

ESSAYS ON CHILD LABOR

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By

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ABSTRACT

This research studies the time allocation of all family members, including the children, where it is assumed that parents distribute their time between market work and household work, and the children may work in the labor market, do the household chores or study. In this framework, the labor supply of family members, the household work and the hours of education are determined simultaneously. The main hypothesis is that wages play an important role in the time allocation of family members. For example, a drop in the child wage could cause the child to spend more hours at home work (cleaning, taking care of the siblings, cooking, etc.) and/or studying, and less time working. The substitution and income effects on household work and market labor of changes in wages are derived formally. I also carry out the analysis when the family faces a subsistence level restriction (the minimum level of consumption for survival). The theoretical model is estimated by econometric methods, using data from the Peruvian Living Standard Measurement Survey from the years 1997 and 2000. Unlike other papers on child labor, this research estimates the child's labor supply and household work while taking into account the child's wage and the wages of other family

members. The main result of this research is that wages are relevant when it comes to assigning chores at home and determining the hours that the child works in the labor market. The parameters of the home production function and some parameters of the family utility function are also estimated. Finally, the effect of child labor and household work on school attainment is analyzed econometrically. School attainment is measured by two indicators: the Schooling-Age ratio and the probability of studying in high level education (college, technical school). Results show that in general, household work does not have a clear effect on school attainment. On the other hand, child labor has a clear negative and significant effect on those indicators.

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To Sara
To Hildegardi
To My Mother

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INTRODUCTION

In recent years, the economics of child labor has become a very popular topic in empirical research. Several authors have written on this subject in an attempt to understand the economic causalities behind the problem and to propose policies that may lead to less child labor.

Child labor is a big issue in the less developed world. According to statistics from UNICEF, around 250 million children around the world work and 170 million of them work in risky jobs¹. More refined statistics –like those from the International Labor Office– show different figures². According to them, 211 million children of ages 5 to 14 around the world are engaged in some sort of economic activity. Of these, 206 million live in less developed countries and 186 million work in jobs that represent a serious risk for their lives and integrity. In the case of youngsters of ages 15 to 17, 141 million work around the world, 59 million of them in dangerous jobs.

¹ UNICEF, “Child Protection. Child Labour,” available from http://www.unicef.org/protection/index_childlabour.html; Internet; accessed 10 January 2006.

² International Labour Office (ILO), *Global Report 2002: A Future without Child Labour*, (Genebra: ILO, 2002), 14.

The participation rate of children in the less developed world is also remarkably high: 26% in Sub-Saharan Africa, 15% in Arab world, 16% in Latin America and 19% in Asia in 2000. In Peru, the country to be analyzed in this study, that percentage is close to 26%, which means that one of every four children of ages 6 to 17 works. This percentage represents 2 million individuals of that age group, in a country with 27 million inhabitants.

In addition to these well-known types of child labor, this study includes the analysis of another kind of child labor: the household work performed by children. Household work is important to child development for many reasons. One of them is that it is a good training for children (especially girls) who will be housewives in the future. It also teaches some basic skills and promotes maturation. However, it also consumes time and energy, and, without adult supervision, it could be a dangerous activity to children.

This research considers not only the labor performed by children outside their household (usually, paid work), but also household work, which is an activity performed at home whose output is consumed inside the household (not

for sale in the market)³. In Peru, according to our calculations using data from the Living Standard Measurement Surveys, three of every four children are engaged in some kind of housework. I argue that this activity is also very important to human capital formation basically because it consumes time. The study shows that the children who work more hours at home doing housework are less likely to achieve higher levels of education.

This study is divided into three chapters. Each of them can be read independently from the others and they are complete essays by themselves. However, they have been organized in a logical sequence. Chapter 1 presents a theoretical model of allocation of time, where child labor, household work, hours of education and the labor supply of the parents are determined simultaneously. A key idea of the model is that labor supply functions are connected through the wages of the family members and through the time of household work. Since household work can be carry out by any of the family members, changes in wages may mean that some members can work more hours at home, giving extra time to the others to work in the market. The theoretical results in the interior case show that the effect of wages on the hours dedicated to child labor can be decomposed in the standard income and substitution effect, plus a new effect, the “household

³ It is important to point out that I do not include in this research another kind of child labor: non paid family work. This is work performed at home or in home businesses whose output is sold in the market.

work effect”. This latter effect shows the substitution between child labor and household work when the child wage increases. In the analysis of corner solutions, I find the conditions under which the child would participate in the labor market and/or in household work. Essentially, it depends on the comparison of the marginal returns of alternative activities (the “reservation wage”). Finally, I repeat the analysis when the family faces a subsistence level restriction (the minimum level of consumption for survival), a common fact in less developed countries.

In Chapter 2 the model presented in Chapter 1 is estimated by econometric techniques using Peruvian data. Unlike other papers on child labor time allocation, this chapter estimates the child’s labor supply and household work while taking into account the child’s wage and the wages of other family members. This requires estimation technique to deal with sample selection with double selectivity since most of the equations include child and mother’s wage, which are observed only when they participate and work in the labor market. The main result of this chapter is that wages are relevant when it comes to assigning chores at home and determining the hours that the child works in the labor market. The parameters of the home production function and some of the family utility function were also estimated. All data was taken from the Peruvian Living Standard Measurement Survey of years 1997 and 2000.

In Chapter 3, I go one step forward and analyze the consequences of child labor and household work on school attainment, which is measured by the Years of Schooling-Age ratio and the probability of attaining a high level of education. TO do this, I estimate a model of distributed lags where the current outcomes depend on present and past values of hours of child labor and household work. The econometric estimation shows that, for the younger group of individuals, neither household nor past child labor affect significantly school attainment. For the other age groups, household work has limited effect on the outcomes, but child labor has a clear negative and significant effect on school attainment, in the short and/or the long run.

CHAPTER I
CHILD LABOR, HOME PRODUCTION AND THE FAMILY LABOR
SUPPLY

Recent literature on child labor has developed models that explain the determinants of child labor and their effects on the labor market. Many of them relate child labor with poverty, and have given explanations like those that claim child labor occurs because it is a “strategy of survival,” because children are exploited by parents, or because credit constraints prevent the children from attending school. In the case of poor peasant economies, child labor is understood as a cost reduction strategy of small family businesses.

However, there is an aspect that has not been dealt in depth in the literature: there is a time consuming activity, “household work,” which may not only affect the labor supply of family members but also create links among them. Surveys show that individuals spend many hours at home doing chores⁴. Since this task can be performed by any of the household members, if one individual

⁴ Using Peruvian data of 2000, on average a household spends 64 hours per week doing chores. This figure is the result of the sum of hours individuals spend time doing chores.

works more hours doing chores, then the others may have extra time to distribute among their activities, including work in the labor market. For example, if household work is carried out by the children of the home, this offers additional hours to the adults to work in the labor market, increasing the aggregate family income.

Household chores consume the time of adults and children. There must be some kind of rule to decide who does the chores, who works in the labor market, how many hours children study, etc. Usually, adults engage in three activities: work in the labor market, work at home doing chores and leisure activities. On the other hand, children may engage in four activities: studying, working in the labor market, working at home and enjoying free time from duties. The wages each individual may earn working in the labor market have an important role in the intra-household allocation of time. This finding relies on two key assumptions: (a) a family planner decides how to allocate the time of each member among their different activities, and (b) the allocation of time depends on the marginal returns of the activities.

In this context, higher wages would imply an increase in the labor supply (provided that the substitution effect is greater than the income effect), and a decrease in the hours spent in other activities. Moreover, the decision of how

many hours a child should dedicate to study, work in the labor market, work at home and do leisure activities depend not only on the salary he or she can receive in the labor market but also on the salaries of the parents⁵. The analysis is complex because an increase in parents' wages may mean a reduction in parents' household work and an increase in child's household work. Thus, we would observe a reduction in child's labor supply and a reduction in hours of study. Nevertheless, this effect could be offset by an income effect if parents' wages increase enough to hire housekeeping services in the labor market, which would give the child more time to study.

In summary, there exist many intra-household decisions that determine simultaneously not only the supply of child labor, but also the hours dedicated to education, the labor supply of the parents and the hours that the members dedicate to household work. The great majority of studies on this theme have ignored the role of household work and its important role in the labor supply decisions of the parents and children.

This chapter presents a model of family labor supply that includes child labor and production of household work. The main objective is to study the effect of household work on the labor supply, and the determinants of those two

⁵ Later on, leisure will be eliminated for simplicity.

activities. The questions this research addresses are: how does household work affect the child labor supply and the parents' labor supply, how do changes in child's and parents' wages affect household work, the labor supplies and the hours spent in child's education? The approach I use here is the theory of allocation of time and the family labor supply, which permits to study carefully intra-family decisions that family members take when the labor supply and home production are determined. Carefully using the family labor supply approach can shed light on some of the facts that earlier models cannot, for the most part, explain. The same analysis is repeated when the family income is so low that it reaches the subsistence level.

The model of family labor supply that would be the base for this research is the standard model in the literature as presented by Richard Blundell and Thomas MaCurdy with some new features. Nevertheless, my model is, in some sense, an extension and application to child labor of the models presented by Reuben Gronau and Mark Rosenzweig. The former shows the determination of leisure, home production and work in the market for a single individual that faces time constraints. The latter present a model where a couple (husband and wife) allocate time between home production (in a small family business) and work in the market. This chapter also shares ideas with the work of Nancy Birdsall and her

joint work with Susan E. Cochrane, who introduced the idea of the schooling model and the effect of parents' wages on schooling⁶.

The chapter is organized as follows: the first section presents a literature review on child labor, family labor supply and home production; the second section presents a theoretical model of family labor supply with home production. The model is solved using the Kuhn-Tucker method, paying special attention to the possible corner solutions of the variables. The third section presents comparative static results. The substitution and income effects on household work and market labor of changes in wages and unearned income are shown and explained in the interior solution case. In the fourth section, a complete analysis of corner solutions and the appropriate opportunity costs (shadow prices) of the activities are presented. In the fifth section, the implications of the model are compared to the situation in which the family is at subsistence level (the minimum level of consumption for survival) and I find the "slope" of the child labor supply

⁶ See for example Richard Blundell and Thomas MaCurdy, "Labor Supply: A review of alternative approaches," in *Handbook of Labor Economics 3A*, ed. O. Ashenfelter and D. Card, 1559-1695 (Oxford: North Holland, 1999); Reuben Gronau, "Leisure, home production, and work – the theory of the allocation of time revisited," *Journal of Political Economy* 85, no.6 (1977): 1099-1123; Mark R. Rosenzweig, "Neoclassical theory and the optimizing peasant: an economic analysis of the market family labor supply in a developing country," *Quarterly Journal of Economics* 94, no.1 (February 1980): 31-55; Nancy Birdsall, *Child Schooling and the Measurement of Living Standards*, Living Standards Measurement Study Working Paper No. 14, (Washington, D.C.: World Bank, 1982); Nancy Birdsall and Susan E. Cochrane, "Education and parental decision making: a two generation approach," in *Education and Development*, ed. Anderson Lascelles and Douglas M. Windham, (Lexington, Mass.: Lexington Books, D.C. Heath and Company, 1982).

at the subsistence level, a discussion point in child labor literature. The sixth section shows an example of the model, using a particular specification of the functions. The last section presents the main conclusions of the chapter.

Overview of Literature

As I mentioned in the introduction, the model I present in this paper is based on models of family labor supply and the theory of allocation of time. In terms of the allocation of time, Reuben Gronau formalized the trichotomy of work in the market, work at home, and leisure for a single individual. In his model, the distribution of time depends on the wage, and changes in the exogenous income do not affect household work except when the individual does not work at all in the market. An increase in the wage reduces household work, but the effect on leisure time and work in the market depends on a substitution and income effect⁷.

Mark Rosenzweig presents a model of family labor supply of a husband and a wife where they also work in a family business. In his model, the work in the family business has an effect on the labor supply functions of the family members. His model has no applications to child labor. On the other hand, Nancy

⁷ Gronau, 1104-1113.

Birdsall and Susan Cochrane develop a model of time allocation that explains the determinants of schooling. In her model, schooling and child labor are decisions taken by the family, and they depend on the wages of each individual in the household. In a more general framework, Deborah Levison is concerned with the multiple activities of children in a developing country, including schooling. She analyzes the effects of changes in children's and mother's wages on what she calls "total home production time of a specific child," which includes time spent on child care, home maintenance and education⁸. Unlike my research, her paper does not separate education from home production.

Many papers have analyzed different aspects of the family labor supply approach. Ashenfelter and Heckman focus on the estimation of the substitution and income effect in the family labor supply model. The peasant family labor supply has been analyzed in papers like that of Hanan Jacoby. The relationship between child labor, fertility and schooling in peasant economies is studied by Mark Rosenzweig and Robert Evenson. A model with labor supply and multiple activities of the family members is analyzed, applied and estimated to rural areas by John L. Newman and Paul Gertler⁹.

⁸ Rosenzweig, 33-40; Birdsall, 25-35; Birdsall and Cochrane, 175-179.; Deborah Levison, "Children's labor force activity and schooling in Brazil," (Ph.D. diss., University of Michigan, 1991), 20-31.

⁹ Orley Ashenfelter and James Heckman, "The estimation of income and substitution effects in a model of family labor supply," *Econometrica* 42, no. 1 (January 1974): 74-78; Hanan

Many works have been written on child labor around the world¹⁰. However, the family labor supply approach has been applied to child labor by not many authors, and then usually in empirical papers. For example, Sonia Bhalotra's paper focuses its attention on the wage elasticities of child labor supply. Using a family labor supply model with child labor but without home production, she states that child labor supply depends on his/her wage, parents wage, exogenous income and household characteristics. Then she finds that when the level of consumption falls to the subsistence level, the wage elasticity of child labor supply is negative because the income effect is stronger than the substitution effect, which forces the child to work more in order to provide more income for his or her family. Unlike her paper, I will include household work and will recalculate the substitution and income effect, and the wage elasticities¹¹.

Jacoby, "Shadow wages and peasant family labour supply: an economic application to the Peruvian Sierra," *Review of Economic Studies* 60 (1993): 903-921; Mark R Rosenzweig and Robert Evenson, "Fertility, schooling, and the economic contribution of children in rural India: an econometric analysis," *Econometrica* 45, no.5 (July 1977): 1065-1079; John L. Newman and Paul J. Gertler, "Family productivity, labor supply and welfare in a low income country," *Journal of Human Resources* 29, no. 4. Special Issue: The family and intergenerational relations (Autumn 1994): 989-1026.

¹⁰ See for example, Drusilla K. Brown, Alan V. Deardorff and Robert M. Stern, "Child Labor: Theory, Evidence and Policy," Discussion paper 474, (Medford, M.A.: Tufts University, Department of Economics, 2001); Alessandro Cigno, Furio C. Rosati y Zafiris Tzannatos, *Child Labor Handbook*, Social Protection Discussion Papers Series N° 0206, (Washington, D.C.: World Bank, 2002); Sonia Bhalotra and Zafiris Tzannatos, *Child labour: what have we learnt?*, Social Protection Discussion Paper Series, (Washington, D.C.: World Bank, 2003).

¹¹ Sonia Bhalotra, *Is child work necessary?*, Social Protection Discussion Paper Series, (Washington, D.C.: World Bank, 2001), 6-10.

Drusilla Brown, Alan Deardorff and Robert Stern present a model with child labor and household labor. Their model is based on the idea of comparative advantage and it analyzes the specialization of the family members on market work, home work and leisure. However, their model is very restrictive since it uses ricardian production functions, and the results depend on the comparison of constant marginal productivities at home to the market wages. Their model does not present child labor supply functions nor analyzes the determinants of child's household work¹².

Several empirical papers estimate the determinants of child labor, schooling and household work. E. Skoufias estimates the determinants of market work, work at home (which includes domestic work and farm work), and schooling in agricultural households in India. Deborah DeGraff, Richard Bilsborrow and Alejandro Herrin, using ideas from the standard time allocation model, points out that time allocation decisions of all household members are interrelated and thus must be viewed as endogenous. Nonetheless, in their empirical model they focus on the time allocation of children at school age only. In a posterior work, Deborah DeGraff and Richard Bilsborrow estimate the same model using the same exogenous variables, but in this case they use the Tobit

¹² Drusilla K Brown, Alan V. Deardorff and Robert M. Stern, "U.S. trade and other policy options and programs to deter foreign exploitation of Child Labor," Discussion paper 99-04, (Medford, M.A.: Tufts University, Department of Economics, 2003), 29-32.

method instead of Probit in the estimation of the determinants of market work and household work. Deborah Levison and Karine Moe analyze household work as a deterrent to schooling. In addition to market work, they propose that household work may present a more significant barrier to schooling for girls than boys. Based on the theoretical framework of home production models and the allocation of time, they estimate the reduced form of the determinants of hours spent on household work and studying¹³.

Several authors study other aspects of the problem. Melissa Binder and David Scrogin use the time allocation framework to estimate the determinants of child work for Mexico. In particular, they focus their attention on the effect of parent and child wages on their decisions. Hideo Akabayashi and George Psacharopoulos investigate the degree to which there is a trade-off between child labor and human capital formation using data of children from Tanzania. These authors analyze the effect of hours of work in the market, work at home and school attendance on the development of reading and mathematical skills, but they treat the allocation of time as endogenous. Ranjan Ray, in an empirical study of

¹³ E. Skoufias, "Market wages, family composition and the time allocation of children in agricultural households," *Journal of Development Studies* 30 (1994): 335-360; Deborah S. DeGraff, Richard E. Bilsborrow and Alejandro N. Herrin, "Children's education in the Philippines: does high fertility matter?," *Population Research and Policy Review* 15, no.3 (1996): 219-247; Deborah S. DeGraff, Richard E. Bilsborrow, "Children's school enrollment and time at work in the Philippines," *Journal of Developing Areas* 15, no.1 (2003): 127-158; Deborah Levison and Karine S. Moe, "Household work as a deterrent to schooling: an analysis of adolescent girls in Peru," *Journal of Developing Areas* 32 (Spring 1998): 339-356.

child labor in Pakistan and Peru, finds that there is a positive relationship between female wages and child labor in Pakistan. In the Peruvian case, the effect of an increase in parents' wages on child labor is not clear for boys but reduces girl's labor¹⁴.

In an empirical work, Marcel Kerkhofs and Peter Kooreman identify and estimate a household production model. Based on Gronau's model, they estimate the parameters of a quadratic household production function. They argue that they cannot include in the sample individuals that have a paid job because the sampling rule depends on the labor market status, which is endogenous, and therefore, this would bias the result of the home production estimation. This occurs because individuals with low productivity will be most likely to have a paid job. They do not solve the complete household optimization problem because to do so would require a simultaneous model for the participation and home production decisions, and according to them this analysis would require a specification of the utility function¹⁵.

¹⁴ Melissa Binder and David Scrogin, "Labor force participation and household work of urban schoolchildren in Mexico: characteristics and consequences," *Economic Development and Cultural Change*, 48, no.1 (1999): 123-154; Hideo Akabayashi and George Psacharopoulos, "The trade-off between child labour and human capital formation: a Tanzanian case study," *Journal of Development Studies* 35(1999): 120-140; Ranjan Ray, "Analysis of child labour in Peru and Pakistan: a comparative study," *Journal of Population Economics* 13 (2000): 3-19.

¹⁵ Marcel Kerkhofs and Peter Kooreman, "Identification and estimation of a class of household production models," *Journal of Applied Econometrics* 18 (2003): 337-369.

Other analyses of child labor have been written in past years. Most of them provide explanations about the causes of child labor and its effects on labor markets. The papers of Christiaan Grootaert and Ravi Kambur, and Kaushik Basu initiated a discussion of the economic perspective of child labor. Kaushik Basu and Pham Hoang Van presented an equilibrium analysis of a labor market with child labor. Priya Ranjan, Jean-Marie Baland and James Robinson, and Carol A. Rogers and Kenneth Swinnerton focus their attention on capital market restrictions as a main cause of child labor. Sylvain Dessy and Stephane Pallage explain the persistence of child labor (chronic child labor) as a non-desired equilibrium in labor markets¹⁶.

The Model

¹⁶ Christiaan Grootaert and Ravi Kanbur, "Child labor: an economic perspective," *International Labour Review* 134, no.2 (1995): 187-203; Kaushik Basu, "Child labor: cause, consequence, and cure, with remarks on international labor standards," *Journal of Economic Literature* 37, no.3 (1999): 1083-1119; Kaushik Basu and Pham Hoang Van, "The economics of child labor," *American Economic Review* 88, no.3 (June 1988): 412-427; Priya Ranjan, "An economic analysis of child labor," *Economics Letters* 64 (1999): 99 – 105; Priya Ranjan, "Credit constraints and the phenomenon of child labor," *Journal of Development Economics* 64 (2001): 81-102; Jean-Marie Baland and James Robinson, "Is child labor inefficient?," *Journal of Political Economy* 108, no.4 (August 2000): 663-679; Carol Ann Rogers and Kenneth Swinnerton, "Does child labor decrease when parental income rises?," *Journal of Political Economy* 112, no.4 (2004):939- ; Sylvain E. Dessy and Stephane Pallage, "Child Labor and coordination failures," *Journal of Development Economics* 65 (2001): 469-476.

The model presented in this section adds home production and child labor to a family labor supply model. Suppose that the family has three members: the *husband* (head of household), the *wife* (or spouse) and a *child*. It is assumed that in this family all decisions are made in a dictatorial way (no negotiation among agents).

The family consumes three goods: the aggregated consumption good (c), a good called “household chores” (Z) and the hours of education of the child (E). It is assumed that the family preferences are strictly quasiconcave, and can be represented by a continuous twice-differentiable utility function $U(c,Z,E)$, where $U_C > 0$, $U_Z > 0$, and $U_E > 0$. Education has been included in the family utility function following altruistic reasons.

The consumption good is bought in the market; in contrast, the “household chores” can be produced at home using wife and child work (z_1 and z_2 respectively), or can be bought in the market in an amount f_0 at a price P . Then,

$$Z = f(z_1, z_2) + f_0$$

where the function $f(\cdot)$ is the home production function. It is assumed that $f(\cdot)$ is strictly concave and twice differentiable.

The husband's labor supply is determined in an earlier step, and I assume he works a fixed number of hours a day (his labor supply is perfect inelastic). Therefore, the husband's income (Y) is constant and exogenous. In this context, the family must decide how much to consume of both goods, how many hours the mother and the child should be employed in the production of the good Z , and how many hours the wife and the child will offer to the labor market in order to maximize the family utility.

This family faces some restrictions: the time and budget constraints. The total time allotted to each individual has been normalized to unity. The mother has one unit of time a day that can be employed working at home (z_1), or working in the labor market (H_1) receiving a wage w_1 . The child employs her time in working at home (z_2), studying (E) or working in the labor market (H_2).

The budget constraint for this family is: $c + P.f_0 = Y + H_1.w_1 + H_2.w_2$. Finally, let us assume that there are minimum levels of consumption of the two goods, called c^* and Z^* . This means that the family consumption of these goods cannot be below those levels in order to survive.

A summary of the variables in the model is the following:

c = family aggregated consumption

Y = Husband total income (exogenous in this model)

f_0 = total domestic services bought in the market

z_1 = hours that wife spends on domestic work

z_2 = hours that child spends on domestic work

H_1 = hours of labor supply

H_2 = hours of child labor

w_1 = wife's wage

w_2 = child's wage

P = price of home services

E = Hours of education

In order to simplify the model, I assume that there is only one single period; the family spends all its income in that period, and there is no leisure. The problem that the head of household (the “planner”) solves is the following:

$$\begin{aligned} & \text{Max} && U(c, Z, E) \\ & c, f_0, z_1, z_2, E, H_1, H_2 \\ & \text{s.t.} && c + P \cdot f_0 = Y + H_1 \cdot w_1 + H_2 \cdot w_2 \\ & && Z = f(z_1, z_2) + f_0 \\ & && 1 = z_1 + H_1 \end{aligned}$$

$$1 = z_2 + H_2 + E$$

$$c \geq c^*$$

$$Z \geq Z^*$$

$$f_0 \geq 0, z_1 \geq 0, z_2 \geq 0, E \geq 0, H_1 \geq 0, H_2 \geq 0$$

Notice that the wife and the child are not symmetric since the latter has one more alternative activity: education¹⁷. Another point to note is that it has been assumed that education is costless.

This problem can be rewritten as

$$\begin{aligned} & \text{Max} && U(c, f(z_1, z_2) + f_0, E) \\ & && c, f_0, z_1, z_2, E \\ \text{s.t.} & && c + P_0 = Y + (1 - z_1)w_1 + (1 - z_2 - E)w_2 \\ & && 1 - z_1 \geq 0 \\ & && 1 - z_2 - E \geq 0 \\ & && c \geq c^* \\ & && f(z_1, z_2) + f_0 \geq Z^* \\ & && f_0 \geq 0, z_1 \geq 0, z_2 \geq 0, E \geq 0 \end{aligned}$$

¹⁷ The role of education has been introduced in this model in a very simple way. In fact, it is just an activity performed by the child that affects positively the family utility.

The lagrangean to this problem is:

$$\begin{aligned} \mathcal{L} = & U(\cdot) + \lambda_1(Y + (1 - z_1)w_1 + (1 - z_2 - E)w_2 - c - Pf_0) + \lambda_2(c - c^*) + \\ & \lambda_3(f(z_1, z_2) + f_0 - Z^*) + \lambda_4(1 - z_1) + \lambda_5(1 - z_2 - E) \end{aligned}$$

The first order conditions are:

$$\frac{\partial \mathcal{L}}{\partial c} = U_C - \lambda_1 + \lambda_2 \leq 0, \quad c \geq 0$$

$$\frac{\partial \mathcal{L}}{\partial f_0} = U_Z - \lambda_1 \cdot P + \lambda_3 \leq 0, \quad f_0 \geq 0$$

$$\frac{\partial \mathcal{L}}{\partial z_1} = U_Z f_1 - \lambda_1 \cdot w_1 + \lambda_3 f_1 - \lambda_4 \leq 0, \quad z_1 \geq 0$$

$$\frac{\partial \mathcal{L}}{\partial z_2} = U_Z f_2 - \lambda_1 \cdot w_2 + \lambda_3 f_2 - \lambda_5 \leq 0, \quad z_2 \geq 0$$

$$\frac{\partial \mathcal{L}}{\partial E} = U_E - \lambda_1 \cdot w_2 - \lambda_5 \leq 0, \quad E \geq 0,$$

and the complementary slackness conditions:

$$c \cdot (U_C - \lambda_1 + \lambda_2) = 0$$

$$f_0 \cdot (U_Z - \lambda_1 \cdot P + \lambda_3) = 0$$

$$z_1 \cdot (U_Z f_1 - \lambda_1 \cdot w_1 + \lambda_3 f_1 - \lambda_4) = 0$$

$$z_2 \cdot (U_Z f_2 - \lambda_1 \cdot w_2 + \lambda_3 f_2 - \lambda_5) = 0$$

$$E \cdot (U_E - \lambda_1 \cdot w_2 - \lambda_5) = 0$$

When consumption levels are above the subsistence level, λ_2 and λ_3 equal zero.

Solution to the Model in the Interior Case

In this section, I solve the model and find the effect of the exogenous variables Y , w_1 , w_2 and P on the endogenous variables. In order to do this, I impose and discuss assumptions on the utility function and the home production function.

Let us look at the case in which the restrictions of poverty are not binding ($c > c^*$, $Z > Z^*$), and assume that all the variables are strictly positive (i.e. the “interior case”), and then λ_2 , λ_3 , λ_4 and λ_5 equal zero. From the first order conditions presented in the previous sub-section and the restrictions of the model we have a system of nine equations and nine unknowns. The equations are the following.

$$(1.1) \quad U_C = \lambda_1$$

$$(1.2) \quad U_Z = \lambda_1 \cdot P$$

$$(1.3) \quad U_Z f_1 = \lambda_1 w_1$$

$$(1.4) \quad U_Z f_2 = \lambda_1 w_2$$

$$(1.5) \quad U_E = \lambda_1 w_2$$

$$(1.6) \quad c + P \cdot f_0 = Y + H_1 \cdot w_1 + H_2 \cdot w_2$$

$$(1.7) \quad Z = f(z_1, z_2) + z_0$$

$$(1.8) \quad 1 = z_1 + H_1$$

$$(1.9) \quad 1 = z_2 + H_2 + E$$

The unknowns are: f_0 , z_1 , z_2 , Z , H_1 , H_2 , c , E and λ_1 . The lagrange multiplier λ_1 is the marginal utility of income. The first order conditions (1.1) – (1.5) can be rewritten as the following expression:

$$(1.10) \quad \lambda_1 = U_c = \frac{U_Z f_1}{w_1} = \frac{U_Z f_2}{w_2} = \frac{U_E}{w_2} = \frac{U_Z}{P}$$

Equations (1.10) tell us that in equilibrium the marginal utility of each of the components (in dollars) must be equal to the marginal utility of income.

Solving the model I obtain five important functions: the *household work functions* $z_1 \equiv z_1(w_1, w_2, Y, P)$ and $z_2 \equiv z_2(w_1, w_2, Y, P)$, the *spouse's labor*

supply function $H_1 \equiv H_1(w_1, w_2, Y, P)$, the child labor supply function $H_2 \equiv H_2(w_1, w_2, Y, P)$ and the education function $E \equiv E(w_1, w_2, Y, P)$ ¹⁸.

Taking differentials to equations (1.1) – (1.5), and rearranging in matrix form I have

(1.11)

$$\begin{bmatrix} U_{CC} & U_{CZ} & U_{CE} & -1 & U_{CZ}f_1 & U_{CZ}f_2 \\ U_{CZ} & U_{ZZ} & U_{ZE} & -P & U_{ZZ}f_1 & U_{ZZ}f_2 \\ U_{CE} & U_{ZE} & U_{EE} & -w_2 & U_{EZ}f_1 & U_{EZ}f_2 \\ -1 & -P & -w_2 & 0 & -w_1 & -w_2 \\ U_{CZ}f_1 & U_{ZZ}f_1 & U_{EZ}f_1 & -w_1 & U_{ZZ}f_1^2 + U_Zf_{11} & U_{ZZ}f_1f_2 + U_Zf_{12} \\ U_{CZ}f_2 & U_{ZZ}f_2 & U_{EZ}f_2 & -w_2 & U_{ZZ}f_1f_2 + U_Zf_{12} & U_{ZZ}f_2^2 + U_Zf_{22} \end{bmatrix} \begin{bmatrix} dc \\ df_0 \\ dE \\ d\lambda \\ dz_1 \\ dz_2 \end{bmatrix} = \begin{bmatrix} 0 \\ \lambda_1 dP \\ \lambda_1 dw_2 \\ -dY - (1 - z_1)dw_1 - (1 - z_2 - E)dw_2 - f_0 dP \\ \lambda_1 dw_1 \\ \lambda_1 dw_2 \end{bmatrix}$$

The comparative static can be performed using Cramer's Rule. After few manipulations I get the expression:

¹⁸ There are two more functions that are not important at this moment: the consumption function $c = c(w_1, w_2, Y, P)$ and the demand for housekeeping services $f_0 = f_0(w_1, w_2, Y, P)$.

(1.12)

$$\begin{bmatrix} U_{CC} & U_{CZ} & U_{CE} & -1 & 0 & 0 \\ U_{CZ} & U_{ZZ} & U_{ZE} & -P & 0 & 0 \\ U_{CE} & U_{ZE} & U_{EE} & -w_2 & 0 & 0 \\ -1 & -P & -w_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & U_Z f_{11} & U_Z f_{12} \\ 0 & 0 & 0 & 0 & U_Z f_{12} & U_Z f_{22} \end{bmatrix} \begin{bmatrix} dc \\ df_0 \\ dE \\ d\lambda \\ dz_1 \\ dz_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ \lambda_1 & 0 & 0 & 0 \\ 0 & 0 & \lambda_1 & 0 \\ -f_0 & -H_1 & -H_2 & -1 \\ 0 & \lambda_1 & 0 & 0 \\ 0 & 0 & \lambda_1 & 0 \end{bmatrix} \begin{bmatrix} dP \\ dw_1 \\ dw_2 \\ dY \end{bmatrix}$$

which is easier to solve and explain.

The 6x6 matrix on the left hand side is the Bordered Hessian which must be negative definite in order to have a maximum. Given the assumptions of strict quasiconcavity of U and strict concavity of f , the determinant of the 6x6 matrix is negative, and it is equal to $|\Theta| \cdot \Delta \cdot U_Z^2$, where $|\Theta| < 0$ is the determinant of the upper-left 4x4 matrix, and $\Delta = f_{11} \cdot f_{22} - f_{12}^2 > 0$.

The system suggests that the variables z_1 and z_2 can be solved separately from the other variables¹⁹. The derivatives are:

$$\frac{\partial z_1}{\partial w_1} = \frac{f_{22}}{P} \cdot \frac{1}{\Delta} < 0 \qquad \frac{\partial z_2}{\partial w_1} = -\frac{f_{21}}{P} \cdot \frac{1}{\Delta} \geq \text{or} \leq 0$$

¹⁹ This is so since from equations (1.2) – (1.4) I get: $w_1 = P \cdot f_1$ and $w_2 = P \cdot f_2$. These equations constitute a subsystem of two equations and two unknowns, z_1 , and z_2 .

$$\frac{\partial z_1}{\partial w_2} = -\frac{f_{12}}{P} \cdot \frac{1}{\Delta} \geq \text{or} \leq 0$$

$$\frac{\partial z_2}{\partial w_2} = \frac{f_{11}}{P} \cdot \frac{1}{\Delta} < 0$$

$$\frac{\partial z_1}{\partial Y} = 0$$

$$\frac{\partial z_2}{\partial Y} = 0$$

$$\frac{\partial z_1}{\partial P} = \frac{(f_1 f_{21} - f_2 f_{11})}{P} \cdot \frac{1}{\Delta} > 0$$

$$\frac{\partial z_2}{\partial P} = \frac{(f_2 f_{12} - f_1 f_{22})}{P} \cdot \frac{1}{\Delta} > 0$$

The derivatives have those signs provided that the f function is strictly concave, $f_{11} < 0$, $f_{22} < 0$, and the cross derivatives f_{12} , f_{21} have the same sign and magnitude (positive, negative or zero).

These assumptions mean that the marginal product is decreasing for both inputs and the production function exhibits decreasing returns to scale. Notice that neither z_1 nor z_2 depends on the husband's exogenous income Y ²⁰. It is more difficult to explain the sign of the derivatives $\partial z_1 / \partial w_2$ and $\partial z_2 / \partial w_1$. Both depend on the cross derivative f_{ij} , which could be positive, negative or zero²¹. This means that the marginal product of one factor could increase, decrease or not change when more units of the other factor are used. For example, if the cross derivative is positive (the two factors are "complements"), an increase in w_1 (wife's wage)

²⁰ This result is the same as that found by Rosenzweig.

²¹ For a Cobb-Douglas technology, the cross derivative is positive. For a function like $f(z_1, z_2) = z_1^{0.5} + z_2^{0.5}$, the value is zero.

will cause less demand of z_1 and then a reduction in the marginal product of the child's household work z_2 . Consequently, less child's household work will be demanded by the household. We would observe the opposite effect if the cross derivative f_{ij} were negative (factor are "substitutes").

At this point, it is easy to get the derivatives of the *wife labor supply function* $H_1 \equiv H_1(w_1, w_2, Y, P)$ since they are the opposite to the derivatives of z_1 (see equation 1.8), then:

$$\frac{\partial H_1}{\partial w_1} > 0 \quad \frac{\partial H_1}{\partial w_2} \geq \text{or} \leq 0 \quad \frac{\partial H_1}{\partial Y} = 0 \quad \frac{\partial H_1}{\partial P} < 0$$

The woman labor supply curve is increasing in w_1 as usual, and it does not depend on the exogenous income Y . What is new is that this labor supply may depend on the child wage.

Now let's calculate the derivatives for the other endogenous variables. Using Cramer's Rule and after few manipulations, the derivatives of the education variable are:

$$(1.13) \quad \frac{\partial E}{\partial Y} = \frac{1}{|\Theta|} \begin{vmatrix} U_{CC} & U_{CZ} & -1 \\ U_{CZ} & U_{ZZ} & -P \\ U_{EC} & U_{EZ} & -w_2 \end{vmatrix}$$

$$(1.14) \quad \frac{\partial E}{\partial w_1} = H_1 \frac{\partial E}{\partial Y}$$

$$(1.15) \quad \frac{\partial E}{\partial w_2} = \left(\frac{\partial E}{\partial w_2} \right)_{U=\bar{U}} + H_2 \frac{\partial E}{\partial Y}$$

Equation (1.13) shows the effect on the hours of study of a change in the exogenous income. The sign of that effect is ambiguous unless additional restrictions are imposed²². If that derivative is positive, education will be a normal good; otherwise, it will be inferior.

Equation (1.14) shows that the effect of a change in mother's wage is proportional to the hours she works, and the sign depends on whether education is a normal good or an inferior good. Equation (1.15) shows the effects of changes in child wage on the hours of education. I have decomposed those effects in the income and substitution effect. It can be shown that the substitution effect is

$$\left(\frac{\partial E}{\partial w_2} \right)_{U=\bar{U}} = \frac{\lambda_1}{|\Theta|} \cdot [2PU_{CZ} - U_{ZZ} - P^2U_{CC}] < 0$$

This derivative is negative given the assumption of strict quasiconcavity of the utility function and the fulfillment of the second order condition. This means

²² If the utility function were strictly concave, the derivative would be positive for sure.

that, holding the utility constant, an increase in child wage will reduce the hours of education.

On the other hand, the sign of the income effect depends on whether education is a normal or inferior good, and its size depends on the magnitude of H_2 (child labor). Common sense tells us that it is likely that it is a normal good. Therefore, the two effects go in opposite directions and then the sign of the derivative is ambiguous. An increase on child wage will increase education because the family income is higher and it is able to buy more units of this good (income effect). However, the opportunity cost of education is higher and the child should work more hours in the labor market. Consequently, the child should study fewer hours (substitution effect).

Now I am able to present the derivatives of the *child labor supply function* $H_2 \equiv H_2(w_1, w_2, Y, P)$. From equation (1.9) I obtain

$\partial H_2 / \partial w_j = -\partial E / \partial w_j - \partial z_2 / \partial w_j$, $j=1,2$, and $\partial H_2 / \partial Y = -\partial E / \partial Y$, therefore

$$(1.16) \quad \frac{\partial H_2}{\partial w_1} = - \underbrace{\frac{\partial z_2}{\partial w_1}}_{HWE} + \underbrace{\frac{\partial H_2}{\partial Y} H_1}_{IE < 0}$$

$$(1.17) \quad \frac{\partial H_2}{\partial w_2} = - \underbrace{\frac{\partial z_2}{\partial w_2}}_{HWE > 0} - \underbrace{\left(\frac{\partial E}{\partial w_2} \right)_{U=\bar{U}}}_{SE > 0} + \underbrace{\frac{\partial H_2}{\partial Y} H_2}_{IE < 0}$$

The first element in the right hand side of equation (1.16) is the “household work effect” (*HWE*) because it is the effect due to a change in the demand for child’s household work. Its sign depends on the sign of the cross derivative f_{21} . The second element is the standard income effect (*IE*), which is negative under the assumption of normality of the education. There is no substitution effect in this equation.

Equation (1.17) says that the slope of the child labor supply curve could be positive or negative. The first element in the right hand side is the “household work effect”, which is positive. A raise in w_2 will reduce child’s household work and increase child market labor. The second element is the substitution effect (*SE*). The sign is positive since a higher wage represents fewer hours dedicated to study and more hours dedicated to market work. The third element is the income effect, which is negative under the assumption of normality of education. An increase in child wage also increases the family total income and the demand for education will increase too. This reduces the supply of child’s market labor²³.

²³ These results are consistent with Rosenzweig (1980) who found the three effects for the husband and wife labor supply in a model with home production and two symmetric agents. In our model, they are not symmetric because of the education, and because we do not have leisure here.

Corner Solutions and Shadow Prices

The previous analysis applies to the interior case. Nevertheless, in the real world it is very frequent to observe corner solutions in the variables z_1, z_2, H_1, H_2 and E . In that case, some of those variables can take the value zero (or one) and equation (1.10) does not hold anymore. The decision of to work or not to work is analyzed in the literature by comparing the “reservation wages” and the market wages. Indeed, equation (1.10) holds if I replace the observed wages and prices with the “shadow prices”. In this model, the analysis is a bit complex since there are several possibilities of corner solutions. As before, I will do the analysis in the non-poverty case, which is $(c > c^*, Z > Z^*)$ and which implies that λ_2 and λ_3 are zero.

When both the wife and the child work in the job market ($H_1 > 0, H_2 > 0$) receiving wages w_1 and w_2 per hour, and the child studies a positive number of hours, the opportunity cost of one hour employed in the production of the good Z is just the market salary. In that case, the wife works some hours at home if the marginal return of the wife’s household work at $z_1 = 0$ is greater than the market wage. Let me define that marginal return or “*shadow price*” as

$$w_1^Z \equiv \left. \frac{U_Z \cdot f_1}{\lambda} \right|_{z_1=0} \quad \text{where } U_Z \text{ is the marginal utility of household chores, } f_1 \text{ is the}$$

marginal product of wife's household work, and λ is the marginal utility of income²⁴. Thus,

$$(1.18) \quad \begin{aligned} z_1 &= z_1(w_1, w_2, Y, P) && \text{if } w_1 < w_1^Z \\ &= 0 && \text{Otherwise} \end{aligned}$$

Now, let's see what determines the participation of wives in the labor market. Define the "reservation wage" as $w_1^H \equiv \frac{U_z \cdot f_1}{\lambda} \Big|_{H_1=0}$. Following the Kuhn-

Tucker conditions, the wife's labor supply function is:

$$(1.19) \quad \begin{aligned} H_1 &= H_1(w_1, w_2, Y, P) && \text{if } w_1 > w_1^H \\ &= 0 && \text{Otherwise} \end{aligned}$$

Notice that $w_1^Z > w_1^H$ because the marginal product is decreasing and λ is constant. Therefore, for any wage below w_1^H we observe $H_1 = 0$ and $z_1 > 0$; for any wage in between w_1^H and w_1^Z we observe $H_1 > 0$ and $z_1 > 0$; and for any wage above w_1^Z we observe $H_1 > 0$ and $z_1 = 0$. Figure 1 shows three regions defined by these thresholds along the line.

²⁴ In previous sections it was called λ_1 . Now I call it λ to simplify notation.

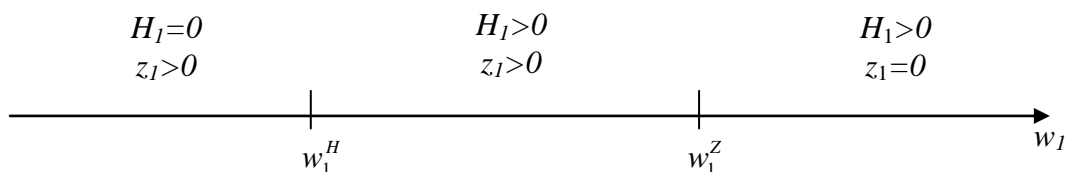


Figure 1. Regions defined by spouse's shadow wages

On the other hand, the child can perform three activities: H_2 , z_2 and E . In the interior solution, the return of each activity must be equal to the others. From equation (1.10), the marginal return of child labor (w_2) equals the marginal return of child's household work $\frac{U_Z \cdot f_2}{\lambda}$, and equals the marginal return of education $\frac{U_E}{\lambda}$.

$$(1.20) \quad w_2 = \frac{U_Z \cdot f_2}{\lambda} = \frac{U_E}{\lambda}$$

The second and third expressions are decreasing in z_2 and E respectively, and then an interior solution is possible²⁵. However, when we have inequality signs in (1.20) and the variables (H_2 , z_2 , E) reach their minimum values, we observe corner solutions on one or more of these variables.

²⁵ Newman and Gertler, 993-994.

In general terms, we will observe that one of those variables reaches the value zero if at least one of the other variables always has a higher marginal return.

I define the shadow price or opportunity cost of the first hour of child's

household work as $w_2^Z \equiv \max \left\{ w_2 \Big|_{z_2=0}, \frac{U_E}{\lambda} \Big|_{z_2=0} \right\}$, and then:

$$(1.21) \quad z_2 = z_2(w_1, w_2, Y, P) \quad \text{if } \frac{U_Z \cdot f_2}{\lambda} \Big|_{z_2=0} \geq w_2^Z$$

$$= 0 \quad \text{Otherwise}$$

Likewise, in the case of the child labor supply H_2 , I define the reservation

wage as $w_2^H \equiv \max \left\{ \frac{U_Z \cdot f_2}{\lambda} \Big|_{H_2=0}, \frac{U_E}{\lambda} \Big|_{H_2=0} \right\}$. Hence, the child works in the labor

market when $w_2 \geq w_2^H$. I redefine the child labor supply function as follows:

$$(1.22) \quad H_2 = H_2(w_1, w_2, Y, P) \quad \text{if } w_2 \geq w_2^H$$

$$= 0 \quad \text{Otherwise}$$

The level of education is also censored. This variable takes the value zero

$$\text{when } \frac{U_E}{\lambda} \Big|_{E=0} \leq \max \left\{ w_2, \frac{U_Z \cdot f_2}{\lambda} \right\}.$$

Finally, let me present an additional interpretation for the corner solutions of z_1 and z_2 . As we know, the first two variables solved in the model are z_1 and z_2 . In the interior case (as it was mentioned before), I get the tangency condition:

$$(1.23) \quad \frac{f_1}{f_2} = \frac{w_1}{w_2}$$

where f_i is the Marginal Product of z_i . In the case of corner solutions, it is not difficult to show that

$$z_1 = 0, z_2 > 0 \quad \text{if} \quad \frac{f_1}{f_2} \leq \frac{w_1}{w_2^Z}$$

$$z_1 > 0, z_2 = 0 \quad \text{if} \quad \frac{f_1}{f_2} \geq \frac{w_1}{w_2^Z}$$

where w_2^Z was defined above. As a result, the existence of positive hours of child's household work depends on the parameter w_1 , the marginal productivities and the opportunity cost of household work²⁶.

The child labor supply at the subsistence level $c = c^*$ and $Z = Z^*$

It is interesting to analyze these effects when a family reaches the subsistence level restriction. In Bhalotra's paper, the slope of the child labor supply function is calculated at the subsistence level. In this section, I do the same and compare the results with hers. Given that the family is constrained to these levels, the internal allocation of resources could be different with respect to the previous case.

The mathematical problem is similar to that presented in the previous section, but in this case $c = c^*$ and $Z = Z^*$. The Kuhn-Tucker conditions in the interior case are:

$$(1.24) \quad U_C + \lambda_2 = \lambda_1$$

²⁶ This result is similar to that in Brown, Deardorff and Stern, *U.S. trade and policy options*, 31. The difference is that they assume constant marginal products and, consequently, they have specialization.

$$(1.25) \quad U_Z + \lambda_3 = \lambda_1 \cdot P$$

$$(1.26) \quad (U_Z + \lambda_3)f_1 = \lambda_1 w_1$$

$$(1.27) \quad (U_Z + \lambda_3)f_2 = \lambda_1 w_2$$

$$(1.28) \quad U_E = \lambda_1 w_2$$

And the constraints:

$$(1.29) \quad c + P \cdot f_0 = Y + H_1 \cdot w_1 + H_2 \cdot w_2$$

$$(1.30) \quad c = c^*$$

$$(1.31) \quad f(z_1, z_2) + f_0 = Z^*$$

$$(1.32) \quad 1 = z_1 + H_1$$

$$(1.33) \quad 1 = z_2 + H_2 + E$$

Taking differentials to equations (1.24) to (1.31), and using Cramer's Rule, the derivatives of the household work functions are exactly the same expressions as those in the non-subsistence level case²⁷. The derivatives of the education function are:

$$(1.34) \quad \frac{\partial E}{\partial Y} = \frac{1}{w_2} > 0$$

$$(1.35) \quad \frac{\partial E}{\partial w_1} = H_1 \frac{\partial E}{\partial Y}$$

²⁷ From equations (1.25) – (1.27) it is easy to get $w_1 = P \cdot f_1$ and $w_2 = P \cdot f_2$. Thus, the results discussed in the previous section about household work and the wife's labor supply functions are the same.

$$(1.36) \quad \frac{\partial E}{\partial w_2} = H_2 \frac{\partial E}{\partial Y}$$

Notice that unlike equation (1.13), in this case the sign of (1.34) is positive for sure. Consequently, education is a normal good at this level.

Given equations (1.32) and (1.33), the derivatives of the child labor supply are:

$$(1.37) \quad \frac{\partial H_2}{\partial Y} = -\frac{1}{w_2} < 0$$

$$(1.38) \quad \frac{\partial H_2}{\partial w_1} = -\underbrace{\frac{\partial z_2}{\partial w_1}}_{HWE} + \underbrace{\frac{\partial H_2}{\partial Y} H_1}_{IE < 0}$$

$$(1.39) \quad \frac{\partial H_2}{\partial w_2} = -\underbrace{\frac{\partial z_2}{\partial w_2}}_{HWE > 0} + \underbrace{\frac{\partial H_2}{\partial Y} H_2}_{IE < 0}$$

The sign of the derivatives in equations (1.38) and (1.39) is ambiguous. In (1.38), an increase in mother's wage may reduce child market labor H_2 . It depends on the sign and the magnitude of the cross derivative $\partial z_2 / \partial w_1$. In equation (1.39), the net effect would depend on the magnitude of the derivatives that correspond to the household work effect (HWE) and the income effect (IE). If the child's wage increases, more time would be spent in the market and less time at home (HWE). In addition, since a rise in child's wage raises the family income, we will observe

more education and less child labor according to the income effect (*IE*). Comparing (1.39) to (1.17), the only difference is the substitution effect which does not exist at the subsistence level. This means that the family would not give up more hours of child labor in order to have more education.

In Bhalotra's paper the derivative in equation (1.39) is negative at the subsistence level because her model does not include home production. Her explanation that the slope of the child labor supply is negative at the subsistence level because the family has a target income applies for the second term on the right hand side of equation (1.39). A drop in child wage will cause a drop in the hours of education and consequently an increase in the child labor supply, in order to reach the target income. However, in our model there is a positive effect given by the effect on child's household work. That drop in the child's wage reduces the opportunity cost of child's household work, and increases the demand for child's household work z_2 , reducing the supply of child labor H_2 .

An Example

In this section I solve the model using a particular utility function and production function. The utility function is:

$$U(c, Z, E) = \alpha_C \ln(c) + \alpha_Z \ln(Z) + \alpha_E \ln(E)$$

where $\alpha_C + \alpha_Z + \alpha_E = 1$. The home production function is:

$$f(z_1, z_2) = z_1^{1/2} + \gamma z_2^{1/2}$$

which exhibits decreasing returns to scale. The parameter $0 < \gamma < 1$ shows that the marginal product of child labor is smaller than the mother marginal product. Both marginal products are decreasing, but the cross derivative is zero.

I solved the model for the interior case, when all the variables are positive. Again, I assume that the subsistence level restrictions are not binding. The explicit solutions for the variables are the following:

$$z_1 = \left(\frac{P}{2w_1} \right)^2 \quad \text{Wife household work}$$

$$z_2 = \left(\frac{P\gamma}{2w_2} \right)^2 \quad \text{Child household work}$$

$$H_1 = 1 - \left(\frac{P}{2w_1} \right)^2 \quad \text{Wife labor supply}$$

$$H_2 = 1 - (1 + \alpha_E) \left(\frac{P\gamma}{2w_2} \right)^2 - \frac{\alpha_E}{w_2} (Y + w_1 + w_2) - \frac{\alpha_E}{w_2} \cdot \frac{P^2}{4w_1} \quad \text{Child labor supply}$$

$$Z = \frac{\alpha_Z}{P} \cdot \left(Y + w_1 + w_2 + \frac{P^2}{4w_1} + \frac{P^2 \gamma^2}{4w_2} \right) \quad \text{Total demand for household chores}$$

$$c = \alpha_C \cdot \left(Y + w_1 + w_2 + \frac{P^2}{4w_1} + \frac{P^2 \gamma^2}{4w_2} \right) \quad \text{Household consumption}$$

$$E = \frac{\alpha_E}{w_2} \cdot \left(Y + w_1 + w_2 + \frac{P^2}{4w_1} + \frac{P^2 \gamma^2}{4w_2} \right) \quad \text{Child's education}$$

Notice that $f_{12} = f_{21} = 0$, then the demand for child's household work does not depend on wages of other family members. Here the income effect can be seen clearly because some of the variables depend on the full income ($Y + w_1 + w_2$).

Using these results for this particular example, I can discuss under what values of the exogenous variables we would observe child market labor. To do this, first, let us draw the combinations of (Y, w_1) such that $H_2 = 0$, $c = c^*$ and $Z = Z^*$. In this particular example, $f_{21} = 0$ then the three curves have the same slope. They are downward sloping and concave to the origin²⁸.

Figure 1 shows the level curve $H_2 = 0$: all the combinations of father's income and mother wage that produce exactly zero hours of child labor. Points to

²⁸ This is true in this case, but it is not a general rule for any utility and production function.

the left of $H_2 = 0$ represent positive child labor (indeed, there exist several level curves with $H_2 > 0$). Points to the right of $H_2 = 0$ also represent zero hours of child labor because labor cannot be negative. Positive changes in child wage (w_2) shift the curve to the right, and negative changes to the left.

Likewise, the level curves $c=c^*$ and $Z=Z^*$ show the combinations of mother's wage and husband's income such that the family consumption reaches the minimum levels. To avoid unnecessary complications, let me assume that both curves lay one over the other, and that occurs if $c^*/\alpha_c = P \cdot Z^*/\alpha_z$. Points to the left represent levels of consumption below the subsistence level, and so, they are ruled out. Points to the right represent levels of consumption above the subsistence level. In figure 2, the shaded area represents combinations of (Y, w_1) where child labor exists.

Likewise, I can find the same curves in the plane (Y, w_2) given w_1 . Following our example, the subsistence level curves are still parallel and downward sloping and the slope of the $H_2 = 0$ curve is positive. Figure 3 is similar to figure 2 in the sense that it presents the regions where child labor is observed. What this figure says is that child labor will be observed only if w_2 is

higher than a certain critical level w_2^{**} , given a value of w_1 . This critical value is exactly the child's wage w_2 that makes curve $H_2 = 0$ lay over curve $c=c^*, Z=Z^*$ in figure 2. In addition to this, an increase in mother's wage w_1 shifts both curves downward, but w_2^{**} does not change. This value depends on the preference parameters, the price P and the subsistence values c^* and Z^* .

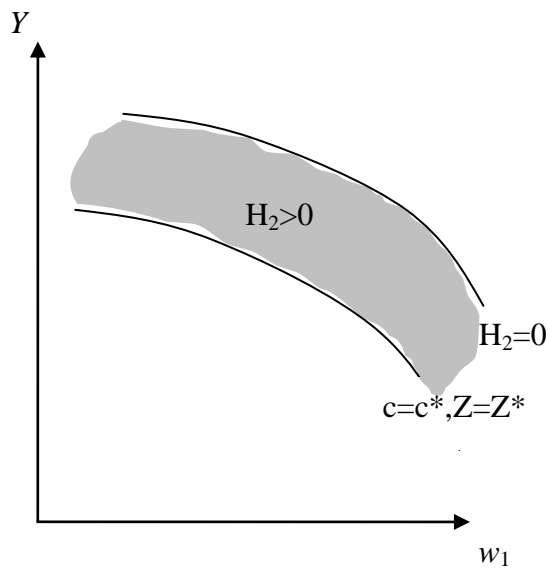


Figure 2. Existence of child labor in the plane (Y, w_1)

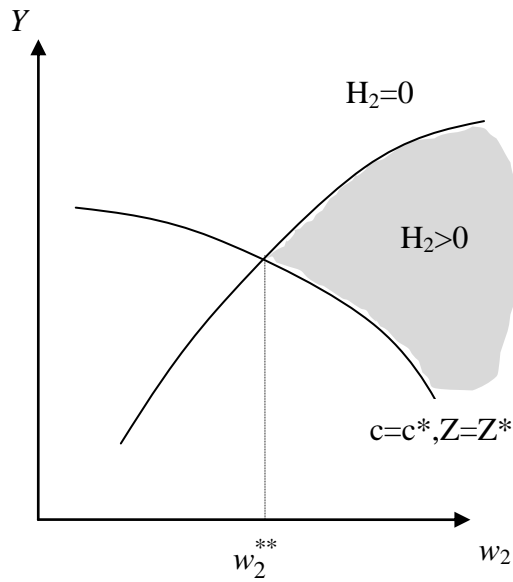


Figure 3. Existence of child labor in the plane (Y, w_2)

Conclusions to Chapter 1

The model presented here shows that the phenomenon of child labor is not restricted to families in the subsistence level, as the Basu and Van model states²⁹.

We can observe child labor in families that do not operate in the subsistence level.

²⁹ The Basu and Van's model says that we observe child labor if the family income drops below the subsistence level.

The determinants of the child's household work and wife's household work have been found. Household work functions depend on the wages of the family members and the price of substitutes in the market but not on the exogenous income. The model also shows that the variables related to home production are solved prior to the determination of the labor supply functions, which is consistent with Rosenzweig's work and by Brown, Deardorff and Stern's work³⁰.

As I expected, the introduction of household work affects the labor supply of the wife and the child. In addition to the standard income and substitution effects, a third effect related to household work may affect the derivatives of the labor supply functions and the education function. That effect shows how changes in wages of individual members may reallocate the time dedicated to household chores.

In the analysis of the slope of the child labor supply at the subsistence level, I show that the Bhalotra finding may overstate the value of that slope (and consequently overestimate the value of the corresponding elasticity). This happens because the omission of home production in her model yields a negative slope, but in our model that derivative has a negative and a positive component.

³⁰ Rosenzweig, 37-38; Brown, Deardorff and Stern, *U.S trade and policy options*, 30-31.

CHAPTER II
ESTIMATION OF A HOUSEHOLD PRODUCTION FUNCTION AND THE
CHILD LABOR SUPPLY

The goal of this chapter is to estimate a model of time allocation of family members including children, when it is assumed that parents allocate their time between market work and household work and the children allocate their time between market work, household work and study. Household work is understood as work performed at home involving the production of output for direct family consumption, but not for market sale. The economic model is a standard static model of family labor supply with home production where the labor supply of family members, household work and hours of education are solved for simultaneously. The main hypothesis is that those functions are connected through the wages of the family members and through the time family members spend on household work. Since this activity can be carried out by adults and children, changes in wages may cause some members to work more (or fewer) hours at home, and spending more (or fewer) hours working in the market. Therefore, this research attempts to answer the following question: Is it true that wages play an important role in allocation of time, and to what extent do wages affect household

work and child labor supply? To answer these questions, I use Peruvian data and econometric techniques.

Related Literature

The economic model estimated in this paper is related to standard models of family labor supply and the theory of allocation of time³¹. The family labor supply and time allocation approach has been recently applied to the child labor literature from a theoretical and empirical point of view. In Bhalotra's work, a theoretical model of child labor is presented, but it does not include household work³². Brown, Deardorff and Stern present a theoretical model of child labor with household work, but under restrictive assumptions about the production function³³.

Several empirical papers estimate the determinants of child labor, schooling and household work using Probit or Tobit methods, while others use

³¹ Gary Becker, "A theory of the allocation of time," *The Economic Journal* 75, no. 299 (1965): 493-517; Gronau, 1099-1123; Mark R. Rosenzweig and Robert Evenson, "Fertility, schooling, and the economic contribution of children in rural India: an econometric analysis," *Econometrica* 45, no.5 (July 1977): 1065-1079; Rosenzweig, 31-55; Nancy Birdsall, *Child Schooling and the Measurement of Living Standards*, Living Standards Measurement Study Working Paper No. 14, (Washington, D.C.:World Bank, 1982); Newman and Gertler, 989-1026.

³² Bhalotra, 6-10.

³³ Brown, Deardorff and Stern, *U.S trade and policy options*, 30-31

simultaneous equations methods. In what follows, I review some of those empirical papers stressing two aspects: the econometric method used to estimate the time allocation model, and the way they include wages in their estimations³⁴.

Deborah DeGraff, Richard E. Bilsborrow and A. Herrin estimate an econometric model of simultaneous determination of school attendance, market work and household work, using data from the Philippines. They note that time allocation decisions of all household members are interrelated and thus must be viewed as endogenous. However, in their empirical model they focus on the time allocation of school-aged children. They define four mutually exclusive and exhaustive categories: school attendance, market work, household work and leisure. They also define a simultaneous equations model where the endogenous variables are hours allocated to schooling, market work and home work, and each one depends on the other two variables and a set of exogenous covariates related to household and community characteristics. In their regressions they use binary versions of the endogenous variables and estimate the reduced form by Probit. After that, the estimates are used to estimate the structural equations. These authors include in the regressions the logarithm of child wage, which is defined as

³⁴ Later we will see that the observation of wages is one of the greatest obstacles in the estimation of this kind of models.

the logarithm of the average community agriculture and service wage for children³⁵.

In a posterior work, D. DeGraff and R. E. Bilsborrow³⁶ estimate the same model for the same country using the same exogenous variables but this time by the Tobit method instead of Probit in the estimation of the determinants of market work and household work. Probit is still the preferred method in the estimation of the determinant of schooling since the data provides only the enrollment decision but not the hours of work. In the case of hours of household work and market work, the reduced form of the functions is estimated by standard Tobit. Unlike DeGraff, Bilsborrow and Herrin's work, the structural equations are not estimated.

Deborah Levison and Karine Moe³⁷ analyze household work as a deterrent to schooling in Peru. In addition to market work, they propose that household work may present a more significant barrier to schooling for girls than boys. Based on the theoretical framework of home production models and the allocation of time, they estimate the reduced form of the determinants of hours worked in household chores and hours spent in school. To do this, they use the Generalized Tobit (sample selection) method. Focusing on unmarried adolescent girls ages 10

³⁵ DeGraff, Bilsborrow and Herrin, 219-247.

³⁶ DeGraff and Bilsborrow, 127-158.

³⁷ Levison and Moe, 339-356.

to 19, first they estimate the determinants of the probability that a girl will participate in schooling or household work. Then, the standard Heckman selection correction method is applied in the estimation of hours worked at home and spent in school the week before the survey. Wages are not included in the regressions.

Melissa Binder and David Scrogin³⁸ use the time allocation framework to estimate the determinants of child work in Mexico. In particular, they focus their attention on the effect of parents' wages and child's wages on their labor decisions. Since wages are not observed when an individual does not work, they impute wages of individuals who do not report earnings. The father's wage is predicted by ordinary least squares (OLS); and for the mother and children, they estimate a wage equation and correct the selection bias using the Heckman procedure. They also use proxies of wages (like age) instead of wages. In their estimation, using Probit models, they evaluate the time-allocation model's effectiveness in predicting whether a child works in the market or at home. Then, when imputed wages are included, they estimate by OLS and two stage least squares (2SLS) the determinants of hours spent in work activities (labor force, housework and child care), human capital activities and leisure. In the estimation, observations with zero hours were excluded from the analysis of work activities.

³⁸ Binder and Scrogin, 123-154.

Martin Ravallion and Quentin Woodon³⁹ analyze to what extent child labor can displace schooling, using data from Bangladesh. They study how a change in the price of schooling (through a subsidy) affects both child labor and school attendance. They found that the reduction in the price increased school attendance but the effect on child labor was small. They argue that the common belief that child labor comes largely at the expense of schooling has to be reviewed.

Hideo Akabayashi and George Psacharopoulos⁴⁰ investigate the degree to which there is a trade-off between child labor and human capital formation using data on children from Tanzania. These authors analyze the effect of hours of work in the market, work at home and school attendance on the development of reading and mathematical skills, but treat time allocation as endogenous. In their first step, they perform a Probit estimation of children's school attendance and a Tobit estimation of hours of work and study. In the second step, they use the predicted hours of work and the predicted probability of school attendance to estimate the effects of those activities on the cognitive skills. Wages are not included in any of the regressions.

³⁹ Martin Ravallion and Quentin Wodon, "Does child labor displace schooling? Evidence on behavioral responses to an enrollment subsidy," *The Economic Journal* 110 (March 2000): C158-C175.

⁴⁰ Akabayashi and Psacharopoulos, 120-140.

In a different work, Marcel Kerkhofs and Peter Kooreman⁴¹ identify and estimate a household production model. Based on Gronau's model, they estimate the parameters of a quadratic household production function. They argue that they cannot include individuals who have a paid job in the sample because the sampling rule depends on the labor market status, which is endogenous, and therefore, this would bias the result of the home production estimation. This occurs because individuals with low productivity at home will be most likely to have a paid job. They do not solve the complete household optimization problem because this would lead to a simultaneous model for the participation and home production decisions, and according to them this analysis would require a specification of the utility function. They take into account the process of selection extending their structural model⁴² with the inclusion of a bivariate Probit model describing the individuals' employment status (to participate or not in the job market).

The Empirical Model

In this section, I briefly review the model presented in Chapter 1 and derive the econometric specification. The model is a standard model of time

⁴¹ Kerkhofs and Kooreman, 337-369.

⁴² Their structural model is composed by the first order conditions of the production function, where the inputs are the hours that family members spend at home.

allocation where household work has been included as a single activity that the children and one of the parents can perform. The time spent on this activity produces a certain level of output which represents how clean or neat the house is. To simplify the model, it is assumed that there are two parents and only one child who may spend her time studying, working at home doing the chores or working in the labor market. The spouse spends her time in household work or market work. The head of household is the family planner who allocates the time of the spouse and the child to maximize the aggregated family utility $U(c, Z, E)$ where c is the total aggregated consumption, Z the total level of house chores, and E represents the hours the child studies. The planner works full time so his income is constant. Household chores can be produced at home or bought in the market. The home production function $f(z_1, z_2)$ is a strictly concave function whose inputs are the hours that the spouse and the child spend at home doing chores. In addition, the family faces a budget constraint, where the income is the sum of the labor income of the parents and the child. The family consumes a composite good and a housekeeping service (if not produced at home). Family members also face time constraints $z_1 + H_1 = T$ and $z_2 + H_2 + E = T$, which generate trade-offs between the time they spend among activities.

The solution of the model involves four important functions. The first two are the demands for child and spouse's household work $z_1 \equiv z_1(w_1, w_2, P)$ and $z_2 \equiv z_2(w_1, w_2, P)$, where z_1 and z_2 represents the time the spouse and child spend doing the chores respectively, w_1 and w_2 are their market wages and P is the market price of housekeeping services. Mathematically, it can be shown that these functions do not depend on the planner's income (Y). The other two important functions are the labor supply functions $H_1 \equiv H_1(w_1, w_2, Y, P)$ and $H_2 \equiv H_2(w_1, w_2, Y, P)$ of the spouse and the child.

The strategy to estimate the structural parameters of the model is to obtain information from the first order conditions. According to the solution of the theoretical model and assuming the interior solution, the first order conditions yield:

$$(2.1) \quad f_1 = \frac{w_1}{P}$$

$$(2.2) \quad f_2 = \frac{w_2}{P}$$

$$(2.3) \quad U_E = U_C \cdot w_2$$

$$(2.4) \quad U_Z = U_C \cdot P$$

where f_i is the marginal product with respect to input i , and U_j is the marginal utility with respect to the variable j . Equations (2.1) and (2.2) determine the optimal values of the household work variables z_1 and z_2 while (2.3) and (2.4) determine the child labor supply and the demand for housekeeping services.

Econometric Specification of the Home Labor Functions

The first order conditions (2.1) and (2.2) say that the marginal product of inputs must equal the ratio of wages with respect to the price of housekeeping services (the opportunity cost of home labor).

Usually the total output produced at home is not observed; we only observe the time employed in that activity. However, working with the first order conditions we can recover the structural parameters of the production function.

The first step is to define a parametric functional form for the production function. In the theoretical model we assumed the home production function is a

strictly concave function. For empirical purposes it is convenient to assume a quadratic function⁴³

$$(2.5) \quad f(z) = b'z + \left(\frac{1}{2}\right)z'\Omega z$$

where $z = [z_1 \ z_2]$, $b' = [b_1 \ b_2]$, and Ω is a 2x2 symmetric negative definite matrix. The first order conditions are:

$$(2.6) \quad b_1 + \omega_{11}z_1 + \omega_{12}z_2 = \frac{w_1}{P}$$

$$(2.7) \quad b_2 + \omega_{12}z_1 + \omega_{22}z_2 = \frac{w_2}{P}$$

I assume that the parameters b_1 and b_2 are a linear combination of individual and household characteristics and an error term.

$$(2.8) \quad b_i = x_i'\theta_i + \mu_i \quad i = 1,2$$

where $\mu_1, \mu_2 \sim N(0, \Sigma)$.

These equations are a system of structural equations that determine simultaneously the values of z_1 and z_2 .

⁴³ Kerkhofs and Kooreman use this function in their estimation of the home production function in Sweden. One of the advantages is that the derivatives are linear and it is easy to verify if time inputs are substitutes or complements. It is also easy to introduce stochastic error terms. Other paper which also uses quadratic functions but in utility functions is Michael M. Ransom, "An empirical model of discrete and continuous choice in family labor supply," *The Review of Economics and Statistics* 69, no. 3 (1987): 465-472.

The goal is to estimate the home labor functions derived from equations (2.6) and (2.7) as well as the structural parameters of the production function. Since this is a simultaneous equation problem, one might try to use one of the standard methods in the econometric literature, like the 2SLS method. However, problems arise in the attempt to use this method. There is a significant problem of missing data since wages can be observed only when individuals participate in the labor market. In the reduced form of the system, hours worked at home depend on the wages of both the spouse and the child, and as a consequence, we can use only those observations where both the spouse and the child work in the labor market. This creates a sample selection problem which may bias the parameters estimated by 2SLS. I would namely use only information of individuals that work in the market, who may be less productive in housework than individuals who stay at home doing chores. Estimation by standard 2SLS gives inconsistent estimates of the parameters due to the sample selection bias.

It is helpful to express equations (2.6)-(2.7) in the standard simultaneous equations notation.

$$(2.9) \quad z_1 = \gamma_2 z_2 + \beta_0 + \beta_1 \left(\frac{w_1}{P} \right) + \boldsymbol{\beta}' \mathbf{x}_1 + u_1$$

$$(2.10) \quad z_2 = \gamma_1 z_1 + \alpha_0 + \alpha_1 \left(\frac{w_2}{P} \right) + \boldsymbol{\alpha}' \mathbf{x}_2 + u_2$$

where vectors \mathbf{x}_1 and \mathbf{x}_2 may contain common explanatory variables as well as some specific variables, and the error terms u_1 and u_2 are normal variables with zero mean and variance-covariance matrix Σ_{uu} .

The reduced form of system (2.9)-(2.10) is:

$$(2.11) \quad z_1 = \mathbf{x}'\pi_1 + v_1$$

$$(2.12) \quad z_2 = \mathbf{x}'\pi_2 + v_2$$

where \mathbf{x} includes a constant term, w_1/P , w_2/P , \mathbf{x}_1 and \mathbf{x}_2 . The error terms v_1 and v_2 are linear combinations of u_1 and u_2 , and are also normally distributed with zero

mean and covariance matrix $\Sigma_{vv} = (\Gamma^{-1})'\Sigma_{uu}\Gamma^{-1}$, where $\Gamma = \begin{bmatrix} 1 & -\gamma_1 \\ -\gamma_2 & 1 \end{bmatrix}$. We can

estimate equations (2.11) and (2.12) only when we observe w_1 and w_2 at the same time.

To correct for selection bias, we include two more equations representing the decision whether the individuals (spouse and child) participate in the labor market or not.

$$(2.13) \quad I_1^* = A_1'\psi_1 + \varepsilon_1$$

$$(2.14) \quad I_2^* = A_2'\psi_2 + \varepsilon_2$$

where I_1^* and I_2^* are latent variables that determine the participation in the labor market. We observe that, for example, the spouse participates in the labor market if and only if $I_1^* > 0$. The error terms are assumed to have a normal distribution with zero mean, $\text{var}(\varepsilon_1) = \text{var}(\varepsilon_2) = 1$ and $\text{cov}(\varepsilon_1, \varepsilon_2) = \rho$. Moreover,

$$\begin{pmatrix} u_1 \\ u_2 \\ \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \sim N\left(0, \begin{pmatrix} \Sigma_{uu} & \Sigma_{u\varepsilon} \\ \Sigma_{\varepsilon u} & \Sigma_{\varepsilon\varepsilon} \end{pmatrix}\right)$$

Equations (2.11) and (2.12) cannot be estimated by OLS since:

$$E(v_i / I_1^* > 0, I_2^* > 0) = E(v_i / \varepsilon_1 > -A_1' \psi_1, \varepsilon_2 > -A_2' \psi_2) \neq 0.$$

The procedure we use to estimate the model is an extension of the Heckman-Lee method of estimation of simultaneous equations with selectivity, applied to the case of double selection⁴⁴.

- (a) In the first stage, equations (2.13) and (2.14) are estimated using bivariate Probit.

⁴⁴ See Lung-Fei Lee, G.S. Maddala and R.P. Trost, "Asymptotic covariance matrices of two-stage probit and tobit methods of simultaneous equations models with selectivity," *Econometrica* 48, no. 2 (1980): 491-504; and Insan Tunali, "A general structure for models of double-selection and an application to a joint migration/earnings process with remigration," *Research in Labor Economics* 8, Part B (1986): 235-282.

(b) In the second stage, using $\hat{\psi}_1$, $\hat{\psi}_2$ and $\hat{\rho}$ we calculate

$$E(v_i / I_1^* > 0, I_2^* > 0) = \lambda_{i1}M_{12} + \lambda_{i2}M_{21} \quad i = 1,2$$

$$\text{where } M_{ij} = (1 - \hat{\rho}^2)^{-1}(P_i - \hat{\rho}P_j), \quad P_j = \frac{\int_{-A_1\hat{\psi}_1}^{+\infty} \int_{-A_2\hat{\psi}_2}^{+\infty} \varepsilon_j f(\varepsilon_1, \varepsilon_2) d\varepsilon_1 d\varepsilon_2}{F(A_1\hat{\psi}_1, A_2\hat{\psi}_2, \hat{\rho})}$$

and F is a standard bivariate normal c.d.f.⁴⁵. Using the moments of a truncated multivariate normal distribution⁴⁶, let:

$$c_1 = -A_1\hat{\psi}_1, \quad c_2 = -A_2\hat{\psi}_2, \quad C_1 = (1 - \hat{\rho}^2)^{-1/2}(c_2 - \hat{\rho}c_1) \text{ and}$$

$$C_2 = (1 - \hat{\rho}^2)^{-1/2}(c_1 - \hat{\rho}c_2).$$

P_1 and P_2 can be expressed as,

$$P_1 = \{\phi(c_1)[1 - \Phi(C_1)] + \hat{\rho}\phi(c_2)[1 - \Phi(C_2)]\} \cdot F(-c_1, -c_2, \hat{\rho})^{-1}$$

$$P_2 = \{\hat{\rho}\phi(c_1)[1 - \Phi(C_1)] + \phi(c_2)[1 - \Phi(C_2)]\} \cdot F(-c_1, -c_2, \hat{\rho})^{-1}$$

where ϕ and Φ are the univariate standard normal p.d.f. and c.d.f. respectively. After that, I regress (2.11) and (2.12) by OLS, including \hat{M}_{12} and \hat{M}_{21} as regressors and calculate the fitted values \hat{z}_1 and \hat{z}_2 .

⁴⁵ See Raymond P.H. Fishe, R.P. Trost and Philip M. Lurie, "Labor force earnings and college choice of young women: an examination of selectivity bias and comparative advantage," *Economics of Education Review* 1, no. 2 (1981): 169-191; G.S. Maddala, *Limited-Dependent and Qualitative Variables in Econometrics*, (New York: Cambridge University Press, 1983), 282.

⁴⁶ See Samuel Kotz, N. Balakrishna and Norman L. Johnson, *Continuous Multivariate Distributions: Volume 1: Models and Applications*, (New York: Wiley, 2000), 207.

- (c) In the third stage, I estimate the “structural” equations (2.9) and (2.10) using \hat{z}_1 and \hat{z}_2 as regressors. In this case we also have selection bias because,

$$E(u_i / I_1^* > 0, I_2^* > 0) = E(u_i / \varepsilon_1 > -A_1' \psi_1, \varepsilon_2 > -A_2' \psi_2) \neq 0.$$

To correct for selection bias, the expressions \hat{M}_{12} and \hat{M}_{21} must be included on the right-hand side of each equation. The coefficients of these variables are the covariances $\text{cov}(u_i, \varepsilon_1)$ and $\text{cov}(u_i, \varepsilon_2)$, $i=1,2$, respectively.

- (d) There is a fourth stage where structural parameters of the home production function in equation (2.5) can be recovered. Those parameters can be easily obtained by using the estimated parameters of equations (2.9) and (2.10), and the standard errors are obtained using the delta method⁴⁷.

Econometric Specification of the Child Labor Supply

Having estimated the functions z_1 , the spouse’s labor supply H_1 is automatically determined given the time constraint $z_1 + H_1 = T$ under the assumption of no leisure in the model. In the case of the child labor supply and the

⁴⁷ In STATA it is easy to get these estimates and standard errors from the estimates of equations (2.6) and (2.7) and including M_{12} and M_{21} in the system, and doing the estimation by 2SLS.

hours of education, having estimated z_2 and according to the time constraint $z_2 + H_2 + E = T$, it is necessary to estimate either the labor supply H_2 or the hours of education E . From equation (2.3) I will derive an econometric specification to estimate the structural parameters of the utility function.

The first step is to estimate a utility function. The only properties that this function must have are strict quasiconcavity and twice-differentiability. A common function which is both tractable and easy to estimate is the C.E.S. function. Let

$$(2.15) \quad U(c, Z, E) = \left(\alpha_C c^\theta + \alpha_Z z^\theta + \alpha_E E^\theta \right)^{\frac{1}{\theta}}$$

be the utility function with $\alpha_C > 0$, $\alpha_Z > 0$, $\alpha_E > 0$ and $-\infty < \theta < 1$. The first order condition (2.3) becomes

$$(2.16) \quad \alpha_E \cdot E^{\theta-1} = \alpha_C \cdot c^{\theta-1} \cdot w_2$$

From here on, I will set the term $Pf_0=0$, so $c = Y + w_1 H_1 + w_2 H_2$ and $E = T - z_2 - H_2$ ⁴⁸. Plugging in this terms into (2.16) and after some manipulations I get

⁴⁸ Data supports this late assumption because in the sub sample where w_2 is observed (children work), households do not hire housekeeping services at all.

$$(2.17) \quad \frac{Y + w_1 H_1 + w_2 H_2}{1 - z_2 - H_2} = \left(\frac{\alpha_C}{\alpha_E} \right)^{\frac{1}{1-\theta}} \cdot (w_2)^{\frac{1}{1-\theta}}$$

Taking natural logarithm to (2.17), and adding an error term $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ we get the linear equation

$$(2.18) \quad \log\left(\frac{Y + w_1 H_1 + w_2 H_2}{1 - z_2 - H_2}\right) = \frac{1}{1-\theta} \log\left(\frac{\alpha_C}{\alpha_E}\right) + \frac{1}{1-\theta} \log(w_2) + \varepsilon_i$$

The term on the left hand side contains the endogenous variable H_2 as well as the endogenous (but pre-determined) H_1 and z_2 . The estimation of the child's labor supply requires taking the child's wage as an endogenous variable (what we observe is the equilibrium wage, not the minimum wage individual would be willing to accept to participate in the labor market). For that reason and due to the selectivity problem (the inclusion of w_2 in the regression restricts the sample to working children), I cannot estimate (2.18) directly by OLS.

It is necessary to estimate the child's wage first. Define the following linear wage equation:

$$(2.19) \quad \log(w_{2i}) = x_i' \beta + u_i$$

where x_i contains variables that may determine the child's wage, such as sex, age, region, and economic activity. Once $\log(\hat{w}_2)$ is estimated by OLS, I substitute it in (2.18) and regress this equation by OLS which gives consistent estimates of the parameters.

Concerning identification, I can obtain estimates of the structural parameter θ and the ratio α_C/α_E . However, this is enough information to obtain the slope of the child labor supply function.

The data

I use Peruvian Living Standard Measurement Survey (LSMS) of years 1997 and 2000 to estimate the model. This survey collects information on employment and time allocation as well as a detailed description of socioeconomic characteristics of the household and contains data on individuals of six years of age and older.

One limitation of these estimations is that they require the observation of wages. In spite of the fact that child labor is a significant concern in Peru, where one of every four children works in an economic activity, only a minority of them

receive a wage. This dramatically reduces the sample size which may affect the consistency of the econometric results. For this reason, I pooled the surveys of 1997 and 2000 in order to increase the sample size. Since a substantial percentage of households were interviewed in both surveys⁴⁹, I included each household only once to avoid possible serial correlation. Therefore, I used the whole sample of 1997 and only those households from 2000 that were not surveyed in 1997.

For empirical purposes, I define a “child” –who may potentially work– as an individual in the household between 6 and 17 years old. However, when I counted the family size, I included all the individuals that belong to a household, regardless the age.

Because the number of “children” in a household varies, I took into account only one child per household when I performed the econometric estimations. It is not feasible to estimate a model with a variable number of children. The criterion to select one child per household was to choose the child that worked the greatest number of hours in the market. If there were no working children in the household, I picked the oldest child in the subset of “children” aged 6 to 17.

⁴⁹ 45.7% of households from the 2000 survey were also surveyed in 1997.

The variables “Household work” and “Market work” were defined as the hours individuals spent on those activities during a week. Household work is that work performed at home doing household chores, whose output is not intended to be sold in the market. By contrast, market work is defined as any activity (employed or self-employed) with the objective to sell the output in the market.

There is a third labor category, the “Non-paid family work”, defined as hours worked in a family business or farm, without receiving a monetary wage. Individuals who are non-paid family workers were excluded from the sample because it seems that their behavior is systematically different than the one I propose in the model. In my model, wages determine the time allocation of family members. In the case of non-paid family workers, since they do not receive wages, other variables determine the participation in economic activities. Consequently, I excluded from the sample all households where at least one of the members (head, spouse or child) is a non-paid family worker.

Concerning unemployed workers, not all of them were included in the sample. The criterion was to include an individual who chose not to work and to exclude individuals that may report zero hours of work due to labor force conditions, beyond their control. Retired, individuals who were handicapped,

unemployed applying to new jobs and waiting for an answer, workers on vacation, sick workers, and workers on strike were excluded from the sample.

To calculate the weekly wages, we used the information provided in the survey on wages and salaries received in the last 7 days in the main job. Since the time unit of this earnings may vary (daily, monthly, quarterly, etc.), the wages were multiplied or divided appropriately by a scalar, to convert to weekly earnings. The main problem with wages is that they are not observed when the individual does not work in the market. I did not impute wages but left them as missing data wherever they were not reported.

Additional restrictions were applied to the sample. Households with no children between the ages of 6 and 17 were excluded. I also excluded households with one parent. In other words, I restricted the sample to households with a household head and spouse, and with at least one “child”. Finally, I excluded all cases with missing data in the variables hours of home work and market work.

Results

Participation in the Labor Market

The first step is to estimate the bivariate Probit model for the participation of the spouse and child in the labor market. In each equation, I included variables related to individual characteristics such as age, education (in years) and sex, and variables that reveal household characteristics such as household head's wage, number of adults, and number of children less than 18 years old.

The results presented in table 1 are consistent with what standard theory predicts. In the case of the spouse's participation, the variables Age, Age Squared and Education have the correct signs and are significant. The "number of children with ages less than 6 years old" variable has a negative sign and it is significant, which means that this variable is an important barrier to spouse's participation in the labor market. In addition, the head's wage and the income of other household members have a negative sign, which would mean that the probability of participation in the labor market decreases when these variables increase. In contrast, the sign of the non-labor income per capita is positive. It is hard to find an explanation for this result.

Table 1. Probit Estimation of Participation in Labor Market

	Coefficient	t-statistic
<i>Spouse:</i>		
Spouse's age	0.1038 ***	4.75
Spouse's age square	-0.0012 ***	-4.71
Spouse's education (years)	0.0288 ***	3.52
Spouse's sex (1=male, 0=female)	0.7102	1.59
# of children < 6 years old	-0.1404 ***	-3.84
Urban/Rural (urban=1, rural=0)	0.0188	0.22
Log(head's wage)	-0.2732 ***	-6.63
Log(non labor income per capita)	0.0674 **	2.08
Log(income of other household members)	-0.0547 ***	-3.25
Constant	-1.0426 **	-2.19
<i>Child:</i>		
Child's age	0.1758 ***	7.87
Child's sex (1=male, 0=female)	0.2600 *	1.91
# adults in household	-0.1590 ***	-2.79
# children < 18	0.1575 ***	4.29
# girls 11 – 17 years old	-0.2770 ***	-2.87
Urban/Rural (urban=1, rural=0)	-0.1022	-0.81
Log(head's wage)	-0.1824 ***	-2.83
Log(non labor income per capita)	-0.1307 **	-2.32
Log(income of other household members)	0.0898 ***	2.68
Attends school? (1=yes, 0=no)	-0.9454 ***	-7.32
Constant	-1.9091 ***	-4.23
ρ (rho)	0.1860 ***	$\chi^2_{(1)} = 7.54$
Number of obs.	1681	
Log likelihood	-1458.79	
Wald $\chi^2_{(18)}$	341.59	
Prob > χ^2	0.00	

* significant at 10% level, ** significant at 5% level, *** significant at 1% level

In the case of childhood labor force participation, the older the child is, the more likely he or she participates in the labor market. This result agrees with

empirical papers on child labor⁵⁰. There is also a greater participation for boys than for girls. The number of adults in the household decreases the probability of child participation. More adults in household mean more individuals who can work, and it is plausible that the household would “buy” more education and more leisure for the child, and consequently we would observe less child labor. The number of girls ages 11 – 17 also has negative impact on the participation in labor market. I expected a positive sign, since girls usually work at home and give more time to boys to work in the market.

Concerning the effect of head’s wage, the coefficient on the log of the head’s wage is negative. Non labor income also has a negative effect on childhood participation, but the effect of the income of other members is positive. A possible explanation for the latter result is if other members in the family work (like older siblings), the child would feel motivated to work as well. Finally, there exists a negative relationship between school attendance and participation of children in the labor market.

Regarding the other parameters and statistics, the parameter ρ , which is the correlation between the error terms in both equations, is positive and significant. This means that whenever we observe a working spouse, it is more likely to

⁵⁰ For example, Bhalotra and DeGraff & Bilsborrow.

observe at least one working child in household, and it confirms that the bivariate Probit estimation is the correct method instead of the standard Probit. The Wald statistic of joint significance of the variables shows that the model is a good fit.

Structural Parameters

The second step involves estimating the model by two-stage least squares method and correcting for sample selection. All the results presented here are compared to the signs of the theoretical derivatives of the functions, as presented in chapter 1. Table 2 presents the results of the estimation of equations (2.9) and (2.10). The sign of the derivative of z_1 with respect to z_2 is insignificant and close to zero. The same occurs with the derivative of z_2 with respect to z_1 . Theory says that a positive sign of this parameter means that the two labor inputs are complements, and a negative sign corresponds to substitutes. Since the parameters are not significant, I am unable to determine the relationship between z_1 and z_2 .

Table 2. Estimation of the Simultaneous Regression Model

	Z_1 (Spouse's Housework)		Z_2 (Child's Housework)	
	Coefficient	t	Coefficient	t
<i>Household work:</i>				
Z_1	--	--	0.0808	0.41
Z_2	-0.1270	-0.40	--	--
<i>Wages:</i>				
Log(spouse's wage)	-6.2411 ***	-3.00	--	--
Log(child's wage)	--	--	-3.3202 *	-1.77
Log(price housekeeping)	24.9618 ***	3.58	-4.8016	-0.69
<i>Individual characteristics:</i>				
Spouse's age	-0.2176	-0.67	--	--
Spouse's education	-1.1778 **	-2.22	--	--
Child's age	--	--	1.8798 *	1.93
Child's sex(1=male, 0=female)	--	--	-6.1234 **	-2.01
<i>Household characteristics:</i>				
# adults in household	-1.7955	-0.88	-2.4570 **	-2.27
# children 0-6 years	-0.5206	-0.22	-2.2588 *	-1.70
Material of Walls: Adobe	2.8045	0.48	-8.6971 **	-2.35
Material of Walls: Bricks or Concrete	2.6460	0.48	-6.7657 **	-1.98
# of floors	7.7182 *	1.84	-2.2822	-0.72
Water connection inside dwelling	-10.1384 **	-2.17	5.8652	1.35
<i>Sample Selection Variables:</i>				
m12	-16.4023	-1.21	19.4168 **	2.47
m21	-6.9900	-1.58	1.9672	0.47
<i>Constant:</i>	5.0443	0.16	10.6640	0.51
Number of observations	75		75	
F(13, 61)	4.1		3.1	
Prob > F	0.0001		0.0014	
R-squared	0.4638		0.3943	
Adj R-squared	0.3495		0.2652	

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level

Concerning the relationship between hours worked at home and market wages, table 2 shows that there is a significant negative relationship between those variables in the two equations, and the parameters are significant different from zero. In the case of the price of housekeeping services, the theory indicated that the relationship between household work and this price was positive. The results confirm this hypothesis in the first regression, but do not confirm in the case of child home labor equation.

Some of the individual characteristics affected the hours spent doing household work. The more educated the spouse was, the fewer hours the spouse worked at home. Spouse's age was not significant in the regression⁵¹. In the case of child's characteristics, the age and sex variables affected child's hours of household work. Older children participated more in housework than younger children. It is also observed in table 2 that girls work more at home than boys. These results are quite intuitive and expected.

Regarding the group of household characteristics, I included six: number of adults in household, number of children with ages 0-6 years old, two dummy variables describing the materials of walls, the number of floors of the dwelling, and water connection inside dwelling. The first two were significant only in the

⁵¹ In the sample, 95% of the spouses are women.

child's regression, and all the signs of the parameters are negative. This means that when more adults are present in household, children work less hours doing house chores. Perhaps, those adults engage in household production, giving more time to children to study or play. Also, the presence of children from 0 to 6 years decreased the hours of child housework. An interpretation of this result is that very young children require the presence of an adult in household, and that adult does some chores, thus reducing the load of older siblings.

Concerning house characteristics, I included four variables to capture the effect of the quality of the house or dwelling and its effect on household work. The results show that in the case of Material of Walls: Adobe and Material of Walls: Bricks/Concrete, children worked less hours at home than the rest of the categories: walls made of cane and mud, stone and mud, wood, matting, and others. These variables were significant only in the child's regression. Something different occurs in the case of number of floors and the water connection inside dwelling variable. They are significant only in the spouse's regression. A larger house with more floors implies more spouse housework, and a water connection inside the dwelling implies less spouse housework. This last result is intuitive since a house without water connection requires large amounts of work in order to get the water the family needs.

The last group of variables in table 2 is the group of sample selection variables that correct the double selection problem. Only one of them was significant, but the “t” statistics of them in the spouse’s regression are high. Perhaps the small fraction of the sample that was selected, only 75 observations out of 1681 observations in the simultaneous Probit in table 1, influenced these low “t” statistics.

It is interesting to obtain the technical parameters of the production function as well. Table 3 shows the estimation of the technical parameters in equations (2.6) and (2.7).

To obtain these results I estimate equations (2.6) and (2.7) directly, which produces estimates of the parameters of equation (2.5) and the “composite” parameters b_1 and b_2 . Additionally, I imposed a cross equation restriction $\omega_{12} = \omega_{21}$, which means that the cross derivatives are equal, $\partial^2 f / \partial z_1 \partial z_2 = \partial^2 f / \partial z_2 \partial z_1$. This restriction was not imposed in table 2 because it would require the imposition of non-linear restrictions to the system (2.9) and (2.10). Table 3 shows the results of these estimations, which are slightly different from those on table 2.

Table 3. Parameters of the Production Function

	Spouse's equation			Child's equation		
	Coefficient		t	Coefficient		t
<i>Technical Parameters:</i>						
ω_{11}	-0.0944	***	-3.78	--		--
$\omega_{12}=\omega_{21}^\dagger$	-0.0114		-0.48	-0.0114		-0.48
ω_{22}	--		--	-0.1750	**	-2.36
<i>Prices:</i>						
Log(price housekeeping service)	2.5253	***	2.86	-0.2343		-0.22
<i>Individual Characteristics:</i>						
Spouse's age	-0.0166		-0.51	--		--
Spouse's education	-0.1108	*	-1.9	--		--
Child's age	--		--	0.2819		1.46
Child's sex(1=male, 0=female)	--		--	-0.9810		-1.25
<i>Household Characteristics:</i>						
# adults in household	-0.0917		-0.46	-0.5131	**	-2.14
# children 0-6 years	-0.0854		-0.38	-0.4613	*	-1.73
Material of Walls: Adobe	0.2498		0.44	-1.3745		-1.55
Material of Walls: Bricks or Concrete	0.4069		0.77	-1.0401		-1.27
# of floors	0.7052		1.54	-0.2136		-0.4
Water connection inside dwelling	-0.7969		-1.46	0.5851		0.76
<i>Sample Selection Variables:</i>						
m12	-2.0098		-1.51	3.4227	**	1.79
m21	-0.8595	**	-1.98	-0.0750		-0.11
Constant	1.4310		0.47	3.4671		0.99
<hr/>						
$\Delta = \omega_{11} \cdot \omega_{22} - \omega_{12} \cdot \omega_{21}$	0.0164					

\dagger Cross-equation restriction: $\omega_{12}=\omega_{21}$

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

The negative sign of the parameters ω_{11} and ω_{22} show that the marginal products of labor are downward sloping. The parameter ω_{12} is close to zero and not significant, which confirms that the labor inputs are neither substitutes nor complements. Moreover, the sign of the determinant $\Delta = \omega_{11} \cdot \omega_{22} - \omega_{12} \omega_{21}$ is positive, which confirms that the production function is strictly concave because the Ω matrix in equation (2.5) is negative definite.

Finally, table 4 shows some results on the parameters b_1 and b_2 , which vary across individuals because they depend on the individual and household characteristics. According to the economic theory, these parameters should be strictly positive. In these results, this holds for parameter b_1 , but not for all estimates of b_2 . Fortunately, only one observation was negative, with a value close to zero.

Table 4. Estimation of b_1 and b_2

	b_1	b_2
Mean	6.7294	7.0337
Standard Deviation	1.0390	2.7170
Minimum	3.2492	-0.3149
Maximum	10.8280	23.4858
Number of observations	1769	1769

Estimation of the Parameters of the Utility Function and the Child Labor Supply

In this section, I estimate equations (2.18) and (2.19) in order to obtain the parameters of the utility function. The first step is to estimate the wage equation. The child's wage is affected by several variables, such as child's age, child's sex, the economic activity in which the child is involved, and some regional differences. Table 5 presents three OLS regressions of the child's wage equation controlling for the child's demographic characteristics, economic activity and geographic region. The standard errors were calculated using a robust variance estimator.

We observe that both the child's age and sex are significant in the three regressions. In all cases, boys receive higher wages than girls and wages increase with child's age. In column (2) I include dummy variables of the sector in which the child works. Children who work in agriculture, construction and transportation receive higher wages than their peers who work in manufacturing, sales, domestic services and other services. In column (3), I included a group of dummy variables

related to geographic regions. The excluded category was the Rural Sierra, which is traditionally the poorest region in Peru⁵².

Table 5. Determinants of the Child's Wage

	<i>Log(child's wage)</i>		<i>Log(child's wage)</i>		<i>Log(child's wage)</i>	
	(1)		(2)		(3)	
	Coef.	t	Coef.	t	Coef.	t
<i>Child's characteristics:</i>						
Sex (1=male, 0=female)	0.3473 ***	2.91	0.2425 **	1.94	0.1883 *	1.66
Age	0.1409 ***	4.08	0.1458 ***	4.16	0.1165 ***	3.23
<i>Economic Activity</i> ^a :						
Agriculture	--	--	0.3279 **	2.21	0.3402 **	2.05
Construction	--	--	0.5235 **	2.51	0.5759 ***	2.91
Transportation	--	--	0.4292 **	2.5	0.4161 **	2.43
<i>Geographic Region</i> ^b :						
Lima Metropolitan Area	--	--	--	--	0.7420 ***	3.90
Urban Coast	--	--	--	--	0.2604	1.21
Rural Coast	--	--	--	--	0.5044 **	2.10
Urban Sierra	--	--	--	--	0.4997 **	2.35
Urban Jungle	--	--	--	--	0.4241 *	1.87
Rural Jungle	--	--	--	--	0.5505 **	2.25
Lambda	-0.067	-0.57	0.0468	0.36	-0.0361	-0.27
Constant	1.2895 *	1.91	0.9923	1.42	1.1119	1.56
Number of observations	202		202		202	
F- statistic	14.21		10.40		8.20	
Prob > F	0.00		0.00		0.00	
R-squared	0.17		0.21		0.28	

^a Omitted categories: manufacturing, selling, domestic services, and other services.

^b Omitted category: Rural Sierra

* significant at 10% level, ** significant at 5% level, *** significant at 1% level.

⁵² Peru has three natural regions: the Coast, the Sierra (highlands) and the Jungle (Amazonia). The coast is the most developed region while the Sierra is the poorest. Additionally, as in most developing countries, the rural areas are less developed than urban areas.

The results of equation (3) show that wages in all the regions are higher than in rural sierra, except the urban coast. Finally, since in these regressions there is only one possible source of selection, I included the standard Mill's ratio. The parameter λ of this regression was not significant in any of the three regressions.

Given the estimates of child's wage, the next step is to estimate equation (2.18) which involves the use of the predicted values of log of child's wage from column (3). Additionally, it is necessary to construct the variable in the left hand side of equation (2.18). I consider three regressions depending on the use of the actual or fitted values of H_1 and z_2 in the left hand side.

- Regression (a): Actual values of H_1 and z_2

$$\log\left(\frac{Y + w_1H_1 + w_2H_2 + \text{other income}}{1 - z_2 - H_2}\right) = \frac{1}{1-\theta} \log\left(\frac{\alpha_C}{\alpha_E}\right) + \frac{1}{1-\theta} \log(\hat{w}_2) + \varepsilon_i$$

- Regression (b): Actual value of H_1 , fitted value of z_2

$$\log\left(\frac{Y + w_1H_1 + w_2H_2 + \text{other income}}{1 - \hat{z}_2 - H_2}\right) = \frac{1}{1-\theta} \log\left(\frac{\alpha_C}{\alpha_E}\right) + \frac{1}{1-\theta} \log(\hat{w}_2) + \varepsilon_i$$

- Regression (c): Fitted values of H_1 and z_2

$$\log\left(\frac{Y + w_1\hat{H}_1 + w_2H_2 + \text{other income}}{1 - \hat{z}_2 - H_2}\right) = \frac{1}{1-\theta} \log\left(\frac{\alpha_C}{\alpha_E}\right) + \frac{1}{1-\theta} \log(\hat{w}_2) + \varepsilon_i$$

Table 6 presents the results of the estimations by OLS of regressions (a), (b) and (c). Each equation was regressed twice, with and without the sample selection terms. We see that the estimated parameters do not vary across the three equations. Also note that the coefficient of $\log(\hat{w}_2)$ is significant in all the equations. In the case of the sample selection parameters, they are not significant in any of the three regressions. The estimated parameters of the utility function, θ and α_C/α_E , were only significant in regressions without the sample selection variables. The values of the parameter θ lie between 0 and 1, which corresponds to an intermediate function between the Cobb-Douglas function ($\theta = 0$) and the case of perfect substitution ($\theta = 1$).

I use the parameter estimates to obtain the slope and the wage elasticity of the child labor supply function. From equation (2.17), the explicit solution of the child labor utility function is:

$$H_2 = \frac{w_2^{\frac{\theta}{1-\theta}}}{\left(\frac{\alpha_C}{\alpha_E}\right)^{\frac{1}{\theta-1}}} \left(112 - z_2 - \left(\frac{\alpha_C}{\alpha_E}\right)^{\frac{1}{\theta-1}} w_2^{\frac{1}{\theta-1}} \cdot (Y + w_1 H_1) \right)$$

Table 6. Estimation of Parameters of the Utility Function

(t statistics in parenthesis)						
	Regression (a)		Regression (b)		Regression (c)	
<i>OLS regression:</i>						
Constant	-0.954 (-1.065)	-0.559 (-0.385)	-0.942 (-1.008)	-0.531 (-0.351)	-0.351 (-0.410)	-0.248 (-0.175)
Log(child's wage)	1.354 *** (5.459)	1.141 *** (3.885)	1.353 *** (5.234)	1.131 *** (3.695)	1.329 *** (5.607)	1.224 *** (4.263)
m12	--	0.826 (1.412)	--	0.863 (1.416)	--	0.508 (0.888)
m21	--	-0.173 (-0.610)	--	-0.181 (-0.609)	--	-0.069 (-0.247)
<i>Utility parameters:</i>						
α_C/α_E	0.494 * (1.873)	0.612 (0.861)	0.499 * (1.791)	0.625 (0.816)	0.768 * (1.674)	0.817 (0.894)
Θ	0.261 * (1.932)	0.123 (0.546)	0.261 * (1.850)	0.116 (0.484)	0.247 * (1.843)	0.183 (0.953)
R-squared	0.290	0.337	0.273	0.321	0.301	0.317
F-statistic	29.805	12.040	27.397	11.212	31.435	10.984
Prob(F)	0.000	0.000	0.000	0.000	0.000	0.000
Number of obs.	75	75	75	75	75	75

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

where 112 represents the total time allotted to individuals per week (16 hours per day).

After several manipulations, the derivative with respect to the child wage is:

$$\frac{\partial H_2}{\partial w_2} = \left(\frac{\theta}{1-\theta} \right) \cdot \frac{w_2^{\frac{2\theta-1}{1-\theta}}}{\left(\frac{\alpha_C}{\alpha_E} \right)^{\frac{1}{\theta-1}}} \cdot (112 - z_2)$$

In table 7, I calculate the average slope of the child labor supply and the corresponding wage elasticity. The standard deviation reflects the variability in individual characteristics, since slopes and elasticities vary across individuals. It is not the standard error of any specific parameter.

Results indicate that the slope of the child's labor supply with respect to wage is positive, as standard theory predicts. This also means that the substitution effect is greater than the income effect. We also see that the results change if we correct for sample selection. The child labor supply is inelastic if I correct the sample selection problem, but it is elastic if I do not correct it (except in regression (c) where in both cases the labor supply is elastic).

Table 7 does not show minimum and maximum values of slopes and elasticities. All minimum values are positive, and the distribution of these variables has a thick right tail. In a few cases, estimated values were 30 units or more. However, the majority of values are concentrated around 1.

Table 7. Slope of the Child Labor Supply and the Wage Elasticity

	$\partial H_2 / \partial w_2$		Wage elasticity	
	Mean	Standard Deviation	Mean	Standard Deviation
<i>Regression (a)</i>				
Without sample selection correction	1.5670	1.1565	2.3745	2.5766
With sample selection correction	0.4925	0.5391	0.6616	0.8375
<i>Regression (b)</i>				
Without sample selection correction	1.5834	1.1694	2.3988	2.6033
With sample selection correction	0.4590	0.5105	0.6130	0.7837
<i>Regression (c)</i>				
Without sample selection correction	2.4665	1.9145	3.6869	4.0469
With sample selection correction	1.3588	1.2871	1.9152	2.2503

Conclusions to Chapter 2

Unlike other papers on child labor time allocation, this work estimates the child's labor supply and household work while taking into account the child's wage and the wages of other family members. My hypothesis was that wages play an important role in the time allocation of household members. The main result of this research is that wages are relevant when it comes to assigning chores at home and determining the hours that the child works in the labor market.

In the first part of the chapter, I estimated the household work function for a child and one parent, and the technical parameters of the household production function. These functions were estimated separately from the other endogenous variables because the theoretical model suggests that they depend on wages and the production function only. The econometric estimation required to correct two sources of sample selectivity, the observation of child's and spouse's wages. The results showed that the hours that individuals spend on household work depend negatively on their respective wages, but child housework does not depend on the spouse's household work (and vice versa). Additionally, hours spent on household work depend on individual characteristics like sex, age and education, and household characteristics. However, one shortcoming of these estimations is that the number of selected observations is very small compared to the total sample.

According to the estimation results, boys are more likely to participate in the labor market. That probability of labor force participation also increases with age. Some family characteristics also affect the participation in the labor market, as does the head's income, the non labor income and the income of other family members.

The results from the utility function parameters showed that child's wage depended on child's characteristics such as sex, age, the kind of economic activity in which the child was engaged and the geographic region. Additionally, I calculated some of the parameters of utility function and the standard errors.

Finally, using the estimates of the parameter of the utility function, I calculated the slope of the child's supply function and the corresponding elasticity. The labor supply has positive slope for all individuals, and the average elasticity was lower than 1 (inelastic supply) when I used the parameters of the regression corrected by sample selection. The elasticity was greater than 1 (elastic supply) when I used the parameters of the regression without that correction.

CHAPTER 3
THE EFFECT OF CHILD LABOR AND HOUSEHOLD WORK ON SCHOOL
ATTAINMENT

It is widely accepted that child labor is dangerous to children less than 14 years old, who are exposed to exploitation and abuse. In addition to those risks, data shows that many children in developing countries spend a considerable amount of time working or doing household chores. For example, in Peru, one of every four children is engaged in some kind of economic activity and three of every four children do household work, which is understood as those chores performed at home like cleaning, cooking, etc.

There are some positive effects of work at an early age such as a better management of time and resources, the acquisition of experience, maturation and independence⁵³. Nevertheless, very important negative effects exist such as: the decrease of the time dedicated to education, dropping out of school, difficulty

⁵³ Rhoda V. Carr, James D. Wright and Charles J. Brody, "Effects of high school work experience a decade later: evidence from the National Longitudinal Survey," *Sociology of Education* 69, no. 1 (1966): 67.

finding good jobs in the future, low educational attainment, low school attendance, lower wages, and unemployment, among others.

The objective of this research is to find the extent to which child labor and child household work affect human capital accumulation, paying special attention to the short-term and long-term effects. I propose here that both activities have a negative effect on school attainment, in the short and long run. In other words, any positive effect of child labor is surpassed by negative effects in the long run.

The argument that supports this hypothesis is the following: in the short run, when a child is engaged in child work and/or household work, he or she has less time to study. This may affect directly school attendance and school attainment. On the other hand, the medium and long-run effects are related to human capital accumulation. The current educational indicators and the labor force outcomes (such as wages, participation in labor markets, employment, etc.) depend not only on the current allocation of time, but also on the flow of past time allocations. For example, if in the present a child studies full time but in the past he or she was a child worker, it is likely that this boy or girl will be behind compared to other students of the same age group who were always fulltime students. Since there are certain skills that are not acquired at the right time (like reading and writing, for example), students who do not take advantage of

education at the right time will need a great effort in the future to overcome this disadvantage and to recover the time lost.

To support this hypothesis I have selected two indicators of school attainment: the Schooling-Age ratio and the probability of studying in higher education. This chapter evaluates econometrically the effect of current and past hours of household work and labor on the outcomes selected. To achieve this task I use panel data on 575 individuals who were surveyed in 1994, 1997 and 2000 as part of the Peruvian Living Standard Measurement Survey.

The chapter is organized in the following way. The first section reviews the literature on child and youth employment and its effect on some socioeconomic outcomes. The next section describes the econometric methods to be employed in the paper. The third section presents and discusses the main results. The last section provides a conclusion.

Review of Literature

Most of the studies in this area focus on short-term effects when they regress, for example, school attendance on hours of child labor, using data from

the same survey (cross section). Some papers have studied the effect of high school work on future earnings, but only in the developed world. Only a handful of papers in the child labor and youth labor literature have studied directly the consequences of past child labor on current education attainment and labor market performance.

In a recent paper, K. Beegle, R. Dehejia and R. Gatti use data from Vietnam to find the impact of child labor five years later on school participation, educational attainment (highest grade completed), occupation, earnings and health. This empirical model includes an explanatory dummy variable whether the child did or did not work 5 years ago. According to the authors that dummy may cause some potential biases in estimates, so they use an instrumental variable approach to deal with this problem. Neither household work nor contemporary values of child labor are considered in the regressions. Their results show a negative and significant effect of child labor on school attendance and the highest grade completed five years later⁵⁴.

In a study using data from the United States, R. Carr, J. D. Wright and C. J. Brody study the effect a decade later of high school work on educational

⁵⁴ Kathleen Beegle, Rajeev Dehejia and Roberta Gatti, *Why should we care about child labor? The education, labor market, and health consequences of child labor*, World Bank Policy Research Working Paper 3479 (Washington, D.C.:World Bank, 2005), 19-20.

attainment, wages and participation in the labor market. They find a negative effect of high school work on the level of education attained but a positive effect on wages, labor force participation and employment status⁵⁵. In contrast, using a shorter horizon, other studies have found different results such as Ronald D'Amico who found that, for the female group, working at high school reduces the probability of dropping out school (except for white females who worked more than 20 hours a week). In the case of males, working less than 20 hours a week reduces the probability of dropping out school, but for individuals who work more than 20 hours a week it is more likely to drop out high school (except for white males)⁵⁶.

There are several papers that focus their attention on the short-run effect of child labor on school achievement. All of them use cross section data and, as a consequence, include contemporary values of child labor and school achievement only. For example, G. Psacharopoulos studies the effect of child labor on years of schooling, using data from two Latin American countries. He finds that child labor reduces schooling by two years on average. In other work, P. Jensen and H.S. Nielsen analyze the determinants of school attendance, under the assumption

⁵⁵ Rhoda V. Carr, James D. Wright and Charles J. Brody, "Effects of high school work experience a decade later: evidence from the National Longitudinal Survey," *Sociology of Education* 69, no. 1 (1966): 72-73.

⁵⁶ Ronald D'Amico, "Does employment during high school impair academic progress?," *Sociology of Education* 57, (1984): 160-161.

that there is an exact trade off between child labor and hours of study (provided there are no more activities during the day). M. Ravallion and Q. Wodon do not make this assumption and ask if child labor displaces schooling. They find that a school-price subsidy increases schooling but has limited effect on child labor. H. A. Patrinos and G. Psacharopoulos, using data from Peru, do not find evidence that child labor influences the age-grade distortion. Finally, D. Levison and K. Moe state that child labor is not the only obstacle to schooling. Rather, household work is also an important deterrent to schooling, especially in the case of girls⁵⁷.

Another group of papers measures the impact of child labor on learning achievement. Paul Glewwe presented a theoretical model of hours of work, schooling and acquisition of cognitive skills. V. Gunnarson *et al* analyze the impact of child labor on language and math scores in 11 Latin American countries, finding a negative impact. In a similar work and using data from Ghana, C. Heady includes in his regressions two kinds of child labor (at home and outside home) and child housework. He finds that child labor has a negative and significant effect on math and reading scores. Household work also has a negative

⁵⁷ George Psacharopoulos, "Child labor versus educational attainment: some evidence from Latin America," *Journal of Population Economics* 10 (1997): 377-386; Peter Jensen and Helena Skyt Nielsen, "Child labor or school attendance? Evidence from Zambia," *Journal of Population Economics* 10 (1997): 407-424; Martin Ravallion, and Quentin Wodon, "Does child labor displace schooling? Evidence on behavioral responses to an enrollment subsidy," *The Economic Journal* 110 (March 2000): C158-C175; Harry Anthony Patrinos and George Psacharopoulos, "Family size, schooling and child labor in Peru – an empirical analysis," *Journal of Population Economics* 10 (1997): 387-405; Levison and Moe, 339-356.

effect, but only has a significant effect on the easy math test. In an earlier work, H. Akabayashi and G. Psacharopoulos also analyze the effect on reading and math scores in the Tanzanian case. They find a negative effect of child labor on these scores, but their results are not robust when other variables are included in the regression such as school attendance and hours of study⁵⁸.

Hypothesis and Methodology

In this research I propose that child labor and household work have not only a short run effect on education outcomes but also a long run effect, due to the effect on human capital accumulation. Due to the dynamic nature of this hypothesis, it can only be measured and estimated using a panel of individuals.

A general econometric model is the following:

$$(3.1) \quad y_{it} = \alpha_0 + \sum_{j=0}^2 \beta_j h_{it-j} + \sum_{j=0}^2 \gamma_j z_{it-j} + \delta X_i + \varepsilon_{it}$$

⁵⁸ Paul Glewwe, "School and skills in developing countries: education policies and socioeconomic outcomes," *Journal of Economic Literature* 40 (2002): 438-441; Victoria Gunnarson, Peter Orazem and Mario A. Sanchez, "Child labor and school achievement in Latin America," Working Paper # 03023, (Ames: Iowa State University, Department of Economics, 2003): 17-22; Christopher Heady, "The effect of child labor on learning achievement," *World Development* 31, no.2 (2003): 385-398; Akabayashi and Psacharopoulos, 132-138.

where y_{it} is the outcome which corresponds to individual i in period t (year 2000), h_{it} represents the hours of child labor of individual i in period t , z_{it} represents the hours of household work of individual i in period t , and X_i is a vector of other variables. Note that this is a model of distributed lags where two lags have been included due to restrictions on data. There is a short run effect (current effect) if β_0 and γ_0 are significantly different from zero, and there is a long run effect (past effect) if $\beta_1, \beta_2, \gamma_1$, and γ_2 are significantly different from zero.

The outcomes to be analyzed are: age-grade distortion or SAGE, and the probability of having some education beyond high school.

Definition of Dependent Variables

- The SAGE formula

The age-grade distortion or SAGE is measured as

$$SAGE = \frac{S}{A - E} * 100$$

where S is years of schooling, A is age and E is entry age to school. Usually SAGE is a real number in between 0 and 1, where 1 means that the individual has a good performance and she has not repeated any year nor has abandoned school. However, in few cases it could be the case that $SAGE > 1$ because some children might start education at an earlier age than the entry age. If SAGE is low (close to zero), it is a sign that this child has stopped studying for some years or has had a very low performance⁵⁹. It is desirable that SAGE be close to 1.

- The Probability of having “higher” education

The probability that an individual receives education in addition to high school is estimated through a binary decision model. The dependent variable is 1 if the individual studies some kind of higher level education (college or technical education) after high school and 0 if the individual does not study at all after high school.

$$y_{it} = \begin{cases} 1 & \text{if individual has studied for at least 1 year after high school} \\ 0 & \text{if individual attains at most complete high school} \end{cases}$$

⁵⁹ In the Peruvian Education System, a student who has a very low performance and his/her grades are low or below a minimum standard during the year must enroll in the same grade the next academic year.

I prefer to refer to this variable as likelihood, rather than a decision because, even though attending or not attending college involves some prior decisions of individuals, it is also true that some individuals do not have the chance to choose. For example, individuals who never finished high school –for any reason- cannot choose to apply to a university. I am not testing the decision to attend a higher level of education or not, but rather examining how some variables may affect the probability of achieving this kind of education.

Data and Definition of Groups

The data were taken from the Peruvian Living Standards Measurement Survey from 1994, 1997 and 2000. Roughly, each survey has information on about 3,800 households nationwide, from which only 602 constitute a panel. These surveys include detailed information of hours of child work, hours of child household work, household characteristics, years of schooling, wages, as well as other socioeconomic characteristics.

From that panel, many households did not have children aged 6 to 17 in 1994, so they were excluded. In addition, since the unit of analysis is the child, I

used data only from the children in 1994 who were followed in the next two surveys. In addition, many individuals had to be excluded because there was no record of them in one or two of the surveys. The total number of individuals selected for the sample is 575, where two or more could belong to the same family. Of those individuals, 280 belong to Group I, 147 to Group II and 148 to Group III, as defined below.

Since the sample includes minors of ages 6 to 17 in 1994, I decided to separate them into three age groups. I did this because the decisions and outcomes individuals face are different across groups. The groups are:

- Group I: Ages 6 to 10 in 1994 (ages 12 to 16 in 2000)

These are children who are teenagers in 2000. According to their ages they should still be in high school because in the Peruvian system, a child who starts school at 6 years old and does not repeat or drop out of school should start high school at 12 years old and finish it at 16. The outcome to be analyzed is the SAGE ratio.

- Group II: Ages 11 to 13 in 1994 (17 to 19 in 2000)

The individuals of this group are supposed to have completed the mandatory education in year 2000, and are deciding whether to continue higher education or work. However, many of them could still be high

school students, or could be studying superior education. For this reason, I will also study the effect of child labor on the SAGE ratio.

Another reason to study this group separately from Group I is that we observe child labor and household work more frequently at ages 11 to 13 compared with ages 6 to 10 in Group I.

- Group III: Ages 14 to 17 in 1994 (20 to 23 in 2000)

Some authors do not consider this age group as “child laborers”, but they are labeled “youth workers”⁶⁰. In the year 2000 all of them were adults and it is likely that they were working or studying higher education. In this group I analyze how child or youth labor and household work may affect the probability of continuing superior education or not.

The Econometric Specification

The econometric method depends on the outcome selected, but it must take into account the endogeneity of the regressors h_{it} and z_{it} . Current hours of labor and household work are correlated with SAGE and school achievement because all of them depend on the time allotted to study. For that reason, some kind of

⁶⁰ The definition of “youth workers” is vague and sometimes it goes from 11 to 25 years old. However, in Peru an individual of 18 years and older is considered an adult.

instrumental variable approach must be used; otherwise, the results may be biased due to the correlation between h_{it} and z_{it} and the error term in equation (3.1).

The lagged variables h_{it-1} , h_{it-2} , z_{it-1} and z_{it-2} could also be correlated with the error term ε_i in equation (3.1) because the latter may include some household characteristics that could have affected h_{it-1} , h_{it-2} , z_{it-1} and z_{it-2} in the past. However, given the data in the sample, it is infeasible to find relevant instruments for 6 endogenous variables on the right hand side. Consequently, I decided to use instruments only for h_{it} and z_{it} , and to include variables in equation (3.1) related to household preferences. Thus, the remaining error term should be “clean” of household preferences and should not be correlated with the lagged variables.

In the case of the SAGE variable for groups I and II, the econometric model to be estimated by instrumental variables is:

$$(3.1') \quad y_{it} = \alpha_0 + \beta_0 h_{it} + \sum_{j=1}^2 \beta_j h_{it-j} + \gamma_0 z_{it} + \sum_{j=1}^2 \gamma_j z_{it-j} + \boldsymbol{\delta}' \mathbf{X}_i + \varepsilon_{it}$$

where the vector \mathbf{X}_i includes variables related to household preferences.

Since h_{it} and z_{it} are correlated with ε_{it} , a two stage least squares procedure is carried out, including two more equations:

$$(3.2) \quad h_{it} = \alpha_0^h + \mathbf{a}_h' \mathbf{Z} + \sum_{j=1}^2 \beta_j^h h_{it-j} + \sum_{j=1}^2 \gamma_j^h z_{it-j} + \boldsymbol{\phi}_h' \mathbf{X}_i + u_{1i}$$

$$(3.3) \quad z_{it} = \alpha_0^z + \mathbf{a}_z' \mathbf{Z} + \sum_{j=1}^2 \beta_j^z h_{it-j} + \sum_{j=1}^2 \gamma_j^z z_{it-j} + \boldsymbol{\phi}_z' \mathbf{X}_i + u_{2i}$$

where \mathbf{Z} is a vector of instrumental variables which satisfy the conditions of exogeneity (not correlated with ε_{it}) and relevance (correlated with the endogenous variables), and the Greek letters are parameters to be estimated. Notice that the \mathbf{Z} vector must be the same for the two endogenous variables.

The fitted values of h_{it} and z_{it} are substituted into equation (3.1'), and that equation is estimated by OLS. However, the standard errors of the OLS regression are not the correct ones because they do not consider the endogeneity of h_{it} and z_{it} . Fortunately, current software packages present the correct estimates of the standard errors. Also, u_{1i} and u_{2i} are error terms with zero mean, and constant variance, zero covariance and not serially correlated.

The same regression is also estimated by the Generalized Method of Moments, which is a more efficient method than instrumental variables⁶¹. In the SAGE regressions I use the same vector of instruments for the IV method and the GMM method. One important advantage of these two methods is that they do not require assuming a specific distribution of the error term and inference is made on the basis of asymptotic theory.

In the case of the probability of having some college or technical education, a standard Probit model may give erroneous results due to the correlation between h_{it} , z_{it} and ε_{it} . In contrast the method of Instrumental Variable Probit takes into account that some of the right hand side variables may be endogenous. An explanation of this method in its Maximum Likelihood version and the two-step version can be found in W. Newey's work, and in a paper written by D. Rivers and Q.H. Vuong⁶². In this work I will estimate the IV Probit model by two methods: the two-step IV and the full-information maximum likelihood method.

⁶¹ For an explanation of the method, see Fumio Hayashi, *Econometrics*, (New Jersey: Princeton University Press, 2000), 204-207.

⁶² Whitney Newey, "Efficient estimation of limited dependent variable models with endogenous explanatory variables," *Journal of Econometrics* 36 (1987): 235-238; Douglas Rivers and Quang H. Vuong, "Limited information estimators and exogeneity test for simultaneous probit models," *Journal of Econometrics* 39 (1988): 350-351.

Results

Table 8 summarizes some of the main characteristics of the sample. As we see in the table, participation in household work increases with age up to some point when it stops growing or decreases. In contrast, participation in labor market increases steadily with age. Concerning the hours spent in housework, they also increase slightly with age and decrease in the early twenties. On the other hand, hours of labor also increase steadily with age. One explanation for this result is that as labor increases with age, individuals have less time to dedicate to household chores.

The average SAGE indicator in 2000 is very similar in Groups I and II, but lower in Group III. Since education after high school is not mandatory, in the third group the gap between age and years of schooling increases. Another interesting statistic is the decrease in the fraction of workers who are non-paid family workers (NPFW) as age increases. It starts at 80% in Group I and ends at 30% in Group III. Table 8 also shows that an important fraction (38.5%) of the sample reaches some kind of higher education at ages 20-23. We can also observe that the fraction of individual who live in urban areas increases with age. This result may have this interpretation: that individual migrate to cities when they grow up.

Table 8. Descriptive Statistics of the Sample

	Group I	Group II	Group III
Number of individuals	280	147	148
Ages in 1994	6 to 10	11 to 13	14 to 17
Ages in 1997	9 to 13	14 to 16	17 to 20
Ages in 2000	12 to 16	17 to 19	20 to 23
% who does housework in 1994	61.8%	83.7%	79.1%
% who does housework in 1997	86.1%	88.4%	81.8%
% who does housework in 2000	86.4%	78.9%	79.7%
% who works in 1994	10.4%	12.2%	26.4%
% who works in 1997	28.2%	33.3%	44.6%
% who works in 2000	35.0%	46.2%	64.2%
Average weekly hours of household work (excluding zeros):			
In 1994	10.78	10.68	14.14
In 1997	10.34	12.93	14.01
In 2000	11.87	13.72	12.88
Average weekly hours of labor (excluding zeros):			
In 1994	13.86	18.28	26.23
In 1997	15.35	22.88	38.80
In 2000	19.30	32.28	39.94
<i>Statistics in year 2000</i>			
Average SAGE	0.76	0.77	0.69
% in University and others	0.0%	10.9%	38.5%
% Individual lives in urban areas	58.9%	63.3%	73.0%
% NPFW from those who work	80.6%	50.0%	30.5%
% of males	53.2%	51.7%	61.5%

Note: Statistics are calculated from the sample (not weighted).

Finally, concerning the sex of the individual, there is a slight bias in group III where 61% are males and 39% are females. The bias is not observed in groups I and II.

Estimation of the Effect of Child Labor and Household Work on SAGE

In this section I estimate the effect of household work and child or youth labor on the SAGE ratio. I have estimated these effects for the first two groups only because in Group III the SAGE ratio loses its power to represent school attainment (education is not mandatory after high school in Peru). In Group II (17 to 19), SAGE captures not only those students who continue studying in universities or other kinds of technical education, but also students who are behind and are still in high school at ages above 16. In Group I, SAGE captures how far teenagers at high school age are from the “perfect score” (SAGE equal to 1).

In all the regressions, standard statistics such as the F test on the significance of all the parameters in the regression and the R-squared have been calculated. In addition, I perform some tests that assess the validity of the instrumental variables in the model. As is well known, instruments must satisfy two conditions: “relevance” and “exogeneity”. The first condition states that the

instruments must be correlated with the endogenous variables on the right-hand side. If this condition does not hold (i.e. instruments are “weak”), linear IV estimates are inconsistent and the limiting distribution of the parameters may not be normal. The second condition says that the instruments must not be correlated with the error term in the main equation, or in other words, they have been correctly excluded from the main equation and, if they have any effect on the endogenous variable in the left-hand side (y_{it} in equation (3.1)), that effect should occur through the effect on the endogenous variables on the right-hand side. This condition is also related to identification of the model.

Some tests have been proposed in the literature to evaluate these conditions. In the case of “relevance”, the easiest way to test this is to conduct an F test on the “excluded” instruments in the first-step regressions, in the IV and GMM regressions⁶³. D. Staiger and J. Stock⁶⁴ proposed a “rule of thumb” when we have only one endogenous variable in the right hand side. If the F statistic is greater than 10, the instruments are strong; otherwise, they are weak. However, when we have more than one endogenous variable in the right-hand side, the F test and the “rule of thumb” is not good to test relevance. J.S. Cragg and S.G.

⁶³ The excluded instruments are those which appear in the reduced form equations but do not appear in the main equation.

⁶⁴ D. Staiger and J. H. Stock, “Instrumental variables regression with weak instruments,” *Econometrica* 65, no. 3 (May 1997): 557-586, quoted by James Stock and Motohiro Yogo, *Testing for weak instruments in linear IV regressions*, NBER Technical Working Paper N° 284, (Cambridge, MA: NBER, 2002), 29.

Donald proposed a test on identification of the model which J. Stock and M. Yogo used as a generalization of the F test⁶⁵. The Cragg-Donald statistic is compared to the critical values tabulated by Stock and Yogo to assess if the instruments are weak or not. This statistic tests if the instruments are weak not for a single equation but for the model as a whole. The null hypothesis is that the instruments are weak, and the alternative hypothesis is that they are not weak.

When instruments are “weak”, inference should be carried out with caution. The typical “estimate/standard error” statistic may be meaningless if weakness is severe. Two approaches arise in recent literature to deal with this problem. One requires correcting the bias in estimates and standard errors in order to improve the normal approximation. The second approach just presents the estimates and uses confidence intervals and tests which are fully robust to weak instruments. The Anderson-Rubin test is an example of this type of test. It tests if the parameters of the endogenous variables in the right-hand side of the main equation are jointly significant. This test is good when we have only one endogenous regressor but its power declines when two or more endogenous regressors are present⁶⁶.

⁶⁵ J.S. Cragg and S.G. Donald, “Testing identifiability and specification in instrumental variable models,” *Econometric Theory* 9, (1993): 222-240, quoted by Stock and Yogo, 5.

⁶⁶ Andrews and Stock (2005), 8-10.

Concerning tests related to the “exogeneity” condition, the Anderson canonical correlations LR statistic tests if the model is identified or not. The null hypothesis is that the model is underidentified (matrix of data in the reduced form equations has rank = $k-1$, where k is the number of regressors in the main equation). The Hansen-Sargan statistic is used to test if instruments are correlated or not with the error term. The null hypothesis is that instruments are not correlated with the error term, or in other words, they have been correctly excluded from the main equation.

The instruments I finally chose were a dummy variable if the family has a gas stove, the sex of the child, the hours of housework performed by the head of household’s spouse, the logarithm of the non labor income per household member, the head of household’s hours of market labor and a dummy which states if the child works in agriculture or retail sales. Some of them are highly correlated with one of the endogenous variables but not with the other. For example, the dummy “gas stove” is highly correlated with hours of household work, but it has little correlation to hours of market work. The same occurred with child’s sex and head’s hours of market labor. In contrast, the dummy variables “agriculture” and “retail sales” were highly correlated with child’s total hours of market work but they were not correlated with hours of household work.

Table 9 shows the results for the first group where the main equation was estimated by OLS, IV and efficient GMM. The first group of statistics shows that all the parameters are jointly significant at the 1% level, but the R-squared is low in the three regressions. The second group of tests assesses the fulfillment of the “relevance” and “exogeneity” conditions. It is difficult to find good instruments that work for the two variables at the same time. Comparing the Cragg-Donald statistic with the critical values provided by Stock and Yogo, the instruments are weak at the 5% significance level when we consider a relative bias of 0.10 or lower⁶⁷, but are strong if we tolerate a relative bias of 0.20. The critical values are 9.92 and 6.16 respectively. The Anderson-Rubin test shows that the endogenous variables are jointly significant, but the t-statistic says that only current market work is significant. The other two tests show that the model is identified. With the Anderson canonical correlations test, the null of underidentification is rejected, and according to the result of the Hansen-Sargan test, I cannot reject the null of no correlation between the instruments and the error term.

⁶⁷ The relative bias is measured as $b = \text{IV bias} / \text{OLS bias}$. For example, $b = 0.10$ means that the IV bias due to weak instruments is 10 percent of that bias if we estimate by OLS.

Table 9. Regression of SAGE ratio: Group I

(All regressions with robust standard errors, t statistics in parenthesis)

Independent Variables	OLS		IV (2SLS)		GMM	
<i>Household work:</i>						
z_2000	-0.0003		0.0031		0.0030	
	(-0.24)		(0.97)		(0.95)	
z_97	0.0015		0.0011		0.0005	
	(0.87)		(0.64)		(0.30)	
z_94	-0.0025		-0.0031		-0.0027	
	(-1.23)		(-1.52)		(-1.33)	
<i>Market work:</i>						
h_2000	-0.0026	***	-0.0039	**	-0.0037	**
	(-3.44)		(-2.28)		(-2.17)	
h_97	-0.0009		-0.0009		-0.0011	
	(-0.56)		(-0.53)		(-0.65)	
h_94	-0.0020		-0.0010		-0.0016	
	(-0.69)		(-0.33)		(-0.52)	
<i>Other variables:</i>						
Child's age in 1994	0.0342	***	0.0362	***	0.0366	***
	(4.09)		(4.24)		(4.32)	
Head's years of schooling	0.0107	***	0.0102	***	0.0105	***
	(3.76)		(3.25)		(3.44)	
Family size	-0.0149	***	-0.0162	***	-0.0175	***
	(-2.71)		(-2.85)		(-3.23)	
Studied in Primary Public School	-0.0869	*	-0.0843	*	-0.0863	*
	(-1.84)		(-1.69)		(-1.78)	
Constant	0.4236	***	0.3862	***	0.3942	***
	(3.18)		(2.80)		(2.98)	
Number of observations	278		278		278	
F(10, 267)	6.55		5.68		6.20	
Prob > F	0.0000		0.0000		0.0000	
R-squared	0.1856		0.1615		0.1629	
Root MSE	0.1978		0.2007		0.1965	
Cragg-Donald F statistic	--		7.66		7.66	
Anderson-Rubin test Chi-sq	---		16.05		16.05	
Chi-sq(7) P-val	---		0.0246		0.0246	

Table 9 -*Continued*

Anderson canon. correlation LR test	---	51.76	51.76
Chi-sq(6) P-val	---	0.0000	0.0000
Hansen-Sargan overident. test	---	8.17	8.17
Chi-sq(5) P-val	---	0.1472	0.1472

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

Excluded instruments in IV&GMM: Dummy gas stove, child's sex, spouse's hours of housework, log(non labor percapita income), head's hours of labor, dummy child works in agriculture, and retail sales.

As we can observe in the table, household work seems not to affect the SAGE ratio under any method in the short or long run. On the other hand, market work has a negative and significant effect only in the short run (year 2000). There is no evidence that market work at ages before 12 affects the SAGE ratio at ages 12-16. The signs are negative but the parameters are not significant. One possible explanation for this small or null effect is the small number of hours that are spent in both market work and household work when children are less than 12 years old, as we observed in Table 8.

At the age of 12-16, other variables seem to have stronger effects on the SAGE ratio, for example, the age of the child, the head of household's education level and the size of the family. The child's age has a positive and significant effect on SAGE, which is a possible result at early ages, because in the SAGE formula both the numerator and denominator increase with age. In the case of the

head's education, it has a positive effect which makes sense because a higher educated head of household would give a higher weight to education, paying more attention to child's education and increasing the probability of success (reducing the probability of failure).

SAGE is also lower as family size increases. Usually, a large family means many children who represent a big burden on household budget, especially in a poor country like Peru. The effect can be interpreted in this way: the economic situation may cause that some young members of a large family to stop studying for some time, while the family faces the crisis and finds a way to survive.

There is also a negative effect of having studied in a Public Primary School, represented as a dummy variable which assigns 1 to students who studied in public schools and 0 to those who studied in private schools. In Peru, poor children enroll in public schools because of the low fees despite the low quality of education they receive. In my opinion, this low quality of education increases the probability to fail in school and fall behind other students who received a private education.

Now I perform the same regressions with the second group (individual with ages 17 to 19 in 2000) by the same methods. The results of the regressions

are shown in table 10 and this time some new instruments were introduced: a dummy variable which assigns 1 if the house is connected to public sewage and 0 if not, the hours of housework per head of other family members who are not the parents or the children (cousins, uncles, aunts, grand parents, etc.), the spouse's hours of labor, a dummy if the child works in manufacturing, the total area of dwelling, and a dummy variable if individual is ill or suffers a chronic disease. Some of the instruments used in table 9 were not used this time. In addition, as in the first regression, some instruments were correlated to household work but not to child labor, and vice versa.

The Cragg-Donald test shows that the instruments are weak at the 5% level for a relative bias of 0.10, but they are strong if we tolerate a relative bias of 0.20. The critical values are 10.22 and 6.20 respectively. However, the Anderson-Rubin test shows that the two coefficients are jointly significant, despite the weakness of the instruments. Observing the other two tests, the Anderson canonical correlation test and the Hansen-Sargan test show that the model is identified and that the instruments selected are not correlated with the error term. A quick review of the results for group II show that they are different compared with Group I.

Table 10. Regression of SAGE ratio: Group II

(All regressions with robust standard errors, t statistics in parenthesis)

Independent Variables	OLS		IV (2SLS)		GMM	
<i>Household work:</i>						
z_2000	-0.0034	**	-0.0057	**	-0.0044	**
	(-2.03)		(-2.20)		(-1.96)	
z_97	-0.0020		-0.0020		-0.0004	
	(-0.81)		(-0.79)		(-0.79)	
z_94	0.0021		0.0034		0.0023	
	(1.22)		(1.50)		(1.50)	
<i>Market work:</i>						
h_2000	-0.0017	**	-0.0028	***	-0.0027	***
	(-1.98)		(-2.71)		(-2.77)	
h_97	-0.0020	*	-0.0017		-0.0021	*
	(-1.68)		(-1.30)		(-1.68)	
h_94	-0.0085	***	-0.0086	***	-0.0081	***
	(-3.84)		(-4.03)		(-3.99)	
<i>Other variables:</i>						
Child's age in 1994	-0.0379	**	-0.0362	**	-0.0259	*
	(-2.52)		(2.37)		(-1.89)	
Head's years of schooling	0.0077	**	0.0068	*	0.0060	*
	(2.05)		(1.92)		(1.84)	
Family size	-0.0198	**	-0.0217	***	-0.0180	**
	(-2.43)		(-2.66)		(-2.31)	
Constant	1.6110	***	1.6302	***	1.4127	***
	(5.37)		(5.22)		(4.94)	
Number of observations	147		145		145	
F(10, 267)	8.10		8.89		9.12	
Prob > F	0.0000		0.0000		0.0000	
R-squared	0.3368		0.3197		0.3214	
Root MSE	0.1868		0.1817		0.1815	
Cragg-Donald F statistic	--		6.26		6.26	
Anderson-Rubin test Chi-sq	---		25.22		25.22	
Chi-sq(8) P-val	---		0.0014		0.0014	
Anderson canon. correlation LR test	---		47.542		47.542	
Chi-sq(7) P-val	---		0.0000		0.0000	

Table 10 - *Continued*

Hansen-Sargan overidentification test	---	9.953	9.953
Chi-sq(6) P-val	---	0.1266	0.1266

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

Excluded instruments in IV&GMM: Child's sex, Dummy Sewage connection inside dwelling, Hours of housework of other family members per head, spouse's hours of labor, dummies child works in manufacturing and retail sales, dummy variable if the individual is sick or suffers a chronic disease, and the area of land.

In Table 10, current household work affects the SAGE ratio negatively but there is no evidence of long-term effects. In the case of market work, the three regressions show that there is an important negative effect of current labor and past (child) labor on SAGE. This means that individuals who worked at ages 11 to 13 and then 14 to 16 had a lower SAGE ratio, compared to those who did not work at all. Notice that the effect is stronger for those who worked at ages 11 to 13.

Concerning the other variables, unlike regressions for Group I where age was positively correlated with SAGE, in this case the sign of the parameter is negative, which means that the gap between schooling and age increases with age. As in Group I, a more educated Head of household increases the SAGE ratio, and the family size also reduces SAGE. In this regression I did not included the dummy variable on public school because it was not significant.

Finally concerning the statistics on goodness of fit, they show a good fit in the three regressions. These statistics are higher than those in Table 9.

Estimation of the Effect of Household Work and Child Labor on the Probability of Studying in Higher Education

As I explained above, for the third group I analyze the probability of studying in higher education beyond high school (university, technical schools, etc.) in year 2000. In my definition, it is not necessary to have completed this higher level of education, just to have studied at least one year to be considered an individual with higher education. The independent variables considered in this regression were almost the same as those in the SAGE regressions, where two of them (household work and labor in 2000) are endogenous. Because the dependent variable is dichotomous, I use appropriate methods of estimation for this kind of econometric model. Results are shown in Table 11, where the model was estimated using four alternative methods: linear probability model, linear probability with instrumental variables, Probit and Probit with instrumental variables. The standard linear probability model and the standard Probit have been included as benchmarks although it is known that their results are incorrect when there are endogenous variables on the right-hand side.

Table 11. Regression of Probability of Higher Education: Group III

(All regressions with robust standard errors except IV probit (2 step), t statistics in parenthesis)

Indep. Variables	Linear Probability (OLS)	Linear Probability (IV)	Probit	IV Probit (2 step)	IV Probit (MLE)
<i>Household work:</i>					
z_2000	-0.0019 (-0.64)	-0.0011 (-0.27)	-0.0023 (-0.21)	0.0028 (0.13)	0.0040 (0.19)
z_97	-0.0077 *** (-2.86)	-0.0079 *** (-2.82)	-0.0325 *** (-2.90)	-0.0339 ** (-2.33)	-0.0318 *** (-2.64)
z_94	-0.0045 (-1.40)	-0.0047 (-1.50)	-0.0183 (-1.33)	-0.0183 (-1.23)	-0.0192 (-1.45)
<i>Market work:</i>					
h_2000	-0.0062 *** (-4.15)	-0.0054 ** (-2.16)	-0.0222 *** (-3.51)	-0.0129 (-1.18)	-0.0113 (-0.82)
h_97	-0.0027 (-1.65)	-0.0029 * (-1.74)	-0.0098 (-1.61)	-0.0116 * (-1.66)	-0.0119 * (-1.94)
h_94	-0.0034 ** (-2.33)	-0.0035 ** (-2.55)	-0.0267 *** (-2.67)	-0.0303 * (-1.78)	-0.0310 *** (-2.90)
<i>Other variables:</i>					
Head's years of schooling	0.0158 ** (2.21)	0.0162 ** (2.33)	0.0563 * (1.90)	0.0567 * (1.81)	0.0577 ** (2.01)
Family size	-0.0328 ** (-1.99)	-0.0329 ** (-2.09)	-0.1158 * (-1.71)	-0.1142 (-1.51)	-0.1219 * (-1.79)
Rural Sierra	-0.2258 *** (-2.64)	-0.2281 *** (-2.78)	-0.8660 * (-1.92)	-0.8784 (-1.56)	-0.9033 ** (-2.04)
Domestic service at home	0.3746 *** (3.78)	0.3870 *** (3.94)	2.7071 *** (4.43)	2.9091 (-1.15)	3.1341 *** (4.53)
Constant	0.8876 *** (4.66)	0.8667 *** (4.57)	1.4259 ** (2.08)	1.2104 * (1.72)	1.1770 (1.51)
Number of observations	148	148	148	148	148
F(10, 267) or Wald Chi ² (10)	18.93	16.82	63.32	32.18	58.01
Prob > F or Prob > Chi ²	0.0000	0.0000	0.0000	0.0004	0.0000
R-squared	0.4036	0.4024	---	---	---
Pseudo R-squared	---	---	0.3829	---	---

Table 11-Continued

Root MSE	0.3906	0.3762	0.1812	---	---
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* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

Excluded instruments in IV: Child's sex, Dummy Sewage connection inside dwelling, log(sum of income of other family members), Hours of housework of other family members per head, hours of head's household work, dummies child works in agriculture, manufacturing, transportation and retail sales.

Statistics in linear probability IV: Cragg-Donald test=7.54; Anderson-Rubin test Chi-sq=17.5, p-value = 0.04; Anderson canon. corr. test=62.18, p-value=0.00; Hansen overident. test=8.843, p-value =0.2641

The results of Table 11 show that household work three years before the year 2000 affects the indicator of school attainment. Using all of the methods, there is evidence of an effect of year 2000 or year 1994 household work on school attainment (however, the parameters for 1994 are significant at 15% under some methods). Results are different in the case of market work, where working 3 years and 6 years beforehand negatively affects the probability of having some higher-level education. As intuition predicted, the signs of these parameters are negative, which means that individuals who worked at ages 11 to 13 and 14 to 17 are less likely to study in universities or technical schools. Unlike the linear probability models and standard Probit, the IV Probit models predict that current hours of labor do not affect school attainment. Notice that in all the methods the negative effect is stronger (coefficients are greater) for child labor six years ago. It can thus be interpreted that child labor at an early age has a worse effect than child labor at a later age.

Other variables that affect this kind of school attainment are the head of household's years of schooling, which has a positive effect for the same reasons explained in the previous section. Family size also has negative and significant effect on the probability of enrollment at a higher level of education. This result can be interpreted as showing that in large families children are less likely to be highly educated.

In these estimations I also included a couple of new dummy variables which were significant⁶⁸. The first one is a dummy variable which assigns 1 to individuals who live in the Rural Highlands (Sierra), the poorest and least developed region in Peru. As is easy to predict, the sign of the parameter is negative and significant. The second dummy variable assigns 1 to households that hire some sort of domestic service. This dummy variable has a positive effect on the probability, because housekeeping service gives free time to youngsters to study. Another interpretation of this dummy variable is that it may represent some poverty/richness effect because poor households do not have enough economic resources to hire housekeeping services.

⁶⁸ They were also included in the regressions of section 4.1, but they were not significant (they did not pass the test of exclusion of variables).

Conclusions to Chapter 3

In this chapter, I studied the short-run and long-run effect of household work and child labor on the schooling-age ratio (SAGE) and the probability of studying in higher education. The results show that in general, household work does not have the same effect as child labor on school attainment. Even though in some regressions household work may have a negative effect, in general its effect is not significant. For example, in the case of the effect on SAGE, only current household work has a “weak” effect for Group II. In the case of the probability of studying in superior education for Group III (ages 20 to 23), only household work performed at ages 17-20 has a negative effect on that probability.

On the other hand, child labor has a clear negative effect on the analyzed school-attainment variables. For Group I, only current child labor affects the SAGE variable, perhaps because the small number of hours that children spend in child labor for ages below 12. The results for Group II show that both short-run and long-run effects of child labor on SAGE are negative and significant as intuition predicted. Finally, for Group III and according to the results of IV Probit, only the long-term effect of child labor on the probability of superior education is significant.

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