Understanding Children's Work Project Working Paper Series, September 2005

Understanding Children's Work
An Inter-Agency Research Cooperation Project

The shadow wage of child labour: an application to Nepal

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As part of broader efforts toward durable solutions to child labor, the International Labour Organization (ILO), the United Nations Children's Fund (UNICEF), and the World Bank initiated the interagency Understanding Children's Work (UCW) project in December 2000. The project is guided by the Oslo Agenda for Action, which laid out the priorities for the international community in the fight against child labor. Through a variety of data collection, research, and assessment activities, the UCW project is broadly directed toward improving understanding of child labor, its causes and effects, how it can be measured, and effective policies for addressing it. For further information, see the project website at www.ucw-project.org.

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ABSTRACT

This paper estimates the contribution of child labour to the formation of household farm income in rural enterprises. The contribution to household income from the employment of children comes either from the employment on-farm at a shadow wage or off-farm in the agricultural or other sectors. The paper uses a cost function with household labour as a quasi-fixed factor in order to estimate the shadow wage for each component of the household labour force. The study also provides an estimate of contribution of child labour to household income in the rural sector, both at the household and national level. A set of simulation also highlight the role that child labour plays in insuring household subsistence and how it does affects income distribution.

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1. INTRODUCTION

1. Child labour is the result of a complex household decision. Such a decision reflects, inter alia, the intertemporal allocation of resources, the access to credit markets and the relative returns of education versus work. If schools are not available, or their quality is very poor, the decision to send a child to work might be due more to the lack of alternatives than to the additional income generated through work. On the other hand, if the household is very poor and lacks access to credit market, the income generated by the children might be essential to guarantee the survival of the household and of the child.

2. Information about the value of children's time outside of school is also very important for many aspects of policy design, such as incentive schemes, like contingent cash transfers, and more traditional transfer schemes. In general, policies aimed at providing incentives for child schooling need information of the likely contribution of children's to household income in order to be properly designed.

3. Knowledge of the value of children's output also helps to shed light on the issue of the relative productivity of child versus adult labour. In order to understand better the demand for child labour and the possible substitutability between child and adult labour, information on relative productivity is important.

4. The main difficulty encountered in this area is given by the fact that most of the children do not work for a wage, but with their family: typically a farm or petty business. Therefore it is difficult to measure their contribution to family income. Given the imperfection of the labour market, especially in agriculture, it is difficult to infer children's contribution to household income by using observed market wage. Moreover, even if it were possible, in the typical data sets available the number of observations on children's wage is too small to allow for any robust inference.

5. Up to now very few systematic attempts have been made to fill this gap of information. Researchers have mainly used extrapolation from children's wage equation, with the limitations discussed above, cell averages or direct estimation of production function in farm or business sector applied only to estimate the shadow wage of adult labour (Jaboby 1993, Skoufias 1994).

6. This paper tries to address the problem in a systematic and consistent way starting from the observation that the contribution of children to household farm income cannot be assessed, where it is most prevalent, by relying on market measures. It is necessary to model the whole production and consumption process of the household in order to obtain a consistent measure of the children's and other household members "shadow" wage rate. On this basis it is possible to "impute" the value of the children's contribution in terms of output of the family farm or business and obtain an estimate of the relative importance of child labour for the current welfare of the household.

7. In particular we will focus on the contribution of child labour to the formation of household income in agricultural enterprises. Such a contribution comes from the self-employment of children on the family farm, where labour is evaluated as a shadow wage, or from off-farm employment in the agricultural or other sectors.

8. The shadow wage is estimated using a cost function, that treats household labour as a quasi-fixed factor. This approach allows to obtain a measure of the shadow wage for each component of the household labour force. The study also provides an estimate of the size of the children's shadow economy compared to the adult contribution.

9. It is unrealistic to assume that agricultural labour markets are competitive in Nepal. About 40 per cent of the Nepalese farm economy is subsistence agriculture isolated from both output and factor markets. The basic economic unit of Nepalese agriculture is the farm-household. When the production and consumption decision variables are non-separable, then market goods and leisure are not priced at the market value. The evaluation of labour, therefore, is shadow and is revealed by the value of the marginal farm product. Non-separability is present by definition in subsistence farming[1] which can be considered as closed micro-economy, as first described in Chayanov (1986) and Sen (1966). The shadow wage depends on the characteristics of the workers and their hedonic value (Brown 1983, Barten1964, Benjamin 1992). Accounting for the heterogeneity between adult and child work allows us to estimate a different shadow wage for the adult and the child.

10. The estimation of the shadow wage can be performed either from the primal side, as traditionally done (Jacoby 1993, Skoufias 1994, Lambert and Magnac 1994) or from the dual side using either a cost, as in the present work, or a profit function. While we will focus here on estimations based on the dual side, we will also compare our results with those stemming from the direct estimation of a production function.

11. One of the main problems encountered in the estimation of the shadow wages for the Nepalese agricultural sector is the modelling of multiple-output production technologies and of zero realizations due to the fact that not all farms produce all outputs using all inputs. We deal with this censoring problem by adopting an extension of the Heckman model to estimate a system of equations with censored variables.

12. We make use of Nepal Living Standard Survey (NLSS) 1996 to estimate a system of equations that includes the total cost function and the input demand shares modified to allow for quasi-fixed factors and both worker and farm characteristics. As mentioned above we prefer to derive the shadow wages from the dual side as marginal costs, rather than from direct estimates of marginal productivities as done in other studies (Jacoby 1993 and Skoufias 1994). The dual approach permits modelling household labour as a quasi-fixed factor. Shadow wages can then be modified to take into account differences in parents' and children's characteristics. This structure permits deriving effective shadow wages with relevant policy implications.

13. The paper first discusses the importance of child labour for the Nepalese farm-household economy and describes its main features. The third section introduces the estimated farm-household model. The econometric methodology is described in the subsequent section. Section 5 presents a description of the data. In Section 6, we report the econometric technique adopted to deal with censoring in hired labour input. Then, in Section 7 we comment the results of our empirical evidence. The conclusions follow.

2. CHILD LABOUR IN NEPAL: IMPORTANCE FOR THE FARM-HOUSEHOLD ECONOMY

14. The following section, as well as the rest of the empirical analysis, is based on the Nepal 1996 LSMS survey. The Nepal Living Standards has been designed and managed by the World Bank. Data collection has been planned over a full year to cover a complete cycle of agricultural activities and capture seasonal variation in

[1] We define subsistence farms as those farms that do not sell the product to the market and therefore self-consume what they produce.

variables such as water availability. Field work took place in four subsequent phases starting in June 1995 and finishing in May 1996. The actual dataset numbers 3,373 households. The Nepal Living Standards are being used by the Central Bureau of Statistics in preparation of findings. World Bank used the data in the preparation of a Poverty Assessment.[2]

15. About 81 per cent of Nepalese labour force is employed in the agricultural sector which accounts for about 40 per cent of GDP. Because of low investments, the level of human development is also low, limiting people's choices and capabilities. Child labour is mainly employed in agriculture. In Nepal, child work is concentrated mainly in self-employed agriculture and is more frequent in poor households. Basu and Van's (1998) luxury argument is not the only reason for employing a child in the farm or in the household (Deb and Rosati 2002, Rosati and Tzannatos 2005). Lack of off-farm job or educational opportunities (Balhotra and Heady 2003), food insecurity and health status also help explaining the high demand for farm work. Child labour is also a consumption-smoothening strategy for poor households operating in risky environments and in regions where credit markets are missing or inefficient (Guarcello, Mealli, and Rosati 2003). As maintained by Skyt Nielsen and Dubey (2002), the lack of parental human capital may explain high fertility rates making less resources available to enrol children to school.[3]

16. As it is reasonable to think, a precondition for child labour is that children can substitute adults' labour (Basu and Van 1998). In general, substitution between child and adult labour implies that a child can do the same type of job as an adult, but not necessarily equally well. In agriculture, children can substitute for adults, but they may produce a product of lower quality either because of differences in strengths or skills and/or because are employed in different agricultural activities. Farm child labour is seasonal when competing with schooling.

17. The Nepalese micro-data from the Living Standards Survey brings interesting evidence on the importance of child labour in the farm household economy, the trade-off between employing a child on the farm or sending the child to school, and the substitution between adult and child labour.

18. Table 1 reports the geographical distribution and selected family characteristics for the whole Nepalese NLSS sample and for household without and with at least one working child 10-14 years old. The latter sub-sample is divided in children self-employed in the household farms and children employed in other paid jobs. About 50 per cent of the households in the whole sample have children. Among those who have children 10-14 years old, about 60 per cent of the households have children who do not work. In the remaining households with working children, amounting to 21 per cent of the sample, 90 per cent of the households self-employ their children in agricultural activities.

19. Inspection of Table 1 reveals that the average household is headed by a 44.7 years old breadwinner and is composed of 6 members, 3 adults and 3 children. The household composition does not differ significantly across classes with and without working children. The level of education of the head of the household with non-working children is, though low, about twice as much as the level of education of

[2] For more details on sample design, survey questionnaires, and field work see the Nepal Living Standards Survey - Survey Design and Implementation (1998 World Bank).

[3] For instance, in the NLSS absence or distance of schools from home are marginal reasons (less than 5 per cent) for which children 10-14 years old never attended school. School cannot be afforded by 25.4 per cent of the sampled Nepalese households. This constraint seems especially stringent in households with girls (16.1 per cent of the total). In 19.4 per cent of the cases help was needed at home especially from girls (69 per cent).

households with working children. About 39 per cent of the households live in Central Nepal and more than half of the households is located in the hillside. About 52 per cent of the whole NLSS has at least a child 10-14 years old. In 69 per cent of the cases, there are children either working in agriculture (90 per cent) or in other paid job (10 per cent). Among the households with children self-employed in agriculture and for households with children employed in other paid jobs the average age of the head does not vary significantly. The average size of the household with children self-employed in agriculture is 0.9 times bigger than the average size of households with children employed in other sectors. In the Terai region there are more off-farm opportunities as it can be deduced by the high proportion (0.51) of children not self-employed in agriculture.

20. Table 2 addresses the link between household consumption and child labour in Nepal. It shows the distribution of children's working hours by quintiles of household total consumption. Interestingly, the consumption level of households with non working children is about 50 per cent higher than the level of total expenditure of households with working children (Table 1). In general, children belonging to the first two quintiles work more than children belonging to households relatively more well-off. Working children self-employed in agriculture work less than children employed in other sectors. This is mainly due to the seasonality of the agricultural activities.

21. In the Nepalese sample, 33 per cent of the farms produce for subsistence. Subsistence farms are those farms that do not sell the product to the market and therefore self-consume what they produce. This informal agricultural sector deserves special attention because these households are less connected to markets, enjoy lower off-farm job opportunities and have a more critical access to educational or other services. Table 3 compares the farm as well family characteristics of the households engaged in subsistence agriculture with the other farming households. As expected, subsistence farm households on average have an annual household total consumption lower that non-subsistence families. The household size is slightly lower and the numerosity within age classes is comparable. Subsistence farming is relatively more frequent in the Far-West and mountain regions of Nepal. Curiously, children employed in subsistence farms work as much as children employed in non subsistence farms. The average level of years of head's education of non subsistence farm-households is higher with respect to the years of education of the head of subsistence farms.

3. A FARM-HOUSEHOLD THEORETICAL MODEL

22. We utilize a farm-household model to analyze the decisions concerning child labour based on the classical literature of subject (Singh, Squire and Strauss 1986, Huffman 2001). In order to specify a tractable model and to take into consideration the characteristics of child labour in Nepal, we find reasonable to make the following assumptions.

Assumption 1. Until children reach maturity, the parents exert control upon children's choices over time and activities. For example, a child works and/or goes to school according to the parents' decision.

Assumption 2. Parents have the control of all the income that accrues to the household, both from adult and from child work. The parents distribute the income to the household members according to an undeclared sharing rule known to the

household members but not directly observable by the researcher. The model refers to a unitary household "glued together" and represented by the preferences of the adults.[44]

Assumption 3. A Nepalese child works in the household farm or off-farm mainly in agriculture. Therefore, we do not model the opportunity for the child to work outside the agricultural sector.

Assumption 4. Children consumption of leisure is invested in education. Hence, in our setting
demand for leisure is equivalent to demand for schooling or human capital accumulation.

Assumption 5. The number of children is assumed to be exogenous to the family decisions.

23. The household maximizes a social welfare function W defined over a composite consumption good x and leisure l of both adults a, and children c. Each household member has a total time endowment given by $T_i(d) = l_i + L_i^I + L_i^0$, where L_i^I is on-farm labour, and L_i^0 is off-market labour. The production technology $F(.)$ adopts two quasi-fixed but allocable inputs, adult L_a^I and child L_c^I family labour, and a variable input, adult hired labour L^H. Both the household welfare function W and the production technology $F(.)$ are assumed to be affected by a set of exogenous characteristics d, such as parents and children age, gender and education, that influences the utility of the household.

24. The household maximization program is

$$\max_{\substack{x_a, l_a, L_a^I, x_c, l_c, L_c^I, \\ L^H, q}} W = U(x_a, x_c, l_a, l_c; d_a, d_c),$$

$$\text{s.t.} \sum_{i=a}^{c} x_i + \sum_{i=a}^{c} w_i l_i = \left[p_q q - w_a L^H - \sum_{i=a}^{c} w_i L_i^I \right] + \sum_{i=a}^{c} w_i T_i + y,$$

$$q = F(L^H, L_a^I, L_c^I; d_a, d_c),$$

$$L_i^O \geq 0, \quad i = a, c,$$

$$(C_i, l_i, L_i^I, L_i^O, L^H) \in \wp, \quad i = a, c,$$

[4] The unitary model is often empirically rejected when compared to collective models (Chiappori 1992, Donni 2001, Arias *et al.* 2003) based on individual behaviour. However, the main interest in this study is the derivation of shadow wages of child labour rather than learning something about the child participation to the household decision-making process and the intra-household distribution of resources.

25. where q is the farm output sold at a market price equal to $p_q.L_i^o$. is labour supplied by parents and sons off-market either in agriculture or other sectors, though at a small extent in Nepal, at the market wage w. The off-farm wage is assumed to be different for adults and children, though children's wage is often informal, but equal across employment possibilities, either on other farms or in other sectors. All off-farm time uses have the same price. We assume that the market prices of both the composite goods, x_a and x_c, are equal across households and therefore are set to one. The terms in brackets represent the non maximized "accounting" function of farm profits and the exogenous variable y measures non labour income. $\wp$ is the constraint set limiting the choices of $(C_i, l_i, L_i^o, L^H, L_i^F) \in \wp$. The set can include positive constraints, or rationing factors because of particular market structures or other causes.

26. The maximization of the household welfare program leads to the following Lagrangian function

$$L = U(x_a, x_c, l_a, l_c; d_a, d_c) +$$

$$+\lambda\left(p_q F(\cdot) - w_a L^H - \sum_{i=a}^{c} w_i L_i^I + \sum_{i=a}^{c} w_i T_i + y - \sum_{i=a}^{c} x_i - w\sum_{i=a}^{c} l_i \right) + \mu_a L_a^O + \mu_c L_c^O,$$

where λ is the Lagrange multiplier associated with the budget constraint, and μ_a, μ_c are the Lagrange multipliers associated with the inequality constraints related to the off-farm market labour choices of adults and children.

27. Maximization of the Lagrangian with respect to the endogenous variables yields the following first order conditions

$$L_{x_i} = 0 \rightarrow U_{x_i} = \lambda,$$

$$L_{l_i} = 0 \rightarrow U_{l_i} = \lambda w_i + \mu_i,$$

$$L_{L_i^I} = 0 \rightarrow F_{L_i^I} = \frac{1}{p_q}\left(w_i + \frac{\mu_i}{\lambda} \right),$$

$$L_{L^H} = 0 \rightarrow F_{L^H} = \frac{w_a}{p_q},$$

along with the derivatives with respect to the Lagrange multipliers. Rearranging in terms of marginal rate of substitutions, the first order conditions become

$$\frac{U_{l_i}}{U_{x_i}} = w_i + \frac{\mu_i}{\lambda} = w_i^*, \qquad (1)$$

$$\frac{F_{L_i^f}}{F_{L^H}} = \frac{w_i + \frac{\mu_i}{\lambda}}{w_a} = \frac{w_i^*}{w_a}, \tag{2}$$

for $i = a, c$. Equation (1) represents the equilibrium condition for family utility maximization. The household equates the marginal rate of substitution between consumption and leisure and the shadow wage of member i. If member i works off-farm the corresponding complementary slackness condition μ_i is zero and the shadow wage is equal to the respective market wage. On the other hand, if member i does not supply his labour on the market, μ_i is greater than zero and her shadow wage in general will be greater than the respective market wage. The equilibrium condition for production maximization is given in equation (2). The family-farm will hire adult labour up to the point where the marginal rate of transformation between family and hired labour is equal to the ratio between the family shadow wage and the wage paid to hired labour.

28. When off-farm work and hired labour is zero, that is when such decisions are at a corner and family and hired labour are not perfect substitutes (Deolalikar and Vijverberg 1987, Jacoby 1993), then implicit shadow prices must be adopted because the model is non separable.[5] The choice not to work off-farm may be explained by objective causes such as a missing labour market or the lack of contractual flexibility in the off-farm labour market. On the other hand, low subjective expectations about the probability to find a job off-farm, especially for low-skilled workers such as children, may generate expected off-farm wages that are lower than a return to labour employed with certainty on the own farm. This observation is especially appropriate in Nepal where off-farm opportunities are virtually lacking.

29. The production and consumption sides of the household economy illustrate the general equilibrium structure of the model. The exogenous characteristics d of the household and the enterprise affect both sides of the micro economy. Within the theory of the household enterprise this is an interesting feature since it permits testing the separability hypothesis between consumption and production decisions (Singh, Squire, and Strauss 1986, Benjamin 1992, Udry 1996). Under separability, the general equilibrium program of the household is recursive. Production decisions are not affected by the household's endowments, preferences, characteristics or decision processes. On the other hand, consumption decisions are affected by production choices since profits are part of the budget constraint.

30. The separation between production and consumption decisions is ensured by the household rational behaviour in presence of complete markets. Recent empirical works (Benjamin 1992, Udry 1996, Pavoni and Perali 2000) show that production decisions do depend on farmers' preferences and endowments. The simultaneity in decision making is evident even in the absence of market failures when the same input, such as time, is shared across the household and home production processes, and in presence of home consumption of the household marketable product. Imperfections in the labour, credit and land markets are commonly observed in empirical work (Benjamin 1992, Udry 1996, Balhotra and Heady 2003). Under these

[5] The qualitative properties of the model do not change if we assume perfect substitutability between adult considered in the next section.

conditions, farm production and household consumption decisions are nonseparable and leisure/labour demand on the household is not independent from the on-farm demand of family labour. As a consequence, shadow wages, rather than market wages, determine adults and children's labour/leisure choices. The case of a Chayanovian farm-household closed economy, which in Nepal is represented by subsistence farming, where the household members are not employed off-farm and no agricultural labourers are hired-in is non recursive by construction (Lambert and Magnac 1994).

4. THE ECONOMETRIC SPECIFICATION

31. The production technology is described as a restricted cost function with three allocable quasi-fixed factors: 1) adult labour, 2) child labour, and 3) land and capital. By specifying family labour as a quasi-fixed factor, it is not necessary to impute a market wage for family labour, but we can estimate it as the shadow wage corresponding to the value of the marginal product. By separating hired and family labour, it means that we need to model a censoring process also on the input side.

32. The econometric specification pays special attention to the modelling of adult/child separability that is obtained when adults' and children's work are not perfect substitutes. When the work of the child is not a perfect substitute for the work of an adult and/or children do not perform the same activities as the adults, then the marginal productivity is different both because adults and children have different skills and because they are allocated to different activities according to a natural division of labour in Becker's sense. In general, heavy activities such as ploughing are naturally undertaken by adults, while picking or other less demanding activities are parts of children's jobs. Children do not drive tractors. There are also other constraints known to the farm management and unknown to the researcher. Because of the questionnaire design, we do not know "who does what" in the field either for the adults or for the children. Since we do not know whether adults and children are employed in different activities in the farms, it is impossible to differentiate the productivity associated with each task. Because of this informational constraint, both adult and child labour is modelled in our framework as a quasi-fixed factor which affects only the joint product.

33. Given this informational constraint, we are bound to assume that adults and children produce the same product with different levels of quality/quantity per unit of time, which, in turn, are associated with age (adult/child) specific shadow wages. This relationship can be modelled with *a la* Barten (1964) specification relating differences in the quality/quantity of a product with the hedonic characteristics of the worker (Benjamin 1992). This is a reasonable assumption if the agricultural wage of interest is the implicit shadow wage paid to family labour, which, differently from the wage paid to hired labour, is not observable. Objective market wages and subjective shadow wages differ if markets are non competitive so that the agricultural household model is non separable. The case of child work is a case of non-separability due to a labour market failure. If recursivity holds, the influence of demographic variables on production should not be significant.

34. In line with these conditions, the econometric analysis takes into account the following assumptions

Assumption 6. The farm-household economy is non-separable.

Assumption 7. Adult and child family labour are quasi-fixed factors.

35. Interestingly, only the dual representation of the technology can explicitly model quasi-fixed factors as translating terms. This is one of the reason why we estimate the dual rather than the primal representation of the technology.

36. In the primal representation of the farm production, we consider a general production technology $q = F(L_H, L_a^I, L_c^I)$, where L_H is hired labour, L_a^I and L_c^I represent adult and child labour respectively modelled as allocable quasi-fixed factors. If we do not account for quality differences of the product obtained from adult and child labour due to heterogeneity in their skills, the shadow wage w_i^*, corresponding to the value of the marginal product of both adult L_a and child labour L_c, is the same for both adults and children but differs from the market wage w prevailing in the agricultural sector

$$w_i^* = \underbrace{\frac{\partial q}{\partial L_a} p_q = \frac{\partial q}{\partial L_c} p_q}_{\text{unobservable}} \neq w,$$

where p_q is the market price of the aggregate output q. In order to differentiate adult from child labour, effective family labour is here modeled as modified factor

$$L_i^* = L_i \theta_i(d_i)$$

for i=a, c= , , where d are individual specific characteristics affecting the Barten (1964) scaling modifying function $\theta_i(d_i)$. [6] The scaling transformation leads to the following definition of the effective wage

$$w_i^* = \left(\frac{\partial q}{\partial L_i} \theta_i(d_i) \right) p_q \neq \frac{\partial q}{\partial L_i} p_q = w \quad \text{for } i = a, c. \tag{3}$$

The scaling function $\theta_i(d_i)$ also generates the shadow effective wage w_i^{*e}

$$w_i^{*e} = \frac{w_i^*}{\theta_i(d_i)}.$$

[6] See also Yotopoulos and Lau (1973), Benjamin (1992), Kuhmbhakar and Knox-Lovell (2000) in more recent production applications.

The scaling function attributes differences in shadow wages to "hedonic" differences in worker characteristics (Brown 1983). The scaling function can be interpreted as a quality correction factor reflecting the fact that children with different characteristics may perform their tasks with significantly different levels of quality.

37. The implementation of the dual side of the above program requires the definition of a modified(*a la* Barten in our case) total cost function which can be written as

$$c(q,w,z,d) = \underset{x}{\text{Min}}\left\{w'r + w^{*'}z \mid q = F(r,z;d)\right\}$$

where w is an n-vector of input market prices, r is an n-vector of inputs, z is a k-vector of quasi-fixed factors, q is an m-vector of predetermined levels of outputs, and d is an l-vector of exogenous characteristics of the farm-workers, F is a transformation function with the usual properties and $w^{*\prime}$ is defined by equation (3). The structure of the minimization problem implies that the cost function is homogeneous of degree one in input and output prices. Two additional properties of the cost function are of interest for estimation purposes. First, by Shephard's lemma we have that

$$r_i(q,w,z,d) = \frac{\partial c(q,w,z,d)}{\partial w_i}$$

where r_i is the i -th component of the input vector and $_i w$ is the price of that input. These input demand functions are homogeneous of degree zero on input prices. Second, if entrepreneurs are minimizing costs, we obtain the quasi-fixed factor's shadow wage

$$w_i^* = \frac{\partial q}{\partial z} p = \frac{\partial c(q,w,z,d)}{\partial z} = \left(\frac{\partial c}{\partial z}\theta(d)\right) p$$

by differentiating total costs with respect to the level of the quasi-fixed factor. As shown by Paris (1989), the dual shadow price approach is appropriate also in the case of multiple outputs with fixed allocable inputs. This is the behavioural basis of our modelling strategy. Therefore, we use a restricted cost function where farm assets and adult and child labour are quasi-fixed factors.

38. We proceed then by estimating a system composed by a restricted translog cost function with four outputs, three inputs modified with a translating function to accommodate three-quasi fixed factors and its derivatives with respect to input prices. Quasi-fixed inputs act as exogenous factors modifying the cost function via shifting. The translog total cost function modified via a translating transformation (Pollak and Wales 1981, Lewbel 1985) can be written as

$$\ln c(q,w;z,d) = \alpha_0 + \sum_{i=1}^{4} \alpha_i \ln q_i + \sum_{r=1}^{3} \beta_r \ln w_r + \sum_{g=1}^{2} \gamma_g \ln\left(z_g\ \theta_g(d)\right) + \gamma_3 \ln z_3 +$$

$$+0.5\sum_{i=1}^{4}\sum_{j=1}^{4} \alpha_{ij} \ln q_i \ln q_j + 0.5\sum_{r=1}^{3}\sum_{s=1}^{3} \beta_{rs} \ln w_r \ln w_s + \sum_{r=1}^{3}\sum_{i=1}^{4} \gamma_{ri} \ln w_r \ln q_i + \sum_{r=1}^{3}\sum_{k=1}^{5} \zeta_{rk} \ln w_r \ln d_k,$$

where $_r w$ is the price of input r . The demographic function

$$\theta_g(d) = \exp\left(\sum_{j=1}^{3} \delta_j d_j\right)$$

is specified as linear in the logarithm function of the exogenous characteristics *d*. The set of demographic characteristics transforming adult work includes the household head's age grouped in four classes (1= less than 30 years old, 2= 30-44 years old, 3 = 45-60 years old, 4 = more than 60 years old), education of the household head, and a dummy indicating whether ploughs are used in farm activities. On the other hand, the set of children's characteristics is formed by a dummy whether children go to school, a dummy equals to one if more than the 50 per cent of consumed food is produced by the family, and a dummy taking the value of one if the household considers inadequate the level of consumption of its members.

39. Using Shephard's lemma, the derivatives of the cost function with respect to the logarithm of input prices can be written as:

$$s_r = \beta_r + \sum_{k=1}^{5} \zeta_{rk} \ln d_k + \sum_{s=1}^{3} \beta_{rs} \ln w_s + \sum_{i=1}^{3} \gamma_{ri} \ln q_i$$

where $s_r = -w'x/c = -\partial \ln c / \partial \ln w$ is the share of the *r*-th input in costs. Homogeneity of degree one in *w* of the cost function implies the following parametric restrictions

$$\sum_{r=1}^{3} \beta_r = 1, \sum_{i=1}^{4} \gamma_{ri} = \sum_{r=1}^{3} \beta_{rs} = \sum_{k=1}^{5} \zeta_{rk} = 0,$$

and symmetry

$$\alpha_{ij} = \alpha_{ji}, \beta_{rs} = \beta_{sr}.$$

40. In general, the properties derived from the optimization structure of the model can be tested. In the present case, linear homogeneity in prices, and symmetry are imposed as maintained hypothesis.

41. The shadow wage is derived as the marginal effect of a change in fixed factors on total costs, which, in the long run, corresponds to total revenues

$$w_z^* \equiv \frac{\partial c(q,w,z,d)}{\partial z_g} = \frac{\partial \ln c(q,w,z,d)}{\partial \ln z_g}\frac{c}{z_g} = \gamma_g \frac{c}{z_g}. \quad (4)$$

where c and z_g are total costs and adult or child labour respectively. The effect of demographic characteristics on total costs, on the other hand, correspond to the following partial contribution

$$\frac{\partial c}{\partial d_j} = \frac{\partial \ln c(q,w,z,d)}{\partial d_j} c = \left(\gamma_g \cdot \delta_j\right) c.$$

Finally, the effective shadow wage w_z^{*e} of adult and child labour is given by the sum of the effective shadow wage with the total contribution to the marginal productivity of labour provided by the characteristics of the worker

$$w_z^{*e} = w_z^* + \frac{\partial c}{\partial d_j}.$$

5. DATA

42. The empirical analysis is based on the Nepal Living Standard Survey 1996. The household survey is made up of the following eleven sections 1) Information of head of the household, and wife such as age, education, paid working hours, and wages; 2) Family and children 10-14 years old paid working hours and family wages; 3) Health information at the household level of aggregation; 4) Farming and livestock; 5) Production, sales and prices of agricultural activities; 6) Expenditure on agricultural inputs; 7) Credit and savings; 8) Remittance and transfers, plus other income; 10) Household consumption and expenditure; and finally, 11) Geographic location of the household. For the purpose of estimating the shadow wage of child labour it is relevant to report that the data do not include information on who does what in the farm.

43. The estimation has been carried out on a sample of 2,380 farm households obtained excluding observations with singles, 2.16 per cent, landless households, 23 per cent, non-farming households, 3.44 per cent, those farming households without adults self-employed in agriculture, 0.56 per cent, and households with head younger than 17 years old, 0.15 per cent.

44. Table 4 reports the descriptive statistics of the data used in the estimation along with standard errors, minimum and maximum values. In the table are also reported the definitions of the variables and the unit of measurement.

45. In presence of sharecropping contracts, which are found in 18 per cent of the sample, and subsistence farms, representing 33 per cent of the cases, as shown in Table 4, prices are not observed and have been imputed using *ad hoc* techniques. This measurement aspect is crucial because without output prices the implicit valuation of labour corresponding to the value of the farm marginal product cannot be derived.

46. Total costs have been computed as the sum of variable and fixed costs including adult and child labour and the use value of land and capital assets. In particular, family labour is evaluated as the accounting value left after having paid all other factors of production and value of fixed assets is computed as the 1 per cent of the overall value of land and capital. Output prices of subsistence farms have been imputed with the prevailing average price in the observed location of the farm. Note that when fixed costs are included, then by construction total costs equal total revenues (TR) because the accounting value of fixed costs is computed assuming a long run perspective. Total fixed costs (TFC) are composed by the opportunity cost of the money invested in the fixed plant R and the fixed costs associated with fixed labour. The return to family labour (RFL) is defined as $RFL = TR - TVC - R$, where TVC are total variable costs. Given this accounting construction, profits are zero $\delta = TR - TVC - (R + RFL) = 0$ and total

47. costs equal total revenues. We assume that when $RFL > 0$, then the returns to family labour are sufficient to keep a family farming in the long-run.

6. ECONOMETRIC ESTIMATION

48. In order to deal with the censoring in the input equation for hired labour, we adopt the Generalized Heckman approach which is the Heckman two-step estimator extended to a system of censored equations. This method gives unbiased estimates as compared to the maximum simulated likelihood method (Hajivassiliou, McFadden, and Ruud 1996) that uses multiple integrals that are computed with a simulated algorithm to reproduce the statistical process that generated the zero realizations (Arias and Perali 2003).[7]

49. Our methodological approach assumes that the zero realizations are the outcome of a rational economic choice or it is determined by physical, technological or normative constraints thus justifying a Tobit structure. The data generating process that we assume reproduces the unconstrained choice of not undertaking a certain activity if the output price is below a reservation price corresponding to a break-even point.

50. In a general representation of a system of equations with censored endogenous variables, each equation in the system can be written as

$$\begin{aligned} y_i &= f_i(x_i, \beta_i) + u_i \text{ if } f_i(x_i, \beta_i) + u_i > 0, \\ y_i &= 0 \qquad\qquad\quad \text{if } f_i(x_i, \beta_i) + u_i < 0, \end{aligned} \tag{5}$$

where x_i is the endogenous variable corresponding to the i -th equation in the system, y_i is a vector of explanatory variables, β_i is a vector of parameters and u_i is a random variable. Precisely, u_i is the i -th component of a multivariate normal random vector u of mean zero and variance Σ . Therefore, $u_i \quad N(0, \sigma)$, where, σ_i^2 is the i-th diagonal term of the matrix Σ.

51. The Generalized Heckman procedure transforms the system of censored equations in (5) into a system of uncensored equations by using the appropriate

[7] In the simulated maximum likelihood approach the variance covariance matrix of the parameters is a full matrix, while in the generalized Heckman estimator only the diagonal terms can be estimated.

correction. We start by considering the expected value of the endogenous variable conditional on a positive observation

$$E\left[(y_i \mid y_i > 0\right] = f_i(x_i, \beta_i) + \sigma_i \frac{\phi\left(f_i(x_i, \beta_i)\sigma_i\right)}{\Phi\left(f_i(x_i, \beta_i)\sigma_i\right)}$$

where φ and Φ are respectively the probability density function and the cumulative density function of a standard normal distribution. Then, the unconditional mean (conditional only on explanatory variables) can be written as:

$$E\left[(y_i \mid x_{it}\right] = f_i(x_i, \beta_i)\Phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right) + \sigma_i\phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right).$$

52. Using the expression for the unconditional expected value of each endogenous variable we consider the following system of uncensored equations

$$y_i = f_i(x_i, \beta_i)\Phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right) + \sigma_i\phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right) + \xi_i$$

where $\xi_{it} = y_{it} - E[y_i|x_{it}]$. The system of censored equations can be estimated by maximum likelihood assuming that ξ MVN $(0, \Omega)$ where ξ is a random vector which i-th element is ξ_i . Note that the random variables i ξ are different from the random variables of the censored system u_i.

7. RESULTS

53. The estimates of the modified translog cost function obtained using a maximum likelihood procedure are presented in Table 5. The proportion of significance of the parameters is homogenous across the group of price, outputs (cereals and vegetables, fruit, milk, livestock) and demographic characteristics. The farm characteristics included in the analysis are the regional dummies which distinguish the Eastern and Central regions from the other regions of Nepal and the Terai planes. The dummies for sharecropping and subsistence farming are intended to capture some crucial structural and institutional characteristics of the Nepalese farming mode.

54. The Allen elasticity of substitution for the three variable inputs, hired labour, chemicals and materials, reported in Table 6 show the correct sign along the diagonal. This evidence says that at the data means the curvature of the cost function is regular. The own impact of hired labour is highly elastic. The inputs are all substitutes.

55. The marginal effects of farm characteristics and fixed factors on total farm costs are presented in Table 7. In the Eastern regions of Nepal and in subsistence farming, where the agricultural product is not sold on the market, costs are relatively higher. Costs are lower where sharecropping is the mode of agricultural production, in Terai plans and in central Nepal. In the case of sharecropping the marginal evaluation of labour is based on the value of total production farmed not just on the proportion of production sold on the market after having paid the rent to the landlord. Similarly, the

shadow wage of workers producing in subsistence farms is evaluated at an imputed price. The coefficients associated with the fixed factors are the marginal effect on total costs. Given the definition of returns to family labour described in the data section and the long run perspective taken in our study, the effect on total costs equates the impact on total revenues. The coefficient then provides a direct evaluation of the shadow wage as illustrated in equation (4). As expected, the effect of adult and child labour is positive and significantly different from zero.

56. The estimated adults' and children's shadow wages are presented in Table 8. The shadow wages are evaluated 1) at the unconditional mean of all the variables E(w_i^*) 2) conditional on positive levels of child labour, E($w_i^*|z_2$>0) and 3) conditional on absence of child labour but in presence of children 10-14, E($w_i^*|z_2$=0, nchld1014>14).

57. Observe that the shadow wage of the adults is lower in households that employ children in agricultural production. This seems to indicate that farms characterized by a low productivity of labour are those more in need to employ children in order to guarantee the subsistence of the household. However, we may also consider the possibility that households employ children because of lack of alternatives in the use of their time (school not present, school costs to high, low return to education, etc.) which may generate a situation of "over-employment" that reduces productivity. In households with school aged children in non-working condition, the adult shadow wage is higher.

58. The adult and child wage differential is about 0.36 rupees per hour

$$w_p^* - w_s^* = 1.044 - 0.683 = 0.361$$

corresponding to a child-adult wage ratio of $\frac{w_s^*}{w_p^*} = 0.0654$. The shadow value of the child productivity is more than a half of the adult at the data mean. This result shows that adult and child labour are not perfect substitutes (Basu 1999 and 2000).

59. For the sake of establishing a form of control of the experiment's outcomes, we estimate adults' and children's shadow wages using a primal approach based on the estimation of a production function (Jacoby 1993 and Skoufias 1994). The primal estimates are reported in the appendix.

60. The shadow wages obtained from the primal estimation are in general higher than those estimated using the dual approach. Inspection of Table A.2 reveals that, in presence of children self-employed in the farm, the adult shadow wage is 1.90 rupees per hour, while the total household labour income, obtained by adding adult and child shadow wages, is 2.55 rupees per hour. This figure increases at 5.48 rupees per hour when children are not working. In this case, the adult shadow wage appears to be overestimated if compared with the market wage of a hired worker, 1.86 rupees per hour.[8]

[8] In the sample used for carrying out the estimation only 2.6 per cent of farms hire permanent workers. On average, these farms hire less than two full-time workers (1.45) and the cost for each worker is about 4,292 rupees per year. Note that a permanent hired worker earns an amount of money slightly lower than the estimated poverty line, 4,404 rupees (Prennushi 1999). Assuming that each employee annually works about 2304 hours, the wage for hired labour is 1.863 rupees per hour. Note that in 1997 one US $ corresponds to 63 Nepali rupees.

61. Moreover, assuming that an adult household member works on average 2,304 hours in a year,[9] his own contribution to household income is about 4,368 rupees, when there are working children, and 12,628 rupees, otherwise. For the present exercise, the per capita poverty line in Nepal was estimated by the World Bank (Prennushi 1999) to be NRs. 4,404 on the basis of a daily per capita calorie requirement of 2,124 calories. The poverty line was evaluated at the average price level prevailing in 1995/96 for a food basket insuring a daily consumption of 2,124 calories, adjusted for a factor accounting for the proportion of non-food expenditures. Because 42 per cent of the population (Prennushi 1999) is classified as poor, it is reasonable to think that shadow wages obtained using the production function are overestimated.

62. Conversely, adult and child shadow wages estimated using the dual approach represent the Nepalese shadow economy more closely. Indeed, if there are working children the adult shadow wage is 1.04 rupees per hour. This figure is lower than the market wage. Families with such a low income experience severe poverty and may feel strongly pressured to send children to work. With the contribution of child labour, the total household wage sums to 1.73 rupees per hour. When children are not working but are present in the household, the value of the adult productivity is 3.23 rupees per hour. The annual contribution to household income of an adult is 7,433 rupees, slightly less than twice the per capita poverty line. In these farm-households children do not work because their involvement is not needed.

63. The shadow labour income estimated using the primal approach in general is higher than the per capita poverty line, for instance where children do not work the estimated shadow income is about three times the level of the per capita poverty line, which does not seem to reflect accurately the depressed living conditions of rural Nepal. On the basis of these evidences, we may conclude that the primal approach overestimates the productivity of agents self-employed in agriculture in Nepal.

64. It is important to remark that the degree of adult/child substitutability is affected by differences in characteristics. For example, an educated child going to school may be a better substitute for the labour performed by an adult with a low level of education. Therefore, a proper comparison between shadow wages should take into consideration differences in the effectiveness in performing the work, as it can be deduced from the different characteristics of adult and child labour employed in the farm. Table 9 shows that the use of ploughs in agricultural activities has a positive impact on the productivity of the adults.. The effective shadow wage of farmers with a head relatively younger, with lower education and using of ploughs is significantly larger, especially because of the contribution of the effect of experience cumulated with age.

65. Effective shadow wages for children are positively influenced by high level of household consumption of home products, but are negatively influenced by the presence of working students. As it is reasonable to expect, children's productivity is lower when consumption levels are inadequate and precarious health conditions affect their performance.

66. From these estimates, we may conclude that the child marginal contribution to the shadow farm economy in Nepal is about two third of the contribution of the adult. Considering that children in Nepal provide 17.6 per cent of rural labour, in terms of annual working hours, we may attribute to children a contribution of $17.6 \times 0.654 = 11.51$ per cent of the value of Nepalese agricultural production.

67. This represents a substantial contribution to agricultural production and clearly illustrates the important role that child labour plays in the Nepalese economy. It is

[9] The figure is obtained assuming that an employee works on average 8 daily hours per 288 days in a year.

also very important to assess whether and to what extent child labour does help poor households to meet their subsistence needs. If the role of child labour in guaranteeing the subsistence of the household were negligible, than policy actions should be focused on reducing the direct and indirect costs of accessing education, on improving returns to education, on raising awareness of the importance of education etc. Less attention should be paid to the returns to child labour and to the need to compensate the household for the forgone income.

68. In order to gauge whether the presence of a working child has a significant impact both on the level of poverty and inequality, we simulate the distribution of household income for the households with working children as if children were not contributing the value of their labour and compare the associated measures of poverty and inequality with the measures for the whole sample and the households with and without working children. Table 10 reports the headcount, poverty gap, the Foster, Greer and Thorbecke indexes and standard measures of dispersions along with the Gini coefficient for the whole sample and the subgroups of interest.

69. Farming households with working children have higher levels of poverty both in terms of number of households below the poverty line and in terms of depth and severity of poverty. These figures are substantially more marked if working children do not pool their incomes. If the contribution of child labour is not taken into account, there is an increase of 7 percentage points in the number of household below the poverty line. The headcount ratio increases from 52 to 65 per cent. This indicates that poor farmers are those more likely to "hire" the unpaid work of their children on the farm. The fact that the poverty gap ratio also increases significantly if children do not pool incomes suggests that child labour is vital for very poor households. The absence of the additional source of revenues provided by the children may push those households below subsistence. This is also reflected in the increase in the Sen and FTG index in the simulated case. The difference in the impact on inequality for the actual and simulated situation, as described by standard measures of dispersion and the Gini coefficient, is negligible.

8. CONCLUSIONS

70. This work has estimated the shadow wages and effective shadow wages of adult and children in Nepal. The technique differs from the prevailing literature (Jacoby 1993 and Skoufias 1994) because it adopts a dual approach. This avenue has been pursued because the primal representation of the technology does not allow to treat fixed and variable factors differently. Because of this indeterminacy, in the traditional dual representation fixed factors would be evaluated implicitly at their market value rather than the implicit shadow evaluation. Shadow prices are appropriate when farm and household decisions are non-separable, which we assume to be the case in Nepal where agricultural labour and other factor markets often fail or are missing. The presence of child labour is also an intrinsic cause of nonseparability.

71. The estimation is carried out using a cost function rather than a production function as previously done in the literature. The dual approach evades the problem of treating fixed- factors, such as family labour, as variable factors as traditionally done in a primal context. This problem implicitly assumes that family labour can be evaluated at the market wage and that rural labour markets clear. This is an hypothesis which is in sharp contrast with the Nepalese rural economy. In this regard, we deem that this asymmetry can be properly solved only if a joint primal-dual estimation is undertaken. This operational aspect is left for future research.

72. The results show that adult and child labour employed in Nepalese farms are substitutes. The child shadow wage is at the mean about 60 per cent of the adult shadow contribution. This conclusion may not be generalized. For example, in terms of the effective shadow wage obtained by a child with inadequate consumption, the degree of substitutability is significantly lower. According to these estimates, children contribute about 11.51 per cent of the value of total agricultural production in Nepal. Considering that agriculture is responsible for 81 per cent of Nepalese GDP, 9.32 per cent of Nepalese GDP is produced by children. The simulation about the impact on poverty and inequality associated with the children pooling or not their income contributions show that children significantly contribute to lower poverty at the household level and, at a lesser extent, to reduce inequality.

73. Under a policy point of view, it is important to ask how much of the value of the output produced by children remains under their control. When children are employed on-farm, the value of the child product is managed by the adults, who are the final claimants and responsible for the redistribution of income within the household. When children offer their time outside the household enterprise, then they may maintain full, partial or no ownership of their incomes. This question can find an answer at the household level if we can measure how the resources produced by the children from their work on their farm, but traditionally managed by the adults, are redistributed within the household.

REFERENCES

Arias, C., V. Atella, R. Castagnini, and F. Perali (2003): "Estimation of the Sharing Rule between Adults and Children and Related Equivalence Scales within a Collective Consumption Framework," in *Household Behaviour, Equivalence Scales, Welfare and Poverty,* eds. Dagum, C. and G. Ferrari, Physica-Verlag.

Arias, C. and F. Perali (2003): "Estimation of System of Equations with Corner Solutions: a Comparison of the Generalized Heckman Procedure, Minimum Distance and Maximum Simulated Likelihood," mimeo, University of Verona.

Balhotra, S. and C. Heady (2003): "Child Farm Labour: the Wealth Paradox," Discussion Paper No. 03/553, Department of Economics, University of Bristol, U. K.

Barten, A. P. (1964): "Family Composition, Prices and Expenditure Patterns," in *Econometric Analysis for National Economic Planning: 16th Symposium of the Colston Society,* eds. P. Hart, G. Mills, and J. K. Whitaker, London: Butterworth.

Basu, K. (1999): "Child Labour: Cause, Consequence, and Cure, with Remarks on International Labour Standards," *Journal of Economic Literature,* 37(3): 1083-119.

Basu, K. (2000): "The Intriguing Relation Between Adult Minimum Wage and Child Labour," *Economic Journal,* 110(462): C50-C61.

Basu, K. and P. H. Van (1998): "The Economics of Child Labour," *American Economic Review,* 88(3): 412-27.

Benjamin, D. (1992): "Household Composition, Labour Markets, and Labour Demand: Testing for Separation in Agricultural Household Models," *Econometrica,* 60(2): 287-322.

Brown, J. N. (1983): "Structural Estimation in Implicit Markets," in *The Measurement of Labour Cost,* ed. J. E. Triplett, Chicago: Chicago University Press.

Chayanov, A. V. (1986): *The Theory of Peasant Economy,* Madison: The University of Wisconsin Press (original edition 1926).

Chiappori, P. A. (1992): "Collective Labor Supply and Welfare," *Journal of Political Economy,* 100(3): 437-67.

Deb, P. and Rosati, F. C. (2002): "Determinants of Child Labor and School Attendance: The Role of Household Unobservables," UCW Working Paper, http://www.ucw-project.org/.

Deolalikar, A. B. and W. Vijverberg (1987): "A Test of the Heterogeneity of Family and Hired Labour in Asian Agriculture," *Oxford Bulletin of Economics and Statistics,* 49(3): 291-305.

Donni, O. (2001): "Collective Household Labor Supply: Theory and Application," Working Paper no. 141, CREFÉ and Université du Québec à Montréal.

Guarcello, L., F. Mealli, and F. C. Rosati (2003): "Household Vulnerability and Child Labour: the Effects of Shocks, Credit Rationing and Insurance," Social Protection Working Paper, The World Bank.

Hajivassiliou, V., D. McFadden, and P. Ruud (1996): "Simulation of Multivariate Normal Rectangle Probabilities and their Derivatives: Theoretical and Computational Results," *Journal of Econometrics,* 72(1-2): 85-134.

Huffman, W. (2001): "Human Capital: Education and Agriculture," *Handbook of Agricultural Economics, Vol.I,* eds. B. Gardner and G. Rausser, Amsterdam: Elsevier Science B.V.

Jacoby, H. G. (1993): "Shadow Wages and Peasant Family Labour Supply: An Econometric Application to Peruvian Sierra," *Review of Economic Studies,* 60(4): 903-21.

Kumbhakar, S. C. and C. A. Knox-Lovell (2000): *Stochastic Frontier Analysis,* Cambridge: Cambridge University Press.

Lambert, S. and T. Magnac (1994): "Measurement of Implicit Prices of Family Labour in Agriculture: an Application to Cote d'Ivoire," in *Agricultural Household Modelling and Family Economics,* eds. F. Caillavet, H. Guyomard, and R. Lifran, Amsterdam: Elsevier Science B. V.

Lewbel, A. (1985): "A Unified Approach to Incorporating Demographic or Other Effects into Demand Systems," *Review of Economic Studies,* 52(2): 1-18.

Paris, Q. (1989): "A Sure Bet on Symmetry," *American Journal of Agricultural Economics,* 71(2): 344-35 1.

Pavoni, N. and F. Perali. (2000): "Analisi Dinamica dell'Azienda-Famiglia," in *Microeconomia Applicata,* ed. F. Perali, Roma: Carocci.

Pollak, R. and T. J. Wales (1981): "Demographic Variables in Demand Analysis," *Econometrica,* 49(6): 1533-51.

Prennushi (1999): "Nepal: Poverty at the Turn of the Twenty-First Century," Report No. IDP 174 Washington D. C.: World Bank.

Rosati, F. C. and Z. Tzannatos (2005): "Child Labour in Vietnam," *Pacific Economic Review,* forthcoming

Sen, A. K. (1966): "Peasants and Dualism with and without Surplus Labour," *Journal of Political Economy,* 74(5): 425-50.

Singh, I. J., L. Squire, and J. Strauss (1986): *Agricultural Household Models: Extensions, Applications, and Policy,* Baltimore: John Hopkins Press.

Skyt Nielsen, H. and A. Dubey (2002): "Child Labour in Rural India: A Micro-Economic Perspective," *The Indian Journal of Labour Economics,* 45(3): 479-496.

Skoufias, E. (1994): "Using Shadow Wages to Estimate Labour Supply of Agricultural Households," *American Journal of Agricultural Economics,* 76(2): 215-27.

Udry, C. (1996): "Gender, Agricultural Production, and the Theory of the Household," *Journal of Political Economy,* 104(5): 10 10-46.

Yotopoulos, P. A. and L. J. Lau (1973): "A Test for Relative Economic Efficiency: Some Further Results," *American Economic Review,* 63(1): 214-23.

APPENDIX A: STATISTICAL TABLES

Table 1. Demographic Characteristics of NLSS and Samples of Interest

	NLSS	Households with at least a child 10-14 years old			
		With not working children	With working children	With working children	
				self-employed in agric.	not self-employed in agric.
No. of observations	3,373	1,032	714	642	72
Eastern	0.213	0.234	0.181	0.181	0.181
Central	0.391	0.370	0.353	0.347	0.403
Western	0.185	0.231	0.125	0.115	0.208
Mid-West	0.107	0.090	0.171	0.181	0.083
Far-West	0.104	0.076	0.171	0.176	0.125
Mountain	0.121	0.074	0.174	0.188	0.042
Hill	0.516	0.571	0.385	0.379	0.444
Terai	0.363	0.356	0.441	0.433	0.514
Head's education	1.914	3.102	0.812	0.643	2.319
Head's age	44.70	45.47	44.89	45.18	42.24
No. of adults	3.220	3.354	3.303	3.358	2.806
No. of children 10-14	0.753	1.408	1.524	1.523	1.528
No. of children 0-18	2.757	3.505	4.003	4.040	3.667
Family size	5.977	6.859	7.305	7.399	6.472
Total consumption[a]	49,053	61,789	39,062	37,434	53,579

Note: [a] Annual household total consumption is in rupees.

Table 2. Means of Children Working Hours by Quitile of Household Total Consumption and by Working Activity

Quitile	NLSS	With working children	With working children	
			self-employed in agric.	not self-employed in agric.
No. of observation	3,373	714	642	72
1st	242	1,297	1,311	1,183
2nd	403	1,404	1,386	1,666
3rd	284	1,181	1,164	1,376
4th	239	1,113	1,104	1,196
5th	112	870	812	1,095

Table 3. Relevant Characteristics of Subsistence and Non Subsistence Farm Households as Child Labour Varies

Variable	Farm Households	Non Subsistence	Subsistence		
				without working children	with working children
No. of observations	2,380	1,600	780	615	165
			Farm Characteristics		
Total costs	30,668	37,003	17,672	18,649	14,032
Total hectares	0.983	1.123	0.698	0.666	0.819
Adult working hours	3,428	3,637	3,000	2,802	3,736
Child working hours	280	281	278	0	1317
Sharecropping	0.181	0.211	0.119	0.112	0.145
Subsistence	0.328	-	-	-	-
			G eographical Location		
Eastern	0.216	0.246	0.154	0.154	0.152
Central	0.316	0.339	0.268	0.276	0.236
Western	0.207	0.193	0.237	0.263	0.139
Mid-West	0.129	0.134	0.119	0.104	0.176
Far-West	0.133	0.089	0.222	0.202	0.297
Mountain	0.153	0.133	0.196	0.167	0.303
Hill	0.492	0.466	0.545	0.567	0.461
Terai	0.355	0.402	0.259	0.265	0.236
			F amily Characteristics		
Head's education	1.351	1.622	0.796	1.003	0.024
Head's age	45.14	45.50	44.38	44.32	44.62
No. of adults	3.366	3.443	3.208	3.218	3.170
No. of children 0-18	2.278	2.306	2.222	1.961	3.194
No. of children 10-14	0.807	0.840	0.738	0.540	1.479
Family size	6.397	6.558	6.068	5.807	7.042
Total consumption	39,242	41,118	35,394	36,094	32,783

Note: Total costs and annual household total consumption are in rupees.

Table 4. Summary Statistics of the Variables Used in the Estimation of the Modified Translog Total Cost Function and Input Shares. No. of Observations 2,380

		Mean	Std. Dev.	Min	Max
Lntc	log of total costs	9.574	1.078	5.897	14.638
Lo1	log of cereals and vegetables output	3.980	1.574	0	12.631
Lo2	log of fruit output	1.020	1.976	0	10.602
Lo3	log of milk output	1.026	2.086	0	11.590
Lo4	log of livestock output	0.666	1.464	-1.386	10.491
Sh_hireda	hired labour input share	0.138	0.23	0	0.985
Sh_chem	chemicals input share	0.304	0.263	0.002	0.996
Sh_mater	materials and other input share	0.558	0.324	0.002	0.997
P1l	log of hired labour wage	3.808	2.918	-1.553	8.001
P2l	log of chemicals price	2.259	0.524	0.584	5.299
P3l	log of materials price	6.652	1.372	1.099	12.357
z1	log of adults' on-farm working hours	7.763	1.018	2.303	10.543
z2b	log of children's on-farm working hours	1.623	2.888	0	9.072
z3	log of average of land and capital costs	-0.963	1.287	-5.942	4.118
Terai	dummy: 1 if live in Terai	0.355		0	1
Eastern	dummy: 1 if live in east Nepal	0.216		0	1
Central	dummy: 1 if live in centre Nepal	0.316		0	1
Sharecropping	dummy: 1 if sharecropping contract	0.181		0	1
Subsist	dummy: 1 if subsistence agriculture	0.328		0	1
Adult_agec	age classes of household's head	2.424	0.950	1	4
Adult_edud	household head education	1.539	0.829	1	3
Plough	dummy: 1 if use plough	0.644		0	1
Child_school	dummy: 1 if children go to school	0.632		0	1
Home_produce	dummy: 1 if food is own-produced	0.661		0	1
Food_we	dummy: 1 if consumption is inadequate	0.440		0	1

Notes: All variables refer to the twelve-month period foregoing the date of interview. a 36.97 per cent of the sample employs hired labour either casual or permanent. b 24.70 per cent of the sample employs child labour on the farm. c The classes of head age are: 1 if younger than 30 years old, 2 if between 31 and 45 years old, 3 if between 46 and 60 years old, 4 if older than 60 years old. d The classification of the head education is as follows: 1 if never attended school, 2 if less than five years of school, 3 if more than five years of school. e Home_produc is equal to 1 if more than the 50 per cent of family food consumption is self-produced within the household.

Table 5. Estimates of the Modified Translog Total Cost Function with Three Inputs and Three Quasi-Fixed Factors

Parameter	Coefficient	Std. Error	Parameter	Coefficient	Std. Error
α0	3.275	0.2119	γ21	0.018	0.0033
α1	0.326	0.0603	γ22	0.007	0.0024
α2	0.324	0.0374	γ23	0.008	0.0023
α3	0.255	0.0429	γ24	-0.004	0.0032
α4	0.165	0.0598	1δ*a*	-0.256	0.2085
α11	-0.013	0.0116	2δ*a*	-0.146	0.4191
α12	-0.020	0.0061	3δ*a*	1.813	0.7149
α13	-0.017	0.0058	1δ*c*	-4.649	2.3579
α14	-0.009	0.0108	2δ*c*	0.817	0.3491
α22	-0.026	0.0092	3δ*c*	-3.388	2.3413
α23	-0.005	0.0037	γ*g* 1	0.087	0.0204
α24	-0.015	0.0058	γ*g* 2	0.020	0.0064
α33	-0.028	0.0101	γ*g* 3	0.149	0.0175
α34	-0.006	0.0058	ς1 1	-0.057	0.0108
α44	-0.036	0.0100	ς12	0.029	0.0145
β1	0.245	0.0233	ς13	0.018	0.0121
β2	0.502	0.0221	ς14	0.065	0.0118
β1 1	0.030	0.0024	ς15	0.000	0.0129
β12	0.008	0.0017	ς21	0.079	0.0076
β22	0.057	0.004 1	ς22	-0.048	0.0102
γ1 1	-0.005	0.0040	ς23	0.017	0.0089
γ12	0.009	0.0026	ς24	0.029	0.0096
γ13	0.006	0.0026	ς25	-0.015	0.0097
γ14	-0.004	0.0036	σ1	0.187	0.0158
Mean log-likelihood		-8.5245			

Table 6. Allen Elasticity of Substitution for Hired Labour, Chemicals, and Materials

Hired labour	Chemicals	Materials
-3.807	1.127	0.496
1.127	-1.214	0.614
0.496	0.614	-0.722

Table 7. Marginal Effects of Farm Characteristics and Fixed Factors

Variable	Coefficient
Farm Characteristics	
Terai	-0.290
Eastern	0.185
Central	-0.123
Sharecropping	-0.270
Subsistence Farming	0.075
Fixed Factors	
z1 - Adult labour	0.087
z2 - Child labour	0.020
z3 - Fixed assets	0.149

Table 8. Means of Adults' and Children's shadow wages calculated from the dual side

Variables	$E(w_i^*)$	$E(w_i^*\|z2>0)$	$E(w_i^*\|z2=0, nchl1014>0)$
Adult labour	1.926	1.044	3.226
Child labour		0.683	
Child / Adult ratio		0.654	

Note: The estimated shadow wages are in rupees per hour

Table 9. Contribution of Demographic Attributes of Household Members to the Marginal Cost of Household Labour

Attributes	Percentage
Adults	
Adult_age	-2.223
Adult_edu	-1.267
Plough	15.754
Children	
Child_school	-9.159
Home_produc	1.609
Food we	-6.675

Table 10. Poverty and Inequality Simulation as Child Labour Varies

	NLSS	Farm Households	Farm Households		
			Without working children	with working children	
				actual data	simulation
No. of observations	3,373	2,380	1,792	588	
			Poverty indexes		
Headcount ratio	34.450	39.580	35.547	51.871	65.136
Poverty gap ratio	9.763	11. 148	9.72 1	15.495	23.497
FGT index (0.5)	17. 168	19.641	17.382	26.524	37.369
FGT index (1.5)	6.009	6.862	5.909	9.766	15.64
FGT index (2.0)	3.904	4.466	3.806	6.479	10.846
Sen index	13.321	15.258	13.327	21.077	30.608
			Inequality indexes		
Relative mean deviation	0.345	0.252	0.253	0.232	0.232
Coefficient of variation	1.223	0.834	0.840	0.725	0.725
Standard deviation of logs	0.772	0.607	0.611	0.560	0.560
Gini coefficient	0.466	0.351	0.353	0.323	0.323

Note: The annual per capita poverty line is set at 4,404 rupees.

APPENDIX B: ESTIMATION OF SHADOW WAGES FROM THE PRIMAL SIDE

One of the main contribution of this work is the specification of a modified cost function modelling the quality differences between adult and child labour. This approach has been explained in Section 3 and implemented in Section 4. As a means to control the experiment developed in Section 4, this appendix measures the marginal product of family labour from the estimation of the primal side production. The empirical exercise consists in estimating a production function in order to derive shadow wages of adults and children directly from the marginal agricultural productivity. Note that the production estimation does not allow for an explicit distinction of fixed and variable factors. By considering fixed factors as if they were variable, we implicitly assume that there is not a shadow wage, but a market wage, in the dual side. We now explore whether this inconsistency has important practical consequence.

For convenience, the production function is assumed to have a Cobb-Douglas functional form "demographically modified" *a la* Barten (1964):

$$\ln y = \alpha + \sum_{i=1}^{5} \varsigma_i d_i + \beta_a \ln\left(z_a^*\right) + \beta_c \ln\left(z_c^*\right) + \sum_{i=1}^{4} \gamma_i \ln x_i + \varepsilon,$$

where ln$y$ is the log of the value of total production and ε is a spherical error term. $z_a^* = z_a\theta_a(d)$ and $z_c^* = z_c\theta_c(d)$ are linear function in the logarithms, where the set of adult demographic variables $\theta_a(d) = \exp\left(\sum_i \delta_i d_i^a\right)$ comprises age classes and education of the head and the information whether ploughs are used in farm activities. The set of demographic characteristics of children, $\theta_c(d) = \exp\left(\sum_i \delta_i d_i^c\right)$ is formed by a dummy whether children go to school, a dummy equals to one if more than the 50 per cent of household food consumption is self-produced within the family, and a dummy taking the value of one if the household considers inadequate the level of consumption of its members. The notation x_i denotes the quasifixed factor land and capital and the three variable inputs: hired labour, materials, and chemicals. The shadow wages associated with the Cobb-Douglas specification of the production function is

$$w_i^* = \hat{\beta}_i \frac{y}{z_i},$$

where $\hat{\beta}_i$ is the coefficient associated with z_i, y and z_i are the values of total production and adult or child labour, respectively, evaluated at the mean.

Table A. 1 presents the nonlinear estimates of the production function. The marginal effects on ln$y$ of the three variable factors, family labour and land, are positive and significantly

different from zero at the 1 per cent level in the case of adult labour and land. However, magnitude of the parameter associated with child labour is smaller.

Table A.1 Parameter Estimates of Nonlinear Cobb-Douglas Production Function

Variable	Coefficient	Std. Error*
Constant	6.538	0.217
Terai	0.148	0.043
Eastern	0.283	0.042
Central	0.051	0.051
Sharecropping	0.025	0.056
Subsist.	-0.433	0.042
Z1 - Adult Labour	0.165	0.022
Head_age	0.039	0.009
Head_education	0.652	0.160
Plough	1.989	0.439
Z2 - Child Labour	0.019	0.007
Child study	1.835	2.837
Home_produc	1.838	1.350
Food_adequacy	3.472	6.924
Z3 - Fixed Assets	0.206	0.020
Sh_hired	0.023	0.010
Sh_chem	0.096	0.014
Sh_mater	0.082	0.015

Note: *Standard errors are bootstrapped.

As a consequence, the contribution of children to the agricultural production is relatively modest. The input factors, hired labour, chemicals and materials, exhibit statistically significant coefficients. The coefficients of the variables affecting the effort supplied by family workers and, in turn, the effective shadow wage are all positive and statistically significant. If we concentrate our attention on the effect of the demographic characteristics of children, we can observe that none of them is statistically significant.

Table A.2 Means of Adults and Children's Shadow Wages Calculated from the Primal Side

Variables	$E(w_i^*)$	$E(w_i^*\|z2>0)$	$E(w_i^*\|z2=0, nchl1014>0)$
Adult labour	3.316	1.896	5.481
Child labour		0.654	
Child / Adult ratio		0.345	

Note: The estimated shadow wages are in rupees per hour.

Among the three dummies for geographical characteristics only Eastern and Central regions are significantly different from zero at the 1 per cent significance level. Sharecropping is not

significantly different from zero at any conventional level of confidence. The farm characteristic related to the presence of subsistence agriculture has a statistically significant negative effect.

Although the functional forms adopted for the estimation of production and cost function are not directly comparable because the cost function is a translog, the sign of the parameters associated with adult labour, child labour, and fixed assets are the same when comparing the two approaches (Table 5 for the cost function results). In both cases, the estimates associated with these input factors have a positive effect on the dependent variable. The magnitude of the related parameters differs among the

production and cost function estimates. This is especially evident for adult labour that from a value of 0.165 in the production estimate decreases to 0.087 in the cost function. However, the significance levels are generally comparable among the two estimations.

In Table A.2 we report the shadow wages of adults and children calculated under three different conditions: 1) at the unconditional mean of all the variables, $E(w_i^*)$, 2) conditional on positive levels of child labour, $E(w_i^*|z2 > 0)$, and 3) conditional on absence of child labour but in presence of children 10-14, $E(w_i^*|z2 = 0, nchl1014 > 0)$. The shadow wage of adults is always higher than the shadow wage calculated for children. In particular, in presence of child labour, the adults' shadow wage is lower than the other two conditions, indeed it is equal to 1.896 rupees per hour. This outcome seems to bear the initial assumptions that child labour is a consequence of lower family income. If children are not employed in agricultural activities the adult shadow wage increases to 5.481. Controlling then for positive value of child labour, the shadow wage of children is 0.654 rupees per hour and it is similar to the shadow wage calculated from the dual approach. In the NLSS the average of hourly market wage paid at hired workers is about 1.863 rupees and is a support of our computed shadow wages. Finally, the shadow wages estimated from the production side are generally twice as much as the shadow wages estimated from the dual side (Table 8).