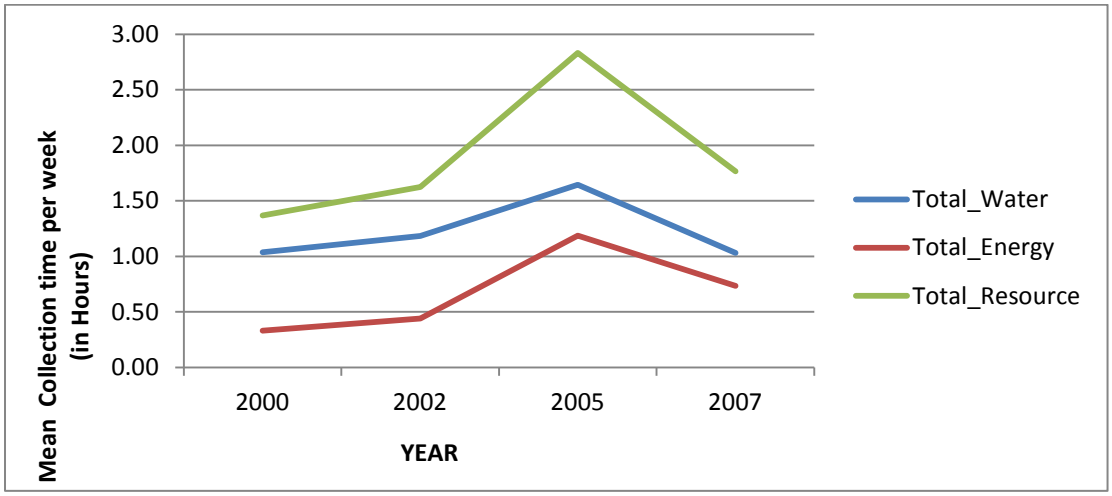
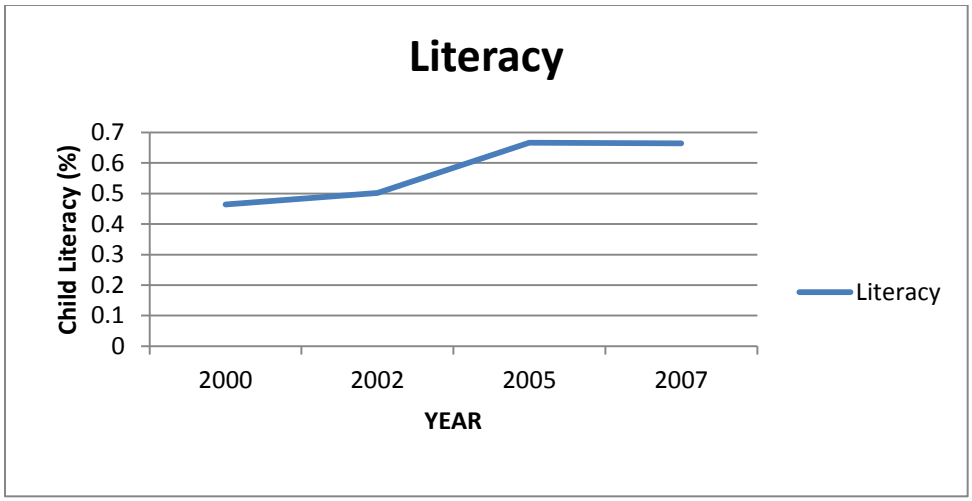


Figure 2.C. Child literacy



4. Empirical Approaches

Several related studies on child work and schooling have employed a bivariate probit model due to the joint decisions of child work participation and school attendance. If the error terms of the two probit equations are correlated (which depends on the significance and value of rho), then joint estimation of the two equations would be necessary. Otherwise, a univariate probit model should be estimated. However, as explained below, we employed a relatively more complex method due to the panel nature of the data and endogeneity.

4.1 Model Specification

Because we assume the disturbance of the two equations (i.e., resource work participation, which we call participation, and literacy) to be correlated, we employ a bivariate probit model. Following Greene (2005), the bivariate probit specification for a two-equation model that can accommodate unobserved common effects in panel data settings can be specified as follows:

$$Y^{*}_{1,it} = X^{'}_{1,it}\beta_1 + \varepsilon_{1,it} + \mu_{1,i} \quad , Y_{1,it} = 1 \quad if \quad Y^{*}_{1,it} \succ 0 \, , 0 \text{ otherwise.} \tag{1}$$

$$Y^{*}_{2,it} = X^{'}_{2,it}\beta_2 + \varepsilon_{2,it} + \mu_{2,i} \quad , Y_{2,it} = 1 \quad if \quad Y^{*}_{2,it} \succ 0 \, , 0 \text{ otherwise.} \tag{2}$$

The $\varepsilon_{1,it}$ are jointly distributed with mean vector 0 and covariance,

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \Big| \mathrm{X}_1, \mathrm{X}_2 \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}, \right. \tag{3}$$

Where $X^{'}_{1,it}$ and $X^{'}_{2,it}$ are the set of explanatory variables determining resource work participation and child literacy. β_1 and β_2 are vectors of coefficients to be estimated. $\mu_{1,i}$ and $\mu_{2,i}$ are random variables representing unobserved individual heterogeneity (time-invariant). $\varepsilon_{1,it}$ and $\varepsilon_{1,it}$ are the time-varying components.

A direct estimation of this using STATA is very complex in practice. We, therefore, use an approach suggested by Mundlak (1978). This is the pseudo-fixed effects estimation approach (Wooldridge 2002), which involves explicitly modeling the relationship between time-varying regressors and the unobservable effect in an auxiliary regression (Mundlak 1978). Specifically, the random effects are associated with the strong assumption of no correlation between the fixed effect and the regressors/observed covariates. The fixed effects estimator, on the other hand, relies on a transformation to remove this individual specific constant term along with time-invariant observed covariates (Wooldridge 2002). Accordingly, Mundlak's (1978) approach, which allows the unobserved individual effects to be correlated with observed variables through a linear form, is specified as follows:

$$\eta_i = \overline{x_i}\,\pi + \mu_i \tag{4}$$

In addition to the panel nature of the data, which we handle using Mundlak's approach as explained above, we also need to deal with endogeneity of collection time, which is an

explanatory variable in the literacy equation. This endogeneity will overestimate the negative effect of work on education. One can employ a two-stage conditional maximum likelihood (2CML) approach in order to account for the potential endogeneity of hours of work. Rivers and Vuong (1988) suggest that, in the first stage, the suspected endogenous variable be regressed on a set of instruments and the residuals from the first stage be added as an explanatory variable in the second-stage probit regression to obtain a consistent estimate. The variables 'availability of pipe water in the community' and 'availability of community forest in the Kebele' are included as instruments. We argue that these variables are not correlated with children's literacy level but they can influence the time spent on resource collection, as they are indicators of resource availability. So, in the estimation results for the literacy equation where the residual is included as a right hand side variable, the coefficient for the residuals can serve both as a test and as a correction for the potential endogeneity of resource work. Following Arendt (2001), we extend this to our panel data. To obtain consistent standard errors, corrections are needed to account for the first-stage estimation. However, due to the presence of random effects, this is complicated in the case of the two stage conditional maximum likelihood random effect estimator (Arendt 2001). Though cumbersome, we have bootstrapped the standard errors in the final equation only.

Thus, for the first stage estimation, the determinants of hours spent for each type of resource collection is modelled as a tobit specification with Mundlak fixed effects. The following equations show the empirical model used for analysis of total hours spent in collection of natural resources.

$$\ln\left(R_{ht}^{*}\right)=\beta_1^{'} X_{ht}+\theta_1^{'} \bar{X}_{h}+\pi_1 Z_{ht}+\varepsilon_{1ht} \tag{5}$$

$$\ln\left(R_{ht}^{*}\right)=\ln\left(R_{ht}^{*}\right) \text{ if } R_{ht}^{*}>0 \text{ , 0 otherwise} \tag{6}$$

where the level of resource collection of child *h at* time *t* is given by R_{ht} , X_{ht} represents a vector of household and child characteristics, and $\overline{X}_{h}$, represents the means of time-variant explanatory variables.

Thus, the estimation approach, in brief, is to estimate a bivariate probit model which also uses the Mundlak approach to exploit the panel nature of the data. However, while estimating the bivariate probit model, we include residuals from the first stage estimation (Equations 5 and 6 above) in the literacy equation of the bivariate probit model. All this is done for the three sets of results that we have (i.e., results for all resource collection together (Table 3) and two sets of results for each of water collection (Table 4) and energy collection (Table 5)).

5. Results

In this section, we present and discuss the results of the econometric estimation. As described earlier, the main objective of this study is to examine and understand the effect of children's involvement in natural resource collection on their level of literacy, considered in terms of their reading and writing ability. We have estimated and presented the bivariate relationship between resource work and children's literacy as well as the determinants of hours worked. Table 3 presents the estimation results for participation in resource collection, and the effect of collection time on children's literacy when water and energy are combined as one resource. Thus, the participation (Column 1) in Table 3 refers to participation in resource collection and the hours spent variable (which appears as an explanatory variable under literary (Column 3) in Table 3) refers to total hours spent in the collection of both water and energy. Separate estimation results for the effects of water and energy collection on child schooling are presented in Tables 4 and 5, respectively. In all the regressions, standard errors are bootstrapped with 200 replications. It is also important to note that, in Tables 3, 4 and 5, Column 2 (representing hours worked) is the result of the first stage estimation explained above, from which the residual is inserted as an explanatory variable in Column 3 (the literary equation), which serves as a test as well as a correction for endogeneity of the variable hours spent in the literacy equation.

The Wald test of rho = 0 (chi2(1) = 43.1979; Prob> chi2 = 0.0000) indicates that there is a correlation between the disturbance terms of the two equations. Thus, unexplained factors that affect the participation of children in resource collection and children's literacy (or their ability to read and write) are positively correlated. Unlike other similar studies (e.g., Nankhuni and Findeis 2004; Ndiritu and Nyangena 2010), this study supports the joint estimation of the participation and schooling equation. Hence, a univariate probit model of literacy and resource-collection work participation is not appropriate. Columns 1 and 3 report estimates of the bivariate probit model for resource-work participation and literacy, respectively. Column 2 reports the determinants of hours of work (the first stage regression).

Table 3. Regression results of child resource collection work and child literacy

Explanatory Variable	Participation in resource-collection work		Resource collection time		Literacy	
Hours spent					-0.194	(0.07)***
Residuals					0.158	(0.07)**
Sex of child (=1 if male)	-0.791	(0.03)***	-1.842	(0.06)***	-0.334	(0.13)**
Child age is b/n 6 - 10 years	-1.112	(0.04)***	-2.345	(0.06)***	-0.921	(0.17)***
Child age is b/n 11 - 14 years	-0.262	(0.03)***	-0.521	(0.06)***	0.206	(0.05)***
Household head (=1 if male)	-0.205	(0.04)***	-0.488	(0.10)***	-0.157	(0.05)***
Age of household head in years	0.008	(0.00)***	0.018	(0.00)***	0.010	(0.00)***
Household head is literate (yes =1)	0.013	(0.03)	0.033	(0.07)	0.279	(0.03)***
No. of male children below 5	0.064	(0.04)*	0.143	(0.06)**	0.060	(0.03)**
No. of female children below 5	0.081	(0.04)**	0.174	(0.08)**	0.032	(0.04)
Number of male adults	-0.040	(0.03)	-0.069	(0.06)	-0.058	(0.03)**
Number of female adults	-0.168	(0.03)***	-0.356	(0.06)***	-0.095	(0.04)***
Number of livestock in TLU	-0.001	(0.01)	-0.009	(0.01)	0.009	(0.01)
Mean Variables						
Mean male children below 5	-0.075	(0.05)	-0.101	(0.09)	-0.164	(0.04)***
Mean female children below 5	-0.228	(0.06)***	-0.452	(0.15)***	-0.205	(0.07)***
Mean Number of male adults	0.005	(0.03)	0.013	(0.07)	0.054	(0.03)*
Mean Number of female adults	0.040	(0.04)	0.051	(0.07)	0.072	(0.03)**
Mean Number of livestock	0.014	(0.01)	0.032	(0.02)*	0.006	(0.01)
Mean Number of dependents					-0.149	(0.05)***
House has corrugated roof	0.024	(0.03)	0.006	(0.07)	0.306	(0.03)***
Household is in East Gojjam	0.093	(0.03)***	0.149	(0.06)**	-0.433	(0.03)***
Availability of piped water in the community	0.155	(0.03)***	0.360	(0.07)***		
Availability of community forest in the Kebele	0.101	(0.03)***	0.147	(0.06)**		
Distance to primary school					-0.003	(0.00)***
Distance to secondary school					-0.002	(0.00)***
Number of dependents					-0.028	(0.04)
Yr2002	0.024	(0.05)	0.140	(0.09)	0.175	(0.04)***
Yr2005	0.087	(0.05)*	0.483	(0.09)***	0.607	(0.05)***
Yr2007	0.005	(0.05)	0.163	(0.11)	0.507	(0.05)***
_cons	-0.074	(0.09)	-0.152	(0.20)	0.074	(0.10)

Note: N = 12955; bootstrapped standard errors are in parentheses.***, **, and * indicate significance level at 1%, 5%, and 10%, respectively.

5.1 Determinants of Resource Collection Work

We first discuss the determinants of children's participation in resource collection work. Compared to older children, the younger ones are less likely to participate in resource collection work. The effect of gender was also considered and the results show that boys are less likely than girls to participate in resource collection. This is not surprising, as the traditional division of labor in sub-Saharan Africa involves a higher work burden on girls than boys (Nankhuni and Findeis 2004).

We also examined the effect of household characteristics on the likelihood of a child participating in resource collection, as well as on the child's reading and writing ability. Children in male headed households are less likely to participate in resource collection. On the other hand, as the age of the household head increases, the likelihood of participating in resource collection will increase. Availability of more adult members in the household does not seem to affect the participation of children in resource collection.

Studies suggest that poverty is an important driving force behind child labor in rural Africa (Nkamleu 2006; Ersado 2005). Our findings do not seem to support this, as ownership of livestock, considered as an indicator of economic status, is not statistically significantly associated with children's participation in resource collection. Similarly, ownership of a house with a corrugated roof, which is considered here as another indicator of economic status, is not significant.

Based on the information in the survey, we have included variables that can represent the availability of the two types of resources considered for this study (i.e., water and fuelwood). Availability of piped water and presence of a community forest may represent the availability of both water and fuel wood, respectively. Availability of piped water and a community forest in the community will likely increase the participation of children in resource collection work.[7] We have not included these variables in the schooling equation, as they do not have a direct impact on child literacy. As shown in Table 3, the variables are statistically significant and positively correlated with both participation and time spent for resource collection.

Unlike most other related studies, we have analysed the effect of the various explanatory variables on the participation of children in collecting a specific resource. What determines

[7] However, one may also argue the opposite. That is, if these are available, this could reduce the physical scarcity of these resources and hence reduce the need for additional labor to collect them.

participation in water collection or energy collection? Table 4 presents the results of the joint estimation of determinants for water collection and children's literacy. The test statistics for the water-literacy regression in Table 4 show that there is a high correlation between the two equations, which supports our estimation strategy of using a bivariate probit method. Most of the results are the same as the estimation results presented in Table 3. Consistent with the results in the total resource regression (Table 3), availability of piped water is positively and significantly related with both the participation and time spent for water collection. The dummy variables for regions show that a child living in the East Gojjam zone is less likely to participate in water collection than the counterpart in South Wollo.

Table 4. Regression results for child water collection work and child literacy

Explanatory variable	Participation in resource-collection work		Resource collection time		Literacy	
Hours spent					-0.291	(0.08)***
Residuals					0.190	(0.07)***
Sex of child (=1 if male)	-1.214	(0.03)***	-2.820	(0.06)***	-0.604	(0.21)***
Child age is b/n 6 - 10 years	-1.017	(0.04)***	-2.258	(0.08)***	-0.996	(0.17)***
Child age is b/n 11 - 14 years	-0.208	(0.04)***	-0.432	(0.08)***	0.200	(0.05)***
Household head (=1 if male)	-0.179	(0.04)***	-0.446	(0.11)***	-0.168	(0.06)***
Age of household head in years	0.008	(0.00)***	0.019	(0.00)***	0.010	(0.00)***
Household head is literate (yes =1)	0.032	(0.03)	0.060	(0.09)	0.284	(0.03)***
No. of male children below 5	0.053	(0.04)	0.118	(0.08)	0.060	(0.03)*
No. of female children below 5	0.059	(0.04)	0.142	(0.10)	0.034	(0.04)
Number of male adults	0.031	(0.03)	0.062	(0.07)	-0.034	(0.03)
Number of female adults	-0.145	(0.03)***	-0.336	(0.07)***	-0.107	(0.03)***
Number of livestock in TLU	-0.011	(0.01)	-0.025	(0.02)	0.006	(0.01)
Mean Variables						
Mean male children below 5	-0.101	(0.05)**	-0.148	(0.11)	-0.174	(0.04)***
Mean female children below 5	-0.229	(0.09)***	-0.512	(0.18)***	-0.236	(0.07)***
Mean Number of male adults	-0.069	(0.04)*	-0.126	(0.08)	0.025	(0.03)
Mean Number of female adults	-0.009	(0.04)	-0.034	(0.09)	0.059	(0.03)**
Mean Number of livestock	0.024	(0.01)*	0.044	(0.02)*	0.009	(0.01)
Mean Number of dependents					-0.142	(0.04)***
House has corrugated roof	0.031	(0.03)	0.045	(0.09)	0.315	(0.03)***
Household is in East Gojjam	-0.205	(0.03)***	-0.433	(0.07)***	-0.543	(0.05)***
Availability of piped water in the community	0.143	(0.03)***	0.360	(0.08)***		
Distance to primary school					-0.003	(0.00)***
Distance to secondary school					-0.002	(0.00)***
Number of dependents					-0.032	(0.03)
Yr2002	0.036	(0.05)	0.102	(0.10)	0.181	(0.04)***
Yr2005	0.037	(0.05)	0.221	(0.11)**	0.579	(0.04)***
Yr2007	0.009	(0.06)	-0.034	(0.12)	0.477	(0.05)***
_cons	-0.035	(0.10)	-0.150	(0.20)	0.106	(0.10)

Note: N = 12955; bootstrapped standard errors are in parentheses.*** indicates significance at 1%; ** at 5%; and *at 10%. Likelihood-ratio test of rho = 0; chi2(1) = 40.842; Prob>chi2 = 0.0000.

In Table 5, we present the results from the bivariate probit regression of energy collection and literacy. Again based on the likelihood-ratio test of rho = 0 (chi2(1) = 19.454, Prob>chi2 = 0.0000), our estimation procedure using a bivariate probit, instead of a univariate probit estimation, is preferred. Consistent with the previous discussions, child characteristics such as age and being a male child have negative effects on their participation in collection of firewood. Children in male headed households are less likely to be involved in collection of fuel wood. Compared to the older children, the younger ones are less likely to participate in energy collection. The older children are relatively more involved in fuel collection, which may result in less time for schooling. Also, households with male heads and older household heads have a negative and positive effect on the participation of children on energy collection, respectively. This result is also consistent with that for total resource collection, as well as the participation of children in fetching water. In terms of household composition, the presence of more adult members negatively affects the likelihood of participation in fetching water, but there is no significant association with the number of female adult members.

The presence of community forest has a positive and significant effect on both the participation and time spent for fuel collection. We also find variation across locations, as children living in East Gojjam are more likely to participate in energy collection than children living in South Wollo zone.

Table 5. Regression results for child fuelwood collection work and child literacy

Explanatory Variable	Participation in resource-collection work		Resource collection time		Literacy	
Hours spent					0.007	(0.09)
Residuals					-0.024	(0.08)
Sex of child (=1 if male)	-0.559	(0.03)***	-0.971	(0.05)***	-0.005	(0.08)
Child age is b/n 6 - 10 years	-1.098	(0.04)***	-1.882	(0.06)***	-0.490	(0.16)***
Child age is b/n 11 - 14 years	-0.272	(0.04)***	-0.433	(0.05)***	0.305	(0.05)***
Household head (=1 if male)	-0.224	(0.04)***	-0.402	(0.08)***	-0.068	(0.05)
Age of household head in years	0.008	(0.00)***	0.016	(0.00)***	0.006	(0.00)***
Household head is literate (yes =1)	-0.014	(0.03)	-0.014	(0.06)	0.275	(0.03)***
No. of male children below 5	0.059	(0.03)*	0.124	(0.06)**	0.031	(0.03)
No. of female children below 5	0.093	(0.05)**	0.152	(0.07)**	-0.003	(0.04)
Number of male adults	-0.034	(0.03)	-0.073	(0.05)	-0.045	(0.03)*
Number of female adults	-0.199	(0.03)***	-0.307	(0.05)***	-0.031	(0.03)
Number of livestock in TLU	0.007	(0.01)	0.000	(0.01)	0.010	(0.01)
Mean Variables						
Mean No. of male children below 5	-0.044	(0.05)	-0.070	(0.08)	-0.144	(0.04)***
Mean No. of female children below 5	-0.197	(0.08)**	-0.306	(0.13)**	-0.120	(0.07)*
Mean Number of male adults	-0.008	(0.03)	0.018	(0.06)	0.053	(0.03)*
Mean Number of female adults	0.083	(0.04)**	0.089	(0.06)	0.065	(0.03)**
Mean Number of livestock	0.005	(0.01)	0.018	(0.02)	0.001	(0.01)
Mean Number of dependents					-0.150	(0.04)***
House is corrugated roof	-0.005	(0.03)	-0.038	(0.07)	0.302	(0.03)***
Household is in East Gojjam	0.295	(0.03)***	0.458	(0.05)***	-0.449	(0.04)***
Availability of community forest in the Kebele	0.204	(0.03)***	0.272	(0.05)***		
Distance to primary school					-0.003	(0.00)***
Distance to secondary school					-0.002	(0.00)***
Number of dependents					-0.029	(0.04)
Yr2002	-0.027	(0.05)	0.109	(0.08)	0.137	(0.04)***
Yr2005	0.029	(0.05)	0.467	(0.08)***	0.522	(0.06)***
Yr2007	-0.015	(0.05)	0.326	(0.10)***	0.474	(0.06)***
_cons	-0.477	(0.10)***	-1.148	(0.17)***	0.019	(0.13)

Note: N = 12955; bootstrapped standard errors are in parentheses.*** indicates significance at 1%; ** at 5%; and *at 10%.

5.2 Determinants of Children's Literacy

It has been argued that it is not only the participation of children in work that affects human capital accumulation, but that the outcome also depends heavily on the number of hours that she/he is working. Therefore, a main focus of this study is to look at the effect of time spent for resource collection on child education and hence on their reading and writing ability. We have examined this by including total hours of work in resource collection as an additional regressor in the regression for literacy. We have taken into account the potential endogeneity of hours of work. The significance of the residuals indicates that hours of work is indeed endogenous. The results show that time spent for resource collection in general has a negative and significant effect on children's literacy. Findings from other studies also show that those involved in resource collection work are less likely to attend their school, which supports the hypothesis of resource-collection work having a negative influence on schooling (Nankhuni and Findeis 2004). Hence, the result may not be surprising. The result is the same when we look at the effect of time spent for water collection on the probability of children's ability to read and write. It is negatively correlated with their reading and writing ability and significant at the1% level. However, the coefficient is not significant in the case of energy. Although this is unexpected, there might be various reasons for the insignificance of this result. First, fuel wood is a major and serious problem in the regions studied and cannot be easily obtained using child labor. That means it may require the involvement of adults, which reduces the burden on children. Based on exploratory regression analysis, Assefa and Bedi (2003) found that collecting water and fuel wood and domestic work do not have a detrimental effect on child school attendance in rural Ethiopia. Our results may suggest that policy makers may give priority to increasing the availability of water via construction of piped water or development of streams. In this regard, there is room for development agents to direct resources so that the burden on children could be reduced. This may improve child education in the region.

We also find that children who have more educated household heads had more probability of reading or both reading and writing. This suggests that education policy should be comprehensive, in that it may be difficult to promote child education without taking into account the role of literate parents. Thus, efforts to enhance adult education will help improve the likelihood of child school attendance and hence their literacy level.

The results show that the presence of children under five in the household (both male and female) is associated with a lower likelihood of school attendance. This is perhaps due to the demand for child labor to take care of the younger children. Similarly, children living in households with more dependents are less likely to attend school. Of the wealth indicators

included in the regression, those children living in houses with a corrugated roof are more likely to read and write. Unlike studies by Admassie and Bedi (2003) and Woldehanna et al. (2008) in Ethiopia, our results suggest that livestock ownership does not have a significant effect on literacy.

School related infrastructure was also included to examine their effect on child education. As expected, if both primary and secondary schools are located far from the child's residence, then the probability of children's ability to read and write will decrease. The result is consistent when we look at the estimates by resource type. A cross-country study on the causes of child labor by Ersado (2005) also argued that lack of access to school and low school quality are among the significant factors that could affect child schooling and work decisions. This implies that child education can be enhanced if the school is located near the community.

Child characteristics were also included in the analysis. The results suggest that, if the child is male, then it is less likely that the child will attend school and more likely that the child will have a low literacy level. This might be because male children are busy working in farm activities. So, the probability of reading and writing is higher for female children in our study areas. Compared to older children (15-17 years), the very young children (6-10 years) are less likely to participate in resource collection. But those between the ages of 11 and 14 are more likely to participate than the older children. The result is consistent across the different resource type estimations. However, children between 11 and14 years are more likely to attend schools and have better reading and writing ability than children between 15 and 17 years. This seems to indicate that the age-schooling relationship follows a sort of inverted U shape. That is, the probability of child literacy is lower at the lower age level, becomes higher somewhere in the middle (11-14) and then declines for the children aged 15 to 17. This is an interesting result in that it shows which category of children is less likely to attend school. Therefore, policy interventions could focus on children in the top and bottom age categories.

6. Conclusion and Policy Implications

As in many other developing countries, in sub-Saharan Africa in particular, children in Ethiopia engage in work activities. This has resulted in a negative impact on their education. Although there are a number of studies that show the effect of child labor on schooling in general, there is limited literature that examines the effect of participation of children in environmental resource collection. This paper has examined the effect of resource collection on child education using panel data collected in four rounds from the Amhara region of rural Ethiopia. We model resource work participation and children's literacy as a joint decision that

takes into account the correlation between the disturbance terms. This approach is based on earlier results which show the importance of taking into account the simultaneity of the decisions about participation in resource collection work and schooling in order to assess the role played by hours worked and other explanatory variables. We have also employed Mundlak's approach to exploit the panel nature of the data.

The regression results show that, in general, natural resource collection has a negative impact on child literacy. Unlike other related studies, this paper separately analyzes the effect of collection of water and energy on children's literacy. We found that energy collection has no significant impact on literacy. However, this is a country and region specific study and further research is necessary to make a general conclusion about the effect of fuel wood scarcity on children's education. Our findings also show that more time spent for fetching water has a negative impact on child education. Hence, measures need to be taken to reduce the burden on children and enhance child education in the study areas by giving priority to problems such as water, which have more serious impacts on child education. Development agents may reallocate their limited resources to those sectors which affect children's education the most. An important contribution of this research is that it hints at the importance of separately analyzing the effect of each type of resource.

This study has also identified other factors that affect child education in rural Ethiopia. Infrastructure facilities such as school proximity are important determinants of child education. As may be expected, expanding access to schools in the different parts of rural areas may have a considerable impact on human development. Education policy should also consider the role of educating household heads, which has a positive and significant influence on child education. We also find that households with a larger number of members above age 65 and below age 5 have lower child literacy, suggesting the role of dependency in reducing child education.

Future research may also include other activities such as herding animals and collection of other forest resources. Detailed data on child activities will help to identify the most important activity that hinders child education in a particular location.

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Appendix A. Descriptive statistics of explanatory variables by year

	Year = 2000		Year = 2002		Year = 2005		Year = 2007	
	N=2720		N=3051		N=3677		N=3709	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Sex child	0.553	0.50	0.530	0.50	0.523	0.50	0.521	0.50
Age_6-10	0.489	0.50	0.465	0.50	0.426	0.49	0.373	0.48
Age_11-14	0.293	0.46	0.312	0.46	0.339	0.47	0.363	0.48
Sex head	0.869	0.34	0.884	0.32	0.882	0.32	0.863	0.34
Age head	48.620	12.93	49.505	13.07	50.100	13.51	50.143	13.03
Literacy head	0.491	0.50	0.509	0.50	0.525	0.50	0.491	0.50
Under five_male	0.477	0.66	0.404	0.61	0.377	0.59	0.359	0.57
Under five_female	0.450	0.64	0.001	0.03	0.003	0.05	0.353	0.56
Livestock	3.447	3.29	3.782	3.36	4.450	3.39	4.543	3.38
Adult size male	1.398	0.82	1.571	0.89	1.827	1.08	2.075	1.20
Adult size female	1.300	0.64	1.461	0.72	1.736	0.90	1.988	1.05
Corrugated _roof	0.525	0.50	0.557	0.50	0.688	0.46	0.772	0.42
Dummy for East Gojam	0.468	0.50	0.467	0.50	0.486	0.50	0.503	0.50
Availability of piped water	0.429	0.50	0.652	0.48	0.490	0.50	0.598	0.49
Availability of community forest	0.694	0.46	0.612	0.49	0.494	0.50	0.554	0.50
Distance primary education	42.894	18.46	41.360	19.85	35.454	15.40	30.288	20.89
Distance secondary education	69.804	19.93	95.157	53.87	75.121	19.15	71.035	37.30
Number of dependents	0.219	0.47	0.254	0.51	0.387	0.62	0.507	0.83