The Collective Household Enterprise Model: A Microsimulation Analysis*

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Abstract

We model the household as making Pareto-efficient production and consumption-leisure decisions within a collective framework. The collective household model developed in the paper is used to carry out a microsimulation analysis assessing the intrahousehold distributional consequences of changing in prices and wages due to exogenous market perturbations. The microsimulation analysis is implemented on two farm-household types derived derived by a sample of Italian farm-households. The paper provides evidences that the collective approach to household behaviour is a valid instrument for analyzing individual as well household responses to exogenous changes or hypothetical policies.

Keywords: Collective household enterprise model, household production, separability, microsimulation analysis.
JEL: D11, D12, D13, C61.

1 Introduction

Collective household models, initially developed by Apps and Rees (1988) and Chiappori (1988, 1992), represent the household as a collection of persons, each of whom is characterized by a specific utility function, participates in the household decision process and shares household resources with the other household members. Differently from unitary household models that describe the household as an undifferentiated

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decision unit ascertaining limited information on individual behaviour, the collective model permits recovering private consumption, the intrahousehold resource allocation, and individual welfare functions. For this reason, the collective model is a worthwhile instrument for evaluating the impacts of socio-economic policies both at the household level and, more interestingly, at the individual level.

In general, the resource allocation process is not directly observable but it can be recovered from available information on private consumption of assignable or exclusive goods (Bourguignon, Browning, and Chiappori 2009, Chiappori and Ekeland 2006, 2009). The collective approach makes no assumption about the decision process. It only requires that the outcome of the household model is Pareto efficient. Family decisions then take place as if it were a two-stage budgeting process. Supposing that the family pools its resources, total household income is then allocated to single members according to a predetermined sharing rule defining the intrahousehold income distribution. It follows that each member, while choosing the most preferred utility maximizing bundle of goods and leisure, faces an individual budget constraint.

Our aims are to provide a collective model that applies to household enterprises and to assess the impacts of exogenous market changes on the individual optimal decisions and welfare levels. The household enterprise may be a farm or a non-farm household depending on the production activity undertaken by its members, but where the economic activities are mainly conducted by the family. The household enterprise is a miniature economy in which the family reproduces the characteristics of a macro society at the micro level. In particular, members of the household enterprise are involved both in producing goods and services supplying some of the inputs, such as labour, and in consuming market and domestically produced goods, and leisure.

While the prevailing collective household literature (Apps and Rees 1997, Chiappori 1997, Donni 2008) offers models accounting for one production activity, in general the nonmarketable production, the collective household model proposed in the paper has the peculiar feature of describing the family as taking part in two production activities, a marketable and a nonmarketable production. The exclusion of marketable productions omits to represent the behaviour of farm households, typical of developing countries, where the subsistence economy of the family is based on rural activities whose products are partly sold on markets and parlty consumed by the family.

In order to accomplish the objectives of the paper, we model the household as making Pareto-efficient production and consumption-leisure decisions within a collective framework. Household members are engaged both in a marketable activity, that may be an agricultural or commercial business, and in nonmarketable activities, such as housework, caring for household members, food preparation. Furthermore, given a certain allocation of resources within the family, each individual chooses the preferred consumption bundle of market goods, domestically produced goods and lesiure. In the model we allow each individual to specialize in the on-farm and domestic activities implying that individuals may decide not to work in the off-farm labour market. When an individual does not participate in the labour market her marginal productivity may be different from her market wage. The equilibrium solution of the household enterprise model is based on the separability property between production and consumption-leisure choices.

The collective household model developed in the paper is then used to assess the intrahousehold distributional consequences of exogenous changing in output prices and market wages. The microsimulation analysis is implemented on two farm-household types. Farm-household data are drawn from the 1995 Survey on Socio-Economic Characteristics of Italian Rural Household conducted by the Italian Institute for Agri-Food Business Markets (ISMEA). The ISMEA household data are also used to construct the Household Social Accounting Matrix (HSAM) for two farm-household types. The HSAM is an accounting scheme of the farm household economy. It describes the flows of all economics transactions that take place within the household economy. The parametric estimation of the collective farm household model employed in the simulation exercise is based on a paper by Menon and Perali (2010). The estimated production and consumption-leisure parameters together with the HSAM are used to calibrate the equilibrium of the collective farm household model and then to gauge the effects of market changes on individual behaviour.

The paper unfolds as follows. Section 2 shows the collective household enterprise model highlighting the conditions that assure separability between production and consumption-leisure decions. Section 3 shows results of the comparative statics performed on individual labour supply equation. In Section 4, we describe the Italian farm-household data used to construct the Household Social Accounting Matrix specific to each farm-household types. The programming model system and the practical technique employed to calibrate the household equilibrium model are shown in Section 5. Section 6 shows the results of the microsimulation analysis of exogenous market changes. Section 7 concludes the paper.

2 A Collective Household Enterprise Model

The household enterprise[1] model representes the family as a miniature economy where goods are produced and consumed by its members (Benjamin 1992, Chayanov 1986, de Janvry, Fafchamps, and Sadoulet 1991, Singh, Squire, and Strauss 1985). As a producer, the family purchases inputs from the market and provides itself inputs, such as family labour, in order to produce goods that can be partly sold in the market and partly consumed by its members. As a consumer, the family maximizes a utility

[1] Throughout the paper we use the terms "enterprise" and "farm" interchangeably. With the term "enterprise" we emphasize that the family may run a commercial business, such as a bakery shop or a pet shop, but where members provide labour force to the family economic activity.

function subject to a cash income constraint in order to find the optimal consumption bundle.

Although the recent progress of family economics (Browning, Chiappori, and Weiss 2010), the decision behaviour of the household enterprise is in general studied within the unitary model, in which the basic decision unit is the family with a unique preference structure and each individual has same preferences and weight (see for example Carter and Yao 2002, Chavas, Petrie, and Roth 2005, de Janvry and Sadoulet 2006, Henning and Henningsen 2007, Le 2010, Taylor and Adelman 2003).

Differently, we represent the production-consumption decisions of the farm household within the context of a collective approach (Apps and Rees 1988, and Chiappori 1988, 1992). The collective household model describes the family as a collection of individuals each of whom is characterized by her own preferences and shares household resources with the other members. The collective model only assumes that outcomes of the household decision process are Pareto-efficient.

Note that in general throughout this section superscript i indicates endogenous variables while subscript i indicates exogenous variables.

2.1 Individual and Household Preferences

The family comprises two-adult persons denoted by $i = 1, 2$. Each individual has rational preferences over the private consumption of a composite market good c^i, leisure l^i, and a domestically produced good z^i. Individuals' preferences are characterized by a quasi-concave and strictly increasing 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 that affect preferences directly.All members of the family allocate their total time T_i to a marketable production activity, h^i, and a nonmarketable prodution activity, t^i. Moreover, they may work in the off-farm labour market, L^i. Thus the individual endowment of total time is $T_i = L^i + h^i + t^i + l^i$.

The utility function of the household is represented by a weighted sum of the individuals' utilities, $U^H = \mu U^1\left(c^1, l^1, z^1; d_1\right) + (1-\mu)U^2\left(c^2, l^2, z^2; d_2\right)$, where the Pareto weight $\mu \in [0, 1]$ is a differentiable function that may depend on the exogenous variables entering the budget constraint and distribution factors.[2] The Pareto weight μ represents the bargaining power that each member can exert on family resources. If $\mu = 1$ the household welfare is entirely determined by the preferences of individual 1 and it implies that she has the total control over the household resources. On the other hand, the reverse is true if $\mu = 0$.

[2]Distribution factors are variables that do not affect either individual preferences or the budget constraint. They are are helpful in recovering the structure of the collective model and play an important role in empirical applications. Browning, Chiappori, and Lechene (2006), and Chiappori and Ekeland (2006, 2009) show the key role played by distribution factors to identify the sharing rule and present an exhaustive review of distribution factors used in the collective household literature.

Throughout the paper we ignore both the consumption of public goods and externalities within the family.

2.2 Household and Domestic Production Technologies

Production activities of the household can be generalized by the following technology

$$Q = F(\Gamma; d_Q), \tag{1}$$

where Γ represents the amount of inputs used to produce the good Q, and d_Q are demographic variables of the household that affect the production technology. Goods produced by the household can be sold either on a market yielding profit or can be consumed by its members generating costs. The production factors Γ can be both family working hours and bought-in market inputs, such as capital, general equipment, and hired labour. Equation (1) can model either the production of "commodities" from which agents derived utility (Becker 1965), or the production activities of farm households (Singh, Squire, and Strauss 1985), or the production of quality when Γ is not observed (Gorman 1956, Lancaster 1966).

In our model, the household enterprise is involved in the production of two goods, a household good q and a domestic good z, by transforming labour and market inputs, hence $Q = \{q, z\}$. The output q of the household production is entirely sold on a competive market at price p_q, and therefore the family is taken to be a "pure" seller. Conversely, there are not markets for the domestic good z and its implicit price is determined within the family. Thus, the domestic good is entirely consumed by the family members. In the corrent context, equation (1) represents two different technologies as it is shown in the following definitions.

Definition 1. (Marketable Production Function) The household production technology is described by a strictly increasing and concave function

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

where h^1 and h^2 are family labour, x are market inputs bought at price p_x, and d_q is a set of demographic factors affecting household productivity. The output q is sold on perfect markets at price p_q.

On the other hand, the production of the domestic good z is based on the following technology.

Definition 2. (Nonmarketable Production Function) The domestic production technology is described by a strictly increasing and concave function

$$z = g\left(t^1, t^2, x_z; d_z\right), \tag{3}$$

where t^1 and t^2 are family labour, x_z are bought-in market inputs, and d_z is a set of demographic factors affecting domestic productivity. Differently from the household product, the output z is entirely consumed by the family and in general the production level is not observed by researchers.

Notice that the vector of socio-demographic factors affecting productivities are not the same across production activities. Moreover, the specification of equations (2) and (3) do not admitt joint-production between the marketable and nonmarketable productions.

We introduce the following assumption for the domestic technology.

Assumption 1. *(Constant returns to scale) The domestic production technology* $g(t^1, t^2, x_z; d_z)$ *exhibits constant returns to scale.*

The implication of constant returns to scale will be consider in the next sections.

2.3 The Centralized Decision Program

The Pareto production and consumption-leisure problem of the family is described by the maximization of the weighted utility function

$$\max\ U^H = \mu U^1\left(c^1, l^1, z^1; d_1\right) + (1-\mu)U^2\left(x^2, l^2, z^2; d_2\right) \tag{4}$$

subject to the following five constraints

1. budget constraint: $p_1c^1 + p_2c^2 = w_1L^1 + w_2L^2 + y + p_qq - p_xx,$
2. household technology: $q = f\left(h^1, h^2, x; d_q\right),$
3. domestic technology: $z = z^1 + z^2 = g(t^1, t^2; d_z),$
4. time constraint: $T_i = L^i + h^i + t^i + l^i, \quad i = 1, 2,$
5. non-negativity constraints: $L^i \geq 0, h^i > 0, t^i > 0, \quad i = 1, 2,$

where p_i is the market price faced by the family to buy c^i, w_i is the market wage of member i, and y is the family nonlabour income. Without loss of generality, in the domestic technology bought-in inputs x_z are omitted.

The first-order conditions for problem (4) related to the consumption-leisure variables can be expressed as

$$\mu_i U^i_{c^i} - \lambda p_i = 0, \quad i = 1, 2, \tag{5}$$

$$\mu_i U^i_{l^i} - \gamma_i = 0, \quad i = 1, 2, \tag{6}$$

$$\mu_i U^i_{z^i} - \vartheta_z = 0, \quad i = 1, 2, \tag{7}$$

where λ, γ_i and ϑ_z are Lagrangian multipliers associated with the budget, time and domestic technology constraints, respectively. Equations (5) to (7) are the usual equilibrium conditions of consumer theory within the context of a collective model. For reasons of convenience, here we have replaced the Pareto weight with μ_i, where $\mu_1 = \mu$ and $\mu_2 = 1 - \mu$.

The equilibrium conditions for the household production decisions are

$$\vartheta_q f_{h^i} - \gamma_i = 0, \quad i = 1, 2, \tag{8}$$

$$\vartheta_q f_x - \lambda p_x = 0, \tag{9}$$

$$\lambda p_q - \vartheta_q = 0, \tag{10}$$

where ϑ_q is the Lagrangian multiplier associated with the household technology constraint. Condition (10) shows that in equilibrium there is equality between the market price of q and the ratio of the Lagrange's multipliers

$$p_q = \frac{\vartheta_q}{\lambda}, \tag{11}$$

this equality partially defines the separability property between production and consumption decisions that we will show in the following sections.

From the Pareto problem (4), the equilibrium conditions for the domestic production decisions are

$$\vartheta_z g_{t^i} - \gamma_i = 0, \quad i = 1, 2. \tag{12}$$

Note that because the domestically produced good z is nonmarketable, its price is endogenous to each family and in equilibrium is equal to the ratio of the Lagrange multipliers associated with the domestic technology and budget constraints.[3] By the envelope theorem, we know that this ratio is equal to the marginal costs of producing z. Thus, the implicit price of z is derived as

$$p_z^* = \frac{\vartheta_z}{\lambda} = \frac{\partial TC\,(w_1, w_2, z, d_z)}{\partial z}, \tag{13}$$

where $TC(w_1, w_2, z, d_z)$ is the minimum total cost function of producing z. Given Assumption 1, the cost function is linear homogeneous in the level of output and can be written as $\widetilde{TC} = P_z(w_1, w_2, d_z)z$, where $P_z(\cdot)$ is a unit cost function and is independent of the production scale. Then, equation (13) becomes

$$p_z^\star = P_z\,(w_1, w_2, d_z)\,, \tag{14}$$

where the implicit price $p_z^\star$ of the domestic good depends only on market wages and demographic characteristics of the family.

[3] This result is obtained from the marginal rate of substitution between the domestic and the market goods: $p_i \frac{U^i_{z^i}}{U^i_{c^i}} = \frac{\vartheta_z}{\lambda}$, with $p_z^* = \frac{\vartheta_z}{\lambda}$.

The equilibrium expressions for the off-farm labour supply are

$$w_i - \frac{\gamma_i}{\lambda} \leq 0, \quad \text{if} \quad w_i - \frac{\gamma_i}{\lambda} < 0 \quad \text{then} \quad L^i = 0, \quad i = 1, 2. \tag{15}$$

The conditions in (15) allow three distinct off-farm labour supply regimes: a) a benchmark regime where both the family members may supply labour in the off-farm market, $L^i \geq 0$ for all $i = 1, 2$, hence equation (15) holds with equality $w_i = \frac{\gamma_i}{\lambda}$, b) a "single" corner solution regime where only member $i \neq j$ does not supply labour in the off-farm labour market and equation (15) holds with strict inequality $w_i < \frac{\gamma_i}{\lambda}$ for $i \neq j$, and c) a "double" corner solution regime where both family members do not supply off-farm labour, so equation (15) holds with strict inequality $w_i < \frac{\gamma_i}{\lambda}$ for all $i = 1, 2$. In the corner solution regimes individuals set their time constraint to $T_i = h^i + t^i + l^i$ and time is valued at its implicit wage. In what follows, we analyse the three labour supply regimes in detail.

Benchmark Regime When the marginal productivity[4] of family members is equal to the market wage, the individual labour supply is determined by condition

$$w_i = \frac{\gamma_i}{\lambda}, \qquad L^i \geq 0, \qquad \forall \quad i = 1, 2. \tag{16}$$

Conditions (11), (14) and (16) define the separability result between production and consumption-leisure choices. As a consequence of the separability property, the Pareto problem (4) can be decomposed into two stages: first, the family chooses production activities, and second it chooses consumption-leisure demands.

Formally, the decision process of the household unfolds as follows. In the first stage, acting as a profit maximizer, the family makes decision about the household production

$$\tilde{h}^i = h^i \left(p_q, w_1, w_2, p_x, d_q\right), \quad i = 1, 2, \tag{17}$$

$$\tilde{x} = x \left(p_q, w_1, w_2, p_x, d_q\right), \tag{18}$$

$$\tilde{q} = q \left(p_q, w_1, w_2, p_x, d_q\right), \tag{19}$$

with optimal profits equal to $\tilde{\pi} = \pi \left(p_q, w_1, w_2, p_x, d_q\right)$. Then, acting as a cost minimizer, the family decides the input factor demands of the domestic production

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

with optimal costs equal to $\widetilde{TC} = TC\left(w_1, w_2, z, d_z\right)$. Note that the decisions of domestic production are not taken together with those of the household production and further are not affected by individual preferences, income and prices of market goods.

In the second stage, the family chooses the optimal consumption and leisure bundles. From the constrained maximization of the welfare function, the demand functions are

[4] At the optimum, the value of i's marginal product is equal to the ratio of the values of the Lagrange multipliers on individual time and budget constraint $p_q f_{t^i} = \frac{\gamma_i}{\lambda}$.

derived as

$$\begin{aligned}
\tilde{c}^i &= c^i\left(p_1, p_2, p_z^\star, w_1, w_2, y, \tilde{\pi}, \tilde{\mu}, d\right), \quad i = 1, 2, &(21)\\
\tilde{z}^i &= z^i\left(p_1, p_2, p_z^\star, w_1, w_2, y, \tilde{\pi}, \tilde{\mu}, d\right), \quad i = 1, 2, &(22)\\
\tilde{l}^i &= l^i\left(p_1, p_2, p_z^\star, w_1, w_2, y, \tilde{\pi}, \tilde{\mu}, d\right), \quad i = 1, 2, &(23)
\end{aligned}$$

and the off-farm labour supply is obtained by the individual time constraint

$$\tilde{L}^i = L^i\left(p_1, p_2, p_z^\star, w_1, w_2, y, \tilde{\pi}, \tilde{\mu}, d\right) = T_i - \tilde{h}^i - \tilde{t}^i - \tilde{l}^i \geq 0, \quad i = 1, 2, \tag{24}$$

where the implicit price of the domestic good is $p_z^\star = P_z\left(w_1, w_2, d_z\right)$, and $d \in \left(d_1, d_2\right)$.

Single Corner Solution Regime When the marginal productivity of member i is greater than or equal to her market wage and, on the other hand, the marginal productivity of j is equal to his market wage,

$$w_i \leq \frac{\gamma_i}{\lambda},\ L^i = 0, \quad \text{and} \quad w_j = \frac{\gamma_j}{\lambda},\ L^j \geq 0, \tag{25}$$

then, even though labour markets exist, individual i specializes in the family business activities and supplies no time to the off-farm labour market. In this regime, the marginal productivity of i is valued at her "shadow wage" $w_i^\star = \frac{\gamma_i}{\lambda}$ derived as the ratio of the values of the Lagrange multipliers on individual time and budget constraints at the optimum. Furthermore, in equilibrium it must be $w_i^\star = p_q f_{h^i} = p_z^\star g_{t^i} = p_i \frac{U_l^i}{U_{c^i}^i}$.

The main consequence of this result is that in general the separability property fails to hold and the Pareto program (4) cannot be solved recursively in disjoint stages. Moreover, in the context of collective models, nonseparability in production-consumption decisions implies that the sharing rule approach is generally not applicable.

In this regime, the production-consumption program is jointly solved in a stage with solution equal to

$$\begin{aligned}
\tilde{h}^i &= h^i\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right), &(26)\\
\tilde{x} &= x\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right), &(27)\\
\tilde{q} &= q\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right), &(28)\\
\tilde{t}^i &= t^i\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right), &(29)\\
\tilde{c}^i &= c^i\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right), &(30)\\
\tilde{z}^i &= z^i\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right), &(31)\\
\tilde{l}^i &= l^i\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right), &(32)
\end{aligned}$$

and the off-farm labour supply of j is obtained as

$$\tilde{L}^j = L^j\left(p_i, p_j, p_q, w_i^\star, w_j, p_x, y, \tilde{\mu}, d\right) = T_j - \tilde{h}^j - \tilde{t}^j - \tilde{l}^j \geq 0, \tag{33}$$

where the implicit wage of i is $w_i^\star = \varpi_i\left(p_1, p_2, p_q, w_j, p_x, y, \mu\left(p_1, p_2, w_1, w_2, y\right), d\right)$ with $i \neq j = 1, 2$ and $d \in \left(d_1, d_2, d_q, d_z\right)$.

Double Corner Solution Regime In the last labour supply regime the marginal productivity of both family members is greater than or equal to their market wages. Thus, the equilibrium conditions of the off-farm labour choices reduce to

$$w_i \;\; \leq \;\; \frac{\gamma_i}{\lambda},\; L^i = 0, \quad \forall\, i = 1, 2. \tag{34}$$

The system of production-consumption equations is similar to that of the single corner solution regime and, for reasons of space, we report just the solution of the individual leisure demand

$$\tilde{l}^i \;\; = \;\; l^i\left(p_1, p_2, p_q, w_1^\star, w_2^\star, p_x, y, \tilde{\mu}, d\right), \quad i = 1, 2, \tag{35}$$

where the implicit wage is $w_i^\star = \varpi_i\left(p_1, p_2, p_q, p_x y, \mu\left(p_1, p_2, w_1, w_2, y\right), d\right)$ for $i = 1, 2$.

Note that the Pareto weight μ is function of individual market wages even when individuals do not participate in the labour market. This is a common assumption in the household collective literature (Bloemen 2010, Blundell *et al.* 2007, Donni 2003, Donni and Matteazzi 2010) in which it is assumed that bargaining power within the family is exerted on the potential market wage that household members would earn entering the labour market.

We now show how the Pareto problem (4) can be recursively solved in more stages employing the second theorem of welfare economics.

2.4 The Decentralized Decision Program

Given conditions (11), (14) and assuming that individual implicit wages are equal to market wages $w_i^\star = w_i$, then the Pareto problem (4) can be recursively solved in the following stages.

First, the household makes decisions on production activities. Formally, the output supply and inputs' demands of the household production are the solution of the problem

$$\max_{q, h^1, h^2, x} \; \pi = p_q f\left(h^1, h^2, x; d_q\right) - w_1^\star h^1 - w_2^\star h^2 - p_x x, \tag{36}$$

with optimal equations equal to $\tilde{q} = q\left(p_q, w_1^\star, w_2^\star, p_x, d_q\right)$, $\tilde{x} = x\left(p_q, w_1^\star, w_2^\star, p_x, d_q\right)$, and $\tilde{h}^i = h^i\left(p_q, w_1^\star, w_2^\star, p_x, d_q\right)$ for $i = 1, 2$. Optimal profits of the household production are $\tilde{\pi} = \pi\left(p_q, w_1^\star, w_2^\star, p_x, d_q\right)$.

The input demand factors of the domestic production are the solution of

$$\min_{t^1, t^2} \quad TC = w_1^\star t^1 + w_2^\star t^2, \quad \text{subject to} \;\; z = z^1 + z^2 = h(t^1, t^2; d_z), \tag{37}$$

yielding the optimal factor inputs $\tilde{t}^i = t^i\left(w_1^\star, w_2^\star, z, d_z\right)$, for $i = 1, 2$, and substituting these two equations into the objective function we derive the minimum cost function $\widetilde{TC} = \sum_{i=1}^{2} w_i^\star t^i\left(w_1^\star, w_2^\star, z, d_z\right) = p_z^\star \sum_{i=2}^{1} z_i$. Note that in the case of nonmarketable production the corresponding cost function is interpreted as an implicit cost of producing the domestic good.

Then, in the second stage, the family makes decisions on consumption-leisure demands. According to the second theorem of welfare economics, given an appropriate allocation of household resources, the Pareto consumption-leisure problem (4) can be decentralized into two individual consumption programs. Individuals agree on an unspecified rule to allocate family resources, then each individual solves the following problem

$$\max_{c^i,z^i,l^i} U^i(c^i, z^i, l^i; d_i) \mid p_i c^i + p_z^\star z^i = w_i^\star L^i + \varphi_i, \quad T_i = L^i + \tilde{h}^i + \tilde{t}^i + l^i, \text{ and } L^i \geq 0, \tag{38}$$

where φ_i is the sharing rule function with $\varphi_1 = \varphi\left(p_1, p_2, w_1^\star, w_2^\star, y + \tilde{\pi}\right)$ and $\varphi_2 = (y + \tilde{\pi}) - \varphi_1$. Notice that family members decide the allocation among them of non-labour income and optimal profits. As a consequence of this result, the sharing rule changes also because of changes in profits (Matteazzi, Menon, and Perali 2010).

From the solution of (38), we obtain the demand functions

$$\tilde{c}^i = c^i(p_i, p_z^\star, w_i^\star, \varphi_i\left(p_1, p_2, w_1^\star, w_2^\star, y + \tilde{\pi}\right), d_i), \tag{39}$$

$$\tilde{z}^i = z^i(p_i, p_z^\star, w_i^\star, \varphi_i\left(p_1, p_2, w_1^\star, w_2^\star, y + \tilde{\pi}\right), d_i), \tag{40}$$

$$\tilde{l}^i = l^i(p_i, p_z^\star, w_i^\star, \varphi_i\left(p_1, p_2, w_1^\star, w_2^\star, y + \tilde{\pi}\right), d_i), \tag{41}$$

with labour supply equal to $\tilde{L}^i = T_i - \tilde{h}^i - \tilde{t}^i - \tilde{l}^i \geq 0$. Note that from the second theorem of welfare economics the solutions to problems (36), (37), and (38) obtained recursively are equal to the optimal solution obtained solving problem (4) simultaneously.

3 Comparative Statics

In this section we are interested in formalizing the individual's response to changes in the output price of the household product p_q, and changes in individual market wages w_i. The comparative statics is performed on i's off-farm labour supply within the benchmark setting, while in the context of corner solutions only the empirical simulation analysis appraises the impact of these changes on individual behaviour. It is worth noticing that the model does not predict how individual i reallocates her time between the production activities and leisure due to market changes, but we can only observe (positive or negative) changes of her off-farm labour supply.

In order to predict the sign of the exogenous changes under examination, we introduce more structure into the collective household model. In particular, we define the complementary relationships between goods and establish how exogenous increases of household resources influence the sharing rule.

Assumption 2. *Leisure is a normal good.*

The individual demand of leisure is positively correlated with the sharing rule, and for increases in the sharing rule the partial derivative $\frac{\partial l^i}{\partial \varphi_i}$ is positive.

Assumption 3. *The domestic good and leisure are substitutes.*

Assumption 4. *Time inputs are substitutes both in the marketable and nonmarketable production function.*

Assumption 5. *Any exogenous change increasing the household budget set leads to increases in individual income transfers.*

Keeping prices constant, the household budget set can become larger due to positive variations of labour and nonlabour income, and of farm profits. Assumption 5 argues that each household member will benefit by these positive changes and thus the income transfer of each individual will expand for effect of increases in y, w_1, w_2, and π. Formally, Assumption 5 states that the following partial effects $\frac{\partial \varphi_i}{\partial y}, \frac{\partial \varphi_i}{\partial w_i}, \frac{\partial \varphi_i}{\partial w_j}$, and $\frac{\partial \varphi_i}{\partial \tilde{\pi}}$ are all positive. However, the assumption supposes nothing about the fairness (unfairness) on which these extra resources can be shared within family members.

Recall that when labour markets are competitive the optimal solution of i's off-farm labour supply is

$$\begin{aligned} \tilde{L}^i &= T_i - h^i(p_q, w_1, w_2, p_x, d_q) - t^i(w_1, w_2, z, d_z) - \\ & \quad l^i(p_i, p_z^\star, w_i, \varphi_i(p_1, p_2, w_1, w_2, y + \tilde{\pi}), d_i), \quad i = 1, 2, \end{aligned} \tag{42}$$

where $p_z^\star = P_z(w_1, w_2, d_z)$ and $\tilde{\pi} = \pi(p_q, w_1, w_2, p_x, d_q)$, and the marginal effects of the exogenous changes of interest on equation (42) are shown in Propositions 1 to 3.

Proposition 1. *(Output Price Effect) Given Assumptions 2 and 5, an increase (ceteris paribus) in the price of the marketable output p_q has a negative effect on i's off-farm labour supply.*

Proof. The marginal impact of p_q on equation (42) is equal to

$$\frac{\partial \tilde{L}^i}{\partial p_q} = -\frac{\partial h^i}{\partial p_q} - \frac{\partial l^i}{\partial \tilde{\varphi}_i} \frac{\partial \varphi_i}{\partial \tilde{\pi}} \frac{\partial \pi}{\partial p_q}, \quad i = 1, 2, \tag{43}$$

the result of the proposition derives from noting that by economic theory, that is $\frac{\partial h^i}{\partial p_q} > 0$ and $\frac{\partial \pi}{\partial p_q} > 0$, and together with the given assumptions each partial derivative in equation (43) is positive. □

The negative effect of this derivative is plausible. As the price of the market output increases, and therefore i's marginal product increases, the decision of individual i to work off-farm becomes less likelihood. Note that accounting only for nonmarketable productions, where the price of the domestic good is shadow, the effect of Proposition 1 would not be derived.

The following proposition shows the own-wage effect.

Proposition 2. *(Own-Wage Effect) Given Assumptions 2, 3 and 5 and for negative partial effects of $\frac{\partial \pi}{\partial w_i}$ sufficiently small, then the effect of an increase (ceteris paribus) in w_i on i's off-farm labour supply is positive.*

Proof. From equation (42) we derive the following marginal effect

$$\frac{\partial \tilde{L}^i}{\partial w_i} = -\frac{\partial h^i}{\partial w_i} - \frac{\partial t^i}{\partial w_i} - \frac{\partial l^i}{\partial p_z^\star}\frac{\partial P_z}{\partial w_i} - \frac{\partial l^i}{\partial \tilde{\varphi}_i}\left[\frac{\partial \varphi_i}{\partial w_i} + \frac{\partial \varphi_i}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial w_i}\right], \quad i = 1, 2, \tag{44}$$

$P_z(\cdot)$ is a unit cost function thus $\frac{\partial P_z}{\partial w_i} > 0$, then given the conditions of the proposition the result follows. □

The last partial derivative studied in the paper is the cross-wage effect.

Proposition 3. *(Cross-Wage Effect) Given Assumptions 2 to 5 and for negative partial effects of* $\frac{\partial \pi}{\partial w_j}$ *sufficiently small, then the effect of an increase (ceteris paribus) in* w_j *on i's off-farm labour supply is negative.*

Proof. From equation (42) we derive the following marginal effect

$$\frac{\partial \tilde{L}^i}{\partial w_j} = -\frac{\partial h^i}{\partial w_j} - \frac{\partial t^i}{\partial w_j} - \frac{\partial l^i}{\partial p_z^\star}\frac{\partial P_z}{\partial w_j} - \frac{\partial l^i}{\partial \tilde{\varphi}_i}\left[\frac{\partial \varphi_i}{\partial w_j} + \frac{\partial \varphi_i}{\partial \tilde{\pi}}\frac{\partial \pi}{\partial w_j}\right], \quad i \neq j = 1, 2, \tag{45}$$

$P_z(\cdot)$ is a unit cost function thus $\frac{\partial P_z}{\partial w_j} > 0$, then given the conditions of the proposition the result follows. □

Note that with marketable and nonmarketable productions the own- and cross-wage partial derivatives have four effects: 1) a change in the optimal input allocation in the household production, 2) a change in the optimal input allocation in the domestic production, 3) a change in the shadow price of the domestic good, and 4) an income effect given by the compensation between an increase in the sharing rule and a reduction in the farm profits. Moreover, the cross-wage effects in general are not symmetric between family members.

We now turn to the empirical simulation performed within an equilibrium framework.

4 Data and the Household Social Accounting Matrix

In this section we describe the Household Social Account Matrix (HSAM) and the sample of Italian farm household data, from which we derive the farm household types employed in the empirical simulation.

Data The empirical simulation is carried out on two specific farm-household types: the *professional*, formed by the large and very large farm-households, and the *non-professional*, which is the mean of the medium and residential farm-households. The distinction between professional and non-professional farm-households is of special relevance because professional farm-households are the elected recipients of agricultural policies, while non-professional farm-households are the subject of interest of rural policies. Thus the distinction between farm-household types can be useful to gauge the differential effects of coupling agricultural with rural policies.

The two farm-household types are drawn by the nationwide survey on socio-economic characteristics of Italian rural household undertaken in 1995 by the Italian Institute for the Agri-Food Business Market (ISMEA). The sampling design of the ISMEA farm household survey is based on the 1992 Italian Agriculture Census, conducted by the Italian National Statistical Institute (ISTAT), selecting agricultural farms with an economic size of at least four European size units[5] (about EUR 4,500). Given this sampling design, 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 people. The questionnaire has the specific aim of gathering statistical information on the behaviour of family members and the sharing of resources within the household. The farm-household survey combines information about household and farm characteristics, farm profits, a stylized time use, off-farm money income, governmental and intrahousehold transfers, consumption and information about the degree of autonomy in decision making by household members.

A further feature of the ISMEA survey is that it records information about the consumption of exclusive goods, such as clothing for women, men and children. This information is sufficient to identify the rule governing the intrahousehold allocation of resources (Bourguignon, Browning, and Chiappori 2009). The stylized time use survey is another source of individual information about the private consumption of leisure.

Some descriptive statistics of professional and non-professional farm-households are shown in Table 1. Professional and non-professional farms present some common elements but also peculiar features.

Professional farm-households are equally distributed in the North and in the South of Italy but relatively less frequent in the Centre of Italy. Non-professional farms are mainly in the South of Italy. Most farm-households are located in plain areas. However, Table 1 shows that only 4.51% of non-professional farms are in mountain regions compared with the 7.81% of professional farms.

On average, the professional farm-households are twice as wide 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, we can observe that the professional farm-households are much more capital intensive with respect to the non-professional farms, while the latter are much more family-labour intensive. In-

[5]An European size unit, abbreviated as ESU, is a standard gross margin of EUR 1,200 used to express the economic size of an agricultural farm. For each activity on a farm, for example wheat production, dairy cows or the output from a vineyard, the standard gross margin SGM is estimated based on the area used for the particular activity or the number of heads of livestock and a regional coefficient. The sum of all such margins derived from activities on a particular farm is its economic size, which is then expressed in European size units by dividing the total SGM in euro by 1,200.

terestingly, the shares for hired labour and chemicals are comparable across the two farm-household types. As for production choices, aside from crop and milk production shares which figures are almost equal between the two farm-household types, professional farms are more farming oriented, whereas non-professional farms are more fruit oriented farms. Regarding individual labour marginal productivity, Table 1 shows that figures are comparable across farm-household types and, on average, husband's marginal productivity of labour is greater than wife's one.

The value of the individual total expenditure is greater for both spouses of professional farms. Table 1 shows that, on average, the husband and the wife of professional farm-households spend their incomes mainly to buy market goods, whereas the spouses of non-professional farm-households spend their income principally to consume the domestic produced good and to enjoy leisure.

An important distinguishing feature of non-professional farms is that their members, differently from the household members of professional farms, work not only on-farm but also in the labour market. Thus, professional and non-professional farms present different labour market regimes: the benchmark regime characterises non-professional farms, whereas the double corner solution regime marks professional farms.

Household Social Accounting Matrix The ISMEA household data are used to construct the Social Accounting Matrix (SAM) for the professional farm-household type and the non-professional farm-household type. The SAM is a square matrix where rows give receipts of accounts while columns give the expenditure. The total of each row is equal to the total of the corresponding column. The SAM describes all transactions and transfers between various production activities, factors of production, and institutions, such as households, firms, and government, within the economy and with respect to the rest of the world. The Household SAM (HSAM) is an accounting scheme of the household economy that represents the flows of all economic transactions and transfers taking place within the household and between the household and the rest of the economy. The farm-household thus has the advantageous feature of representing simultaneously the production side and consumption side of the economy.

The account structure of the HSAM employed in this paper is shown in Table 2 for the professional farm-household type and in Table 3 for the non-professional farm-household type. Values are expressed in Euros per month. The agricultural production of farm-households is aggregated in four outputs - crops, livestock, milk and fruit, and olives and grapes - that are sold on competitive markets at exogenous prices. The aggregate value of the agricultural production is EUR 8559.03 for the professional farm-household type and EUR 1430.88 for the non-professional farm-household type (Row 3 in Tables 2 and 3). The agricultural production's value includes also agricultural premiums and transfers received by the Italian Government. The production factors are partly bought on the market (market inputs) and partly owned by the household (family labour) and are remunerated from the value added (Rows 1 and 2 in Tables 2 and 3). The aggregate cost of market inputs is EUR 3973.21 for the professional farm-household type and EUR 688.09 for the non-professional farm-household type (Column 1 in Tables 2 and 3). The total cost for the on-farm family labour is EUR 1463.45 per month for the professional and EUR 1043.91 per month for the non-professional farm-household type (Column 2 in Tables 2 and 3). Given the structure of the ISMEA data, the on-farm labour cost can be distinguished between the household members. For both the farm-household types, on average, the husband is remunerated more than his wife. The husband of the professional farm-household type (non-professional farm type) is remunerated EUR 1001.93 (EUR 657.61) per month whereas the wife is remunerated EUR 461.73 (EUR 386.30) per month. Because we consider a short-run model, profits may be different from zero. Profits accrued from the agricultural activity amount to EUR 3122.16 per month for professional farms whereas the loss undergone by non-professional farms amounts to EUR 301.11 per month. (Column 1 in Tables 1 and 2).

The individual full incomes (Rows 4 and 5 in Tables 2 and 3) are obtained summing up the value of the individual total time endowment, that is the sum of on-farm work, domestic work, off-farm work and leisure, the individual share of household nonlabour income (EUR 597.20 per month for professional farms and EUR 928.67 per month for non professional farms) and profits or losses from the agricultural business. Profits and household nonlabour income are shared between spouses according to the sharing rule estimated by Menon and Perali (2010). The estimation results show that, on average, the wife belonging to professional farms (non-professional farms) gets 54.2% (52.4%) of the total amount of household resources shared by spouses (i.e., household nonlabour income and profit or losses from the agricultural production) compared to the 45.8% (47.6%) got by the husband.

The household members spend their full income in purchasing market goods - food, clothing and an aggregated market good - the domestic good, and leisure (Columns 4 and 5 in Tables 2 and 3). The representative man of professional (non-professional) farms spends EUR 493.54 (EUR 499.46) per month to consume the domestic good, EUR 966.96 (EUR 1119.27) per month to enjoy leisure and EUR 2706.53 (EUR 1182.36) per month to buy market goods. The representative woman of professional (non-professional) farms spends EUR 746.00 (EUR 671.54) per month to consume the domestic good, EUR 1110.88 (EUR 1172.68) per month to enjoy leisure and EUR 2476.50 (EUR 881.51) per month to buy market goods.

The rest of the economy, row 9 in Tables 2 and 3, gains by supplying market inputs (EUR 3973.21 per month for the professional farm type and EUR 688.09 per month for the non-professional farm type) and selling market goods (EUR 5183.03 per month for professional farms and EUR 2063.87 per month for non-professional farms). The rest of the economy, column 9 in Tables 2 and 3, acquires the assets produced by the household (EUR 8559.03 per month for professional farms and EUR 1430.88 per month for non-professional farms), pays nonlabour income (EUR 597.20 per month to professional farms and EUR 928.67 per month to non-professional farms) and off-farm work (EUR 0 per month to professional farms and EUR 392.42 per month to non-professional farms). Notice that family members of the professional farm-households do not supply off-farm work.

5 The Programming Model and Calibration Technique

The collective household enterprise model presented in Section 2 is programmed as an equilibrium model using the General Algebraic Modeling System (GAMS) software. In the programming model we can consider the household decisions about production, consumption and leisure simultaneously.

We define the set of market inputs $r = \{\text{chemicals, materials, and hired labour}\}$, the set of quasi-fixed factors owned by the family $a = \{\text{land, capital, and family labour}\}$ and the set of outputs as $s = \{\text{crop, beef, milk and fruits, olives and grapes}\}$. The set of consumption goods is denoted as $k = \{\text{leisure, domestic good, food, clothing, and other market goods}\}$ and the subset of market consumption goods $b = \{\text{food, clothing, and other market goods}\}$. We set member 1 to be the husband and member 2 the wife.

As described below and summarised in Table 4, the programming model is a system of equations setting out the production and consumption-leisure decisions of the family. Parameters of the system of equations are econometrically estimated by Menon and Perali (2010) and therefore the need for calibration is limited to the calibration of the intercepts of demand and production equations to match the levels of the household SAMs.

Household production decisions The equations describing the marketable production activities of the farm-household are the total cost function, input factor demands, and the profit equation.

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

$$\ln TC = \alpha_0 + \sum_{s=1}^{4} \alpha_s \ln q_s + \sum_{r=1}^{3} \beta_r \ln W_r + \sum_{a=1}^{3} \chi_a \ln H_a + \frac{1}{2} \sum_{s=1}^{4} \sum_{u=1}^{4} \delta_{su} \ln q_s \ln q_u +$$

$$+ \frac{1}{2} \sum_{r=1}^{3} \sum_{v=1}^{3} \gamma_{rv} \ln W_r \ln W_v + \sum_{s=1}^{4} \sum_{r=1}^{3} \rho_{sr} \ln q_s \ln W_r + \sum_{a=1}^{3} \sum_{r=1}^{3} \xi_{ar} \ln H_a \ln W_r, \tag{46}$$

where TC denotes total cost of the agricultural production, W_r is the price of market input r, H_a is the quantity index of the quasi-fixed factor a and q_s is the level of the agricultural output s. α_0, α_s, β_r, χ_a, δ_{su}, γ_{rv}, ρ_{sr}, ξ_{ar} are the estimated parameters.

Factor demands Using Shephard's lemma, the derivatives of equation (46) with respect to the logarithm of input prices W_r define the share of the r-th input

$$\omega_r = \beta_r + \sum_{v=1}^{3} \gamma_{rv} \ln W_v + \sum_{s=1}^{4} \rho_{sr} \ln q_s + \sum_{a=1}^{3} \xi_{ar} \ln H_a. \tag{47}$$

In the econometric application (Menon and Perali 2010) on-farm family labour is treated as a quasi-fixed factor, together with land and capital. The quasi-fixed factor on-farm family labour however is allocatable between the two spouses. We model the factor demands for market inputs as

$$X^r = \omega_r \frac{TC}{W_r}, \quad r = 1, 2, 3, \tag{48}$$

where X_r denotes the quantity of market input r, and for individual on-farm labour as

$$h^i = \omega_{h^i} \frac{TC}{w_i^\star}, \quad i = 1, 2, \tag{49}$$

where ω_{h^i} is the share associated with spouse i's on-farm labour. While the shares associated with market inputs are derived as in equation (47) and treated as endogenous variables, the shares associated with spouses' on-farm labour are calibrated from the HSAM, as ratio between the value of the individual on-farm labour and the total cost of agricultural production, and treated as parameters. Notice that $\sum_i \omega_{h^i} + \sum_r \omega_r = 1$.

While prices of chemicals, materials and hired labour W_r are given by the market, the prices of husband's and wife's on-farm labour $w_i^\star$ are endogenously determined within the household. However, in the base model, that is the model calibrated on the HSAM, shadow wages are equal to market wages. This means that, as in the econometric application, the base model is separable. The model may become non separable if as a consequence of a simulation shadow wages differ from market wages.

Profit equation The equation for farm profits is

$$\pi = \sum_s p_{q_s} q_s - TC + TR, \tag{50}$$

where p_{q_s} and q_s are the market price and the produced quantity of good s, respectively, TC is the anti-log of equation (46) and TR are the decoupled payments[6] that farm-households receive from the Italian Government.

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

Domestic production decisions The implicit price $p_z^\star$ of the domestic good and input demands t^i are specified as follows.

Implicit price of the domestic good The equation for the implicit price $p_z^\star$ is

$$p_z^\star = \exp\left(a_0 + \sum_{i=1}^{4} a_i \ln w_i + 0.5 \sum_{i=1}^{4}\sum_{j=1}^{4} a_{ij} \ln w_i \ln w_j\right), \tag{51}$$

and is derived as the exponent of a Translog unit cost function.

Factor demands Given the assumption of constant return to scale, the value of the individual consumption of the domestic good equals the value of the time spent by that individual on domestic tasks. Therefore, the individual demand for domestic labour is given by the following equation

$$t^i = \frac{p_z^\star}{w_i^\star} z^i, \quad i = 1, 2. \tag{52}$$

Consumption-leisure decisions The consumption side of the household economy comprises the equations for the individual full-income and for the individual demand of consumption goods.

Individual full income The individual full income is defined as

$$I_i = w_i^\star(l^i + h^i + t^i + L^i) + \psi_i(y + \pi), \quad i = 1, 2, \tag{53}$$

with

$$\psi_i = \frac{\varphi_i}{I} \in [0, 1], \tag{54}$$

where I is the household full income and the intrahousehold income transfer φ_i for member 1 is specified as

$$\varphi_1(w_1, w_2, p_1, p_2, y, I, d_f) = I_1 m(w_1, w_2, p_1, p_2, y, d_f) \tag{55}$$

so that the sharing rule of member 2 is

$$\varphi_2(w_1, w_2, p_1, p_2, y, I, d_f) = I - \varphi_1(\cdot). \tag{56}$$

The scaling function $m(\cdot)$ takes a Cobb-Douglas form

$$m = w_1^{\theta} w_2^{\theta_2} p_1^{\theta_3} p_2^{\theta_4} y^{\theta_5} d_f^{\theta_7} \tag{57}$$

with $\theta_5 = -\sum_{n=1}^{4} \theta_n$ in order to have an individual income share φ_i homogeneous of degree one in monetary variables and, as a results, consumption demands satisfying homogeneity of degree zero in prices and nonlabour income. For a detailed characterisation of the structural sharing rule (55) see Menon and Perali (2010).

Individual consumption demands The individual consumption shares are derived from individual preferences of Gorman polar form. Therefore, the individual equation share of good k is

$$\omega_{ik} = \alpha_{ik} + t_{ik}(d_i) + \sum_n \nu_{ink} \ln P_{ik} + \beta_{ik} \ln \left(\frac{\varphi_i}{A_i(P_{ik})} \right), \tag{58}$$

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

$$c_b^i = \omega_{ib} \frac{I_i}{p_{ib}}, \tag{59}$$

for the market goods, that is food, clothing and other market goods,

$$l^i = \omega_{il} \frac{I_i}{w_i^\star} \tag{60}$$

for leisure, and

$$z^i = \omega_{iz} \frac{I_i}{p_z^\star} \tag{61}$$

for the domestic good, where ω_{ib}, ω_{il} and ω_{iz} are the individual budget shares with $\sum_b \omega_{ib} + \omega_{il} + \omega_{iz} = 1$ for $i = 1, 2$.

Equilibrium conditions The closure equations of the programming model are individual time constraints,

$$T = l^i + h^i + t^i + L^i, \ \forall\, i = 1, 2, \tag{62}$$

and the labour market clearing conditions modelled as a Mixed Complementarity Problem (Lofgren and Robinson 1997 and 1999) through the following Kuhn-Tucker condition

$$L^i \left(w_i - w_i^\star \right) = 0, \ \forall\, i = 1, 2. \tag{63}$$

If $w_i < w_i^\star$ then individual i does not participate in the off-farm labour market, $\tilde{L}^i = 0$, and her shadow wage $w_i^\star$ solves equation (62) and is function of all exogenous variables entering the household model. Otherwise, if $w_i = w_i^\star$, then individual i may work in the off-farm labour market and $\tilde{L}^i = T - \tilde{h}^i - \tilde{t}^i - \tilde{l}^i \geq 0$.

Homogeneity and numeraire All demands and supplies are homogeneous of degree zero in all prices and the system of equations describing the production choices, consumption-leisure decisions and the equilibrium conditions will solve for relative prices. The numeraire is the price of the other market goods.

Exogenous variables The programming model is a useful tool to describe the behavioural responses of both the production and consumption choices to economic and social policies and to evaluate their impact on individual welfare levels. Our model can be used to perform simulations and policy experiments and predict the impact of changes in exogenous variables or parameters on production activities, individual consumption and labour supply decisions. In particular, on the production side the exogenous variables that can be altered are the prices of output, the optimal quantity to be produced, the prices of variable inputs, or the level of quasi-fixed factors. On the other hand, on the consumption side we can vary the price of market goods and non-labour income considered exogenous. Market wages may also change. The government transfers received by farm-households, in the form of decoupled payments, can be used as policy instruments.

The Micro-Calibration The programming model is calibrated using both the average values of production, consumption-leisure variables and the income transfers of each farm-household types derived in the HSAM and the corresponding parameters empirically estimated by Menon and Perali (2010).

Considering now the following general equation

$$Y = \hat{\alpha}_0 + \zeta(X; \hat{\alpha}) + \varepsilon, \tag{64}$$

where Y is the dependent variable, for instance the input demand or consumption shares, X are exogenous variables, $(\hat{\alpha}_0, \hat{\alpha})$ are estimated parameters where $\hat{\alpha}_0$ represents the constant term, and ε is an optimisation and measurement error. Then, in order to match the estimated value of the dependent variable to its corresponding value computed in the HSAM, the calibration technique implies that only a term, in general the intercept, of the estimated equation is calibrated.

Thus, given equation (64), the calibration consists in finding the intercept as

$$\hat{\alpha}_0^C = \hat{\alpha}_0 + \varepsilon = Y - \zeta(X; \hat{\alpha}), \tag{65}$$

where $\hat{\alpha}_0^C$ is the calibrated intercept of the programming model. The calibrated intercept $\hat{\alpha}_0^C$ includes the residual term and allows us to balance the HSAM ensuring consistency.

The intercept β_r of the input share equation (47) and the intercept α_k^i of the consumption share equation (58) are calibrated in order to match the level of input demands and consumption shares derived from the HSAM. In a similar way, the constant term a_0 of the implicit price $p_z^\star$ is calibrated in order to ensure that the value of the total household consumption of the domestic good equals the total production cost of the domestic good.

As for the sharing rule, using equations (55) and (54) we have

$$\psi_1 = \frac{I_1 m(\cdot)}{E} = \lambda^\star m(\cdot), \tag{66}$$

where the unknown term $\lambda^{\star}$ is calibrated in order to match the level of individual expenditure reported in the HSAM, while the intrahousehold income transfer ψ_1 and the function $m(\cdot)$ are estimated functions (Menon and Perali 2010).

6 Microsimulation Analysis

The farm-household programming model can be used to carry out microsimulation analyses assessing the intrahousehold distributional consequences of changing in prices and wages due to exogenous market perturbations. The programming model can play the role of a policy lab which simulates the micro impacts of macro policy changes under several assumptions on the structure and functioning of markets. This is consistent with the 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, we should model those parameters related to preferences, technology and resources constraints that drive individual behaviour and that are invariant to policy changes.[7]

In this section we present the results of the microsimulation analysis carried out on the base model, i.e. the model calibrated on the HSAM. In the base model shadow wages equal market wages, so the base model exhibits the property of separability between production and consumption-leisure decisions. As previously underlined, the labour market regimes characterising professional and non-professional farms are different. The labour market regime peculiar to non-professional farm-households is the benchmark one, characterised by the participation in the labour market of both the household members. The labour market regime typical of professional farm-households is the double corner solutions regime, characterised by the non participation in the labour market of both the household members.

The scenarios analysed in the microsimulation are positive changes in the household members' market wages and in the household nonlabour income. We begin by analysing the effect on the household economy of a five percent increase in husband market wage.

Impact of a 5% increase in husband's market wage (Table 5) As expected, a 5% increase in husband's market wage leads to an increase in his marginal labour productivity. Table 5 shows that the impact of the increase in husband's market wage on his marginal productivity of labor is different across farm types. More precisely, the husband's marginal labor productivity rises by 5% in non-professional farms and by 10.96% in professional farms. Table 5 shows also that the increase in husband's mar-

[7] The Lucas quote: "Given that the structure of an econometric model consists of optimal decisions rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric model" (Lucas 1976:41).

ket wage has no effect on wife's marginal labour productivity, neither for professional nor for non-professional farms. As a results, non-professional farms continue to exhibit the separability property between production and consumption decisions whereas professional farm-households do not.

Notice that as a consequence of the increase in husband's market wage, the wife of professional farms supplies now positive hours of work in the off-farm labour market and the wife of non-professional farms increases her market working hours by 6.82%. The husband of professional farms does not participate in the labor market whereas the husband of non-professional farms reduces his market working hours by 11.41%. Professional farms switch from the double to the single corner solution regime whereas no change in the labor market regime is observed for non-profesisonal farms.

Let us now turn to the effects of a change in husband's market wage on the production side of the household economy. Husband's labour in production declines due to the increase in his marginal productivity of labour. We observe that wife's on-farm labour decrases as well. This shows that there is some gross complementarity between husband's and wife's time inputs in the household production. The demand for hired labour also decreases. On the contrary, the demands for chemicals and materials increase. Total production cost decreases and profit increases. As a result, the total amount of resources shared within the household, thai is nonlabour income and profits from the agricultural production, increases as well.

The increase in husband's market wage has an impact on the sharing rule defined by equation (66) through the scaling function m. This effect is shown in the last row of Table 5. The share of household resources got by the husband grows by 0.64% in both the farm types. Thanks to the increase in the value of his endowment of time (because of the increase in his marginal labor productivity) and the raise in his share of household resources, husband's full income increases by 7.53% in professional farms and by 4.69% in non-professional farms. On the contrary, we observe a very moderate increase of wife's full income in both the farm types. The raise in wife's full income is due only to the increase of household resources shared by spouses, given that the value of the her endowment of time is unchanged.

Whatever the farm type we consider, simulation results show that the wife increases the demand for all consumption goods except for leisure. The husband behaves differently. The husband of professional farms increases the demand for all consumption goods except for the domestic good. On the contrary, the husband of non-professional farms increases his demand only for leisure and food. Notice that for the husband both the price of leisure and the price of the domestic good are increased, but while the demand for leisure raises the consumption of the domestic good decreases. We can argue that the income effect dominates the price effect for leisure whereas the contrary happens for the domestic good.

Let us now consider the domestic production. The increase in man's marginal labor productivity reduces the time he spends in domestic activities. On the contrary the woman devoted much more time to domestic tasks revealing some gross substituability between man and woman's time inputs in domestic production.

In terms of time-uses, there is a deterioration in the condition of the wife due to the increase in her husband's market wage, because she spends much more time in labour activities, in particular domestic chores and off-farm work, and she devotes less time to leisure activities. On the contrary, the husband works less hours on-farm and inside domestic walls. The husband of non-professional farms also reduces his market working hours.

We now study the effect of an increase in woman's market wage on individuals' decisions.

Impact of a 5% increase in woman's market wage (Table 6) Whatever the farm type we consider, simulation results show that an increase of 5% in wife's market wage translates to a 5% increase in her marginal labour productivity. The raise in wife's market wage has no impact on the husband's marginal productivity of labour. In addition, both farm types continue to exhibit the separability property between production and consumption decisions given that the equality between individual market wage and individual labour marginal productivity still holds. However, the labour market regime for the members of professional farms changes and it switchs from the double corner solution regime to the benchmark regime. Both spouses of professional farm-households now supply positive hours of work in the off-farm labor market. As for the non-professional farms, Table 6 shows that the husband increases his market working hours by 5.22% whereas the wife reduces her market labor supply by 10.75%.

Let us now consider the effects of the positive change in wife's market wage on the production side of the household economy. Once more, simulation results are comparable across the two farm types. Husband's labour in production declines together with wife's on-farm labour (revealing again some gross complementarity between man and woman's time inputs in the household production), hired labour and materials. Only the demand for chemicals increases. Total production cost decreases, so profit increases. As a consequence, the total amount of resources shared by spouses raises.

The increase in woman's wage has a positive effect on her sharing rule. Woman's full income increases by 2.88% in professional farms and by 4.51% in non-professional farms. The increase in wife's full income is also due to the raise in the value of her time endowment. On the contrary, we observe a very moderate increase in man's full income in both the farm types.

Simulation results show that the husband increases the demand for all consumption goods but for leisure. As for the wife, we have to distinguish among the two farm types. The woman belonging to professional farms increases the consumption of all goods except for the domestic good, become more expensive. On the contrary, the woman of non-professional farms increases the consumption of all goods except clothing and other market goods. Surprisingly, she increases the demand for leisure and the dometic good even if they are now more expensive.

As a consequence of the increase in wife's marginal labour productivity the price of the domestic good increases. We observe that man's contribution to domestic chores increases whereas the woman spent less time in domestic activities. Once more, simulation results show some gross substituability between husband and wife's time-inputs in domestic chores.

Finally, if we compare the condition of the representative woman of professional and non-professional farms in terms of time-use we can state that the condition of the latter is much better. Actually, not only she enjoys more leisure, reduces her working hours inside the domestic walls and on-farm, but she also cuts her market working hours. On the contrary, simulation results show a deterioration in the condition of the husband in terms of time-use and the deterioration is comparable across farm types.

We conclude this section analysing the effect of a increase in non labour income on household production, consumption and labour supply decisions.

Impact of a 10% increase in husband's non-labour income (Table 7) Simulation results show that an increase of 10% in nonlabour income has a different effect on professional and non-professional farms, in particular in terms of separability between production and consumption decisions. While an increase in household nonlabour income has no effects on the marginal labour productivity of spouses of non-professional farms, the increase in nonlabour income affects the marginal labor productivity of the wife belonging to professional farms. As a result, the separability property fails to hold for professional farms. Table 7 shows also that professional farms switch from the double to the single corner solution regime because the husband now supplies positive hours of work in the off-farm labour market. In non-professional household, instead, both the husband and the wife cut their market working hours.

Simulation results show, for professional farms, that husband's labour in production declines together with wife's on-farm labour (revealing again some gross complementarity between man and woman's time inputs in the household production) and hired labour. The demand for chemicals and materials increases. Total production cost decreases, so profit increases. As a result, the total amount of resources shared by spouses of professional farms raises not only because the increase in the household nonlabour income but also because the increase in profits from the agricultural production. As for non-professional farms, the increase in nonlabour income has no impact on the production side of the household economy.

Table 7 shows that the increase in household nonlabour income has a positive effect of wife's share of household resources. The impact is the same for both professional and non-professional farms. Wife's full income increases by 7.40% in professional farms and by 1.79% in non-professional farms. Husband's full income increases by 1.05% in professional farms and by 1.58% in non-professional farms.

Both the spouses of non-professional farms increase the consumption of all goods, reduce their market labour supply and spend more time in domestic activities in order to satisfy the increase in the demand for the domestic good. As a results, we observe a improvement in time-uses for both the husband and the wife belonging to non-professional farms.

Let us turn to professional farms. The husband increases his demand for all consumption goods but for leisure. He also spends more time in domestic tasks in order to face the increase in his demand for the domestic good. Once more, simulation results show some gross substituability between man and woman's time-inputs in domestic chores. As for the wife, simulation results show that she increases her consumption of all goods, except for the domestic good become more expensive. Finally, if we compare the condition of the husband and the wife in terms of time-use we can state that the condition of the foster is notably worsen whereas the condition of the latter is considerably improved.

7 Conclusion

Unlike unitary models of household behavior that describe household as an undifferentiated decision unit, collective models describe household as a collectivity of persons, characterized by specific preferences and making Pareto-efficient decisions. This allows the analysis of intra-household redistribution of family resources. \medskip

Collective models may be used to evaluate the impact of social and economic policies not only at the household level but also the individual level. The aim of this paper is to illustrate how the collective model of the household behavior can be used for policy analysis and to provide policy makers with an instrument that can be used to evaluate the impact of macro policies on individual behavior and welfare.

The programming model is based on an Household Social Accounting Matrix (HSAM) for the average Italian farm-household and it is calibrated using both the HSAM and estimated elasticities (Menon and Perali, 2009). The programming model reproduces the structural specification of the sharing rule, the implicit price of the domestic good and output, variable input and consumption shares underlying the econometric model estimated in Menon and Perali (2009). This programming model of the household enterprise represents a useful tool to analyze the behavioral responses of both the farm and the household to economic and social policies and to evaluate their impact on individual welfare levels.

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Table 1. Descriptive Statistics of the Farm and the Household Characteristics by Farm Types

	Professional farm	**Non-professional farm**
Farm characteristics		
Number of observations	947	197
Macro-region		
north	39.81%	28.43%
centre	22.07%	22.84%
south	38.12%	48.73%
Area		
plain	78.04%	75.63%
hill	14.15%	19.80%
mountain	7.81%	4.57%
Farm dimensions (hectare)	15.27	7.15
Land value (index) [(1)]	4943.81	1064.88
Capital value (index) [(2)]	297.94	111.68
Total production costs[(3)]	5436.86	1732.00
Input demand in share		
hired labour	0.15	0.14
chemicals	0.11	0.11
materials	0.46	0.14
family labour	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
Family size	3.88	3.62

Household Members' Characteristics	**Professional farm**		**Non-professional farm**	
	Man	**Woman**	**Man**	**Woman**
Age	48.91	45.15	47.50	46.06
Education[(4)]	1.70	1.16	1.89	1.25
Marginal labour productivity[(5)]	5.87	5.71	5.90	5.71
Total expenditure[(3)]	4157.03	4198.61	2801.09	2725.74
Consumption demand in share				
domestic good	0.116	0.172	0.178	0.246
leisure	0.233	0.256	0.400	0.430
food	0.270	0.236	0.175	0.133
clothing	0.006	0.005	0.004	0.003
other market goods	0.375	0.330	0.244	0.188
Time-use (monthly hours)				
leisure	164.63	194.45	189.83	205.39
domestic work	82.32	130.58	84.71	117.62
on farm work	170.584	80.82	111.53	67.65
off farm work	-	-	38.35	29.13
Share of nonlabour income and profits	0.46	0.54	0.48	0.52

Note:

(1) The index is the 2% of the land use value.
(2) The index is the 5% of the capital value.
(3) Monthly value in EUR.
(4) Education takes values 1= primary education, 2 = lower secondary education, 3 = upper secondary education, and 4 = tertiary education.
(5) Hourly wage.

Table 2. Household Social Accounting Matrix for the Professional Farm-Household Type [1]

	market inputs	family labour	agricultural production	husband	wife	off-farm labour	nonlabour income	domestic labour	leisure	rest of the economy
market inputs			3973.21							
family labour			1463.65							
agricultural production										8559.03
husband		1001.93	1430.90			0.00	273.70	483.54	966.96	
wife		461.73	1691.26			0.00	323.50	746.00	1110.88	
off-farm income										0.00
nonlabour income										597.20
domestic good				483.54	746.00					
leisure				966.96	1110.88					
rest of the economy	3973.21			2706.53	2476.50					

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

market inputs:	hired labour	chemicals	materials	total
	832.82	624.62	2515.77	3973.21 [2]

agricultural production:	crop	livestock	milk	fruit	premiums	total
	3135.79	1819.66	1921.18	963.07	719.33	8559.03 [3]

consumption of market goods:	food	clothing	other market goods	total
husband	1121.07	24.52	1560.93	2706.53 [4]
wife	1022.33	23.13	1431.04	2476.50 [5]

Note:

(1) Values expressed in EUR per month.
(2) Total value reported in cell (rest of the economy, market inputs) and in cell (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).
(5) Total value reported in cell (rest of the economy, wife).

Table 3. Household Social Accounting Matrix for the Non-Professional Farm-Household Type [1]

	market inputs	family labour	agricultural production	husband	wife	off-farm labour	nonlabour income	domestic labour	leisure	rest of the economy
market inputs			688.09							
family labour			1043.91							
agricultural production										1430.88
husband		657.61	-143.29			226.12	441.93	499.46	1119.27	
wife		386.30	-157.82			166.30	486.74	671.54	1172.68	
off-farm income										392.42
nonlabour income										928.67
domestic good				499.46	671.54					
leisure				1119.27	1172.68					
rest of the economy	688.09			1182.36	881.51					

Disaggregated values:

market inputs:	hired labour	chemicals	materials	total
	249.99	188.10	250.01	688.09 [1]

agricultural production:	crop	livestock	milk	fruit	premiums	total
	471.86	35.39	204.30	364.53	354.81	1430.88 [2]

consumption of market goods:	food	clothing	other market goods	total
husband	489.00	10. 30	683.06	1182.36[3]
wife	362.01	8.29	511.20	881.51 [4]

Note:

(1) Values are expressed in EUR per month.
(2) Total value reported in cell (rest of the economy, market inputs) and in cell (market inputs, agricultural production).
(3) T value reported in cell (agricultural production, rest of the economy).
(4) Total value reported in cell (rest of the economy, husband).
(5) Total value reported in cell (rest of the economy, wife).

Table 4. A Stylized Equilibrium Model for Professional and Non-Professional Farms

Description	Equation	End.Var.	Set	# Eq.
AGRICULTURAL PRODUCTION				
Cost function	$\log(TC) = TRANSLOG(W_r, q_s; H_a, d_q)$	TC		Eq. (46)
Market input shares	$\omega_r = TRANSLOG(W_r, q_s; H_a, d_q)$	ω_r	$r \in R$	Eq. (47)
Market input demands	$X_r = \omega_r \frac{TC}{W_r}$	X_r	$r \in R$	Eq. (48)
Individual's on-farm labour demand	$h^i = \omega_{h^i} \frac{TC}{w_i^*}$	h^i	$i = 1,2$	Eq. (49)
Profit	$\pi = \sum_s p_s q_s - TC + TR$	π	$s \in S$	Eq. (50)
DOMESTIC PRODUCTION				
Implicit price of the domestic good	$p_z^* = TRANSLOG(w_1^*, w_2^*; d_z)$	p_z^*		Eq. (51)
Individual domestic labour demand	$t^i = \frac{p_z^* z^i}{w_i^*}$	t^i	$i = 1,2$	Eq. (52)
INCOME DEFINITION				
Individual full-income	$I_i = w_i^* T + \varphi_i(y + \pi)$	I_i	$i = 1,2$	Eq. (53)
Wife's sharing rule	$\psi_1 = \lambda^* m$	ψ_1		Eq. (55)
Husband's sharing rule	$\psi_2 = 1 - \psi_1$	ψ_2		Eq. (56)
Scaling function	$m = CD(w_1, w_2, p_1, p_2, y, d_f)$	m		Eq. (57)
INDIVIDUAL CONSUMPTION				
Consumption shares	$\omega_k^i = AIDS(w_1^*, w_2^*, p_1, p_2, \varphi_i, d_i)$	ω_k^i	$i = 1,2$ $k \in K$	Eq. (58)
Market goods	$b^i = \omega_{b^i} \frac{I_i}{p_b^i}$	b^i	$i = 1,2$ $b \in B$	Eq. (59)
Leisure	$l^i = \omega_{l^i} \frac{I_i}{w_i^*}$	l^i	$i = 1,2$	Eq. (60)
Domestic good	$z^i = \omega_{z^i} \frac{I_i}{p_z^*}$	z^i	$i = 1,2$	Eq. (61)
MARKET CLEARING CONDITIONS				
Individual's time constraint	$T = l^i + t^i + h^i + L^i$	w_i^*	$i = 1,2$	Eq. (62)
Labour market participation	$L^i(w_i - w_i^*) = 0$ if $w_i < w_i^*$ then $L^i = 0$ if $w_i = w_i^*$ then $L^i \geq 0$	L^i	$i = 1,2$	Eq. (63)

Sets definition:
$R = \{chemicals, materials, hired\ labor\}$;
$S = \{crop, livestock, milk, fruit\}$;
$A = \{family\ labor, land, capital\}$;
$K = \{leisure, domestic\ good, clothing, food, other\ market\ goods\}$
$B \subset K = \{clothing, food, other\ market\ goods\}$

Table 5. Simulation Results: Impact of a 5% Increase in Husband's Market Wage by Farm-Household Types [1]

	Professional farm		Non-professional farm	
Farm Characteristics				
Total production costs	-1.33		-0.54	
Input demands				
hired labour	-0.54		-0.17	
chemicals	0.41		0.26	
materials	-2.02		-1.50	
man's labour	-11.07		-5.27	
woman's labour	-1.33		-0.54	
Profits	2.31		3.08	
Price of the domestic good	4.37		2.15	
Household Members' Characteristics				
	Man	**Woman**	**Man**	**Woman**
Market wage	5	-	5	-
Marginal labour productivity	10.96	-	5	-
Total expenditure	7.53	0.65	4.69	0.11
Consumption demands				
domestic good	-3.87	2.05	-0.52	0.28
leisure	16.25	-5.66	6.60	-2.25
food	2.49	2.49	0.02	1.51
clothing	1.53	1.70	-0.86	1.47
other market goods	0.16	0.16	-1.50	1.46
Time-use (monthly hours)				
leisure	16.25	-5.66	6.60	-2.25
domestic work	-9.56	6.53	-3.22	2.43
on-farm work	-11.07	-1.33	-5.27	-0.54
off-farm work	-	3.55 hours per month	-11.41	6.82
Sharing rule	0.64	-0.54	0.64	-0.58

Note:

(1) Figures represent percentage changes.

Table 6. Simulation Results: Impact of a 5% Increase in Wife's Market Wage by Farm-Household Types [(1)]

	Professional farm		Non-professional farm	
Farm Characteristics				
Total production costs	-0.30		-0.32	
Input demands				
hired labour	-0.12		-0.10	
chemicals	0.09		0.16	
materials	-0.45		-0.90	
man's labour	-0.30		-0.32	
woman's labour	-5.05		-5.07	
Profits	0.52		2.86	
Price of the domestic good	3.06		2.89	
Household Members' Characteristics				
	Man	**Woman**	**Man**	**Woman**
Market wage	-	5	-	5
Marginal labour productivity	-	5	-	5
Total expenditure	0.18	2.88	0.10	4.51
Consumption demands				
domestic good	1.71	-0.59	0.13	0.24
leisure	-3.95	2.83	-2.27	4.06
food	0.84	1.39	1.13	0.34
clothing	0.91	0.84	1.28	-0.58
other market goods	0.81	0.25	1.07	-1.59
Time-use (monthly hours)				
leisure	-3.95	2.83	-2.27	4.06
domestic work	4.82	-2.43	3.02	-1.77
on-farm work	-0.30	-5.05	-0.32	-5.07
off-farm work	3.05 hours per month	1.75 hours per month	5.22	-10.75
Sharing rule	-0.002	0.002	-0.002	0.002

Note:

(1) Figures represent percentage changes.

Table 7. Simulation Results: Impact of a 10% Increase in Nonlabour Income by Farm-Household Types (1)

	Professional farm		Non-professional farm	
Farm Characteristics				
Total production costs	-0.65		-	
Input demands				
hired labour	-0.26		-	
chemicals	0.20		-	
materials	0.99		-	
man's labour	-0.65		-	
woman's labour	-10.98		-	
Profits	1.14		-	
Price of the domestic good	7.15		-	
Household Members' Characteristics				
	Man	**Woman**	**Man**	**Woman**
Market wage	-	-	-	-
Marginal labour productivity	-	11.60	-	-
Total expenditure	1.05	7.40	1.58	1.79
Consumption demands				
domestic good	3.71	-1.16	0.48	0.77
leisure	-7.36	7.99	3.26	3.52
food	2.27	3.51	0.37	0.21
clothing	2.44	2.23	0.33	0.24
other market goods	2.23	0.87	0.50	0.29
Time-use (monthly hours)				
leisure	-7.36	7.99	3.27	3.52
domestic work	11.13	-5.01	0.48	0.77
on-farm work	-0.65	-10.98	-	-
off-farm work	4.08 hours per month	-	-20.78	-38.75
Sharing rule	-0.011	0.010	-0.011	0.010

Note:

(1) Figures represent percentage changes.