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Garcia, Luis

Departamento de Economia, Pontificia Universidad Catolica del Peru

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Who does the chores? Estimation of a household production function in Peru[+]

Luis Garcia[a,*]

[a] *Department of Economics, Pontifical Catholic University of Peru, Av. Universitaria 1801, San Miguel, Lima 32, Peru*

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Abstract

In less developed countries like Peru, it is very frequent to observe that, in poor households, parents and children work together doing household work in their own home. This fact is even more evident among girls, who work at home cleaning, cooking, taking care of younger siblings, etc., which may deter them from attending school. In the current literature on child labour, it is always assumed that this occurs because girls are more productive at home than boys; therefore is more likely to observe girls staying home and boys working in the labour market. To check to what extent this common assumption is true, this paper estimates the determinants of household work in Peru, and obtains the parameters of the production function of "chores". Since the total amount of "chores" is not observable, I use wages and the first order conditions of a standard time allocation model to estimate the model. The estimated production function is consistent with a strictly concave production function in which the inputs are substitutes. It also shows that girls have a higher marginal product than boys in the production of "chores". All data was taken from the Peruvian Living Standard Measurement Survey of 1997 and 2000.

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* Corresponding author: Phone: (511)626-2000 Ext.4976, Fax: (511) 626-2874, email address: lgarcia@pucp.edu.pe.
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1. Introduction

In recent years, literature on child labour has paid special attention to the work of children as household workers, work which is understood as that performed at home involving the production of output for direct family consumption, but not for market sale.[1] Like standard child labour, household work consumes time and effort, which leaves less time for children to do other activities, like studying. It could also deter girls in less-developed countries from attending school, as some papers suggest.[2]

To give an idea of the magnitude of this phenomenon, in Peru (a poor and less-developed country), three of every four children work some positive number of hours per week on housework, where the total average of hours worked is roughly 11 hours per week. In the six-to-fourteen-year age range, poor girls work at home, on average, twice as much as non-poor boys do. In addition, girls who do not attend school work more hours on housework than girls who do attend school, and the gap between those averages increases with age.[3]

These facts suggest that it is important to study and understand this phenomenon from an economic point of view. What makes adults and children work in this activity? What variables could increase or decrease the time individuals spend on housework? Why is it that we observe more housework performed by girls than by boys? Literature on household economics offers models that can be used to examine this problem in depth. To answer these questions, I find the main determinants of household work and estimate a household production function, controlling by those variables that affect the production function. Using econometric methods and survey data, this paper achieves both tasks.

In the setting proposed in this paper, wages play an important role in the time allotted to household work, since wages are the opportunity costs of hours spent on this activity. Standard neoclassical

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[1] Household work includes activities like cleaning, cooking, taking care of younger children, etc.
[2] Levison and Moe (1998).
[3] These figures were calculated by the author using the Peruvian Living Standard Measurement Survey of year 2000.

theory predicts a negative relationship between wages and hours of housework. In addition – as will be clear in the empirical section — wages are an important instrument in the estimation of the parameters of the production function.

It is also important to note that household work is not always seen as a "bad thing" for children, because it can create a sense of responsibility in children and develops skills that will be useful in the future. It is reasonable to think about an "acceptable" level of household work performed by children. The problem with household work occurs when parents make children work so many hours that they do not have enough time to study, play or rest. Parents can use household work as a strategy to increase a family's total income, in the sense that if children do the chores at home, the parents may have more free time to offer in the labour market.[4]

Besides classical papers on the theory of allocation of time (Becker, 1965; Gronau, 1977; Rosenzweig, 1980; Birdsall, 1982; Newman & Gertler, 1994), some works have developed this theory in the context of household work with child workers. For example, Brown *et al.* (2003) present a theoretical model of child labour with household work, but assume a Ricardian production function with fixed coefficients, which yields specialisation of children in housework or market work. Recently, Garcia (2006) has presented a theoretical model which approaches this problem using the "unitary approach"[5], in which household work, child labour, and hours of children's education are determined simultaneously along with the parents' labour supply and household work. In that model, we do not observe specialisation; the time is allocated according to the opportunity cost of the activities individuals may perform.

Several empirical papers estimate the determinants of child labour, schooling, and household work under the time-allocation framework and using Probit or Tobit methods, while others use simultaneous-equations methods. Skoufias (1994) studies the effect of market wages on time allocation in rural India. This study shows significant differences between boys and girls when it comes to participation in productive activities within the household and schooling. Using average

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[4] Skoufias (1994) proposed this idea.

[5] The unitary approach considers the existence of a family utility function, and an aggregated family budget constraint. The resources are allocated in order to maximise this utility subject to the budget and time constraints. Although there are other approaches, which include bargaining between individuals and individual utility functions, in this case it seems reasonable to assume that there is no bargaining process because children simply follow parents' decisions.

community wages to estimate parents' and children's wages, the author finds that wages have no effect on participation in household production activities, and that only the child's wage has a negative effect on leisure and a positive effect on the remaining activities – home production, schooling and market work. DeGraff *et al.* (1996), using data from the Philippines, estimate a simultaneous Probit model in which the endogenous variables are dummy variables of school attendance, market work and household work. They find that household work increases with age, and that its incidence is higher for girls. Some household characteristics such as number of siblings and housing material have an impact on the hours worked by children at home. In a later paper, DeGraff and Bilsborrow (2003) estimate the same model using the same exogenous variables, but this time they estimate only the reduced form equations by the Tobit method; however, their results are not good because almost none of the variables are a good predictor of household work hours. Levison & Moe (1998) analyse household work as a deterrent to schooling. Focusing on unmarried adolescent girls ages 10 to 19, they find that household work may present a more significant barrier to schooling for girls than boys. They do not include wages in the regressions. Binder and Scrogin (1999) estimate the determinants of child work in Mexico. In particular, they focus their attention on the effect of parents' wages and children's wages on their labour decisions. Using imputed child wages, they find a negative effect on the participation of children in substantial household responsibilities. They also find that this participation is lower for boys and for younger siblings. Hours worked in housework are also fewer for boys than for girls.

In a different work outside the child labour literature, Kerkhofs and Kooreman (2003) identify and estimate a household production model. Based on Gronau's model, they estimate the parameters of a quadratic household production function for married couples in Sweden. As they argue, the inclusion of wages in the regressions may bias the results of the home production estimation, because individuals with low productivity at home will be most likely to have a paid job. That sample selection must therefore be corrected, taking into account the decisions of males and females to participate in the labour market. Due to difficulties in the estimation of the utility function, the authors focus their work on the estimation of the production function with the correction of sample selection.

In short, the current literature on this topic has identified some of the main variables that determine housework. However, it has not considered the interaction between parents' and children's housework in the production of chores nor has it estimated this production function. In addition, most papers report that girls work more hours than boys at home, and provide explanations for this result related to customs and differences in productivity. Here I do not assume that girls are more productive at home than boys, but the estimation results show that indeed girls are more productive at home.

The paper is organised as follows: section 2 summarises the empirical model to be estimated and describes the econometric strategy to conduct the estimations; section 3 briefly describes the data; section 4 presents and discusses the results, and finally, section 5 concludes.

2. The Empirical Model

In this section, I briefly review the model presented in Garcia (2006) and derive the econometric specification. The model is a standard model of time 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 total amount of housework done (for example, how clean or neat the house is). To simplify the model, it is assumed that there are only three individuals in the household: the head of household, the spouse and only one child. [6] The spouse spends her time (*T*) in household work (z_1) or market work (H_1) thus her time constraint is $z_1 + H_1 = T$, but the head of household only works full time in the labour market. The child may spend her time studying (E), working at home doing housework (z_2) or working in the labour market (H_2), thus her time constraint is $z_2 + H_2 + E = T$. The head of household is the family planner who allocates the time of the spouse and the child to maximise the aggregated family utility $U(c, Z, E)$ where *c* is the total aggregated consumption, *Z* the total level of housework produced. Housework can be produced at home or bought in the market, so its total amount is expressed by the equation $Z = f_0 + f(z_1, z_2)$, where f_0 are the hired domestic services, and $f(z_1, z_2)$ is a strictly concave home production function whose inputs are the hours that the

[6] If there are more children, they do not work nor do housework.

spouse and the child spend at home doing housework. The household faces a budget constraint, where the aggregated household income is the sum of the labour income of the head of household (Y), the spouse (w_1H_1) and the child (w_2H_2), and the total expenditure is $c+Pf_0$, where c represents the family consumption of a composite good (whose price is set to one) and P is the price of housekeeping service. The optimisation problem the family planner solves is to maximise the utility function subject to the time constraints, the budget constraint and the equation which defines the total amount of Z.[7]

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:

$$f_1(z_1,z_2)=\frac{w_1}{P} \tag{1}$$

$$f_2(z_1,z_2)=\frac{w_2}{P} \tag{2}$$

where f_i is the marginal product with respect to input *i*. Equations (1) and (2) determine the optimal values of the household work variables $z_1 \equiv z_1(w_1,w_2,P)$ and $z_2 \equiv z_2(w_1,w_2,P)$ which are the demands for child and spouse's household work.

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

The first order conditions (1) and (2) say also that the marginal product of inputs must equal the ratio of wages with respect to the price of housekeeping services (the opportunity cost of household work). It is also true that

$$\frac{f_1(z_1,z_2)}{f_2(z_1,z_2)}=\frac{w_1}{w_2} \tag{3}$$

[7] See Garcia (2006) for all theoretical results on the child labor supply function and the optimal hours of education. They are not stated here because I want to focus on the production function only.

so the family will allocate the time such that the ratio of marginal products equals the ratio of wages.

The next step is to define a parametric functional form for the production function. In the theoretical model we assumed the home production function is a concave function. For empirical purposes it is convenient to assume a quadratic function[8]

$$f(z) = b'z + \left(\frac{1}{2}\right)z'\Omega z \tag{4}$$

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

$$b_1 + \omega_{11} z_1 + \omega_{12} z_2 = \frac{w_1}{P} \tag{5}$$

$$b_2 + \omega_{12} z_1 + \omega_{22} z_2 = \frac{w_2}{P} \tag{6}$$

It is assumed that the parameters b_1 and b_2 are a linear combination of individual and household characteristics and an error term.

$$b_j = x_j'\theta_j + \mu_j \qquad j = 1,2 \tag{7}$$

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.

The goal is to estimate equations (5) and (6). Since this is a simultaneous equation problem, one might try to use one of the standard methods in the econometric literature, like the two-stage least squares (2SLS) method. However, there is a significant problem of missing data since wages can be observed only when individuals participate in the labour 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 labour market. This creates a sample selection problem which may bias the parameters estimated

[8] Kerkhofs and Kooreman (2003) use this function in their work. One of its 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. Ransom (1987) also uses quadratic functions but in utility functions.

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 (5)-(6) in the standard simultaneous equations notation[9].

$$z_1 = \gamma_2 z_2 + \beta_0 + \beta_1 \left(\frac{w_1}{P} \right) + \boldsymbol{\beta}' \boldsymbol{x}_1 + u_1 \tag{8}$$

$$z_2 = \gamma_1 z_1 + \alpha_0 + \alpha_1 \left(\frac{w_2}{P} \right) + \boldsymbol{\alpha}' \boldsymbol{x}_2 + u_2 \tag{9}$$

where vectors $\boldsymbol{x}_1$ and $\boldsymbol{x}_2$ 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 (8)-(9) is:

$$z_1 = \boldsymbol{x}' \pi_1 + v_1 \tag{10}$$

$$z_2 = \boldsymbol{x}' \pi_2 + v_2 \tag{11}$$

Where vector $\boldsymbol{x}$ includes a constant term, $w_1/P, w_2/P$, $\boldsymbol{x}_1$ and $\boldsymbol{x}_2$. 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 (10) and (11) only when we observe w_1 and w_2 at the same time.

To correct for selection bias (as in Kerkhofs and Kooreman, 2003), I include two more equations representing the decision whether the individuals (spouse and child) participate in the labour market or not.

$$I_1^* = A_1' \psi_1 + \varepsilon_1 \tag{12}$$

$$I_2^* = A_2' \psi_2 + \varepsilon_2 \tag{13}$$

[9] To avoid cumbersome notation, all subscripts referred to the i-th observation have been omitted from equations (8)-(13).

where I_1^* and I_2^* are latent variables that determine the participation in the labour market of each individual, and A_1 and A_2 are vectors of variables that determine such participations. The spouse participates in the labour market if and only if $I_1^* > 0$ and the child participates if $I_2^* > 0$. 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 (10) and (11) cannot be estimated by OLS because:

$$E(v_i / I_1^* > 0, I_2^* > 0) = E(v_i / \varepsilon_1 > -A_1'\psi_1, \varepsilon_2 > -A_2'\psi_2) \neq 0 \qquad i = 1,2 .$$

The procedure I use to estimate the model is an application of the Heckman-Lee method of estimation of simultaneous equations with sample selection to the case of double selection[10].

(a) In the first stage, equations (12) and (13) are estimated using bivariate Probit.
(b) In the second stage, using $\hat{\psi}_1$, $\hat{\psi}_2$ and $\hat{\rho}$ I estimate

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

by $M_{ij} = (1-\hat{\rho}^2)^{-1}(P_i - \hat{\rho} P_j)$, where $P_j = \dfrac{\int_{-A_1\hat{\psi}_1}^{+\infty} \int_{-A_2\hat{\psi}_2}^{+\infty} \varepsilon_j f(\varepsilon_1, \varepsilon_2) d\varepsilon_1 d\varepsilon_2}{F(A_1\hat{\psi}_1, A_2\hat{\psi}_2, \hat{\rho})}$ and F is a standard bivariate normal c.d.f.[11]. Using the moments of a truncated multivariate normal distribution[12], let:

[10] See Lee, Maddala and Trost (1980) and Tunali (1986).
[11] See Fishe et al. (1980), Maddala (1983), p. 282.

$c_1 = -A_1\hat{\psi}_1$, $c_2 = -A_2\hat{\psi}_2$, $C_1 = (1-\hat{\rho}^2)^{-1/2}(c_2 - \hat{\rho}c_1)$ 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 standard univariate normal p.d.f. and c.d.f. respectively.

(c) In the next step, I estimate the "structural" equations (8) and (9) by 2SLS (instrumental variables) where $\hat{M}_{12}$ and $\hat{M}_{21}$ are included in the main regression as well as in the set of instruments. 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.

3. The data

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

One limitation of the estimation method proposed here is that it requires the observation of wages. In spite of the fact that child labour is a significant concern in Peru, where one in every four children works at an economic activity, only a minority of working children 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 many households were interviewed in both surveys, I included each household only once to avoid possible correlation between observations. I thus used the whole sample of 1997 and only those households from 2000 that were not surveyed in 1997.

[12] See Kotz, Balakrishna and Johnson (2000), p.207.

For empirical purposes, I define a “child” –who may potentially work– as an individual in the household who is between six and seventeen years old. Nevertheless, when I counted the family size, I included all the individuals belonging to a household, regardless of 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 used in selecting the one child per household was that it must be the child who worked the greatest number of hours in the labour market. If there were no working children in the household, I picked the oldest child in the subset of “children” aged 6 to 17.

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 involving household chores, whose output is not intended to be sold in the marketplace. By contrast, market work is defined as any activity (generated by the employed or self-employed) executed with the objective of selling the output in the market.

In the survey, there is a third labour category, that of “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 behaviour is systematically different than that which 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 their participation in economic activities. Consequently, I excluded from the sample all households in which 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 criteria were to include an individual who chose not to work and to exclude individuals who may report zero hours of work due to labour force conditions, which are beyond their control. Retired people, individuals who were handicapped, the unemployed still in the process of applying for new jobs, workers on vacation, sick workers, and workers on strike were excluded from the sample.

To calculate the weekly wages, I used the information provided in the survey on wages, salaries and earnings received in the last seven days in the main job. Since the time unit of these earnings may vary (daily, monthly, quarterly, etc.), the reported wages were multiplied or divided appropriately by an scalar, in order to convert all earnings to weekly earnings. The main problem with wages is that they are not observed when the individual does not work in the market. Unlike most who do empirical work on child labour (which usually does not get good results on the wage effect), 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 six and seventeen were excluded. I also excluded single-parent households. 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 data missing from the variables hours of home work and market work.

The following table shows descriptive statistics on all variables included in regressions. There are two columns; the first one includes only the observations which were included in Table 2 (a bivariate Probit estimation), and the second column includes those which were employed in tables 3 and 4 (an instrumental variables regression). Although the full sample is larger, its size decreased due to missing data.

Even though the sample size is considerably smaller in the second column, I do not observe major changes in the sample averages of the variables. There are a few cases on which I would like to remark. Concerning a child's age, the second sample selects older children, perhaps because the definition of "child" selects –in many cases- working children. There is also an important selection by gender for the same reason, because empirical evidence on child labour reveals that boys are more likely to work than girls. Regarding the level of education of the spouse and the head of household, both are lower in the second group. Since the small sample size is the result of the selection of households where the child and the spouse work, this selection seems to be correlated with those low levels of education. Something similar occurs with child's earnings, spouse's earnings and head of household's earnings.

Table 1. Descriptive Statistics

Variable name	Sample in bivariate Probit	Sample in simultaneous equation
Child's weekly hours of housework	9.6747	10.4433
	(9.9932)	(10.9868)
Spouse's weekly hours of housework	42.1712	38.2401
	(18.7670)	(17.9523)
Child's age	12.3805	15.3607
	(3.5551)	(2.0976)
Fraction of male children	0.5029	0.6464
	(0.5001)	(0.4813)
Spouse's age	39.1720	41.5203
	(9.6560)	(7.7994)
Spouse's years of schooling	7.9738	5.0444
	(4.6873)	(4.3314)
Head of household's years of schooling	9.4184	7.1184
	(4.4073)	(4.0113)
# of adults in household	2.9286	3.0454
	(1.2922)	(1.4131)
# children < 18 in household	2.7298	3.7028
	(1.3785)	(1.6760)
# of children < 6 years old in household	0.9156	0.8991
	(0.9489)	(0.9781)
# girls 11 – 17 years old in household	0.5464	0.8235
	(0.7074)	(0.8653)
# adult women 18-55 years in household	1.3499	1.4491
	(0.6948)	(0.7891)
Child's weekly earnings (in Peruvian Soles of 2000)	102.9098*	64.6644
	(182.7668)	(66.2594)
Spouse's weekly earnings (in Peruvian Soles of 2000)	48.6639**	43.6597
	(34.0677)	(27.3152)
Head of household's weekly earnings (in Peruvian Soles of 2000)	202.2015	119.4114
	(287.6296)	(81.0058)
Per capita weekly income from other household members (in Peruvian Soles 2000)	46.7616	37.2842
	(118.1911)	(65.0598)
Per capita weekly non labor income (in Peruvian Soles of 2000)	16.6871	8.1973
	(31.8968)	(7.4411)
# of floors in dwelling	1.2450	1.2094
	(0.5166)	(0.4910)
Water connection inside dwelling	0.7489	0.6995
	(0.4338)	(0.4616)
Material of Walls: Adobe	0.3094	0.3545
	(0.4624)	(0.4816)
Material of Walls: Bricks or Concrete	0.5414	0.4564

	(0.4984)	(0.5015)
Dwelling in urban area	0.8011	0.7482
	(0.3993)	(0.4370)
Child attends school?	0.9099	0.6163
	(0.2865)	(0.4896)
Number of observation	1681	75

Standard error in parenthesis
* Includes 151 observations only
** Includes 748 observations only

4. Results

4.1 Participation in the labour market

The first step is to estimate the bivariate Probit model for the participation of the spouse and child in the labour market. In each equation, I included variables related to individual characteristics such as age, sex, and education and variables that describe household characteristics such as wages, income, number of adults, and number of children younger than 18 years old. Since this is a stratified sample, weighted regressions were used.

Table 2 presents the results of the participation in the labour market for the spouse and the child. In the "Probit" column I show the results of individual Probit regressions, assuming that the two decisions are not correlated. On the other hand, the "BiProbit" column estimates a bivariate Probit regression. As we can see, the results in the first column are very similar to those in the second column. These results in Table 2 are consistent with what standard theory predicts. In the case of the spouse's participation, the variables of age, age squared and education have the correct signs and are significant. The "number of children of less than six years of age" variable has a negative sign and it is significant, which means that this variable is an important barrier to a spouse's participation in the labour market. 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 labour market decreases when these variables increase. In contrast, the sign of the per capita non-labour income is positive. It is hard to find an explanation for this result, because standard labour supply theory says that unearned income has a negative impact on labour supply. Finally, the "spouse's sex" variable has no effect on that participation[13]. It seems that households in which the head is a woman (and the spouse is male) do not behave differently than those in which the head is male and the spouse is a woman.

Table 2: Probit Estimation of Participation in Labour Market

	Probit			Biprobit		
Spouse	Coefficient		z	Coefficient		z
Spouse's age	0.1035	***	7.01	0.1175	***	5.45
Spouse's age square	-0.0012	***	-7.10	-0.0014	***	-5.56
Spouse's education (years)	0.0223	***	3.11	0.0176	**	2.02
Spouse's sex (1=male, 0=female)	0.4300		1.12	0.5853		1.32
# of children < 6 years old	-0.1308	***	-3.90	-0.1556	***	-3.84
Urban/Rural (urban=1, rural=0)	-0.1157		-1.53	-0.0062		-0.07
Log(head's wage)	-0.2310	***	-6.52	-0.2591	***	-5.60
Log(per capita non-labour income)	0.0877	***	3.10	0.0785	**	2.27
Log(income of other household members)	-0.0437	***	-3.08	-0.0566	***	-3.24
Constant	-1.0529	***	-3.31	-1.2475	***	-2.60
Number of obs	2452			1681		
Wald $\chi^2(8)$ and $\chi^2(19)$	130.91			315.17		
Prob > χ^2	0.00			0.00		
Child						
Child's age	0.1805	***	7.93	0.1704	***	6.85
Child's sex (1=male, 0=female)	0.3088	**	2.47	0.2811	**	1.99
# adults in household	-0.1704	***	-2.99	-0.1515	**	-2.44
# children < 18	0.1357	***	3.67	0.1591	***	3.79
# girls 11 – 17 years old	-0.1204		-1.33	-0.2034	*	-1.92
Urban/Rural (urban=1, rural=0)	-0.1055		-0.79	-0.0794		-0.51
Log(head's wage)	-0.2198	***	-3.90	-0.1827	***	-2.65
Log(per capita non-labour income)	-0.1321	***	-2.69	-0.1143	**	-2.04
Log(income of other household members)	0.0822	***	2.72	0.0816	**	2.32
Attends school? (1=yes, 0=no)	-0.9331	***	-7.75	-0.9493	***	-6.90
Constant	-1.7844	***	-4.23	-1.9309	***	-4.02
Number of observations	2096			1681		
Wald $\chi^2(7)$	241.96			315.17		
Prob > χ^2	0.00			0.00		
ρ	--		--	0.1676341	**	2.33
Wald test of ρ=0: $\chi^2(1)$				5.45126		
Prob > chi2				0.0196		

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

[13] In the sample, 95% of the spouses are women.

In the case of child labour force participation, the older the child is, the more likely it is that he or she will participate in the labour market. There is also a greater level of participation for boys than girls. These two results agree with many empirical papers on child labour[14]. Also, the number of adults in the household reduces the probability of child participation. An explanation for this result is that more adults in a household means more individuals who can work, and the household will thus be able to "buy" more education and more leisure time for the child; consequently, we would observe less child labour. The number of girls of ages 11 – 17 also has a negative impact on the participation in the labour market. I expected an opposite sign, since girls usually work at home, and this affords more time to boys to work in the market.

Concerning the effect of the head of household's wage, its coefficient is negative; non-labour 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 that if other members in the family (such as older siblings) work, the child may feel motivated to work as well. Finally, there is a negative relationship between school attendance and participation of children in the labour market.

Regarding the other parameters and statistics, the parameter ρ, which is the correlation between the error terms in both equations in the bivariate Probit regression, is positive and significant. This means that whenever we observe a working spouse, it is more likely that we will also observe at least one working child in household, and this confirms that the bivariate Probit estimation is the correct method to use, rather than the standard Probit. The Wald statistic of joint significance of the variables shows that the model fits well.

4.2 Determinants of household work

The second step involves estimating the model by the two-stage least-squares method and correcting for sample selection as described in section 2. Table 3 presents the results of the estimation of equations (8) and (9), in which all tests are heteroskedasticity robust.

[14] See, for example, Binder and Scrogin (1999), Bhalotra (2001), DeGraff and Bilsborrow (2003).

Table 3: Determinants of the demand for household work

Dependent Variable	z_1 (Spouse's housework) Coef.		t	z_2 (Child's housework) Coef.		t
Household work: (instrumented)						
z_1	--		--	-0.1618	*	-1.90
z_2	-0.2438		-0.74	--		--
Wages:						
log(spouse's wage)	-7.1215	***	-3.56	--		--
log(child's wage)	--		--	-4.1978	***	-3.12
log(price housekeeping)	34.5599	***	6.15	1.2538		0.35
Individual characteristics:						
Spouse's age	0.1384		0.42	-0.0436		-0.17
Spouse's education	-1.4894	***	-3.14	--		--
Child's age	-4.4979	***	-4.44	0.9250		1.38
Child's sex (1=male, 0=female)	-10.4642	**	-2.24	-7.4784	***	-2.88
Head of household characteristics						
Head's wage	10.6052	***	2.77	1.0485		0.52
Head's education	-0.3877		-0.87	-0.8079	***	-2.91
Household characteristics:						
# adult women 18-55 years	2.5086		0.91	-4.4265	***	-3.07
# children 0-6 years	2.3750		0.79	-1.9290		-0.82
Material of Walls: Adobe	--		--	-7.5723	***	-3.15
Material of Walls: Bricks or Concrete	2.8066		0.90	-2.8610		-0.98
# of floors	11.4009	***	2.78	--		--
Water connection inside dwelling	-13.6501	***	-3.97	--		--
Sample Selection Variables:						
m12	-63.4020	***	-3.13	7.4663		0.54
m21	-22.9564	***	-5.09	-2.6044		-0.81
Constant:	30.3846		1.28	30.2469		1.47
Number of observations	75			75		
R-squared	0.5719			0.4441		
F - statistic	9.48			4.72		
P-value	0.0000			0.0000		
Excluded instruments in spouse's regression:	Child's wage and Material of Walls: Adobe					
Excluded instruments in child's regression:	Log of spouse's wage, Spouse's education, # of floors and Water connection inside dwelling					
First-stage F-stat on excluded instruments	10.34			12.88		
Anderson canonical correlation LR test	14.24			40.83		
P-value	0.0008			0.0000		
Hansen J statistic	1.70			2.16		
Chi-sq(1) P-value	0.1920			0.5408		

All tests are heteroskedasticity robust.

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

The sign of the derivative of z_1 with respect to z_2 is negative but not significant; the derivative of z_2 with respect to z_1 is also negative but significant. Theory says that a positive sign of this parameter means the two labour inputs are complements, and that a negative sign corresponds to substitutes. Since both signs are negative, I suspect the fulfilment of the substitution hypothesis, but that evidence is not strong because one of the parameters is not significant.

In relation to the relationship between hours worked at home and market wages, Table 3 shows that there is a significant negative relationship between those variables in the two equations, and the parameters are significantly different from zero. In the case of the market price of housekeeping services, the theory indicated that the relationship between household work and this price was positive. The results are consistent with this hypothesis in the first regression, but I cannot confirm that in the case of the child home labour equation, because the parameter is not significant.

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. Also, the spouse's age was not significant in either regression. In the case of the child's characteristics, the age and sex variables affected the spouse's hours of household work, but only the child's sex affected the child's household work. An older child in the household meant less housework for the spouse, but surprisingly, a male child in the house meant less housework performed by the spouse. On the other hand, older children participate more in housework than younger children, but the effect is not significant. It is also observed in Table 2 that girls work more at home than boys. These results are intuitive and expected.

The head of household characteristics also have an effect on the demand for household work. A higher head wage implies fewer hours of household work for a spouse. Also, a higher level of education for the head of a household is related to fewer hours of household work for a child.

Regarding the group of household characteristics, I included six: number of adult women in the household; number of children in the zero-to-six age range, two dummy variables describing the materials of walls; the number of storeys of the dwelling; and water connection inside the residence. Some of them were included in one regression only for identification purposes. The number of adult women in a house decreases a child's household work and increases the spouse's work, but the latter is not significant. This result makes sense because in less-developed countries, women play an important role in household work. Perhaps those adults engage in household production, giving more time to children to study or play. Also, the presence of children from zero to six years of age decreased the hours of child housework, but the parameter is not significant. It is also not significant for a spouse's housework.

Concerning house characteristics, the results show that in the case of "Material of Walls: Adobe", the material reduces child housework compared to the rest of the categories: walls made of cane and mud, stone and mud, wood, matting, and others. In Peru, adobe walls are very common in poor rural houses in the *sierra* (highlands). In this area, children are used to working many hours outside the home, so it is reasonable that they have little time to spend at home doing housework. In contrast, walls made of bricks/concrete are common in cities in poor and non-poor areas. The effect on child housework is negative but not significant.

Something different occurs in the case of the number of storeys and the water connection inside the dwelling. They were included only in the spouse's regression because they had no impact on child housework. A larger house with more floors implies more spousal housework, and a water connection inside the dwelling causes less spousal housework. This last result is intuitive, since a house with a water connection requires less work of a housekeeper to get the water the family needs.

The last group of variables in Table 3 is the group of sample selection variables that correct the double selection problem. They were significant in the spouse's regression only. The set of goodness-of-fit statistics shows acceptable results, despite the low number of observations. The instruments selected passed the "rule of thumb" because the first-stage F statistic is greater than 10 in both equations, so they are relevant. The Anderson test rejects the null hypothesis of underidentification. The Hansen J statistic tells us that we cannot reject the null of no correlation between the instruments and the error term.

4.3 Estimation of a household production function

It is interesting to obtain the technical parameters of the production function. One way to do it is to compare the parameters in equations (8) and (9) with those in (5) and (6) and then solve for the parameters ω. This is not difficult to do, but the standard errors have to be calculated by the delta method, which is not accurate here because of the low number of observations. Another weakness is that it is hard to impose a cross equation restriction in the estimation of equations (8) and (9) related to the equality of the second derivative $\partial^2 f / \partial z_1 \partial z_2 = \partial^2 f / \partial z_2 \partial z_1$. In terms of the parameter in (8) and (9), it is equivalent to impose the restriction $\gamma_2 / \beta_1 = \gamma_1 / \alpha_1$. An alternative way is to estimate equations (5) and (6) directly as a system by IV, which produces estimates of the parameters of equation (4), and the "composite" parameters b_1 and b_2. Additionally, it is easier to impose the cross-equation restriction mentioned above, which is in this case simply $\omega_{12} = \omega_{21}$. Therefore, I estimate (5) and (6) by 2SLS as a system taking z_1 and z_2 as endogenous and including the same group of variables and instruments in the regressions in Table 3, including the sample selection variables $\hat{M}_{12}$ and $\hat{M}_{21}$[15].

These regressions permit one to test easily if there are differences in the production function when the child who works at home is boy or girl. We could think that the parameter ω_{22} (which represents the slope of the marginal return of child household work) may vary by sex. The next equation is an alternative specification of equation (7), where S is the dummy variable which equals 1 if the child is a boy and 0 if the child is a girl. The parameter φ_{22} measures that gender effect.

$$b_2 + \omega_{12} z_1 + \omega_{22} z_2 + \varphi_{22} (S \cdot z_2) = \frac{w_2}{P} \tag{14}$$

Table 4 shows the results for two regressions, with and without the cross-equation restriction. Column (I) shows the estimated parameters derived from the regressions in Table 3, whose standard errors were calculated by the delta method. That column is the only one that shows robust

[15] Unfortunately, the standard errors reported in STATA using this method are not heteroskedasticity robust. The STATA command I used is reg3 with the options 2sls and small.

standard errors. The other three columns were estimated “as a system” in the way explained above. Column (II) also assumes that $\omega_{12} \neq \omega_{21}$ and was estimated. We observe little change in the estimates, but important changes in the calculated “t-ratios”. The last two columns assume that $\omega_{12} = \omega_{21}$, but the fourth one estimates (15) instead of (6). The parameters of all remaining control variables are not shown, but they were the same as those in Table 3.

As we see, the estimates are very similar in the restricted and unrestricted model because ω_{12} is very close to ω_{21} in the unrestricted model. The negative sign of the parameters ω_{11} and ω_{22} shows that the marginal products of labour are downward-sloping. The negative sign of ω_{12} is consistent with the hypothesis that labour inputs are substitutes. Furthermore, the sign of the determinant $\Delta = \omega_{11} \cdot \omega_{22} - \omega_{12} \cdot \omega_{21}$ is positive in all cases, which confirms that the production function is strictly concave because the Ω matrix in equation (5) is negative definite.

Table 4. Parameters of the production function

	$\omega_{12} \neq \omega_{21}$				$\omega_{12} = \omega_{21}$			
	(I)		(II)		(III)		(IV)	
ω_{11}	-0.1404	***	-0.1305	***	-0.1307	***	-0.1304	***
	(-3.44)		(-3.56)		(-3.57)		(-3.60)	
ω_{12}	-0.0342		-0.0325		-0.0351	*	-0.0288	*
	(-0.02)		(-0.58)		(-1.71)		(-1.77)	
ω_{21}	-0.0385		-0.0355		-0.0351	*	-0.0288	*
	(-0.39)		(-1.61)		(-1.71)		(-1.77)	
ω_{22}	-0.2382	***	-0.2026		-0.202	***	-0.1911	***
	(-9.15)		(-2.62)	***	(-2.64)		(-2.62)	
φ_{22}	--		--		--		0.1518	**
							(2.02)	
$\Delta = \omega_{11} . \omega_{22} - \omega_{12} . \omega_{21}$			0.0253		0.0252		0.0241	
$\Delta' = \omega_{11} . (\omega_{22} + \Phi_{22}) - \omega_{12} . \omega_{22}$							0.0043	

t-ratios in parenthesis
* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

In the last two columns, all the parameters are significant at the level of 10%, including φ_{22}. The parameter for boys is $\omega_{22} + \varphi_{22}$, and it is still negative, as expected, but is smaller in absolute value than that for girls (ω_{22}). This result suggests that the technology is different when a boy or girl does the housework.

Finally, Table 5 shows the results of the predicted values of b_1 and b_2, which vary across individuals because they depend on the individual and household characteristics. The table has been divided in two. On top we see descriptive statistics on the predicted values of b_1 and b_2 when the child who does housework is a boy; on bottom we find the same statistics when the child is a girl. According to the economic theory, these predicted values should be strictly positive. Fortunately, only one observation was negative, with a value close to zero.

Concerning the results for b_1 (a parameter of the spouse's marginal product), there is little change whether the working child at home is boy or girl. On the other hand, b_2 is smaller for boys than for girls. These estimates, along with the estimation of the $\omega's$, tells us that girls are more productive at home than boys (at least up to some level).

Table 5. Estimation of b_1 and b_2

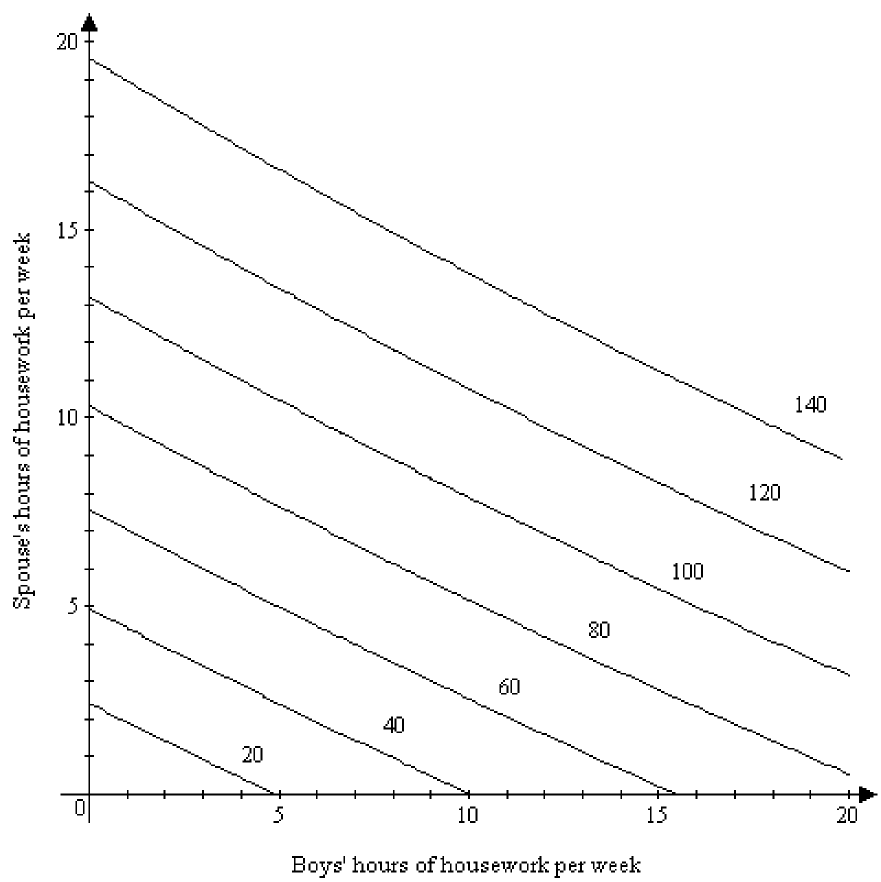
	Mean	Std. Dev.	Min	Max	Obs
Boys					
b_1	8.4320	1.9713	0.4011	16.6114	899
b_2	4.1840	1.3132	0.0328	10.0728	912
Girls					
b_1	8.9090	2.0088	-0.2628	14.4136	870
b_2	6.4435	1.3010	3.0125	11.8050	879

From the results of the fourth column in Table 4 and those in Table 5, I have simulated the isoquants of the production function and the marginal products when the working child is a boy or girl. To construct this curves, I used the average values of b_1 and b_2. As we can easily observe in Figures 1 and 2, the slope and concavity are different in both sets of isoquants. In addition, when the child is a girl, fewer hours of child household work are required to produce a fixed level of output.

Finally, Figure 3 shows the marginal product curves for boys and girls, taking the average value of b_1, b_2 and z_1. The graph shows that both curves are downward-sloping, and that girls are more productive than boys in the range of zero to 15 hours of household work per week. Beyond that point, boys have a higher marginal product.

I propose two possible explanations for the latter result. One could be related to natural differences between boys and girls when it comes to do housework. Another more plausible explanation says that the observed difference in productivity could be the result of previous training in house chores, which could be the result of cultural differences[16]. Thus, if girls are trained to do housework since an early age, they would be more productive than boys due to human capital accumulation.

Figure 1. Isoquant map when the child is a boy



[16] I owe this idea to Cecilia Garavito.

Figure 2. Isoquant map when the child is a girl

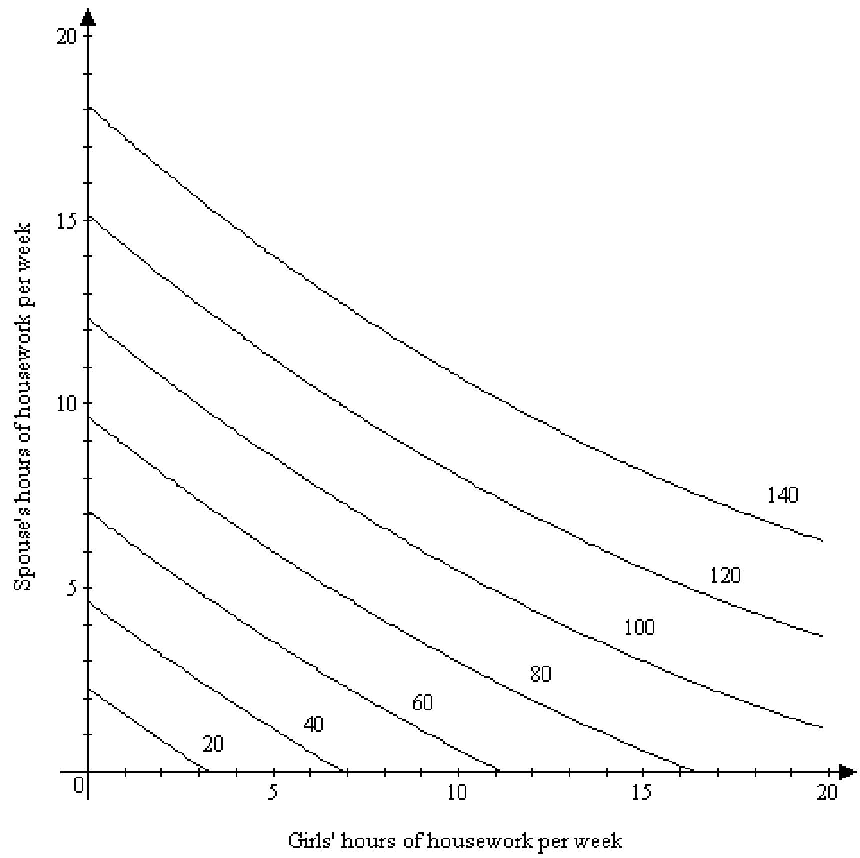
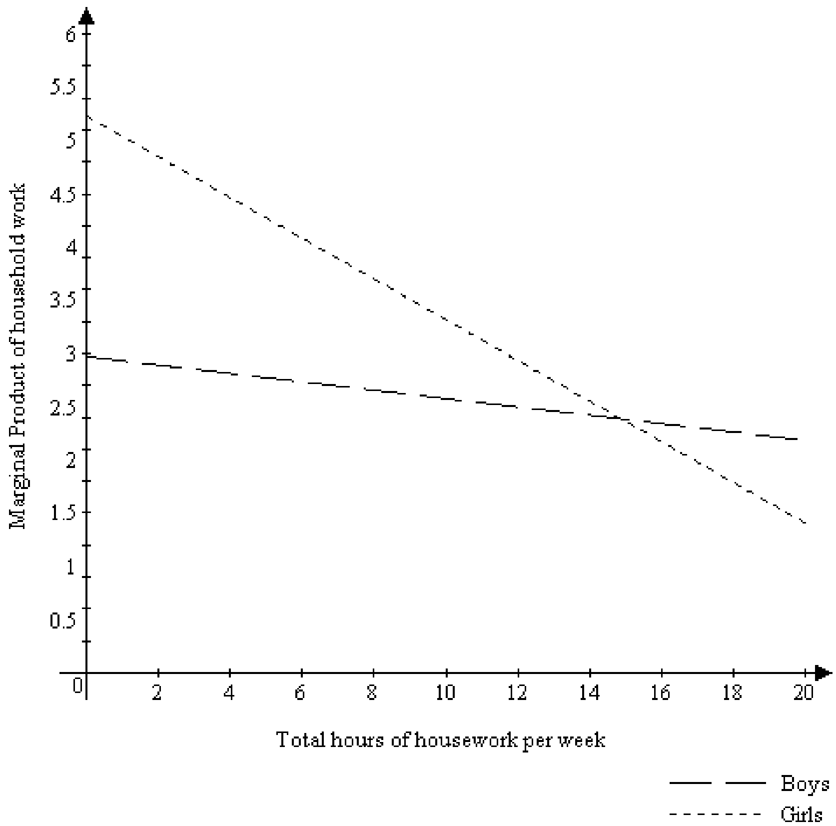


Figure 3. Marginal product of housework for boys and girls



5. Summary and Conclusions

Unlike other papers on child labour time allocation, this paper estimates the determinants of a child's household work, stressing the role of its wage and the wages of other family members.

The econometric estimation corrected two sources of the sample selection: the observation of child's wage and spouse's wage. Firstly, the method required us to estimate the participation of children and spouses in the labour market. Results found for the spouses are similar to those reported in standard theory of female participation in the labour market, because a large majority of spouses are women. In the case of child's participation, the participation is greater for boys and it increases with age. Other household characteristics also influence the child's participation in labour markets.

The results showed that the hours that individuals spend on household work depend negatively on their respective wages, and there are signs that the two inputs are substitutes. Additionally, hours spent on household work depend on individual characteristics like sex, age, head of household's 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.

Finally, the parameters of the quadratic home production function were estimated. The results are consistent with a strictly-concave production function. The estimates confirm that a child's household work and a spouse's household work are substitutes for each other. Besides, the isoquants show that when girls work at home, fewer hours of work are required to produce the output, and the graph of marginal products shows that girls are more productive than boys in the range of zero-to-15 hours per week, although the productivity of girls declines faster than that of boys.

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