

Horticultural Households Profit Optimization and the Efficiency of Labour
Contract Choice

By

Ndoye Niane, Aifa Fatimata; Burger, Kees; and Butle, Erwin

Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010.

Horticultural Households Profit Optimization and the Efficiency of Labour Contract Choice

Aifa Fatimata NDOYE NIANE

PhD candidate

Dr. Kees BURGER

Prof. Dr. Erwin BULTE

Development Economics Group

Social Sciences Department

Wageningen University, The Netherlands

E-mail: Aifa.Ndoye@wur.nl

Content

- 4.1. Introduction
- 4.2. A literature review on land tenancy
- 4.3. The theory
- 4.4. Household modelling and labour
- 4.5. The empirical analysis
 - 4.5.1. Functional forms and variables
 - 4.5.2. Endogeneity and the choice of estimator
- 4.6. Empirical results and discussion
 - 4.6.2. An estimation of the production functions
 - 4.6.3. Household profit optimization across plots under a sharecropping labour contact and a wage labour contract
 - 4.6.4. An efficiency test of the labour contract choice based on optimum profit: the sharecropping labour contract versus the wage labour contract
- 4.7. Conclusion and policy implications

Abstract

In agriculture, the coexistence of different forms of land tenancy or labour contract has been explained so far by several theories related to Marshallian inefficiency, incentives, risk sharing, and transaction costs, including supervision costs. These theories and the empirical evidences have greatly contributed to explain the reasons behind land tenancy or labour contract choice. This study follows up on this. Moreover, it intends to take a further step by focusing particularly on the production technologies at plot level, and by designing and testing a theoretical model based on household profit optimization. This model will take into account the supervision costs of labour (i) to compare optimum profit derived from plots based on household labour, a sharecropping labour contract, and a wage labour contract, controlling for irrigation equipment (ii) to test the efficiency of the labour contract choice using data from Senegal's horticultural zone.

As expected, the production elasticity of labour decreases when improved irrigation equipment like a motor pump is used. The technology displays an increasing return to scale on plots without a motor pump and a constant return to scale on plots irrigated with a motor pump. While on plots without a motor pump the sharecropping contract is the efficient labour contract choice, leading to a higher optimum profit for the household, on plots irrigated with a motor pump, the wage contract is the best labour contract choice. Consequently, we can conclude from this finding that the use of a motor pump drives out the sharecropping contract in favour of household labour and the wage labour contract.

Key words: *land tenancy, labour, sharecropping, wage, contract, supervision, household, profit optimization, efficient, irrigation equipment, horticulture, Senegal*

1.1. Introduction

In Senegal, like in most African countries, horticultural households' production systems are highly labour-intensive with a low capital input. The area of land that a household can crop out of the owned land is mainly conditional on the availability of labour. While some households can rely only on their household labour, others take recourse to hired labour. This hired labour can be based on a sharecropping contract or on a wage contract.

Sharecropping is a form of tenancy based on an agreement between the landowner and the tenant in terms of input contribution and output sharing. Sharecropping has a long, worldwide history, but the types of agreement between landowner and tenant vary from one location to another. In Senegal, for instance, sharecropping is chiefly used on horticultural crops that are cash crops. The agreement is informal, verbal, and hence not written down; it is only witnessed by a third party, who can be a parent or a friend of the landowner, or the head of the village. The agreement is for one horticultural season and is generally based on the share in two equal parts of the profit of production. One part is for the sharecropper, who provides the labour force and expertise required for the production. The other part is for the landowner, who provides to the sharecropper the land plot as well as all the required inputs (seeds, organic and mineral fertilizers, pesticides, fuel) and some facilities, such as housing, feeding, and occasionally health care.

For hired wage labour, on the other hand, the landowner pays a fixed wage to the worker. Usually, the wage is paid at the end of the cropping season rather than monthly, in agreement with the worker. The landowner usually provides the same facilities to the hired wage workers as is the case in sharecropping contracts, particularly when they come from far away.

More and more land tenancy based on fixed rent is less observed in Senegal. On the one hand, only very rarely are households willing to rent out their land because they fear to lose their land rights, due to the land law providing the right to continued occupancy to the person who cultivates the land for a couple of consecutive years. On the other hand, the tenants are generally not only landless, but they also are so poor that they lack the financial means that would enable them to rent in land and to provide the inputs required for the production. Both for the households' landlord and the landless tenants, who have a limited liability, contracting based on sharecropping and wage are the remaining alternatives. A household's choice between these two labour contracts varies in general, depending on the plot size cropped and

the level of the irrigation equipment. The reasons behind the labour contract choice need to be further investigated. While several theoretical and empirical studies have provided valuable information about land tenancy, comparing sharecropping to a fixed rent, very few studies have scrutinized the choice between a sharecropping and a wage labour contract, in particular in Africa and in a context of modernization of the agricultural production systems.

Are the contracts with hired labour, either as sharecroppers or as wage labourers, comparable to household labour in terms of household profit optimization? At the plot level, controlling for irrigation equipment, did the household make the efficient labour contract choice, the choice that provides a higher optimum profit? Did the household use inputs efficiently across labour contract? This chapter tries to answer these research questions through an in-depth investigation of plot-level profit optimization over the labour arrangement made. Therefore, after a survey of the literature on land tenancy and the specification of the theoretical and empirical models, this chapter will focus on a comparative analysis of household profit optimization across plots under household labour, a sharecropping labour contract, or a wage labour contract. Then, the chapter will provide evidence on the efficiency of the labour contract choice and the inputs used at plot level. From the results, a conclusion will be drawn with some policy implications.

1.2. A literature review on land tenancy

In agriculture, a broad assortment of land tenancy forms is practised worldwide. While some land lease arrangements are based on sharecropping and a fixed rental, others are in the form of wage labour. In fixed rental tenancy, the tenant pays a fixed rent to the landowner, provides all inputs and earns the entire output. In share tenancy or sharecropping, the landlord provides the land plot and agrees with the tenant the terms of the share of input costs and output, depending on the location. These land or labour contracts can be seen as suitable strategies, developed to equate land-man ratios over households with different, relative endowments of land and labour.

Many empirical studies have examined the reasons behind the existence and the continuation of sharecropping and its social, economic, and policy implications, especially in Asia and, to a lesser extent, in Africa (Stiglitz, 1989; Ray 1998; Ghatak and Pandey, 2000; Garrett and Xu, 2003; Otsuka and Hayami, 1988; Ahmed *et al.*, 2002; Pender *et al.*, 2002; Benin *et al.*, 2005; Reiersen, 2001; Araujo and Bonjean, 1999; Canjels, 1996). Despite numerous studies done,

land tenancy still remains an attractive subject of research, as shown by several recent publications by Ahmed *et al.* (2002), Benin *et al.* (2005), Tesfay (2006), Kassie and Holden (2007), Holden (2007), and Braido (2008).

The existing theories of sharecropping were subject to critical reviews in terms of the general theory of agency or principal-agent relations. The advantage of sharecropping was associated with its savings in transaction costs, but also with risk sharing (Stiglitz, 1989). As supervision costs are part of the transaction costs, obviously, a wage labour contract may involve higher transaction costs than sharecropping does (Eswaran and Kotwal, 1985). The supervision of the work effort of wage labour is more costly than that pertaining to sharecroppers (Ahmed *et al.*, 2002). Otsuka and Hayami (1988) have emphasised the importance of supervision and other forms of transaction costs for the use of hired wage labour. While in a wage labour contract, the supervision is undertaken by the landlord and in a fixed rental contract by the tenant, in a sharecropping contract, both tenant and landlord have incentives to self-supervise so as to mitigate any moral hazard behaviour (Eswaran and Kotwal, 1985). The supervision time spent by the household's landlord to prevent hired workers from cheating is an important part of the labour input, particularly in a wage labour contract. The supervision costs evaluated at the household's off-farm wage rate may have an impact on the profitability and the efficiency of the labour contract choice to make. This research intends to provide theoretical and empirical evidence on this impact.

Under uncertain circumstances, the existence of sharecropping can be justified by its role in risk sharing with and without any enforcement, as long as both landlord and tenant are risk-averse (Ahmed *et al.*, 2002). While in a fixed rental arrangement, the tenant bears the entire risk linked to the production, in a wage labour contract, it is the landlord who bears the whole risk, and in a sharecropping contract, it is both the landlord and the tenant who share the risk. As demonstrated theoretically (Ray, 1998), a sharecropping contract lowers the return to the tenant in a good state and raises it in a bad state, comparatively to a fixed rent. Benin *et al.* (2005) have found that factors increasing the production risk are in favour of sharecropping or risk-pooling arrangements, while factors reducing the risk tend to shift land tenancy away from sharecropping and in favour of fixed rent leases. All recent models, including that of Pender and Fafchamps (2000), incorporate some degree of risk sharing between landlord and tenant. Sharecropping is viewed in the literature as a constrained efficient tenancy, which balances incentives and risk sharing (Braido, 2008).

According to the Marshallian argument, supported by several authors, share tenancy is inefficient because the tenant receives only a share of his own marginal product of labour as marginal revenue. Contrary to this standard opinion that criticized sharecropping because it is inefficient and dampens incentives and productivity, according to Stiglitz (1989), Ray (1998), Ghatak and Pandey (2000), and Garrett and Xu (2003), sharecropping is desirable because it increases incentives, particularly compared to a wage labour contract. Benin *et al.* (2005), Tesfay (2006), Braido (2008) and others have provided empirical evidence that challenges the conventional wisdom connecting sharecropping to disincentives. In particular with regard to sharecropping in a Senegalese context, in which the landlord provides all the inputs, the tenant actually would have incentives to work hard in order to maximize his profit, especially in case he does not have any other alternative off-farm work or can only work at a low wage rate. It has been demonstrated that the Marshallian inefficiency implied in many of the share tenancy models (Binswanger *et al.*, 1995; Otsuka and Hayami, 1988; Ahmed *et al.*, 2002; Pender *et al.*, 2002; Reiersen, 2001; and Araujo and Bonjean, 1999) was a consequence of a partial or incomplete analysis, in which the optimizing behaviour of landlords was neglected, the characteristics of tenants and plots were not taken into account, or the range of contract choice was very limited (Otsuka and Hayami, 1988). For instance, in Senegal, while the landlords have enough land but suffer from a labour shortage, the sharecroppers or tenants are landless because they come from other, dry areas, which are inappropriate for any horticultural production.

Altogether, the review of the literature shows that, so far, the coexistence of the different forms of land tenancy or labour contract have been explained by different theories relative to Marshallian inefficiency, incentives, transaction costs, including the supervision costs of labour, moral hazard, risk sharing, screening, and eviction. These theories and the empirical evidence have greatly contributed to explain the reasons behind land tenancy or labour contract choice. This study follows up on this and also intends to take a further step, by focusing particularly on the production technologies at plot level and by making thorough use of a theoretical model based on household profit optimization, to compare the optimum profit derived from plots based on household labour, a sharecropping labour contract, or a wage labour contract. This chapter does not take risk behaviour into account, which we will deal with in the next chapter, but focuses mainly on supervision costs. This chapter therefore attempts to find out to what extent the supervision rate and the opportunity wages ratios of the landlord, the sharecropper, and the wage worker may determine the efficiency of the labour

contract based on household profit optimization. In order to test this efficiency of the labour contract choice, for each plot, simulations were made to see whether another labour contract than presently applied would have yielded a higher profit to household. In doing so, this research makes a scientific contribution to the theory of land tenancy, providing theoretical and empirical evidence on household profit optimization across labour contract, by using data from the Niayes Zone in Senegal.

1.3. Household modelling and labour

Horticultural production is highly labour-demanding. In Senegal, for most households, household labour is not sufficient to crop all the land owned. Instead of leaving the land idle or renting it out, households try to use the area of land as much as possible. Therefore, many households take recourse to hired labour, some based on sharecropping contracts, while others prefer to hire labour based on wage contracts. What are the reasons behind these labour contract choices? Observations show that households that have large size farms and more advanced irrigation equipment are likely to opt for hired wage labour. Households with a medium size farm with relatively less irrigation equipment opt for sharecropping. Households with small farms and less equipment have a tendency to limit themselves to their own household labour.

Let us consider the problem faced by the household of allocating labour and non-labour inputs to a given plot of land. We denote the opportunity cost or wage of household labour by w_e , of sharecroppers by w_o , and of hired workers by w .

Household labour

Accordingly, in case the household uses only household labour L_h , the profit maximization problem can be specified as:

$$\text{Max } \pi_h = p_y Y(L_h, X_h) - p_x X_h + w_e L_e \quad (4.1)$$

with respect to L_h and X_h .

subject to :

- a time constraint: $L = L_e + L_h$ (4.2)

- a production constraint: $Y_h = CL_h^\lambda X_h^\gamma$

If we specify the production function to be Cobb-Douglas, land-fixed and $\lambda + \gamma < 1$, we have

$$\text{Max } \pi_h = p_y CL_h^\lambda X_h^\gamma - p_x X_h + w_e(L - L_h) \quad (4.3)$$

First-order conditions (FOC):

- With respect to L_h , the total household labour used on the plot ,

$$\begin{aligned} \frac{\partial \pi_h}{\partial L_h} = 0 &\Leftrightarrow p_y \lambda CL_h^{\lambda-1} X_h^\gamma - w_e = 0 \\ \Leftrightarrow L_h^* &= \frac{p_y \lambda Y_h}{w_e} \end{aligned} \quad (4.4)$$

- With respect to X_h , the total inputs used on the plot:

$$\begin{aligned} \frac{\partial \pi_h}{\partial X_h} = 0 &\Leftrightarrow p_y \gamma CL_h^\lambda X_h^{\gamma-1} - p_x = 0 \\ \Leftrightarrow X_h^* &= \frac{p_y \gamma Y_h}{p_x} \end{aligned} \quad (4.5)$$

- Knowing L_h^* , the optimum household labour, and X_h^* , the optimum input, we can derive Y_h^* , the optimum production to supply by household to maximize profit:

$$\begin{aligned} Y_h &= CL_h^{\lambda} X_h^{\gamma} \\ \Leftrightarrow Y_h &= C \left(\frac{\lambda p_y Y_h}{w_e} \right)^\lambda \left(\frac{\gamma p_y Y_h}{p_x} \right)^\gamma \\ \Leftrightarrow Y_h^* &= C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w_e} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{\lambda+\gamma}{1-\lambda-\gamma}} \end{aligned} \quad (4.6)$$

- The optimum household labour L_h^* and input X_h^* can be expressed as follows, as a function of prices and wage:

$$\begin{aligned}
L_h^* &= C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w_e} \right)^{\frac{1-\gamma}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}} \\
X_h^* &= C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w_e} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{1-\lambda}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}}
\end{aligned} \tag{4.7}$$

Hired wage labour under supervision

If the household opts to hire labour based on a wage contract L_w at wage w , we assume that for each unit of wage labour, σ units of supervision by the household are needed, at a wage rate of household off-farm work w_e . This is the household's labour opportunity cost of supervising wage labour instead of doing off-farm work. When the household opts for hiring labour based on a wage contract, the profit maximization problem is:

$$\text{Max } \pi_w = p_y Y(L_w, X_w) - p_x X_w - wL_w - \sigma w_e L_w \tag{4.8}$$

$$\text{subject to production constraint: } Y_w = CL_w^\lambda X_w^\gamma \tag{4.9}$$

$$\text{Max } \pi_w = p_y CL_w^\lambda X_w^\gamma - p_x X_w - L_w(w + \sigma w_e)$$

This leads to the following expressions for optimal production and inputs:

$$Y_w^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w + \sigma w_e} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{\lambda+\gamma}{1-\lambda-\gamma}} \tag{4.10}$$

$$L_w^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w + \sigma w_e} \right)^{\frac{1-\gamma}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}}$$

$$X_w^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\lambda}{w + \sigma w_e} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{p_x} \right)^{\frac{1-\lambda}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}}$$

Compared with the first case of using household labour only, we see that the production and use of inputs are lower if $w + \sigma w_e$ is greater than w_e .

Sharecropping labour

Instead of hiring labour based on a wage contract, a household may opt to hire labour based on a sharecropping contract. In Senegal, under the usual sharecropping contract, the landlord pays for all the inputs. These inputs are deducted from the revenue, to obtain the profit that is shared between the landlord and the tenant. The usual share is 50%-50%, but to generalize, the share of profit received by the tenant is set to β and that received by the landlord to $1-\beta$.

From a total labour endowment L_t , the tenant or worker can allocate labour L_s to sharecropping and L_o to alternative sources of off-farm work at wage w_o . So, the tenant's profit maximizing problem is:

$$\text{Max } \pi_{st} = \beta[p_y Y(L_s, X_s) - p_x X_s] + w_o L_o \quad (4.11)$$

subject to :

- a production constraint: $Y_s = C.L_s^\lambda X_s^\gamma$ (4.12)
- a time constraint: $L_t = L_s + L_o$

FOC :

$$\begin{aligned} \frac{\partial \pi_{st}}{\partial L_s} = 0 &\Leftrightarrow \beta p_y \lambda C L_s^{\lambda-1} X_s^\gamma - w_o = 0 \\ \Leftrightarrow L_s^* &= \left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C} \right)^{\frac{1}{\lambda-1}} \end{aligned} \quad (4.13)$$

Knowing the optimum sharecropping labour L_s^* , the optimum production Y_s^* can be deduced:

$$Y_s^* = C \left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C} \right)^{\frac{\lambda}{\lambda-1}} X_s^\gamma \quad (4.14)$$

The household's profit maximization problem when opting for a sharecropping labour contract is:

$$\text{Max } \pi_s = (1 - \beta)[p_y Y_s^*(L_s^*, X_s) - p_x X_s] \quad (4.15)$$

with respect to X_s , and with

$$Y_s^* = C \left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C} \right)^{\frac{\lambda}{\lambda-1}} X_s^\gamma$$

or

$$\begin{aligned} \text{Max} \pi_s &= (1-\beta) \left[p_y C \left(\frac{w_o X_s^{-\gamma}}{\beta p_y \lambda C} \right)^{\frac{\lambda}{\lambda-1}} X_s^\gamma - p_x X_s \right] \\ \Leftrightarrow \text{Max} \pi_s &= (1-\beta) \left[p_y C \left(\frac{w_o}{\beta p_y \lambda C} \right)^{\frac{\lambda}{\lambda-1}} X_s^{\frac{-\gamma}{\lambda-1}} - p_x X_s \right] \end{aligned}$$

FOC:

- With respect to X_s , the total inputs used on a sharecropped plot:

$$\frac{\partial \pi_s}{\partial X_s} = 0 \Leftrightarrow (1-\beta) \left[p_y C \left(\frac{w_o}{\beta p_y \lambda C} \right)^{\frac{\lambda}{\lambda-1}} \left(\frac{-\gamma}{\lambda-1} \right) X_s^{\frac{1-\lambda-\gamma}{\lambda-1}} - p_x \right] = 0 \quad (4.16)$$

$$\Leftrightarrow X_s^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\beta \lambda}{w_o} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{(1-\lambda)p_x} \right)^{\frac{1-\lambda}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}}$$

- Knowing the optimum X_s^* , the optimum sharecropping labour L_s^* can be expressed as follows as a function of prices and wage:

$$\Leftrightarrow L_s^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\beta \lambda}{w_o} \right)^{\frac{1-\gamma}{1-\lambda-\gamma}} \left(\frac{\gamma}{(1-\lambda)p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{1}{1-\lambda-\gamma}} \quad (4.17)$$

- And the optimal production is

$$Y_s^* = C^{\frac{1}{1-\lambda-\gamma}} \left(\frac{\beta \lambda}{w_o} \right)^{\frac{\lambda}{1-\lambda-\gamma}} \left(\frac{\gamma}{(1-\lambda)p_x} \right)^{\frac{\gamma}{1-\lambda-\gamma}} p_y^{\frac{\lambda+\gamma}{1-\lambda-\gamma}} \quad (4.18)$$

Knowing the optimum production, the optimum labour and the optimum inputs, the maximum profits for the household can be deduced and expressed as follows as a function of prices and wage:

- on plots based on household labour,

$$\pi_h^* = p_y Y_h^* (1 - \lambda - \gamma) \quad (4.19)$$

- on plots based on a wage labour contract:

$$\pi_w^* = p_y Y_w^* (1 - \lambda - \gamma) \quad (4.20)$$

- on plots based on a sharecropping contract:

$$\pi_s^* = (1 - \beta) p_y Y_s^* \left(1 - \frac{\gamma}{1 - \lambda}\right) \quad (4.21)$$

The choice between the three land tenancy regimes is based on which profitability is higher:

π_h^* or π_s^* or π_w^* .

At the given plot size, the household prefers sharecropping over using hired wage workers if

$$\pi_s^* = (1 - \beta) p_y Y_s^* \left(1 - \frac{\gamma}{1 - \lambda}\right) > \pi_w^* = p_y Y_w^* (1 - \lambda - \gamma) \quad (4.22)$$

Or the profit ratio R

$$R = \frac{\pi_s^*}{\pi_w^*} > 1 \quad (4.23)$$

$$\Leftrightarrow (1 - \beta) \beta^{\frac{\lambda}{1 - \lambda - \gamma}} (1 - \lambda)^{\frac{\lambda - 1}{1 - \lambda - \gamma}} \left(\frac{w_0}{w_h}\right)^{\frac{-\lambda}{1 - \lambda - \gamma}} > 1$$

Here, w_h may include supervision costs ($w_h = w + \sigma w_e$). For $\sigma=0$ (no supervision), $w_h = w$ and if $w_o = w = w_h$, i.e. the sharecropper could also work as a hired worker, this is the case if the profit ratio denoted R0:

$$R0 = \frac{(1-\beta)}{(1-\lambda)} \left(\frac{\beta^\lambda}{(1-\lambda)^\gamma} \right)^{\frac{1}{1-\lambda-\gamma}} > 1 \quad (4.24)$$

For $\beta=0.5$, this will not be the case for values of λ and γ that sum to less than 1. Figure 4.2 shows the values of the profit ratio R0 for $\gamma=0.1$ and varying values of λ . It also shows the values of the wage ratio w_o / w_h at which the profit ratio R is equal to one (equation 4.23).

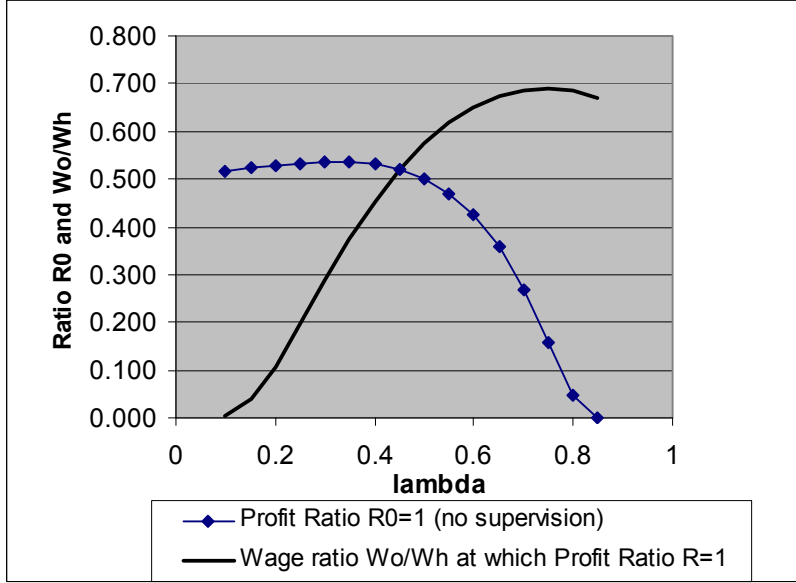


Figure 4.2: Values of the profit ratio R0 (no supervision and the sharecropping opportunity wage equals the wage paid by the household: $\sigma=0$ and $w_o = w = w_h$), and values of the wage ratio $\frac{w_o}{w_h}$ (opportunity cost of sharecropper / wage including supervision cost) at which the profit ratio R ($\frac{\pi_s^*}{\pi_w^*}$) is equal to one for $\gamma=0.1$ and varying values of λ .

Hence, sharecropping would be preferred only if the wages are not equal. If the profit ratio R0 takes on a value of 0.5 (as the graph shows to be perfectly possible), in order to make sharecropping the preferred option for the household, we would require a ratio for the wages to be

$$\left(\frac{w_o}{w_h} \right)^{\frac{-\lambda}{1-\lambda-\gamma}} > 2 \quad (4.25)$$

or the sharecropper's opportunity wage to be far below that of the hired worker plus supervision costs ($w_o < 1.74w_h$).

Sharecropping would be preferred, for example, if the supervision costs are 60%, the hired wages are the same as the sharecropper's opportunity costs, and lambda exceeds 0.55.

High values of λ typically coincide with technologies that are largely based on labour. For in these cases, high shares of the revenues would accrue to the factor labour. If λ falls, due to other factors of production that demand a share of the revenues, such as land scarcity, other inputs or capital (such as motor pumps), the opportunities for sharecroppers fall. Only at very low relative wages would sharecropping still be the preferred option for landlords.

At large plots that would typically show a relatively ample availability of land compared to labour, we would expect relatively high values of λ , and more incidence of sharecropping than there would be at very small plots. Similarly, with other capital inputs, such as motor pumps, we should expect less use of sharecroppers.

Comparing to household labour, a sharecropping contract would be preferred if:

$$(1 - \beta)\beta^{\frac{\lambda}{1-\lambda-\gamma}}(1 - \lambda)^{\frac{\lambda-1}{1-\lambda-\gamma}}\left(\frac{w_0}{w_e}\right)^{\frac{-\lambda}{1-\lambda-\gamma}} > 1 \quad (4.26)$$

or

$$\begin{aligned} \left(\frac{w_0}{w_e}\right)^{\frac{-\lambda}{1-\lambda-\gamma}} &> (1 - \beta)^{-1}\beta^{\frac{-\lambda}{1-\lambda-\gamma}}(1 - \lambda)^{\frac{1-\lambda}{1-\lambda-\gamma}} \\ \Leftrightarrow \frac{w_0}{w_e} &\leq (1 - \beta)^{\frac{1-\lambda-\gamma}{\lambda}}\beta(1 - \lambda)^{\frac{\lambda-1}{\lambda}} \end{aligned} \quad (4.27)$$

Comparing to household labour, a wage labour contract would be preferred if the hired wage paid to hired wage workers, supervision costs included, is lower than the household opportunity cost or wage:

$$w + \sigma w_e < w_e \quad (4.28)$$

The household's efficiency is reflected in its allocation of land to hired wage workers, sharecroppers or family workers. As the allocation is done plot by plot, rather than as a continuous function of the size of the farm, we can compare the plot regimes and simulate the profits that would arise if another regime would be applied. For each farm, we can simulate whether another regime than presently applied would yield higher profits to the household. If so, the household should be considered inefficient, as an option for higher profits is not used.

Another comparison of efficiency can be made at the level of the plots themselves. As the optimality conditions show, we should expect the marginal product of hired workers to equal their wages plus the costs of supervision, both measured per unit of labour (say an hour). The marginal product of the sharecropper's labour should equal his wage rate divided by the share accruing to him ($\frac{w_o}{\beta}$). (4.29)

1.4. The empirical analysis

1.4.1. Functional forms and variables

The technology is assumed to be similar over labour contract. The production function is considered as translog instead of a pure Cobb-Douglas function, in order to capture the interaction between a number of variables. Preliminary, all the squared variables and interactions terms were used, but most of them were dropped because they were not statistically significant at the 10% level and did not improve the model. Finally, the log-linear functional form of the production function estimated was specified as follows:

$$\log Y_{hic} = \alpha + \lambda_1 \log Lab_{hic} + \gamma \log Input_{hic} + \delta \log Plot_{hic} + \chi Mp_01_{hic} + \lambda_2 \log LabMp_{hic} + \phi S_01_{hic} + \eta Soil_01_{hic} + \varepsilon_{hic} \quad (4.32)$$

where in household h, on plot i (i=1, 2, ..n) and for crop c ∈ {all, onion, cabbage, tomato}, the dependent variable logarithm output in value per plot (log Y_{hic}) is a function of logarithm of:

- *Lab*, the aggregated working time of household labour or sharecropping labour or wage labour, depending on the labour contract, in hours per plot;
- *Plot*, plot area cultivated in square meters;
- *Input*, the aggregated costs in fcfa per plot of non-labour inputs used, such as mineral fertilizers (urea and NPK);

- *Mp_01*, dummy variable for a motor pump (1=motor pump used for plot irrigation, 0=otherwise),
- *LabMp*, the interaction labour and motor pump (logarithm (labour) *dummy motor pump);
- *S_01*, dummy variable for horticultural season (1= 1st and 2nd seasons, 0 = 3rd season);
- *Soil_01*, dummy variable for soil suitability appreciation by the plot manager (1=good or medium, 0=bad);
- ε_{hic} , error term.

1.4.2. Endogeneity and the choice of estimator

In the production function, problems of endogeneity, related to a measurement error or simultaneity and reverse causality, may arise particularly with the explanatory variables input (fertilizers), labour (household labour, sharecropping labour, or wage labour) and the interaction labour-motor pump. This endogeneity may lead to a correlation between these explanatory variables with the error terms making the ordinary least squares (OLS) estimates biased and inconsistent (Verbeek, 2008).

To test the potential endogeneity of the variables input, labour, and interaction labour-motor pump, the Durbin-Wu-Hausman test was done. Each of these endogenous right-hand side variables was estimated as a function of all exogenous variables to obtain the reduced-form equations. The residuals predicted from each reduced-form equation were added to the structural form of the production function. The t-test done showed that the residuals were significantly different from zero ($p=0.05$), suggesting a non-zero covariance between the error term and the variables input, labour, and interaction labour-motor pump. Consequently, the test confirmed the endogeneity of these variables. In such a situation, instrumental variables should be used; the Generalized Instrumental Variable (GIVE) known as the Two-Stage Least Squares (2SLS) is one of the best alternative estimators.

Furthermore, the test of parameters done showed that the variables “use of garden hose for irrigation”, “use of sprinkler for irrigation”, “sharecropping dummy”, “share of women’s off-farm income”, “share of men’s off-farm income”, “log women’s total annual income”, “land owned”, “bovine cattle”, “log plot-household distance”, and the interaction terms “share of women’s off-farm income and motor pump” and “log women’s total annual income and motor pump”, may be considered as strong instruments, because they are significantly

correlated with the endogenous variables ($p=0.001$ to $p=0.07$) in the reduced forms. With the F-statistic greater than 10, following the Stock-Watson rule-of-thumb (Verbeek, 2008), these variables can indeed be considered as strong instruments. We are careful about the problem of endogeneity and we did our best to identify these variables as valuable instruments. However, we are also cautious about the perfect exogeneity of some of these instrumental variables.

As the data used are cross-sectional, with household as the first sampling unit and plot the second one, for the estimation, the option standard errors “clustered robust” is used with household as cluster to allow for intra-household correlation, since the observations (plots) are independent across households (clusters) but not necessarily within households (repeated plot managers).

1.5. Empirical results and discussion

1.5.1. An estimation of the production functions

Table 4.1 presents the descriptive statistics of the variables used in the production functions estimation.

Table 4.1: Descriptive statistics of variables used in the plot level, crop-specific production functions estimation.

Variables	Overall crops		Onion		Cabbage		Tomato	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.

Output value (fcfa)	601,693	93,318	772,039	1,112,354	432,843	717,881	288,213	345,348
Labour (hour)	955	1,456	1,480	2,119	619	533	518	283
Input (fcfa)	27,290	43,055	32,247	51,018	21,141	31,396	71,345	14,834
Plot area (m ²)	1,720	2,204	1,696	1,960	1,404	2,008	1,081	1,264
Motor pump_01	0.15	0.36	0.01	0.13	0.22	0.41	0.21	0.41
Season_01	0.94	0.23	1	0	0.88	0.31	0.90	0.29
Soil suitability_01	0.98	0.10	0.98	0.11	1.00	0.00	0.96	0.17
Garden hose_01	0.18	0.38	0.01	0.11	0.16	0.37	0.24	0.43
Sprinkler_01	0.08	0.27	0.006	0.07	0.04	0.21	0	0
Sharecropping_01	0.29	0.45	0.43	0.49	0.23	0.42	0.27	0.45
Share of women's off-farm income (%)	32.78	38.18	21.33	30.84	34.41	38.26	39.61	40.00
Share of men's off-farm income (%)	20.77	23.74	23.66	21.65	19.44	24.85	18.52	23.51
Women's annual income (fcfa)	342,803	493,124	290,446	315,905	415,695	579,432	330,759	646,992
Land owned (ha)	4.03	3.78	3.69	3.88	4.18	3.46	4.09	3.01
Bovine cattle	4.60	8.76	5.88	10.32	3.65	7.48	4.56	8.99
Distance house-plot (km)	1.37	1.19	1.16	0.96	1.57	1.32	1.46	1.37

Table 4.2 presents the results of the 2SLS and OLS estimations of the production functions for overall horticultural crops and for the dominant specific crops, such as onion, cabbage and tomato, using data at the plot level. For other horticultural crops, such as potato and green bean, the limited number of observations (respectively 9 and 11) did not allow the estimation of their crop-specific production functions, particularly when 2SLS is used. The results of the estimation differ from those of the previous chapter, because of the difference of the variables controlled in the production function and the estimation procedure. In the previous chapter, the stochastic frontier production functions were estimated with a maximum likelihood for cross-sectional data, in order to derive the efficiency scores. Here, mean production functions are estimated rather than frontier production functions.

Table 4.2: The Two-Stage Least-Squares (2SLS) and Ordinary Least-Squares (OLS) estimation for plot level crop-specific production functions (robust clusters in households).

Dependent variable: Log output in value (fcfa)	Overall crops		Onion		Cabbage		Tomato	
	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS

Log Labour (hr)	0.39** (0.19)	0.28*** (0.05)	0.56 (0.40)	0.36*** (.07)	0.43 0.35	0.20* (0.11)	0.61* 0.35	0.33* (0.17)
Log Input (fcfa)	0.53** (0.23)	0.14* (0.08)	0.38* (0.23)	0.05 (0.08)	0.52** 0.24	0.11* (0.06)	0.36*** 0.12	0.48** (0.20)
Log Plot area (m2)	0.36** (0.17)	0.69*** (0.07)	0.33 (0.30)	0.71*** (0.08)	0.34* 0.19	0.70*** (0.06)	0.54*** 0.09	0.46*** (0.16)
Motor pump_01	1.51 (2.33)	0.82 (0.85)		14.11*** (5.14)	2.08 2.78	0.93 (1.05)	2.73 3.87	0.64 (3.29)
Log labour*	-0.30 (0.36)	-0.17 (0.12)	-0.23 (0.29)	-2.09*** (0.81)	-0.34 0.43	-0.13 (0.16)	-0.54 0.62	-0.25 (0.51)
Pump_01								
Season_01	-0.65*** (0.20)	-0.47 (0.14)			-0.42*** 0.18	-0.40*** (0.16)	-0.94*** 0.35	-1.02*** (0.42)
Soil suitability_01	-0.08 (0.28)	-0.08*** (0.19)	0.59** (0.26)	0.25 (0.18)			-0.46 0.33	-0.31 (0.37)
Constant	3.19*** (1.06)	5.25*** (0.37)	2.33 (1.87)	4.66*** 0.33	2.88 2.40	5.73*** (0.65)	3.05* 1.63	4.04 (1.07)
N (plots)	336	382	141	156	134	138	53	63
Cluster (household)	140	169	72	81	94	98	46	56
R2	0.72	0.77	0.74	0.86	0.72	0.79	0.71	0.59
Wald Chi2 or F	1302***	317***	3937***	390***	632***	138***	179***	22***
Instrumented	Log Input (fcfa), Log labour, Log labour*pump_01							
Additional instruments	Garden hose_01, sprinkler_01, sharecropping_01, land, bovine cattle, share of women's off-farm income, share men's off-farm income, log plot-household distance, log women's annual income, share of women's off-farm work*motor pump, log women's annual income*motor pump							
Test of endogeneity: Robust F	2.40*		5.23***		1.52		0.63	
Test of overidentifying restrictions: Chi2	2.03 (p=0.84)		1.71 (p=0.42)		1.89 (p=0.86)		2.81 (p=0.72)	

***, **, * significant respectively at the 1%, 5%, and 10% level; robust standard errors in parentheses.

The estimates of the 2SLS differ from those of the OLS. Since OLS is supposed to be biased and inconsistent because of the endogenous variables input, labour, and labour*pump, the analysis focuses on the 2SLS estimates. As the production functions estimated are log-linear models, the coefficients of the different inputs used can be interpreted as elasticities. Thus, the coefficients are also equivalent to the percentage change in the output in value, resulting from a one percent change in the explanatory variables. Regarding overall crops, except the variable motor pump and its interaction with labour and variable soil suitability, all other variables are significant at least at the 5% level. In terms of elasticity, the coefficients show

that a one percent (1%) increase in labour time, whether household labour or sharecropping or wage labour, leads to an increase by 0.39% of the output in value per plot if there is no motor pump, and only by 0.09% if there is a motor pump. The output in value is significantly responsive to input (mineral fertilizers), with an elasticity of 0.53%. A one percent increase in plot area cropped also results in an increase of 0.36% of the output in value per plot. The seasonal effect is significant and negative, which means that it is increasing from the first and second seasons (November-February and March-June, respectively) to the third season (July-October). This seasonal effect reflects the higher output prices observed in the third season.

The effect of the use of a motor pump is positive (as long as log labour is lower than 5), while the interaction labour-motor pump is negative, showing a decrease of labour working time when a motor pump is used. As shown previously in the descriptive chapter, irrigation is the most time-costly cropping operation, particularly when it is done manually, with 50% and 74% of the total time, respectively, on men's and women's plots. Thus, it is important to understand the effect of a motor pump on the reduction of the working time, even if it is statistically not significant at the 10% level. Soil suitability appreciation is negatively related to the output in value, but not significant at the 10% level as well. With an R-squared of 0.72, the model shows a high goodness of fit for such cross-sectional data. The robust test of endogeneity is significant at the 10% level, confirming that the variables input, labour, and interaction labour-motor pump are indeed endogenous. The test of overidentifying restrictions is not significant ($p=0.84$), suggesting the validity of all the instruments used and the well-correct specification of the model.

As can be read from table 4.2, crop-specific production functions present a great difference. The responsiveness of the variables differs from one crop to the other, as shown by the difference in terms of magnitude and significance of the coefficients. While the onion output is significantly responsive (at the 10% level) to inputs and soil suitability, the cabbage output is responsive to input and plot area, and tomato to input, plot area, and labour. As for overall crops, the seasonal effect is significant for cabbage and tomato. One percent increase in mineral fertilizers input leads to an increase of 0.36%, 0.38% and 0.52% of output in value respectively for tomato, onion and cabbage. So, cabbage is more responsive to fertilizers than the other crops. The high values of the R-squared (0.71 - 0.74) signal a goodness of fit of the crop-specific production functions. Variables such as a motor pump, the season, and soil

suitability are dropped on the onion production function because they are quite invariant. The same goes for the variable soil suitability in the cabbage production function.

The technology shows an increasing return to scale, with a total elasticity of land, labour and input greater than one on plots without a motor pump. This means that scaling up all inputs by one unit may lead to an increase of the output in value by more than one unit for all crops as well as for each crop. Thus, plots without a motor pump are smaller than the optimal size. Contrary, on plots irrigated with a motor pump, the technology displays a constant return to scale, with a total elasticity close to one (table 4.3).

Table 4.3: The return to scale, controlling for crop and irrigation equipment

Plots	All crops	Onion	Cabbage	Tomato
Without a motor pump	1.28	1.27	1.29	1.51
With a motor pump	0.98	1.04	0.95	0.97

1.5.2. Household profit optimization across plots under a sharecropping labour contract and a wage labour contract

For each plot under a wage labour contract, we collected the time spent by household labour and wage workers. For each plot, the ratio time spent by household labour and time spent by hired wage workers was computed. The result shows that, for all crops, for each unit of wage labour working time, a household spent on average 0.96 units of time supervising hired workers and working, since wage labour is generally hired in order to complement household labour. According to households hiring wage labour and the agricultural technicians working on the extension services, the supervision itself represents on average a quarter of the time spent by household members. For each unit of wage labour working time, a household spent on average 0.96 units of time, of which 0.24 was for supervision and 0.72 for a contribution to cropping operations. The supervision rate varies greatly from one household to another and from one crop to another. As can also be seen from the kernel density (figure 4.2), most of the household members spent about 0.20 of their time supervising the wage labour, while very few spent more than 0.30 for each unit of wage labour working time.

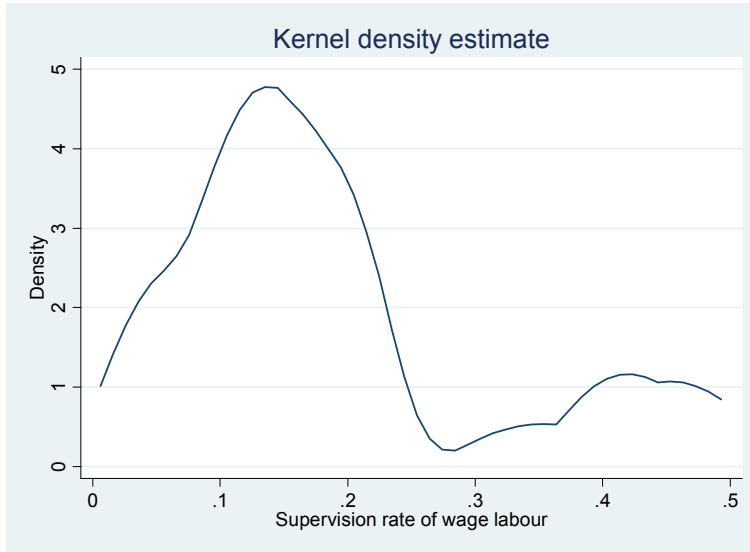


Figure 4.2: Distribution of the supervision rate of wage labour.

As defined in the household model (equation 4.23), the profit derived by the household from a plot under a sharecropping contract is higher than that from a plot under a wage contract if the profit ratio

$$\frac{\pi_s^*}{\pi_w^*} > 1 \Leftrightarrow \frac{(1-\beta)}{(1-\lambda)} \left(\frac{\beta^\lambda}{(1-\lambda)^\gamma} \right)^{\frac{1}{1-\lambda-\gamma}} \left(\frac{w_0}{w_h} \right)^{\frac{-\lambda}{1-\lambda-\gamma}} > 1 \quad (4.23)$$

with $w_h = w + \sigma w_e$

where :

- β is the share of profit paid to sharecroppers, equal to 0.5;
- λ is the production elasticity of labour: $\lambda = \lambda_1 + \lambda_2 * \text{motor pump}_{01}$. For each plot, λ was calculated.
- γ is the production elasticity of other inputs (mineral fertilizers);
- σ is the supervision rate of wage labour;
- w_0 is the sharecropper's opportunity cost or wage for farm or off-farm work;
- w_e is the household opportunity cost or off-farm wage;
- w is the wage paid to hired wage labour by the household;
- w_h is the wage paid by the household to wage labour, including the supervision cost σw_e .

As expected, it can be deduced from the production function estimated (table 4.2) that higher values of λ are obtained without a motor pump ($\lambda=0.39$ for overall crops, 0.56 for onion, 0.43 for cabbage, and 0.61 for tomato). When a motor pump is used, the production elasticity of labour falls ($\lambda=0.09$ for overall crops, 0.33 for onion, 0.09 for cabbage, and 0.07 for tomato) because the irrigation equipment takes a share of the revenue or output in value. Consequently, it is hypothesized that when a motor pump is used, producers would not prefer to hire labour based on sharecropping so much because it is less profitable.

Given β and the estimates λ and γ of the production function (table 4.2), simulations were made at plot level to calculate the optimum profit ratio π_s^*/π_w^* above (equation 4.23):

- first, by setting the opportunity cost of sharecropping equal to the wage paid to wage workers by the household, including supervision costs: $w_o=w_h$ or $w_o/w_h=1$;
- second, by setting the opportunity cost of sharecropping lower than the wage paid to wage workers by the household, including supervision costs ($w_o < w_h$), but equalizing hired wages for household plot managers, sharecroppers, and wage labourers ($w_e=w_o=w$) and varying the supervision costs of wage labour (σ). This means varying w_o/w_h (figure 4.3).

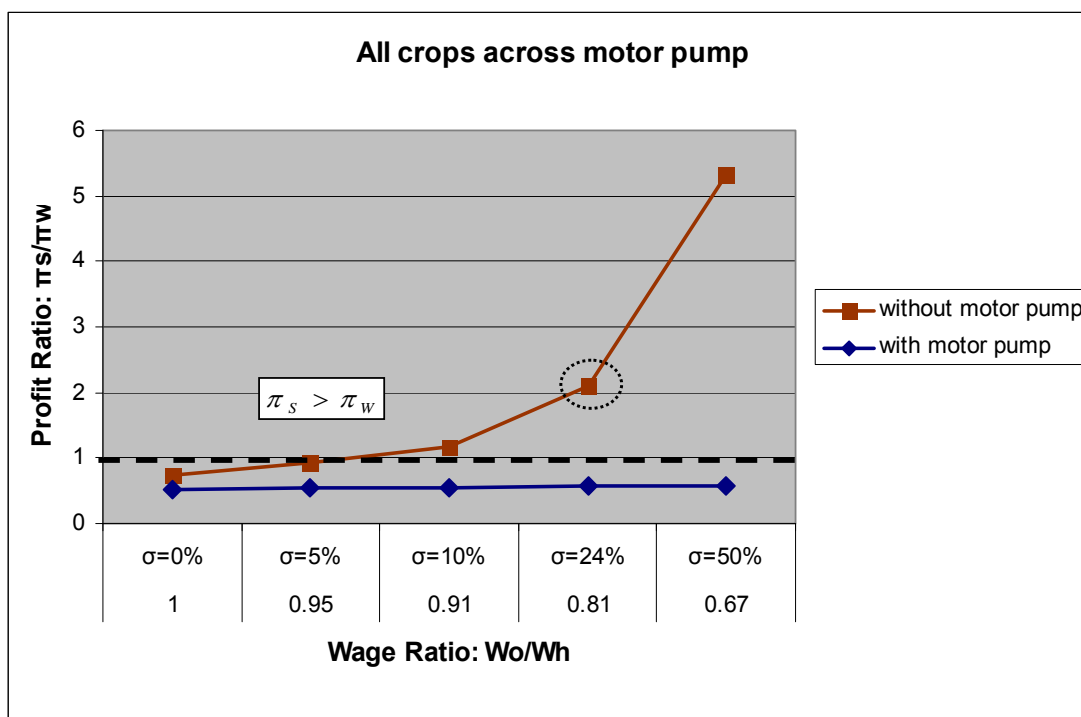


Figure 4.3: A comparison of the average optimum profit derived by the household from plots under a sharecropping contract and a wage labour contract and controlling for a motor pump.

Figure 4.3 is based on the estimates of the production function and shows the variation of the average profit ratio π_s^*/π_w^* (equation 4.23), varying the wage ratio w_o/w_h and the supervision rate σ . As can be read from figure 4.4, the results of the simulations of the profit ratio π_s^*/π_w^* show that if the opportunity cost or wage of sharecroppers equals the wage paid by the household to hired wage labour plus their supervision cost ($w_o=w_h$ or $w_o/w_h=1$), for overall crops, the optimum profit derived by the household from a sharecropping contract is lower than that from a wage labour contract (profit ratio $\pi_s^*/\pi_w^*<1$). This is the case whether a motor pump is used for irrigation on the plot or not. Consequently, at equal wages, for overall horticultural crops, the household would prefer to hire labour based on a wage contract rather than a sharecropping contract to maximize profit. This conclusion also holds for onion, cabbage and tomato.

The production elasticity of labour (λ) falls when a motor pump is used for irrigation, and as can be observed from graph 4.4, the profit ratio π_s^*/π_w^* (equation 4.23) is much lower, making sharecropping less profitable compared to the same case without a motor pump. When the ratio opportunity cost or the wage of the sharecroppers and the wage paid by the household to hired wage labour, supervisions cost (w_o/w_h) included, decreases, or the other way round, when the wage paid by the household to hired wage labour becomes much higher (due to a higher supervision rate) than the opportunity cost of the sharecroppers ($w_h>w_o$), the profit ratio π_s^*/π_w^* increases. When w_o/w_h is equal to 0.9, corresponding to a supervision rate (σ) of about 10%, the profit ratio π_s^*/π_w^* becomes greater than one and, consequently, the profit derived by the household from plots under a sharecropping contract is higher than that from a wage labour contract ($\pi_s^*>\pi_w^*$). This applies to plots without a motor pump, whereas for plots irrigated with a motor pump, a wage labour contract would be more profitable.

Considering the average rate of the supervision of wage labour applied by a household, which is 24%, the ratio opportunity cost or the wage of sharecroppers and the wage paid by the household to hired wage labour (w_o/w_h) is equal to 0.81, while the profit ratio π_s^*/π_w^* is equal to 2.10 for plots without a motor pump and 0.56 for plots irrigated with a motor pump. Consequently, on average, the profit ratio π_s^*/π_w^* is greater than one on plots without a motor pump, contrary to plots with a motor pump. This result suggests that, on average, on plots

without motor pumps, a sharecropping contract provides to the household a higher optimum profit than a wage contract does. However, on average, on plots irrigated with a motor pump, a wage labour contract leads to more optimum profit than a sharecropping contract does. On these plots with a motor pump, the simulations show that even when the wage paid by the household is two times greater than the wage of a sharecropper ($w_o/w_h=1/2$), corresponding to a supervision rate of 100%, the household would still prefer to hire labour based on a wage labour contract rather than on sharecropping. Definitively, on plots equipped with a motor pump, hiring labour based on a wage contract is always more profitable for the household than that based on a sharecropping contract.

For crops like onion, cabbage and tomato, and without a motor pump, a sharecropping contract leads to a higher optimum profit for the household (profit ratio $\pi_s^*/\pi_w^*>1$) compared to wage contract, at the average rate of supervision applied by the household ($\sigma=24\%$), corresponding to a wage ratio of w_o/w_h , equal to 0.81. When plots are irrigated with a motor pump, at this average rate of supervision, hiring labour based on a wage contract is more profitable for the household (profit ratio $\pi_s^*/\pi_w^*<1$).

Graph 4.4 provides a better illustration of the optimization of the household's profit under a labour contract, controlling for crop and motor pump. As can be seen from the graph, the profit optimization from plots equipped with a motor pump differs from that without a motor pump. While cabbage and onion present the same profit optimization, there is a great difference regarding tomato. To sum up, without a motor pump, for all crops together as well as for each crop, sharecropping becomes the most profitable labour choice when the wage ratio w_o/w_h decreases corresponding to an increase of the supervision costs of wage labour. However, when plots are equipped with a motor pump, sharecropping is not the optimum choice, either at 0% or at 100% of the supervision cost for overall crops and for most of the crops.

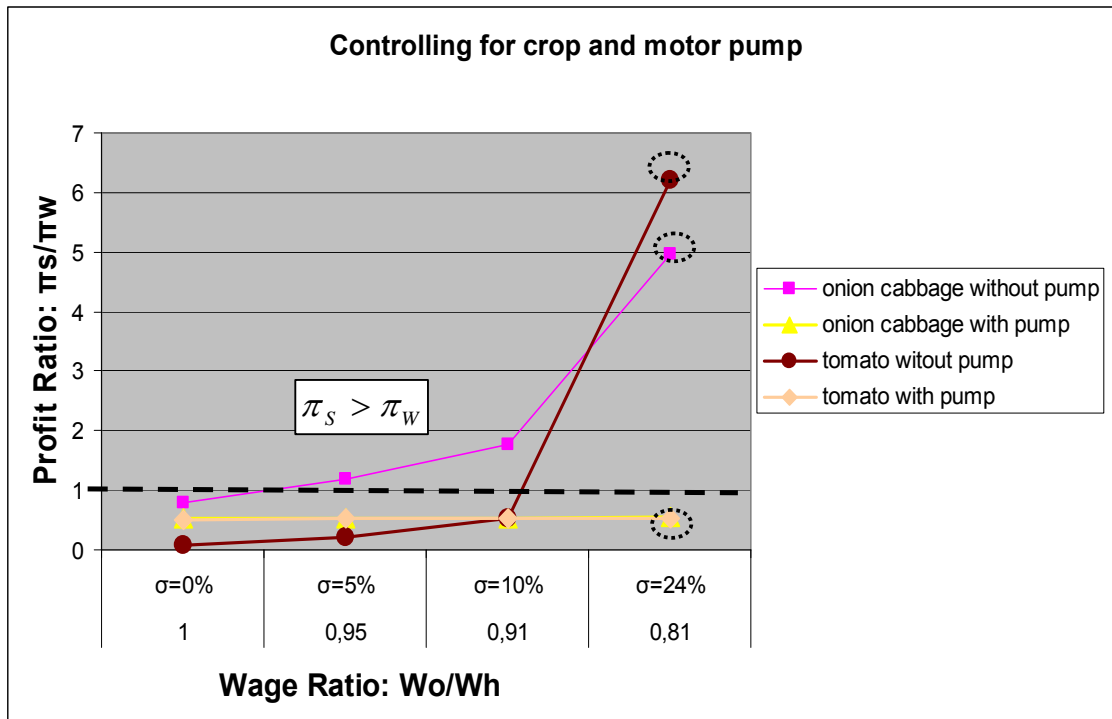


Figure 4.4: A comparison of the average optimum profit derived by the household from plots under a sharecropping contract and a wage labour contract, and controlling for crop and motor pump.

1.5.3. An efficiency test of the labour contract choice based on optimum profit: the sharecropping labour contract versus the wage labour contract

The test was done for overall crops as well as for cabbage and tomato. Due to limited observations under a wage labour contract, the test was not done for onion. Figure 4.5 presents the results of the simulations of the ratios by labour contract.

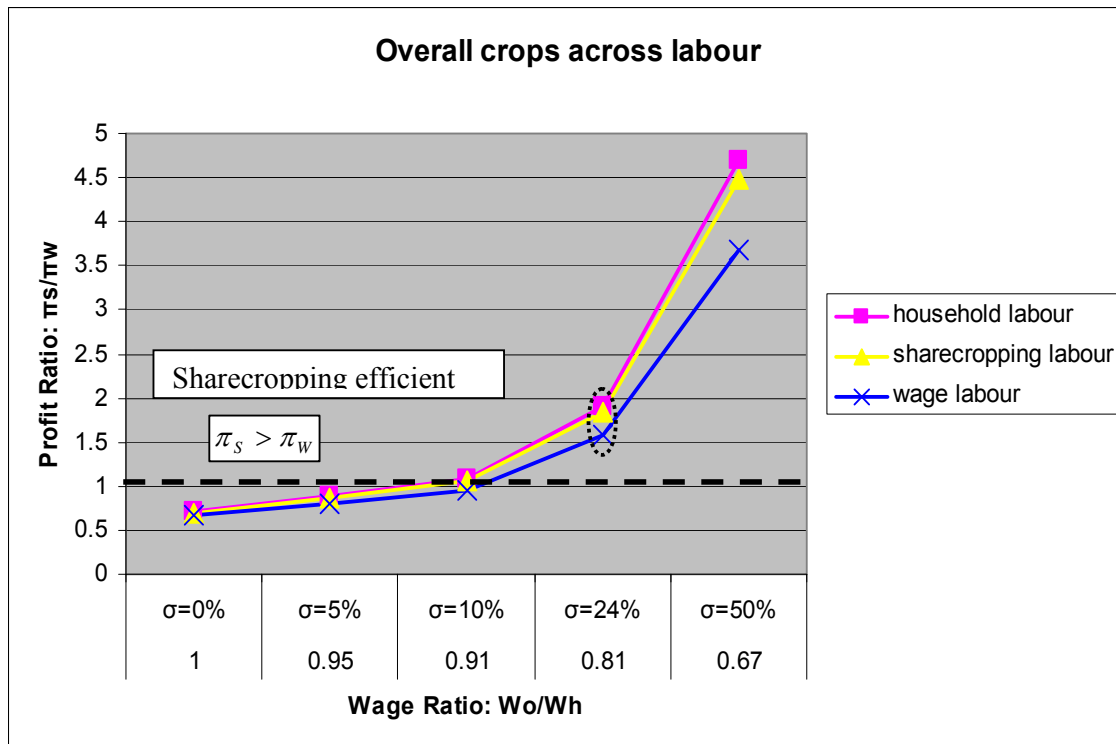


Figure 4.5: An efficiency test of labour contract choice based on optimum profit and varying supervision rate or wage ratio: sharecropping labour contract versus wage labour contract.

For overall crops, on plots based on household labour, sharecropping labour and wage labour, when w_o/w_h is equal to 0.9, corresponding to a supervision rate (σ) of about 10%, the profit ratio π_s^*/π_w^* becomes greater than one, implying that the optimum profit derived from a sharecropping contract is higher than that derived from wage contract. Consequently, from 10% of the supervision rate, the labour choice is efficient on plots based on sharecropping labour and is not efficient on plots based on a wage contract.

Considering the average rate of supervision of wage labour ($\sigma=24\%$) applied by the household and corresponding to a wage ratio w_o/w_h equal to 0.81, the profit ratio π_s^*/π_w^* is greater than one on plots without a motor pump, whether under sharecropping, a wage contract or household labour, and for overall crops as well as for each crop. These findings mean that, on average, the labour choice is efficient on plots without a motor pump and under sharecropping labour, because this choice provides the highest optimum profit to the household. Contrary, on average, the labour choice is not efficient on plots without a motor

pump and under wage labour. Inversely, when a motor pump is used for irrigation, the profit ratio π_s^*/π_w^* is always lower than one suggesting that a higher optimum profit would be derived from a wage labour contract. Accordingly, wage labour would be the efficient labour choice for plots equipped with a motor pump.

The analysis of the data shows that the labour choice is efficient on 82% of the plots under sharecropping labour and on 34% of the plots under a wage labour contract. Many plots without a motor pump under a wage labour contract would be under a sharecropping contract for household profit optimization. Altogether, plot managers made the right labour choice on 73% of the plots under a sharecropping or a wage labour contract (table 4.4).

Table 4.4: Plots with an efficient labour contract choice

Labour	Plots			Plots with an efficient labour contract choice	
	Total	Without a motor pump	With a motor pump	Frequency (plots)	Percent
Sharecropping labour contract	124	102	22	102	82
Wage labour contract	29	19	10	10	34
Total	153	121	32	112	73

1.6. Conclusion and policy implications

In Senegal, labour contracts are used by horticultural households' landowners as suitable strategies to overcome their labour deficit. They are also convenient arrangements for the tenants, who are landless because they come from areas that are inappropriate for horticulture. This chapter provides theoretical and empirical evidence by designing and testing a model based on household profit optimization, to compare the optimum profit derived from plots based on household labour, a sharecropping labour contract and a wage labour contract, while controlling for irrigation equipment. In doing so, this research makes a scientific contribution to the theory of land tenancy, using data from Senegal's Niayes Zone.

Considering the average rate of supervision of wage labour applied by the household which is estimated at 24%, the results suggest that, on average, on plots without motor pumps, a sharecropping contract provides to the household a higher optimum profit than a wage contract does. However, on plots irrigated with a motor pump, even if the wage paid by the

household is two times higher than the wage of a sharecropper ($w_o/w_h = 1/2$), corresponding to a supervision rate of 100%, the household would still prefer to hire labour based on a wage labour contract rather than on sharecropping. Consequently, we can conclude from this finding that the use of a motor pump drives out the sharecropping contract in favour of the wage labour contract.

In terms of the efficiency implication, the test of the labour contract choice based on optimum profit suggests that, at the average rate of the supervision of wage labour applied by the household (24%), without a motor pump, the labour choice is efficient on plots under sharecropping labour, because this choice provides the highest optimum profit to the household. However, on plots equipped with a motor pump, wage labour would be the efficient labour choice. Altogether, plot managers made the efficient labour choice on 73% of the plots under a sharecropping or a wage labour contract.

To sum up, these findings provide a better understanding of the reasons behind the existence and perpetuation of sharecropping over time and over developing countries like Senegal. The findings sketch the trend or the dynamic of the labour contract in a context of mechanization of the production. With the use of the motor pump, the future of the sharecropping arrangement is threatened in favour of the wage labour contract, unless the sharing terms for the landowner change. These findings call for some policy implications. Most of all, an improvement of irrigation equipment is urgently required, not only to make the production system less labour-intensive and to reduce the horticultural households' labour dependence on sharecropping and wage labour, but also to enable large-scale production and to improve the economic performance. Actually, the plots, and particularly those under household labour, are mostly very small. They often are under the optimum size, mainly because of labour and water constraints rather than land availability. Good agricultural programmes should be able to address these constraints and to lead to key achievements if designed and implemented successfully.

References

- Braido, L. H. B., 2008. Evidence of the incentive properties of share contracts. *Journal of Laws and Economics*, 51: 327-349.
- Ghatak, M. and P. Pandey, 2000. Contract choice in agriculture with joint moral hazard in effort and risk. *Journal of development economics*, 63(2): 303-326.
- Garrett, M. A. and Z. H. Xu, 2003. The efficiency of sharecropping: evidence from the post bellum south. *Southern Economic Journal*, 69 (3): 578-595.
- Otsuka, K. and Y. Hayami, 1988. Theories of share tenancy: a critical survey. *Economic Development and Cultural Change*, 37(1): 31-68. The University of Chicago Press.
- Ahmed, M. M., B. Gebremedhin, S. Benin and S. Ehui, 2002. Measurement and sources of technical efficiency of land tenure contracts in Ethiopia. *Environment and Development Economics*, 7: 505-527. UK: Cambridge University Press.
- Pender, J., B. Gebremedhin and H. Mitiku, 2002. Livelihood strategies and land management practices in the highlands of Tigray. Paper presented the workshop on policies for sustainable land management in the highlands of Tigray. Ethiopia.
- Benin, S., M. Ahmed, J. Pender and S. Ehui, 2005. Development of land rental markets and agricultural productivity growth: the case of Northern Ethiopia. *Journal of African Economies*, 14 (1), 21-54.
- Reiersen, J., 2001. Bargaining and efficiency in sharecropping. *Journal of Agricultural Economics*, 52(2): 1-15.
- Araujo, C. and C. A. Bonjean, 1999. Measurement of the economic efficiency of tenurial patterns in Brazil. *Canadian Journal of Agricultural Economics*, 47(2): 181-197.
- Canjels, E., 1996. Essays on time series econometrics and sharecropping in agriculture. PhD thesis. Evanston, Illinois: Northwestern University.

- Kassie, M. and S. Holden, 2007. Sharecropping efficiency in Ethiopia: threats of eviction and kinship. *Agricultural Economics* 37: 179-188.
- Eswaran, M. and A. Kotwal, 1985. A theory of contractual structure in agriculture. *The American Economic Review*, 75(3): 352-367.
- Pender, J. and M. Fafchamps, 2000. Land Lease Markets and Agricultural Efficiency: Theory and Evidence from Ethiopia. Working paper, Washington: IFPRI.
- Binswanger, H. P. *et al.*, 1995. Ch 42: Power, distortions, revolt and reform in agricultural land relations. *In* Behrman, J., T. N. Srinivasan (ed.), 1995. *Handbook of development economics*, volume 3B, Amsterdam: Elsevier.
- Garrabou, R., J. Planas and E. Sagner, 2001. Sharecropping and the management of large rural estates in Catalonia, 1850-1950. *Journal of peasant studies*, 28 (3): 89-108.
- Verbeek, M., 2008. *A guide to modern econometrics*. 3rd ed. England: John Wiley & Sons Ltd.
- Ray, D., 1998. *Development Economics*. Princeton: Princeton University Press.
- Stiglitz, J. E., 1989. Rational peasants, efficient institutions and a theory of rural organization.