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The Collective Household Enterprise Model: An Empirical Analysis*

Martina Menon† and Federico Perali‡

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Abstract

This paper estimates a household model where both the production and consumption sides are observed. The household activities produce both marketable and nonmarketable products. Family members consume market goods, domestically produced goods and leisure. This household equilibrium model is described within a collective framework. The data are from a nation-wide sample of Italian farm-households. The estimation is implemented using a generalized Heckman estimator to account for corner solutions generated by the fact that not all households are engaged in all enterpreneurial activities and do not consume some of all goods and leisure. The identification of the sharing rule stems from the assignability of clothing consumption and leisure.

Key words: Household collective model, household and domestic productions, consumption and leisure, separability.

1 Introduction

This paper estimates a household economy model where both the production and consumption sides are observed. The general equilibrium representation of the farm household is a landmark model in development microeconomics (Singh, Squire and Strauss 1986, Benjamin 1992, Udry 1996, Bardhan and Udry 1999, Jorgenson and Lau 2000, UPDATE). Recently, the farm household model is gaining renewed interest also in more developed societies, because it lends the basic theory to explain the behaviour of household enteprises in general. In the present work, in order to analyze the household as a

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collection of individuals rather than a undifferentiated unitary decision unit, the household farm model is extended to embrace the recent results introduced by Apps and Rees (1988, 1997) and Chiappori (1988, 1992, 1997).

Econometric estimations of the farm model are an effort that has been undertaken since the late 1970s (Lau, Lin, and Yotopoulos 1978, Lau *et al.* 1981) and then abandoned because of the lack of appropriate survey data. The objective of this paper is to take advantage of the availability of a data set of italian farm household incorporating farm level data and information about time use and consumption habits of the rural households. In order to implement the estimation of the household general equilibrium model an empirical issue is the presence of specialized production and consumption responsible for zero realizations. We deal with this problem using an extension of the heckman model that we term generalized Heckman.

The paper contributes to the existing household collective literature in many respects. In Section 2, we show a household collective equilibrium model that takes into account both marketable and nonmarketable productions and consumption-leisure decisions. In general, only one production activity (the nonmarketable) is modelled (Apps and Rees 1997, 2001, Chiappori 1997). The equilibrium of the household economy is supported by separability between production and consumption-leisure decisions making empirical applications tractable.

Section 3 shows the empirical application of the household equilibrium model. The model is estimated within a collective framework allowing the recovery of individual utilities and welfare levels. We estimate recursively the marketable production, the domestic production, and two individual-specific demand systems for three market goods, a domestically produced good and leisure. The estimation of the household production side permits us to test the separability property between production and consumption choices underlying our estimation procedure. Moreover, the individual-specific demand system allows recovering the sharing rule by means of a structural approach developed by Menon and Perali (2010). Information about assignable clothing and leisure consumption is used to estimate the rule governing the distribution of resources within the household.

The estimation is carried out using a sample of Italian farm household described in Section 4. Household data are drawn from the 1995 Survey on Socio-Economic Characteristics of Italian Rural Household (ISMEA). These farm household data have the features required to employ our household collective model. The survey combines information about household and farm characteristics, time use, farm profits, off-farm money income, governmental and intra-household transfers, consumption, and information about the degree of autonomy in decision making by household members.

Section 5 shows that the distribution of power moves toward the woman when her education is higher and the age difference is smaller and the wife having greater independence in deciding whether to work off-farm. In general, the household production, domestic production, and consumption results are coeherent with the theory. We deem that the approach to household behaviour proposed in the paper can provide valuable information for designing appropriate welfare policies in general.

2 The Collective Household Enterprise Model

Each family can be viewed as an *enterprise* producing goods by transforming factors which are in part nonmarket goods. The *enterprise household model* presented in this section is general because it describes the family as involved both in production and in consumption activities. It embraces both urban and rural households in relation to the location of both the household and the entrepreneurial activity. The *enterprise household model* is a miniature equilibrium model where it fully reproduces the characteristics of a macro society at the micro level.

Whether the produced goods are marketable has important implications on the structure of the model. If markets exist, then the production can be sold on the market, or, the same goods and services can be bought on the market at a given price. Because households are price takers for every commodity including labour, production decisions are taken independently from consumption and labour supply decisions. If markets of the domestic good are incomplete, its price is endogenous to household behavior and in general the separation property between production and consumption decisions does not longer hold.[1]

Our model is general also in the sense that the household is represented as a collection of individuals (Chiappori 1988, 1992, 1997). Differently from the unitary approach that considers the family as the basic decision unit with a joint preference structure, collective models describe the family as a group of individuals each of whom is characterized by specific preferences interacting within a collective decision process explaining the rules of intrahousehold allocation of individual consumption and welfare. The intrahousehold allocation process is not directly observable but it can be recovered from available information on the private consumption of exclusive goods or assignable goods (Chiappori 1988, 1992, Chiappori and Ekeland 2009).

The collective approach makes no assumption about the decision process. It only requires that the outcome of the family model is Pareto efficient. Family decisions therefore take place as if it were a two-stage budgeting process. Supposing that the family pool its resources, total household income is then allocated to single members according to a predetermined sharing rule defining the intrahousehold income distribution. It follows that each member, while choosing the most preferred utility maximizing bundle of goods and leisure, faces an individual budget constraint. The collective approach permits recovering

[1] Notice that in both market regimes, the value of labour not employed outside the family is implicit. However, only in the complete market case the value of labour is objectively deducible from the value of the marginal product, while in the case of missing markets the value of labour may be imputed at the opportunity cost (Jenkins and O'Leary 1994, 1995, 1996).

both private consumption and individual welfare functions.

Note that throughout this section superscript i indicates endogenous variables while subscript i indicates exogenous variables. Moreover, to simplify notation, in this section we ignore socio-demographic variables that may affect both production technologies and preferences of the family. Observable heterogeneity will be consider in the empirical section.

2.1 Individual Preferences and Production Technologies

We assume that the family comprises two adult members, denoted by $i = 1, 2$, each of whom has individual preferences over the consumption of an aggregate market good c^i, a domestically produced good z^i, and leisure time l^i. Individual preferences are represented by a strictly quasiconcave and increasing utility function $U^i(c^i, z^i, l^i)$, where it is assumed that individual consumption is purely private. Family members can allocate their time to the labour market at a market wage of w_i. The family faces a market price p_i to buy good c^i.

The family is engaged in the production of both marketable and nonmarketable goods. To distinguish between the two type of products, we term the former household products and the latter domestic products.[2] In the present setting, the household economy is endowed with two technologies describing the production processes of marketable goods and goods that cannot be sold in the market and are entirely consumed within the household. We consider that all family members work both in the household business and in the home activities. The production environnment has no externalities and products are disjoint.

In the case of perfect markets, the implicit valuation of time is the value of the marginal product. if household labour is allocated both in the household enterprise and home production, then consumption and production decisions are separable. profits are exogenous and affect the consumption decision process.

The technology to produce the household product q sold at the market price p_q is represented by a concave and strictly increasing production function with nonincreasing returns to scale

$$q = f\left(h^1, h^2, x_q\right), \tag{1}$$

where h^i is the time supplied by member i to the business activity and x_q is a bought-in market input whose price is p_x. The household product q can be totally or partially sold

[2]Interestingly, while a household may not be engaged in producing marketable goods, it is always involved in household activities. In this sense, all households can be considered as an enterprises. For example, rural households engage in farming, urban households may run a job from home being connected to the workplace through internet, may run an ice-cream factory, or a tailor shop. At the same time, they are all involved in managing and undertaking household activities. However, household technologies employed in producing nonmarket goods can be observed if time use data are also available.

on the market at an exogenous price equal to p_q. In our model we assume that the family does not consume any quantity of the household product.

The domestic technology to produce the good z is represented by a concave and strictly increasing production function

$$z = \left(z^1 + z^2\right) = g\left(t^1, t^2\right), \tag{2}$$

where t^i is the time supplied by member i to produce z. Note that, without loss of generality, the domestic technology is specified in terms of working-time supplied by family members only. This assumption is common to other papers (Apps and Rees 1996, 2001). Because the domestic good is not marketable it is entirely consumed by family members in an unkonwn proportion and both its price and the scale of the domestic activities are unknown. However, a sufficient condition to specify an observable technology comes from the following assumption.

Assumption 1. *(Constant Returns to Scale) We assume that the domestic production function is homogenous of degree one.*

Each member allocates her own time endowment T_i to three different working activities: off-farm labour L^i, household h^i and domestic t^i activities. Thus, the individual time constraint is

$$T_i = L^i + h^i + t^i + l^i, \tag{3}$$

with $L^i, h^i, t^i, l^i > 0$ for all $i = 1, 2$. Matteazzi, Menon, and Perali (2010) extend this enterprise household collective model to the cases of individual specialization to on-farm labour and domestic works and, therefore, the contraint $L^i \geq 0$ is introduced in the structure of the model.

The family faces a linear budegt constraint

$$\sum_{i=1,2} p_i c^i = \sum_{i=1,2} w_i L^i + y + p_q q - p_x x_q, \tag{4}$$

where y is non-labour family income assumed to be exogenously. Measuring the total value of individuals' time, the budget constraint can be written in terms of family full income

$$\sum_{i=1,2} p_i c^i + \sum_{i=1,2} w_i l^i = \sum_{i=1,2} w_i T_i + y + p_q q - \sum_{i=1,2} w_i h^i - p_x x_q - \sum_{i=1,2} w_i t^i, \tag{5}$$

where $\pi = p_q q - \sum_{i=1,2} w_i h^i - p_x x_q$ is the profit function of household production activity, and $TC = w_1 t^1 + w_2 t^2$ are the total costs faced by the family to produce the domestic good z.

2.2 The Centralized Equilibrium Model

Within a collective framework (Browning and Chiappori 1998), the family makes Pareto-efficient production and leisure-consumption decisions maximizing the welfare function

$$\max_{c^1,z^1,l^1,c^2,z^2,l^2,q,h^1,h^2,t^1,t^2,x_q} \mu U^1(c^1,z^1,l^1) + (1-\mu)\, U^2(c^2,z^2,l^2), \tag{6}$$

where the Pareto weight μ is a function that captures the bargaining power of individuals and in general depends on prices and non-labour income, subject to the following three constraints

$$q = f\left(h^1, h^2, x_q\right), \tag{7}$$

$$z = z^1 + z^2 = g\left(t^1, t^2\right), \tag{8}$$

$$\sum_{i=1,2} p_i c^i + \sum_{i=1,2} w_i l^i = \sum_{i=1,2} w_i T_i + y + p_q q - \sum_{i=1,2} w_i h^i - p_x x_q - \sum_{i=1,2} w_i t^i. \tag{9}$$

From the first-order conditions, in equilibrium the market price p_q of the household product q is equal to the ratio of the Lagrange multipliers assocated with the household technology (7) and the budget constraint (9)

$$p_q = \frac{\lambda_q}{\delta}, \tag{10}$$

and the equilibrium conditions of the household input factors are

$$p_q \frac{\partial f}{\partial h^i} = w_i, \tag{11}$$

$$p_q \frac{\partial f}{\partial x_q} = p_x, \tag{12}$$

they show that in equilibrium the optimal level of inputs is determined by equality between the marginal value products and their market prices. Equations (11) and (12) together with household technology (7) are sufficient to derive the optimal household production decisions

$$\tilde{q} = q\left(p_q, w_1, w_2, p_x\right), \tag{13}$$

$$\tilde{x}_q = x_q\left(p_q, w_1, w_2, p_x\right), \tag{14}$$

$$\tilde{h}^i = h^i\left(p_q, w_1, w_2, p_x\right), \qquad i = 1, 2. \tag{15}$$

On the other hand, the first-order conditions of the domestic production are

$$\frac{\lambda_z}{\delta} \frac{\partial g}{\partial t^i} = w_i, \qquad i = 1, 2. \tag{16}$$

Note that when the output's market is missing, from the first-order conditions we do not have relationship (10). This implies that the price of the domestic good is *shadow* and equal to the ratio of the Lagrange multipliers $\frac{\lambda_z}{\delta}$. In general, because of this result the domestic decisions are affected by family preferences and therefore the separation property between production and leisure-consumption choices fails to hold. However, the following proposition shows a sufficient condition for the separation to hold even though the price of the domestic product is endogenous to family preferences and the decision process μ.

Proposition 1. *When markets of the domestic goods are missing, given Assumption 1 the implicit price p_z^* of the domestic good is not affected by preferences and the decision process μ of the family.*

Proof. A crucial implication of technologies with constant returns to scale is that the corresponding minimum cost is a function linear in the output, that is

$$\widetilde{TC} = TC\left(w_1, w_2, z\right) = P_z\left(w_1, w_2\right) \sum_{i=1,2} z_i. \tag{17}$$

In equilibrium we define the implicit price p_z^* of the domestic good as the marginal cost of producing the domestic good

$$p_z^* \triangleq \frac{\partial TC\left(w_1, w_2, z\right)}{\partial z_i}, \tag{18}$$

that given equation (17) it reduces to

$$p_z^* = P_z\left(w_1, w_2\right), \tag{19}$$

where $P_z\left(w_1, w_2\right)$ is a unit cost function that is independent of the production scale. □

This result is a sufficient condition for the separation property to hold when markets of the domestic goods are absent. Another feature of this result is that the implicit price p_z^* is the same for both family members. This follows from assuming production technologies of the form $z^1 + z^2 = g(t^1, t^2)$. By standard economic theory, in equilibrium marginal costs are equal to the Lagrange multipliers and in equation (16) $\frac{\lambda_z}{\delta}$ can be opportunely replaced with the implicit price of the domestic good p_z^*.

Given Proposition 1, equation (16) becomes $p_z^* \frac{\partial g}{\partial t^i} = w_i$ yielding the input factor demands

$$\tilde{t}^i \quad = \quad t^i\left(w_1, w_2, z\right), \qquad i = 1, 2, \tag{20}$$

that are function of market wages and a given output level z.

The equilibrium conditions of the individual leisure-consumption decisions are

$$\frac{U^i_{l^i}}{U^i_{c^i}} = \frac{w_i}{p_{c^i}}, \tag{21}$$

$$\frac{U^i_{z^i}}{U^i_{c^i}} = \frac{p_z^*}{p_i}, \tag{22}$$

that along with the linear budget constraint

$$\sum_{i=1,2} w_i T_i + y + \pi\left(p_q, w_1, w_2, p_x\right) - p_z^* \sum_{i=1,2} z_i - \sum_{i=1,2} p_i c^i - \sum_{i=1,2} w_i l^i = 0, \tag{23}$$

where the minimum cost function $\widetilde{TC} = p_z^* \sum_{i=1}^{2} z_i$ and the optimal profits $\pi(p_q, w_1, w_2, p_x)$ have been substituted, we obtain the optimal solution of the leisure-consumption choices

$$\widetilde{c}^i = c^i(p_1, p_2, p_z^*, w_1, w_2, y, \mu), \tag{24}$$

$$\widetilde{z}^i = z^i(p_1, p_2, p_z^*, w_1, w_2, y, \mu), \tag{25}$$

$$\widetilde{l}^i = l^i(p_1, p_2, p_z^*, w_1, w_2, y, \mu), \tag{26}$$

for the family members $i = 1, 2$. To summarize, in this section we show that production and leisure-consumption choices are separable even though markets for the domestic good are missing. In the case of missing markets for the separation property to hold a sufficient condition is that household technology exhibits constant returns to scale. The implication is that the household equilibrium model can be solved recursively in two stages. In the first stage, the household will decide the optimal time devoted to the production activities, then it will decide the optimal consumption of the market goods, leisure and domestic goods.

2.3 The Decentralized Equilibrium Model and Double Separability

In general, in the unitary farm household model the separability property is limited to the space of production and consumption decisions made at the household level. Differently, in collective model the separability property extends to consumption decisions as well. In particular, in collective models there exists separability between consumption choices of family members. We introduce a definition of the separability property accounting for the collective framework of our model.

Definition 1. *(Double Separability) In the context of collective models with production and consumption decisions, if markets are competitive, individual preferences and technologies are convex, and given a redistributive rule ϕ of household resources between family members such that the sum of the individual income transfers satisfies the total household income, then the optimal solution $\left(\tilde{q}, \tilde{x}_q, \tilde{h}^i, \tilde{t}^i, \tilde{c}^i, \tilde{z}^i, \tilde{l}^i\right)$ with i=1,2 of the Pareto farm household collective model (6) can be obtained by solving recursively the following optimal problems*

1. *First, the household makes production decisions by maximizing profits subject to technology constraints independently of consumption-leisure decisions;*

2. *Secondly, given an income transfer, each individual makes consumption-leisure decisions by maximizing her individual utility function subject to an individual budget constraint.*

In Definition 1, the first point refers to the traditional concept of separability between production and consumption within farm household model, while the second point is specific to collective models and is independent of modelling production together with consumption. Note that competitive markets are a sufficient condition for the separability between production and consumption to hold, Proposition 1 shows that separability is maintained even when markets are imperfect or missing.

Therefore, by Definition 1, first the family decides about the production activities. In our model there are two specific production decisions. In particular, the optimal household production is derived by the maximization of the profit function

$$\max_{q,h^1,h^2,x_q} \quad \pi = p_q q - w_1 h^1 - w_2 h^2 - p_x x_q \tag{27}$$

subject to the techonology constraint $q = f\left(h^1, h^2, x_q\right)$. The first-order conditions for this problem can be written as

$$p_q \frac{\partial f}{\partial h^i} = w_i, \quad i = 1, 2, \tag{28}$$

$$p_q \frac{\partial f}{\partial x_q} = p_x, \tag{29}$$

yielding the optimal output supply $\bar{q} = q\left(p_q, w_1, w_2, p_x\right)$ and input factors demands $\bar{x}_q = x_q\left(p_q, w_1, w_2, p_x\right)$, $\bar{h}^i = h^i\left(p_q, w_1, w_2, p_x\right)$ for $i = 1, 2$, with profits equal to $\bar{\pi} = \pi\left(p_q, w_1, w_2, p_x\right)$. Note that within farm household models profits stemming from marketable production activities generate real (positive or negative) flows of net income to the family. In other words, here profits are not a concept of imputed or shadow income.

Given Proposition 1, even though the market of z is missing, also the domestic production choices are separable from the consumption-leisure decisions. Differently from the case of marketable household good q, here the family has a cost minimizing behaviour. This evidence clearly appears in the budget constraint of program (6). Thereby, the family decides the input factor demands by solving the following constrained program

$$\min_{t^1,t^2} \quad TC = w_1 t^1 + w_2 t^2, \tag{30}$$

subject to $z = z^1 + z^2 = g(t^1, t^2)$. The first-order conditions of this problem are

$$\bar{\lambda}_z \frac{\partial g}{\partial t^i} = w_i, \qquad i = 1, 2. \tag{31}$$

where $\bar{\lambda}_z$ is a Lagrange multiplier, that yield the optimal factor inputs $\bar{t}^i = t^i\left(w_1, w_2, z\right)$ for $i = 1, 2$. Substituting these two equations into the objective function we derive the minimum cost function $\overline{TC} = \sum_{i=1}^{2} w_i t^i (w_1, w_2, z) = p_z^* \sum_{i=2}^{1} z_i$. Because the domestic good is nonmarketable, the costs bear by the family to produce z are interpreted as implicit costs.

The double separability property comes from the fact that in collective models, given an appropriate allocation of household resources, the Pareto optimum consumption-leisure model (6) can be decentralized into two individual consumption-leisure problems. Individuals agree on an unspecified rule to allocate nonlabour income and profits, then each individual solves the following problem

$$\max_{c^i, z^i, l^i} \quad U^i(c^i, z^i, l^i), \tag{32}$$

$$\text{subject to} \quad p_i c^i + p_z^* z^i + w_i l^i = w_i T_i + \phi_i \left(p_1, p_2, w_1, w_2, y + \bar{\pi}\right),$$

where ϕ_i is the sharing rule function with $\phi_1 = \phi \left(p_1, p_2, w_1, w_2, y + \bar{\pi}\right)$ and $\phi_2 = \phi_1 - \left(y + \bar{\pi}\right)$. Notice that family members decide the allocation among them of nonlabour income and optimal profits. As a consequence of this result, the sharing rule changes also because of changes in profits (Matteazzi, Menon, and Perali 2010).

The efficient conditions of the individual consumption-leisure choices are

$$\frac{U^i_{l^i}}{U^i_{c^i}} = \frac{w_i}{p_i}, \tag{33}$$

$$\frac{U^i_{z^i}}{U^i_{c^i}} = \frac{p_z^*}{p_i}, \tag{34}$$

and substituting back into the budget constraint we get the set of optimal demands

$$\bar{c}^i = c^i(p_i, p_z^*, w_i, \phi_i \left(p_1, p_2, w_1, w_2, y + \bar{\pi}\right)), \tag{35}$$

$$\bar{z}^i = z^i(p_i, p_z^*, w_i, \phi_i \left(p_1, p_2, w_1, w_2, y + \bar{\pi}\right)), \tag{36}$$

$$\bar{l}^i = l^i(p_i, p_z^*, w_i, \phi_i \left(p_1, p_2, w_1, w_2, y + \bar{\pi}\right)). \tag{37}$$

Note that by letting $\bar{\lambda}_z = \frac{\lambda_z}{\delta}$, we have a one-to-one correspondence between (28-29), (31), (33-34), and (11-12), (16), (21-22). Therefore, any solution to problems (27), (30), and (32) is a solution to the Pareto problem (6), and vice versa. In the following sections we estimate the enterprise household model presented in this section. The empirical estimation of the model is based on the double separability condition. Consequently, the proposed empirical procedure is based on estimating separately production from consumption-leisure variables and, then, consumption-leisure decisions are estimated for each household member independently from each other.

3 The Econometric Specification

Under separability, the equilibrium problem 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. The separation between production and consumption decisions is ensured by the household rational behavior in presence of complete markets. Recent empirical works (Benjamin 1992, Udry 1998, Pavoni and Perali 2000) show that production decisions do depend on farmers' preferences and endowments. The jointness 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.

The household economy is described by specifying a technology for the marketable and nonmarketable production and the individual consumption of goods bought on the market, of domestic product and of leisure. We rule out the possibility of family consumption of the marketable household product. The sharing rule is estimated using a structural approach exploiting the assignability of both the individual expenditure of clothing and leisure. We first present the empirical specification of the production side of the household economy and then its consumption side.

3.1 The Production Side of the Enterprise Household Economy

We specify a restricted short-run cost function with two quasi-fixed factor, family labor and land structure and capital. By specifying family labour as a quasi-fixed factor, we do not have 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. In doing so, we can derive the implicit wage of the on-farm family labour supply and testing for the hypothesis of separability between production and consumption decisions underlying our theoretical household model. Moreover, by separating hired and family labour it implies that we need to model a censoring process also on the input side for the hired labour.

3.1.1 Household Production and the Implicit Value of On-Farm Family Labour

Cost functions can be used to measure the features of the adopted technology and the impact of agents' behaviour as input or output prices change. The welfare impact can be different depending on the exogenous characteristics of the farm household. The modified cost function of the household production C_q can be written as:

$$C_q(p_x, q, \bar{h}, d_q) = \min_{x_q, h} \left\{ p_x' x_q | \; q = f\left(h, x_q; d_q\right), \; \bar{h} = h \right\}, \tag{38}$$

where p_x is a n-vector of input prices, x_q is an n-vector of bought-in market inputs, h is a k-vector of quasi-fixed factors, q is an m-vector of predetermined levels of outputs, and d_q is an l-vector of exogenous characteristics of the farm-family workers, f is a transformation fuction with the usual properties. The quasi-fixed factors are on-farm family labour supply, capital, and land.

We estimate a system composed by a restricted translog cost function with four outputs - crop, livestock, milk, and fruit olives and grapes - three variable inputs - materials, chemicals, and hired labour - and three quasi-fixed factors - family labour h_1, land h_2 and capital h_3 - modified with a translating function to accomodate 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

$$\begin{aligned} \ln C_q &= \alpha_0 + \sum_{i=1}^{4} \alpha_i \ln q_i + \sum_{r=1}^{3} \beta_r \ln p_{xr} + \gamma_1 \ln \left(h_1 \theta(d_\theta)\right) + \gamma_2 \ln h_2 + \gamma_3 \ln h_3 + \\ &+ 0.5 \sum_{i=1}^{4} \sum_{j=1}^{4} \alpha_{ij} \ln q_i \ln q_j + 0.5 \sum_{r=1}^{3} \sum_{s=1}^{3} \beta_{rs} \ln p_{xr} \ln p_{xs} + \sum_{r=1}^{3} \sum_{i=1}^{4} \gamma_{ri} \ln p_{xr} \ln q_i + \\ &+ \sum_{r=1}^{3} \sum_{k=1}^{3} \tau_{rk} \ln p_{xr} \ln d_{qk} + \sum_{r=1}^{3} \sum_{j=1}^{3} \rho_{rj} \ln p_{xr} \ln h_j + \varepsilon_q, \end{aligned} \tag{39}$$

where p_{xr} is the market price of the r-th input x_q, and ε_q is the error term assumed to be independent and identically distributed. The scaling demographic function

$$\theta(d_\theta) = \exp\left(\textstyle\sum_{j=1}^{3} \delta_j d_{\theta j}\right) \tag{40}$$

is specified as linear in the logarithm function of the exogenous characteristics d_θ. The set of demographic characteristics transforming family work includes age and education of household head and family labour per hectare.

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

$$s_r = \beta_r + \sum_{k=1}^{3} \tau_{rk} \ln d_{qk} + \sum_{j=1}^{3} \rho_{rj} \ln h_j + \sum_{s=1}^{3} \beta_{rs} \ln p_{xs} + \sum_{i=1}^{4} \gamma_{ri} \ln q_i + \varepsilon_{qr}, \tag{41}$$

where $s_r = -\frac{p_x' x_q}{C_q} = -\frac{\partial \ln C_q}{\partial \ln p_x}$ is the share of the r-th input in costs. Homogeneity of degree one in p_x of the cost function implies the following parametric restrictions

$$\sum_{r=1}^{3} \beta_r = 1, \quad \sum_{r=1}^{3} \gamma_{ri} = \sum_{r=1}^{3} \beta_{rs} = \sum_{r=1}^{3} \tau_{rk} = 0 = \sum_{r=1}^{3} \rho_{rj} = 0, \tag{42}$$

and symmetry

$$\alpha_{ij} = \alpha_{ji}, \beta_{rs} = \beta_{sr} \tag{43}$$

are imposed as maintained hypothesis.

Implicit wage of on-farm family labour and a test for separability The exogenous characteristics, such as wages, prices, nonlabour income, of the farm household affect both the production and consumption sides of the micro economy. Within the theory of the enterprise households this is an interesting feature since it permits testing the separability hypothesis between production and consumption-leisure decisions (Benjamin 1992, Jacoby 1993, Le 2010, Udry 1996). We test the hypotehsis of separability by comparing the effective shadow wage of on-farm labour supply with the competitive market wage of hired labour.

The derivation of the implicit wage for the on-farm labour supply is as follows. From the equilibrium conditions of problem (38), the value of the marginal product of family labour is equal to the corresponding Lagrange multiplier

$$\delta = \frac{\partial f}{\partial h} p_q, \tag{44}$$

where the Lagrange multiplier δ can be interpreted as the implicit wage of family labour w^*. Then, if farm households are minimizing costs, in equilibrium we have

$$\frac{\partial C_q \left(p_x, q, \bar{h}, d_q, d_\theta\right)}{\partial \bar{h}_1} = \mathcal{L}_{\bar{h}_1} = \delta, \tag{45}$$

and, therefore, equation (44) can be expressed as

$$w^* = \frac{\partial C_q \left(p_x, q, \bar{h}, d_q, d_\theta\right)}{\partial \bar{h}_1}, \tag{46}$$

where the implicit wage of family labour is obtained by differentiating total costs with respect to the level of the quasi-fixed factor.

Calculating the implicit price of all the quasi-fixed inputs, we potentially can derive the *augmented* cost function[3] of the farm household $\hat{C}_q$ as

$$\hat{C}_q(p_x, q, \bar{h}, d_q, d_\theta) = C_q \left(p_x, q, \bar{h}\left(p_x, w^*, q\right), d_q, d_\theta\right) + w^* \bar{h}\left(p_x, w^*, q\right) = C_q + \frac{\partial C_q}{\partial \bar{h}} \bar{h}. \tag{47}$$

The economic interpretation of this equation is that the total farm costs are obtained by summing up the *imputed* cost of the quasi-fixed inputs $w^* \bar{h}\left(p_x, w^*, q\right)$ to the short-run total costs $C_q\left(\cdot\right)$.

Using equation (39), the implicit wage of family labour is derived as the marginal effect of a long-run change in fixed factors on total costs

$$w^* = \frac{\partial C_q(p_x, q, \bar{h}, d_q, d_\theta)}{\partial \bar{h}_1} = \frac{\partial \ln C_q(p_x, q, \bar{h}, d_q, d_\theta)}{\partial \ln \bar{h}_1} \frac{C_q}{\bar{h}_1} = \left(\gamma_1 + \sum_{k=1}^{3} \rho_{rj} \ln p_{xr}\right) \frac{C_q}{\bar{h}_1}, \tag{48}$$

where C_q and h_1 are total costs and family on-farm working hours, respectively. Given the functional form of the total costs, we can also perform the marginal effect of demographic

[3]The *augmented* cost function is the dual concept of the purefied profit function analysed by Paris (1989).

characteristics on total costs

$$\frac{\partial C_q(p_{x_q}, q, \bar{h}, d_q, d_\theta)}{\partial d_{\theta j}} = \frac{\partial \ln C_q(p_{x_q}, q, \bar{h}, d_q, d_\theta)}{\partial d_{\theta j}} C_q = (\gamma_1 \cdot \delta_j)\, C_q. \tag{49}$$

which allow deriving the effective shadow wage of family labour

$$w_e^* = w^* + \frac{\partial C_q(p_x, q, \bar{h}, d_q, d_\theta)}{\partial d_{\theta j}} \tag{50}$$

that is obtained by summing up the effective shadow wage with the total contribution to the marginal productivity of labour provided by the characteristics of the worker.

3.1.2 Domestic Production

The observability of domestic production requires that at least some of the inputs employed in the household technology are observed. Time use data report information on the allocation of time between the different household activities and leisure. In this setting, leisure is no longer defined as the complement of hours of work. When the household product is not marketable, as is the case of family activities undertaken within the household, both the price of the output good is unknown and the scale of the activities is often unknown so the necessary condition to specify an observable technology comes from the assumption of constant returns to scale. When the domestic product cannot be sold on the market, the price is endogenous and specific to each household.

The shadow price of the domestic good can be determined from the production side of the domestic-household model. Considering that we do not know the level of the aggregate domestically produced good z, we assume that the domestic production function has constant returns to scale and is linearly homogeneous. It follows that returns equal costs, $p_z z = \sum_{i=1}^{3} w_i t^i$, and the cost function is homothetic $TC(w_1, w_2, w_3, z, d_z) = P_z(w_1, w_2, w_3, d_z)z$. Therefore, the shadow price of the domestic good equals the unit cost function $p_z = P_z(w_1, w_2, w_3, d_z)$ and depends on wages of the husband w_1, wives w_2, other household components w_3, and household characteristics d_z.

The household program consists in minimizing the following domestic cost function TC

$$TC(p, w, d_h, d_f) = \min_t \{w't \mid z = g(t; d_z)\}. \tag{51}$$

We assume that the domestic cost function takes the translog functional form. The unit cost function can be recovered from the estimates of the share equations associated with the cost of time allocated to domestic production by each family member as follows

$$\frac{w_i t^i}{\sum_i w_i t^i} = a_i + \sum_l a_l d_z^l + \sum_j a_{ij} \ln w_j, \quad i, j = 1, ..., 3. \tag{52}$$

The shadow price of the domestic good can then be computed as the exponent of the unit cost function

$$\begin{aligned} p_z^* &= P_z\left(w_1, w_2, w_3, d_z\right) = && (53) \\ &= \exp\left(a_0 + \sum_i \sum_l a_{li} d_z^l \ln w_i + \sum_i a_i \ln w_i + 0.5 \sum_i \sum_j a_{ij} \ln w_i \ln w_j\right) + \varepsilon_z, \end{aligned}$$

where ε_z is the error term assumed to be independent and identically distributed. As pointed out by Chiappori (1997), this aspect is critical for identification of the sharing rule. Functionally different parametric structural models may be consistent with the same reduced form, thus revealing an identification problem. Because of this, the price of the domestic product has been instrumented and the sharing rule can be recovered also in presence of nonmarketable domestic production (Rapoport, Sofer, Solaz 2003).

3.2 The Consumption Side of the Enterprise Household Economy

The household consumes four market goods aggregated into food, clothing for the male, clothing for the female and other goods, the domestic product and leisure. The assignability of clothing and leisure is the source of identification of the sharing rule.

3.2.1 Individual-Specific Demand Systems and the Sharing Rule

The chosen structure of individual preferences taking the Gorman polar form (PIGLOG?) is linear in individual full income Y_i and is demographically transformed using the translating technique (Pollak and Wales 1971). The associated indirect utility function for individual $i = 1, 2$ is

$$V^i(P_{ik}, Y_i; d_i, d_f) = \frac{\ln \phi_i\left(\xi, Y_i\right) - \ln \wp_i^T(d_i, P_{ik}) - \ln A_i(P_{ik})}{B_i(P_{ik})}, \tag{54}$$

where $P_{ik} = \{p_i, p_z, w_i\}$ is the set of prices for three market composite goods c^i, the domestic good z^i, and leisure l^i differentiated by individual i which is indexed by $k = \{c^i, z^i, l^i\}$ and $\ln \wp_i^T = \sum_k t_{ik}(d_i) \ln(P_{ik})$ is the individual specific fixed cost component associated with the demographic characteristics. The traslating demographic function $t_{ik}(d_i)$ is specified for empirical convenience as $t_{ik}(d_i) = \sum_n \tau_{ikn} \ln(d_{in})$ for the set of demographic characteristics for each individual i, $d_i = (d_{i1}, ..., d_{iN})$. Part of the heterogeneity across households is captured by the variables describing the number of children, two region dummies, and (years?) education of the wife. The function $\phi_i(\xi, Y_i)$ is the sharing rule where Y_i is the individual full income, and ξ is a set of variables explaining the decision process within the family. These variables in general are the exogenous prices entering the budegt constraint and distribution factors d_f. Distribution factors affect the decision process without influencing preferences or the budget constraint. In the estimation we use the information about the degree of independence of the wife in making decisions about her off-farm employment, family nonlabuor income, wife and husband age and education ratio as distribution factors.

The price indexes $A_i(P_{ik})$ and $B_i(P_{ik})$ take the translog and Cobb-Douglas form, respectively,

$$\ln A_i(p_i, p_z, w_i) = \ln A_i(P_{ik}) = \alpha_{i0} + \sum_{k=1}^{K} \alpha_{ik} \ln P_{ik} + \frac{1}{2} \sum_{r=1}^{R} \sum_{k=1}^{K} \nu_{ikr} \ln P_{ir} \ln P_{ik}, \quad (55)$$

$$B_i(p_i, p_z, w_i) = B_i(P_{ik}) = \beta_{i0} \prod_{k=1}^{K} P_{ik}^{\beta_{ik}}. \quad (56)$$

Roy's identity yields the following system of modified share equations

$$s_{ik} = \alpha_{ik} + t_{ik}(d_i) + \sum_{r=1}^{R} \nu_{ikr} \ln P_{ir} + \beta_i \ln \left(\frac{\phi_i^* (\xi, Y_i, d_i)}{A_i(P_{ik})} \right) + \varepsilon_{ik}, \quad (57)$$

where $s_{ik} = P_{ik} k^i / Y_i$, $\phi_i^* = \phi_i(\xi, Y_i) - \sum_k t_{ik}(d_i) \ln(P_{ik})$, and ε_{ik} is the error term assumed to be independent and identically distributed.

For the sharing rule we assume the following structural form[4]

$$\phi_i(\xi, Y_i) = Y_i m(\xi), \quad (58)$$

such that $\phi_i(\cdot) + \phi_j(\cdot) = Y$,[5] and therefore $\phi_j(\cdot) = Y - \phi_i(\cdot)$, where Y is the household full income. The sharing rule represents the household income transfer to individual i. In the context of consumer behaviour, the sharing rule defines the opportunity set bounding consumer choices of each family member. Equation (58) can be interpreted as the *shadow* full income of individual i. It is shadow in the sense that one cannot correctly observe the intrahousehold transfer to member i. The function $m(\cdot)$ acts as a scaling function of individual full income capturing the size of the intrahousehold transfers. Notice that for $Y - Y_i m > 0$, then $0 < m \leq Y/Y_i$.

For the budget shares (57) to be derived from rational preferences, in addition to the usual conditions of adding-up, homogeneity and symmetry, the following restriction on the scaling function $m(\cdot)$ is in order.[6]

Proposition 2. *The scaling function $m(\cdot)$ is homogeneous of degree zero in all its monetary arguments*

Proof. Let $\hat{Y}_i = \hat{\phi}_i \left(\xi, \bar{U}_i \right) = Y_i m(\xi)$ be the cost function of individual i corresponding to the minimum expenditure necessary to attain utility level $\bar{U}_i$ at some price vectors ξ.

[4] The structural form used for the sharing rule is analogue to the definition of Barten prices. Differently, here individual income (rather than prices) interacts with exogenous variables capturing the bargaining power of household members.

[5] In order to guarantee this adding-up restriction in the logarithms, let $\ln Y_i = \omega_i \ln Y$ be the logarithm of i full income, where $\omega_i = \frac{Y_i}{Y}$ with $\sum_{i=1,2} \omega_i = 1$. Defining the sharing rule in log terms as $\ln \phi_i = \ln Y_i + \ln m(\cdot)$, and $\ln \phi_j = \ln Y_j - \ln m(\cdot)$, then $\ln \phi_1 + \ln \phi_2 = \ln Y$ is fullfilled.

[6] To our knowledge Chiuri and Simmons (1997) is the only other paper arguing that the sharing rule is homogenous of degree one.

For $\hat{\phi}_i(\cdot)$ to be a legitimate cost function homogeneuos of degree one, the multiplicative scaling function $m(\cdot)$ must be homogenous of degree zero in all its arguments (or just in the monetary variables?) . □

It is worth remarking that the demand systems of the two individuals have in common only the set of parameters of the scaling function $m(\cdot)$, and therefore the two systems of share equations are estimated jointly. Estimation of the parameters of the scaling function $m(\cdot)$ is achieved by means of this joint estimation procedure.[7] For the scaling function $m(\xi)$, we choose a Cobb-Douglas form

$$m(\xi) = \prod_{j=1}^{J} \xi_j^{\sigma_j}, \tag{59}$$

where $\xi_j = (w_1, w_2, p_1, p_2, y, d_f)$ are information about the individual wages w_i, the price of the exclusive market goods p_i, nonlabour income y, and distribution factors d_f. In principle, the sharing rule can be a function of all prices entering the budget constraint. However, for the sake of estimation parsimoniousness, we decide to use only the information that potentially predicts the allocation process between the family members. Note that the identification of the sharing rule, conditional on the chosen functional form, comes from leisure and individual clothing expenditure which are exclusive goods (Chiappori and Ekeland 2009).

For equation (57) to be consistent with the collective model derived in Section 2 and result of Proposition 2, the restrictions of adding-up, homogeneity and symmetry of the Slutsky terms,

$$\sum_{k=1}^{K} \alpha_{ik} = 1, \quad \sum_{k=1}^{K} \nu_{ikr} = \sum_{k=1}^{K} \beta_{ik} = \sum_{n=1}^{N} \tau_{ikn} = \sum_{j=1}^{J} \sigma_j = 0,$$

must hold, with $k = 1, ..., 5, n = 1, ..., 4$, and $j = 1, ..., 6$. We estimate the individual demand systems (57) for the two members by imposing these consistency restrictions as maintained hypothesis.

4 Data

The empirical analysis of this work is based on a sub-sample of the 1995 ISMEA Survey on Socio-Economic Characteristics of Italian Rural Household. The survey combines information about household and farm characteristics, time use, farm profits, off-farm money income, governmental and intra-household transfers, consumption, and information about the degree of autonomy in decision making by household members. The availability of

[7] Menon and Perali (2010) provide the formal proof for the identification of the parameters of the scaling function $m(\cdot)$.

this information is the basis for the estimation of both global and full income. The ISMEA data base merges four survey types in one: 1) farm accounting survey, 2) stylized time use survey, 3) expenditure survey, and 4) income survey.

The ISMEA 1995 survey is a nationwide farm household survey of 1xxx farm-households. The sampling has been based on the last Agricultural Census conducted in 1992 by the Italian National Statistical Institute (ISTAT). The questionnaire has been designed on the basis of a behavioral model (Caiumi and Perali 1997) with the specific aim of gathering statistical information on the behavior of each family member and on the sharing of public and private resources within the household. The consumption survey records information about the consumption of some exclusive goods such as clothing for the mother, father and children. The stylized time use survey is also a source about the private consumption of leisure and its use for child care activities or housekeeping. This information about the consumption of exclusive goods is a sufficient set of information to identify the rule governing the intrahousehold allocation of resources. The evaluation of the household unpaid work has been carried out using the market opportunity cost for the domestic activities reported in the time use section of the survey undertaken by each household member during an average week-day (Castagnini and Perali 2001). This method estimates the potential wage that could have been obtained by each household member given her/his level of personal characteristics and related skills .

The descriptive statistics of the variables included in the econometric execution along with their definition and unit of measurement are reported in Table 1, 2 and 3 for farm production, household production and consumption, respectively.

5 Results

The econometric results related to the production elasticities of domestic and farm production, shadow wages, the elasticities of consumption for both the husband and the wife along with the sharing rule governing the intra-household resource allocation process are described in Table 5 through Table 13. In general, the results of both the production and the consumption side of the household economy conform with economic theory.

Table 5 shows the own and cross price elasticities of household production with respect to changes in the wages of the husband, the wife, and other household members and in the price of input goods used in the production of the composite household product. In line with expectations, the effect of an increase in wage is especially significant for the wife and the other members of the household. Husbands contribute relatively less. The wife's wage is a complement of the domestic production of the husband; conversely, the husband's wage is a complement.

Domestic wages have been constructed using the opportunity cost approach valuing the time spent by a household member as the income foregone when deciding to be employed in home activities rather then taking on a off-family working option. The estimates of the domestic technology have been used to derive the price of the domestic good to be used on the consumption side of the household economy. Being endogenous by construction it has been instrumented.

5.1 Household Production

Tables 6 through 9 describe the farm technology. Inspection of Table 6 reveals that the demand for variable inputs conform with theory because higher prices reduce demand. Hired labor, chemicals and materials are complements. The output elasticities with respect to a change in variable inputs are described in Table 7. In line with expectations, an increase in crop or milk production has a positive and significant impact on hired labor. An increase in crop production also increases the use of chemicals and materials. The use of chemicals reduces if the production of fruits and other vegetables increase. An expansion of the production of milk or livestock does not increase the demand for chemical products. An increase in milk production demands more materials, while an increase in livestock production can be obtained with a reduction in the use of materials.

The specification of the demand for inputs is a function of their prices, whose impact is described in Table 6, outputs, described in Table 7, and farm and personal characteristics of the head of the farm-household which are presented in Table 8. The demand for hired labour is relatively higher if a farm-household is located in the South with respect to the North. In the South, farm-households demand relatively less chemicals and materials. A farm-household located in the plains have a relatively higher demand for hired labour and chemicals with respect to farm-households located in the hills and the mountains. The remaining three variables have an indirect impact on the demand for inputs and a direct effect on the effective use of the quasi-fixed factor family labor. These effects are also present in the cost function where they interact with factor prices as shown in equation (9). Their effect is more properly described in the impact of the effective shadow wage capturing the differences across farmers due to their level of experience, related to age, and skills, related to education. Two farmers with the same productivity may differ in terms of effectiveness because of differences in their experience and skills. The number of children per hectare is a proxy for the lower effective wage of the female component when the number of children is large, especially when the farm size is large and the demand for family labor is relatively higher.

Table 9 reports the Allen elasticities of substitution describing the curvature of the farm technology. The negative signs of the own-effects associated with a change in the price of the variable inputs is an evidence of the regularity of the technology.

Estimated shadow wages for family labour are presented in table 10 along with the objective market wages available off-farm to the people with the average characteristics of the farm-household type they belong (Castagnini, Menon, and Perali 2004), and the wage of hired labourers as collected in the ISMEA questionnaires. The comparison of the shadow wage with the market wage is a test of the separability hypothesis. The fact that shadow wages are significantly different from market wages is an evidence in support of the hypothesis of non-separability of production and consumption household decisions. This property is incorporated in the micro general equilibrium model of the farm-household.

Interestingly, the mean of the shadow wage for the non-professional farm-households, that is the sum of the limited resource, retirement, residential, and small farms, is lower than the mean market wage and wage paid to hired workers. The fact that non-professional farmers keep farming seems to be an expression of irrational behaviour. However, the decision to be self-employed in the farm stems from the comparison of the shadow wage with the expected market wage derived by multiplying the subjective perception of the probability to find a job in the market with the estimated market wage. Considering the increasing aging process of the non-professional agricultural manpower, it would not be surprising that the subjective probabilities to find a job are sufficiently low so that shadow wages can be in fact higher than expected market wages.

On the other hand, the average shadow wage for the professional farms, composed by the remaining farm-household types, is higher than the observed market wage. It is therefore rational for professional farmers to keep themselves in business.

5.2 Individual Consumption and Estimates of the Intrahousehold Resource Allocation

The consumption side of the economy is described by the own and cross-price elasticities for the demand of domestic goods, leisure and food, clothing and other goods both the husband and for the wife. The own elasticities are in line with expectations, but for other goods where the effect is positive but not significantly different from zero for both the husband and the wife. The consumption behaviour of the husband and the wife is comparable both in term of price and income effect. Leisure, as expected, is a luxury good for both couple members. Demographic elasticities described in Table 12 are also in line with expectations. The number of children, for example, positively affects the demand of food and clothing consumed by both the husband and the wife.

The knowledge of the sharing rule is useful to derive individual utilities of the couple members in order to identify the individual behavioural response to a policy shock. The sharing rule is a function that can be modified by intervening in the exogenous policy variables represented by the distribution factor. Inspection of the graphs reveals that relative prices of leisure and clothing have a negligible impact on the allocation rule, while male non-labor income and the age difference between members of the couple decrease the bargaining power held by the husband. In the micro-simulation of the general equilibrium model, we will see that small changes in the distribution of power across couple members has a highly significant impact on behaviour.

It is relevant to note that the set of estimated elasticities is the same for all household types, but heterogeneity has been dealt with by introducing modifying functions which incorporate the characteristics of the farm, operators and consumers. Farm-households technologies may in fact differ because of the level employed of quasi-fixed factors and other exogenous characteristics describing differences across farms and farm-operators. The collective model of the household also incorporates heterogeneity in a natural way by identifying the behaviour of the members of the household.

6 Conclusions

The simulation analysis of the impact at the microlevel of the macro agricultural policies requires the estimation of the supply elasticity of agricultural products, of the input demands, and substitution effects. Farmers respond differently to the variation of market prices and to government incentives in relation, for example, to farm size, to the human and physical resources available to both the farm and the household entetrprises and the geographic locatioin. The success of many environmental policies depends by the farm technolgies adopted in the production process. The cross-effects related to the products supplied and factors used can be as important as the direct effects. The comprehension of the distributive effects requires estimates of direct and cross-elasticites disaggregated for the policy relevant farm typologies. The results presented here are for the representative type.

The model specification descends from the theory of the farm-household. It represents the basic economic unit of Italian agriculture. In 1990, 79 percent of Italian farms is at the same time a consumption and production unit employment exclusively household members as workers. Farm-household manage 52 percent of the Italian agricultural land.

The study lends special attention to the econometric problems generated by the fact that not all farms produce at least some quantity of each product and not all household consume some quantity of all goods. This is a problem typical of individual data which is particularly sensible when individual rather than household consumption is taken into account. The estimation of the sharing rule is obtained from consumption information considering that we do not know who does what within the farm, while we know, at least for those goods exclusively consumed by the husband or the wife, who consumes what within the household. The distribution of power moves toward the woman when her education is higher and the age difference is smaller and the wife having greater independence in deciding whether to work off-farm. In general, the farm production, domestic production, and consumption results are coeherent with the theory. Therefore, they can be properly used to undertake behavioral microsimulation analysis both at the micro and macro economic level within a general equilibrium framework of the household enterprise.

References

[1] Apps, P. F. and R. Rees (1997): "Collective Labor Supply and Household Production," *Journal of Political Economy*, 105(1): 178-90.

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

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

[4] _________ (2000): "The Intriguing Relation Between Adult Minimum Wage and Child Labour," *Economic Journal*, 110: C50-C61.

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

[6] Basu, K. and R. Ray (2001): "The Collective Model of the Household and an Unexpected Implication for Child Labor: Hypothesis and an Empirical Test," .

[7] Becker, G. S. (1965): "A Theory of Allocation of Time," *Economic Journal*, 75: 493-517.

[8] Benjamin, D. (1992): "Household Composition, Labor Markets, and Labor Demand: Testing for separation in Agricultural Household Models," *Econometrica*, 60(2): 287-322.

[9] Chiappori, P. A. (1988): "Rational Household Labor Supply," *Econometrica*, 56(1): 63-90.

[10] _________ (1992): "Collective Labor Supply and Welfare," *Journal of Political Economy*, 100(3): 437-67.

[11] _________ (1997): "Introducing Household Production in Collective Models of Labor Supply," *Journal of Political Economy*, 105: 191-209.

[12] Chiappori, P. A., B. Fortin, and G. Lacroix (2002): "Marriage Market, Divorce Legislation, and Household Labor Supply," *Journal of Political Economy*, 110(1): 37-72.

[13] Chiappori, P. A., R. Blundell, and C. Meghir (2002): "Collective Labour Supply with Children," working paper 02/08, Institute for Fiscal Studies.

[14] Conlon, J. R. (1990): "Profit, Supply, and Factor Demand Functions: Comment," *American Journal of Agricultural Economics*, 488-92.

[15] Driscoll, P. J. and R. N. Boisvert (1988): "Empirical Implications of Reconciling the Behavioral Assumptions in Dual Models of Production," working papers in Agricultural Economics no. 88-9, Dept. of Agricultural Economics, New York State College of Agriculture and Life Sciences.

[16] Fortin, B. and G. Lacroix (1997): "A Test of the Unitary and Collective Models of Household Labor Supply," *Economic Journal*, 107: 933-55.

[17] Gustafsson-Wright, E. and H. H. Pyne (2002): "Gender Dimension of Child Labor and Street Children in Brazil," World Bank Policy Research Working Paper 2897.

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

[19] Jenkins, S. P. and N. C. O'Leary (1996): "Household Income Plus Household Production: The Distribution of Extended Income in the U. K.," *Review of Income and Wealth*, 42(4): 401-19.

[20] Kruger, D. (2001): "Child Labor as an Input in Household Production," Dept. of Economics, University of Maryland.

[21] McElroy, M. and M. J. Horney (1981): "Nash-Bargained Household Decisions: Toward a Generalization of the Theory of Demand," *International Economic Review*, 22: 333-49.

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

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

A Econometric Methodology Used to Estimate the System of Censored Equations

In this section, we review two feasible methods of estimation for systems of equations with multiple censored variables. In our problem, censoring comes both from the production and the consumption side of the household economy. The generalized Heckman procedure is the Heckman two-step estimator extended to a system of equations, while the maximum simulated likelihood method (Hajivassiliou, McFadden and Ruud 1996) uses multiple integrals that are computed with a simulated algorithm to reproduce the statistical process that generated the zero realizations. Both methods provide unbiased estimates of the structural parameters. However, in the simulated maximum likelihood approach the variance covariance matrix of the parameters is a full matrix, while in the case of the generalized Heckman estimator only the diagonal terms can be estimated. We discuss both methods, because we use the generalized Heckman approach, which is computationally less demanding, to obtain reliable starting values for the simulated maximum likelihood estimation.

We describe the two proposed estimation methods using a general representation of a system of equations with censored endogenous variables. Each equation in the system can be written as:

$$\begin{aligned} y_i &= f_i(x_i,\beta_i) + u_i \text{ if } f_i(x_i,\beta_i) + u_i > 0 \\ y_i &= 0 \qquad\qquad\qquad \text{if } \; f_i(x_i,\beta_i) + u_i < 0 \end{aligned} \tag{60}$$

where, y_i is the endogenous variable corresponding to the i-th equation in the system, x_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,

$$u_i \sim N(0,\sigma_i^2)$$

where, σ_i^2 is the i-th diagonal term of the matrix Σ.

A.1 Generalized Heckman estimator

This procedure amounts to transform the system of censored equations in (60) into a system of uncensored equations by using the appropriate correction. We start by considering the expected value of the endogenous variable conditional on a positive observation.

$$E\left[(y_i|y_i>0\right] = f_i\left(x_i,\beta_i\right) + \sigma_i \frac{\phi\left(\dfrac{f_i(x_i,\beta_i)}{\sigma_i}\right)}{\Phi\left(\dfrac{f_i(x_i,\beta_i)}{\sigma_i}\right)} \tag{61}$$

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:

$$E\left[(y_i|x_{it}\right] = f_i\left(x_i, \beta_i\right)\Phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right) + \sigma_i \phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right) \tag{62}$$

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

$$y_i = f_i\left(x_i, \beta_i\right)\Phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right) + \sigma_i \phi\left(\frac{f_i(x_i, \beta_i)}{\sigma_i}\right) + \xi_i \tag{63}$$

where $\xi_{it} = y_{it} - E\left[(y_i|x_{it}\right]$.

The system in (63) can be estimated by maximum likelihood assuming that:

$$\xi \sim MVN\left(0, \Omega\right)$$

where, ξ is a random vector which i-th element is ξ_i. Two point can be made here. First, this is a straightforward maximum likelihood estimation since the system in (63) does not contain any censored equation. Second, it important to keep in mind that the random variables ξ_i are different from the random variables of the censored system u_i.

B Results of the Econometric Collective Family Enterprise Model

Table 1. Descriptive Statistics of the Variables used in the Econometric Analysis Source ISMEA 1995

Variable		Mean	Std. Dev.	Min	Max
Couple full income - log		9.002	0.2366	8.160	9.938
			Male Budget Shares		
Domestic		0.215	0.1164	0.019	0.702
Food		0.156	0.0684	0.029	0.540
Clothing		0.003	0.0029	0.000	0.035
Other goods		0.212	0.1120	0.039	0.827
Leisure		0.415	0.1465	0.009	0.777
			Female Budget Shares		
Domestic		0.268	0.1335	0.043	0.823
Food		0.135	0.0614	0.022	0.604
Clothing		0.003	0.0024	0.000	0.019
Other goods		0.184	0.1027	0.038	0.778
Leisure		0.410	0.1572	0.008	0.810
			Prices in Log		
Male domestic		3.540	0.5756	2.132	5.699
Food		2.369	0.2541	1.163	3.698
Male clothing		1.858	0.9570	-1.276	4.972
Other goods		6.547	0.6521	4.735	8.722
Male leisure		2.256	0.0485	2.097	2.575
Female domestic		3.855	0.6990	2.132	5.795
Female clothing		1.956	0.9203	-2.414	4.458
Female leisure		2.226	0.0619	2.097	2.419
North	D1	0.363		0	1
South&Islands	D2	0.416		0	1
Hill	D12	0.771		0	1
No. of children	D3	1.367	1.0925	0	7
Wife education	D4	1.169	0.4246	1	3
D.my =1 wife decides on off farm labour	D7	0.068		0	1
Male full income in log		8.225	0.2642	7.306	9.206
Female full income in log		8.376	0.2546	7.419	9.300
Male non labor income in log	Newlexp_m	4.643	3.7545	-11.629	10.865
Female non labor income in log	Newlexp_f	6.719	2.5633	-11.496	11.475
D.my =1 if farm inherits by the husband	D9	0.658		0	1
Wife and husnad age poroportion	D10	0.479	0.0235	0.378	0.722
Wife and husnad education proportion	D11	0.420	0.0878	0.2	0.667
Wife and husband relative price of leisure	prleis	0.971	0.0463	0.791	1.135
Wife and husband relative price of clothing	prcloth	1.413	1.2641	0.007	20.333
Husband age / mean (husband age)	D5	1	0.2104	0.389	1.331
D.my =1 if high educated husband	D6	0.545		0	1
D13					
Z1 – Log of family labour, hours per month		5.296	0.8313	0.916	7.404
Z2 – Log of 5% of capital		4.412	1.9367	-2.120	9.188
Z3 – Log of total hectares		1.658	1.7271	-6.377	5.521

The Production side of the Household Economy

Domestic Production

Table 2 Household Production

	Husband Wage	Wife Wage	Others Wage	Price of Inputs
Own and Cross-price Elasticities				
Husband Domestic Share	-0.147	0.420	-0.911	2.580
Wife Domestic Share	-0.558	-0.958	1.350	0.089
Other Components Domestic Share	-0.029	-0.137	-1.650	0.619
Demand for Inputs - Share	-0.060	0.278	-0.670	-0.939

Farm Production

Table 3. Input Prices

	Hired labour	Chemicals	Materials
Hired labour	-0.3647	0.1403	0.1866
Chemicals	0.304	-0.6513	0.3094
Materials	0.3095	0.2411	-0.6072

Table 4: Output Elasticities - Factors

	Crops	Fruits and Other Vegetables	Milk	Livestock
Hired labour	0.266	0.006	0.234	0.061
Chemicals	0.335	-0.155	0.036	0.029
Materials	0.222	0.073	0.265	-0.109

Table 5: Elasticities with respect to Farm Characteristics - Factors

	North	South	Planes	Head's Age	Head's Educ	No.Children/Ha
Hired labour	0.339	0.674	0.181	0.123	0.055	-0.010
Chemicals	0.102	-0.366	0.335	0.081	0.020	0.045
Materials	-0.245	-1.012	-0.088	0.311	0.000	0.059

Table 6: Allen Elasticities of Substitution - Factors

	Hired labour	Chemicals	Materials
Hired labour	-2.923	0.364	0.396
Chemicals		-2.698	0.999
Materials			-1.961

Shadow Wages and Separability Test

Table 7: Shadow Wage, Wage off, and Wage of Hired Labour by Farm Typologies, Values are in Italian Lire

	Shadow wage	**Wage-off**	**Wage hired labour**
Sample	8571	11589	8896
Limited-resource	1515	12083	10360
Retirement	3851	19240	10319
Residential/lifestyle	4146	12795	14535
Farming occupation/lower-sales	2286	11293	12030
Farming occupation/higher-sales	5020	11339	8038
Large family farms	12677	11684	8301
Very large family farms	34390	11625	9378

Consumption side of the Household Economy

Table 8: Compensated Price Elasticites and Income Elasticicities

	Husband					
	Domestic good	Food	Clothing	Other	Leisure	Income
Domestic good	-0.338	0.007	0.036	0.045	0.142	0.410
Food	0.005	-0.409	0.071	0.071	0.106	0.115
Clothing	0.001	0.002	-0.199	-0.001	0.001	0.085
Other	0.044	0.097	-0.041	0.037	-0.074	0.191
Leisure	0.288	0.303	0.134	-0.153	-0.176	1.998
	Wife					
	Domestic good	Food	Clothing	Other	Leisure	Income
Domestic good	-0.254	0.022	-0.005	0.041	0.134	0.484
Food	0.011	-0.390	0.051	0.065	0.085	0.115
Clothing	0.000	0.001	-0.205	0.000	0.001	0.096
Other	0.028	0.089	0.020	0.056	-0.068	0.140
Leisure	0.215	0.278	0.139	-0.162	-0.152	1.960

Table 9: Demographic Elasticities

	North	South-Island	No. Children	Wife educ.
	Husband			
Domestic good	-0.069	0.062	-0.006	0.012
Food	0.249	-0.100	0.154	-0.018
Clothing	0.095	0.203	0.136	-0.002
Other	0.004	0.016	-0.014	-0.032
Leisure	-0.056	-0.005	-0.046	0.016
	Wife			
	North	South-Island	No. Children	Wife educ.
Domestic good	0.051	0.066	-0.028	-0.027
Food	0.239	-0.098	0.153	-0.025
Clothing	0.033	0.123	0.123	0.001
Other	0.009	0.016	-0.016	0.007
Leisure	-0.109	-0.019	-0.024	0.021

Intrahousehold Resource Allocation

Table 10: Summary of Predicted and Actual Sharing Rules

Variable	Mean	Std. Dev.	Min.	Max.
		Husband		
Predicted sharing rule	0.401	0.0447	0.252	0.615
Actual sharing rule	0.463	0.0505	0.291	0.705