School absenteeism, work and health among Brazilian children: Full information versus limited information model

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Abstract

We estimate a system of three behavioral equations for Brazilian children and teenagers (school absenteeism, health status and child labor). We relieved the assumption of independence of the disturbance terms of each equation. Moreover, if causality mechanisms between these three components (school absenteeism, health status and child labor) can occur either way, it can also be the result of a simultaneous decision-making process. Thus, to take into account both endogenous causality aspects and simultaneity, we estimate using the FIML method, which provides some improvement to the quality of the estimation, allowing us to simultaneously estimate all relevant parameters, including covariance parameters, and also to the subsequent interpretation of the results.

Resumo

Estimamos um sistema com três equações comportamentais para crianças e adolescentes do Brasil (absenteísmo escolar, status da saúde e trabalho infantil). Relaxamos a hipótese de independência dos termos de erro de cada equação. Se os mecanismos de causalidade entre estes três componentes (absenteísmo escolar, status da saúde e trabalho infantil) podem ocorrer em qualquer direção, também podem ser resultantes do processo de escolha simultânea. Desta forma, para considerar tanto os aspectos relacionados à causalidade endógena quanto os de simultaneidade, estimamos usando o método FIML, que melhora a qualidade da estimação, permitindo a estimação simultânea de vários parâmetros relevantes, incluindo os parâmetros da matriz de variância-covariância, e também a interpretação dos resultados.

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Palavras chave: criança, educação, saúde, trabalho, modelo de informação limitada e modelo de informação completa

Introduction

Until 2005, in Brazil,[4] the educational system was compulsory for children aged 7 to 14 years old. The literature (Barros et al., 2001; Barros et al., 1996; Kassouf, 2001) shows that where school resources are worse and where child labor[5] could be an important source of income for the household, absenteeism rates are highest. Borrowing constraints are also an important factor determining withdrawal from school (Jacoby, 1994). If household income falls short of the subsistence consumption level, children are sent to work instead of going to school or having more leisure time.

As a matter of fact, a parent's income is not the only element affecting a child's school attendance. Children's education is also influenced by household composition, standards of living, social context, children's participation in the labor market, and their own characteristics, particularly children's health. A policy that intends to increase children's education should consider all these aspects of children's life, which influence the well being and the quality of future life. The three aspects, education, health and work, reflect household decisions that are made while taking into account preferences, costs and benefits that result from resource allocation inside the household.

So far the literature has generally focused on two of these three aspects. A large literature exists on child labor and education (Barros et al, 2001; Barros et al, 1996; Barros and Lam, 1993; Carvalho, 2000; Emerson and Souza, 2000; Kassouf,

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[4] In 1996 and 1997, reference years of our database, the compulsory age to enter elementary school in Brazil was 7 years old. Elementary education takes 8 years. Since 2005, Law # 11.114/2005 reduced the compulsory age for school admission to 6 years old.

[5] People with more than 5 years old answer the question "Have you worked in the last 7 days?" The labor concept considers if people have an economic occupation remunerated in cash, merchandise, or only benefits (housing, food, clothing, etc.) or an economic occupation, without pay, for at least 1 hour per week, helping a member of the household who has an economic activity or as an apprentice, trainee, etc. We consider as child labor the children aged 7 to 14 years old in our sample that answered "yes" to this question. So it can include labor without pay and also domestic labor.

2001; Vasconcellos, 2005). The main purpose is to study why parents prefer to send their children to work rather than to school (Basu, 1999 for an extensive survey). Concerning children's health, the literature focuses on estimations of reduced-form health demand and on which factors affect more or less this demand (Alves and Beluzzo, 2004; Kassouf, 1994; Kassouf and Senour, 1996; Thomas et al, 1991), but there are very few articles studying the interrelations between children's health and children's education or child labor.

However, children's schooling progress depends on their health situation and on the time devoted to study. Working children do not have enough time to dedicate to school. Child labor could also negatively affect children's current or long-term health situation. The working child could also evaluate his/her health negatively, since he/she feels more tired than other children who are not working. This child has probably a very busy day: school, work and homework. Moreover, children who are not in good health could have difficulties in following the educational system (Glewwe and Jacoby, 1995; Behrman and Lavy, 1994). Berger and Leigh (1989) point out that there is no consensus in economics about mechanisms through which education contributes to health improvement. Positive correlations between education and health could be explained by the causal effect of education on health or by the causal effect of health on education.

Our novel approach is to propose a full information model to assess the interactions between education (school absenteeism), health and work, considering all possible or relevant causal and simultaneous effects between those three aspects. Our econometric specification is therefore a simultaneous equations model we can estimate by using a full information maximum likelihood (FIML) method. Thus, we will be able to take into account both endogenous causality aspects and simultaneity, providing some improvement to the quality of the estimation and to the understanding of the results (we estimate direct and indirect effects of the variables). It is important to note that with this method we can simultaneously estimate all relevant parameters, including covariance parameters.

The data come from the Living Standards Measurement Study Survey 1996/1997 (Pesquisa de Padrões de Vida – PPV).[6] This household survey is

[6] We are investigating school absenteeism and not only attended school or attended educational level (something about school delay, for example). The only Brazilian household survey that has the three dimensions we are interested in (school absenteeism, child work and health) is Living Standards

conducted in two Brazilian regions (Northeast and Southeast), with information on health, child labor, household characteristics and education. As this survey was completed before the existence of the "Bolsa Escola" program, we assess the impact of income on school attendance and on children's health before its implementation. The next Section presents the data and some preliminary results. Section 2 presents the econometric model; Section 3 provides the results and Section 4 concludes.

1. Descriptive analysis and data information

1.1. Data information

The data come from LSMS Brazilian Survey – 1996/1997 (Pesquisa de Padrões de Vida – PPV), conducted in the Northeast and Southeast of Brazil[7]. We use a sample of 3,087 children aged 7 to 14 years old[8].

Our database provides anthropometric measurements,[9] such as weight and height. Using these anthropometric measures, we construct the health indicator ***Height for Age z-score* (HAZ).**[10] As recommended by WHO (2005), HAZ is the result of the transformation of the child's height into a normal, standardized variable, considering a "healthy" reference population for comparison.

This indicator reflects cumulative linear growth, and its deficit indicates past or chronic nutritional inadequacies and/or chronic or frequent illness. Low height for age z-scores relative to a child of the same sex and age in the reference population are referred to as "shortness". Extreme cases of low height for age z-score, where shortness is interpreted as pathological, are referred to as "stunting".

According to WHO (2005), this indicator is largely used to describe the long-run nature of nutrition and health, and is more adequate to capture the influence of

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Measurement Study Survey 1996/1997. We believe that the relationships between them have not been significantly modified through time.

[7] Published by the Brazilian Institute of Geography and Statistics (IBGE) and the World Bank.

[8] The proportion of children in each region is similar to what is found in the National Household Survey, called PNAD.

[9] Weight and height are collected in the first or in the second home visit. These measurements have limited value as indicators of malnutrition, in particular because they depend on both age and gender, and are affected by many intervening factors other than nutrient intake, such as genetic variation. However, even in the presence of such natural variation, it is possible to use physical measurements to assess the adequacy of diet and growth, in particular in infants and children, by comparing indicators with the distribution of the same indicators for a "healthy" reference group, and identifying "extreme" or "abnormal" deviation from this distribution.

[10] To compute the HAZ we used the EpiInfo software.

health on a child’s education. Following WHO (2005), we present a more general classification of malnutrition, which distinguishes between mild (HAZ < -1), moderate (HAZ < -2), and severe malnutrition (HAZ < -3).

To analyze aspects of children's education, we look at school attendance and the numbers of days, in the last 30 days, children were absent from school.

In the literature on child labor, particularly in studies involving developing countries, household decisions are important to define a child's time allocation between school, work and leisure. A large part of this literature emphasizes the determinants of child labor and demonstrates the influences of parental decisions towards child labor.[11]

Even though Brazil has a law protecting children and teenagers[12] – work is only allowed for children aged 16 and older, with apprenticeship available only at the age of 14 –, in 1999, three million children aged between 5 and 14 years old, or 9% of the population this age, were working (Kassouf, 2001).

1.2. Descriptive analysis

The mean HAZ is always negative, so there are average deficits in height per age concerning a reference population in all Brazilian regions (Table 1). This indicates that children aged 7 to 14 years old have past or chronic nutritional inadequacies. This phenomenon is aggravated in the poorest locations, such as in rural areas (-0.84) and in the Northeast region (-0.57). Table 1 also shows that 30% of the children aged 7 to 14 years old were classified as suffering from malnutrition (HAZ < 1): 43% in rural areas and 34% in the Northeast region.

Table 1 shows that 65% of children attended school in the last 30 days. This percentage increases for children living in the Southeast (68.5%) and in urban areas (68.3%).

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[11] Menezes-Filho et al. (2002) analyzed time allocation decisions for children and adolescents in several Latin American and Caribbean countries. Problems with school attendance can be linked to variables reflecting the household structure in the various countries, in particular parental education and the number of young children.

[12] The federal government created the Program for the Eradication of Child Labor to target specific cases in which activities represent hazard to children (e.g.: coal mines, shoe manufacturing, sugar cane harvesting and sisal plantations). Families with children at risk of working receive some money if they keep their children at school. Coverage of this program is not so large and focuses on hazard activities.

Looking at our database, we find that 21% of children in the poorest income class work. This percentage, for the richest income class, decreases to 4.5%. Table 1 shows this work rate for each region and rural/urban areas. As the majority of working children (60%) are employed in agricultural activities, it is no surprise that children's participation in the economic activity is larger in rural areas (25.8%) and in the Northeast region (14.98%).

Economic activity influences a child's participation in the labor market. Depending on the parent's activity, children may help them in their work. In those regions where agricultural economic activity predominates, child labor is usual, particularly among younger boys.

Table 1: Our sample - children with 7-14 years old

		Regions		Areas		
		Northeast	**Southeast**	**Rural**	**Urban**	**All regions (a)**
Sample	# obs.	1762	1325	928	2159	3087
WORK	# work	264	92	240	116	356
	% work	14,98	6,94	25,86	5,37	11,53
School Absenteism (%)						
How many days were you absent?	= 30	3,35	1,36	1,29	3,01	2,49
	< 30 and >= 20	1,25	0,91	0,86	1,20	1,10
	< 20 and >=10	2,67	1,06	2,48	1,76	1,98
	< 10 and >=1	21,06	22,87	22,20	21,68	21,83
	zero	63,00	68,53	58,41	68,36	65,37
	% not enrolled	8,68	5,28	14,76	3,98	7,22
Health						
HAZ	mean	-0,57	-0,21	-0,84	-0,22	-0,41
	HAZ < -1 (%)	34,11	24,45	43,21	24,27	29,96
	HAZ < -2 (%)	10,90	8,53	15,09	7,64	9,88
	HAZ < -3 (%)	2,27	3,55	3,34	2,59	2,82

Notes: (a) All regions and rural and urban areas together

(b) Rural and urban areas incorporate southeast and northeast regions

Source: Tabulation made from the 1996/1997 PPV database.

Table 2 presents some descriptive analysis on the interactions between health (*HAZ*), child labor and school absenteeism.

As expected, the HAZ is highly dependent on child labor (Table 2). In terms of nutritional conditions, child labor seems to have a negative impact on health, probably because a working child feels more tired. Hard work, demanding a great physical activity, should be incompatible with children’s age and development.

Child labor also has a negative relationship with children’s school participation. When a child begins to work, he/she may not be successful in juggling school or study time and working time. In some cases, he/she would prefer to drop out of school. We note that children who are not working miss fewer days of school: 67% of them were present at school during the last 30 days. This percentage drops to 65% for children who work.

Table 2: Relations between health, labor and education - children aged 7 to 14 years old

		Children who work	Children who do not work
HAZ	mean	-0.80	-0.36
	HAZ < -1 (%)	44.14	30.61
	HAZ < -2 (%)	15.12	10.02
Education	% enrolled	83.15	94.03
School Absenteeism			
Number of days of school absence (%)	= 30	2.49	2.56
	< 30 and >= 20	1.10	1.17
	< 20 and >=10	1.98	1.61
	< 10 and >=1	21.83	21.64
	zero	65.37	67.05

Source: Tabulation made from the 1996/1997 PPV database.
Notes: (a) All regions and rural and urban areas computed together, (b) Rural and urban areas include the southeast and northeast regions.

Education can allow a child to learn some basic notions of hygiene, positively influencing his/her health status in the long and short run. Concerning school attendance, child labor and bad health conditions may prevent the child from going to school and studying hard: the former because less time is dedicated to school, and the latter for physical reasons. Children's health is widely perceived to strongly affect schooling (Behrman and Lavy, 1994).

When we look at school participation, we note that the rate is higher for children with a better HAZ. For children with a HAZ below minus one, minus two and minus three, these rates are 88.1%. 86.2% and 80.5%, respectively (Table 3).

Table 3: Relations between health, labor and education - children aged 7 to 14 years old

		Children with HAZ < -1	Children with HAZ < -2	Children with HAZ < -3
Education	% enrolled	88.1	86.23	80.46
School Absenteeism				
Number of days of school absence (%)	= 30	3.68	4.26	3.45
	< 30 and >= 20	0.97	0.66	0
	< 20 and >=10	2.7	2.62	3.45
	< 10 and >=1	20.43	19.02	21.84
	zero	60.32	59.67	51.72

Source: Tabulation made from the 1996/1997 PPV database.
Notes: (a) All regions and rural and urban areas computed together, (b) Rural and urban areas include the Southeast and Northeast regions.

We also note that children with better nutritional conditions have a lower absenteeism rate. A proportion of 60.3% of the children with a HAZ of less than minus one were present at school during the last 30 days. For children with a HAZ of less than minus two and minus three, this proportion dropped to 59.6% and 51.7%, respectively.

Thus a good health status, in terms of nutritional conditions, is also important when it comes to school participation. Policies with a positive impact on children's health should have positive effects on school participation. Hence adding a health component to a policy that creates incentives to school participation could be more efficient in increasing children's welfare state in terms of health.

Interactions between these three variables are summarized in Figure 1. In the following sections, we consider all of these relations. We explore the possible correlations between these variables, and we show how interrelations affect a policy and how to take potential channels into account to increase its impact.

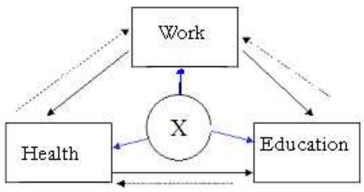

Figure 1

2. Econometric specification[13]

In this section, we explain our econometric strategy. Our model is composed of three behavioral equations for children, explaining the following endogenous dependent variables:

[13] For each equation, the independent variables and their definitions are presented in Appendix.

- ***WORK:*** labor market participation (Have you worked during the last 7 days? Yes or No). The variable y_1^* is an unobserved continuous latent endogenous variable with which the discrete variable y_1 is associated, taking value 1 if $y_{1n}^* > 0$ (working) and 0 otherwise;

- ***HAZ:*** health status, denoted by y_2, corresponds to the height per age z-score, a long-term measure of health; as already described in section 1.1.

- ***EDUC:*** School attendance, denoted by y_3, is built from the number of school days missed during the month. This indicator is based on two questions: "(i) In the last 30 days, were you ever absent from school? If so, (ii) how many days were you absent?". So, this indicator is defined in equation 1 below:

$$\begin{cases} EDUC = 0 \quad \text{if the child is not enrolled in school} \\ EDUC = \ln\left(100 \times \left(1 - \left({days}/{30} \right)\right)\right) \quad \text{if the child is enrolled in school} \end{cases} \qquad \text{(eq. 1)}$$

If the child is not enrolled in school, this variable takes the value zero. The variable *EDUC* increases with school attendance, and is highest for a child who was never absent from school. In this article, we focus on the compulsory education[14] for kids aged between 7 and 14 years old.

Some studies on school attendance and child labor are based on the estimation of a multinomial logit model (Menezes-Filho et al., 2002 and Corseuil, Santos and Foguel, 2001). Normally, they use four alternatives: work and study, only study, only work, no study and no work. Multinomial logit models may not accommodate some features that might seem sensitive, such as correlations of unobservable variables across alternatives that have common elements, i.e. some unobservable variables can simultaneously affect the alternatives. For example, in the cases of "work and study" and "work and no study", children's ability could affect them. In addition, the

[14] The law enacted in 1996 obliges parents to send their children aged 7 to 14 years old to school, except if the eight elementary school grades have already been completed. If the child follows a standard education profile, which means that the child does not fail a grade or drop out of school, he/she will finish elementary and high school education at the age of 14 years.

multinomial logit model assumes these two variables (child labor and school attendance) to be the result of a common decision. Because we want to relieve this assumption and test it, we use the alternative approach of a simultaneous equations model. Moreover, we want to incorporate an additional dimension: health status. Furthermore, the multinomial logit approach requires the presence of dichotomous endogenous variables only, while we have a mixture of dichotomous and continuous endogenous variables.

The model can be written, for each observation *t, as*:

$$\begin{cases} y_{1t}^* = x_{1t}'\beta_1 + y_{2t}\alpha_{12} + y_{3t}\alpha_{13} + u_{1t} \\ y_{2t} = x_{2t}'\beta_2 + y_{1t}^*\alpha_{21} + y_{3t}\alpha_{23} + y_{1t}\gamma_{21} + u_{2t} \\ y_{3t} = x_{3t}'\beta_3 + y_{1t}^*\alpha_{31} + y_{2t}\alpha_{32} + y_{1t}\gamma_{31} + u_{3t} \end{cases} \quad \text{eq. (2)}$$

For simplicity's sake, the exogenous variables of equation *i* are denoted by x_{it}, with the relationship $x_{it} = s_i.x_t$, where x_t is the vector of all exogenous variables and s_i is the selection matrix corresponding to equation *i*.

Table A.1, in the Appendix, presents our exogenous variables for each equation and their definitions.

The disturbance terms $u_t = (u_{1t}^{'}, u_{2t}^{'}, u_{3t}^{'})^{'}$ are jointly normally distributed as $u_t \rightarrow N(0, \sum)$, and assumed to be independent across *t,* with the covariance between u_{it} and u_{jt} being σ_{ij}.

The conditions for identification require some exclusion restrictions on the exogenous variables x_{it}.[15] They also require a well-known normalization of the variances σ_1^2 of the disturbances u_{1t}, since all parameters of the first equation are only identified up to a scaling factor. As usually, for simplicity's sake, the variance σ_1^2 is set to unit value. Given the explicit exclusion restrictions of the model, no further identification restriction is needed. As our model contains only one dichotomous endogenous variable (first equation) associated with a latent variable,

[15] We have some variables that affect only one y_i. For the choice of the instrumental variables, we follow the literature on economic development. More details are given in the Results Section.

the conditions for logical consistency[16] are always satisfied without further constraints.

The estimation is performed by maximizing the log-likelihood function with respect to all parameters (first and second order). This allows estimating the marginal effects η_{ij} of the independent variable x_j on the dependent variable y_i by the average of the estimated marginal effects for each observation. The marginal effects are defined by $\eta_{ij} = \frac{\partial E(y_i)}{\partial x_j} = \frac{\partial \Pr(y_i = 1)}{\partial x_j}$ in the case of a dichotomous dependent variable y_i, and by $\eta_{ij} = \frac{\partial E(y_i)}{\partial x_j}$ in the case of a continuous dependent variable y_i.

And eventually, some cross effects ζ_{ij} of the dependent variables on each other can be estimated in the same way, with:

$$\zeta_{ij} = E\left({y_i}/{y_j = 1} \right) - E\left({y_i}/{y_j = 0} \right) = \Pr\left({y_i = 1}/{y_j = 1} \right) - \Pr\left({y_i = 1}/{y_j = 0} \right)$$

The presence of endogenous variables on the right-hand side of some equations may yield biased or inefficient estimates, and there are possible simultaneous decision processes. To take into account both endogenous aspects and simultaneity, all three equations are estimated by full information maximum likelihood (FIML) using a simultaneous equations specification.

We chose FIML in contrast to limited information maximum likelihood (LIML) in part because LIML estimation does not take into account the simultaneous decision process.

A FIML method provides some improvement to the quality of the estimation, allowing us to simultaneously estimate all relevant parameters, including covariance parameters, and also some improvement to the subsequent interpretation of the

[16] The problem of the logical consistency in a simultaneous equations model has been previously treated in a general framework by Gouriéroux et al. (1980). Maddala (1983) proposes an approach based on the probabilities of the possible outcomes in a bivariate probit setting. Here we apply the extension of Huguenin (2004) to a general multivariate probit setting. The logical consistency of the model requires that the probabilities of the different possible joint values of the dichotomous endogenous variables for each observation add up to unit value. However, this discussion and subsequent conditions apply only when there is more than one dichotomous endogenous variable in the model.

results.[17] We propose here to apply the exact maximum likelihood method developed by Huguenin (2004), which avoids the stochastic nature of a simulation-based method (as with simulated maximum likelihood or simulated score methods), while circumventing the difficulties arising from the necessity to numerically evaluate a great number of multivariate normal probabilities.[18] This method can be performed with all its virtues on systems of equations of relatively small dimension. For comparison reasons, we also estimated our model using an LIML approach, where each equation is estimated separately. We show that these results lead to some misinterpretations, so, FIML method seems a better alternative of estimation.

3. Results

Methodologically, we estimated several different forms and specifications of our model, especially in terms of exclusions of explanatory variables and constraints on the covariance parameters, and then settled for the specification displaying the highest likelihood. In this section, we present the results obtained from this "best model".

With the methodology applied here, we can identify interactions between our three endogenous variables since we are considering both simultaneity in the mechanisms and possible causal influences of these variables on each other. First, we can identify direct effects, for example, the impact of a child's participation in the labor market on his/her health status, or the impact of school attendance on a child's probability of working (as shown in Table 4). Second, with this method we take into

[17] The respective virtues and disadvantages of both approaches are well known, and will not be discussed here (see Heckman (1978) and Amemiya (1978) for early developments of the estimation of multivariate probit models).

[18] Amongst papers estimating such multivariate probit model using FIML, most assume some constraints on the covariance parameters to simplify the multiple integration problem (Ashford and Sowden (1970), Sickles and Taubman (1986), Block and Gibbons (1996)}). Some FIML estimation procedures, following the development of techniques based on simulation (Gourièroux and Montfort (1996)), have also been implemented to overcome the difficulty arising from the numerical evaluation of multiple integrals as encountered in this context (see McFadden (1989)} for the method of simulated moments and Hajivassiliou and McFadden (1998)} for the method of simulated scores). These techniques have mainly been developed for the estimation of multinomial models, but their application to multivariate probit models is quite straightforward. Although there is no doubt about the virtues of simulation based estimations, they contain two sources of criticism: first, the results are stochastic in essence; second, their implementation can be extremely time-intensive. We offer here an alternative method without resorting to simulations, by the approach of exact maximum likelihood developed by Huguenin (2004). This method can be performed with all its virtues on systems of equations of relatively small dimension, based on exact analytical results.

account all indirect effects, presented in Table 5. We present the indirect effects for our main variables, health, labor and school absenteeism, estimated by our model.

We first discuss the results from the three equations estimated by FIML (Table 4 and Table 5), before turning to the comparison and differences between this method and LIML (Table 6), showing some advantages from FIML estimation.

3.1. Intuitive features and policy implications

Regarding work probability, we note that boys have a higher probability than girls. The age variable is also relevant to child labor. As the child becomes older, the probability of working increases in 0.02 points (Table 5).[19]

As expected, a child living in a rural area and with a mother who has an unpaid job has a positive effect on the probability of child labor (Table 4). Having a mother with an unpaid job increases child labor probability in 0.13 points (Table 5) and also has indirect negative effects on health (0.12 points). Living in a rural area increases child labor probability in 0.06 points and has an indirect negative effect on health (0.07 points). The indirect negative effects on education for both unpaid mother's job and living in rural areas were not significant.

School absenteeism is explained by three education supply variables, namely, number of teachers (*teachers)*, number of school desks (*desks)* and an indicator of the quality of school resources, considering the presence of libraries, books, computers, rooms, and other equipment in the school in the geographical area where the child lives (*school quality)*.[20]

The number of school desks has a positive significant effect on school attendance. The greater the number of desks (an indicator of a good school) in the area where the child lives, the lower the absenteeism. The elasticity is 0.35, so, an increase of 1% in the number of school desks increases school attendance in 0.35% (Table 5).

[19] We have tested different forms for the effect of age on our dependent variables. Results are not significantly modified.
[20] For details about the construction of these variables, see Table A.1 in Appendix.

With regard to income and parents' education, effects are not always so intuitive. We tested different forms of effects for income (linear, multiplicative, or more flexible effects through a polynomial form). We present here four dummy variables that appeared to be most adequate. As to parents' education, only that of the mother (and not of the father) has a significant effect on some of the dependent variables. The effect of parental education on child labor is not significant when we control for the type of parents' employment, parents' income and living conditions. We thus decided to present the results of parents' education using the variable of mother's education only.

The direct effect of mother's education is only significant in the children's health equation. When the mother is more educated, her child has a better health status.

A more educated mother would be more conscious about factors affecting her children's human capital accumulation and, consequently, future life opportunities for her children. She could be more conscious about the importance of investment in education and health. Mother's education is one of the principal determinants of children's health. Having a mother with the highest education level increases HAZ by 0.26 compared to having an illiterate mother (Table 5). If she has only elementary school (1st to 4th grade), the increase in HAZ, compared to an illiterate mother, is smaller (0.17).

Even though the coefficients of mother education dummies are not significant in the equation of children's school attendance (Table 4), the marginal effects are significant (the coefficients reflect only the direct effect, while the marginal effects also include the indirect effects – Table 5). As the mother's education increases, her child's school attendance also increases. Having a mother with the highest education level increases school attendance by 0.21 compared to having an illiterate mother (Table 5).

For the equation of children's probability of working, we note that only the marginal effect of a child whose mother has more than 8 years of education is significant and negative (a reduction of 0.036 points in the probability of the child to work).

Thus, mother's education seems to play an important role in two of our three dependent variables – health and education. Since these variables are not independent from each other, the impact of mother's education has a direct and indirect effect on children's health and school attendance, and an indirect effect on child labor.

Regarding per capita family income, the results are surprising. When we control for housing conditions, we observe that we do not obtain significant direct effects, except on children’s health (Table 4). The marginal effect of income on children’s health increases with the level of income. Children in the highest income class compared to children in the lowest income class increase their HAZ in 0.36 (Table 5).

The income also has indirect effects on child labor and school attendance. It increases the probability of school attendance from 0.13 to 0.15 depending on the income level, but it has no significant effect on the child’s probability of working (Table 5). In fact, proxies for permanent income and housing conditions can better explain child labor.

We find that the availability of filtered water in the household where a child lives affects his/her health status positively, increasing HAZ by 0.11 (Table 5). It highlights the importance of the environment on children’s health, as also shown by Deaton (2003). Filtered water also has an indirect effect in education, increasing school attendance in 0.14 points.

Household infrastructure is important to children's education. It could reflect good conditions for studying and living. We find that living in a house with electric supply increases school attendance in 0.17.

An efficient policy of monetary transfer should not consider only one of its potential effects alone – even if that is its main target – but also its other potential effects, which may be only indirectly related. It can even be contradictory if an indirect effect cancels out the direct causal effect. A monetary transfer aiming at an improvement of the education level might not only affect a child’s education, but also his/her health status and his/her probability of participating in the labor market. Moreover, in the long run, this monetary transfer could affect different aspects of children’s lives, especially human capital accumulation in terms of education and health. We show that when considering a simultaneous equations model, environmental variables seem to have more impact simultaneously on children’s health, child labor and school attendance.

3.2. Education, labor and health: full versus limited information

School attendance has an impact on a child's probability of working, and child labor affects his/her health status (Table 5). Thus, school attendance may have a significant indirect effect on children's health through the effect of child labor on health.

We obtain that the covariance between the error terms of labor and health equations and the coefficient of education in the health equation are both not significant.

The significance levels of the estimated covariance between the error terms of equations 1 and 3 show that the decision to work is simultaneously determined by school attendance (at the end of Table 4). We can consider that a child's available time is composed of his/her participation in the labor market, his/her school attendance and his/her leisure time. That means that for a child to consider entering the labor market, the time he/she spends working has a direct effect on his/her school attendance.

Health status and decision to work do not seem to be simultaneously determined. Our health variable is a long-term variable, whereas the dependent variable of child labor is a short-term variable. This may therefore explain why we do not observe a simultaneous effect.

A less intuitive result is the covariance between the error terms of the equations representing school attendance and health status. That means there is at least one variable that affects school attendance and health status and this variable is not present in our set of independent variables. We can think of a variable related to knowledge. Usually, a child who goes to school has more access to information about health and about the importance of education.

A child's health status is influenced by his/her participation in the labor market. It seems reasonable to assume that a painful working activity influences a child's health status. In fact, child labor has a negative impact on children's health. That could be another justification to introduce a policy against child labor. However, since a child's income could be the only way to keep the household out of poverty, a policy of monetary transfer could be insufficient to avoid this poverty gap. Thus, in our results, we show some evidence that decision-makers have to be very careful about the measures to be implemented and their unintended consequences.

Concerning school attendance, we observe a direct effect of the health status. This result is completely intuitive. Moreover, in poor areas, access to school could be made more difficult for different reasons, which include, for example, the lack of transportation to school. Therefore, the difficulty of access to school is increased for a child in a bad state of health.

Moreover, the school attendance rate has a negative direct effect on child labor. Therefore, a policy having a higher school attendance as a goal improves the fight against child labor.

Indeed, a policy aiming at improving health status is important from the standpoint of improving the performance of children in terms of life conditions. In this sense, we will have healthier children, potentially more able to fulfill their school obligations. The result also shows that there is a positive relationship between these actions to improve the health of children and insertion in the labor market. That is, healthier children, as expected, are also more likely to fit into the labor market than less healthy children. In the long term, it is expected that health policies could contribute to better educate children and parents on the dangers involved in child labor.

All these results show the importance of taking into account the interactions between child labor, health status and school attendance for a policy to be relevant.

We now propose to compare these results with those obtained in a partial, limited information model. First of all, we note that, in general, the standard errors are smaller for a limited information model estimation, which yields more significant coefficients (Table 6). We now focus on each dependent variable.

We find the same effect of the school attendance rate in child labor. The effect of the health status is not significant at the 5% level. This effect is significant and positive when estimating the full information model.

We detect no direct effect of child labor and school attendance on health status, whereas a direct effect of child labor was highlighted in the full information model.[21] If we explain the health status by controlling for child labor, but not for school attendance, we then find the result of the full information model (at the significance level of 6%). This difference in the results could be due to a negative correlation

[21] We made this estimation but we do not present this result in the paper, since our FIML does not consider school attendance in the health equation.

between the school attendance rate and child labor. Note that we take the simultaneous effect into account in the full information model.

Finally, we show a direct effect of health status and child labor on school attendance. With the limited information model, it appears that child labor has a negative effect on school attendance that is not detected when estimating the full information model. However, the full information model shows a simultaneity effect between both of these variables, which is not accounted for in the limited information model, explaining the different results.

The comparison between both limited and full information models highlights the importance of the simultaneity effect. Actually, we show that some effects that appear as causal in the limited information model are in fact simultaneous. Furthermore, the non-significance of some causal effects in the limited information model can also be explained by the fact that simultaneous effects are not taken into account.

4. Conclusion

This study highlights the complex interactions between three components: child labor, children's health and school attendance. An econometric estimation of only two of these three components could suffer from misspecification, especially from missing variables. Moreover, by comparing the partial, separate limited information model with the full information model, we show the importance of taking simultaneity effects into account.

We demonstrated that a policy aiming at an increase in human capital should focus on some aspects of school attendance and also be concerned with children's health. Variables focusing on mothers' conditions, especially education, play a significant role in explaining children's health. The mother's education has a positive effect on health, and moreover, more educated mothers are more conscious about the negative effects of child labor on their future life and the importance of school attendance. Since child labor has a negative effect on education, there is an indirect effect of mothers' education on children's education. The same is observed through children's education. Non-remunerated occupations create incentives to child labor since a mother could ask her children to help her.

In order to reduce child labor, and, consequently, to have an impact on children’s education, an alternative could be to focus on families in which the working mother is unpaid and which live in rural areas. Another important instrument to increase children's health and education and to reduce child labor seems to be a policy that focuses on living conditions.

One of the main conclusions of our article is that the development of children’s human capital should consider both health and education, and particularly local living conditions. Another important conclusion is that the estimation of a full information model allows distinguishing simultaneity effects from causal ones.

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Appendix

Table A.1 – Variables: definition

Variables	**Definition**
Individual characteristics	
Age	Age, between 7 and 14 years old
Boy	1 for boys and 0 for girls
Non white	1 for non white and 0 otherwise.
child reports a chronic disease	value 1 if child reports a chronic disease, and value 0 otherwise;
Household characteristics	
The condition or state of repair of the household	1 if excellent or good and 0 otherwise;

Dummies for per capita household income classes (*income) R$*	• *Reference group*: *income*<=38.443 • Income >38.443 and *income* <=90.992) • Income >90.992 and *income* <=224.3333 • Income >224.3333
Dummies for the classes of mother´s education level:	• *Reference group*: without any education and incomplete elementary school or up to the 3rd grade of elementary school; • *4 years of education*: completed elementary school or through the 4th grade of elementary school; • *5 to 7 years of education*: incomplete lower elementary education or 5th to 7th grades of elementary school; • *More than 8 years of education*: completed lower elementary education or completed elementary school, those mothers who have completed at least the upper education level or incomplete high school education;
mother was an unpaid worker	1 if the mother is an unpaid worker, and 0 otherwise;
mother had a formal job	1 if the mother has a formal job (employees in the private sector with a formal registration, employers, employees in the public sector, including the military), and 0 otherwise;
rural area	1 for rural area and value 0 for urban area;
log of total expenses per capita in food	household expenses with food (per capita), in logarithm;
house has filtered water	value 1 if the house has filtered water, and value 0 otherwise;
house has electric light	value 1 if the house has electric supply, and value 0 otherwise.
Other variables	
med	number of medical doctors (or similar occupations) in the area where the child lives;
teachers	number of elementary school teachers in the area where the child lives;
desks	% of schools in the geographical area where the child lives which have at least one desk for the students in the classroom.
school quality	indicator of school resources, it is constructed from the sum of points for each positive answer to the questionnaire: if the school has books for the students (1 point), items for the students (2 points), videos for the students (4 points), TV set (8 points), computer (16 points), lab (32 points), and other equipment for education (64 points).

TABLE 4 - Three-Equations Simult. Maximum Likelihood Linear-Probit Estimation

Variables	Equation #1 Dependent Variable: WORK			Equation #2 Dependent Variable: HAZ			Equation #3 Dependent Variable: EDUC		
	Coef.	SE	P-Value	Coef.	SE	P-Value	Coef.	SE	P-Value
Constant	2.2828	2.0638	0.2687	-0.9057	0.2048	0.0000	3.5715	1.1900	0.0027
Age	0.2698	0.0279	0.0000	-0.0110	0.0151	0.4658	0.0215	0.0387	0.5787
Boy	0.5164	0.1150	0.0000	-0.0294	0.0454	0.5163	0.0619	0.1053	0.5565
Non white	0.2681	0.2301	0.2439	0.2731	0.0884	0.0020	-0.4186	0.3655	0.2521
The condition or state of repair of the residence is excellent/good	0.1027	0.1519	0.4990	0.1668	0.0466	0.0003	-0.2366	0.2269	0.2969
Per capita household income									
> R$ 38.44 and <= R$ 90.99	0.1728	0.1950	0.3755	0.2340	0.0520	0.0000	-0.3973	0.3160	0.2086
>R$ 90.99 and <= R$ 224.33	0.3210	0.2286	0.1603	0.3342	0.0598	0.0000	-0.5187	0.4396	0.2381
> R$ 224.33	0.3478	0.2616	0.1838	0.3768	0.0740	0.0000	-0.5822	0.5075	0.2513
Mother's education									
4 years of education	0.2306	0.2054	0.2615	0.1536	0.0527	0.0035	-0.1278	0.2055	0.5341
5 to 7 years of education	0.3442	0.2528	0.1733	0.2233	0.0734	0.0023	-0.1822	0.2841	0.5213
more than 8 years of education	-0.0712	0.2349	0.7617	0.1940	0.0685	0.0046	-0.1800	0.2678	0.5014
Mother was an unpaid worker	0.8322	0.2214	0.0002						
Mother had a formal job	0.1962	0.1367	0.1513						
Rural area	0.5345	0.1245	0.0000						
HAZ	**0.3671**	**0.0957**	**0.0001**				**1.9633**	**1.1595**	**0.0904**
EDUC	**-2.2703**	**0.6562**	**0.0005**						
log of total expenses per capita in food				0.0006	0.0004	0.1016			
child reports a chronic disease				0.0043	0.0245	0.8613			
house has filtered water				0.0670	0.0455	0.1410			
Med				0.0002	0.0001	0.0650			
WORK				**-0.1408**	**0.0464**	**0.0024**	**0.2493**	**0.2362**	**0.2912**
the house has electric light							0.1562	0.0806	0.0525
teachers							0.0000	0.0000	0.0039
desks							1.1539	0.4679	0.0137
school quality							-0.0001	0.0004	0.7911
Var				0.9103	0.0430		4.2705	4.0956	
corr1&3	0.4214	0.2391	0.0780						
corr2&3	-0.8874	0.1444	0.0000						
Log-Likelihood	-8274.0664								
Observations	2807.0000								

Source: PPV/IBGE 1996/97.

TABLE 5: Marginal Effects and elasticities for the variables of the Model

Three-Equations Simult. Maximum Likelihood Linear-Probit Estimation

	Marginal Effects				**Elasticities**			
Variable	**WORK**	**HAZ**	**EDUC**	**Total**	**WORK**	**HAZ**	**EDUC**	**Total**
Age	0.025	-0.049	-0.007	-0.015	6.035	1.766	-0.023	22.805
	0.002	*0.008*	*0.009*	*0.003*				
Boy	0.046	-0.100	-0.009	-0.030				
	0.007	*0.035*	*0.036*	*0.007*				
Non white	0.010	0.259	0.115	0.043				
	0.017	*0.084*	*0.073*	*0.018*				
	-0.004	0.173	0.092	0.025				
The condition or state of repair of the residence is excellent/good	*0.009*	*0.044*	*0.037*	*0.007*				
Per capita household income								
> R$ 38.44 and <= R$ 90.99	0.012	**0.217**	0.059	0.032				
	0.011	*0.050*	*0.066*	*0.009*				
>R$ 90.99 and <= R$ 224.33	0.013	**0.315**	**0.134**	0.049				
	0.013	*0.057*	*0.061*	*0.012*				
> R$ 224.33	0.013	**0.358**	**0.154**	0.056				
	0.017	*0.070*	*0.059*	*0.015*				
Mother's education								
4 years of education	-0.010	0.169	0.177	0.024				
	0.008	*0.049*	*0.056*	*0.007*				
5 to 7 years of education	-0.013	0.245	0.261	0.032				
	0.011	*0.066*	*0.055*	*0.010*				
more than 8 years of education	-0.036	0.259	0.213	0.037				
	0.010	*0.056*	*0.049*	*0.008*				
Mother was an unpaid worker	0.134	-0.118	-0.023	-0.123				
	0.029	*0.032*	*0.077*	*0.031*				
Mother had a formal job	0.020	-0.028	-0.005	-0.011				
	0.012	*0.019*	*0.017*	*0.008*				

Rural area	0.060	-0.076	-0.015	-0.040				
	0.020	*0.029*	*0.052*	*0.016*				
log of total expenses per capita in food	0.000	0.001	0.001	0.000	-0.519	-0.320	0.036	-2.960
	0.000	*0.000*	*0.000*	*0.000*				
child reports a chronic disease	-0.002	0.007	0.009	0.001				
	0.009	*0.038*	*0.048*	*0.008*				
house has filtered water	-0.027	0.106	0.139	0.025				
	0.006	*0.041*	*0.042*	*0.008*				
Med	0.000	0.000	0.000	0.000	0.208	0.128	-0.015	1.186
	0.000	*0.000*	*0.000*	*0.000*				
the house has electric light	-0.041	0.050	0.166	0.026				
	0.016	*0.027*	*0.065*	*0.014*				
teachers	0.000	0.000	0.000	0.000	0.548	0.124	-0.036	1.804
	0.000	*0.000*	*0.000*	*0.000*				
desks	-0.244	0.373	1.226	0.125	-5.374	-1.218	0.349	-17.692
	0.088	*0.210*	*0.340*	*0.058*				
School quality	0.000	0.000	0.000	0.000	0.010	0.002	-0.001	0.034
	0.000	*0.000*	*0.000*	*0.000*				
WORK		**0.245**	**-0.065**	**-0.156**				
		0.004	***0.001***	***0.060***				
HAZ	**0.000**		**0.041**	**0.334**				
	0.000		***0.000***	***0.042***				
EDUC	**0.000**	**0.038**		**-0.006**				
	0.000	***0.000***		***0.002***				

Source: PPV/IBGE 1996/97.

Note: standard errors are on the second line of each variable with a small letter.

TABLE 6: Limited Information Model

Single Equation Maximum Likelihood Estimation

ariable	**Probit Estimation Dependent Variable: WORK**			**Linear Estimation Dependent Variable: HAZ**			**Linear Estimation Dependent Variable: EDUC**		
	Coeff.	**Standard error**	**P-Value**	**Coeff.**	**Standard error**	**P-Value**	**Coeff.**	**Standard error**	**P-Value**
onstant	-2.360	1.330	0.075	-0.670	0.159	0.000	3.538	0.523	0.00
ge	0.231	0.023	0.000	-0.031	0.012	0.011	0.071	0.020	0.00
oy	0.430	0.089	0.000	-0.072	0.040	0.072	0.135	0.049	0.00
on white	0.362	0.170	0.033	0.261	0.085	0.002	-0.027	0.087	0.76
ne condition or state of repair of the esidence is excellent/good	0.068	0.109	0.536	0.156	0.043	0.000	0.005	0.050	0.92
er capita household income									
R$ 38.44 and <= R$ 90.99	0.210	0.126	0.095	0.228	0.049	0.000	0.001	0.075	0.98
R$ 90.99 and <= R$ 224.33	0.300	0.153	0.050	0.325	0.054	0.000	0.045	0.080	0.57
R$ 224.33	0.330	0.186	0.076	0.364	0.068	0.000	0.049	0.085	0.56
other's education									
years of education	0.088	0.116	0.447	0.158	0.050	0.001	0.096	0.059	0.10
to 7 years of education	0.173	0.168	0.303	0.227	0.066	0.001	0.109	0.063	0.08
ore than 8 years of education	-0.170	0.163	0.298	0.221	0.059	0.000	0.015	0.069	0.82
other was an unpaid worker	1.040	0.109	0.000						
other had a formal job	0.193	0.104	0.064						
ural area	0.522	0.099	0.000						
g of total expenses per capita in food				0.001	0.000	0.051			
ild reports a chronic disease				0.102	0.068	0.132			
ouse has filtered water				0.129	0.040	0.001			
ed				0.000	0.000	0.117			
e house has electric light							-0.022	0.118	0.85
eachers							0.000	0.000	0.55
esks							-1.181	0.623	0.05
chool quality							-0.001	0.000	0.01
ORK				-0.063	0.034	0.062	-0.179	0.055	0.00
AZ	-0.551	0.322	0.087				0.563	0.175	0.00
DUC	-0.811	0.396	0.041						
og-Likelihood	-666.123			-3768.866			-3857.667		
bservations	2807			2807.000			2807		

ource: PPV/IBGE 1996/97.