ANALYSING THE COLLECTIVE MODEL IN DEVELOPING COUNTRIES: EVIDENCE FROM UGANDA AND TANZANIA

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Abstract

This Thesis applies one of the most popular household models to the allocation of resources within poor rural households. Based on Browning & Gørtz’s (2007) seminal Collective Household Model, the first Chapter conducts a literature review and derives conditions for identifying and testing the model.

The next Chapter amends this model to evaluate efficiency of the intra-household allocation of male and female labour inputs in the domestic production of multiple crops. Using survey data from Uganda it is found that the division of labour between food and cash crops is made according to comparative advantage, but that Pareto improvements could be achieved by reallocating labour between male- and female-controlled plots.

The final Chapter analyses the distribution of private consumption and leisure within rural couples in Tanzania. The findings provide limited support for the Collective Model, but are consistent with non-unitary household behaviour.

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Analysing the Collective Model in Developing Countries
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To my father,
he would have been so proud.
Chapter 1

Introduction

There is little doubt that individuals within couples allocate their time, incomes and assets differently than individuals that live on their own. Also, most people probably agree that individuals benefit in some way from partnership. These benefits can result from material advantages such as the tax benefits of a specific legal partnership arrangement, savings that may result from lower rent payments, or consumption good expenses. Intangible benefits may include, for example, the happiness generated through children, love or company. In addition, partners may save time, effort and raise productivity through specialization in different activities within the same household.

For instance, traditionally, women were responsible for the provision of domestic chores, such as cooking, child care and laundry, and men used to earn an income in the labour market. As domestic chores are services that are not captured by market mechanisms, they are not directly remunerated. In consequence, this traditional division of time is also accompanied by a specific division of incomes between partners. Through the development of time-saving innovations such as washing machines, new inventions such as the contraceptive pill, exogenous factors such as wars that increased female labour force participation, technological and economic advances as well as changes in the political and legal representation of women, the traditional division of time and distribution of incomes between a couple has undergone fundamental changes in Western societies.

However, many of these structural transformations have not, or have only partially, occurred in developing countries. Especially in Sub-Saharan Africa, which is one of the poorest regions in the world, smallholder production is still the main source of income and subsistence preservation. Often small farm households lack access to functioning labour markets and off-farm employment opportunities. Also, in many
countries access to output markets for selling their own produce and input markets, such as of fertilizer or land, are limited. High transaction and transportation costs distort market prices and may prevent smallholders from market participation. Thus, on family farms the allocation of time follows traditional lines with certain activities executed, crops cultivated and incomes controlled by different members within the same household; in particular, along gender-specific lines.

A central aim of this Thesis is to test conditions that determine an optimal allocation of labour inputs between rural farm couples in developing countries to answer the question of whether the existing allocation of resources is efficient. This question is crucial, as resource allocation patterns affect farm outputs and so a country’s poverty level.

Apart from the traditional allocation of resources into farm production, in many developing countries the status of women is below that of men. This is for instance witnessed by the acceptance of wife-beating in many societies or child preferences that are biased towards boys instead of girls. Also, in many countries there is a gap between the official law and its application. Traditions and social norms may prevent the feasibility of certain laws, such as the claim on property upon divorce or divorce itself. The degree to which these structures are associated with an unequal intra-household allocation of consumption or leisure and so with a general deprivation of well-being of women constitutes the second principal aim of this Thesis. This aim is of interest in its own right.

To address these two aims, this Thesis analyses intra-household resource allocation in poor rural households in Sub-Saharan Africa using standard economic theory that has been developed to explain intra-household allocations. Although it seems evident that husbands and wives, or partners in general, may have very different preferences and disagree about their spending priorities, it was only during the late 1980s that this idea was integrated into the economic modelling of household behaviour. Before, household members were assumed to have the same preferences and could be modelled by a single utility function. During the late 1980s and early 1990s, many empirical studies provided evidence that cast serious doubt on these type of models, both in applications to developed and especially developing countries.

Economic models of the household can be classified into cooperative models, in which partners negotiate, and which yield Pareto efficient decision-outcomes, and non-cooperative models, in which Pareto efficiency is not guaranteed. The so-called Collective Model is the most general cooperative household model and has been established as one of the most popular economic models of the household. In contrast to a single-utility-function model, the Collective Model takes utility differences
between partners and their power to determine household choices explicitly into account. As such, the second Chapter uses a generic Collective Model to discuss the conditions and requirements for testing and identifying the model. We also derive conditions for the distribution of well-being and relative labour allocation in domestic production between partners.

After discussing variants of the Collective Model and models that have been developed to analyse the choices of rural farm households, Chapter 3 introduces the production of multiple crops into this model. We also model labour market imperfections, as typically faced by farm households, and analyse their implications. The Chapter seeks to explain why, rural household seemingly fail to allocate male and female on-farm labour inputs in optimal ways. Identifying two channels that may explain sub-optimal intra-household labour allocations and using very rich survey data from Uganda, we test whether labour is allocated optimally and to explain the apparent inefficiencies while testing our hypotheses.

Moving from production to consumption choices, Chapter 4 analyses the allocation of time and welfare within rural households using survey data from Tanzania. Given the importance of wages for the intra-household allocation of well-being, we use different measures to overcome the problem of missing wage data because of missing labour markets in developing countries. Using data on individual consumption and time-use, we test whether the Collective Model is supported by the data. In addition, we aim at partially identifying the decision-weight of women within Tanzanian couples, and at detecting determinants of their relative well-being. Although there are some studies that test collective behaviour in developing countries, studies that try to identify structural parameters of the Collective Model are very rare.

While the Uganda Chapter covers production efficiency in a multi-crop setting, the Tanzania application concentrates on identification issues and the estimation of a ‘structural’ or theoretical model as discussed in Chapter 2. Both studies consider the implications of absent and distorted labour markets for the intra-household allocation of time.

Finally, a last Chapter summarises the key findings and draws some conclusions. In particular, we find some evidence that farm households in Uganda fail to efficiently allocate female and male labour inputs. Total farm output could be increased by reallocating male labour to female-controlled plots. However, the identified inefficiencies do not seem to be necessarily related to market integration. The Tanzanian application complements these results. We find that men have a bigger share in private consumption than their spouses, but leisure seems to follow a more egalitarian distribution. Using various wage measures, we find that the relative wage has
a positive impact on relative consumption and a negative impact on leisure. This is evidence against the single-utility-function model. However, we are limited in identifying structural parameters of the model, and provide only partial support for collective behaviour.

Taken together, our results thus highlight the need for further research in modelling household behaviour to better describe and analyse rural households in the less-developed world.
Chapter 2

Browning and Gørtz’s Collective Model

In this Chapter, we write down and discuss the properties of the conditions that solve a generic Collective Household Model. This follows Browning & Gørtz (2007) very closely. After deriving conditions that distinguish this model from other competing household models, we show how it nests other Collective Models and captures recent advances in this literature, which is in line with two recently developed studies by Browning, Chiappori & Weiss (2007) and Bourguignon, Browning & Chiappori (2009). Finally, we discuss a parallel strand of models developed to analyse farm households. This provides the basis for analysing resource allocation within rural households in developing countries in the following Chapters.

2.0.1 Preferences

Each household comprises two partners, labelled A and B. We abstract from whether or not they have dependents such as children, elderly parents and so on. First consider Partner A. Her utility function $u^A$ depends on her private consumption of a composite good $q^m_A$ bought in the market at price $p^m$, hours of leisure $l_A$, the household public good $Q$, and a vector of preference factors $a_A$. This is written:

$$u^A = u^A(q^m_A, l_A, Q; a_A).$$  \hspace{1cm} (2.1)

The household public good $Q$ is said to be non-rival in the sense that the consumption of one partner does not reduce the available consumption of the other. Examples are children’s welfare and a clean house. The vector $a_A$ represents an idiosyncratic heterogeneity term that reflects variations in tastes between individuals such as captured by exogenous factors like age or education. As these are not determined while
deciding on private and public consumption, they are separated by semicolon. \( u^A \) is a utility function which is continuous, non-decreasing and quasi-concave, representing complete, reflexive, transitive and monotonic preferences.

Partner B’s utility \( u^B \) depends on exactly the same arguments and has the same characteristics:

\[
\begin{equation}
    u^B = u^B(q_m^B, l_B, Q; a_B).
\end{equation}
\]

We assume that A cares about B in the sense that she derives utility if B does. In other words, A’s total utility comprises her own \( u^A \) plus a proportion \( \lambda_A \) of B’s. A’s individual social welfare function \( \Psi_A \) is defined as:

\[
\begin{equation}
    \Psi_A = u^A + \lambda_A u^B, \quad \lambda_A \in [0, 1].
\end{equation}
\]

Notice that B’s consumption of goods and leisure does not affect A directly, but through B’s enjoyment of these goods.

If A does not care about B, \( \lambda_A = 0 \). If this is the case then A’s utility is said to be egoistic (Bourguignon, Browning, Chiappori & Lechene 1994). A is indifferent between her own utility or her partner’s if \( \lambda_A = 1 \). We rule out the possibility that \( \lambda_A < 0 \), namely that she dislikes her partner. Also, we do not allow that she cares more about her partner than about herself, namely that \( \lambda_A > 1 \). Nothing hinges on this assumption. Exactly the same considerations apply to B:

\[
\begin{equation}
    \Psi_B = u^B + \lambda_B u^A.
\end{equation}
\]

In (2.3) and (2.4), both \( \Psi_A \) and \( \Psi_B \) are additively separable in \( u^A \) and \( u^B \). We define \( \Psi_h \) as the household’s welfare function. It is a weighted average of A’s and B’s social welfare, or felicity, functions,

\[
\begin{equation}
    \Psi_h = \tilde{\mu} \Psi_A + (1 - \tilde{\mu}) \Psi_B \quad \tilde{\mu} \in [0, 1],
\end{equation}
\]

where the weight \( \tilde{\mu} \) reflects the so-called balance of power within the household. If \( \tilde{\mu} = 1 \), then A is all-powerful, in the sense that B’s social welfare does not contribute to household welfare. Substituting the individual felicity functions into household
welfare:
\[
\Psi_h = \hat{\mu} \Psi_A + (1 - \hat{\mu}) \Psi_B
\]
\[
= \hat{\mu} (u^A + \lambda_A u^B) + (1 - \hat{\mu}) (u^B + \lambda_B u^A)
\]
\[
= [\hat{\mu} + (1 - \hat{\mu}) \lambda_B] u^A + [1 - \hat{\mu} + \hat{\mu} \lambda_A] u^B
\]
\[
= \mu_A u^A + \mu_B u^B.
\] (2.5)

The ‘weights’ \(\mu_A\) and \(\mu_B\) both lie between 0 and 1. As discussed in more detail below, their ratio becomes important, and so we define the so-called Pareto weight as
\[
\mu \equiv \frac{\mu_A}{\mu_B} = \frac{\hat{\mu}}{1 - \hat{\mu} + \hat{\mu} \lambda_A}, \quad \mu \in [0, \infty)
\] (2.6)
and redefine \(\Psi_h\),
\[
\frac{\Psi_h}{\mu_B} = \mu u^A + u^B.
\]

It is only the parameter \(\mu\) that is identified in these type of models, and so we will never know whether a high \(\hat{\mu}\) is the result of a high \(\hat{\mu}\) or a high \(\lambda_B\), or low \(\lambda_A\) and so on. To put it differently, caring is observationally equivalent to a lack of power.

### 2.0.2 Distribution factors

Formal economic theory does not provide a framework explaining the content of \(\hat{\mu}\), but it is here hypothesised to be a function of distribution factors (‘z-factors’), relative wages \(w_A/w_B\), prices and total household income. Prices can be argued to affect the Pareto weight because if one partner prefers more expensive goods than his spouse, this may lead to a comparatively lower amount of consumption of these goods. Total household income may affect power as it could be correlated with other factors that influence the partners’ ability to determine household choices such as relative education levels or societal factors. In the following, we have abstracted from prices and incomes for the sake of illustration, but we will discuss these factors in Section 2.1 below. So that
\[
\hat{\mu} = \hat{\mu}(z_1, z_2, w_A/w_B).
\] (2.7)

Substituting this into (2.6):
\[
\mu[\hat{\mu}(z_1, z_2, w_A/w_B), \lambda_A, \lambda_B] = \mu(z_1, z_2, w_A/w_B, \lambda_A, \lambda_B).
\]

Distribution factors \((z_1, z_2)\) are exogenous factors that impact on the allocation of
power within the household but not on preferences like \( a_A \) or \( a_B \) or the budget constraint like prices or total household income (Browning & Chiappori 1998). For instance, McElroy (1990) discusses governmental transfers conditional on being single as distribution factors since these determine the opportunity costs of being married. In Chiappori (1992) the Pareto weight is modelled in terms of reservation utility which depends on wages and total household income. In Bourguignon, Browning, Chiappori & Lechene (1993) individual labour earnings replace wages as labour supply is assumed to be fixed by, for example, a legal maximum. Thomas & Chen (1994) analyse non-wage incomes and in Bourguignon et al. (1994) distribution factors comprise age and income differences, which are similar to those considered by Browning & Gørtz (2007). Chiappori, Fortin & Lacroix (2002) extend the analysis of collective labour supply to sex ratios in the marriage market and divorce laws as distribution factors. Qian (2008) considers changes in sex-specific earnings. While entering the budget constraint in an aggregate manner, the partners’ individual non-wage incomes shares can also be classified as distribution factors (Bourguignon et al. 2009).

Distribution factors are factors that determine partners relative well-being and affect the individual income share each partner receives for maximising her own utility over private goods and leisure (also called ‘sharing rule’ in this literature). These factors are crucial for identifying the Collective Model. We will illustrate in Sections 2.0.4 and 2.0.5 below why this is the case. As a result, it is very important to have information on relative wages, about individual income control or cultural and institutional factors that affect the Pareto weight in the data used for being able analyse the Collective Model.

Summarizing, household welfare depends on both partners’ consumption of the market good and leisure, the household public good, both vectors of preference factors, and the Pareto weight:

\[
\Psi_h = \Psi_h(q^m_A, q^m_B, Q, l_A, l_B; a_A, a_B, \mu).
\]

### 2.0.3 Constraints

Each partner has a total (exogenous) time endowment of 24 hours a day, \( T \). For A, \( T \) can be allocated to leisure \( l_A \), public good production \( h_A \) or to the labour market \( m_A \). The same applies for B. So, in maximising household welfare, the partners face the following constraints on their allocation of time:

\[
T \geq l_A + m_A + h_A \quad (2.8)
\]

\[
T \geq l_B + m_B + h_B.
\]
The production of the household public good \( Q \) depends on each partner’s time input \( h_A, h_B \) and material inputs bought in the market \( q_H \) at price \( p^H \). The production function of the public good \( F^Q \) is a concave function and is increasing in all inputs:

\[
Q = F^Q(h_A, h_B, q_H).
\] (2.9)

The household budget constraint states that expenses on private consumption, i.e. the price of the private consumption goods bought in the market \( p^m \) multiplied by the quantities consumed by the partners \( q^m_A + q^m_B \), and on inputs for public good production, \( p^H q_H \), cannot exceed total household income. Total household income consists of non-wage income \( y \) and wage earnings of each partner for spending \( m_A \) and \( m_B \) hours in the labour market at wage \( w_A \) and \( w_B \). The household budget constraint is:

\[
p^H q_H + p^m(q^m_A + q^m_B) = w_A m_A + w_B m_B + y = Y.
\] (2.10)

We assume both partners supply a positive amount of labour to the local labour markets but we relax this assumption in the next Chapter. Also, note that it is not possible to hoard time and we assume the partners cannot afford to accumulate money. This implies that the inequality restrictions on time and income can be treated as equalities.

Substituting the time constraints for market work into the household budget constraint, we get a ‘full income constraint’ of the form:

\[
p^H q_H + p^m(q^m_A + q^m_B) = w_A(T - h_A - l_A) + w_B(T - h_B - l_B) + y,
\] (2.11)

and re-arranging

\[
p^H q_H + p^m(q^m_A + q^m_B) + w_A(h_A + l_A) + w_B(h_B + l_B) = (w_A + w_B)T + y.
\] (2.12)

\((w_A + w_B)T\) is the hypothetical or potential income that could be earned if each partner spent \( T \) hours in the labour market.

### 2.0.4 Model Solutions

The model is solved by maximising household welfare with respect to the eight choice variables

\[
x = (q^m_A, q^m_B, l_A, l_B, h_A, h_B, q_H, Q)
\]
which, subject to the full income constraint in (2.11), yield a Lagrange function of the form:

\[ \mathcal{L} = \mu u^A(q^m_A, l_A, F^Q) + u^B(q^m_B, l_B, F^Q) + \gamma[w_A(T - h_A - l_A) + w_B(T - h_B - l_B) + y - p_m(q^m_A + q^m_B) - p^H q_H]. \]

The Lagrange multiplier associated with the income constraint \( \gamma \) captures the household’s valuation of an additional unit of income. Differentiating \( \mathcal{L} \) with regard to the choice variables in \( \mathbf{x} \) allows the First-Order Conditions (FOC) to be written down. These show that the Marginal Rate of Substitution (MRS) between leisure and private consumption is equal to the relative prices for both A and B

\[ \frac{\partial u^A}{\partial l_A} / \frac{\partial u^A}{\partial q^m_A} = w_A/p^m, \]

\[ \frac{\partial u^B}{\partial l_B} / \frac{\partial u^B}{\partial q^m_B} = w_B/p^m. \]

The allocation of leisure between the partners is determined by the ratio of the FOCs for choosing \( l_A \) and \( l_B \):

\[ \frac{\partial u^A}{\partial l_A} / \frac{\partial u^B}{\partial l_B} = \mu^{-1}w_A/w_B. \] (2.13)

This result shows that, all other things being equal, an increase in the Pareto weight acts as if A’s marginal utility of an additional unit of leisure were reduced and so increases her leisure share. It is essentially the same as decreasing her relative wage.

As both partners face the same price for private consumption, the MRS is given by

\[ \frac{\partial u^A}{\partial q^m_A} / \frac{\partial u^B}{\partial q^m_B} = \mu^{-1}. \] (2.14)

Hence, the allocation of consumption between the partners depends simply on the Pareto weight. These two conditions for relative leisure and private consumption will be very important for Chapter 4 below, in which we discuss the allocation of welfare between partners.

Accordingly, all of the demand functions, \( \mathbf{q} \), generated by maximising household welfare, \( \Psi_h \), by choosing \( \mathbf{x} \) subject to (2.11) depend on prices, incomes and the Pareto weight:

\[ \mathbf{q} = (q^m_A, q^m_B, Q) = \mathbf{q}(p^h, p^m, Y, \mu; \mathbf{a}_A, \mathbf{a}_B). \] (2.15)

Efficiency requires that at the margin, the relative impact of the different distribution factors is equalised over the different goods. We can show this by recalling that \( \mu = \mu(z_1, z_2, w_A/w_B, \lambda_A, \lambda_B) \), and differentiating private consumption with regard
to $z_1$ and $z_2$, we get the following conditions:

\[
\frac{\partial q^m_A}{\partial z_1} = \frac{\partial q^m_A}{\partial \mu} \frac{\partial \mu}{\partial z_1},
\]

\[
\frac{\partial q^m_A}{\partial z_2} = \frac{\partial q^m_A}{\partial \mu} \frac{\partial \mu}{\partial z_2},
\]

\[
\frac{\partial q^m_B}{\partial z_1} = \frac{\partial q^m_B}{\partial \mu} \frac{\partial \mu}{\partial z_1},
\]

\[
\frac{\partial q^m_B}{\partial z_2} = \frac{\partial q^m_B}{\partial \mu} \frac{\partial \mu}{\partial z_2}.
\]

These conditions are very important because they only apply to models in which the weight for aggregating utility across partners depends on $z$-factors and decision-outcomes are efficient. As such, they allow the derivation of a generic test for collective behaviour, which is also called the ‘proportionality condition’ in this literature. Taking ratios of the first and second, and the third and fourth expressions, eliminates the good-specific impact of the Pareto weight and so:

\[
\frac{\partial q^m_A}{\partial q^m_A} \frac{\partial q^m_A}{\partial z_1} = \frac{\partial q^m_B}{\partial q^m_A} \frac{\partial q^m_A}{\partial z_2} = \frac{\partial q^m_A}{\partial q^m_B} \frac{\partial q^m_B}{\partial z_1} = \frac{\partial q^m_B}{\partial q^m_B} \frac{\partial q^m_B}{\partial z_2}.
\]

(2.16)

In words, the relative marginal effect of $z$-factors is equal across goods since it is equal to their relative impact on the Pareto weight. This condition has been proven to be necessary and sufficient for the Collective Model (see Bourguignon et al. (2009) for a recent statement).

Another interesting condition that one can derive from the FOCs is the condition that determines relative male and female labour allocation into public good production:

\[
\frac{\partial F^Q}{\partial h_A} (\mu \partial u_A / \partial Q + \partial u_B / \partial Q) = \gamma w_A
\]

\[
\frac{\partial F^Q}{\partial h_B} (\mu \partial u_A / \partial Q + \partial u_B / \partial Q) = \gamma w_B,
\]

so that

\[
\frac{\partial F^Q / \partial h_A}{\partial F^Q / \partial h_B} = w_A / w_B.
\]

The last expression shows that relative labour allocation will be such that the relative marginal products are equal to the relative marginal cost; that is, the relative wage. This condition will be crucial in the next Chapter, where we analyse efficiency of male and female on-farm labour allocations.
2.0.5 A special case: the Unitary Model

In the Unitary Model, the partners behave as if they maximise a single utility function. Using the model discussed above, if one partner, say B, were the only decision-maker then $\mu = 0$ and so:

$$\Psi_h = u^B.$$

However, to convert the Collective Model into a Unitary Model it is not necessary that one partner is an effective dictator. Rescuing the assumption of a single welfare function, Becker (1991, 1981, 1974) stipulates conditions that allow for a unitary representation of the household.

Assuming a caring household head that maximises his utility, and is able to redistribute income among household members, Becker shows that each family member will aim to take actions that maximise overall household income. The famous ‘rotten-kid theorem’ articulates this finding: any action that would disproportionately benefit one member at the expense of household income would lead to reductions in the income allocated to this person. Thus, “A family acts ‘as if’ it maximized a consistent and transitive utility function subject to a budget constraint that depended only on family variables” (Becker 1974, p.1091). The caring head model is nested in our model as it modifies the Pareto weight to $\lambda_B$, as $\tilde{\mu} = 0$, so that

$$\Psi_h = \Psi_B = u^B + \lambda_B u^A = u^B + \mu u^A.$$

This also follows from (2.6), i.e. $\lambda_B = \mu$ are the same parameter:

$$\mu \equiv \frac{\tilde{\mu} + (1 - \tilde{\mu}) \lambda_B}{1 - \tilde{\mu} + \tilde{\mu} \lambda_A} \equiv \lambda_B.$$

The key difference between the Unitary and the Collective Model is that the weight given to Partner A, $\mu = \lambda_B$, is not a function of $\tilde{\mu}$, and so does not depend on distribution factors. As a result, the demand functions derived from a Unitary Model do not depend on $z_1$ or $z_2$. Now, differentiating private consumption with regard to $z_1$ and $z_2$, as in section 2.0.4 above, we get the following conditions:

$$\frac{\partial q^m_A}{\partial z_1} = 0, \quad \frac{\partial q^m_B}{\partial z_1} = 0,$$

$$\frac{\partial q^m_A}{\partial z_2} = 0, \quad \frac{\partial q^m_B}{\partial z_2} = 0.$$
This means that the proportionality condition in (2.16) is modified to:

\[
\frac{\partial q^a_1}{\partial z_1} = \frac{\partial q^a_2}{\partial z_2} = \frac{\partial q^b_1}{\partial z_1} = \frac{\partial q^b_2}{\partial z_2} = 0.
\]

As a result, a very intuitive and popular test against the Unitary Model is to estimate a standard collective demand function, as summarised in (2.15), and to test whether the z-factors do not affect demand as stipulated in the Unitary framework. A very famous example is the inclusion of husband and wife’s individual incomes, while controlling for overall household income. To test whether the individual incomes do not have any impact is also called ‘income pooling’ and has been widely rejected in the literature (see Chapter 4 for a review or Alderman, Chiappori, Haddad, Hoddinott & Kanbur (1995)).

If there are no distribution factors, and there is no price variation as illustrated below, but other factors that impact on the Pareto weight are available in the data such as household income, empirical results may be consistent with a Unitary Model even though the model may not be in fact unitary (Bourguignon et al. 2009). To put it differently, a change in total household income cannot be uniquely decomposed into a power and a standard demand effect. That is why the existence of distribution factors is crucial for identifying the Collective Model.

2.0.6 Another special case: cooperative Nash Bargaining Models

Apart from the Unitary Model, the Collective Model is related to a further class of cooperative models. These models put more structure on the decision process and assume cooperative Nash bargaining behaviour.

In the Nash bargaining framework each partner has a ‘threat point’ that represents the highest attainable utility level if partners were not able to settle on an agreement. In McElroy & Horney (1981) and McElroy (1990) this represents the utility each partner attains at divorce or separation. Particularly for daily decision-making, Lundberg & Pollack (1993) question the credibility of divorce as a threat. In their model the threat to cooperation is the utility attained in a non-cooperative equilibrium in which resource allocation follows pre-determined gender roles\(^1\).

Having established the threat to cooperation, partners engage in marriage to maximise the gains from partnership; that is, the product of the utility differences between the threat point and cooperation. As indicated in Chapter 1 these gains

\(^1\)In contrast to the models discussed so far, the final outcome does not necessarily guarantee an efficient solution nor does it require negotiations.
can result from the existence of household public goods, $Q$, economies of scale in consumption or simply “love and companionship” (Manser & Brown 1980), $\lambda_A$ and $\lambda_B$.

The weight of each Partner in the decision-process is determined by the threat points. The higher the utility level partner A can achieve if she does not cooperate with B, the higher the utility gain that has to result from cooperation. The threat points depend on factors that influence individual well-being outside the marriage (McElroy 1990). These factors operate in the same way as distribution factors. However, the treatment of distribution factors in the Collective Model is more general because the Nash Model requires $z$-factors to be associated either with A or B’s threat points (Bourguignon et al. 2009).

To illustrate and, in keeping with the model discussed above, suppose the utility at marriage of the partners is $u^A$ and $u^B$. For simplicity, we assume that A’s threat point $v^A$ is only a function of $z_1$, and B’s threat point $v^B$ a function of $z_2$. Also, for simplicity, we do not consider explicitly caring preferences.

In the Nash Model, partners choose $Q, q^A_m, q^B_m, l_A, l_B$ so to maximise the following Nash product

$$(u^A - v^A)(u^B - v^B).$$

Taking logs

$$\log(u^A - v^A) + \log(u^B - v^B)$$

subject to

$$p^h q_H + p^m (q^A_m + q^B_m) + w_A (h_A + l_A) + w_B (h_B + l_B) = (w_A + w_B)T + y. \quad (2.18)$$

In line with the Collective Model discussed above, the FOCs of maximising (2.17) subject to (2.18) by choosing private consumption and leisure, allow the derivation of an expression for relative private consumption

$$\frac{\partial u^A}{\partial q^A_m} / \frac{\partial u^B}{\partial q^B_m} = (u^A - v^A)/(u^B - v^B),$$

and for relative leisure

$$\frac{\partial u^A}{\partial l_A} / \frac{\partial u^B}{\partial l_B} = (u^A - v^A)/(u^B - v^B) \frac{w_A}{w_B}. \quad (2.20)$$

The resulting demand functions depend on prices, total household income and the
threat point variables

\[ q = (q^m_A, q^m_B, Q) = q(p^h, p^m, Y, \mu[v^A(z_1), v^B(z_2)]; a_A, a_B). \]

These functions are empirically indistinguishable from the collective demand summarised above. To see this, recall that in the Collective Model:

\[ \Psi_h = \mu(z_1, z_2)u^A + u^B, \]

where \( \partial \mu / \partial z_1 > 0 \) and \( \partial \mu / \partial z_2 < 0 \). In the Nash Model:

\[ \Psi_h = \log[u^A - v^A(z_1)] + \log[u^B - v^B(z_2)], \]

where we redefined \( \Psi_h = \log \Psi_h \), and \( \partial v^A / \partial z_1 > 0 \), \( \partial v^B / \partial z_2 > 0 \) and \( \partial \mu / \partial v^A > 0 \) and \( \partial \mu / \partial v^B < 0 \).

As such, cooperative Nash Models necessarily satisfy the testable restrictions of the Collective Model. Yet, Bourguignon et al. (1993) argue that bargaining models impose more structure on the decision-process than the Collective Model, and so should add further restrictions for empirical falsification. Bourguignon et al. (2009) propose an additional test for the bargaining framework, which is based on the assumption that \( z_1 \) is exclusively correlated with A’s and \( z_2 \) with B’s threat point. Taking derivatives of the Nash bargained demand with respect to \( z_1 \) and \( z_2 \), we get the following conditions:

\[ \frac{\partial q^m_A}{\partial z_1} \frac{\partial q^m_B}{\partial z_2} = \frac{\partial q^m_A}{\partial \mu} \frac{\partial \mu}{\partial v^A} \frac{\partial v^A}{\partial z_1} \frac{\partial q^m_B}{\partial \mu} \frac{\partial \mu}{\partial v^B} \frac{\partial v^B}{\partial z_2} = 1 \times \left( \frac{+}{-} \right) \leq 0, \]

\[ \frac{\partial q^m_B}{\partial z_1} \frac{\partial q^m_B}{\partial z_2} = \frac{\partial q^m_B}{\partial \mu} \frac{\partial \mu}{\partial v^A} \frac{\partial v^A}{\partial z_1} \frac{\partial q^m_B}{\partial \mu} \frac{\partial \mu}{\partial v^B} \frac{\partial v^B}{\partial z_2} = 1 \times \left( \frac{+}{-} \right) \leq 0, \]

where the third term in the expression indicates the signs of the derivatives. These two conditions illustrate that the Nash Model has to satisfy two restrictions:

1. Collective test
   \[ \frac{\partial q^m_A}{\partial z_1} = \frac{\partial q^m_B}{\partial z_1} \leq 0. \]

2. Bargaining test
   \[ \frac{\partial q^m_A}{\partial z_2} = \frac{\partial q^m_B}{\partial z_2} \leq 0. \]

In words, a change in consumption that results from a change in the partners’ environment is equal across goods (the collective test), and that this effect is negative (the Nash bargaining test). So, the Nash Model can also be regarded as a different
interpretation of the Collective Model.

## 2.1 Variations of the model and identification issues

In the previous Sections, we introduced Browning & Gørtz’s (2007) model as a generic Collective Model and showed how the Unitary and the Nash Bargaining Model are related to it. In this Section, we review the theoretical literature on Collective Models. The particular focus will be on two major concerns that evolved during the 1990s in this literature: testing and identifying structural parameters of the Collective Model. In doing so, we cover many different variants of the Collective Model and discuss also data requirements.

In the first instance, we discuss the terminology which we use for preferences. Preferences can be classified into egoistic, caring and altruistic. In section 2.0.1 we modelled the degree of caring in terms of the two parameters $\lambda_A$ and $\lambda_B$. We defined caring preferences as such that $A$ or $B$ derive utility from their spouse’s utility, and this in an additive separable way i.e. $\Psi_A = u_A + \lambda_A u_B$ and $\Psi_B = u_B + \lambda_B u_A$.

Egoistic preferences mean that neither $A$ nor $B$ derive utility from their spouse’s utility; in other words, $\lambda_A = 0$ and $\lambda_B = 0$. This means the Pareto weight in (2.6) is modified to

$$\mu \equiv \tilde{\mu}/(1 - \tilde{\mu}).$$

As a result, any change in the allocation of resources between the partners that cannot be attributed to preferences must be due to power. In this sense, imposing egoism on preferences facilitates identification.

Preferences are said to be altruistic if the partners’ utilities do not only depend on their own individual private consumption, but also directly on the consumption of their partner. For partner $A$ this means that

$$u^A = u^A(q^m_A, l_A, q^m_B, l_B, Q; a_A).$$

In essence, altruistic preferences abolish separability between $A$ and $B$’s utility functions. Altruistic preferences are the most general form of preferences.

The nature of consumption goods is also related to the nature of preferences. For example, Bourguignon et al. (1994) highlight that if all consumption is public then it is not possible to distinguish egoistic from altruistic preferences since
\[ u^A(Q) = u^A(Q). \] In addition to public and private consumption, the authors distinguish private consumption into assignable and exclusive goods. If the individual consumption of a certain good is directly observed, the good is assignable. If a good’s consumption can be attributed to a certain household member the good is classified as exclusive. In the two partner household one assignable good (for example clothing) is equivalent to two exclusive goods (female and male clothing).

In Chiappori (1992) and Bourguignon et al. (1993) partners are assumed neither to consume nor to produce household public goods. This means that \( Q = 0, q_H = 0 \) and so

\[
\begin{align*}
    u^A &= u^A(q^m_A, l_A; a_A), \\
    u^B &= u^B(q^m_B, l_B; a_B),
\end{align*}
\]

and \( h_A = h_B = 0 \).

Bourguignon et al. (1993) show that the data requirements for testing collective behaviour do not go beyond standard cross-section household survey data. Bourguignon et al. (1994) consider explicitly different preferences and types of goods, including public consumption. The authors clarify that for testing collective behaviour, no assumptions about the nature of preferences (altruistic, caring, egoistic) as well as goods (public or private) are necessary, except the existence of distribution factors. For the proportionality condition \( \text{(2.16)} \) to be satisfied, the only requirement is that there are at least two distribution factors that affect demand and that the ratio of their marginal effects is equated over the goods.

The studies cited so far, including Browning & Gørtz (2007), assume that individuals face identical prices since the data used contain only cross-sectional information. Browning & Chiappori (1998) explicitly analyse the impact of prices on the Pareto weight. In Equation \( \text{(2.7)} \) we defined the distribution of power. For simplification we abstracted from prices and incomes. Prices and incomes modify \( \text{(2.7)} \) to

\[
\tilde{\mu} = \tilde{\mu}(z_1, z_2, w_A/w_B, p^h, p^m, Y)
\]

and so the Pareto weight,

\[
\mu[\tilde{\mu}(z_1, z_2, w_A/w_B, p^h, p^m, Y), \lambda_A, \lambda_B] = \mu(z_1, z_2, w_A/w_B, p^h, p^m, Y, \lambda_A, \lambda_B).
\]

Above, we defined a vector of collective demand functions as:

\[
q = q(p^h, p^m, Y, \mu; a_A, a_B).
\]

The only difference from the demand functions discussed in \( \text{(2.15)} \) is that we now
allow for the possibility that prices and incomes affect $\mu$. A change in prices impacts on demand in two ways. It has a standard substitution and income effect. As the price of a good increases, the household substitutes its consumption with another good. In addition, it alters the total purchasing power of the household; thus, a price change affects the shape of the Pareto frontier on which the allocation of resources between the partners cannot be altered without reducing the utility of one partner. We will illustrate the Pareto frontier in Chapter 4.2 below. Further, it affects the Pareto weight $\mu$ and, as such, shifts the optimal point chosen on the frontier (Bourguignon et al. 2009). Browning & Chiappori (1998) and Browning et al. (2007) show that this provides an additional test for the Collective Model based on the Slutsky substitution matrix. For illustration, assume the prices for private consumption vary across partners, so that $p^m = (p^m_A, p^m_B)$. Also, for the sake of illustration, assume that there are no distribution factors. We can only observe how prices and income affect demand, but not directly how they affect the Pareto weight. So, we observe:

$$\hat{q}(p^h, p^m_A, p^m_B, Y; a_A, a_B) = q(p^h, p^m_A, p^m_B, Y, \mu(p^h, p^m_A, p^m_B, Y); a_A, a_B).$$

Taking derivatives with regard to the price of the private consumption good of B for private demand of A we get:

$$\frac{\partial q^m_A}{\partial p^m_B} = \frac{\partial q^m_A}{\partial p^m_B} + q^m_B \frac{\partial q^m_A}{\partial Y} + \frac{\partial q^m_A}{\partial \mu} \left( \frac{\partial \mu}{\partial p^m_B} + q^m_B \frac{\partial \mu}{\partial Y} \right),$$

with $\frac{\partial q^m_A}{\partial p^m_A} < 0$, $\frac{\partial q^m_B}{\partial p^m_B} < 0$ and $\frac{\partial q^m_A}{\partial p^m_B} = \frac{\partial q^m_B}{\partial p^m_A}$. The first two terms are standard substitution and income effects that correspond to models in which there is no Pareto weight or it is assumed to be constant as, for instance, in the Unitary Model. In essence, these terms capture the partial impact of $p^m_B$ on demand, holding power and utility constant (Browning & Chiappori 1998). The last term expresses how a change in prices also affects the Pareto weight and so the demand composition. If demand does not depend on $\mu$, $\frac{\partial q}{\partial \mu} = 0$, and the last term vanishes. The key point is that the additional effect of prices and incomes enters exclusively through $\mu$. This implies that in addition to the standard Slutsky matrix, collective demand adds a further effect\(^2\).

This implication is independent of the proportionality condition and is very powerful as it tests the Collective Model by testing the number of effective decision-makers within the household. As such, it allows testing whether, in addition to

\(^2\)To be precise, in a two decision-maker household, this effect is a matrix that has a rank of one. In Appendix B we discuss this in detail.
husband and wife, for example, children may be treated as decision-makers. To illustrate this, we derive the Slutsky condition for a household with two partners and a single child in Appendix B using Browning & Gørtz’s (2007) model.

In terms of identification of structural parameters, using a Collective Model similar to the one discussed in Sections 2.0.1 to 2.0.4 above, and assuming egoistic preferences, Chiappori (1992) shows that labour supply data provide sufficient information to identify individual preferences and the sharing rule between partners up to an additive constant. As caring preferences nest egoistic preferences (as $\lambda_A = \lambda_B = 0$), Chiappori’s results also apply to caring preferences.

Using consumption data Bourguignon et al. (1994) state that for retrieving the sharing between partners, the Pareto weight or preferences, some non-public consumption must exist and preferences must be at least weakly separable; that is, caring. In other words, the restriction that one can derive based on altruistic preferences are not sufficient to uniquely identify the underlying model as collective. If we observe private consumption or leisure for both partners, using Browning & Gørtz’s (2007) model, we can use condition (2.13) or (2.14), derived above, to partially identify the Pareto weight. We come back to this in more detail in Chapter 4.

Further, most studies assume that both partners supply a maximum amount of labour to the labour market. However, recent studies by Blundell, Chiappori, Magnac & Meghir (2007) and Lise & Seitz (forthcoming) relax the assumption of full-time employment. In particular, Blundell et al. (2007) show that if one partner, say A, faces a discrete labour supply decision, an efficient allocation rule requires that both partners must be indifferent whether A participates in the labour market or not (so-called ‘Lemma Double Indifference’). Lise & Seitz (forthcoming) highlight that the same considerations apply if both labour supplies are of a discrete nature. The double indifference criteria implies that the whole benefits of participation must be attributed to A, while not altering her or B’s share in total income. To put it differently, despite altering her share in total household consumption, participation does not affect the sharing rule (Lise & Seitz forthcoming).

2.2 Farm household models

The models discussed previously consider domestic production only in terms of household public goods. In agricultural economics the production of subsistence goods...
consumption and marketable goods is of primary interest and was integrated into
the household choice framework decades ago.

The basic agricultural household model has been summarised in Singh, Squire & Strauss (1986). The model is in essence a standard Unitary Model, but as discussed
in more detail in the next Chapter, the time allocation variables and the budget
constraint are modified. In addition to public good production, partners can spend
time in the production of crops such as maize, beans or coffee, $c_A$ and $c_B$, using
production tools and applying other inputs such as fertilizer or manure. Crop output $q^c$ can be traded in the market at the local crop price, $p^c$. So the time constraints
in (2.8) are modified to:

$$T = h_A + l_A + m_A + c_A,$$
$$T = h_B + l_B + m_B + c_B$$

and the budget constraint in (2.10) to

$$p^H q^H + p^m (q^m_A + q^m_B) = p^c q^c + w_A m_A + w_B m_B + y.$$  

In the most basic model, household welfare can be defined as in the Unitary Model
discussed in Section 2.0.5, i.e. $\Psi_h = u^R$.

As a result, the household faces production choices of optimal factor inputs and
output levels, and choices of consumption and leisure or off-farm labour supply at
the same time. If households take prices of agricultural outputs and inputs as given,
the problem can be analysed in two phases. In a first phase, the household allocates
resources into farm production so as to maximise profits. Given domestic profits, in
a second phase the household decides on consumption and leisure so as to maximise
utility. As such, production decisions impact on consumption behaviour as they
impact on the budget constraint but not the reverse. To put it differently, the
model is recursive.

The underlying assumptions include that competitive markets exist and are ac-
cessible to all households, and determine prices of factor inputs and outputs. In
addition, male, female and hired labour inputs are equally productive and perfectly
substitutable. Also wages do not vary by gender or between hired and family labour
inputs.

These assumptions have been relaxed and modified in various other studies. For
instance, de Janvry, Fafchamps & Sadoulet (1991) consider transaction costs that
generate price bands around market prices that may prevent households from market
participation. These costs are household specific and can be attributed to various
factors such as price uncertainty or transportation costs (see Arslan & Taylor (2009)
Benjamin (1992) analyses rural labour supply under rationing and imperfections in the labour market. He considers three different labour market scenarios: rationing of domestic on-farm labour demand; rationing of off-farm labour supply; and price differentials between hired and domestic labour. If there is insufficient domestic and hired labour to satisfy domestic labour demands, the marginal product of labour in farm production exceeds the hired wage rate. This means that total family labour works on the farm and that farm labour allocation is driven by the household’s subjective valuation of an additional unit of income to time but not the market wage. If hired and family labour have different prices that reflect differences in productivity and the costs of hiring-in labour lie below the family off-farm wage, the household will only hire-in and all domestic labour works off the farm. If the costs of hiring labour lie above the domestic off-farm wage, the farm will use exclusively domestic labour. Given the lack of lucrative employment opportunities outside the farm, labour might be employed beyond an optimal level. This result is the same as that prevailing under rationing on off-farm labour supply.

Jacoby (1993) analyses domestic labour supply by gender and considers non-participation in off-farm employment activities. He shows that if partners do not supply labour to off-farm activities, labour supply is a function of shadow wages that are equal to the marginal product in farm production. He also derives a test for market distortions as to whether these shadow prices are equal to market prices. Skoufias’s (1994) study is in line with Jacoby’s study, as is Barrett, Sherlund & Adesina (2008) in a recent application.

Sadoulet, de Janvry & Benjamin (1998) classify domestic labour into skilled and unskilled labour and distinguish these from hired labour. Shadow wages, which are a function of asset endowments, are used to categorise households into different labour regimes i.e. if they sell labour, are self-sufficient or hire-in. Assuming that the hired wage lies above the unskilled wage and both lie below the skilled wage, they find that skilled family labour never works on the farm. In addition, if the farm hires in labour, then no unskilled labour works off the farm and vice versa. Also, the authors derive tests of recursiveness by labour regime.

None of the studies cited so far address utility differences or aggregation across partners and only a few consider labour inputs and consumption disaggregated by gender. In a Collective Farm Model, household welfare is defined as $\Psi_h = \mu u^A + u^B$ while the time and budget constraints are essentially the same as in an Agricultural Household Model that is disaggregated by gender.

One of the first studies that considers farm production in the collective framework
CHAPTER 2. BROWNING AND GØRTZ’S COLLECTIVE MODEL

is Udry (1996). He shows that the standard separation result for agricultural household models is not altered. In addition, he shows that efficiency requires that plots devoted to the same crop in the same season and household should have identical input allocations once controlling for plot characteristics; a condition that does not depend on the existence of a functioning labour market.

Using a dynamic version of the Collective Model, Duflo & Udry (2004) examine efficiency in rural households in Côte d’Ivoire. In the inter-temporal choice framework, efficiency requires that household members insure against short term income fluctuations. Using rainfall information to capture short term variations in farm profits that affect only the household budget constraint, Duflo & Udry (2004) show that the Collective Model predicts no direct impact of these variations on private demand. In fact, the only impact on demand is via its effect on total expenditures, which allows the derivation of testable restrictions. Again, these restrictions do not depend on the state of the labour market.

2.3 Conclusion

In this Chapter, we have reviewed the literature on models of intra-household resource allocation. The Collective Model has replaced the simplistic and repeatedly rejected Unitary Model to analyse cooperative household behaviour. Using Browning & Gørtz’s (2007) canonical Collective Model, we derived conditions and requirements for testing and identifying the Collective Model. Also, we discussed the conditions that determine the distribution of well-being and relative labour allocation in domestic production between partners. We showed how variants of the Collective Model and the most popular cooperative alternatives are related to the model. Finally, we informally discussed models that have been developed to analyse choices of rural households.

The latter are crucial, because in the following we analyse collective behaviour in rural households in Sub-Saharan Africa. In the next Chapter, we introduce the production of multiple crops into Browning & Gørtz’s (2007) model. We also consider different scenarios of on and off-farm labour supply of both partners. Using the modified model, we derive conditions for an efficient allocation of male and female labour inputs in the production of different crops. We test these conditions using household survey data from Uganda. As such, the Chapter complements Duflo & Udry’s (2004) and Udry’s (1996) studies.

Having considered labour allocation in farm production, Chapter 4 analyses the distribution of private consumption and leisure within rural couples.
data from Tanzania, the Chapter tests the Collective Model. In addition, it tries to identify structural parameters of the model and the Pareto weight. There are very few studies that aim to recover structural parameters or the distribution of resources within households in developing countries. This Chapter is in line with Browning & Gørtz’s (2007) application, but uses the modified model to analyse resource allocation within rural couples.

Both Chapters consider the implications of absent or imperfect labour markets and the domestic production of multiple marketable goods for the allocation of resources within the household, and so extend Browning & Gørtz’s (2007) model in an intuitive way.
Chapter 3

Inefficiency of male and female on-farm labour supply: Evidence from Uganda

This Chapter analyses efficiency of the intra-household allocation of female and male labour inputs in farm production of different crops. In a Collective Household Model, spouses’ optimal on-farm labour supply is such that the marginal rate of technical substitution between male and female labour is equated over the crops. We test whether this condition holds using the Uganda National Household Survey 2005/06.

We find that the division of labour between food and cash crops is being made according to comparative advantage, but that Pareto improvements would be possible if labour were reallocated between male- and female-controlled plots.\(^1\)

3.1 Introduction

In many developing countries, smallholder production remains the main source of livelihood of poor rural households. Whether these households are able to escape poverty depends on the sector’s capacity to adjust to the challenges related to globalization, such as increasing market integration, the introduction of new crops, and changes in supply chains (Hazell, Poulton, Wiggins & Dorward 2010). This capacity is determined by and reflected in households’ ability to adapt the allocation of productive resources, including on-farm labour inputs, in optimal ways.

The so-called Collective Model has been established as the ‘workhorse’ for analysing intra-household resource allocation. Like all other cooperative models, a central

\(^1\)This Chapter is authored together with Martyn Andrews (University of Manchester) and Jann Lay (University of Göttingen and GIGA). A significant proportion of this Chapter is my own work.
assumption of the model is that household decision outcomes are Pareto efficient. The predictions of the Collective Model for consumption behaviour have been tested in many countries; see Thomas & Chen (1994) for Taiwan and Quisumbing & Maluccio (2003) for Bangladesh, Ethiopia, Indonesia and South Africa and Duflo & Udry (2004) for Côte d'Ivoire. In most studies, the Collective Model is also not rejected by the data.

The model has been extended for household production by Udry (1996), Apps & Rees (1997), Chiappori (1997) and Donni (2008). As for consumption choices, it also predicts certain conditions for domestic production decisions. Domestically produced goods can be divided into those that can be sold or bought in the market (for example crop production) and non-marketable goods (for example children’s welfare). Chiappori (1997) and Donni (2008) show that if the good has a market substitute, then the allocation of resources in production can be analysed independently from consumption decisions; essentially this is the same as the standard Unitary Agricultural Household Model, where the household has no restrictions in accessing product markets (Singh et al. 1986). In other words, factors of production are allocated to home production as if the household maximises domestic profits. Apart from this marketability assumption, a further challenge for Collective Models with domestic production is that data on inputs and outputs are seldom available in standard data sets. In developing countries domestic production of marketable crops is a main source of household income and standard surveys often also collect input, output and price information of farm production. Although rigorous tests of efficiency of intra-household labour allocations are scarce, based on this information, there is evidence that female and male labour inputs are allocated sub-optimally in smallholder households. This evidence questions whether intra-household farm behaviour can be better described by Collective Models or alternative models, in which conflicts may produce inefficient outcomes.

Udry’s (1996) seminal study concludes that productive resources are allocated inefficiently in rural Burkina Faso. Efficiency requires that two plots that are in all respects equal should have identical yield and input allocations, any deviation should be only a function of plot characteristics. Controlling for plot characteristics and household-year-crop fixed effects, he finds that yields per acre of identical crops are much lower for plots controlled by women than men. On average, female plots exhibit about 30 percent lower yields (Udry 1996).

These yield differences can be explained by input intensity differentials between male and female plots; fertilizer and labour inputs are more intensely used on male plots. In other words, were Burkinabe households to allocate resources efficiently,
given diminishing returns, they would reallocate resources to female plots. Using CES production function estimates, Udry shows that male and female labour inputs are equally productive while all labour inputs are highly substitutable on identical crop-plots. Also, the results indicate no differences in production technology between the plots. This means that, amongst other factors, labour could be reallocated so as to increase output. In fact, using production function estimates and reallocating fertilizer and labour optimally across male and female plots, Udry predicts a crop output increase of 5.89 percent\(^2\).

Analysing also on-farm labour allocation, Jacoby (1992) studies the division of labour of men and women in livestock and crop production in Peru. If labour inputs are allocated in equal proportions over crop and livestock production, efficiency would require that they are equally productive. He finds evidence that women are more productive in livestock and men in crop production. However, the data used do not disaggregate male and female labour inputs by activity, which undermines testing more formally whether labour is allocated optimally\(^3\). In summary, efficiency of the allocation of male and female labour depends not only on the relative factor productivity but also on the production technology employed.

Jones (1983) complements these two studies by explaining why married women, compared to widowed women, allocate ‘insufficient labour’ to paddy rice plots in North Cameroon. Incomes from rice production are controlled by the husband, but cultivation relies on both husband and wife’s labour inputs. Estimating the compensation rate to female labour input in rice production, Jones shows that the sub-optimal labour allocation can be explained by the low compensation married women receive relative to the opportunity costs faced; that is, sorghum production, agricultural wage labour and other incomes. In other words, if households were to allocate resources so as to maximise incomes, compensation would be altered so as to increase female labour on paddy rice plots, thereby cash crop output and so incomes.

In this Chapter we analyse efficiency of the intra-household allocation of female and male labour inputs in farm production of different crops in the very particular context of Uganda, where inefficiencies have been claimed to arise because of social norms that allow men to command women’s labour and the control of income of different crop types.

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\(^2\) Using nationally representative data, Akresh (2005) shows that Udry’s findings are restricted to the provinces from which his data are drawn. Restricting the sample to provinces near Udry’s sample, Akresh confirms Udry’s inefficiencies.

\(^3\) Jacoby estimates ‘pseudo-production functions’ using the disaggregated outputs by livestock and crop production and controlling for the typical inputs used in each activity.
CHAPTER 3. INEFFICIENCY OF ON-FARM LABOUR SUPPLY

The contributions of the Chapter are the following. First, we derive a test of efficiency of male and female labour allocation over different crops using a Collective Model. Second, we model the testable restrictions using a functional form that does not restrict the elasticity of substitution of female and male labour inputs. Third, we use the Uganda National Household Survey (UNHS) 2005/06 that comprises very detailed agricultural information and consider factors that seem to explain potential inefficiencies while testing our hypotheses.

To establish potential channels and causes of inefficiencies, the next section analyses the literature on traditional gender roles and social norms in agriculture production in Sub-Saharan Africa (SSA) and Uganda. Section 3 derives a test of efficiency considering different scenarios of on- and off-farm labour supply using Browning & Gørtz’s (2007) Collective Model extended to introduce the production of different crops. We also discuss hypotheses, functional form and econometric issues concerning the derived implications. Section 4 describes the data and variables generated to proxy the discussed channels explaining inefficiencies. Section 5 discusses the results while comparing the validity of the different estimators and functional form assumptions. A final section concludes.

3.2 Gender roles and on-farm labour allocation

Anthropological, sociological as well as anecdotal evidence points to a ‘gendered division’ of crops and tasks in SSA that might explain intra-household labour allocation. In the SSA context, traditional gender roles not only establish and reinforce comparative advantages in agriculture production, but are in many countries a mechanism for the division of income within the household. If established structures become incompatible with new incentives, such as price increments for a certain type of crop, this may cause difficulties in the adjustment of the distribution of benefits. While this does not necessarily impact on the effort and amount of labour applied, achieving a compensation rule compatible with profit maximising production behaviour may be fairly complicated under rigid traditions and gender roles.

For instance, in many SSA countries women grow food crops mainly to guarantee home food security, while men tend to control output from cash crop production, nonetheless relying on the female and family labour inputs. Jones’s (1983) study shows that if women do not feel adequately compensated they tend to supply insufficient labour. Dolan (2001) provides evidence of struggles over resources in horticulture-producing households in Meru, Kenya. French beans, a crop originally within the female domain, were expanded for export purposes. The resulting shift
in the productive focus of the household, i.e. men trying to extend and control the proceeds of French bean production, increased the labour burden on females, which impacted adversely on their position within the household, and presumably had considerable impact on the effort applied.

Traditional gender roles have also been named as a reason for men being reluctant to contribute to food crop production in Africa (Boserup 1976), despite the possibility that they might be more efficient in performing certain tasks. In addition, women are often excluded from certain tasks as well as entire income generating spheres, illustrating the rigidity and persistence of traditional gender roles.

In Uganda there is also evidence that cash crop production – in particular coffee production – relies on female labour inputs in the production process, while marketing and income control lie in male hands (Kymuhendo & McIntosh (2006), Elson & Evers (1996), Evers & Walters (2001), EPRC (2007), Kasente (1997)). In addition to an amount of time-consuming home duties such as water fetching and firewood collection, the production of food crops and specific tasks (such as weeding) required to produce other crops are typically performed by women (Kasente, Lockwood, Vivian & Whitehead (2000); Dolan (2001)). Evers & Walters (2001) argue that in the Ugandan context men tend to control to a certain extend the labour of their spouses, which is reinforced by social norms such as obligatory bride price payments to the spouses’ family. However, women seem inclined to allocate labour to preserve household food security instead of extending marketed crop production, although this would increase overall household income.

The following statement of a male respondent of a focus group discussion referring to Banana production in Bushenyi district demonstrates the resulting intra-household struggles:

“In order to have harmony in the family, the banana plantation should be divided into two. When you allow women and children to harvest bananas anyhow, they will cut the big ones and leave the small ones. Women and children should be told that the small bunches are for consumption and the big ones for sale. This limits the amount of food they cook because some women are extravagant” (Ministry of Gender 2005, p. 20).

The evidence surveyed in this section leads to the suggestion that inefficiencies may be caused inter alia by an inefficient allocation of labour, which in turn, may be linked to rigid gender roles in agricultural production. In addition, intra-household

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4Golan & Lay (2009) provide evidence contradicting the fact that control over coffee output is predominantly responsibility of the household head.
compensation for labour inputs in domestic farm production typically depends on control over proceeds from certain crops. Again, control over crop output is determined by traditions and social norms and the evidence above suggests that these may not provide adequate incentives for an efficient labour allocation.

3.3 The Collective Farm Model and testable implications

Notwithstanding this anecdotal evidence of intra-household struggles over labour input and income control, which may give rise to production inefficiencies, our reference point will be a ‘Collective Farm Model’. We will also model market imperfections, as typically faced by farm households, and analyse their implications. The model used in this section follows very closely Browning & Gortz’s (2007) Collective Model, but also draws on Singh et al. (1986), Chiappori (1992), Udry (1996), Apps & Rees (1997), Chiappori (1997), Donni (2008), and Apps & Rees (2009).

As such, the first part of the model follows closely the Sections on household welfare discussed in Chapter 2 above. Again, the household consists of two partners, labelled A and B. Partner A’s utility depends on the consumption of a good bought in the market \( q^m_A \), hours of leisure \( l_A \), a domestically produced subsistence good \( q^f_A \), a non-rival household public good \( Q \) and a vector of preference factors \( a_A \):

\[
u_A = u_A(q^m_A, l_A, q^f_A, Q; a_A).
\]

Partner B’s utility \( u_B \) depends on exactly the same arguments:

\[
u_B = u_B(q^m_B, l_B, q^f_B, Q; a_B).
\]

Partner A cares about B and, accordingly, her total utility comprises her own \( u_A \) plus a proportion \( \lambda_A \) of B’s. Her welfare function is defined as:

\[
\Psi_A = u^A + \lambda_A u^B \quad \text{with} \quad \lambda_A \in [0, 1].
\]

If \( \lambda_A = 0 \), A does not care about B’s utility. If \( \lambda_A = 1 \), A is completely indifferent between her own utility and her partner’s utility. We rule out the possibility that \( \lambda_A < 0 \), namely that she dislikes her partner, or \( \lambda_A > 1 \), she cares more about her partner than herself. The same considerations apply for B:

\[
\Psi_B = u^B + \lambda_B u^A \quad \text{with} \quad \lambda_B \in [0, 1].
\]

\( \Psi_h \) is the household’s welfare function. It is a weighted average of the individual welfare functions:

\[
\Psi_h = \tilde{\mu} \Psi_A + (1 - \tilde{\mu}) \Psi_B \quad \text{with} \quad \tilde{\mu} \in [0, 1].
\]

The weight \( \tilde{\mu} \) reflects the power distribution within the household. If \( \tilde{\mu} = 1 \), then A is all-powerful. As indicated before, economists do not propose a theoretical framework that explains the

---

5For the sake of simplicity, we assume that children can be treated as public goods. Evidently, whether children can be treated as decision-makers, consumption or investment goods (see e.g. Browning et al. (2007) and Qian (2008)) depends not only on the cultural context of a country but can be tested empirically.
content of $\hat{\mu}$, but it is hypothesised to be a function of so-called distribution factors. These are exogenous factors that impact on the allocation of power within the household but not on preferences or the budget constraint (Browning & Chiappori 1998).

Substituting the individual felicity functions into household welfare we can redefine $\Psi_h$ as:

$$\mu u^A + u^B. \quad (3.1)$$

The so-called Pareto weight $\mu$ is a composite index of $\hat{\mu}$, $\lambda_A$ and $\lambda_B$. It captures the relative weight of partner A in the decision process.

In contrast to a household in a developed country, in developing countries partners can spend time on producing crops that can be traded in the market or consumed by the household members, as indicated by $q_{fA}$ and $q_{fB}$. So, the following differences to the model we discussed in Chapter 2 are very relevant. Each partner has a total time endowment of 24 hours a day, $T$. For A, $T$ can be allocated to leisure $l_A$, food crop $f_A$, cash crop $c_A$, public good production $h_A$ or off-farm employment activities (self- or wage employment) $m_A$. In maximising household welfare, the partners therefore face the following constraints on their allocation of time:

$$T \geq l_A + m_A + f_A + c_A + h_A \quad (3.2)$$

$$T \geq l_B + m_B + f_B + c_B + h_B. \quad (3.3)$$

Total food crop production $q^f$ can be allocated to subsistence consumption $q_{fm}^f$ or traded in the local market $q_{fm}^f$ at price $p^f$. The food crop production function $F^f$ uses domestic labour inputs $f_A$, $f_B$ and land $L$, which is supposed to be fixed and exogenous. The same applies for cash crop production, except that this crop is entirely traded in the market at the cash crop price $p^c$. The production of the household public good $Q$ depends on each partners time input $h_A$, $h_B$ and material inputs bought in the market $q_H$. All three production functions (food crop $F^f$, cash crop $F^c$ and public good $F^Q$) are increasing in all inputs:

$$q^f = q_{fA} + q_{fB} + q_{fm}^f \quad (3.4)$$

$$q^c = F^c(c_A, c_B, L) \quad (3.5)$$

$$Q = F^Q(h_A, h_B, q_H). \quad (3.6)$$

---

Distribution factors might comprise amongst others: Governmental subsidies and transfers that are conditional on being single (McElroy 1990), divorce laws (Chiappori et al. 2002), sex ratios in the marriage market (Chiappori et al. 2002), relative wages or age and education differences (Bourguignon et al. 1994), assets brought to marriage (Quisumbing & Mahuccio 2003) or a women’s ability to return to her natal home (McElroy 1990).
In addition, domestic on-farm labour inputs and off-farm employment activities are non-negative:

\[ m_A \geq 0 \quad m_B \geq 0 \quad (3.7) \]
\[ f_A \geq 0 \quad f_B \geq 0. \quad (3.8) \]

Moreover, we consider that the women’s optimal off-farm labour supply \( m^*_A \) might be restricted by social norms to a sub-optimal level \( \bar{m}_A \). This means she may be ‘forced’ to allocate her time between leisure, public good and domestic farm production beyond the desired level:

\[ m_A \leq \bar{m}_A \quad \text{where} \quad 0 < \bar{m}_A < m^*_A. \quad (3.9) \]

The income constraint states that expenses on market consumption goods and material inputs into public good production cannot exceed on-farm profits, non-wage income \( y \) and labour incomes \( m_A w_A \) and \( m_B w_B \). It is defined as:

\[
p^m(q^m_A + q^m_B) + p^H q^H \leq p^f [F^f(f_A, f_B, L) - (q^f_A + q^f_B)] + p^c F^c(c_A, c_B, L) + y + m_A w_A + m_B w_B.\]

As indicated in Section 2.0.3, partners cannot hoard time and afford to accumulate money, and so we can disregard the inequality restrictions on time and income and treat them as equalities. For the sake of simplicity we assume both partners supply a positive amount of labour to domestic cash crop production and if it is not explicitly considered that (3.9) does not bind.

The first order conditions (FOC) of maximising total household welfare that are relevant for the analysis are summarised in Appendix C. These imply different scenarios of labour supply:

**Case 1:** \( m_A > 0, m_B > 0, f_A > 0 \) and \( f_B > 0 \). If both partners supply off-farm and on-farm labour, the non-negativity constraints do not bind and the Lagrange multipliers \( \theta_A \) and \( \theta_B \) in Equations \( (C.5) \) and \( (C.7) \) and \( (C.6) \) and \( (C.8) \), and \( \sigma_A \) and \( \sigma_B \) in \( (C.1a) \) and \( (C.3a) \) and in \( (C.2) \) and \( (C.4) \), are equal to zero respectively.

The FOCs with regard to each partner’s on-farm labour inputs \( (C.1) \) and \( (C.3) \) can be interpreted as if the farm is maximising profits of the two crops; hence, the Marginal Revenue Products of Labour (MRPL) are equal to their marginal costs. Since \( m_A > 0 \) and \( m_B > 0 \) and (3.9) does not bind (so that in (3.9) \( \varepsilon = 0 \)), Equations \( (C.5) \) and \( (C.7) \) illustrate that the marginal cost is the wage rate of A.
and B:

\[ A: \quad p^f \frac{\partial F}{\partial f_A} = p^c \frac{\partial F}{\partial c_A} = w_A \]  \tag{3.10} \\
\[ B: \quad p^f \frac{\partial F}{\partial f_B} = p^c \frac{\partial F}{\partial c_B} = w_B. \]  \tag{3.11} \\

So we obtain,

\[ p^f \frac{\partial F}{\partial f_B}/p^f \frac{\partial F}{\partial f_A} = p^c \frac{\partial F}{\partial c_B}/p^c \frac{\partial F}{\partial c_A} = w_B/w_A. \]  \tag{3.12} \\

This means, A and B will supply labour on the farm until condition (3.10) and (3.11) are met, then engage in other employment activities. An optimal farm labour allocation will be to equate the Marginal Rate of Technical Substitution (MRTS) between male and female labour across the crops (condition 3.12).

**Case 2:** \( m_A = 0, m_B > 0, f_A > 0 \) and \( f_B > 0 \). A chooses to supply zero labour to the labour market. This means her marginal product of labour in domestic production exceeds her wage. As \( f_A > 0 \), \( \sigma_A = 0 \) to satisfy (C.2b). If \( m_A = 0 \), then \( \theta_A \geq 0 \) which, using (C.5), means that \( \alpha_A/\gamma \geq w_A \). Hence, her marginal product of on-farm labour exceeds the wage she could achieve in any off-farm employment activity:

\[ A: \quad p^f \frac{\partial F}{\partial f_A} = \frac{\alpha_A}{\gamma} > w_A. \]

The same conditions apply to cash crop production; thus, the marginal product equation between the crops does persist.

**Case 3:** \( m_A > 0, m_B > 0, f_A > 0 \) and \( f_B = 0 \). If B does not contribute to food crop production \( f_B = 0 \), but if he supplies off-farm labour, then

\[ B: \quad p^f \frac{\partial F}{\partial f_B} < w_B. \]  \tag{3.13} \\

Using condition (C.3a) and (C.7), in which \( \theta_B \) has to be zero as \( m_B > 0 \), his marginal product of labour in food production is below the wage as:

\[ p^f \frac{\partial F}{\partial f_B} = \frac{\alpha_B}{\gamma} - \frac{\sigma_B}{\gamma}, \quad w_B = \frac{\alpha_B}{\gamma} \quad \text{and} \quad \frac{\sigma_B}{\gamma} > 0. \]
The marginal products of male labour are not equated between the crops.

**Case 4:** $m_A > 0$, $m_A = \bar{m}_A$, $m_B > 0$, $f_B > 0$ and $f_A > 0$. If A is constrained to supply all the desired labour to the local labour market, then using Equations (C.1a), (C.5) and given that $\theta_A = 0$ and $\varepsilon > 0$:

$$
\frac{p_f \partial F_f}{\partial f_A} = \frac{\alpha_A}{\gamma}, \quad w_A = \frac{\alpha_A + \varepsilon}{\gamma}, \quad \varepsilon > 0 \text{ and } \theta_A = \sigma_A = 0.
$$

Her marginal productivity is below the market wage. This means the marginal rate of substitution of leisure to consumption is below the valuation of an additional unit of income generated by spending an additional hour in the labour market. She would like to trade more labour for leisure or domestic production in the local labour markets, but she is not able to do so. However, this holds equally true for both crops, so MRTS equation does persist.

In other words, within the same household male and female labour inputs cannot be reallocated so to increase output if the MRTS is equated over the crops. This condition does not depend on the distribution of power within the household. MRTS equation also holds in the presence of market imperfections; more specifically, it does not depend on the existence of a functioning labour market.

### 3.3.1 Hypotheses and Functional Form

If both partners supply labour to both crops, the first order conditions in Equations (3.10) and (3.11) can be interpreted as if the farm is maximising the profit of jointly producing the food crop $f$ and the cash crop $c$. In other words, for the female, the marginal revenue products of labour for both crops are equal to each other and equal to her marginal cost $w_A$. As this is also true for the male, the marginal rate of technical substitution between male and female labour is hence equated over the two crops (see Equation (3.12)).

In discussing an appropriate functional form for estimation, note that we want to focus on the elasticity of substitution between A and B, but not between A and other factors, or B and other factors. We choose the Constant Elasticity of Substitution (CES) production function because the elasticity of substitution is completely unrestricted. For the food crop this production function can be written in logs as

$$
\log F_f = \text{const} - \frac{\nu_f}{\rho_f} \log[\delta_{Af} f_A^{-\rho_f} + (1 - \delta_{Af}) f_B^{-\rho_f}] + \ldots \quad (3.14)
$$

where $\nu_f$ measures the returns to labour, $\rho_f$ is the substitution parameter, and $\delta_{Af}$
represents the share or distribution parameter that captures the relative contribution of A to the output produced by A and B only. Following Greene (2003, p.129), a linear approximation, using a Taylor series expansion, is given by

\[
\log F_f \approx \text{const} + \nu_f \delta_{Af} \log f_A + \nu_f (1 - \delta_{Af}) \log f_B + \rho_f \nu_f \delta_{Af} (1 - \delta_{Af})[(\log f_A - \log f_B)^2/2] + \ldots
\]

and so is linear in \( \log f_A, \log f_B \) and

\[
g(f_A, f_B) = [-(\log f_A - \log f_B)^2/2].
\]

The same applies to the cash crop,

\[
\log F_c = \text{const} - \frac{\nu_c}{\rho_c} \log[\delta_{Ac} c_A^{\rho_c} + (1 - \delta_{Ac}) c_B^{\rho_c}] + \ldots
\]

For both crops, estimates of \( \nu, \delta_A, \rho \) are identified uniquely from the estimates of the parameters of these three variables: \( \nu = \beta^A + \beta^B, \rho = \beta^{AB}(\beta^A + \beta^B)/(\beta^A \beta^B) \) and \( \delta_A = \beta^A/(\beta^A + \beta^B) \). From \( \rho \), one computes the elasticity of substitution as \( \sigma = (1 + \rho)^{-1} \). Our test of the theory is whether the marginal rate of technical substitution between male and female labour inputs is the same across both crops (see Equation (3.12) above). For the food crop, this is defined as:

\[
MRTS_{fA} = \frac{\partial \log F_f / \partial \log f_A}{\partial \log F_f / \partial \log f_B} = \frac{\delta_{Af}}{\delta_{Bf}} \left( \frac{f_B}{f_A} \right)^{1+\rho_f}.
\]

Substituting the above Equation into (3.12):

\[
\frac{\delta_{Af}}{1 - \delta_{Af}} \left( \frac{f_A}{f_B} \right)^{-(1+\rho_f)} = \frac{\delta_{Ac}}{1 - \delta_{Ac}} \left( \frac{c_A}{c_B} \right)^{-(1+\rho_c)},
\]

In modelling male and female labour inputs as a single CES aggregate, we assume that their marginal products are separable or independent from the other factor inputs, such as child labour or land. Using a Translog production function, we test whether this assumption is supported by the data. We fail to reject that male and female labour inputs are independent from the other variable inputs with an F-statistic of 1.21 in the pooled regression. At the crop level the results are similar for the majority of crops. Only maize and millet have significant test statistics but the significance levels are comparatively low (with p-values of 0.0779 and 0.0778, respectively).
and taking logs yields:

\[
\log \delta_{Af} - \log(1 - \delta_{Af}) - (1 + \rho_f) \log \left( \frac{f_A}{f_B} \right) \\
= \log \delta_{Ac} - \log(1 - \delta_{Ac}) - (1 + \rho_c) \log \left( \frac{c_A}{c_B} \right). \tag{3.16}
\]

This (non-linear) restriction involving four parameters \((\delta_{Af}, \rho_f, \delta_{Ac}, \rho_c)\) forms the basis of our test of efficiency in the allocation of male and female labour inputs.

In the Cobb-Douglas production function the elasticity of substitution is restricted to unity \((\rho = 0)\), which means \(\beta_{AB} = 0\) and (3.15) reduces to

\[
\log F_f = \text{const} + \beta^A \log f_A + \beta^B \log f_B + \ldots \tag{3.17}
\]

The test of efficiency then involves two fewer parameters:

\[
\frac{\delta_{Af}}{1 - \delta_{Af}} \left( \frac{f_A}{f_B} \right)^{-1} = \frac{\delta_{Ac}}{1 - \delta_{Ac}} \left( \frac{c_A}{c_B} \right)^{-1}.
\]

A different case is when the elasticity of substitution approaches infinity \((\rho \to -1)\) and so the isoquants become linear. This is one explanation as to why we observe \(f_A = 0\) or \(f_B = 0\) for some crops. To model this, we write

\[
\log F_f = \text{const} + \alpha \log[\delta_A f_A + (1 - \delta_A) f_B] + \ldots \tag{3.18}
\]

A linear approximation is

\[
\log F_f = \text{const} + \beta^A f_A + \beta^B f_B + \ldots
\]

where \(\alpha\) and \(\delta_A\) can be uniquely identified from \(\beta_A\) and \(\beta_B\): \(\beta^A \equiv \partial \log F_f / \partial f_A = \alpha \delta_A / L\), \(\beta^B \equiv \partial \log F_f / \partial f_B = \alpha(1 - \delta_A) / L\) and \(L \equiv \delta_A f_A + (1 - \delta_A) f_B\). For this ‘Linear Isoquants’ specification \(\sigma = \infty\), and \(MRTS_{AB} = \beta_A / \beta_B\). Now our test becomes:

\[
\frac{\delta_{Af}}{1 - \delta_{Af}} = \frac{\delta_{Ac}}{1 - \delta_{Ac}}.
\]

### 3.3.2 Econometric Issues

Given the data structure, we need to amend our notation for writing down the empirical model. For each crop \(c = 1, \ldots, C\), household \(h = 1, \ldots, H\), and cropping season \(t = 1, 2\), we denote \(y_{cht}\) as the output value of crop \(c\) in household \(h\) and season \(t\), which replaces \((q^f, q^c)\). Labour input of partner A on crop \(c\) in household \(h\) and season \(t\), \(f^A_{cht}\), replaces \((f_A, c_A)\) and the same applies to B where \(f^B_{cht}\) replaces
We write the estimating equation as:

\[ \log y_{cht} = \beta_c^A \log f_{cht}^A + \beta_c^B \log f_{cht}^B + \beta_{AB}^c g_{cht} + z_{cht} \delta_c + \beta_c + \eta_h + v_{cht}. \]  

(3.19)

\( z_{cht} \) is a vector of household season-invariant characteristics such as age and education. Apart from female and male labour, it includes the other season-varying covariates (discussed in detail in the next section). \( \beta_c \) is a crop-specific intercept, \( \eta_h \) captures unobserved, season-invariant household effects, and \( v_{cht} \) is an idiosyncratic error term. For notational convenience, we collect all the observables into a single vector \( x_{cht} \) and re-write (3.19) as

\[ y_{cht} = x_{cht} \beta_c + \beta_c + \eta_h + v_{cht}. \]  

(3.20)

If we drop the crop subscript \( c \), the model is written as

\[ y_{ht} = x_{ht} \beta + \beta + \eta_h + v_{ht} \quad h = 1, ..., H; t = 1, 2 \]

and so we have a standard two-way error components model. All we are doing in Equation (3.20) is pooling over \( c_h \) crops per household. As is standard in the estimation of production functions, the unobserved household effect must be correlated with the two variables of interest, \( f_A \) and \( f_B \), and so we remove \( \eta_h \) using a fixed effects (FE) estimator.

This, and on OLS equivalent, form the basis of our empirical test of efficiency. However, we need to address the standard problem that OLS/FE estimates the average output, conditional on observables and unobservables. Production functions, by definition, represent the maximum level of output with given factor inputs. A standard way in the literature to model this is to specify an additional error term that only takes positive values. This so-called ‘stochastic frontier model’ for our CES specification, is specified as follows:

\[ y_{cht} = x_{cht} \beta + \beta_c + v_{cht} - u_{cht}. \]  

(3.21)

The ‘usual’ error term \( v_{cht} \) consists of a random, normally distributed variable \( \varepsilon_{cht} \), with variance \( \sigma^2_{\varepsilon} \), that can take both negative and positive values as it captures factors impacting on output not necessarily under the control of the household (Greene 2008). \( v_{cht} \) comprises also the household fixed effect which is, in this specification, assumed to be uncorrelated with the other covariates and subsumed in \( v_{cht} \) i.e. \( v_{cht} = \varepsilon_{cht} + \eta_h \). In addition, in keeping with the literature, we also specify a
non-negative truncated or half-normal normally distributed variable that measures technical inefficiency \( u_{cht} \), where

\[
u_{cht} \sim N^+(0, \sigma_u^2)\,.
\]

This is the Normal/Half-Normal Model, and is estimated by Maximum Likelihood (ML) (because normality has been assumed for \( v_{cht} \) and \( u_{cht} \)). Standard software, including STATA and LIMDEP, have appropriate routines. Furthermore, if one wants to control for household fixed effects (as in Equation (3.20)), one can do one of three things. First, one can add a complete set of household dummy variables. This is known as Greene’s ‘true fixed effects estimator’ and can be specified as:

\[
y_{cht} = \mathbf{x}_{cht}\beta + \beta_c + \sum_k D^k_h \eta_k + v_{cht} - u_{cht},
\]

where \( D^k_h \) is a dummy variable for household \( k \). However, the use of dummy variables suffers from the incidental parameter problem that biases the estimates if \( T \) is small (Greene 2005).

Second, one can replace the unobserved fixed effect by the mean values of all the time-varying covariates. This is a variant of the so-called ‘Mundlak trick’ in a ML-setting and can be formalised as:

\[
y_{cht} = \mathbf{x}_{cht}\beta + \beta_c + \bar{x}_{ch}\pi + v_{cht} - u_{cht},
\]

where \( \bar{x}_{ch} \) are the mean values of the time-varying covariates and \( v_{cht} = \varepsilon_{cht} + \eta_h \).

A third possibility is to difference away the fixed effect:

\[
\Delta y_{ch} = \Delta x_{ch}\beta + \beta_c + \Delta v_{ch} - \Delta u_{ch},
\]

but this leaves a differenced half-normal error term \( \Delta u \) that does not have a known distribution. In our view, this problem is overstated because, using simulations, \( \Delta u \) has properties very similar to a normal error. Furthermore, one does not even need to assume normality in standard panel data settings. The price paid is that one cannot disentangle estimates of \( u \) from \( v \) in the differenced residuals \( \Delta(v - u) \).
3.4 Data

The data we use come from the UNHS 2005/06, collected by the Ugandan Bureau of Statistics (UBOS) with the financial support of the Economic and Financial Management Programme. The UNHS is nationally and regionally representative and it contains detailed information on agricultural activities. The agricultural questionnaire covers 12 months and two cropping seasons; i.e. July to December 2004 and January to June 2005. These are labelled $t = 1, 2$ respectively. The unit of observation is a ‘household’, $h = 1, \ldots, H$. We restrict the sample to male headed households that live with one or more spouses, leaving a final sample of $H = 3,298$. These households account for 69 percent of households with farm production (or 89 percent of the rural population).

There are two types of plots: mono-cropped plots, on which only one crop is grown, and inter-cropped plots, on which more than one crop is grown. Labour input is only reported by plot, which implies that we cannot tell how much time is spent on each crop on an inter-cropped plot. These plots are therefore dropped from the data. This leaves a sample of 10,542 season-plot observations of which 4,634 and 5,908 plots are observed in the first and second season, respectively. In this sample, there are no plots devoted to the same crop in the same season as in Udry’s study. Further, we restrict the sample to crops with a minimum of 400 season-plot observations, leaving a final sample of 9 crops ($c = 1, \ldots, 9$) for $H = 3,177$ households and two cropping seasons. This gives an unbalanced panel data set with a total of 9,108 observations. See Table 3.1 for the number of observations per crop.
Table 3.1: Sample averages by crop

<table>
<thead>
<tr>
<th>Crop</th>
<th>No obs.</th>
<th>Market share</th>
<th>Female labour</th>
<th>Male labour</th>
<th>Total labour</th>
<th>Zero male lab.</th>
<th>Zero fem. lab.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee</td>
<td>412</td>
<td>0.94</td>
<td>9.32</td>
<td>11.80</td>
<td>27.36</td>
<td>0.07</td>
<td>0.27</td>
</tr>
<tr>
<td>Maize</td>
<td>1480</td>
<td>0.41</td>
<td>22.39</td>
<td>17.30</td>
<td>58.44</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>Matooke(d)</td>
<td>1201</td>
<td>0.24</td>
<td>11.78</td>
<td>8.10</td>
<td>28.69</td>
<td>0.11</td>
<td>0.14</td>
</tr>
<tr>
<td>Groundnut</td>
<td>481</td>
<td>0.23</td>
<td>20.65</td>
<td>8.71</td>
<td>39.42</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Beans</td>
<td>803</td>
<td>0.21</td>
<td>18.28</td>
<td>7.29</td>
<td>36.57</td>
<td>0.14</td>
<td>0.04</td>
</tr>
<tr>
<td>Sorghum</td>
<td>499</td>
<td>0.18</td>
<td>15.72</td>
<td>6.86</td>
<td>31.98</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>Millet</td>
<td>411</td>
<td>0.15</td>
<td>30.42</td>
<td>11.24</td>
<td>55.70</td>
<td>0.18</td>
<td>0.02</td>
</tr>
<tr>
<td>Cassava</td>
<td>1345</td>
<td>0.13</td>
<td>23.11</td>
<td>11.10</td>
<td>44.32</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>Potato</td>
<td>2476</td>
<td>0.07</td>
<td>25.41</td>
<td>5.66</td>
<td>30.99</td>
<td>0.13</td>
<td>0.03</td>
</tr>
<tr>
<td>Total</td>
<td>9108</td>
<td>0.23</td>
<td>20.87</td>
<td>9.58</td>
<td>41.91</td>
<td>0.10</td>
<td>0.06</td>
</tr>
<tr>
<td>Cotton</td>
<td>200</td>
<td>0.95</td>
<td>32.11</td>
<td>33.59</td>
<td>86.65</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>Tea &amp; Cocoa</td>
<td>39</td>
<td>0.93</td>
<td>14.71</td>
<td>19.49</td>
<td>30.80</td>
<td>0.03</td>
<td>0.28</td>
</tr>
<tr>
<td>Tobacco</td>
<td>62</td>
<td>0.83</td>
<td>16.76</td>
<td>35.10</td>
<td>51.86</td>
<td>0.00</td>
<td>0.31</td>
</tr>
<tr>
<td>Vegetables(e)</td>
<td>269</td>
<td>0.72</td>
<td>14.33</td>
<td>17.57</td>
<td>41.90</td>
<td>0.05</td>
<td>0.13</td>
</tr>
<tr>
<td>Other cash crops(f)</td>
<td>64</td>
<td>0.68</td>
<td>10.19</td>
<td>16.12</td>
<td>39.01</td>
<td>0.05</td>
<td>0.28</td>
</tr>
<tr>
<td>Other staple</td>
<td>218</td>
<td>0.60</td>
<td>31.14</td>
<td>24.88</td>
<td>56.02</td>
<td>0.04</td>
<td>0.10</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>96</td>
<td>0.50</td>
<td>6.61</td>
<td>10.37</td>
<td>24.71</td>
<td>0.04</td>
<td>0.33</td>
</tr>
<tr>
<td>Soybean</td>
<td>36</td>
<td>0.48</td>
<td>14.73</td>
<td>9.80</td>
<td>33.53</td>
<td>0.17</td>
<td>0.08</td>
</tr>
<tr>
<td>Other oil(g)</td>
<td>177</td>
<td>0.46</td>
<td>18.40</td>
<td>10.35</td>
<td>38.75</td>
<td>0.12</td>
<td>0.04</td>
</tr>
<tr>
<td>Sweet banana</td>
<td>29</td>
<td>0.38</td>
<td>6.95</td>
<td>3.92</td>
<td>15.12</td>
<td>0.17</td>
<td>0.24</td>
</tr>
<tr>
<td>Fruit(h)</td>
<td>87</td>
<td>0.32</td>
<td>9.85</td>
<td>7.74</td>
<td>20.34</td>
<td>0.07</td>
<td>0.21</td>
</tr>
<tr>
<td>Peas</td>
<td>157</td>
<td>0.18</td>
<td>10.38</td>
<td>5.19</td>
<td>16.57</td>
<td>0.14</td>
<td>0.03</td>
</tr>
<tr>
<td>All crops</td>
<td>10542</td>
<td>0.28</td>
<td>20.54</td>
<td>10.70</td>
<td>43.30</td>
<td>0.10</td>
<td>0.08</td>
</tr>
</tbody>
</table>

* Sample is restricted to households with at least two spouses. The first block refers to the 9 crops for which \(N_c \geq 400\).

* Market share is defined as the sales value to total output value by crop. Table entries are ordered by descending values of this column.

* Labour inputs are measured in person days. Person days represent working days and are based on the individual suggestion about the length of the day.

* Total labour is the aggregate of domestic, hired and other labour inputs.

* 'Matooke' comprises banana food.

* 'Vegetables' comprise cabbage, tomatoes, carrots, onions, pumpkins, dodo, and eggplants.

* 'Other cash crops' comprise ginger, curry, oil palm, vanilla, and black wattle.

* 'Other oil' comprises sunflower and simsim.

* 'Fruit' is the aggregate of oranges, pawpaw, pineapples, mango, jackfruit, avocado, and passion fruit.
Labour inputs are measured in person days per season. Column 4 to 6 of Table 3.1 report domestic adult male, female and total labour inputs per crop. In this questionnaire an adult is defined as being aged eighteen and above. Total labour includes in addition to female and male, child, hired and other labour inputs. Among those crops with more than 400 season-plot observations, maize and millet stand out as very labour-intensive crops, while coffee, matooke, and sorghum require considerably less labour. Table 3.1 confirms that adult female on-farm labour supply is substantial. For most crops, adult female labour accounts for about half of total labour input, and is typically about two to three times higher than adult male labour. This does not hold, however, for traditional cash crops, such as coffee, cotton, tea and cocoa, tobacco and sugar cane. Interestingly, the same can be observed for vegetables. On average, male and female labour inputs on these crops are of similar magnitude or male even exceeds female labour input. This division of work between crops is also reflected in the final two columns of the Table that report the proportion of observations producing crop \( c \) without any male or female labour. No female (male) labour is used on 27% (7%) of the coffee plots, while this holds for only 2% (18%) of the millet plots.

In section 2, we presented two channels that may explain sub-optimal intra-household labour allocations: the rigidity of traditional gender roles (e.g. women grow food and men cash crops) and inadequate sharing of the proceeds from production. The descriptive statistics on labour inputs by crops clearly demonstrate that gender divisions in agricultural production exist. Such a gender division of crops can be efficient if the resulting division and allocation of labour is made according to comparative advantage and compatible with the production technology employed. Similarly, individual control over the proceeds of agricultural production should yield efficient outcomes if it adequately represents amount of effort and labour applied. However, control rules may generate inefficiencies if partners feel inadequately compensated for the labour supplied on crops controlled by their spouse. In this case, they may either under-allocate labour or apply less effort. Alternatively, if one partner has the power to dictate intra-household labour allocation, too much labour may be supplied to this partner’s crops. If violence can be used to sanction inadequate labour supply or effort application, the resulting efficiency implication are ambiguous.

Below, we empirically assess these two possible sources of inefficiencies. In a first step, we examine the efficiency condition derived above, i.e. MRTS equation, by crop type. If MRTS equation holds across different crops the division of work along gender lines present in the data may just reflect comparative advantages in
domestic production. If the MRTS are not equated across crops this may be taken as an indication that an efficient allocation of labour may be inhibited by too rigid labour division patterns.

In a second step, we split the sample into only two groups of crops: ‘subsistence or non-traded crops’, on the one hand, and ‘cash or traded crops’, on the other. We distinguish these two groups by the share of marketed (versus own-consumed) production, which we measure by the ratio of sales to output, with a threshold of 30%, above which a crop is considered a cash or traded crop. Average market shares by crop are reported in the third column of Table 3.1. By examining the efficiency condition across these two groups, we test whether inefficiencies are related to market integration, as suggested by some of the anecdotal evidence presented above.

Third, our data allow us to test more explicitly whether inadequate compensation is causing deviations from efficient labour allocations. For this test, we can make use of a question that asks households for the control of the proceeds from a specific parcel, more specifically “Who mainly manages or controls the output from this parcel among the household members?”. Based on this question, we split the sample according to whether output on all parcels devoted to one crop is controlled (1) only by the head, (2) only by the spouse, or (3) by both and/or other household members and/or others. The information on output control is only available by parcel on which multiple plots can be grown. So, we define crop $c$ as controlled by head or spouse, respectively, if all parcels devoted to $c$ within the household are controlled only by the head or only by the spouse. In our final sample, only 40 percent of the plots are controlled only by the head, 20 percent by the spouse, and in about 40 percent of the cases output is either controlled jointly, by others or for a single crop certain parcels are controlled by the head and others by the spouse.

Table 3.2 cross-tabulates crop-season observations by output control and crop type. The Table shows that men exert control over the proceeds from a considerably higher number of plots than women. Remember that our sample only consists of male-headed household with a female spouse. In these households, male heads

<table>
<thead>
<tr>
<th>Crop</th>
<th>Head</th>
<th>Spouse</th>
<th>Others</th>
<th>Total</th>
<th>Of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash or traded</td>
<td>1,893</td>
<td>511</td>
<td>1,394</td>
<td>3,798</td>
<td>36.03</td>
</tr>
<tr>
<td>%</td>
<td>49.84</td>
<td>13.45</td>
<td>36.70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Subsi. or non-traded</td>
<td>2,671</td>
<td>1,534</td>
<td>2,539</td>
<td>6,744</td>
<td>63.79</td>
</tr>
<tr>
<td>%</td>
<td>39.61</td>
<td>22.75</td>
<td>37.65</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>4,564</td>
<td>2,045</td>
<td>3,933</td>
<td>10,542</td>
<td>100</td>
</tr>
<tr>
<td>%</td>
<td>43.29</td>
<td>19.40</td>
<td>37.31</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
control output from about 45 percent of the plots (season-plots, to be precise), while only 20 percent of the plots are under female control. As suggested by the anecdotal evidence above, the share of female-controlled plots is higher for non-traded than for traded crops. Accordingly, the male share is higher for traded crops. However, it is not the case that all traded crops are male-controlled. The Table also shows that non-traded crops account for a much higher share of total season-plots in our sample.

Using the above classifications, Table 3.3 summarises average labour inputs by output control and trade categories. A comparison of traded and non-traded crops

<table>
<thead>
<tr>
<th></th>
<th>Subsi. or non-traded crops</th>
<th>Cash or traded crops</th>
<th>All crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Head</td>
<td>Spouse</td>
<td>Total</td>
</tr>
<tr>
<td>Fem. lab.</td>
<td>19.87</td>
<td>22.29</td>
<td>20.39</td>
</tr>
<tr>
<td>Male lab.</td>
<td>9.24</td>
<td>4.08</td>
<td>7.48</td>
</tr>
<tr>
<td>N</td>
<td>2,671</td>
<td>1,534</td>
<td>6,744</td>
</tr>
</tbody>
</table>

(the total columns) reflects our discussion of labour input by crops from above with more male labour being more intensively used for the production of traded crops. More interestingly, the Table reveals that much less male labour is used on their spouse-controlled plots. This effect is very strong for both non-traded and traded crops. Men spend between two to three times more labour on their own as compared to their spouse’s plot. The absolute difference in male labour input between own and spouse’s plots amounts to almost 13 person days per season for traded crops. In contrast, spouses spend only slightly more time on their own than on their husbands’ crops. There are no differences in female labour allocation between traded and non-traded crops. In terms of relative labour allocation, this implies that women provide the key labour source for female controlled plots.

These statistics on labour inputs hint at the existence of inefficiencies related to output control. For our test of MRTS between male and female labour equation across crops or groups of crops, we require further variables to estimate the production functions specified in (3.14), (3.17) and (3.18). Output $y$, the dependent variable, is measured as revenue harvested per crop per season. This is the quantity harvested times the producer price. In addition to male and female labour, we include the area (in acres) of the plot, person days of hired labour, child labour, other labour inputs and a dummy variable indicating whether fertilizer has been applied to the crop. The information on child labour is not available by gender. The variable other labour inputs proxies so-called ‘exchange labour’, which refers to non-hired labour from outside the household.
CHAPTER 3. INEFFICIENCY OF ON-FARM LABOUR SUPPLY

3.5 Results

Before we turn to the results on possible inefficiencies, we want to identify the econometric model that fits the data best and present some results on the technology used by the smallholders in our sample. Table 3.4 summarises OLS, fixed effects and frontier estimates for the CES production function. These variants correspond to Equations (3.20) to (3.23) above and are estimated on the pooled season-plot data including crop dummy variables.
Table 3.4: Comparison of OLS and Stochastic production frontier estimates*

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4a)</th>
<th>(4b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>^fA</td>
<td>^fB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>^log f</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>^log f</td>
<td>0.052</td>
<td>0.116</td>
<td>0.0090</td>
<td>0.0031</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>(0.0088)</td>
<td>(0.0122)</td>
<td>(0.0086)</td>
<td>(0.0051)</td>
<td>(0.0054)</td>
</tr>
<tr>
<td>^g(f,A,f,B)</td>
<td>-0.026</td>
<td>0.132</td>
<td>0.0126</td>
<td>0.0040</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>(0.0026)</td>
<td>(0.0126)</td>
<td>(0.0089)</td>
<td>(0.0030)</td>
<td>(0.0047)</td>
</tr>
<tr>
<td>^σ_v</td>
<td>1.65</td>
<td>1.040</td>
<td>0.903</td>
<td>1.038</td>
<td>0.885</td>
</tr>
<tr>
<td>^σ_u</td>
<td>0</td>
<td>0</td>
<td>1.211</td>
<td>1.123</td>
<td>1.221</td>
</tr>
<tr>
<td>^σ_u/σ_v</td>
<td>0</td>
<td>0</td>
<td>1.341</td>
<td>1.082</td>
<td>1.379</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0557)</td>
<td>(0.0233)</td>
<td>(0.0543)</td>
</tr>
<tr>
<td>^Variance(u)</td>
<td>0</td>
<td>0</td>
<td>0.533</td>
<td>0.458</td>
<td>0.542</td>
</tr>
<tr>
<td>^Variance(u)/Variance(ε)</td>
<td>0</td>
<td>0</td>
<td>0.395</td>
<td>0.298</td>
<td>0.409</td>
</tr>
<tr>
<td>^Log Likelihood</td>
<td>-14303.8</td>
<td>-11311.5</td>
<td>-14238.0</td>
<td>-12406.5</td>
<td>-14152.7</td>
</tr>
</tbody>
</table>

* Standard errors in parenthesis. All regressions are based on 9,108 observations pooled over the 9 crops. We do not report estimates associated with the the other control variables z_{cht} in Equation (3.19). Estimates in column (4a) are based on LIMDEP, all other estimates are generated using STATA.

\[ ^a \text{Estimates of Equation (3.20) of main text.} \]
\[ ^b \text{Estimates of Equation (3.20) of main text, but not controlling for the household fixed effect } \eta_h. \]
\[ ^c \text{Estimates of Equation (3.21) of main text.} \]
\[ ^d \text{Estimates of Equation (3.22) of main text.} \]
\[ ^e \text{Estimates of Equation (3.23) of main text.} \]
\[ ^f \text{Defined as } [(\pi - 2)/\pi] \sigma_u^2 \text{ (Greene 2008).} \]
\[ ^g \text{Defined as } [(\pi - 2)/\pi] \sigma_u^2/[(\pi - 2)/\pi] \sigma_u^2 + \sigma_v^2 \text{ (Greene 2008).} \]
The fixed effects estimates (column 2) indicate that the household fixed effect is very significant (the log likelihood increases by 20 percent). In addition, the results suggest a negative correlation of $\eta_h$ with $\log f^A$, $\log f^B$ and $g$: once controlling for household fixed effects, the coefficients increase from 0.052 to 0.081 for the female, 0.116 to 0.132 for the male and $-0.23$ to $-0.26$ for the substitution parameter. Adding the one-sided error term (column 3) increases the flexibility of the model and the likelihood improves by 65.8. The three parameters of primary interest, $\beta^A$, $\beta^B$ and $\beta^{AB}$, and the standard errors remain very close to the OLS estimates.

The true fixed effects frontier model (column 4a) improves the log likelihood by 1831.5 compared to the normal frontier model. In general, the true fixed effects estimates are very similar to the normal frontier model which indicates that the labour inputs and substitution parameter are primarily correlated with the inefficiency term $u_{cht}$ and not with $\eta_h$. We find that the mean values of the time-varying covariates are jointly significant in the Mundlak model (column 4b). Compared to the true fixed effects frontier model the improvement in the log likelihood is only modest and the estimated coefficients are similar to the normal fixed effects estimates (column 2).

Given that (1) the true fixed effects estimator suffers from the incidental parameter problem, (2) female and male labour inputs are correlated with the inefficiency term, and (3) the log likelihood does not yield a proportional improvement compared to the standard fixed effect model, the standard fixed effects model (column 2) seems to us the most appropriate model. As indicated in the last section, the great advantage of using the standard fixed effects estimator is that no additional error term assumptions are needed and that it allows input levels to be correlated with household specific time-invariant effects.

Table 3.5 summarises the results of the fixed effects estimations. The first three rows are estimates of the three production functions (3.14), (3.17) and (3.18), discussed above.
Table 3.5: Results of fixed effects production function estimates and technology parameters

<table>
<thead>
<tr>
<th>Crop</th>
<th>No obs.</th>
<th>Market share</th>
<th>( \log f_A )</th>
<th>( \log f_B )</th>
<th>( g(f_A, f_B) )</th>
<th>( \nu )</th>
<th>( \delta_A )</th>
<th>Elast. param. ( \rho )</th>
<th>Elast. of substn ( \sigma )</th>
<th>( MRTS_{AB} )</th>
<th>SSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CES(^a)</td>
<td>9,108</td>
<td>0.23</td>
<td>0.081</td>
<td>0.132</td>
<td>-0.025</td>
<td>0.213</td>
<td>0.379</td>
<td>-0.508</td>
<td>2.034</td>
<td>0.416</td>
<td>6392</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.014)</td>
<td>(0.014)</td>
<td>(0.004)</td>
<td>(0.018)</td>
<td>(0.050)</td>
<td>(0.095)</td>
<td>(0.354)</td>
<td>(0.068)</td>
<td></td>
</tr>
<tr>
<td>Cobb-Douglas(^b)</td>
<td>9,108</td>
<td>0.23</td>
<td>0.085</td>
<td>0.076</td>
<td>0.163</td>
<td>0.528</td>
<td>0</td>
<td>1</td>
<td>0.513</td>
<td>6435</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.012)</td>
<td>(0.009)</td>
<td>(0.016)</td>
<td>(0.016)</td>
<td>(0.055)</td>
<td></td>
<td></td>
<td>(0.113)</td>
<td></td>
</tr>
<tr>
<td>LI(^c)</td>
<td>9,108</td>
<td>0.23</td>
<td>0.0046</td>
<td>0.0062</td>
<td>0.154</td>
<td>0.424</td>
<td>-1</td>
<td>( \infty )</td>
<td>0.735</td>
<td>6475</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0008)</td>
<td>(0.0012)</td>
<td>(0.018)</td>
<td>(0.073)</td>
<td>(0.220)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>412</td>
<td>0.94</td>
<td>0.093</td>
<td>0.211</td>
<td>-0.050</td>
<td>0.304</td>
<td>0.305</td>
<td>-0.778</td>
<td>4.517</td>
<td>0.462</td>
<td>6052</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(0.038)</td>
<td>(0.039)</td>
<td>(0.014)</td>
<td>(0.055)</td>
<td>(0.094)</td>
<td>(0.217)</td>
<td>(4.439)</td>
<td>(0.218)</td>
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</tr>
<tr>
<td>Maize</td>
<td>1480</td>
<td>0.41</td>
<td>0.027</td>
<td>0.105</td>
<td>0.005</td>
<td>0.132</td>
<td>0.205</td>
<td>0.254</td>
<td>0.797</td>
<td>0.186</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.029)</td>
<td>(0.028)</td>
<td>(0.010)</td>
<td>(0.040)</td>
<td>(0.179)</td>
<td>(0.556)</td>
<td>(0.354)</td>
<td>(0.218)</td>
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</tr>
<tr>
<td>Matooke</td>
<td>1201</td>
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<td>0.143</td>
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<td>-0.021</td>
<td>0.206</td>
<td>0.696</td>
<td>-0.473</td>
<td>1.898</td>
<td>1.879</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.009)</td>
<td>(0.036)</td>
<td>(0.096)</td>
<td>(0.188)</td>
<td>(0.680)</td>
<td>(0.876)</td>
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<tr>
<td>Groundnut</td>
<td>481</td>
<td>0.23</td>
<td>-0.049</td>
<td>0.226</td>
<td>-0.028</td>
<td>0.177</td>
<td>-0.277</td>
<td>0.452</td>
<td>0.689</td>
<td>-0.062</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(0.041)</td>
<td>(0.041)</td>
<td>(0.014)</td>
<td>(0.059)</td>
<td>(0.305)</td>
<td>(0.567)</td>
<td>(0.269)</td>
<td>(0.083)</td>
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<tr>
<td>Beans</td>
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<td>0.21</td>
<td>0.072</td>
<td>0.086</td>
<td>-0.006</td>
<td>0.158</td>
<td>0.458</td>
<td>-0.147</td>
<td>1.172</td>
<td>0.386</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td>(0.045)</td>
<td>(0.042)</td>
<td>(0.015)</td>
<td>(0.047)</td>
<td>(0.230)</td>
<td>(0.366)</td>
<td>(0.503)</td>
<td>(0.274)</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>499</td>
<td>0.18</td>
<td>0.064</td>
<td>0.056</td>
<td>-0.016</td>
<td>0.120</td>
<td>0.532</td>
<td>-0.535</td>
<td>2.150</td>
<td>0.772</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.049)</td>
<td>(0.040)</td>
<td>(0.015)</td>
<td>(0.061)</td>
<td>(0.269)</td>
<td>(0.419)</td>
<td>(1.940)</td>
<td>(0.742)</td>
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<tr>
<td>Millet</td>
<td>411</td>
<td>0.15</td>
<td>0.024</td>
<td>0.145</td>
<td>-0.045</td>
<td>0.169</td>
<td>0.142</td>
<td>-2.207</td>
<td>-0.828</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(0.058)</td>
<td>(0.060)</td>
<td>(0.019)</td>
<td>(0.074)</td>
<td>(0.312)</td>
<td>(4.862)</td>
<td>(3.334)</td>
<td>(1.269)</td>
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</tr>
<tr>
<td>Cassava</td>
<td>1345</td>
<td>0.13</td>
<td>0.046</td>
<td>0.130</td>
<td>-0.029</td>
<td>0.176</td>
<td>0.260</td>
<td>-0.856</td>
<td>6.987</td>
<td>0.317</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.025)</td>
<td>(0.027)</td>
<td>(0.009)</td>
<td>(0.039)</td>
<td>(0.110)</td>
<td>(0.395)</td>
<td>(19.308)</td>
<td>(0.110)</td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td>2476</td>
<td>0.07</td>
<td>0.090</td>
<td>0.130</td>
<td>-0.024</td>
<td>0.220</td>
<td>0.409</td>
<td>-0.459</td>
<td>1.848</td>
<td>0.307</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.030)</td>
<td>(0.028)</td>
<td>(0.009)</td>
<td>(0.032)</td>
<td>(0.112)</td>
<td>(0.188)</td>
<td>(0.643)</td>
<td>(0.074)</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Fixed effects estimates reported, robust standard errors in parenthesis. We do not report estimates associated with the other control variables \( z_{cht} \) in Equation (3.19). Sample average of female and male labour inputs are \( \bar{f}_A = 20.87 \) and \( \bar{f}_B = 9.57 \). Column (2) is the mean share of sales value to total output value by crop (the market share). Table entries are ordered by descending values of the market share.

\(^b\) See Eqn (3.17) of main text.

\(^c\) See Eqn (3.18) of main text. Coefficients of \( f_{Acht} \) and \( f_{Bcht} \) reported.
The elasticity parameter of male and female labour, $\rho$, lies just between the assumed parameter of the Cobb-Douglas and the Linear Isoquant production function. The elasticity of substitution, $\sigma$, is comparatively high and the variable $g(f_A, f_B)$ is significant, which argues against the Cobb-Douglas specification. The CES seems to be best supported by the data as the $R^2_{within}$ is the highest and the Sum of Squared Residuals (SSR) lowest in this specification.

The subsequent analyses and tests will be based on this preferred specification. First, we estimate separate CES functions for all crops with more than 400 season-plot observations. The results are reported at the bottom of Table 3.5. The coefficients of female and male labour vary considerably across crops, but the standard errors also turn out to be fairly high. Almost half of the female labour coefficients are not statistically different from zero. The female labour coefficient in groundnut production is even negative. This means we cannot use the log-transformed version of the test we described in (3.16) above. Using the log-transformed test but excluding groundnuts, we fail to reject the hypothesis that the marginal rate of technical substitution of male and female labour is equated over the crops with an F-statistic of 1.60 and p-value of 0.1298. Repeating the test in a non-linear fashion and including groundnuts, we get a test statistic of 2.46 and p-value of 0.0117. Given that the non-linear Wald test is sensitive to the way the tested restriction is articulated (Verbeek 2004), and that there are few ways to reduce the number of fractions without log-transforming the test, we consider these two findings together as weak evidence in favour of efficiency in the allocation of labour across the crops. However, many of the estimated coefficients and the derived MRTS estimates are insignificant. An F- or Wald test would suggest MRTS equation if all estimated MRTS were insignificant. Relatively small sample sizes at the crop level combined with high measurement errors of agricultural input and output data may partly explain these results. Finally, given our discussion on gender roles in SSA above, it is not clear that we should be able to detect sub-optimal labour allocations across crops within the same households.

With some very weak signs of efficiency across crops we now turn to the analysis.
of labour allocations across traded versus non-traded crops. We split the sample according to the criteria described in Section 3.4 above, and repeat the test for MRTS equation. The results are summarised in the upper part of Table 3.6. The Table summarises the results by crop type and output control regime. We find that

Table 3.6: Production function estimates by crop and output control type

<table>
<thead>
<tr>
<th>Crop</th>
<th>log $f_A$</th>
<th>log $f_B$</th>
<th>$g(f_A, f_B)$</th>
<th>$\nu$</th>
<th>Share Elast. $\delta_A$</th>
<th>Elast. of substn $\rho$</th>
<th>Elast. of output $\sigma$</th>
<th>MRTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-traded</td>
<td>0.106</td>
<td>0.128</td>
<td>-0.026</td>
<td>0.233</td>
<td>0.453</td>
<td>-0.447</td>
<td>1.810</td>
<td>0.467</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.017)</td>
<td>(0.005)</td>
<td>(0.0216)</td>
<td>(0.056)</td>
<td>(0.089)</td>
<td>(0.293)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>Traded</td>
<td>0.051</td>
<td>0.109</td>
<td>-0.014</td>
<td>0.159</td>
<td>0.318</td>
<td>-0.407</td>
<td>1.686</td>
<td>0.378</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.019)</td>
<td>(0.006)</td>
<td>(0.025)</td>
<td>(0.086)</td>
<td>(0.181)</td>
<td>(0.138)</td>
<td>(0.138)</td>
</tr>
<tr>
<td>Fem. control</td>
<td>0.062</td>
<td>0.144</td>
<td>-0.027</td>
<td>0.206</td>
<td>0.303</td>
<td>-0.613</td>
<td>2.587</td>
<td>0.233</td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.040)</td>
<td>(0.012)</td>
<td>(0.042)</td>
<td>(0.182)</td>
<td>(0.480)</td>
<td>(3.213)</td>
<td>(0.056)</td>
</tr>
<tr>
<td>Male control</td>
<td>0.088</td>
<td>0.139</td>
<td>-0.026</td>
<td>0.227</td>
<td>0.386</td>
<td>-0.488</td>
<td>1.956</td>
<td>0.485</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.020)</td>
<td>(0.007)</td>
<td>(0.030)</td>
<td>(0.064)</td>
<td>(0.113)</td>
<td>(0.433)</td>
<td>(0.119)</td>
</tr>
<tr>
<td>N</td>
<td>9108</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fem. control</td>
<td>0.144</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Male control</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fixed effects estimates reported, robust standard errors in parenthesis. We do not report estimates associated with the other control variables $z_{cht}$ in Equation (3.19). The sample is restricted to households living with at least one spouse.*

women are relatively more productive in subsistence or non-traded crop production than in cash or traded crop production, while the coefficients for male labour are similar for traded and non-traded crops. The technology parameters do not show any significant differences between the two groups of crops. The most important result, however, is that we fail to reject MRTS equality for traded and subsistence or non-traded crops, with an F-statistic of 0.34 (probability of 56%). From the descriptive statistics above, we know that men allocate substantially more labour to traded crops while female labour inputs are, on average, distributed equally between the two types of crops. Our finding of MRTS equation suggests that this allocation of labour represents comparative advantages in agricultural production.

In a final step, we now restrict the sample only to male- (head) and female-controlled crops and again test for MRTS equation between these groups. The results are summarised in the lower part of Table 3.6. We find no significant differences in the productivity and production technology parameters between the crops. However, men allocate much more labour to their own plots. As above, the MRTS is significant for both male and female controlled crops and is about twice as large.

10 Using a dummy variable that only indicates whether the sales value to total output value is greater than zero to split the sample into food and cash crops strengthens this result.

11 We fail to reject that the $\delta$ parameters are equal with an F-statistic of 0.19 ($P > F = 0.6643$), for $\sigma$ with an F-statistic of 0.04 ($P > F = 0.8458$) and for $\rho$ with an F-statistic of 0.06 ($P > F = 0.8005$).
CHAPTER 3. INEFFICIENCY OF ON-FARM LABOUR SUPPLY

on male as on female-controlled plots. Formal testing rejects the equality of the MRTS over male and female controlled crops with an F-statistic of 4.57 (probability of 3.26%). This means that households fail to allocate their labour optimally across different plots when these plots are under the control of different household members. The sharing rules implicit in the control regime hence do not seem to be able to provide the right incentives to achieve an efficient labour allocation. In other words, total output could be higher and Pareto improvements possible if labour were reallocated across plots and the partners adequately compensated.

3.6 Conclusion

This Chapter analyses the efficiency of female and male labour allocation in agricultural production of smallholders using data from the Uganda National Household Survey 2005/06. In particular, in Sub-Saharan Africa previous empirical evidence hints at the possibility of sub-optimal labour allocations due to traditional gender roles in agriculture. These roles may limit the flexibility of labour allocation. For example, women may be excluded from participating in the cultivation of certain crops. In addition, these roles typically govern the control of the proceeds of production. Possible inefficiencies are often pointed at in the context of increasing market integration of farmers and the introduction of new crops. There is anecdotal evidence that traditional norms and gender roles may not respond quickly enough to new incentives and therefore lead to sub-optimal outcomes in the presence of such changes.

This Chapter provides some evidence that farm households indeed fail to efficiently allocate female and male labour. We test whether the marginal rate of technical substitution between female and male labour inputs is equated over the crops. This optimality condition does not hold when we compare male- and female-controlled plots. Our results suggest that men allocate significantly more labour to their plots even though we cannot detect any differences in the production technology and male labour productivity. Total farm output could hence be increased by reallocating male labour to female-controlled plots.

However, the identified inefficiencies do not seem to be necessarily related to market integration. While marketed production is more frequently controlled by men than by women, we do not find evidence of inefficient labour allocations when we compare plots of traded and non-traded crops within the household. When we distinguish between these two groups of crops, we again find that both are cultivated
with the same production technology. Yet, men seem to be relatively more productive in cash crop production and allocate relatively more labour to cash crops. As we cannot reject optimality as implied by our test of marginal rate of technical substitution equation, our results suggest that the division of labour within the household follows comparative labour input advantages in this case. Households hence seem to have compensation rules at their disposal that allow them to efficiently allocate their labour between traded and non-traded crops. If control over output is exerted by different individuals in the households, which may be a more frequent arrangement in more traditional households, the underlying compensation rules do not seem to generate adequate incentives.
Chapter 4

The allocation of time and welfare within rural households: Evidence from Tanzania

Using data on individual consumption and time-use from Tanzania, this Chapter analyses the distribution of well-being within rural couples using Browning & Gørtz’s (2007) Collective Household Model.

We find that the relative wage has a positive impact on relative private consumption and a negative impact on leisure. The results also suggest that women are better off in richer households and that inter-generational influences impact on the female position within the household.

While these findings are consistent with non-unitary household behaviour, we find little evidence in support of the Collective Model. Only restricting the sample to couples with individual incomes of both partners allows the recovery of structural parameters of the model and provides partial support of collective behaviour in an application to the rural less developed world.

4.1 Introduction

For many years the household has been taken as one decision-making agent which maximises one utility function and has been analysed on household-level data (the so-called Unitary Model). As discussed in Section 2.0.5, this model implies that once controlling for overall household income, individual income sources ought not impact on the expenditure pattern (‘income pooling’). Income pooling has been widely rejected by, for example, Bourguignon et al. (1993) for France, Thomas & Chen (1994) for Taiwan, Haddad & Hoddinott (1995) for Côte d’Ivoire, Lundberg, Pollack & Wales...

In consequence, in the late 1980s economic models of the household started to model husband and wife with different and potentially conflicting interests. In this setting, household decision-making depends on each member's utility, power and caring.

Chiappori’s (1992) Collective Model has been established as the ‘workhorse’ for the analysis of cooperative household behaviour. This model also allows the derivation of testable implications, which have been tested and confirmed in many of the applications (especially in studies analysing expenditures, such as in Bourguignon et al. (1994) using Canadian data, as well as in Thomas & Chen (1994), and in parts in Quisumbing & Maluccio (2003)). There are fewer studies that aim to recover structural parameters of the model, preferences, or the sharing of resources within the household. Many of the studies are applied to developed countries, although there are exceptions such as Lee (2007).

Also, most of the studies focus either on the analysis of the allocation of expenditures or time. Browning & Gørtz (2007) stress that a full picture of the intra-household allocation of well-being requires looking at the allocation of time and consumption within the same couple. Intuitively, if there are two couples that are in all respects equal but in one of them the women is working more than her husband and at the same time gets comparatively fewer goods she personally enjoys, we might think she lacks power in determining her ‘piece of the pie’. Alternatively, if she works a lot but also consumes relatively more, we might guess she prefers goods over leisure (Browning & Gørtz 2007). Only analysing these two decisions for the same couple at the same time might justify inferring whether household decision outcomes are driven by tastes or power.

In this Chapter, we analyse the allocation of time and spending within rural households. We use Browning & Gørtz’s (2007) model as a generic Collective Model and modify it to accommodate rural households. We follow Browning & Gørtz (2007) and derive a test for collective behaviour using the structural model. We use data from Tanzania which contain information on private consumption of individual household members for a range of goods and time-use information for a sub-sample of panel couples. We test whether the collective restrictions hold and we estimate the structural model.
4.2 Theory

The model used in this section follows very closely Browning & Görtz’s (2007) Collective Model, but draws on Singh et al. (1986), Chiappori (1992), Udrey (1996), Bourguignon et al. (1994), Chiappori et al. (2002), and Browning et al. (2007).

Again, this section follows closely the models outlined in Chapter 2 and Chapter 3. The household consists of two partners, labelled A and B. In all that follows we assume that A is a woman. Partner A’s utility depends on the consumption of a good bought in the market $q^m_A$, hours of leisure $l_A$, a domestically produced subsistence good $q^f_A$, a non-rival household public good $Q$ and a vector of preference factors $a_A$:

$$u^A = u^A(q^m_A, l_A, q^f_A, Q; a_A).$$

Examples of subsistence goods are maize or beans that are grown on land cultivated by the partners. Good examples of public goods are children’s welfare or a clean house. Preference factors can involve factors such as age or education.

Partner B’s utility $u^B$ depends on exactly the same arguments but for him:

$$u^B = u^B(q^m_B, l_B, q^f_B, Q; a_B).$$

A’s total utility comprises her own $u^A$ plus a proportion $\lambda_A$ of B’s. The weight A attaches to B’s utility $\lambda_A$ summarises the degree of caring. We assume that the partners do not dislike or hate each other so that $\lambda_A \geq 0$. Her felicity function is defined as

$$\Psi_A = u^A + \lambda_A u^B.$$

The same considerations apply for B:

$$\Psi_B = u^B + \lambda_B u^A.$$

The household welfare function $\Psi_h$ is a weighted average of both individual welfare functions:

$$\Psi_h = \hat{\mu} \Psi_A + (1 - \hat{\mu}) \Psi_B \quad \text{with} \quad \hat{\mu} \in [0, 1].$$

The weight $\hat{\mu}$ reflects the so-called balance of power within the household. Substituting $\Psi_A$ and $\Psi_B$ into household welfare, we can redefine $\Psi_h$ as:

$$\mu u^A + u^B \quad \text{with} \quad \mu \equiv \frac{\hat{\mu} + (1 - \hat{\mu}) \lambda_B}{1 - (1 + \lambda_A) \hat{\mu}},$$

(4.1)

The Pareto weight $\mu$ is a composite index of power ($\hat{\mu}$), and caring ($\lambda_A$ and $\lambda_B$).
As discussed in Chapter 2 above, there is no theoretical framework that allows deriving the content of \( \tilde{\mu} \), but it is said to be a function of ‘distribution factors’, also called ‘z-factors’, relative wages \( w_A/w_B \), prices and total household income, so that

\[
\tilde{\mu}(z_1, z_2, w_A/w_B),
\]

and

\[
\mu[\tilde{\mu}(z_1, z_2, w_A/w_B), \lambda_A, \lambda_B] = \mu(z_1, z_2, w_A/w_B, \lambda_A, \lambda_B).
\]

As indicated before, distribution factors \((z_1, z_2)\) are exogenous in the sense that they affect the distribution of power within the household \(\tilde{\mu}\) but do not alter preferences, like \(a_A\) or \(a_B\), or incomes (Browning & Chiappori 1998).

Most importantly, in the Unitary Model \(\tilde{\mu}\) is constant in the sense that it does not depend on \(z_1, z_2, w_A/w_B\) or prices and incomes. This means, if we estimate the impact of \(\mu\) on household decision outcomes, for which \(\tilde{\mu}\) ought to matter, then none of these factors should have an impact.

Figure 4.1 is taken from Browning et al. (2007) and illustrates how distribution factors operate. The horizontal axis of the Figure measures A and the vertical

Figure 4.1: Utility possibility frontier and Pareto weight

B’s utility. The quadrant represents the Utility Possibility, or Pareto, Frontier. It captures all the points that are on the contract curve of the Edgeworth box in which the distribution of resources is such that the utility of any partner cannot be increased without decreasing the utility of the other. Efficiency requires that the solution of the household choice problem lies on the Pareto frontier. The marginal rate of substitution of A and B’s private welfare depends on \(\mu\) and so does the slope of the Utility possibility frontier. z-factors do not shift the Pareto frontier but impact via \(\mu\) on the final allocation chosen on this frontier (Browning & Chiappori 1998).
In our model $0 \leq \mu \leq \infty$. If $\mu$ is zero, then we are at the point $A$ in the Utility possibility frontier. This means $A$ does not have any power and $B$ doesn’t care for her either, so household welfare is determined by his utility. At the point of intersection of the $45^\circ$-line with the Utility possibility frontier $\mu = 1$ and both partners have the same say in the household decision process. Increasing $\mu$ results in a move along the frontier i.e. $A$’s utility gains more weight in household welfare.

Each partner has a total (exogenous) time endowment of 168 hours per week, $T$. As discussed in Chapter 3 for partner $A$, $T$ can be allocated to leisure $l_A$, food crop $f_A$, cash crop $c_A$, or public good production $h_A$ and off-farm employment activities (self- or wage employment) $m_A$. The same applies for $B$. In maximising household welfare, the partners therefore face the following constraints:

$$T \geq l_A + m_A + f_A + c_A + h_A \quad (4.2)$$
$$T \geq l_B + m_B + f_B + c_B + h_B. \quad (4.3)$$

Our model differs from Browning & Gørtz’s (2007) as it extends the time allocation variables to the domestic production of multiple marketable goods, in our notation, crops.

Total food crop production $q^f$ can be allocated to subsistence consumption of both partners $q^f_A + q^f_B$ or traded in the local market $q^f_m$ at price $p^f$. For simplifying illustrations, we assume that the food crop production function $F^f$ uses only domestic labour inputs $f_A, f_B$. The same applies for cash crop production. However, we assume that this crop is entirely traded in the market at the cash crop price $p^c$ (i.e. the partners do not consume this good). Good examples of cash crops are coffee and cocoa.

The production of the household public good $Q$ depends on each partner’s time input $h_A, h_B$ and material inputs bought in the market $q_H$. All three production functions, food crop $F^f$, cash crop $F^c$ and public good $F^Q$ production function, are increasing in all inputs:

$$q^f = q^f_A + q^f_B + q^f_m = F^f(f_A, f_B) \quad (4.4)$$
$$q^c = F^c(c_A, c_B) \quad (4.5)$$
$$Q = F^Q(h_A, h_B, q_H). \quad (4.6)$$

The income constraint states that expenses on consumption goods bought in the market and material inputs into public good production cannot exceed domestic farm profits, non-wage income $y$ and labour incomes $m_A w_A$ and $m_B w_B$. 


We assume that both partners supply a positive amount of labour to farm and off-farm employment activities. We will lift this assumption below.

Substituting the time constraints for off-farm employment into the income constraint allows to define a ‘full-income’ constraint of the form:

\[
p^m(q^m_A + q^m_B) + p^Hq^H \leq p^f[F^f(f_A, f_B) - (q^f_A + q^f_B)] + p^cF^c(c_A, c_B) + y
\]

\[
+ w_A(T - f_A - c_A - h_A) + w_B(T - f_B - c_B - h_B).
\]

The First Order Conditions of maximising \((4.1)\) subject to the constraints in \((4.2)\) to \((4.6)\) by choosing private consumption and leisure, show that their distribution between the partners depends on the balance of power within the household. The marginal rate of substitution between A and B’s private welfare depends on \(\mu\):

\[
\frac{\partial u^B}{\partial q^m_B} / \frac{\partial u^m_A}{\partial q^m_A} = \mu(\cdot)
\]

\[
\frac{\partial u^B}{\partial l_B} / \frac{\partial u^A}{\partial l_A} = \mu(\cdot)w_B/w_A.
\]

\[\text{4.3 From Theory to Application}\]

For a household that maximises welfare, conditions \((4.7)\) and \((4.8)\) determine the allocation of leisure and private consumption between the partners. To obtain an empirical expression for the intra-couple distribution of leisure and private consumption, we need to parameterise utility functions.

We follow Browning & Gørtz (2007) and assume additive separable utility functions:

\[
u^A(q^m_A, l_A, q^f_A, Q; a) = \theta_A \log(q^m_A) + \tau_A \left( \frac{\rho}{1 - \rho} \right) l_A^{\frac{\rho - 1}{\rho}} + f(Q)\]

\[
u^B(q^m_B, l_B, q^f_B, Q; a) = \theta_B \log(q^m_B) + \tau_B \left( \frac{\rho}{1 - \rho} \right) l_B^{\frac{\rho - 1}{\rho}} + f(Q),\]

where \(\theta_A(a), \tau_A(a), \theta_B(a), \tau_B(a)\) are preference parameters that determine the weight each partner gives to private consumption and leisure, and \(a\) is a vector of observable determinants for \(\theta_A\), with similar vectors for \(\tau_A, \theta_B\) and \(\tau_B\).

We do not observe \(q^f_A\) or \(q^f_B\) at the individual level, which means we do not observe total private consumption. Both partners have the same preferences for the public good, \(f(Q)\). Nothing hinges on this assumption as we assume additive separability, and the focus of the analysis is the allocation of leisure and private consumption between partners. Also, we have to assume that there is no ‘joint leisure’ i.e. that
the marginal utility of A’s leisure does not depend on B’s leisure.

The parameter $\rho$ is a so-called ‘leisure curvature parameter’ and captures flexibility in time use, where $0 < \rho < 1$. It can also be interpreted as the negative of the Frisch elasticity i.e. the inter-temporal elasticity of labour supply with regard to the wage. Browning & Gørtz (2007) show that values of the parameter range between 0.05 and 0.1, which is based on labour supply elasticities between 0.1 and 0.2 that are frequently found in empirical applications.

Substituting (4.9) and (4.10) into (4.7), we obtain a model for relative private consumption

$$\frac{q^m_A}{q^m_B} = \theta \mu(.),$$

(4.11)

and using (4.8), we obtain a model for relative leisure

$$\frac{l_A}{l_B} = \left[\tau \mu(.)\right]^{\rho}(w_A/w_B)^{-\rho}.$$  

(4.12)

To make notation less cluttered, we have defined $\theta_A/\theta_B \equiv \theta$ and $\tau_A/\tau_B \equiv \tau$. Also, relative private consumption and leisure are hereafter always A’s relative to B’s.

Equations (4.11) and (4.12) are the central Equations to this Chapter. To illustrate, suppose there are just two distribution factors $z_1$ and $z_2$. Remembering that $\mu(z_1, z_2, w_A/w_B, \lambda_A, \lambda_B)$, in the Collective Model, a change in $z_1$ or $z_2$ impacts on both leisure and relative private consumption via $\mu$. As with $z_1$ and $z_2$, a change in the relative wage affects relative private consumption via $\mu$, but impacts on relative leisure twice. It has a negative effect due to the labour supply response; as A’s wage increases, she substitutes marketed time for leisure which decreases her relative leisure. At the same time, an increase in the relative wage has a positive impact on the Pareto weight and so increases her leisure share.

In the Unitary Model, a change in $z_1$ or $z_2$ has no impact on relative consumption and leisure. A change in the relative wage does not affect relative consumption and has a standard negative effect on leisure due to the labour supply response. In words, A’s relative consumption remains the same and A’s leisure share decreases although her wage has increased.

We still need to parameterise $\theta$, $\tau$ and $\mu$. Again following Browning & Gørtz (2007):

$$\theta = \exp(\gamma_{\theta 0} + \gamma_{\theta} a + \varepsilon_\theta)$$
$$\tau = \exp(\gamma_{\tau 0} + \gamma_{\tau} a + \varepsilon_\tau)$$
$$\mu = \exp(\alpha_0 + \alpha' z + \delta_w \log(w_A/w_B) + \varepsilon_\mu).$$
The error terms in the relative preference equations, \( \varepsilon_\theta \) and \( \varepsilon_\tau \), comprise unobserved heterogeneity in tastes between couples such as differences in relative ability or motivation. Factors we cannot control for in determining the Pareto weight are captured by \( \varepsilon_\mu \). Good examples of such factors are the partners’ relative degree of caring and their relative physical attractiveness. Substituting these expressions into (4.11) and (4.12) and taking logs, yields a system of two structural equations:

\[
\begin{align*}
\log(q^A_m/q^B_m) &= (\alpha_0 + \gamma_\theta 0) + \alpha' z + \gamma_\theta a + \delta_w \log(w_A/w_B) + \varepsilon_q \\
\log(l_A/l_B) &= \rho(\alpha_0 + \gamma_\tau 0) + \rho \alpha' z + \rho \gamma_\tau a + \rho(\delta_w - 1) \log(w_A/w_B) + \varepsilon_l,
\end{align*}
\]

where \( \varepsilon_q \equiv \varepsilon_\theta + \varepsilon_\mu \) and \( \varepsilon_l \equiv \rho(\varepsilon_\tau + \varepsilon_\mu) \). We could have an additional error term in each equation to capture measurement errors in the consumption and leisure data. As we are in practice not able to distinguish these factors either from latent preference or power factors, we do not take them explicitly into consideration but assume that \( \varepsilon_\theta \) and \( \varepsilon_\tau \) comprise any measurement error.

The two structural equations are log-transformed and so the coefficient of the relative wage can be interpreted as an elasticity. The relative wage impacts on relative consumption only through the Pareto weight, so \( \delta_w \) must be positive. The final sign of the relative wage on leisure depends on whether \( \delta_w \gtrsim 1 \). If \( \delta_w < 1 \), then the coefficient of the relative wage in the leisure equation is negative, which means that the labour supply response effect dominates the Pareto weight effect.

The Pareto weight enters both equations. If \( \varepsilon_\theta \) and \( \varepsilon_\tau \) are independent from each other and from \( \varepsilon_\mu \), then we expect the errors of the two equations to be positively correlated.

We can write a reduced form model of the two structural equations as

\[
\begin{align*}
\log(q^m_A/q^m_B) &= \beta_{q0} + \beta'_{qz} z + \beta_q a + \beta^w_q \log(w_A/w_B) + \varepsilon_q \\
\log(l_A/l_B) &= \beta_{l0} + \beta'_{lz} z + \beta_l a + \beta^w_l \log(w_A/w_B) + \varepsilon_l.
\end{align*}
\]

Equating (4.13) with (4.15) and (4.14) with (4.16) we get:

\[
\beta^w_q = \rho(\delta_w - 1) \quad \text{and} \quad \beta^w_l = \delta_w.
\]

Hence, the reduced form estimates of \( \beta^w_q \) and \( \beta^w_l \) identify uniquely the structural parameters \( \rho \) and \( \delta_w \).

\[
\delta_w \equiv \beta^w_q \quad \text{and} \quad \rho \equiv \beta^w_l / (\beta^w_q - 1).
\]
Estimates of the $z$-factor parameters are given by
\[ \beta'_{qz} = \alpha' \quad \text{and} \quad \beta'_{lz} = \rho \alpha'. \]

For a given $\rho$, the Pareto weight parameters are identified from either equation, except for the intercept $\alpha_0$. So, given $\rho$ is identified as above or set to a specific value, we get $M$ overidentifying restrictions:
\[ \beta'_{lz} m = \beta'_{qz} \rho m = 1, ..., M, \quad (4.17) \]
where $M$ is the total number of distribution factors available.

Browning & Gørtz (2007) highlight that the restrictions in (4.17) satisfy an extended version of Bourguignon et al.’s (2009) proportionality condition, which has been shown to be necessary and sufficient for the Collective Model.

Hence, if $M$ overidentifying restrictions hold, the structural model is consistent with the reduced form and therefore the Collective Model is consistent with the data.

If $\rho$ is identified as above the relative wage can be treated as being exogenous; however, if it is set to a specific value, we get an additional restriction
\[ \beta'_{l} = \rho (\beta'_{q} - 1). \quad (4.18) \]

Imposing restriction (4.18) can be interpreted as if we ‘forced’ exogeneity upon the relative wage\(^1\). These two properties regarding exogeneity of the relative wage are very valuable because it may be difficult to claim validity for an instrument that should not in any case be in the model as it represents a distribution factor.

### 4.4 Gender Issues in Tanzania

In terms of gender equality, Tanzania performs comparatively well in the Sub-Saharan setting. The new OECD Social Institution and Gender Index database for Non-OECD countries provides index measures that allow cross-country comparisons. The Family Code index aims to capture institutional level factors that

---

\(^1\) Restriction (4.18) can be interpreted as a test of exogeneity of relative wages. To see this assume: $\varepsilon_l = \kappa \log(w_A/w_B) + \tilde{\varepsilon}_l$. The relative wage in the reduced form equation for relative leisure is only exogenous if $\kappa = 0$. Substituting $\varepsilon_l = \kappa \log(w_A/w_B) + \tilde{\varepsilon}_l$ into the structural leisure equation, then $\beta^w = \rho(\delta_w - 1)$ and not $\beta^w = \rho(\delta_w - 1 + \kappa)$ i.e. $\kappa = 0$. Once we solve for $\rho = (\beta^w / \delta_w - 1)$, as above, we force $\kappa = 0$ as $\beta^w = (\beta^w / \delta_w - 1)(\delta_w - 1 + \kappa) \Rightarrow \kappa = 0$. For further discussion, see Browning & Gortz (2007).
determine the position of women within the household. It is a composite index of
the proportion of young women who are married, divorced or widowed, the accept-
ance of polygamy, legal rights to claim parental authority and inheritance rights of
women. The broader Social Institutions and Gender Index (SIGI) comprises as well
as the Family Code index, other indices that capture the status of women. Both
indices lie between zero and one. A low value means that a country has a high
level of gender equality. In terms of the SIGI, the best cross-country rank posi-
tion, i.e. the level of gender equality, has Paraguay with a value of 0.002
while Sudan has the worst index value with a value of 0.678 (for more information,
see http://genderindex.org/). For both indices, Tanzania’s values lie below the
Sub-Saharan averages.

This might be explained by the fact that the government implemented a set of
reforms with beneficial impacts on the status of women within Tanzanian households.
For instance, in 1971 the Law of Marriage Act, concerning marriage and divorce, was
implemented. The law regulates the division of property upon divorce, children’s
custody and enables women to claim maintenance (Rwezaura & Wanitzek 1988).

In 1993, a women development fund was established to expand access to com-
mercial loans and participation of women in economic activities, but only in 2004
were women legally entitled to access bank loans. In 1998, a law on sexual assault
was enacted to address rape and incest, although spousal rape is only marginally
covered by this. In 1999, the Land Act was implemented that allows women to own,
use and sell land.

Still gender and intra-household discrimination are widespread:

“More than half of Tanzanian women are thought to have been beaten
by their husbands […]. Many women are killed by their husbands
or commit suicide after being subjected to domestic violence” (http://genderindex.org/country/tanzania).

Although the minimum legal age for marriage is 15 years for women, circumstance-
dependent exceptions are granted to girls aged 14 and below.

Case study evidence from the town Moshi in Tanzania, confirms that the like-
lihood of intimate partner violence increases with low levels of female education,
polygamous relationships and disproportionate child bearing or delivery problems
(McCloskey, Williams & Larsen 2005).

Taken together, the issues discussed in this Section suggest that, amongst many
other factors, female decision-power within Tanzanian households might depend on
the female education level, the status of the relationship, and the age at marriage.
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4.5 Data

The data we use come from the Kagera Health and Development Survey (KHDS) conducted by the World Bank in cooperation with the University of Dar es Salaam in the Kagera Region of Tanzania. Kagera borders Burundi, Uganda and Rwanda in the Northwest of Tanzania.

The survey is longitudinal and covers four waves between 1991 and 1994, which we call the ‘base sample’. In keeping with the initial survey objective, households with an increased probability of an adult death were over-sampled. In 2004, a fifth wave was added in an attempt to re-interview all base respondents. The base sample contains 912 households of which 93 percent had been re-contacted in 2004. The 2004 sample is much larger, as not only households, but individuals were tracked (Beegle, de Weerdt & Dercon 2006).

In our case, sample attrition is very severe because for the analysis we need couples with private consumption and leisure reported for both partners. In addition, the 2004 survey does not comprise housework in the time use questionnaire, which mitigates against constructing a sensible leisure variable. We therefore analyse the base sample only, comprising a total of 3,482 partners and 1,741 couples with both private consumption and leisure.

4.5.1 Dependent variables

Relative private consumption, $q^m_A/q^m_B$. Apart from Browning & Görtz’s (2007) data, there are very few data sets that have information on private consumption of individual household members. The KHDS contains information on private consumption, from which we construct $q^m_A/q^m_B$. The individual consumption questionnaire is divided into two different sections with different recall periods; one for goods of a semi-durable nature and one for goods of non-durable nature.

A problem is that the goods are already categorised into individual and household consumption, and some of the goods in the individual questionnaire we expect to be consumed jointly by the household members. Browning & Görtz’s (2007) data are similar in the sense that individuals are asked to estimate their private expenses for three types of goods during a month. While the authors can cross-validate their data against another Danish data set, we cannot do this. However, the KHDS interviewer explicitly states “By acquired, I mean items that you bought for yourself, made for yourself, or that were given to you” (KHDS Household Questionnaire, Wave 1, p.135) and asserts in the second section to be “interested only in the items you purchased for yourself or someone else with your own money, and not items purchased for you
by someone else”. So, we believe the data allow the construction of a valid proxy for private consumption.

In the first section, information is collected for khangas (traditional East African clothes worn by women), other clothing, footwear, jewelry or watches, toys, haircuts, handbags, medicines and other medical services. In the second section, information is collected for food and drinks consumed outside the household, tobacco or cigarettes, magazines, entertainment, candles, batteries, gas or motor oil, cosmetics, etc. in a two week recall period. Although husbands and wives are not the only people in the household that report private consumption, taken together, their private consumption amounts to 72 percent of total household private consumption.

In order to guard against overstating the value of certain items, such as khangas, and understating expenses on other purchases, such as of cigarettes, we convert the information into yearly totals. We sum all consumption for each partner and take the ratio of the wife’s private consumption relative to her husband’s, i.e. $q^m_A / q^m_B$.

Figure 4.2 shows the distribution of relative private consumption. On the horizontal axis the Figure illustrates relative private consumption and on the vertical axis the frequency distribution of the variable. Note that we scaled the x-axis to a maximum of four to facilitate comparison with the relative leisure distribution.

The dashed line in the picture represents $q^m_A = q^m_B$. The Figure illustrates that, on
average, husbands get a far bigger share in private consumption than their spouses. Note that many couples or partners do not consume or report private consumption. The median of strictly positive relative consumption is 0.40, which means that in 50% of the couples women receive less than 40% of their husbands consumption, i.e. $q_A^m < q_B^m$.

**Relative leisure, $l_A/l_B$.** For constructing the relative leisure variable $l_A/l_B$, we use the time-use questionnaire. This questionnaire is based on a seven day recall period of hours spent in wage employment, self-employment, livestock cultivation, crop production, domestic household duties, caring for ill household members, job seeking, and funeral attendance.

There are $T = 168$ hours in a week. We assume that 30 hours have to be spent on sleeping and hygienic care. We aggregate the time spend on the activities listed in the questionnaire and add the 30 hours. We exclude observations with more than 168 hours in total and those with no time spend on any of the listed activities. We proxy leisure by 168 minus total time spent on all activities for each partner.

A shortcoming is that we do not have diary information. Browning & Gørtz’s (2007) data contain both diary information for a week and weekend day, and information about the usual time spend on these activities during a normal week. Due to high infrequency in the diary data, i.e. that the information collected on the day of the diary deviates from the time spent on activities normally during a week, Browning & Gørtz (2007) choose the usual week information for their empirical application. Our data do not allow us to make this comparison. However, using seven day recall data, we arguably get close to the variable the authors use in their empirical application.

Figure 4.3 illustrates the distribution of relative leisure. Compared to relative private consumption, relative leisure has a much more egalitarian distribution with a sample median of 0.9; however, there is still a slight left skew, indicating that in this dimension husbands also receive a relatively larger share. In fact, the distributions of the two dependent variables are completely different, which may indicate that leisure and private consumption are very differently valued and distributed amongst partners in Tanzanian households.

Equations (4.11) and (4.12) illustrate that relative private consumption and leisure are both a function of preferences $\theta$, $\tau$, wages $w_A/w_B$ and power $\mu$. Holding relative wages constant, any correlation between the two dependent variables must be driven by preferences or power. If A prefers private consumption over leisure, and there is no variation in power, we expect the two variables to be negatively
correlated since women with high private consumption tend to enjoy comparatively less leisure and vice versa. If preferences for leisure and private consumption are uncorrelated then any correlation must be due to power and we would expect a positive correlation between the two variables. Women with high private consumption also enjoy comparatively more leisure. We can also illustrate this more formally. Taking logs of (4.11) and (4.12) yields:

$$\log\left(\frac{q_m^A}{q_m^B}\right) = \log(\theta) + \log \mu(\cdot),$$

$$\log\left(\frac{l_A}{l_B}\right) = \rho \log \tau + \rho \log \mu(\cdot) - \rho \log\left(\frac{w_A}{w_B}\right).$$

Holding relative wages constant and assuming preference factors are uncorrelated with Pareto factors,

$$\text{Cov}[\log \mu, \log \theta] = \text{Cov}[\log \mu, \log \tau] = 0.$$  

Given these assumptions, the correlation coefficient of the two dependent variables is defined as

$$\text{Corr}(q, l) = \frac{\text{Cov}(q, l)}{\sigma_q \sigma_l} = \frac{\rho^2 \sigma_{\log \mu}^2 + \rho \text{Cov}(\log \theta, \log \tau)}{\sigma_q \sigma_l},$$
where we renamed \( \log(q^m_{A}/q^m_{B}) = q \) and \( \log(l_A/l_B) = l \) as simplifying notation. In other words, the correlation depends on the variance of the Pareto weight, the covariance between preferences for private consumption and leisure, and the size of \( \rho \). We will discuss the correlation of the error terms of the two variables in Section 4.6.3 below. So, analysing the raw correlation between relative leisure and private consumption may give an indication whether partners’ choices are driven by tastes or power. Figure 4.4 illustrates this correlation. In fact, the sample correlation is –0.028 with a significance level of 0.238 and, accordingly, the Figure shows no correlation between the two variables, which may reflect the different valuation of these two private goods in the Tanzanian setting. Notwithstanding the absence of correlation between the variables, we jointly analyse determinants of relative private consumption and leisure based on the structural equations derived in Equations (4.13) and (4.14), controlling for wages, preferences and power, and using standard regression techniques. For doing so, we have to specify the additional variables we control for in the regression analysis.
4.5.2 Control variables

Relative wages. In our theoretical considerations, the relative wage plays a key role in explaining the allocation of time and private consumption between a couple. The model discussed in Section 2 assumes that both partners supply a positive amount of labour to the labour market i.e. $m_A > 0$ and $m_B > 0$. Browning & Gørtz (2007) restrict the sample to partners that are full-time employed. For our empirical application this is not feasible, as it leaves a very small sample size. In the rural setting of developing countries, labour markets are often either absent or distorted, which may explain why we have so few observations that report a wage. To cope with this problem we use three measures to proxy relative wages $w_A/w_B$.

First, we do observe non-wage incomes, self-employed incomes, and wages from employment at the individual level. We aggregate these incomes over each partner and take logs. This means we restrict the sample to only those couples that report an individual income for both partners. This wage measure leaves a small number of observations and is theoretically ambiguous as it combines wages and other incomes that generate very different incentives.

Second, we use the sample of people that have a wage to estimate ‘potential wages’ and impute wages for those not having a wage, using standard techniques.

Third, a condition for a person to be indifferent to participate in the labour market is that her reservation or shadow wage is equal to the offered wage (Gronau 1977). Blundell et al. (2007) and Lise & Seitz (forthcoming) show that in the Collective Model the shadow wage condition has to be stipulated, since efficiency requires that not only must one person be indifferent towards participation but both partners within a couple. A key difference between our and Blundell et al.’s (2007) model is that we consider the domestic production of marketable goods and analyse the Collective Model on leisure and not on labour supply. As discussed in Chapter 2.2 if households have access to functioning output and factor input markets, farm production decisions are separable from consumption choices (Singh et al. 1986). Separability implies that partners first allocate resources to farm production so as to maximise profits and, given domestic profits, they maximise utility (Bardhan & Udry 1999). If functioning markets exist, Jacoby (1993) and Skoufias (1994) show that the marginal product of labour in farm production is equal to the market wage. If labour markets are absent or distorted the marginal product of labour in farm production is equal to the shadow wage, which then guides household time-use choices. Incorporating this discussion into the analysis, we estimate the marginal product of male and female labour inputs in farm production to proxy shadow wages.
Other control variables. Other control variables can be grouped into factors that affect the Pareto weight $z$ and factors that affect preferences, $a$. To proxy the Pareto weight, we include a dummy variable if the community allows women to inherit her husband’s land, since land is a major asset that determines income opportunities in rural households. We also include differences in age and years of schooling between A and B, which we construct on the basis of information on the highest education level completed (we take A minus B’s values for constructing differences). Next, we include a dummy variable if the household contains multiple spouses. In line with the literature, we also include a measure of exogenous income share, which is, in our case, the share of remittances and borrowed income received by the wife to total household remittances and borrowed income. Other control variables include total household income, which also includes domestic farm profits. The survey also contains a fertility questionnaire that contains information that may be associated with the status of women within the household. So we include the age at marriage, which impacts on female education and the training level and, as such, on job opportunities.

To proxy preferences, we include a dummy variable if the couple lives with the family. Because inter-generational influences may impact on preferences, we also include dummy variables if the father and mother have attended an educational system. Also, we include a dummy variable if the religion of the household head is muslim, as we expect this to be associated with a different consumption pattern of certain goods such as, for example, alcohol. We also include a set of dummy variables indicating the tribe of the household head for the same reason. Finally, we include a set of dummy variables for the number of male and female pre-school and school-aged children within the household. (We do not construct a measure of differences in the years of education of the parents, as in Beegle, Frankenberg & Thomas (2001), since this would lead to a further reduction in the number of observations.)

It should be noted that it is somewhat arbitrary which variables are identified as preferences, and those as Pareto factors. For instance, we expect parental education to be correlated with preferences for leisure since it might be correlated with ability, which is often argued to impact on labour supply decisions. Alternatively, it may very well be that growing up in an educated environment affects a woman’s self-perception and so impacts on her relative say in her own household. In other words, there is no sharp distinction between preference and Pareto factors, but empirical analysis may clarify the classification. For example, if parental education were a preference factor we would expect a negative impact on leisure given that it increases
labour supply. By contrast, if it were a Pareto factor we would expect the opposite effect.

We also include a set of year and month dummy variables to capture seasonal and yearly price variations.

4.6 Results

Before discussing the results of the reduced and structural form estimates, we discuss the shadow and potential wage estimations.

4.6.1 Shadow wages

For recovering shadow wages, we have to estimate production functions. The marginal product of labour depends on the functional form assumption of the underlying production function.

We consider three alternative functional form specifications that only differ in the modelling of female and male labour inputs.

In particular, we consider a standard Cobb-Douglas production function (CD) of the form:
\[
\log y = \text{const} + \alpha^A \log f_A + \alpha^B \log f_B + \ldots
\]

For the Collective Model we need to proxy the log of the relative wage. This means we have enough information if we recover the ratio of the marginal products i.e. the marginal rate of technical substitution. For the CD this is defined as
\[
\frac{\partial \hat{y}}{\partial \hat{f}_A} \frac{\partial \hat{y}}{\partial \hat{f}_A} = \hat{\alpha}_A \frac{f_B}{f_A}.
\]

Second, we consider a CD that includes male and female labour inputs as a single Constant Elasticity of Substitution (CES) aggregate:
\[
\log y = \text{const} - \nu \rho_a \log [\delta_A f_A^{-\rho_a} + (1 - \delta_A) f_B^{-\rho_a}] + \ldots
\]

Where \(\nu\) depicts the returns to labour, \(\rho_a\) is the substitution parameter and \(\delta_A\) is the share parameter that reflects A’s contribution to output. Following Greene (2003, p.129), a linear approximation, using a Taylor series expansion, is given by
\[
\log y = \text{const} + \alpha^A \log f_A + \alpha^B \log f_B + \alpha^{AB} g(f_A, f_B) + \ldots
\]
and so is linear in \( \log f_A, \log f_B \) and \( g(f_A, f_B) \equiv \left[ -(\log f_A - \log f_B)^2/2 \right]. \)

Parameter estimates of \( \nu, \delta_A \) and \( \rho_a \) are uniquely identified from the estimates of \( \alpha_A, \alpha_B \) and \( \alpha^{AB} \).

For the CES the marginal rate of technical substitution is defined as

\[
\frac{\partial \hat{y}/\partial f_A}{\partial \hat{y}/\partial f_B} = \frac{\hat{\delta}_A}{1 - \hat{\delta}_A} \left( \frac{f_B}{f_A} \right)^{1+\hat{\rho}_a}.
\]

Third, we estimate a simplified version of a Translog production function:

\[
\log y = \text{const} + \alpha^A \log f_A + \alpha^B \log f_B + 1/2 (\alpha^{AB} \log f_A \log f_B + \alpha^{AA} \log^2 f_A + \alpha^{BB} \log^2 f_B) + \ldots
\]

In this case, the marginal rate of technical substitution is given by

\[
\frac{\partial \hat{y}/\partial f_A}{\partial \hat{y}/\partial f_B} = \left( \frac{\hat{\alpha}^A + 1/2 \hat{\alpha}^{AB} \log f_B + \hat{\alpha}^{AA} \log f_A}{\hat{\alpha}^B + 1/2 \hat{\alpha}^{AB} \log f_A + \hat{\alpha}^{BB} \log f_B} \right).
\]

The CD is strictly nested in both the CES and Translog model. If the parameter \( \alpha^{AB} \) in the CES specification is zero, then the CES reduces to the CD. If the coefficients of the interaction and square terms in the Translog model are jointly zero, then the same happens to the Translog specification.

In terms of data, the KHDS collects information on agriculture outputs in a twelve month period for the first and a six month period for all the subsequent waves. We convert the output information into value measures and aggregate total output value for each household and wave over the crops. We also include the value of harvest kept for seed, lost due to exogenous events, kept in stock and given away in the aggregation.

The data do not include domestic labour inputs in the agricultural questionnaire. This means we have to take the information from the time use questionnaire to proxy male, female and other domestic labour inputs. This is a shortcoming as on-farm labour allocations depend on seasonal fluctuations such as harvesting peak times, but we see no other way to overcome this problem.

We convert all the information into yearly totals. Other inputs include the log of the total crop area in acres, hired labour inputs and a dummy variable indicating whether fertilizer or manure has been applied. We restrict the sample to observations with positive on-farm labour inputs for both men and women, output value and land. To the other labour inputs we add an extra hour to cope with zero inputs. Again, we include a set of year and month dummy variables in all estimations. Table 4.1
compares the three production function estimations.

<table>
<thead>
<tr>
<th></th>
<th>Cobb-Douglas</th>
<th>CES</th>
<th>Translog</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(f_A)</td>
<td>0.051</td>
<td>0.051</td>
<td>-0.870</td>
</tr>
<tr>
<td></td>
<td>(0.051)</td>
<td>(0.051)</td>
<td>(0.499)</td>
</tr>
<tr>
<td>log(f_B)</td>
<td>0.087</td>
<td>0.101</td>
<td>-0.996</td>
</tr>
<tr>
<td></td>
<td>(0.045)</td>
<td>(0.051)</td>
<td>(0.479)</td>
</tr>
<tr>
<td>g(f_A, f_B)</td>
<td>-0.027</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.045)</td>
<td></td>
</tr>
<tr>
<td>1/2 log(f_A) log(f_B)</td>
<td></td>
<td>0.126</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.104)</td>
<td></td>
</tr>
<tr>
<td>1/2 log^2(f_A)</td>
<td>0.107</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.073)</td>
<td></td>
</tr>
<tr>
<td>1/2 log^2(f_B)</td>
<td>0.081</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.076)</td>
<td></td>
</tr>
<tr>
<td>ν</td>
<td>0.138</td>
<td>0.152</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.067)</td>
<td></td>
</tr>
<tr>
<td>δ_A</td>
<td>0.369</td>
<td>0.335</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.286)</td>
<td>(0.261)</td>
<td></td>
</tr>
<tr>
<td>ρ_a</td>
<td>0</td>
<td>-0.788</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.267)</td>
<td></td>
</tr>
<tr>
<td>∂y/∂f_A / ∂y/∂f_B</td>
<td>0.72</td>
<td>0.49</td>
<td>0.64</td>
</tr>
<tr>
<td>SSR</td>
<td>1663.9</td>
<td>1663.5</td>
<td>1652.3</td>
</tr>
<tr>
<td>N</td>
<td>1240</td>
<td>1240</td>
<td>1240</td>
</tr>
</tbody>
</table>

* Robust, couple-corrected standard errors in parenthesis. Other control variables include those discussed in the main text.

We do not find complementarities between male and female labour inputs in the data in the sense that the coefficient on \( g(f_A, f_B) \) in the CES and the interaction term between male and female labour in the Translog specification are not significant.

The parameters of the CES are summarized in the lower part of Table 4.1. The parameter estimate of \( ρ_a \) is \(-0.79\) and the elasticity of substitution is 4.72, which means that female and male labour inputs are highly substitutable. Also, the CES results indicate diminishing returns to female and male labour inputs as \( ν = 0.152 \) and that women are less productive than men because \( δ_A < 0.5 \).

The lower part of Table 4.1 (column 2) summarises the CES parameters generated by the CD specification, which are very close to the CES results. As \( ρ_a \) is statistically not different from zero (see column 3), the results of the CES and CD are observationally equivalent. There is slight evidence that the interaction and square terms in the Translog specification are relevant which seems driven by non-linearities generated by the square terms of male and female labour rather than complementarities, the interaction term of male and female labour. The F-statistic of testing
that \( g(f_A, f_B) = 0 \) is 0.35 and that the interaction and square terms in the Translog are jointly zero is 2.58 with a probability of 55% and 5.3%, respectively. In terms of Sum of Squared Residuals (SSR), the Translog model seems to perform somewhat better than CES and CD. However, many of the marginal products derived from the Translog specification are negative.

Considering that the marginal products are highly correlated across the three specifications, the evidence in favour of the Translog is not definitive and by opting for the Translog we lose about 16% of the observations. Accordingly, we choose the CD specification.

### 4.6.2 Potential wages

In a second step, we impute wages for those partners not having a wage. In line with Blundell et al. (2007) and Lise & Seitz (forthcoming), we estimate wage equations adopting a standard human capital approach. We explain wages as a function of personal characteristics (age, age square, education, gender and parental education), a set of year and month dummy variables and control for community fixed effects.

The data used are taken from the employment and self-employment sections of the activities questionnaire. They contain information on hours worked per week, weeks worked per year and salary by time unit. We generate weekly earnings, and have a so-called ‘division bias’ as wages are constructed by dividing incomes by the number of hours worked (Borjas 1980). In the analysis below, we will discuss explicitly how we cope with the resulting endogeneity of wages.

The number of observations is limited and, as we fail to reject the slope coefficients being equal across gender with a Chow test statistic of 1.44 and probability of 11%, we pool the data across gender.

A standard problem in explaining wages is that the observation of a personal wage depends on the preceding labour supply decision of the individual. This means that Ordinary Least Squares (OLS) estimates might be biased if the same unobserved characteristics that influence the decision to participate in the labour market determine the wage level; that is, the covariance of the error terms of the two equations, \( \sigma_{12}^2 \), is different from zero.
Following Verbeek (2004, p.228), the problem can be formalised as follows

$$\log w^* = x_1' \beta + u_1$$
$$h^* = x_2' \beta + u_2$$
$$w = w^*, \quad h = 1 \quad if \quad h^* > 0$$
$$w = ., \quad h = 0 \quad if \quad h^* \leq 0,$$

where $w^*$ is the potential wage which we do not observe if the person does not have a wage and $w$ is the actual wage. The second line models whether the person has a wage as a function of variables in the vector $x_2$. The vector comprises the variables in $x_1$ plus factors that affect $h^*$ in an exclusive way. For the latter, we include the partner’s demographics, the marginal product of labour in farm production, a dummy indicator of whether the mother resides in the same place as the household, there are children aged below six, the log of the total crop area, and non-wage household income. In the analysis below we exclude non-wage household income as it is not significant and reduces the number of observations.

The last two lines summarise the observation rule: if the person does participate, the potential wage equals the actual wage, $w = w^*$. If she does not participate the actual wage is not observed i.e. $w = .$, as stated in the last line.

The distributional assumptions for the error terms are

$$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \sim N \left[ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix} \right].$$

A standard way to correct OLS for potential bias is using Heckman’s two-step estimation procedure.

Table 4.2 summarises OLS and selection-corrected wage estimates. The inverse Mill’s ratio is significant at a 10% significance level. However, correcting for sample selection bias worsens the estimates: the standard errors get bigger and the signs of the coefficients change. As is standard in explaining wages, we expect a positive relationship between age and wages until a certain maximum age is reached. In other words, we would expect an inverse U-shape relationship which is captured by a negative sign on the age squared term in the OLS regression. The Heckman results reverse this relationship. The weakness of the selection-corrected estimates can be explained by the fact that the $R^2$ of regressing the Mill’s ratio exclusively on the covariates of the wage equation is 0.93. Despite the result that, the marginal product and the mother’s residence impact on participation, this means that only a maximum of 7% of the variation in the Mill’s ratio can be attributed to our selection...
identifying variables. In other words, our results suffer from serious multicollinearity and the identification of the parameter estimate of the Mill’s ratio, also called $\lambda$ in the literature, is most likely achieved by the functional form assumption that underlies the selection equation of the Heckman model. Most importantly, we would expect a positive sign for the Mill’s ratio itself; that is, a positive correlation between the error terms of the two equations since this correlation is driven by unobservable factors that affect wages as well as participation in the labour market. A good example of such a factor is ability, which increases wages and also labour supply. Note that the correlation between wages predicted by the Heckman two-step estimator and OLS is comparatively high with values of 0.71 and 0.69 for men and women, respectively. Using the Heckman estimates instead of those generated by OLS to estimate the reduced form model discussed above generates similar results. So, we choose OLS. Appendix D illustrates the correlation between the different wage measures and summarizes the reduced form results using wages predicted by the Heckman two-step estimator.

### 4.6.3 Reduced and structural form estimates

We expect the error terms of the relative leisure and private consumption equations to be correlated because both equations depend on $\mu$. To see this, remember that the error terms in (4.13) and (4.14) are defined as $\epsilon_q \equiv \epsilon_\theta + \epsilon_\mu$ and $\epsilon_l \equiv \rho(\epsilon_\tau + \epsilon_\mu)$. So, the error term of $\mu$, $\epsilon_\mu$, enters both equations and, depending on the assumed relationship between the unobservable determinants of preferences for leisure $\epsilon_\tau$ and private consumption $\epsilon_\theta$, causes the correlation.

An estimator that is able to exploit this correlation is Zellner’s (1962) Seemingly Unrelated Regression (SUR) model. In addition, this estimator has the advantage that cross-equation restrictions are easily implemented and it reduces the sample to couples that report both relative private consumption and leisure.

Before turning to the results, we have to address a problem that results from pooling the data across the couples. In particular, the observations are correlated at the couple level and are, as such, not independent. This means that the standard errors of the OLS estimates are underestimated i.e. the precision of our estimates is overestimated (the ‘Moulton effect’). This is especially true for coefficients of cluster-invariant regressors (Cameron & Trivedi 2005). We have to address this as the survey is made over short time intervals and the within-variation of many variables is comparatively low. To get an idea about the adjustment dimension, the factor to adjust the variance of the normal OLS estimator is defined as (Cameron
Table 4.2: Wage estimations

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Heckman</th>
<th>Selection eqn.°</th>
</tr>
</thead>
<tbody>
<tr>
<td>A or B’s age</td>
<td>0.0720</td>
<td>-0.0169</td>
<td>0.0152</td>
</tr>
<tr>
<td>A or B’s age2</td>
<td>-0.0008</td>
<td>0.0002</td>
<td>-0.0002</td>
</tr>
<tr>
<td>A or B’s years of edu.</td>
<td>0.0967</td>
<td>0.0753</td>
<td>0.0035</td>
</tr>
<tr>
<td>A or B’s father edu.⋆</td>
<td>0.0917</td>
<td>0.365</td>
<td>-0.0162</td>
</tr>
<tr>
<td>Women⋆</td>
<td>-0.845</td>
<td>-0.307</td>
<td>-0.2230</td>
</tr>
<tr>
<td>Partner’s age</td>
<td></td>
<td>0.0007</td>
<td></td>
</tr>
<tr>
<td>Partner’s age2</td>
<td></td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>Partner’s edu.</td>
<td></td>
<td>0.0053</td>
<td></td>
</tr>
<tr>
<td>No. children &lt; 6⋆</td>
<td></td>
<td>0.0095</td>
<td></td>
</tr>
<tr>
<td>Mother same as hh⋆</td>
<td></td>
<td>0.0501</td>
<td></td>
</tr>
<tr>
<td>log of mprod</td>
<td></td>
<td>0.0274</td>
<td></td>
</tr>
<tr>
<td>log of crop area</td>
<td></td>
<td>-0.0153</td>
<td></td>
</tr>
<tr>
<td>Inverse Mill’s ratio (λ)</td>
<td></td>
<td>-1.0106</td>
<td></td>
</tr>
<tr>
<td>McFadden’s adj. $R^2$</td>
<td></td>
<td>0.156</td>
<td></td>
</tr>
<tr>
<td>Correctly Classified</td>
<td></td>
<td>83.39%</td>
<td></td>
</tr>
<tr>
<td>$N$</td>
<td>906</td>
<td>2480</td>
<td></td>
</tr>
</tbody>
</table>

* Bootstrapped and robust standard errors in parenthesis for Heckman’s two-step and OLS estimates, respectively. Other control variables include those discussed in the main text.

° Marginal effects reported at the mean of the data. (⋆) dy/dx is for discrete change of dummy variable from 0 to 1.

& Trivedi 2005, p.836):

$$\nu = [1 + \varrho(M - 1)],$$

where $\varrho$ is the intra-couple correlation and $M$ is the ‘average cluster size’ i.e. the number of observations ($N$) divided by the number of clusters, in our case couples ($C$). For positive relative private consumption $N = 1830$, $C = 645$ and $\varrho = 0.21$. So the standard errors of the relative expenditure equation would have to be multiplied by $\sqrt{1.4} \approx 1.18$. To correct for this, we bootstrap the standard errors over the
couples using 400 replications (Cameron & Trivedi 2009).

A further problem is that shadow wages are, by definition endogenous, and potential wages are also endogenous but by construction. Above, we defined \( \rho \equiv \frac{\beta_{wl}}{\beta_{wl}(\beta_{wq} - 1)} \), where \( \beta_{wl} \) is the reduced form coefficient of relative wages in the relative leisure equation and \( \beta_{wq} \) is the coefficient of relative wages in the relative private consumption equation. If relative shadow and potential wages are endogenous, we cannot identify \( \rho \) from the parameter estimates of \( \beta_{wl} \) and \( \beta_{wq} \) as they are biased and we have to set \( \rho \) to a specific value. Following Browning & Gørtz (2007) for these two samples we set \( \rho \) to 0.1, and use restriction (4.18) to impose exogeneity upon the relative wage.

Table 4.3 summarizes the results of the reduced form estimates. The first two columns report the relative private consumption and leisure system estimates of equation (4.15) and (4.16) for the sample with positive individual incomes (‘first sample’), followed by the potential wages (‘second sample’) and the shadow wages (‘third sample’).

Remember, a Pareto weight factor has to be relevant for both equations. For all three specification, we find that the relative wage has a significant positive impact on relative consumption and a negative impact on leisure.

In the Unitary Model the relative wage does not affect relative consumption and \( \delta_w = 0 \). So, our results provide evidence consistent with non-unitary household behaviour. In the Collective Model the negative impact on leisure means that the labour supply effect dominates the ‘power effect’. As \( \beta_{wl} = \rho(\delta_w - 1) \), \( \rho > 0 \) and \( \delta_w > 0 \), the reverse could only be true if \( \delta_w > 1 \).

Testing the collective restrictions in (4.17), we do not find the model is supported by the second and third sample. For the second sample the relevant Pareto weight factors are household income and A’s remittance share. The restrictions in (4.17) are rejected with a \( \chi^2(2) \) of 16.42, probability of 0.03%. For the shadow wage sample, age differences and A’s remittance share are relevant and we reject collective behaviour with a \( \chi^2(2) \) of 9.04, probability of 1%.

For individual incomes we get mixed findings. For this sample we have three Pareto weight factors beyond wages: education of A’s father, household income, and A’s remittance share. As discussed above, if the education of A’s father were a preference factor, we would expect a negative impact on relative leisure. Note that we test the joint significance of the other parental education variables over the two equations and do not find any significant effects except for the education of the mother-in-law of the wife. So we exclude the insignificant variables. Our parameter estimates of \( \rho = 0.047 \) (0.011) and \( \delta_w = 0.096 \) (0.024).
### Table 4.3: Relative consumption and leisure system reduced form estimates

<table>
<thead>
<tr>
<th>Preference factors, $\beta_{q/\ell}'$</th>
<th>Individual Incomes $\log(q_A^{m_A}/q_B^{m_B})$</th>
<th>Potential Wages $\log(l_A/l_B)$</th>
<th>Shadow Wages $\log(q_A^{m_A}/q_B^{m_B})$</th>
<th>Log relative wages $\log(w_A/w_B)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. fem. children</td>
<td>0.125</td>
<td>0.0578</td>
<td>-0.0052</td>
<td>0.0774</td>
</tr>
<tr>
<td>age 0 to 5</td>
<td>(0.0957)</td>
<td>(0.0402)</td>
<td>(0.0200)</td>
<td>(0.0797)</td>
</tr>
<tr>
<td>No. fem. children</td>
<td>0.00208</td>
<td>-0.00287</td>
<td>0.0369</td>
<td>-0.0190</td>
</tr>
<tr>
<td>age 6 to 14</td>
<td>(0.104)</td>
<td>(0.0432)</td>
<td>(0.0243)</td>
<td>(0.0086)</td>
</tr>
<tr>
<td>No. male children</td>
<td>0.0365</td>
<td>-0.0563</td>
<td>-0.0611</td>
<td>-0.0102</td>
</tr>
<tr>
<td>age 0 to 5</td>
<td>(0.102)</td>
<td>(0.0484)</td>
<td>(0.0259)</td>
<td>(0.0831)</td>
</tr>
<tr>
<td>No. male children</td>
<td>-0.164</td>
<td>0.00950</td>
<td>-0.0846</td>
<td>-0.00884</td>
</tr>
<tr>
<td>age 6 to 14</td>
<td>(0.102)</td>
<td>(0.0496)</td>
<td>(0.0252)</td>
<td>(0.0804)</td>
</tr>
<tr>
<td>Preference factors, $\beta_{q/\ell}'$</td>
<td>0.108</td>
<td>0.0419</td>
<td>0.0356</td>
<td>0.00631</td>
</tr>
<tr>
<td>log hh income (Y)</td>
<td>(0.0451)</td>
<td>(0.0150)</td>
<td>(0.0231)</td>
<td>(0.00723)</td>
</tr>
<tr>
<td>$A$’s remit. share</td>
<td>0.541</td>
<td>0.277</td>
<td>0.554</td>
<td>0.569</td>
</tr>
<tr>
<td>$A$’s father edu.</td>
<td>(0.180)</td>
<td>(0.107)</td>
<td>(0.0980)</td>
<td>(0.115)</td>
</tr>
<tr>
<td>$B$’s mother edu.</td>
<td>-0.695</td>
<td>0.318</td>
<td>-0.385</td>
<td>-0.365</td>
</tr>
<tr>
<td>$B$’s father edu.</td>
<td>(0.209)</td>
<td>(0.135)</td>
<td>(0.0653)</td>
<td>(0.167)</td>
</tr>
<tr>
<td>$A$’s age – $B$’s age</td>
<td>-0.00557</td>
<td>0.00143</td>
<td>-0.00602</td>
<td>-0.00878</td>
</tr>
<tr>
<td>Multiple Spouses</td>
<td>-0.274</td>
<td>0.103</td>
<td>-0.380</td>
<td>-0.334</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relative wage, $\beta_{q/\ell}'$</th>
<th>Individual Incomes $\log(q_A^{m_A}/q_B^{m_B})$</th>
<th>Potential Wages $\log(l_A/l_B)$</th>
<th>Shadow Wages $\log(q_A^{m_A}/q_B^{m_B})$</th>
<th>Log relative wages $\log(w_A/w_B)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N$</td>
<td>595</td>
<td>1726</td>
<td>1141</td>
<td></td>
</tr>
</tbody>
</table>

$^*$ Couple-corrected, bootstrapped standard errors in parenthesis. All regressions include year and month dummy variables, and the covariates discussed in the main text. The reduced form model jointly estimates Equation (4.15) and (4.16) using SURE. $^a$ Restriction $\beta_{q/\ell}' = 0.1(\beta_{q/\ell}' - 1)$ imposed.
Table 4.4: Relative consumption and leisure system structural form estimates

<table>
<thead>
<tr>
<th>Preference factors, $\gamma_i^\prime/\rho \gamma_i^\prime$</th>
<th>Individual Incomes</th>
<th>Potential Incomes</th>
<th>Shadow Wages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>log($q_{mA}^\prime/q_{mB}^\prime$)</td>
<td>log($l_A/l_B$)</td>
<td>log($q_{mA}^\prime/q_{mB}^\prime$)</td>
</tr>
<tr>
<td>No. fem. children</td>
<td>0.124</td>
<td>0.0601</td>
<td>0.0584</td>
</tr>
<tr>
<td>age 0 to 5</td>
<td>(0.0954)</td>
<td>(0.0412)</td>
<td>(0.0721)</td>
</tr>
<tr>
<td>No. fem. children</td>
<td>-0.0130</td>
<td>0.0247</td>
<td>0.0371</td>
</tr>
<tr>
<td>age 6 to 14</td>
<td>(0.104)</td>
<td>(0.0418)</td>
<td>(0.0654)</td>
</tr>
<tr>
<td>No. male children</td>
<td>0.0428</td>
<td>-0.0678</td>
<td>-0.0612</td>
</tr>
<tr>
<td>age 0 to 5</td>
<td>(0.102)</td>
<td>(0.0469)</td>
<td>(0.0730)</td>
</tr>
<tr>
<td>No. male children</td>
<td>-0.166</td>
<td>0.0142</td>
<td>-0.0839</td>
</tr>
<tr>
<td>age 6 to 14</td>
<td>(0.102)</td>
<td>(0.0476)</td>
<td>(0.0684)</td>
</tr>
<tr>
<td>$z$-factors, $\alpha^\prime/\rho \alpha^\prime$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log hh income (Y)</td>
<td>0.124</td>
<td>0.0124</td>
<td>0.0357</td>
</tr>
<tr>
<td></td>
<td>(0.0443)</td>
<td>(0.00443)</td>
<td>(0.0231)</td>
</tr>
<tr>
<td>A’s remit. share</td>
<td>0.516</td>
<td>0.323</td>
<td>0.571</td>
</tr>
<tr>
<td></td>
<td>(0.179)</td>
<td>(0.0994)</td>
<td>(0.06955)</td>
</tr>
<tr>
<td>B’s mother edu.</td>
<td>-0.689</td>
<td>0.306</td>
<td>-0.385</td>
</tr>
<tr>
<td></td>
<td>(0.211)</td>
<td>(0.123)</td>
<td>(0.140)</td>
</tr>
<tr>
<td>A’s father edu.</td>
<td>0.473</td>
<td>0.0473</td>
<td>0.338</td>
</tr>
<tr>
<td></td>
<td>(0.158)</td>
<td>(0.0158)</td>
<td>(0.0877)</td>
</tr>
<tr>
<td>A’s age – B’s age</td>
<td>-0.00532</td>
<td>0.000075</td>
<td>-0.00604</td>
</tr>
<tr>
<td></td>
<td>(0.00689)</td>
<td>(0.00213)</td>
<td>(0.00420)</td>
</tr>
<tr>
<td>A’s edu. – B’s edu.</td>
<td>-0.0187</td>
<td>0.00411</td>
<td>-0.00786</td>
</tr>
<tr>
<td></td>
<td>(0.0175)</td>
<td>(0.00745)</td>
<td>(0.00110)</td>
</tr>
<tr>
<td>Multiple Spouses</td>
<td>-0.262</td>
<td>0.0811</td>
<td>-0.379</td>
</tr>
<tr>
<td></td>
<td>(0.218)</td>
<td>(0.0838)</td>
<td>(0.163)</td>
</tr>
<tr>
<td>Relative wage, $\delta_w/\rho (\delta_w - 1)$</td>
<td>0.121</td>
<td>-0.0879</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>(0.0256)</td>
<td>(0.00256)</td>
<td>(0.0402)</td>
</tr>
</tbody>
</table>

$N$ | 595 | 1726 | 1141

* Couple-corrected, bootstrapped standard errors in parenthesis. All regressions include year and month dummy variables, and the covariates discussed in the main text. The structural model is recovered by jointly estimating (4.13) and (4.14) and imposing the constraints in (4.17) and (4.18).
For a value of $\rho = 0.047$ we reject collective behaviour. In consequence, we set $\rho$ to 0.1 and re-estimate the model. For household income and education of A’s father we find the test supported with a $\chi^2(2) = 3.39$, probability of 18%. However, this result falls apart once A’s remittance share is added with $\chi^2(3)$ of 10.50, probability of 1.5%. So, we impose the first two restrictions to recover the structural equations derived in (4.13) and (4.14) above. The results are summarised in Table 4.4, column two and three.

Although our findings only partially support collective behaviour, they provide some interesting general results.

For instance, we find that women seem to fare better in richer households both in terms of relative leisure and consumption. An increase in A’s remittance share impacts positively on her private consumption and leisure share. The existence of multiple spouses decreases the first wife’s relative consumption, and education of the father has a positive effect.

In the first sample, education of A’s father also has a positive impact on leisure and the number of school-aged boys decreases female relative consumption. This might indicate that the women in this sample prefer boys over girls or the existence of cultural norms privileging their consumption over their mothers and sisters. An alternative interpretation could be that teenage boys not only depend on the benevolence of their parents but that they are themselves decision-makers (see Browning et al. (2007)).

The years since marriage, miscarriages, and community inheritance patterns do not have any significant impact. We exclude years since marriage and miscarriages as these variables are not available for all wives.

Figure 4.5 illustrates our results for the first sample that most supports the model, as we fail to reject the collective restrictions in (4.17) for two distribution factors. Except for the intercept, the Pareto weight is identified from either equation. This means we cannot recover $\mu$ on a metric but have to make an additional assumption. So we normalise the Pareto weight to unity if wages are equal and the father of the spouse has no education. On the vertical axis, the Figure illustrates changes in the Pareto weight if on the horizontal axis A’s income varies from being 20% to having 60% more than B. The parameter estimates are taken from the relative consumption equation. The illustration is based on the parametrisation of

$$
\mu = \exp(\alpha_0 + \alpha'z + \delta w \log(w_A/w_B) + \epsilon_{\mu}).
$$

The upper line highlights the shift in the Pareto weight if A’s father attended an educational establishment. In essence, the Figure highlights the elasticity of the
Pareto weight with respect to the wage. To put it differently, it illustrates that a one percent increase in her relative wage increases $\mu$ by 0.1 percent.

The equations are only modestly correlated, so that the efficiency gain of using SURE is limited and the $R^2$ are rather low, which means that we fail to explain a large fraction of the variation in relative leisure and private consumptions across partners in Tanzania.

Browning & Gørtz (2007) show that if we are willing to make strong assumptions about the correlation of the preferences and Pareto weight error terms, then we can decompose the unexplained variation into the proportion due to preference factors (and measurement error) and the Pareto weight.

In line with the formal illustration of the correlation between the two dependant variables in Section 4.5 we now assume, in addition, that the unobserved preference factors and measurement error are also uncorrelated from each other and independent of the Pareto factors:

$$E[\varepsilon_\theta \varepsilon_\mu] = E[\varepsilon_\tau \varepsilon_\mu] = E[\varepsilon_\theta \varepsilon_\tau] = 0.$$ 

If independence holds, then the correlation between the two error terms is driven by
\[ \varepsilon_{\mu} : \quad \text{cov}(\varepsilon_q, \varepsilon_l) = \text{cov}[(\varepsilon_\theta + \varepsilon_{\mu}), \rho(\varepsilon_\tau + \varepsilon_{\mu})] = \rho \sigma_{\mu}^2 \Rightarrow \sigma_{\mu}^2 = \text{cov}(\varepsilon_q, \varepsilon_l)/\rho. \]

By assumption \( \rho = 0.1 \), and from the SUR estimation we can retrieve \( \sigma_q \) and \( \sigma_l \). In addition, SUR provides the correlation coefficient of the error terms which allows the derivation of the covariance and so the identification of \( \sigma_{\mu}^2 \):

\[ \text{cov}(\varepsilon_q, \varepsilon_l) = \sigma_q \ast \sigma_l \ast \text{corr}(\varepsilon_q, \varepsilon_l). \]

Substituting in our estimates, we get \( \sigma_{\mu}^2/\sigma_q^2 = 0.035 \) and \( \rho^2 \sigma_{\mu}^2/\sigma_l^2 = 0.002 \).

If we believe these assumptions, then about 3.5% of the latent variation can be attributed to power in the relative expenditure while only 0.2% in the relative leisure equation.

### 4.7 Conclusion

In this Chapter, we modified Browning & Gørtz’s (2007) Collective Model to allow for the production of marketable crops within the household and missing labour markets which rural households in developing countries often face. Based on the theoretical model, we derived empirical conditions for the intra-couple distribution of private consumption and leisure and so for the determinants of the partners’ relative well-being. Using data from the Kagera Health and Development Survey 1991-1994 from Tanzania, we tested whether the Collective Model is supported by the data and tried to identify structural parameters of the model.

Including shadow wages that are thought to guide decision outcomes when labour markets are absent or distorted, potential wages and individual incomes, we consistently found that the relative wage has a positive impact on relative consumption and a negative impact on leisure. Although counterintuitive, this is evidence for the Collective Model or at least non-unitary household behaviour.

Also, our results suggest that women are better off in richer households, both in terms of relative private consumption and leisure. Increasing the remittance share received by the wife has a positive effect on her well-being. In addition, we find that inter-generational influences such as parental education seem to impact on the female position within the household.

While these findings are interesting in their own right, the Collective Model is only partially supported by the data. In particular, for the shadow and potential wage sample we did not find evidence for the Collective Model. Only restricting the sample to couples with positive individual incomes for both partners allowed
us to identify structural parameters of the model. In particular, we found that a one percent increase in the relative wage of the woman increases her decision weight by 0.1 percent. Accepting strong distributional assumption, we showed that about 3.5\% of the latent variation in the relative expenditure equation can be attributed to factors we cannot control for determining power, while only 0.2\% in the relative leisure equation.

Taken together, the results indicate that in the Tanzanian setting household decision outcomes seem not to be Pareto efficient. This is particularly reflected by the results of the shadow and potential wage samples. This finding can be explained by various factors, including, social norms and traditions which may guide household choices when access to functioning markets is limited, as is often the case in the rural setting of developing countries.
Chapter 5

Conclusions

The most commonly used model to analyse household behaviour is based on the assumption that partners’ preferences can be represented by a single utility function. The general rejection of this assumption opened the way for more realistic models of the household. The Collective Model has been established as the leading alternative model to analyse cooperative household behaviour. Like all other cooperative models, a central assumption is that partners yield Pareto efficient decision outcomes. Since partnerships are often long-term arrangements, Pareto efficiency has been argued to be a reasonable assumption.

In this Thesis, we used Browning & Gørtz’s (2007) Collective Model to analyse resource allocation in poor rural households in SSA. We derived conditions and requirements for testing and identifying the Collective Model and related the model to the existing cooperative literature. In line with a parallel strand of models that analyse farm households, we amended the model to introduce the production of multiple crops. Also, we considered labour market imperfections as typically faced by households in developing countries.

Based on this model, we derived a condition for an optimal allocation of female and male labour inputs in farm production of different crops. We showed that this condition is not dependent on the existence of a labour market. Applications of rigorous tests of efficiency of the intra-household allocation of labour inputs are scarce. Using data from the Uganda National Household Survey 2005/06, we tested whether the marginal rate of technical substitution between female and male labour inputs is equated over the crops. This optimality condition does not hold when we compare male- and female-controlled plots. Our results suggest that total farm output could be increased and so poverty reduced by reallocating male labour to female-controlled plots. The identified inefficiencies do not seem to be necessarily related to market integration, as often indicated in the literature, since we do not find inefficiencies when...
we compare plots of traded and non-traded crops. Our results can be interpreted to mean that traditional intra-household compensation mechanisms undermine optimal on-farm labour allocations; which seems incompatible with cooperative, and so with collective farm behaviour. An alternative interpretation could be that in developing countries social norms affect labour markets by generating wage differentials between male and female earnings which may not be related to, or simply do not reflect, marginal productivities. This may explain why women contribute more person days of labour to farm production than men or the division of labour between crops. However, we would still expect that within the same household the opportunity costs of time do not vary for the same individual. Alternatively, it could be that men and women face different prices for identical crops, which may explain why the marginal products are not equated over the crops. A good example for why this may be is that partners face different (transaction) costs for trading identical crops. This might be particularly relevant once an individual controls or manages the output of a certain crop. Our theoretical model does not take this into account.

Using data on individual consumption and time-use from the Kagera Health and Development Survey 1991-1994 from Tanzania, we jointly analysed time allocation and consumption choices of couples using the amended Browning & Gørtz (2007) model. Apart from Browning & Gørtz (2007) data, there are very few data sets that contain information on both private consumption and leisure for the same couple. The data we use allowed to construct measures of relative private consumption and leisure that are in line with Browning & Gørtz’s (2007) model. Also, there are very few studies that test and also try to identify structural parameters of the Collective Model in developing countries.

In our application, we found that husbands get a far bigger share in private consumption than their spouses and that leisure has a much more egalitarian intra-couple distribution. While Browning & Gørtz (2007) find leisure and consumption to be positively correlated we do not find this in our data. The lack of correlation can be interpreted to mean that leisure and private consumption are very differently valued and so distributed in Tanzanian households. A reason for why this might be is that in many developing countries labour markets are often absent or distorted and so partners lack lucrative employment opportunities outside the household. As a result, it is very complicated to determine the individual opportunity costs of time and, consequently, leisure might be very differently valued in developing countries than in developed countries. Given the absence of labour markets, the treatment of relative wages as central determinants of the partners’ relative well-being becomes difficult when analysing intra-household resource allocation using a Collective framework in
developing countries.

Using three different measures to overcome the problem of missing wage data, we found some interesting results. In particular, we found that women seem to fare better in richer households both in terms of relative leisure and consumption. Also, increasing the wife’s remittance share impacts positively on her relative leisure and consumption while the relative wage has the opposite effects on both decision outcomes. Using a sub-sample of couples with individual incomes for both partners allowed identifying structural parameters of the model and so we found that a one percent increase in the relative wage of the women increases her decision weight by 0.1 percent. Testing the Collective Model we found very limited support since we reject in two of the three sub-samples collective restrictions that have been proved to be necessary and sufficient for the model. Using a small sub-sample of couples we find support of the model but only for a sub-set of possible distribution factors. Although we find limited evidence for the Collective Model, our results are consistent with non-unitary household behaviour as we find distribution factors as well as relative wages to be relevant for the intra-couple distribution of well-being.

In conclusion, this PhD thesis provides evidence against the Unitary Model, but provides only very limited support of the Collective Model. Based on two East African case studies, which use two different data sets and analyse three different decision outcomes, we do not find household behaviour to be Pareto efficient. A problem that may arguably cause our results is that the data used in this study were not designed for analysing intra-household resource allocation and so we face many difficulties in the analysis. For instance, the data from Uganda is only aggregated at the level of adult male and female household members but not at the individual level and the Tanzanian data does not comprise diary information. Browning & Gørtz (2007) use very rich intra-household survey data. Their study also faces problems in identifying the Collective Model as the authors confirm collective behaviour only using two distribution factors and restrict their sample to full-time employed couples.

While this PhD thesis clearly highlights the need to collect more detailed and better data in developing countries that comprise information on intra-household time allocation, spending patterns, factors that determine the partners’ relative say as well as different household and individual income sources, it also leads to conclude that the Collective Model may have limitations when it is applied to developing countries. This conclusion is in line with studies that test different efficiency restrictions derived from a Collective Model in Africa, such as Udry (1996) and Duflo & Udry (2004).

As such, this Thesis adds to the evidence that recognises the need for further
research in modelling intra-household behaviour in developing countries, in which market structures, social norms and traditions may prevent household members from agreeing on first best Pareto efficient intra-household resource allocations. Given that household choices take place in a specific social, cultural and institutional setting and that the Collective Model is one of the leading economic models of the household, our results highlight that it might be beneficial to consider models used in other discipline areas, such as in psychology or anthropology, for complementing and enhancing the existing theoretical frameworks. Also, further research in modelling and especially identifying unique restrictions of household allocation patterns that might be of a non-cooperative nature may lead to better understand and model intra-household resource allocation in developing countries.
Bibliography


Bibliography


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Cameron, A. & Trivedi, P. (2009), *Microeconometrics using Stata*, StataCorp LP.


Appendix A

Notation

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<th>Time Allocation Variables</th>
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<tr>
<td>(f_A, f_B)</td>
<td>A’s, B’s time input into domestic food crop production</td>
</tr>
<tr>
<td>(c_A, c_B)</td>
<td>A’s, B’s time input into domestic cash crop production</td>
</tr>
<tr>
<td>(h_A, h_B)</td>
<td>A’s, B’s time input into public good production</td>
</tr>
<tr>
<td>(m_A, m_B)</td>
<td>A’s, B’s time spend in self- or wage employment</td>
</tr>
<tr>
<td>(l_A, l_B)</td>
<td>A’s, B’s time spend on leisure</td>
</tr>
<tr>
<td>(T)</td>
<td>Total individual time endowment</td>
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<table>
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<th>Consumption and Household Welfare</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>(q_H)</td>
<td>Quantity of material inputs into public good production</td>
</tr>
<tr>
<td>(q^m_A, q^m_B)</td>
<td>Quantity of private market-bought consumption of A, B</td>
</tr>
<tr>
<td>(q^f_A, q^f_B)</td>
<td>Quantity of subsistence consumption of A, B</td>
</tr>
<tr>
<td>(Q)</td>
<td>Quantity of the public good</td>
</tr>
<tr>
<td>(\lambda_A, \lambda_B)</td>
<td>Degree of caring of the partners</td>
</tr>
<tr>
<td>(\hat{\mu})</td>
<td>Distribution of power within the household</td>
</tr>
<tr>
<td>(\mu)</td>
<td>Pareto weight</td>
</tr>
<tr>
<td>(a_A, a_B)</td>
<td>Preference factors of A, B</td>
</tr>
<tr>
<td>(u_A, u_B)</td>
<td>Utility function of A, B</td>
</tr>
<tr>
<td>(\Psi_A, \Psi_B)</td>
<td>Social welfare function of A, B</td>
</tr>
<tr>
<td>(\Psi_h)</td>
<td>Social welfare function of the household</td>
</tr>
<tr>
<td>(w_A, w_B)</td>
<td>A’s wage, B’s wage</td>
</tr>
<tr>
<td>(z_1, z_2, \ldots, z_M)</td>
<td>Distribution factors</td>
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Production
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<tr>
<td>$F^Q$</td>
<td>Public good production function</td>
</tr>
<tr>
<td>$F^f$</td>
<td>Food crop production function</td>
</tr>
<tr>
<td>$F^c$</td>
<td>Cash crop production function</td>
</tr>
<tr>
<td>$\nu_f$</td>
<td>Returns to labour in food crop production</td>
</tr>
<tr>
<td>$\rho_f$</td>
<td>Substitution parameter in food crop production</td>
</tr>
<tr>
<td>$\delta_{Af}$</td>
<td>Distribution parameter of A in food crop production</td>
</tr>
<tr>
<td>$\nu_c$</td>
<td>Returns to labour in cash crop production</td>
</tr>
<tr>
<td>$\rho_c$</td>
<td>Substitution parameter in cash crop production</td>
</tr>
<tr>
<td>$\delta_{Ac}$</td>
<td>Distribution parameter of A in cash crop production</td>
</tr>
<tr>
<td>$\rho_a$</td>
<td>Substitution parameter of all crops</td>
</tr>
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### Parameters

<table>
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<tr>
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<tr>
<td>$\theta$</td>
<td>Relative preferences for consumption</td>
</tr>
<tr>
<td>$\gamma_{\theta}, \gamma_{\theta 0}, \varepsilon_{\theta}$</td>
<td>Parameter estimate, intercept, disturbance term of $\theta$</td>
</tr>
<tr>
<td>$\tau$</td>
<td>Relative preferences for leisure</td>
</tr>
<tr>
<td>$\gamma_{\tau}, \gamma_{\tau 0}, \varepsilon_{\tau}$</td>
<td>Parameter estimate, intercept, disturbance term of $\tau$</td>
</tr>
<tr>
<td>$\alpha' = (\alpha_1, \alpha_2, \ldots, \alpha_M)$</td>
<td>Vector of parameter estimates of $z_1, \ldots, z_M$</td>
</tr>
<tr>
<td>$\delta_w$</td>
<td>Parameter estimate of $\log(w_A/w_B)$</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Leisure curvature parameter</td>
</tr>
<tr>
<td>$\alpha_0$</td>
<td>Intercept of $\mu$</td>
</tr>
<tr>
<td>$\varepsilon_q, \varepsilon_l$</td>
<td>Error term of the relative consumption, leisure equation</td>
</tr>
</tbody>
</table>
Appendix B

The Slutsky Condition revisited

In this Appendix, we show how the addition of one decision-maker modifies Browning & Gørtz’s (2007) model and alters the Slutsky condition derived in (2.21). For facilitating illustration, we assume the child derives utility only from her own utility; in other words, she does not care for her parents. Nothing hinges on this assumption. Also, for the sake of illustration, we do not distinguish whether the child is a boy or a girl, or life-cycle considerations such as the child’s future potential income (see Qian (2008) for an elaboration). These are very interesting aspects, but cannot be covered in this Thesis and will be explored at some stage in the future by the author. In other words, we ignore that the child might be an investment good and only consider the present in which a household decides about the allocation of resources and the child may have a say in it.

We use the sub- and superscript $c$ to indicate the child. The child welfare function is defined over private consumption $q_m^c$, leisure $l_c$ and preference factors $a_c$. Note that we ignore the child production function and simply assume that she derives utility from spending time with her parents, $h_A$ and $h_B$, no matter that this may raise, in addition, her physical well-being and cognitive abilities. It is defined as:

$$
\Psi_c = u^c,
$$

where $u^c = (q_m^c, l_c, h_A, h_B; a_c)$. The difference between the household welfare function discussed in Section 2.0.1 and the one that takes children as decision-maker into account is twofold. First, partners also care for their children, which we model by the additional parameters $\lambda_A^c$ and $\lambda_B^c$. Second, the distribution of power $\tilde{\mu}$ is defined for three people, which means that we have to model a weight for $A$, $\tilde{\mu}_A$, and $B$, $\tilde{\mu}_B$. The weight of the child $\tilde{\mu}_c$ is retrieved through the assumption that the sum of the
weights adds to unity:
\[ \tilde{\mu}_c = 1 - \hat{\mu}_A - \hat{\mu}_B. \]

So, household welfare is now defined as:
\[
\Psi_h = \tilde{\mu}_A \Psi_A + \tilde{\mu}_B \Psi_B + (1 - \hat{\mu}_A - \hat{\mu}_B) \Psi_c \\
= \hat{\mu}_A (u^A + \lambda_A^B u^B + \lambda_A^c u^c) + \hat{\mu}_B (u^B + \lambda_B^A u^A + \lambda_B^c u^c) + (1 - \hat{\mu}_A - \hat{\mu}_B) u^c \\
= [\hat{\mu}_A + \lambda_B^B \hat{\mu}_B] u^A + [\hat{\mu}_B + \lambda_A^B \hat{\mu}_A] u^B + [1 + \tilde{\mu}_A (\lambda_A^c - 1) + \tilde{\mu}_B (\lambda_B^c - 1)] u^c \\
= \mu_A u^A + \mu_B u^B + \mu_c u^c.
\]

Again, we can redefine \( \Psi_h \) by using the weight of B, \( \mu_B \), for normalisation, so that
\[
\mu_A = \mu_A / \mu_B, \mu_c = \mu_c / \mu_B, \mu_B / \mu_B = 1 \quad \text{and} \quad \Psi_h = \mu_A u^A + u^B + \mu_c u^c.
\]

(B.1)

Maximising (B.1) subject to a slightly modified budget constraint
\[
p^H q_H + p^m (q^m_A + q^m_B + q^m_c) + w_A (h_A + l_A) + w_B (h_B + l_B) = (w_A + w_B) T + y,
\]
yields demand functions of the form:
\[
q = (q^m_A, q^m_B, q^m_c, Q) = q \left(p^h, p^m_A, p^m_B, p^m_c, Y, \mu_A, \mu_c; a_A, a_B, a_c\right).
\]

As before, taking derivatives with regard to the price of the private consumption good of B for private demand of A, and following Browning et al. (2007), the Slutsky Equation is now defined as
\[
\frac{\partial \hat{q}_A^m}{\partial p_B^m} = \frac{\partial q_A^m}{\partial p_B^m} + q_B^m \frac{\partial \hat{q}_A^m}{\partial Y} + \frac{\partial q_A^m}{\partial \mu_A} \left( \frac{\partial \mu_A}{\partial p_B^m} + q_B^m \frac{\partial \mu_A}{\partial Y} \right) + \frac{\partial q_A^m}{\partial \mu_c} \left( \frac{\partial \mu_c}{\partial p_B^m} + q_B^m \frac{\partial \mu_c}{\partial Y} \right).
\]

Compared to the Slutsky Equation in (2.21), the addition of one decision-maker adds a further term as the price variation also affects the second Pareto weight. In fact, given the normalisation of the Pareto weight there will be \( n - 1 \) of such effects, where \( n \) is the number of decision-makers. These conditions are called ‘generalised Slutsky conditions’ as there is the standard Slutsky matrix plus an additional matrix of rank \( n - 1 \). In a two decision-maker household this matrix is of rank one, in a three decision-maker household of rank two, and so on.
Appendix C

First-Order Conditions

\[ \mathcal{L} = \mu u^A(q^m_A, l_A, F^Q) + u^B(q^m_B, l_B, F^Q) + \gamma [p^c F^c + p^f (F^f - q^f_A - q^f_B) + y + w_A m_A + w_B m_B - p^m (q^m_A + q^m_B) - p^H q_H] + \alpha_A (T - l_A - c_A - f_A - h_A - m_A) + \alpha_B (T - l_B - c_B - f_B - h_B - m_B) + \theta_A m_A + \theta_B m_B + \sigma_A f_A + \sigma_B f_B + \varepsilon (\bar{m}_A - m_A) \]
\[
\frac{\partial L}{\partial f_A} : p' \frac{\partial F_f}{\partial f_A} = \frac{\alpha_A}{\gamma} - \frac{\sigma_A}{\gamma} \quad \frac{\partial L}{\partial c_A} : p_c \frac{\partial F_c}{\partial c_A} = \frac{\alpha_A}{\gamma}
\]  \hspace{1cm} (C.1)

\[
\frac{\partial L}{\partial f_B} : p' \frac{\partial F_f}{\partial f_B} = \frac{\alpha_B}{\gamma} - \frac{\sigma_B}{\gamma} \quad \frac{\partial L}{\partial c_B} : p_c \frac{\partial F_c}{\partial c_B} = \frac{\alpha_B}{\gamma}
\]  \hspace{1cm} (C.3)

\[
\frac{\partial L}{\partial \sigma_A} : f_A \geq 0 \quad \sigma_A f_A = 0 \quad \sigma_A \geq 0
\]  \hspace{1cm} (C.2)

\[
\frac{\partial L}{\partial \sigma_B} : f_B \geq 0 \quad \sigma_B f_B = 0 \quad \sigma_B \geq 0
\]  \hspace{1cm} (C.4)

\[
\frac{\partial L}{\partial m_A} : w = \frac{\alpha_A}{\gamma} - \frac{\theta_A}{\gamma} + \frac{\varepsilon}{\gamma}
\]  \hspace{1cm} (C.5)

\[
\frac{\partial L}{\partial \theta_A} : m_A \geq 0 \quad \theta_A m_A = 0 \quad \theta_A \geq 0
\]  \hspace{1cm} (C.6)

\[
\frac{\partial L}{\partial m_B} : w = \frac{\alpha_B}{\gamma} - \frac{\theta_B}{\gamma}
\]  \hspace{1cm} (C.7)

\[
\frac{\partial L}{\partial \theta_B} : m_B \geq 0 \quad \theta_B m_B = 0 \quad \theta_B \geq 0
\]  \hspace{1cm} (C.8)

\[
\varepsilon(\bar{m}_A - m_A) = 0 \quad \varepsilon \geq 0
\]  \hspace{1cm} (C.9)
Appendix D

Wages

Figure D.1: Cross-correlation of the different wage measures

Graphs by S1Q2: Sex
Table D.1: Relative consumption and leisure system reduced form estimates, potential wage sample

<table>
<thead>
<tr>
<th>Preference factors, $\beta_q' / \beta_r'$</th>
<th>$\log(q^m_A/q^m_B)$</th>
<th>$\log(l_A/l_B)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. fem. children</td>
<td>0.0531</td>
<td>-0.00410</td>
</tr>
<tr>
<td>age 0 to 5</td>
<td>(0.0726)</td>
<td>(0.0214)</td>
</tr>
<tr>
<td>No. fem. children</td>
<td>0.0434</td>
<td>-0.0235</td>
</tr>
<tr>
<td>age 6 to 14</td>
<td>(0.0661)</td>
<td>(0.0258)</td>
</tr>
<tr>
<td>No. male children</td>
<td>-0.0686</td>
<td>-0.00671</td>
</tr>
<tr>
<td>age 0 to 5</td>
<td>(0.0746)</td>
<td>(0.0272)</td>
</tr>
<tr>
<td>No. male children</td>
<td>-0.0813</td>
<td>-0.00420</td>
</tr>
<tr>
<td>age 6 to 14</td>
<td>(0.0694)</td>
<td>(0.0265)</td>
</tr>
<tr>
<td>$z$-factors, $\beta_q'' / \beta_r''$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>log hh income (Y)</td>
<td>0.0292</td>
<td>0.0345</td>
</tr>
<tr>
<td></td>
<td>(0.0229)</td>
<td>(0.00705)</td>
</tr>
<tr>
<td>A’s remit. share</td>
<td>0.563</td>
<td>0.0650</td>
</tr>
<tr>
<td></td>
<td>(0.0999)</td>
<td>(0.0494)</td>
</tr>
<tr>
<td>B’s mother edu.</td>
<td>-0.386</td>
<td>0.147</td>
</tr>
<tr>
<td></td>
<td>(0.142)</td>
<td>(0.0702)</td>
</tr>
<tr>
<td>A’s father edu.</td>
<td>0.295</td>
<td>0.0764</td>
</tr>
<tr>
<td></td>
<td>(0.0877)</td>
<td>(0.0371)</td>
</tr>
<tr>
<td>A’s age – B’s age</td>
<td>-0.00907</td>
<td>0.00363</td>
</tr>
<tr>
<td></td>
<td>(0.00412)</td>
<td>(0.00135)</td>
</tr>
<tr>
<td>A’s edu. – B’s edu.</td>
<td>-0.00631</td>
<td>0.00867</td>
</tr>
<tr>
<td></td>
<td>(0.0109)</td>
<td>(0.00402)</td>
</tr>
<tr>
<td>Multiple Spouses</td>
<td>-0.399</td>
<td>0.0655</td>
</tr>
<tr>
<td></td>
<td>(0.165)</td>
<td>(0.0528)</td>
</tr>
<tr>
<td>Relative wage, $\beta_w q' / \beta_r w'$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\log(w_A/w_B)$</td>
<td>0.0942</td>
<td>-0.0906</td>
</tr>
<tr>
<td></td>
<td>(0.0343)</td>
<td>(0.00343)</td>
</tr>
</tbody>
</table>

$N = 1726$

* Couple-corrected, bootstrapped standard errors in parenthesis. The wage measures are based on selection-corrected wage estimations discussed in Section 4.6.2. All regressions include year and month dummy variables, and the covariates discussed in the main text. The reduced form model jointly estimates Equation (4.15) and (4.16) using SURE. Restriction $\beta_r w = 0.1(\beta_w q - 1)$ imposed.