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Abstract

This study develops a household enterprise model extended to encompass recent advances in collective theory. We use a simulation model, in which production and consumption-leisure choices are represented along with the rule governing intra-household resource allocation, to analyze the income and wage responses of each family member. The household is treated as an equilibrium model whose accounts are based on a collective household accounting matrix, whose social dimension are the wife/husband classes. The simulation analysis illustrates the policy relevance of the collective approach to household behavior for inferring the impact of economic policies on individual behavior and welfare. We also propose insightful comparisons with the unitary model to make the behavioral and policy relevance of the collective approach evident.

Economic theory studies the household enterprise as a miniature economy in which intra-household exchanges do not always function properly. Decisions are often taken with imperfect information and family members may frequently act strategically because coordination costs are relatively low. In developing countries such inefficiency sources, internal to the household, are magnified by a generally low degree of competition in land, credit, insurance and labor markets because factor markets are often thin, at an infant stage, or highly segmented.

In developing countries a large portion of families earn some of their livelihood by investing part of the household labor endowment in their own enterprise (Bardhan and Udry 1999). Such a link between the economics of the firm/farm and the economics of the household is central to development economics and adds to the challenges facing the analysis of behavior at the individual rather than the household level. When the family business is in agriculture, then the household enterprise model specializes in a farm-household model that has firm roots in the agricultural and development economics literature (Nakajima 1969, Singh, Squire, and Strauss 1985, Chayanov 1986, de Janvry, Fafchamps, and Sadoulet 1991, Lambert and Magnac 1998, Taylor and Adelman 2003, de Janvry and Sadoulet 2006, Henning and Henningsen 2007).

Despite the recent progress in family economics (Browning, Chiappori, and Weiss 2014), the decision behavior of the household enterprise is generally studied under the assumption that the basic decision unit is the family in which each individual has the same preferences and weight (Carter and Yao 2002, Taylor and Adelman 2003, Chavas, Petrie, and Roth 2005, de Janvry and Sadoulet 2006, Henning and Henningsen 2007, Le 2010, Chang, Huang, and Chen 2012). Unlike this, the collective approach (Apps and Rees 1988, 1997, Chiappori 1988, 1992, 1997) considers family members, and not the household as a whole, as core decision-makers.

Neoclassical consumption theory is suited to explain the rational behavior of single agents rather than the behavior of a small group of persons living together, where the actions of one member can influence the behavior and wellbeing of the other. The use of the unitary model to understand individual choices thus suffers from a number of relevant drawbacks. Most empirical research rejects the conditions underlying the unitary household model (Browning and Chiappori 1998, Fortin and Lacroix 1997, Phipps and Burton 1998, Schultz 1990, Thomas 1990). In the context of unitary models only the wellbeing of the family as a whole can be recovered by observed market behavior, while policy analysis is concerned with the wellbeing of individuals, which is the object of interest of collective models. Our measurement effort shares the views advocated by Stiglitz, Sen, and Fitoussi (2010) and O'Donnell *et al.* (2014) who suggest to evaluate income together with consumption of market and non-market goods in order to appropriately measure material welfare and exhort governments to measure wellbeing and making it a policy goal.

This study fills the gap in the theory by extending the household enterprise model to the collective theory (Apps and Rees 1988, 1997, Chiappori 1988, 1992, 1997) following the initial work on farm-households by Caiumi and Perali (1997). Our framework considers production, consumption, and labor participation decisions simultaneously in an equilibrium model. The model also has the unique feature of describing the family as taking part in two production activities: a marketable production, that may be an agricultural or a commercial business, and non-marketable domestic production, such as housework, caring for household members, or food preparation. Introducing both marketable and non-marketable production, individuals can invest their time in on-farm, domestic activities, and may decide not to work in the off-farm labor market. In the farm-household literature, the option of engaging in domestic non-marketable activities, crucially to understand especially female labor decisions, has not been considered before. Unlike Chiappori (1997) and Apps and Rees (1997) who modeled labor supply of working couples, we describe labor participation of couples where one or both members may decide not to work in the labor market. Further, while Chiappori (1997) contemplates only the case of marketable production and Apps and Rees (1997) only treat the case of non-marketable production, we account for both marketable and non-marketable household technologies.

Another novel aspect of our paper is that we construct the household model starting from a collective household accounting matrix, analogous to a social accounting matrix, where, thanks to the collective approach, the social classes within the family can be differentiated by gender or generations (adults/children). Interestingly, the programming model, which performs the simulation analysis, is the exact replica of the collective empirical model estimated in Menon and Perali (2013). The functional forms and the associated parameters of the programming model are the same of the econometric model. The analysis is based on Italian farm-household data.

Our collective household enterprise model simulates the impacts of external economic conditions and government policies on individual decisions and welfare levels. We also accommodate failures in the labor market (de Janvry, Fafchamps, and Sadoulet 1991, Löfgren and Robinson 1997, 1999, de Janvry and Sadoulet 2006) as a consequence of market changes. Simulation findings suggest that even small percentage changes in household non-labor income, individual market wages, or output prices are likely to induce policy relevant reallocation of income and other resources, such as time.

The paper mainly focuses on the collective household enterprise model. For illustrative purposes, the theoretical findings of the collective model are compared with those derived as if the model were represented by a unitary household. Section 1 shows the collective household enterprise model. Section 2 derives individual welfare changes in a collective setting. In Section 3, we describe the Italian farm-household data used to construct the household social accounting matrix specific to each farm-household type. In Section 4 we present the household equilibrium programming model and the technique employed for calibration and comment on results of the simulation analysis of exogenous market changes. Section 5 summarizes the main findings and suggests some lines for future research.

1 A Collective Household Enterprise Model

The household enterprise[1] model shows the family as a miniature economy, where the household reproduces the economic characteristics of a macro society at the micro level (Singh, Squire, and Strauss 1985, Chayanov 1986, de Janvry, Fafchamps, and Sadoulet 1991, Benjamin 1992, Caiumi and Perali 1997 and 2015). As a production unit, the family purchases inputs from the market and provides inputs, such as family labor, to produce goods that can be partly sold in the market and partly consumed by its members. As a consumption unit, the

[1]By the term "enterprise" we mean that the production activity run by the family is not restricted to only farming but can be any economic production, such as a bakery shop or a pet shop, and family members provide labor force to the household business. For convenience, throughout the paper we use the terms "enterprise" and "farm" interchangeably.

family chooses its optimal consumption-leisure bundle given individual time and household budget constraints.

When the household enterprise operates in flexible and competitive markets it faces exogenous buying and selling prices for all production-consumption goods and labor. In this case, production and consumption-leisure decisions of the household are recursive and therefore separable. The household enterprise maximizes profits as a producer and then allocates family income, which also includes profits, so as to maximize utility as a consumer. In a non-separable household model, market prices differ from the individual-specific shadow prices within the household and production-consumption decisions must be jointly modeled. According to Löfgren and Robinson (1999:663), separability fails to hold "whenever the household shadow price of at least one production-consumption good is not given exogenously by the market but instead is determined endogenously by the interaction between household demand and supply."

In the following sub-sections we set the notation for individual preferences and production technologies, and then formalize the household enterprise model within a collective decision program. To keep matters simple and to facilitate comparisons with the traditional household enterprise model, we start with a separable model. Market failures are then accounted for in the simulation section.

1.1 Preferences

In our context, the household comprises two adult persons denoted by $i = 1,2$ that take part in production and consumption activities.[2] Each individual has rational preferences over the private consumption of a composite market good c^i, leisure l^i, and the domestically produced good z^i.[3] Individual preferences are characterized by a strictly increasing and strictly quasi-concave utility function $U^i\left(c^i, l^i, z^i; d_i\right)$, where d_i is a set of individual-specific observable characteristics affecting preferences directly. All members of the family allocate their total endowment of time T_i to a marketable production activity, h^i, and a non-marketable production activity, t^i. They enjoy leisure, l^i, and may work in the off-farm labor market, L^i. Thus, each household

[2]In general, superscript i indicates endogenous variables, while subscript i indicates exogenous variables.

[3]The study ignores both the presence of public goods and externalities within the family.

member faces the following time constraint $T_i = L^i + h^i + t^i + l^i$.

1.2 Production Technologies

In our model, the household enterprise is specialized in the production of two goods, a marketable product q and a non-marketable good z. The marketable production technology is represented by a strictly increasing and concave function $q = f\left(h^1, h^2, x_q; d_q\right)$, where h^1 and h^2 are family members' working hours given a fixed stock of family labor $H = h^1 + h^2$, x_q are market inputs also including hired labor, and d_q is a set of demographic factors affecting household productivity. We assume that the output q is entirely sold in a competitive market at a constant price p_q, and therefore the family is taken to be a "pure" seller.[4]

The non-marketable production technology is represented by a strictly increasing, concave, and homogeneous of degree one function $z = g\left(t^1, t^2, x_z; d_z\right)$, where t^1 and t^2 are family domestic labor, x_z are bought-in market inputs, and d_z is a set of demographic factors affecting domestic productivity. Note that the vector of socio-demographic factors d_q and d_z affecting productivity may not be the same across production technologies. Further, the specification of marketable and non-marketable production technologies does not admit joint-production between the marketable and non-marketable productions. Unlike the farm product, output z is non-tradable and entirely consumed by the family $z = z^1 + z^2$ and its price is endogenous and household specific. In addition, the production level of z is in general unobservable by researchers.

In the model, we assume that the non-marketable production technology exhibits constant returns to scale. An implication of this assumption is that household decisions regarding production, such as the choice of production activities and levels, and the use of inputs, are not affected by the characteristics of the consumption unit, such as preferences and consumption side variables such as non-labor income or prices of consumption goods (Pollak and Wachter 1975). This property ensures that the non-marketable production decision can be taken separately from consumption as if the household were operating in perfectly competitive conditions.

[4]Note that the household production could be also self-consumed by family members, especially in developing countries. However, to simplify the analysis we assume that it is entirely sold in the market.

1.3 The Decision Program

The household enterprise program is modeled using the collective approach (Chiappori 1988, 1992). Within this framework, the decision process develops in two stages. In the first stage, acting as a producer, the household makes efficient production choices. In the second stage, household members agree on a rule to allocate family resources and each member freely decides the optimal allocation of her own income among consumption-leisure goods. Notice that under the assumption of separability, household production decisions, both marketable and non-marketable, derived within alternative household approaches do not differ, while consumption-leisure choices in general are model-specific. This implies that the structural demand functions obtained by solving either the collective or the unitary model are not the same. As illustrated in Appendix B, in the context of unitary models the bargaining power between spouses is not taken into account when describing household outcomes. This is not simply a loss in behavioral terms but, because the intra-household resource allocation is ignored, it is impossible to recover individual preferences and to derive individual welfare functions. As a consequence, the unitary representation of the household loses its relevance for those policy makers interested in designing welfare policies targeted to the most vulnerable members of the family, usually children and women.

Marketable household production The marketable production set up has a short run perspective. On-farm family labor is treated as a quasi-fixed factor allocatable both across activities, when information is available, and between spouses, as in our case.[5] This specification avoids considering family and hired labor as homogenous (D'Antoni, Mishra, and Gillespie 2011) and the measurement error associated with treating a quasi-fixed input as variable by associating a market price in lieu of the appropriate shadow value (Mishra, Moss, and Erickson 2004, Menon, Perali, and Rosati 2005). Variable hired labor is paid at the observed market wage, while labor offered by the family members is assigned its shadow value.

Households choose the optimal amount of variable inputs by minimizing the variable costs of producing q conditional on a fixed stock of family labor H and market price for variable

[5] In farm household models other factors that can be modeled as quasi-fixed inputs are land and capital.

inputs r,

$$\min_{x_q,h^1,h^2} VC\left(q,r,H,d_q\right) = rx_q, \mid q = f\left(h^1,h^2,x_q;d_q\right), \; H = h^1 + h^2. \tag{1}$$

We assume that both family members supply some positive hours in the family enterprise. We make the additional assumption that the husband, indexed as $i = 1$, supplies in the family business a minimum number of hours, $\bar{H}_1$, necessary to keep the enterprise operative. This assumption would reflect the traditional division of labor within the couple, where husbands are more likely to run the farm activity, while wives engage both in domestic and enterprise tasks. The optimal conditional demand of bought-in market input is $\tilde{x}_q = x_q\left(q,r,H,d_q\right)$, and by the maximization of the profit function $\max_q \pi = p_q q - VC\left(q,r,H,d_q\right)$ we derive the optimal supply function $\tilde{q} = q\left(p_q,r,H,d_q\right)$. By the envelope theorem, from equation (1) the shadow wage of on-farm labor supply is derived as (Schankerman and Nadiri 1986, Paris 1989)

$$w^*_{on} = w\left(p_q,r,H,d_q\right) = \frac{\partial VC}{\partial H} = p_q \frac{\partial f}{\partial h^i}. \tag{2}$$

The shadow wage w^*_{on} depends on the output's and inputs' prices,[6] other than the level of quasi-fixed factors and observable heterogeneity, implying that the household model is separable in H, though not in h^i, which is determined endogenously. Because we do not observe who does what in the farm the shadow wage is necessarily the same for both household members.[7]

Non-marketable domestic production For the non-marketable production, the household minimizes total costs given the production technology[8]

$$\min_{t^1,t^2} \quad w_1 t^1 + w_2 t^2, \mid z = g(t^1,t^2;d_z). \tag{3}$$

[6] The shadow wage is calculated at optimal values of the output supply function.

[7] The UNECE Manual (2007:217) argues that "shadow wages from agricultural activities can be estimated on an individual basis if data are collected about who does what in the farm." In addition, according to the shadow wage approach the family "unpaid" labor can be evaluated as the marginal product of labour, corresponding to the subjective evaluation of the disutility associated with an extra hour of work. This approach requires the estimation of a production or a cost function in order to obtain an estimate of the marginal productivity.

[8] Without loss of generality, we assume that the domestic production technology depends only on spouses' time inputs.

The first order necessary conditions (FONCs) are $w_i - \delta g_{t^i} = 0$, for $i = 1,2$, where δ is the Lagrange multiplier of the technology constraint in program (3). Given the level of z, the optimal amount of time spent by spouses in domestic chores t^i is determined only by the individual marginal product of labor and production technology. The FONCs yield the optimal input demands $\tilde{t}^i = t^i(w_1, w_2, z, d_z)$, for $i = 1,2$. Because the good z is non-marketable, its price is endogenous. At equilibrium is equal to the Lagrange multiplier. By the envelope theorem the Lagrange multiplier δ is equal to the marginal costs of producing z and its implicit price is obtained as

$$p_z^* = \delta = \frac{\partial TC(w_1, w_2, z, d_z)}{\partial z}, \tag{4}$$

where $TC(w_1, w_2, z, d_z)$ is the minimum total cost function of producing z. Under the assumption of constant returns to scale, the cost function is linearly homogeneous in the level of output and can be written as $TC = P_z(w_1, w_2, d_z)z$, where P_z is a unit cost function and is independent of the production scale. Then, equation (4) becomes

$$p_z^* = P_z(w_1, w_2, d_z), \tag{5}$$

where the implicit price p_z^* of the non-marketable good depends on individual labor marginal productivity and demographic factors affecting domestic productivity. Condition (5) is sufficient to maintain separability between domestic production and consumption-leisure choices of the household.

Consumption-Leisure Decisions

Members of the household enterprise also make consumption-leisure decisions. In line with the collective approach, household members agree on some intra-household distribution of non-labor income y and optimal profits $\tilde{\pi}$ according to a sharing rule function $\varphi(p_1, p_2, w_1, w_2, y, d_1, d_2)$ that depends on exogenous variables, belonging to the consumption sphere and possibly affecting the intra-household distribution process, such as individual wages and the prices of the consumption goods.[9]

[9]The sharing rule may also depend on distribution factors. Distribution factors are variables that do not affect either individual preferences or the budget constraint. Browning, Chiappori, and Lechene (2006) and Chiappori

Once the allocation of resources between household members has occurred, each member freely chooses her own consumption-leisure bundle subject to her budget, time, and non-negativity constraints

$$\max_{c^i,z^i,l^i} U^i(c^i,z^i,l^i;d_i) \mid p_i c^i + p_z^* z^i = w_i L^i + \varphi_i, \quad \overline{T}_i = L^i + l^i, \, L^i \geq 0, \tag{6}$$

where p_i is the market price of the composite good c^i, $\overline{T}_i$ is the individual time available for market labor L^i and leisure l^i activities, $\varphi_1 = \varphi$ and $\varphi_2 = (y + \tilde{\pi}) - \varphi_1$. We allow individuals either to participate or not in the off-farm labor market.

After substitution of the time constraint in the budget, the FONCs are $U^i_{c^i} - \lambda p_i = 0$, $U^i_{l^i} - \lambda w_i = 0$, and $U^i_{z^i} - \lambda p_z^* = 0$, for $i = 1,2$, where λ is the Lagrange multiplier of the budget constraint of program (6). The set of FONCs yields the individual demand functions $\tilde{c}^i = c^i(p_i, p_z^*, w_i, \varphi_i, d_i)$, $\tilde{z}^i = z^i(p_i, p_z^*, w_i, \varphi_i, d_i)$, and $\tilde{l}^i = l^i(p_i, p_z^*, w_i, \varphi_i, d_i)$, for $i = 1,2$, as functions of exogenous prices, the sharing rule and observable heterogeneity.

Individual Labor Supply Decisions

Given the fixed stock of household labor H and the minimum number of hours $\bar{H}_1$ that the husband supplies to keep the farm functioning, the following equations jointly determine the endogenous leisure price w_i^*, the optimal amount of time that spouses supply in the farm activity h^i and in the off-farm labor market L^i

$$\left(w_1^* - w_{on}^*\right)\left(h^1 - \bar{H}_1\right) = 0, \tag{7}$$

$$h^2 = H - h^1, \tag{8}$$

$$(w_i^* - w_i) L^i = 0, \; i = 1,2, \tag{9}$$

$$T_i = L^i - h^i - \tilde{t}^i - \tilde{l}^i, \; i = 1,2. \tag{10}$$

and Ekeland (2006, 2009) show the key role played by distribution factors in identifying the sharing rule and present an exhaustive review of distribution factors used in the collective household literature. Note that the sharing rule depends on market wages even when individuals do not participate in the labor market. This is a common assumption in household collective literature (Donni 2003, Blundell *et al.* 2007, Bloemen 2010) in which it is assumed that the bargaining power within the family is exerted by the potential market wage that household members would earn entering the labor market.

The husband's decision about on-farm labor, h^1, is based on the comparison between his leisure price w_1^* and the on-farm wage w_{on}^* as defined in equation (2), thus equation (7) becomes

$$\begin{aligned} w_1^* > w_{on}^* \quad &\Longrightarrow \quad \tilde{h}^1 = \bar{H}_1, \\ w_1^* = w_{on}^* \quad &\Longrightarrow \quad \tilde{h}^1 \geq \bar{H}_1. \end{aligned} \tag{11}$$

If the husband's endogenous leisure price w_1^* is greater than the on-farm shadow wage w_{on}^*, then he will supply the minimum number of hours $\bar{H}_1$ necessary to keep the farm functioning. If $w_1^* = w_{on}^*$, then he may spend longer hours in the on-farm activity. The wife's on-farm labor is then obtained by equation (8).

Whether an individual participates or not in the off-farm labor market depends on comparisons between her market wage w_i and the endogenous leisure price w_i^*. Thus the Khun-Tucker conditions of equation (9) can be rewritten as

$$\begin{aligned} w_i^* > w_i \quad &\Longrightarrow \quad \tilde{L}^i = 0, \\ w_i^* = w_i \quad &\Longrightarrow \quad \tilde{L}^i \geq 0, \end{aligned} \tag{12}$$

for $i = 1,2$. If w_i^* is greater than the market market wage w_i, then the individual will not be willing to participate in the off-farm labor market. If w_i^* equals her market wage, then the individual may be willing to supply some positive hours in paid work. While in the former case, the model looses the separability property between domestic production and consumption decisions, in the latter case the separability property still holds. Even in the absence of conditions ensuring separability, the decision program of the household enterprise can be decentralized using shadow prices (Jacoby 1993, Skoufias 1994, Apps and Rees 1997, Henning and Henningsen 2007, Browning, Chiappori, and Weiss 2014).[10]

[10]Note that when production decisions are separable from consumption decisions from the Second Fundamental Theorem of Welfare Economics the solutions to problems (1), (3), and (6) obtained recursively are equal to the optimal solution obtained solving the centralized household enterprise problem simultaneously. When solving the household enterprise problem simultaneously, w_i^* is given by the ratio of the Lagrange multiplier associated with the individual time constraint and the Lagrange multiplier associated with the household budget constraint.

1.4 Comparative Statics

We now derive individual behavioral response to exogenous changes in household non-labor income, y, individual market wages, w_i, and output price, p_q, in an efficient economy with perfect markets. The comparative statics is compared with that derived by the unitary representation of the farm-household model. The main difference between the two models is that in the collective model changes of prices and income work through the rule governing the distribution of financial resources within the family. This implies that market perturbations operate on optimal outcomes directly and, in addition, they modify the intra-household allocation of family resources altering, in turn, the family equilibrium. Formal derivation of the comparative statics for the unitary model is shown in Appendix B.

The comparative statics analysis of the model relies on the following set of assumptions based on the empirical results in Menon and Perali (2013): 1. spouses are gross substitute in domestic tasks, 2. leisure and the domestic produced good are gross substitute, and 3. the individual sharing rule is increasing in own market wage rate, non-labor income and profits, while decreasing in partner's market wage rate.

Comparative statics results can be summarized in the following set of propositions and formal proofs are shown in Appendix A. The first proposition considers a positive change in household non-labor income y due, for instance, to a direct income payment that the household receives from the government.

Proposition 1. *(Non-labor income effect) Under assumption 3, members of a household enterprise receiving a direct income transfer increase their consumption demands, including leisure, do not vary their on-farm and domestic labor supply, and reduce their market working hours.*

The result of Proposition 1 states that the increase in household non-labor income has only an income effect on individuals' consumption demands and market labor supply through the sharing rule. Inspection of table B1 shows that in the collective model the non-labor income effect operates through the sharing rule $\frac{\partial \varphi_i}{\partial y}$, while in the unitary model a direct impact is produced by changes in non-labor income on leisure-consumption demands and labor supplies.

Let us now derive individual i's response to an increase in the market wage rate determined, for example, by a rise in a sectoral minimum wage established by law or collective agreements.

Proposition 2. *(Own-wage effect) Under assumptions 1, 2 and 3, a ceteris paribus increase in individual i's market wage leaves her on-farm labor supply unchanged, while it reduces her domestic working hours. The effects on i's off-farm hours and leisure are ambiguous.*

Comparing the corresponding analytical expressions in Appendix A and B, the unitary and collective models show similarities and differences in terms of own-wage effects. The two models have in common the direct effect on the individual demand and the effect on the domestic price. Specific to the collective model is the effect on the sharing rule. However, because of the impact on the domestic price the sign of this effect is ambiguous also in the unitary model.

Proposition 3. *(Cross-Wage Effect) Under assumptions 1, 2, and 3, a ceteris paribus increase in individual j's market wage increases i's domestic hours, while on-farm working hours remain unchanged. The impact on i's demand for leisure and off-farm labor market participation is ambiguous.*

The comparison of the cross-wage effects between the two models is also interesting. In the case of demand equations derived from a collective model, a change of j's wage has an effect on i's demand equation both through the sharing rule and the endogenous domestic price. Differently, in the unitary setting a direct effect is derived together with the effect on the domestic price.

Proposition 4. *(Output Price Effect) Under assumptions 1 and 3, a ceteris paribus increase in the output price increases i's demand for leisure and leaves i's domestic hours unchanged. The rise in output price increases male on-farm working hours while decreasing female on-farm labor supply. The impact on paid work is positive for man and ambiguous for woman.*

The output price effect does not present remarkable changes between the two models. The difference is in the fact that in the unitary model a change in p_q changes the household full-income while in the collective model a change in the output price affects the allocation of resources to member i and the associated level of well-being.

The difficulty in unambiguously signing the comparative statics effects is more complicated in a collective framework because the sign of the partial derivatives of the sharing rule are unknown *a priori*. We now turn to the empirical simulation performed within a household equilibrium framework where we analyze the behavioral content of Propositions 1-4.

2 Evaluating Individual Welfare Changes

The micro-simulation analysis is enriched by measurements of individual welfare changes due to exogenous market perturbations that vary market wages. In a household's labor supply model, the compensating variation (CV) can be separated into price (of leisure) and income effects (Creedy and Kalb 2005). As individual market wages change, individual incomes also vary because of the change in the value of the individual time endowment.

Evaluating welfare variations in a collective setting is especially interesting because a change in market price may affect the well-being of family members differently due to possible adjustments of the rule governing intra-household resource allocation. In a collective model accounting for marketable and non-marketable productions, additional effects arise.[11] For instance, a change in individual i's market wage alters both the implicit price of the non-marketable good and the sharing rule. As a result, the welfare level of member j is also affected by i's market wage change.

Consider a change in member i's market wage from level $w_i^{\tau_0}$ to level $w_i^{\tau_1}$. Define individual i's full-income[12] necessary to attain the utility level $U_{\tau_0}^i$ before the market change occurs as $I_i^{\tau_0}\left(P^{\tau_0}, w_i^{\tau_0}, y^{\tau_0}, U_{\tau_0}^i, H, d^{\tau_0}\right)$, where $P^{\tau_0} = (p_i^{\tau_0}, p_j^{\tau_0}, r^{\tau_0}, p_q^{\tau_0}, w_j^{\tau_0})$ and $d^{\tau_0} = (d_i^{\tau_0}, d_j^{\tau_0}, d_q^{\tau_0}, d_z^{\tau_0})$. After the change in i's market wage individual full-income becomes $I_i^{\tau_1}\left(P^{\tau_0}, w_i^{\tau_1}, y^{\tau_0}, U_{\tau_1}^i, H, d^{\tau_0}\right)$. The individual compensating variation CV_i is thus derived as

$$CV_i = \left[I_i\left(P^{\tau_0}, w_i^{\tau_1}, y^{\tau_0}, U_{\tau_0}^i, H, d^{\tau_0}\right) - I_i^{\tau_0}\right] + \left[I_i^{\tau_0} - I_i^{\tau_1}\right], \tag{13}$$

[11] Donni (2008) explains the relevance of accounting for domestic production in collective models if interested in individual welfare comparisons.

[12] Full-income comprises monetary and non-monetary resources, such as the evaluation of time. Individual full-income has been calculated as suggested by Castagnini, Menon, and Perali (2004).

where I_i is i's full-income ensuring the pre-change utility level $U^i_{\tau_0}$ evaluated at the new market wage $w_i^{\tau_1}$. The first term on the right-hand side of equation (13) measures the price (of leisure) effect, whereas the second term measures the income effect. Note that we calculate the individual compensating variation CV_i as the minimum amount of money to be paid to each household member to ensure each of them is actually compensated for the price change.

An increase in individual market wage increases both the price of leisure and the price of the domestically produced good, so that the welfare change from the price effect is positive. The market wage increase also raises the value of the individual marginal product of labor and full-income, so that the welfare change from the income effect is negative. Therefore, the overall effect may be positive or negative. A positive (negative) value of the CV_i means that the evaluated market change makes an individual worse (better) off.

3 Data and the Household Social Accounting Matrix

Data

The empirical analysis is carried out using a nationwide survey on socio-economic characteristics of Italian rural households undertaken in 1995 by the Italian Institute for Agricultural Markets (ISMEA). The farm-household survey combines information about household and farm characteristics, farm production and profits, stylized time use, off-farm money income, governmental and intra-household transfers, consumption and information about the degree of autonomy in decision making by household members. It is worth noting that, even though the ISMEA survey was carried out in 1995, the survey meets the principles and recommendations about the methodology and data systems on rural development and agricultural household income suggested by the United Nations Economic Commission in the Handbook on Rural Households' Livelihood and Well-Being (2007). A further feature of the ISMEA survey is that it records information about the consumption of exclusive goods, such as clothing for women and men. This information is sufficient to identify the rule governing the intra-household allocation of resources (Chiappori and Ekeland 2009).

For illustrative convenience, the empirical simulation is carried out for two farm-household types of interest: the *non-professional*, which is the average of the medium and small size farm-households, and the *professional*, comprising large and very large farm-households.[13] The distinction between professional and non-professional farm-households is of special relevance from a policy perspective. In general, professional farms are the elective recipients of agricultural and rural development policies, whereas non-professional farm-households are the subject of interest of welfare policies. In principle, the distinction between farm-household types can be useful to gauge the differential effects of coupling agricultural with welfare policies.

Descriptive statistics of professional and non-professional farms are shown in table 1. Professional and non-professional farmers present some common features but also some peculiarities. Both families are in average in the middle of their life-cycle. Professional farm-households are equally distributed in the North and in the South of Italy but are relatively less frequent in the Center of Italy. Non-professional farms are mainly located in the South of Italy (49%). Most professional farm-households are located in plain areas. On average, professional farm-households are twice as large as the non-professional farm-households and the value of their land and capital endowments are significantly greater. By comparing the demand for inputs expressed in shares, professional farm-households are much more capital intensive relative to non-professional farms that are much more family-labor intensive. As for production choices, professional farms are more farming oriented, whereas non-professional farms mainly produce horticulture products or run small vineyards. Figures about individual labor marginal productivity are similar for different types of farm. It is not surprising that marginal labor productivity is greater for men than for women. Members of professional farms generate a larger full-income. They tend to spend their incomes on market goods, whereas members of non-professional farms mainly consume the domestically produced good and leisure time. An important distinguishing feature of non-professionals is that their members provide a positive amount of hours in the off-farm labor market. On the contrary, agricultural activity is the only source of income for professional farms.

The time budget gives us a picture of the typical weekday of a farmer. An individual

[13] The ISMEA household data comprises 1256 farm-households grouped in 947 professional farms, 197 non-professional farms and 112 very small farms with limited resources or run by retired farmers. The latter type of farm-household is excluded from our analysis because the agricultural activity is a residual activity meaning that the majority of household income comes from social transfers or off-farm employment.

normally spends 10 hours per day in activities such as rest, personal care and eating, then 14 hours per day are left to working activities and leisure enjoyment. Whatever the farm-type, men spend, on average, between 9 and 10 hours in working activities. Professional farms' men spend 8 hours in on-farm activities against 5 hours of non-professional farms' men. The latter work on average 1 hour and a half in the off-farm labor market. Irrespective of the farm-type, men spend less than 3 hours per day in domestic chores. On the other hand, in both types of farm, women spend longer hours in domestic work and less time in agricultural activities. Women of non-professional farms supply, on average, about 1 hour and half in paid employment.

Collective Household Accounting Matrix

Accounting matrices of miniature economies, such as farm-household economies or household enterprises, are a common policy tool used to describe the flows of all economic transactions and transfers taking place between the household and the rest of the economy. We contribute to the literature by building a Collective Household Accounting Matrix (CHAM) describing also the flows of financial transfers taking place within the household. The CHAM shows the interdependency of production activities, consumption demands, labor participation choices, income formation and income redistribution across household members or classes, such as male and female gender classes. Notice that only in a collective setting it is possible to derive an accounting matrix at the household level describing the intra-household redistribution of resources, because the collective approach allows the identification of the intra-household transfers between family members. We build the CHAM for both professional and non-professional farms (tables C1 and C2, respectively). The computation of CHAM row and column entries is explained in Appendix 5.

Calibration Technique

The programming model is the exact replica of the collective empirical model estimated in Menon and Perali (2013). The functional forms and associated parameters of the programming model are the same of the econometric model. In particular, as shown in Appendix 5, we adopt a Translog specification for the cost function associated with both the marketable and non-marketable production and a linear AIDS specification for individual preferences.[14]

4 Simulation Results of the Programming Model

The collective household enterprise model presented in Section 1 is programmed as an equilibrium model to describe the behavioral responses of the production, consumption-leisure, and off-farm labor choices to economic and social policies and to evaluate their impact on individual welfare levels. The model can be used to perform simulations and policy experiments and to predict the impact of changes in exogenous variables or parameters on production activities, individual consumption and labor supply decisions.

We examine individual responses to a 10% increase in non-labor income, the wife's wage and output prices in sequence (tables 3, 4 and 5 respectively). The simulation results are compared with the benchmark case described in table 2.[15]

Impact of an increase in family non-labor income (table 3) The simulation results comply with the qualitative prediction of Proposition 1. When all markets are perfect, production and consumption are separable so that a non-labor income increase does not affect production. This is the case for marketable production irrespective of the farm-household types (panel D of table 3). Still, an increase in non-labor income creates a positive effect on individual full-income (panel B of table 3).

For both farm-households, the increase in non-labor income leads to an increase in the individual full-income that in turn produces positive changes in the individual consumption of all goods (panel C of table 3). It also increases the leisure price of both spouses of the professional farm only. Both spouses reduce leisure time but allocate more time to domestic activities, even though the increase is not remarkable (0.16% for the husband and 1.49% for the wife as shown in panel A of table 3).[16] Interestingly, the increase in non-labor income does

[14] Estimated parameters used in model calibration are available from authors upon request.

[15] Our analysis is coherent with Lucas critique because the parameters used to calibrate the model are structural parameters. As suggested by Lucas (1976), in order to predict the impact of a policy simulation, one should model parameters related to preferences, technology and resource constraints that drive individual behavior and that are invariant to policy changes.

[16] Percentage variations of variables are calculated as the difference between the simulated and the benchmark value of the variable of interest.

not affect either off-farm or on-farm work of professional family members. Another relevant difference across farm-households is that spouses of the non-professional farm reduce off-farm working hours by about 20% with respect to the base value.

Panel B of table 3 describes the impact of the increase in non-labor income on the intra-household distribution of both monetary resources φ_i, comprising non-labor income and farm profits, and individual full-income I_i, comprising monetary φ_i and non-monetary resources, such as the value of time. In professional farm-households, the distribution of both monetary and non-monetary resources slightly increases in equal proportions for both the husband and the wife. This is due to the fact that non-labor income is a negligible source of the family income. As a result, the division slightly favors the husband (0.52) versus the wife (0.48) maintaining the status quo described in the benchmark case of table 2. On the other hand, non-labor income is a vital source of the household monetary resources of non-professional farms. The 10% increase in non-labor income increases the availability of monetary resources by about 15%. Because the increase in monetary resources is equally shared, the proportions remain unchanged clearly favoring the husband who maintains a larger control (0.55 versus 0.45) over monetary resources. The husband's contribution in the full-income formation of non-professional farms falls to 0.52 showing the importance of non-monetary resources to achieve a more equal distribution across genders.

Impact of an increase in the wife's market wage (table 4) The increase in the wife's market wage produces comparable results across farm-households. In line with Proposition 2, the raise in the wife's market wage has no effects on the on-farm labor supply of both spouses, while it reduces the wife's domestic working hours and increases husband's domestic work, confirming the gross substitutability between spouses in domestic tasks as shown in Proposition 3 (panel A of table 4). As a result of the increase in the wife's market wage, the wife reduces time spent in leisure activities and allocates more hours to the off-farm labor market. These results are more sizable for non-professional than professional spouses. A decreasing leisure demand and an increasing off-farm labor supply due to an own-wage effect are in line with expectations, though not uniquely defined in Proposition 2. The increase in the wife's market wage also affects the husband labor supply indirectly through the sharing rule. This feature is unique to collective models that describe labor choices as the outcome of the bargaining process between the husband and the wife. Similar to their wives' choices, husbands decide to enjoy less leisure time and to increase off-farm working hours as the effect of an increase in wife's market wage.

Because an increase in the wage rate does not affect on-farm labor decisions, both the size and the distribution of monetary resources remain unchanged. As is reasonable to expect, the rise in the wife's market wage tends to redistribute non-monetary household resources towards the wife. For instance, the wife's full-income share increases by more than 2% in professional farms and by about 3.8% in non-professional farms against a comparable reduction in the husband's share (panel B of table 4). Compared with the benchmark case described in table 2, the sharing of non-monetary resources has a moderate equalizing effect in the professional farm-household, and a marked effect in the non-professional households where the time resources can be adjusted with relatively more degrees of freedom. Note that it would not be possible to simulate this result using a standard unitary household model.

Because we model on-farm labor as a quasi-fixed factor, whose wage is endogenously determined and is independent of market wages, marketable production decisions are not affected by the positive change in the wife's market wage (panel D of table 4). Unlike this, as shown in the bottom line of table 4, the price of the non-marketable good increases by about 6% for both farm-households as a result of the increase in the opportunity-cost of the wife's domestic work.

Impact of an increase in the crop price (table 5) An increase in crop price affects both the production and the consumption side of the household economy. As expected, the price rise results in an increase in the agricultural shadow wage and in higher profits for the professional farm-households and in a fall in losses for the non-professional farm-households (panel D of table 5). As shown in Proposition 4, due to an increase in the crop price, non-professional husbands allocate more hours to farm activities while deciding to quit off-farm labor supply (panel A of table 5). Given the ability to substitute production between spouses, non-professional wives respond by cutting on-farm labor supply. Professional husbands do not participate in the off-farm labor market and, therefore, do not vary their on-farm labor supply. Their wives' on-farm labor supply does not change. In terms of wives' domestic work and off-farm supply, the simulation evidence is remarkably different across farm-households. Professional wives do not participate in the off-farm labor market, they reduce their leisure time and increase their domestic working hours. Non-professional wives allocate the time saved from the agricultural activity to work longer hours in off-farm employment. Changes pertaining to leisure time and domestic work are of negligible magnitude. The wives of both farm-types suffer an important income loss that weakens their power position within the family (-1.54% for professional and -1.45% for non-professional). While the share of monetary resources remains unchanged as for the other households, the wife's control over non-monetary resources falls slightly (panel B of table 5).

As is reasonable to expect, the impact of an increase in the crop price has a positive impact on crop production larger than the 10% change in both farm-household types (panel D of table 5). This increase is associated with a decrease in livestock and milk production in the professional farm-household due to the structure of the substitution effects. An increase in the crop price also increases chemicals and materials, while it has a negligible impact on hired labor for non-professional farm-households because the crop technology is not labor-using. The price of the non-marketable good increases for both farm-households. The effect is much more marked for professional than for non-professional farm-households (bottom of panel D of table 5).

Comparative statics (table 6) We now show a comparative statics exercise implemented for both the collective and unitary models.[17] The analysis uses the theoretical findings of Section 1.4 for the collective model and those of Appendix B for the unitary approach. For illustrative purposes, we focus only on the leisure choices.[18] The analysis assumes that individual leisure prices are equal to individual specific market wages and is confined to interior solutions.

Table 6 shows the variations of individual leisure demands due to simulated changes in family non-labor income, output price and the wife's market wage for the husband and wife of both professional and non-professional farms. A *ceteris paribus* increase in non-labor income (columns (1) and (2) of table 6) has a positive income effect on individual leisure demands in both models. The increase is smaller in the collective model because the non-labor income

[17] The analysis is carried out using the mean values of individual leisure prices (table 2) and simulated changes in the sharing rule (tables 3 to 5).

[18] We do not implement the analysis for on-farm and domestic labor supplies because production is not affected by intra-household consumption decisions due to separability.

increase is shared between spouses and not pooled at the household level. Each spouse receives only a share of the supplemental amount of non-labor income. Similar considerations apply to changes in output price. The increased amount of profits is shared between spouses in the collective model, while it is pooled in the unitary one. As a result, the increased demand of leisure is lower in the collective model because each spouse has command over only a proportion of total household income.

Interestingly, an increase in wife's market wage has a large own effect and a more rigid cross effect, especially in the collective model where the wage increases also affect the decision making process. An increase in the wife market wage has a positive income effect that is smaller than the negative price effect on her own leisure demand. Because the wife does not share her labor income with the husband, the positive income effect is larger and the change of her leisure consumption is lower in the collective framework. In the unitary model the increase in the wife's market wage raises family total income and has a positive income effect on the husband's leisure demand. Given that labor income is assigned to each individual, in the collective model the increase in wife's market wage implies a redistribution of non-labor income and profits in favor of the wife and at the expenses of the husband, who does not benefit from the increase in her wife's labor income. As a consequence, husband's demand for leisure is not affected by the decrease in individual income.

For all shocks described in table 6, the change in hours of leisure per month is lower in the collective representation. Only the behavioral response associated with a change in wife wage is economically significant when compared with the baseline level of monthly hours of leisure reported in table 2. Interestingly, in the collective model, the change in wife wage does not affect the demand for leisure of the males of both professional and non-professional farm-household types. In the unitary model the cross-wage effect has a direct but small impact on leisure. In the collective case, we only have an indirect effect through the sharing rule. On the other hand, the own effect on leisure time due to a change in the wife's wage is important. This significantly different responsiveness across models should be relevant for the design of effective gender-specific labor policies.

Welfare analysis at the individual level (table 7) As shown by the simulation results conducted at the individual level and presented in table 7, a non-labor income change or a variation in market wages or in output prices may result in a change of individual leisure prices, shadow wages, and the endogenous price of the non-marketable good. In addition, individual full-incomes also vary. The change in individual full-incomes occurs both through a change in the value of the time endowment and in the share of household resources. Note that a change in i's market wage also affects j's utility through two channels: the change in the price of the domestic good and in the sharing rule.

Table 7 shows that while the CV_i necessary to maintain individual utility constant in response to a 10% increase in non-labor income is positive for spouses of professional farms and negligible for spouses of non-professional farms. The utility money-metric suggests that spouses of professional farms are worse off because the non-labor income rise increases both individual leisure prices and the price of the non-marketable good. Then, spouses need a monetary compensation for the price increases to preserve their initial utility. Whereas, the non-labor income increase does not affect endogenous prices for non-professional households.

The monthly CV_i necessary to maintain the wife utility constant in response to a 10% increase in her market wage amounts to 539 euros and 233 euros for professionals and non-professionals, respectively. In percentage, the CV_i for wives of professional farms amounts to roughly 13% of their full-income, whereas the percentage is about 9% for non-professional wives. The difference is related to the smaller impact of the wife's market wage increase on the endogenous price of the non-marketable good observed for non-professional households. The CV_i for husbands is the same across farm-types. Husbands need a monetary compensation to preserve their initial utility, otherwise it would decrease partly because of the rise of the endogenous price of the domestically produced good and partly because of the reduction in their share of household resources.

An increase in the crop price gives a monthly CV_i of 1039 euros for husbands and 239 euros for wives of professional enterprises. For instance, the compensating variation related to a change in the output price leads to a household welfare loss of 1278 euros, of which 19% involve the well-being of the wife (239/1278) and 81% the husband (1039/1278). The reduction in the utility level is much more restrained for males of non-professional farms than for professional members experiencing a smaller increase in their leisure price and in the price of the non-marketable good compared to professional members. Differently, the CV_i for wives of non-professional farms is negative, meaning that they are better-off.

5 Conclusions

This study extends several aspects of the farm-household model. We analyze production and consumption-leisure decisions separately for the husband and wife within the collective framework. We also represent the farm-household as involved in the production of marketable and non-marketable goods, such as housework, caring for household members, or food preparation that are traditionally overlooked in the farm-household literature, but crucial to explain female labor choices. We then employ the farm-household collective approach to perform a simulation analysis using a programming model. We simulate the impact of hypothetical policy or market changes on production supply, consumption-leisure demand, intra-household resource allocation and individual welfare.

An innovative element of our programming model is that it is the exact replica of the underlying collective empirical model estimated in Menon and Perali (2013). The functional forms and the associated parameters of the programming model are the same of the econometric model, allowing us to obtain results closer to reality. To implement the household enterprise model we define the new concept of a collective (social) accounting matrix at the household level, whose social dimensions are *intra-household classes*. An interesting extension of our programming approach, here limited to the comparison of the behavioral responses of two household types and their members, can be obtained from building an accounting matrix and its associated equilibrium model for each household in the sample. In so doing, it would be possible to conduct inferential analyses.

Unlike the unitary model, the collective representation of household behavior analyses individual behavioral responses and allows the recovery of the welfare function of each household member. The present application distinguishes between the husband and the wife, but one could extend this study to also include children if interested in studying intra-household transfers across genders and generations (Arias *et al.* 2003, Menon and Perali 2012, Dunbar, Lewbel, and Pendakur 2013). The results show marked differences in marketable and non-marketable production choices and individual consumption of goods and time. These differences not only affect the impact on individual wellbeing, but also have important policy implications that can be differentiated by gender.

As an example, if we compare the level of individual and household wellbeing of professional and non-professional farm-households, then non-professional farmers not only have a very feeble agricultural identity, and as such they hardly represent an elected target group of rural development policies, but their low level of wellbeing also places them at the margin of society as a whole. The non-professional farmers in our sample are households in the middle stage of their life-cycle mainly located in the South that should be a high priority target of both welfare and labor policies independent of rural development policies. Our results show that policies aiming at increasing non-farming job opportunities for women in the South would favorably impact households' welfare and would reduce the wellbeing gap within the couple by achieving a more equalizing effect on the household distribution of resources. The collective approach thus provides policy makers with the relevant information to design and target policies appropriate both for the household and the individual.

One goal of our analysis is to show that the collective representation of household enterprises allows for welfare evaluations at the individual rather than at the household level. The results of the simulation analysis are in line with the qualitative predictions shown in the theory section. In general, the impact of a policy change is distributed between husband and wife in highly different proportions depending on the household types and policy scenarios. The collective approach is also a powerful means to understanding gender-specific labor choices as outcomes of both a bargaining process within the household and the constraints associated with the household production technologies. Our model, for example, predicts how the labor supply of the husband and wife respond to market variations. The simulation shows that labor supply responses often vary remarkably by gender. Benefits from specialization and efficient allocation of tasks (Pollak 2012) are captured especially by the wife who can use her time endowment to undertake unpaid, but valuable, activities in household production. The simulated gender division of paid and unpaid labor is both an effective risk-sharing strategy and a powerful device to reduce the intra-household gender gap. Ad hoc simulations may help to improve our understanding about the specialization and gender specific risk-copying strategy that a miniature household economy has the option to implement with success.

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Table 1: Descriptive Statistics by Farm-type

	Professional farm		Non-professional farm	
Farm characteristics				
Number of observations	947		147	
Macro-region (%):				
North	39		28	
Center	22		23	
South	39		49	
Area (%):				
Plain	78		76	
Hill	14		20	
Mountain	8		4	
Farm dimension (hectares)	15		7	
Land value (index)$^{(1)}$	4944		1065	
Capital value (index)$^{(2)}$	298		112	
Total production costs (EUR)	5437		1732	
Input demand in share:				
Hired labor	0.15		0.14	
Chemicals	0.11		0.11	
Materials	0.46		0.14	
Family labor	0.27		0.60	
Production in share:				
Crop	0.40		0.44	
Livestock	0.23		0.03	
Milk	0.25		0.19	
Fruit	0.12		0.34	
Price of the domestic good	5.75		5.75	
Household members' characteristics				
	Husband	**Wife**	**Husband**	**Wife**
Age (years)	48	44.5	49	45
Hourly wage (EUR)	5.87	5.71	5.90	5.71
Monthly full-income (EUR)	4398	4093	2850	2677
Share of non-labor income and profits	0.52	0.48	0.55	0.45
Consumption demands in share:				
Domestic good	0.11	0.18	0.18	0.25
Leisure	0.22	0.27	0.39	0.44
Food	0.28	0.23	0.18	0.13
Clothing	0.01	0.01	0.00	0.00
Other market goods	0.38	0.31	0.25	0.18
Weekday time use (hh.mm):$^{(3)}$				
Leisure	3.40	5.00	5.00	5.30
Domestic work	2.20	5.15	2.30	4.30
On-farm work	8.00	3.45	5.00	3.00
Off-farm work	0.00	0.00	1.30	1.30

Note: (1) The index is 2% of the land use value; (2) The index is 5% of the capital value; (3) Total day time$= 24 - r$ where $r = 10$ is equal to rest and personal care time.

Table 2: Benchmark Situation: Monthly Base Values

	Professional farm		Non-professional farm	
	Husband	**Wife**	**Husband**	**Wife**
Leisure price (EUR)	5.87	5.71	5.90	5.71
Hourly wages, Labor Market Participation and Time Use (monthly hours)				
Off-farm work	0.00	0.00	38.35	29.13
On-farm work	171.79	79.17	112.76	66.24
Domestic work	82.33	130.58	84.71	117.62
Leisure	164.63	194.45	189.83	205.39
Full-income components				
Off-farm income (EUR)	0.00	0.00	226.12	166.30
On-farm income (EUR)	1001.93	461.73	657.61	386.30
Domestic income (EUR)	483.54	746.00	499.46	671.54
Leisure value (EUR)	966.96	1110.88	1119.27	1172.68
Sharing rule (EUR) - φ_i	1945.23	1774.14	347.66	279.89
Full-income (EUR) - I_i	4397.66	4092.74	2850.12	2676.71
$\varphi_i/(y+\pi)$	0.52	0.48	0.55	0.45
$I_i/(I_1+I_2)$	0.52	0.48	0.52	0.48
Consumption demands (EUR)				
Domestic good	84.03	129.64	86.80	116.71
Food	185.49	140.25	78.28	52.55
Clothing	6.14	4.44	3.04	1.90
Other goods	2768.65	2104.52	1158.78	786.39
Farm production				
Total costs (EUR)	5436.86		1732.00	
Hired labor (Monthly hours)	137.19		35.74	
Chemicals (TONS)	1.05		0.34	
Materials (TONS)	2.59		0.33	
Crop (TONS)	134.12		19.93	
Livestock (TONS)	7.61		0.15	
Milk (TONS)	38.12		4.00	
Fruits (TONS)	22.64		8.14	
Profits (EUR)	3122.17		-301.11	
Shadow wage (EUR)	5.83		5.83	
Domestic production				
Endogenous price (EUR)	5.75		5.75	

Table 3: Simulation Results: Impact of a 10% Increase in Non-labor Income

	Professional farm				Non-professional farm			
	Husband		**Wife**		**Husband**		**Wife**	
	Simulation	%	Simulation	%	Simulation	%	Simulation	%
Panel A - Hourly wages, labor market participation and time use								
Leisure price	6.08	*3.49*	5.83	*2.06*	5.90	-	5.71	-
Off-farm work	0.00	-	0.00	-	30.75	*-19.83*	22.13	*-24.02*
On-farm work	171.79	-	79.17	-	112.76	-	66.64	-
Domestic work	82.46	*0.16*	132.53	*1.49*	85.15	*0.52*	118.42	*0.68*
Leisure	164.50	*-0.08*	192.50	*-1.00*	196.99	*3.77*	211.61	*3.03*
Panel B - Full-income components and the sharing rule								
Off-farm income	0.00	-	0.00	-	181.29	*-19.83*	126.36	*-24.02*
On-farm income	1001.93	-	461.62	-	657.61	-	386.30	-
Domestic income	501.22	*3.66*	772.75	*3.59*	502.05	*0.52*	676.13	*0.68*
Leisure value	999.86	*3.40*	1122.45	*1.04*	1161.50	*3.77*	1208.19	*3.03*
Intra-household distribution of income								
Sharing rule - φ_i	1976.22	*1.59*	1802.87	*1.62*	399.06	*14.78*	321.18	*14.81*
Full-income - I_i	4479.23	*1.86*	4159.80	*1.64*	2901.51	*1.80*	2718.18	*1.55*
$\varphi_i/(y+\pi)$	0.52	-0.01	0.48	0.01	0.55	-0.01	0.45	0.02
$I_i/(I_1+I_2)$	0.52	*0.10*	0.48	*-0.11*	0.52	*0.12*	0.48	*-0.13*
Panel C - Consumption demands								
Domestic good	84.86	*0.99*	130.83	*0.92*	87.25	*0.52*	117.51	*0.68*
Food	188.24	*1.48*	142.43	*1.55*	78.64	*0.46*	52.61	*0.13*
Clothing	6.22	*1.26*	4.51	*1.34*	3.05	*0.41*	1.91	*0.15*
Other goods	2789.09	*0.74*	2127.50	*1.09*	1165.58	*0.59*	787.91	*0.19*

	Professional farm		Non-professional farm	
Panel D - Farm production				
Marketable				
Total costs	5436.86	-	1732.00	-
Hired labor	137.19	-	35.74	-
Chemicals	1.05	-	0.34	-
Materials	2.59	-	0.33	-
Crop	134.12	-	19.93	-
Livestock	7.61	-	0.15	-
Milk	38.12	-	4.00	-
Fruits	22.64	-	8.14	-
Profits	3122.17	-	-301.11	-
Shadow wage	5.83	-	5.83	-
Non-marketable				
Endogenous price	5.91	*2.65*	5.75	-

Notes: Percentage variations are computed with respect to the base value. Blanks (-) indicate no change relative to the base value. Units are reported in table 2.

Table 4: Simulation Results: Impact of a 10% Increase in the Wife's Market Wage

	Professional farm				**Non-professional farm**			
	Husband		**Wife**		**Husband**		**Wife**	
	Simulation	%	Simulation	%	Simulation	%	Simulation	%
Panel A - Hourly wages, labor market participation and time use								
Leisure price	5.87	-	6.28	*10.00*	5.90	-	6.28	*10.00*
Off-farm work	7.13	*nc*	10.25	*nc*	42.74	*11.44*	32.36	*3.81*
On-farm work	171.79	-	79.17	-	112.76	-	66.24	-
Domestic work	90.76	*10.25*	128.22	*-1.80*	89.88	*6.11*	117.43	*-0.16*
Leisure	149.07	*-9.45*	186.57	*-4.05*	180.26	*-5.04*	202.34	*-1.48*
Panel B - Full-income components and the sharing rule								
Off-farm income	41.86	*nc*	64.38	*nc*	252.02	*11.45*	203.25	*22.22*
On-farm income	1001.93	-	461.73	-	657.61	-	386.30	-
Domestic income	533.10	*10.25*	805.76	*8.01*	529.96	*6.11*	737.55	*9.83*
Leisure value	875.54	*-9.45*	1172.42	*5.54*	1062.87	*-5.04*	1270.78	*8.37*
Intra-household distribution of income								
Sharing rule - φ_i	1945.16	*-0.00*	1774.21	*0.00*	347.65	*-0.00*	279.90	*0.01*
Full-income - I_i	4397.59	*-0.00*	4278.51	*4.54*	2850.10	*-0.00*	2877.76	7.51
$\varphi_i/(y+\pi)$	0.52	0.00	0.48	-0.00	0.55	-0.00	0.45	-0.01
$I_i/(I_1+I_2)$	0.51	*-2.14*	0.49	*2.30*	0.50	*-3.51*	0.50	*3.74*
Panel C - Consumption demands								
Domestic good	87.27	*3.86*	131.91	*1.75*	87.04	*0.27*	121.14	*3.79*
Food	188.19	*1.45*	146.15	*4.21*	79.97	*2.12*	56.13	*6.82*
Clothing	6.274	*1.60*	4.59	*3.20*	3.11	*2.47*	1.99	*5.04*
Other goods	2807.610	*1.39*	2145.21	*1.93*	1182.58	*2.05*	807.94	*2.74*

Panel D - Farm production				
Marketable				
Total costs	5436.86	-	1732.00	-
Hired labor	137.19	-	35.74	-
Chemicals	1.05	-	0.34	-
Materials	2.59	-	0.33	-
Crop	134.12	-	19.93	-
Livestock	7.61	-	0.15	-
Milk	38.12	-	4.00	-
Fruits	22.64	-	8.14	-
Profits	3122.17	-	-301.11	-
Shadow wage	5.83	-	5.83	-
Non-marketable				
Endogenous price	6.11	*6.16*	6.09	*5.82*

Notes: Percentage variations are computed with respect to the base value. Blanks (-) indicate no change relative to the base value. Units are reported in table 2.

Table 5: Simulation Results: Impact of a 10% Increase in Output Price

	Professional farm				**Non-professional farm**			
	Husband		**Wife**		**Husband**		**Wife**	
	Simulation	%	Simulation	%	Simulation	%	Simulation	%
Panel A - Hourly wages, labor market participation and time use								
Leisure price	6.84	*16.69*	6.05	*5.87*	6.07	*2.98*	5.71	-
Off-farm work	0.00	-	0.00	-	0.00	*-100*	59.47	*104.27*
On-farm work	171.79	-	79.17	-	145.95	*29.39*	33.010	*-50.04*
Domestic work	80.76	*-1.90*	141.04	*8.00*	85.11	*0.47*	119.659	*1.68*
Leisure	166.20	0.95	183.99	*-5.38*	194.63	*2.53*	206.23	*0.41*
Panel B - Full-income components and the sharing rule								
Off-farm income	0.00	-	0.00	-	0.00	*-100.0*	339.52	*104.17*
On-farm income	1026.82	*2.48*	473.20	*2.48*	886.22	*34.77*	201.00	*-47.97*
Domestic income	553.50	*14.46*	853.05	*14.35*	516.75	*3.46*	682.81	*1.68*
Leisure value	1139.03	*17.79*	1112.85	*0.18*	1181.79	*5.58*	1177.51	*0.41*
Intra-household distribution of income								
Sharing rule - φ_i	2051.38	*5.46*	1870.95	*5.46*	371.04	*6.73*	298.71	*6.73*
Full-income - I_i	4770.72	*8.48*	4310.05	*5.31*	2955.81	*3.71*	2699.47	*0.85*
$\varphi_i/(y+\pi)$	0.52	0.00	0.48	0.00	0.55	0.00	0.45	0.00
$I_i/(I_1+I_2)$	0.52	*1.43*	0.48	*-1.54*	0.52	*1.36*	0.48	*-1.45*
Panel C - Consumption demands								
Domestic good	87.06	*3.62*	134.20	*3.52*	88.69	*2.17*	117.17	*0.39*
Food	197.58	*6.20*	148.15	*5.06*	80.38	*2.69*	52.97	*0.80*
Clothing	6.47	*5.38*	4.67	*4.98*	3.11	*2.28*	1.92	*0.79*
Other goods	2850.12	*2.94*	2194.67	*4.28*	1178.48	*1.70*	792.86	*0.82*

Panel D - Farm production	Simulation	%	Simulation	%
Marketable				
Total costs	5571.592	*2.48*	1803.87	*4.15*
Hired labor	136.81	*-0.27*	37.52	*4.99*
Chemicals	1.20	*14.91*	0.34	*0.06*
Materials	2.60	*0.31*	0.35	*5.96*
Crop	157.80	*17.66*	22.22	*11.49*
Livestock	6.03	*-20.79*	0.17	*11.29*
Milk	34.76	*-8.84*	4.18	*4.26*
Fruits	21.78	*-3.80*	8.02	*-1.49*
Profits	3325.15	*6.50*	-290.54	*-3.51*
Shadow wage	5.98	*2.48*	6.07	*4.15*
Non-marketable				
Endogenous price	6.36	*10.47*	5.83	*1.29*

Notes: Percentage variations are computed with respect to the base value. Blanks (-) indicate no change relative to the base value. *nc* means that percentage values are not computable because the base value is zero. Units are reported in table 2.

Table 6: Comparative Statics Analysis in Response to Changes in Non-labor Income, Output Price and Wife's Market Wage on Individual Leisure Demands (Hours per Month)

	Non-labor income		**Output price**		**Wife's market wage**	
	Husband	**Wife**	**Husband**	**Wife**	**Husband**	**Wife**
Professional farm						
Collective Model	1.16	1.33	3.98	4.60	0.00	-25.16
Unitary Model	2.24	2.83	7.60	9.63	6.96	-70.50
Non-Professional farm						
Collective Model	3.43	3.18	1.56	1.44	0.00	-20.54
Unitary Model	6.19	7.12	2.81	3.24	13.40	-74.25

Table 7: Individual Compensating Variation (CV_i)

	Husband			**Wife**		
	Price effect	**Income effect**	**Overall effect** CV_i	**Price effect**	**Income effect**	**Overall effect** CV_i
Professional farm						
Simulation 1:						
Increase in non-labor income	276.51	-81.57	194.94	151.44	-67.06	84.38
CV_i/I_i			4.43%			2.06%
$CV_i/(CV_1+CV_2)$			69.79%			30.21%
Simulation 2:						
Increase in wife's market wage	41.75	0.07	41.82	725.11	-185.76	539.35
CV_i/I_i			0.95%			13.18%
$CV_i/(CV_1+CV_2)$			7.20%			92.80%
Simulation 3:						
Increase in output price	1412.18	-373.05	1039.13	456.50	-217.31	239.19
CV_i/I_i			23.63%			5.84%
$CV_i/(CV_1+CV_2)$			81.29%			18.71%
Non-professional farm						
Simulation 1:						
Increase in non-labor income		-			-	
CV_i/I_i						
$CV_i/(CV_1+CV_2)$						
Simulation 2:						
Increase in wife's market wage	34.57	0.01	34.58	434.55	-201.07	233.49
CV_i/I_i			1.21%			8.72%
$CV_i/(CV_1+CV_2)$			12.90%			87.10%
Simulation 3:						
Increase in output price	137.44	-106.40	31.03	6.92	-22.76	-15.84
CV_i/I_i			1.09%			-0.59%
$CV_i/(CV_1+CV_2)$			204.28%			-104.28

Notes: Values are in euro per month. Blanks (-) indicate no welfare change. I_i is i's full-income base value.

Appendix A. Proofs

Proof of Proposition 1.

The comparative statics is performed on individual i's demand for leisure $\tilde{l}^i = l^i\left(p_i, p_z^*, w_i, \varphi_i, d_i\right)$, on-farm labor $\tilde{h}^i = h^i\left(p_q, r, H, w_{on}^*, d_q\right)$, domestic work $\tilde{t}^i = t^i\left(w_1, w_2, z, d_z\right)$, and off-farm working hours $\tilde{L}^i = T_i - \tilde{l}^i - \tilde{t}^i - \tilde{h}^i$. In order to highlight that a change in the level of on-farm profit, $\tilde{\pi} = \pi\left(p_q, r, w_{on}^*, H, d_q\right)$, affects individual income shares, we specify the sharing rule as $\varphi_1 = \varphi\left(p_1, p_2, w_1, w_2, y + \tilde{\pi}, d_1, d_2\right)$ and $\varphi_2 = (y + \tilde{\pi}) - \varphi_1$. Recall also that the husband is indexed as $i = 1$ and the wife as $i = 2$.

We start by considering a positive change in household non-labor income y. If leisure is a normal good $\frac{\partial l^i}{\partial \varphi_i} > 0$, and an increase in non-labor income leads to an increase in the sharing rule, $\frac{\partial \varphi_i}{\partial y} > 0$, then the income transfer increases leisure demand

$$\frac{\partial \tilde{l}^i}{\partial y} = \frac{\partial l^i}{\partial \varphi_i} \frac{\partial \varphi_i}{\partial y} > 0, \quad i = 1, 2, \tag{A1}$$

and decreases off-farm labor

$$\frac{\partial \tilde{L}^i}{\partial y} = -\frac{\partial l^i}{\partial \varphi_i} \frac{\partial \varphi_i}{\partial y} < 0, \quad i = 1, 2. \tag{A2}$$

The latter result is because the income transfer does not affect either individual on-farm working hours or domestic labor supply[19]

$$\frac{\partial \tilde{h}^i}{\partial y} = 0 \text{ and } \frac{\partial \tilde{t}^i}{\partial y} = 0, \quad i = 1, 2. \tag{A3}$$

[19] The comparative statics analysis is made considering a fixed level of domestic output z. A non-labor income increase may have indirect effects on domestic production. The rise in exogenous income may increase individuals' demand for the domestic produced good, and, as a consequence, both spouses invest additional time in non-marketable production. The increased demand for spouses' time-input in domestic chores is driven by domestic production technology and the separability property is preserved (Browning, Chiappori, and Weiss 2014).

Proof of Proposition 2.

If leisure is an ordinary good $\frac{\partial l^i}{\partial w_i} < 0$, leisure and the domestic good are gross substitutes $\frac{\partial l^i}{\partial p_z^*} > 0$, and the sharing rule is increasing in i's market wage $\frac{\partial \varphi_i}{\partial w_i} > 0$, then

$$\frac{\partial \tilde{l}^i}{\partial w_i} = \frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_i} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_i} \lesseqgtr 0, \quad i = 1,2 \tag{A4}$$

where $P_z(w_1, w_2, d_z)$ is a unit cost function with $\frac{\partial P_z}{\partial w_i} > 0$.[20] According to the magnitude of price and income effects, the overall effect of a change in w_i on individual i's demand for leisure may be positive or negative. On the production side, the market wage increase has no effects on household labor supplies, while it reduces domestic working hours[21]

$$\frac{\partial \tilde{h}^i}{\partial w_i} = 0 \text{ and } \frac{\partial \tilde{t}^i}{\partial w_i} = \frac{\partial t^i}{\partial w_i} < 0 \quad i = 1,2. \tag{A5}$$

An increase in the market wage ambiguosly affects i's off-farm labor supply

$$\frac{\partial \tilde{L}^i}{\partial w_i} = -\left[\frac{\partial t^i}{\partial w_i} + \frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_i} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_i}\right] \lesseqgtr 0, \quad i = 1,2. \tag{A6}$$

Proof of Proposition 3.

We now analyze the cross-wage effect. If an increase in j's market wage leads to a reduction in i's income share, $\frac{\partial \varphi_i}{\partial w_j} < 0$, then i's leisure demand varies ambiguously with j's wage rate

$$\frac{\partial \tilde{l}^i}{\partial w_j} = \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_j} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_j} \lesseqgtr 0, \quad i = 1,2. \tag{A7}$$

[20] The endogenous price $P_z(w_1, w_2, d_z)$ is an increasing function of individual wages, $\frac{\partial P_z}{\partial w_i} = \frac{\partial^2 TC(w_1, w_2, z, d_z)}{\partial w_i \partial z} = \frac{\partial t^i(w_1, w_2, z, d_z)}{\partial z} > 0$ for $i = 1,2$.

[21] Domestic labor supply has standard properties: decreasing in input prices and increasing in output.

For production choices, we assume that family members are substitutes in domestic production[22] and therefore

$$\frac{\partial \tilde{t}^i}{\partial w_j} = \frac{\partial t^i}{\partial w_j} > 0 \quad i = 1,2. \tag{A8}$$

Following an increase in the off-farm wage, on-farm optimal working hours do not change

$$\frac{\partial \tilde{h}^i}{\partial w_j} = 0 \quad i = 1,2. \tag{A9}$$

In terms of off-farm labor supply, the comparative static result is ambiguous. From the time constraint we have

$$\frac{\partial \tilde{L}^i}{\partial w_j} = -\left[\frac{\partial t^i}{\partial w_j} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_j} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_j}\right] \lesseqgtr 0, \quad i = 1,2. \tag{A10}$$

Proof of Proposition 4.

We now analyze the effect of an increase in the output price p_q. Assuming that member i benefits from the increase in profits due to the rise in the output price, $\frac{\partial \varphi_i}{\partial \tilde{\pi}} > 0$, we have

$$\frac{\partial \tilde{l}^i}{\partial p_q} = \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial p_q} > 0, \quad i = 1,2. \tag{A11}$$

Changes in the output price have no effects on domestic labor supply

$$\frac{\partial \tilde{t}^i}{\partial p_q} = 0, \quad i = 1,2. \tag{A12}$$

The impact of an increase in the output price on husband's on-farm working hours is positive,

$$\frac{\partial \tilde{h}^1}{\partial p_q} = \frac{\partial h^1}{\partial p_q} + \frac{\partial h^1}{\partial w_{on}^*}\frac{\partial w}{\partial p_q} > 0, \tag{A13}$$

[22]The assumptions about responses of production-consumption choices and the sharing rule to market variations are based on empirical results by Menon and Perali (2013).

because we expect $\frac{\partial w}{\partial p_q}$ to be positive and individual 1's on-farm labor supply to be increasing in the shadow wage $\frac{\partial h^1}{\partial w^*_{on}} > 0$. Given the substitutability between spouses' on-farm work, it follows that

$$\frac{\partial \tilde{h}^2}{\partial p_q} = -\frac{\partial \tilde{h}^1}{\partial p_q} < 0. \tag{A14}$$

In terms of market hours, from the time constraint we derive

$$\frac{\partial \tilde{L}^1}{\partial p_q} = -\left[\frac{\partial h^1}{\partial p_q} + \frac{\partial h^1}{\partial w^*_{on}}\frac{\partial w}{\partial p_q} + \frac{\partial t^1}{\partial p_q} + \frac{\partial l^1}{\partial \varphi_1}\frac{\partial \varphi_1}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial p_q}\right] < 0, \tag{A15}$$

and

$$\frac{\partial \tilde{L}^2}{\partial p_q} = -\left[\frac{\partial h^2}{\partial p_q} + \frac{\partial h^2}{\partial w^*_{on}}\frac{\partial w}{\partial p_q} + \frac{\partial t^2}{\partial p_q} + \frac{\partial l^2}{\partial \varphi_2}\frac{\partial \varphi_2}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial p_q}\right] \lesseqgtr 0. \tag{A16}$$

Appendix B. Consumption-Leisure Choices within the Unitary Model

Under separability, production decisions derived within different approaches do not differ, therefore household production choices, both marketable and non-marketable, are those derived in Section 1. Unlike production, the consumption-leisure choices in general are model-specific. In the context of a unitary approach, the household consumption behavior is represented by the maximization of a household welfare function $U^H = u\left(c^1, c^2, z^1, z^2, l^1, l^2\right)$ subject to $\sum_{i\in\{1,2\}} p_i c^i + \sum_{i\in\{1,2\}} p^*_z z^i + \sum_{i\in\{1,2\}} w_i l^i = \sum_{i\in\{1,2\}} w_i \bar{T}_i + Y$. Household full income is $Y = y_1 + y_2 + \pi\left(p_q, r, w^*_{on}, H, d_q\right)$ where π is the profit function, and $\overline{T}_i = L^i + l^i$. The solution for the domestic good is $\hat{z}^i = z^i\left(p_1, p_2, p^*_z, w_1, w_2, Y\right)$, for leisure demand $\hat{l}^i = l^i\left(p_1, p_2, p^*_z, w_1, w_2, Y\right)$ and for consumption $\hat{c}^i = c^i\left(p_1, p_2, p^*_z, w_1, w_2, Y\right)$.[23] The conditions satisfied by these demand functions are the usual restrictions on the Slutsky matrix (symmetry and negative semi-definiteness) and income pooling, both of which in general have been rejected by empirical

[23] In the unitary framework, the demand for the consumption and domestic good is observed as a household aggregate. One of the objectives of the collective approach is to identify individual demands in general.

analyses (Browning and Chiappori 1998, Fortin and Lacroix 1997, Phipps and Burton 1998, Schultz 1990, Thomas 1990). The income pooling condition says that the distribution of household income $y_1 + y_2 = y$ across family members play no role in determining individual optimal choices, only the total level of y does. Formally, this condition is $\frac{\partial l^i}{\partial y_i} = \frac{\partial l^i}{\partial y_j}$ for $i, j = 1, 2$ and for all other demand functions z and c.

Maintaining the assumptions used in the collective model described in Section 1.4, the comparative statics performed on unitary leisure-consumption demands are summarized below and reported in Table B1. The interested reader can compare these results with the ones obtained in the collective framework presented in Propositions 1-4.

Non-labor income effect Under the common assumption of normality, individual leisure demand increases when household non-labor income increases $\frac{\partial \hat{l}^i}{\partial y} > 0$. Because of separability between production and consumption choices, a change in non-labor income does not affect household production choices. Therefore, the non-labor income effect related to the individual off-farm labor supply $\hat{L}^i = T_i - \hat{l}^i - \widetilde{t}^i - \tilde{h}^i$ is $\frac{\partial \hat{L}^i}{\partial y} = -\frac{\partial \hat{l}^i}{\partial y}$. It is worth noting that in unitary models income changes have direct effects on demand equations, while in collective models they are also conveyed through the sharing rule function and affect the other member's choices.

Own-wage effect Exogenous own-wage changes yield variations in individual leisure demands that can be decomposed as $\frac{\partial \hat{l}^i}{\partial w_i} = \frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*} \frac{\partial P_z}{\partial w_i}$ where the direction of the effect, without extra assumptions, is undefined: if the positive effect $\frac{\partial l^i}{\partial p_z^*} \frac{\partial P_z}{\partial w_i}$ is smaller than $\frac{\partial l^i}{\partial w_i}$, then individual i reduces the time allocated to leisure activities probably in favor of paid work if the market wage is higher than the shadow wages of leisure, farm and home production. Reproducing the same analysis on individual labor supplies, one obtains $\frac{\partial \hat{L}^i}{\partial w_i} = -\left[\frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*} \frac{\partial P_z}{\partial w_i} + \frac{\partial t^i}{\partial w_i}\right]$ where the change in the domestic activities reinforces the own-wage leisure effect, increasing the likelihood that individual i increases her paid work time. Given the structure of demand equations underlying unitary models, variations in own-wage do not capture variations in the bargaining power within spouses that are reasonably present in families. The comparative statics for domestic work and on-farm work are referred to those of Section 1.4.

Cross-wage effect The cross-wage effects on leisure demands are $\frac{\partial \hat{l}^i}{\partial w_j} = \frac{\partial l^i}{\partial w_j} + \frac{\partial l^i}{\partial p_z^*} \frac{\partial P_z}{\partial w_j}$. These differ with respect to those derived in the collective model because the cross-wage effect operates directly $\frac{\partial l^i}{\partial w_j}$ on the demand equation. The sign of this effect depends on the substitution-complementarity relationship between leisure demands of the two household members. Similarly, for labor supply we have $\frac{\partial \hat{L}^i}{\partial w_j} = -\left[\frac{\partial l^i}{\partial w_j} + \frac{\partial l^i}{\partial p_z^*} \frac{\partial P_z}{\partial w_j} + \frac{\partial t^i}{\partial w_j}\right]$.

Output-price effect The increase in the output price p_q affects individual leisure demand as follows $\frac{\partial \hat{l}^i}{\partial p_q} = \frac{\partial l^i}{\partial Y} \frac{\partial Y}{\partial \tilde{\pi}} \frac{\partial \pi}{\partial p_q}$. Changes in the output price have no effects on domestic labor supply and the impact on on-farm working hours is positive as described in Section 1.4. In terms of market hours, from the time constraint, we derive $\frac{\partial \hat{L}^i}{\partial p_q} = -\left[\frac{\partial l^i}{\partial Y} \frac{\partial Y}{\partial \tilde{\pi}} \frac{\partial \pi}{\partial p_q} + \frac{\partial h^i}{\partial p_q} + \frac{\partial h^i}{\partial w_{on}^*} \frac{\partial w}{\partial p_q} + \frac{\partial t^i}{\partial p_q}\right]$.

Table B1: Comparative Statics Effects: Unitary versus Collective Household Model

Unitary model	
Income	$\frac{\partial \hat{l}^i}{\partial y} = \frac{\partial l^i}{\partial Y}\frac{\partial Y}{\partial y}$
	$\frac{\partial \hat{L}^i}{\partial y} = -\frac{\partial l^i}{\partial Y}\frac{\partial Y}{\partial y}$
Own-wage	$\frac{\partial \hat{l}^i}{\partial w_i} = \frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_i}$
	$\frac{\partial \hat{L}^i}{\partial w_i} = -\left[\frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_i} + \frac{\partial t^i}{\partial w_i}\right]$
Cross-wage	$\frac{\partial \hat{l}^i}{\partial w_j} = \frac{\partial l^i}{\partial w_j} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_j}$
	$\frac{\partial \hat{L}^i}{\partial w_j} = -\left[\frac{\partial l^i}{\partial w_j} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_j} + \frac{\partial t^i}{\partial w_j}\right]$
Output price	$\frac{\partial \hat{l}^i}{\partial p_q} = \frac{\partial l^i}{\partial Y}\frac{\partial Y}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial p_q}$
	$\frac{\partial \hat{L}^i}{\partial p_q} = -\left[\frac{\partial l^i}{\partial Y}\frac{\partial Y}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial p_q} + \frac{\partial h^i}{\partial p_q} + \frac{\partial h^i}{\partial w_{on}^*}\frac{\partial w}{\partial p_q} + \frac{\partial t^i}{\partial p_q}\right]$
Collective model	
Income	$\frac{\partial \tilde{l}^i}{\partial y} = \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial y}$
	$\frac{\partial \tilde{L}^i}{\partial y} = -\frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial y}$
Own-wage	$\frac{\partial \tilde{l}^i}{\partial w_i} = \frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_i} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_i}$
	$\frac{\partial \tilde{L}^i}{\partial w_i} = -\left[\frac{\partial l^i}{\partial w_i} + \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_i} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_i} + \frac{\partial t^i}{\partial w_i}\right]$
Cross-wage	$\frac{\partial \tilde{l}^i}{\partial w_j} = \frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_j} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_j}$
	$\frac{\partial \tilde{L}^i}{\partial w_j} = -\left[\frac{\partial l^i}{\partial p_z^*}\frac{\partial P_z}{\partial w_j} + \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial w_j} + \frac{\partial t^i}{\partial w_j}\right]$
Output price	$\frac{\partial \tilde{l}^i}{\partial p_q} = \frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial p_q}$
	$\frac{\partial \tilde{L}^i}{\partial p_q} = -\left[\frac{\partial l^i}{\partial \varphi_i}\frac{\partial \varphi_i}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial p_q} + \frac{\partial h^i}{\partial p_q} + \frac{\partial h^i}{\partial w_{on}^*}\frac{\partial w}{\partial p_q} + \frac{\partial t^i}{\partial p_q}\right]$

Appendix C. Collective Household Accounting Matrix

By convention, in an accounting matrix row entries refer to output, receipts and incomes, whereas column entries represent inputs, outlays, and expenditures. Values are expressed in euros per month. The agricultural production is aggregated in four outputs - crops, livestock, milk and fruit, olives and grapes - that are sold on competitive markets at exogenous prices. The aggregate value of the agricultural production is 8559 euros for the professionals and 1431 euros for the non-professionals (Row 3 in tables C1 and C2). These figures also include the monetary value of agricultural transfers that farms received by the government in the form of decoupled payments.[24] The production factors are partly bought on the market (market inputs) and partly owned by the household (family labor) and are remunerated from the value added (Rows 1 and 2 in tables C1 and C2). The aggregate cost of market inputs amounts to 3973 euros for the professional farm-household type and 688 euros for the non-professional farm-household type (Column 1 in tables C1 and C2). On-farm family labor costs 1463 euros to professional farms and 1044 euros to non-professional households (Column 2 in tables C1 and C2). The structure of the ISMEA data allows us to separately evaluate the cost of the husband and wife on-farm work. The husband of professional (non-professional) farms costs 1002 euros (658 euros) to the household enterprise, whereas the wife costs 462 euros (386 euros). Profits accrued from the agricultural activity amount to 3122 euros for professional farms, whereas the loss undergone by non-professional farms amounts to 301 euros (Column 3 in tables C1 and C2).

Individual full-incomes (Rows 4 and 5 in tables C1 and C2) are obtained summing the value of individual total time endowment (the sum of on-farm work, domestic work, off-farm work and leisure) and individual share of household non-labor income and profits or losses from the agricultural business (Castagnini, Menon, and Perali 2003). Profits and household non-labor income (597 euros for professional farms and 929 euros for non-professional farms) are shared between spouses according to the sharing rule estimated from the same ISMEA data by Menon and Perali (2013). The estimation results show that, on average, the husband belonging to

[24] Decoupled payments are lump-sum income transfers to farmers that do not depend on current production, factor use, or commodity prices.

professional (non-professional) farms attracts 52.3% (55.4%) of the total amount of household resources shared by spouses compared to 47.7% (44.6%) obtained by the wife (Column 6 in tables C1 and C2).

Household members spend their full-income in purchasing market goods - food, clothing and an aggregated market good - the domestic produced good, and leisure (Columns 4 and 5 in tables C1 and C2). The representative man of professional (non-professional) enterprises spends 484 euros (499 euros) to consume the domestic good, 967 euros (1119 euros) to enjoy leisure, and 2947 euros (1231 euros) to buy market goods. The representative woman of professional (non-professional) farms spends 746 euros (672 euros) to consume the domestic good, 1111 euros (1173 euros) to enjoy leisure and 2236 euros (832 euros) to buy market goods.

The rest of the economy - Row 11 in tables C1 and C2 - gains by supplying market inputs (3973 euros for the professional farm type and 688 euros for the non-professional farm type) and selling market goods (5183 euros for professional farms and 2064 euros for non-professional farms). The rest of the economy - Column 11 in tables C1 and C2 - acquires the assets produced by the households (8559 euros for professional farms and 1431 euros for non-professional farms), pays non-labor income (597 euros to professional farms and 929 euros to non-professional farms) and off-farm work (0 euros to professionals and 392 euros to non-professionals). Professional and non-professional farms differ substantially in terms of labor market participation. Family members of professional enterprises do not supply off-farm work.

Appendix D. Specification and Equilibrium Conditions of the Programming Model

The functional form specification and equilibrium conditions adopted in the programming model are described below and summarized in table D1. They reproduce the empirical specification of the econometric model estimated by Menon and Perali (2013), whose parameters are used to calibrate the programming model. We define the set of market inputs $f = \{$chemicals,

Table C1: Household Social Accounting Matrix for Professional Farms

	Market inputs	Family labor	Agricultural production	Husband	Wife	Sharing rule	Off-farm labor	Non-labor income	Domestic income	Leisure	Rest of the economy
Market inputs			3973.2								
Family labor			1463.7								
Agricultural production											8559.0
Husband		1001.9				1945.2	0.0		483.5	967.0	
Wife		461.7				1774.2	0.0		746.0	1110.9	
Sharing rule			3122.2					597.2			
Off-farm labor											0.0
Non-labor income											597.2
Domestic income				483.5	746.0						
Leisure				967.0	1110.9						
Rest of the economy	3973.2			2947.2	2235.9						

Here we report disaggregated values for market inputs, agricultural production, and individual consumption of market goods.

Market inputs:	Hired labor	Chemicals	Materials	Total[(2)]
	8323.8	624.6	2515.8	3973.21

Agricultural production:	Crop	Livestock	Milk	Fruit	Decoupled payments	Total[(3)]
	3135.8	1819.7	1921.2	963.1	719.3	8559.0

Consumption of market goods:	Food	Clothing	Other market goods	Total[(4)]
Husband	1220.8	26.7	1699.7	2947.2
Wife	923.0	20.9	1292.0	2235.9

Note: (1) Values expressed in EUR per month. (2) Total value reported in cell (Rest of the economy, Market inputs) and (Market inputs, Agricultural production). (3) Total value reported in cell (Agricultural production, Rest of the economy). (4) Total value reported in cell (Rest of the economy, Husband) and (Rest of the economy, Wife).

Table C2: Household Social Accounting Matrix for Non-professional Farms

	Market inputs	Family labor	Agricultural production	Husband	Wife	Sharing rule	Off-farm labor	Non-labor income	Domestic income	Leisure	Rest of the economy
Market inputs			688.1								
Family labor			1043.9								
Agricultural production											1430.9
Husband		657.6				347.7	226.1		499.7	1119.3	
Wife		386.3				279.9	166.3		671.5	1172.7	
Sharing rule			-301.1					928.7			
Off-farm labor											392.4
Non-labor income											928.7
Domestic income				499.5	671.5						
Leisure				1119.3	1172.7						
Rest of the economy	688.1			1231.4	832.5						

Here we report disaggregated values for market inputs, agricultural production, and individual consumption of market goods.

Market inputs:	Hired labor	Chemicals	Materials	Total(2)
	250.0	188.1	250.0	688.1

Agricultural production:	Crop	Livestock	Milk	Fruit	Decoupled payments	Total(3)
	471.9	35.4	204.3	364.1	354.8	1430.9

Consumption of market goods:	Food	Clothing	Other market goods	Total(4)
Husband	509.3	10.7	711.4	1231.4
Wife	341.9	7.8	482.8	832.5

Note: (1) Values expressed in EUR per month. (2) Total value reported in cell (Rest of the economy, Market inputs) and (Market inputs, Agricultural production). (3) Total value reported in cell (Agricultural production, Rest of the economy). (4) Total value reported in cell (Rest of the economy, Husband) and (Rest of the economy, Wife).

materials, hired labor}, the quasi-fixed factor $H =$ family labor and the set of outputs $s =$ {crop, livestock, milk, fruits, olives and grapes}. The set of consumption goods is denoted as $k = \{l$eisure, domestic good, food, clothing, other market goods} which is disaggregated in the subset of market goods as $b = \{f$ood, clothing, other market goods}. Member 1 is the husband and member 2 the wife.

Household production decisions

The equations describing marketable production activities of the household enterprises are the total cost function, input factor demands, the shadow wage, revenue shares, and profit equation.

Total cost function Menon and Perali (2013) estimate the farm production technology from the dual side to account both for the non-homogeneity of family and hired labor (D'Antoni, Mishra, and Gillespie 2011) and the fact that hired labor is a variable factor with an associated observable market wage, while family labor is a quasi-fixed factor with an associated shadow wage (Paris 1989).

The total restricted cost function for the agricultural production takes a Translog form with four outputs, three market inputs and the quasi-fixed factor

$$\ln VC = \alpha_0 + \sum_{s=1}^{4} \alpha_s \ln q_s + \sum_{f=1}^{3} \beta_f \ln r_f + \chi \ln H + \frac{1}{2} \sum_{s=1}^{4} \sum_{u=1}^{4} \delta_{su} \ln q_s \ln q_u +$$

$$+ \frac{1}{2} \sum_{f=1}^{3} \sum_{v=1}^{3} \gamma_{fv} \ln r_f \ln r_v + \sum_{s=1}^{4} \sum_{f=1}^{3} \rho_{sf} \ln q_s \ln r_f + \sum_{f=1}^{3} \xi_f \ln H \ln r_f, \tag{D1}$$

where VC denotes variable costs of the agricultural production, r_f is the price of market input f, H is the quasi-fixed factor family labor, and q_s is the level of the agricultural output s. α_0, α_s, β_f, χ, δ_{su}, γ_{fv}, ρ_{sf}, ξ_f are estimated parameters (Menon and Perali 2013).

Factor demands Using Shephard's lemma, the derivatives of equation (D1) with respect to the logarithm of input prices r_f define the share of the f-th input

$$\omega_f = \beta_f + \sum_{f=1}^{3} \gamma_{fv} \ln r_f + \sum_{s=1}^{4} \rho_{sr} \ln q_s + \xi_f \ln H. \tag{D2}$$

We model demands for market inputs, x_q^f, as

$$x_q^f = \omega_f \frac{VC}{r_f}. \tag{D3}$$

Shadow wage On-farm family labor is a quasi-fixed factor allocatable both across activities, when information is available, and between spouses, as in our case. If entrepreneurs are minimizing costs, the quasi-fixed factor's shadow wage w_{on}^* for family labor is derived by differentiating total costs with respect to the level of quasi-fixed factor

$$w_{on}^* = \left(\chi + \sum_{f=1}^{3} \xi_f \ln r_f \right) \frac{VC}{H}, \tag{D4}$$

where VC are the minimum variable costs in level.

Revenue shares Assuming marginal cost pricing for output, revenue share equations are obtained by deriving the logarithm of the total cost function with respect to the logarithm of output

$$\frac{p_{q_s} q_s}{VC} = \alpha_s + \sum_{u=1}^{4} \delta_{su} \ln q_u + \sum_{f=1}^{3} \rho_{sf} \ln r_f, \tag{D5}$$

where p_{q_s} is the market price and q_s the quantity of good s.

Profit equation The equation for farm profits is

$$\pi = \sum_s p_{q_s} q_s - C + TR, \tag{D6}$$

where C are total costs including also the cost of the quasi-fixed factor H (Paris 1989), TR are lump-sum income transfers that farm-households receive from the government and that do not depend on current production, factor use, or commodity prices.

Domestic production decisions

The implicit price p_z^* of the non-marketable good and input demands t^i are specified as follows.

Implicit price of the domestic good The equation for the implicit price p_z^* is derived as the exponent of a Translog unit cost function (Apps and Rees 1997)

$$p_z^* = \exp\left(a_0 + \sum_{i=1}^{2} a_i \ln w_i^* + 0.5 \sum_{i=1}^{2}\sum_{j=1}^{2} a_{ij} \ln w_i^* \ln w_j^*\right), \tag{D7}$$

where a_0, a_i, and a_{ij} are estimated parameters (Menon and Perali 2013). The time spent by spouses in domestic tasks is valued at their marginal labor productivity in domestic production, that is w_i^*.

Factor demands Given the assumption of constant return to scale, the value of individual consumption of the domestic good equals the value of the time spent by that individual on domestic tasks. Therefore, individual domestic labor supply is given by

$$t^i = \frac{p_z^*}{w_i^*} z^i. \tag{D8}$$

Consumption-leisure decisions

The consumption side of the household economy comprises the equations for individual full-income and consumption good demands.

Individual full-income Individual full-income is defined as the value of individual endowment of time added up to individual share of total household non-labor income

$$I^i = w_i^*(l^i + t^i) + w_i L^i + w_{on}^* h^i + \varphi_i, \tag{D9}$$

with

$$\varphi_1 = \sigma\left(w_1, w_{2,} p_1, p_2, y, d_f\right)(y + \pi) \tag{D10}$$

and

$$\varphi_2 = y + \pi - \varphi_1. \tag{D11}$$

The function $\sigma()$ is specified as a Cobb-Douglas

$$\sigma = \left(w_1^{\theta_1} w_2^{\theta_2} p_1^{\theta_3} p_2^{\theta_4} y^{\theta_5} d_f^{\theta_6}\right) \in [0,1], \tag{D12}$$

with $\theta_5 = -\sum_{n=1}^4 \theta_n$ in order to have individual income shares φ_i homogeneous of degree one in monetary variables and the consumption demands satisfying homogeneity of degree zero in prices and non-labor income. d_f is a vector of distribution factors. For a detailed econometric characterization of the sharing rule see Menon and Perali (2013).

Individual consumption demands The Individual budget shares are derived from individual preferences of Gorman polar form and the share of the k-th good is

$$\omega_{ik} = \alpha_{ik} + t_{ik}(d_i) + \sum_n \nu_{ink} \ln P_{ik} + \eta_{ik} \ln\left(\frac{I^i}{A_i(P_{ik})}\right), \tag{D13}$$

with $\sum_k \omega_{ik} = 1$ for each member i. $t_{ik}(d_i) = \sum_m \tau_{ikm} \ln d_{im}$ is the k-th translating demographic function with d_{im} denoting demographic variables for spouse i, P_{ik} is the set of good prices differentiated by gender, and $A_i(P_{ik})$ is a price index taking a Translog form. The quantity of good k consumed by member i is defined as

$$c_b^i = \omega_{ib} \frac{I^i}{p_{ib}}, \tag{D14}$$

the hours of leisure are

$$l^i = \omega_{il} \frac{I^i}{w_i^*}, \tag{D15}$$

and the quantity of the domestic good is

$$z^i = \omega_{iz} \frac{I^i}{p_z^*} \tag{D16}$$

where ω_{ib}, ω_{il} and ω_{iz} are the individual budget shares of equation (D13).

Equilibrium conditions

Closure equations are individual time constraints

$$T = l^i + h^i + t^i + L^i, \tag{D17}$$

and labor market clearing conditions modeled as a Mixed Complementarity Problem (Löfgren and Robinson 1997 and 1999) through the following Kuhn-Tucker conditions

$$L^i \left(w_i - w_i^* \right) = 0. \tag{D18}$$

When $w_i < w_i^*$, individual i does not participate in the off-farm labor market and her shadow wage w_i^* solves equation (D17). On the other hand, when $w_i = w_i^*$ individual i may work in the off-farm labor market and $L^i = T - h^i - t^i - l^i \geq 0$.

Given the assumption of quasi-fixed factor, husband and wife on-farm labor supplies add up to H

$$h^1 + h^2 = H. \tag{D19}$$

Assuming that the husband has to supply a minimum number of working hours in the family business, $\bar{H}^1$, the Kuhn-Tucker conditions are

$$\left(w_1^* - w_{on}^* \right) \left(h^1 - \bar{H}^1 \right) = 0. \tag{D20}$$

When $w_1^* > w_{on}^*$, the husband supplies the minimum required number of hours $\bar{H}^1$ to run the family business. On the other hand, when $w_1^* = w_{on}^*$ it may be that $h^1 \geq \bar{H}^1$. The wife on-farm working hours are residually determined by equation (D19).

Homogeneity and numeraire

In the programming model, the system of equations describing production choices, consumption-leisure decisions, and equilibrium conditions are solved using relative prices, because demands and supplies are homogeneous of degree zero in prices. We thus choose as numeraire the price of other market goods.

Table D1: A Stylized Equilibrium Model for the Household Enterprise

Description	Equation	Endogenous Variable	Set	Equation reference
Agricultural production				
Cost function	$\ln VC = TRANSLOG\left(r_f, q_s; H, d_q\right)$	VC		C1
Market input shares	$\omega_f = TRANSLOG\left(r_f, q_s; H, d_q\right)$	ω_f	$f \in F$	C2
Market input demands	$r_f x_q^f = \omega_f VC$	x_q^f	$f \in F$	C3
Shadow wage	$w_{on}^* = \left(\partial \ln VC / \partial \ln H\right)(VC/H)$	w_{on}^*		C4
Revenue shares	$p_{q_s} q_s = \left(\partial \ln VC / \partial \ln q_s\right) VC$	q_s	$s \in S$	C5
Profit	$\pi = \sum_s p_s q_s - C + TR$	π		C6
Domestic production				
Price of the domestic good	$p_z^* = TRANSLOG\left(w_1^*, w_2^*; d_z\right)$	p_z^*		C7
Domestic labor demands	$w_i^* t^i = p_z^* z^i$	t^i	$i = 1,2$	C8
Income definition				
Individual full-incomes	$I_i = w_i^*\left(l^i + t^i\right) + w_{on}^* h^i + w_i L^i + \varphi_i$	I_i	$i = 1,2$	C9
Husband's sharing rule	$\varphi_1 = \sigma\left(y + \pi\right)$	φ_1		C10
Wife's sharing rule	$\varphi_2 = y + \pi - \varphi_1$	φ_2		C11
Scaling function	$\sigma = CD\left(w_1, w_2, p_1, p_2, y, d_f\right)$	σ		C12
Individual consumption				
Consumption shares	$\omega_{ik} = AIDS\left(w_1^*, w_2^*, , p_1, p_2, \psi_i; d_i\right)$	ω_{ik}	$i = 1,2, k \in K$	C13
Market goods demands	$p_{ib} c_b^i = \omega_{ib} I_i$	c_b^i	$i = 1,2,\ b \in B$	C14
Leisure demands	$w_i^* l^i = \omega_{l^i} I_i$	l^i	$i = 1,2$	C15
Domestic good demands	$p_z^* z^i = \omega_{z^i} I_i$	z^i	$i = 1,2$	C16
Market clearing condition				
Time constraints	$T_i = l^i + h^i + t^i + L^i$	w_i^*	$i = 1,2$	C17
Labor market participation	$L^i\left(w_i^* - w_i\right) = 0$	L^i	$i = 1,2$	C18
Wife's on-farm work	$h^2 = H - h^1$	h^2		C19
Husband's on-farm work	$\left(w_1^* - w_{on}^*\right)\left(h^1 - \bar{H}^1\right) = 0$	h^1		C20